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Terminology

Term	Definition
Pop-up factory (PuF)	Pop-up factories are temporary manufacturing and/or assembling facilities that can be quickly set up and taken down to produce components for construction projects. It is a factory in the district itself for the time of the retrofitting program. The factory will develop and assemble industrialized prefab building components that will be installed in the retrofitting projects.
On-site	Refers to the closeness of the pop-up factory to the construction project. Usually, it means that the factory is located close to the construction site (usually up to district or regional level).
Off-site	The opposite of on-site concept, where a factory is located in a different geographical area from the construction site.
Service	Here refers to any type of service that is provided locally, on-site specifically for construction/retrofitting projects. This could be a consultancy service offering advice on retrofitting activities. Could be a platform to bridge the local demand and supply for renovation projects. It could be a non-profit organization to connect local stakeholders and facilitate knowledge sharing about retrofitting, LCA tools or circularity frameworks.
Manufacturing	(Pre-)Fabrication of materials/products used for construction projects.
Assembling	Assembly of (pre-)fabricated materials/products used for construction projects.
Temporary structure	When a pop-up factory is set-up in a temporary way, e.g. housed in a container, industrial tent or modular building.
Permanent structure	When a pop-up factory is set-up in a permanent building, e.g. in an abandoned building, old industrial building.
Just-in-Time (JIT) delivery	JIT is a well-known Lean Management technique that involves small-scale production at the point of demand. The term "Just in Time" is often used in the construction industry to describe the delivery of goods to a job site. It means that materials will be brought to the site of final installation and installed right away, without being delayed by storage in a laydown or staging area.
PESTLE analysis	An analytical framework used to evaluate the broader external factors that influence a project or system. It stands for Political, Economic, Social, Technological, Legal, and Environmental aspects. When applied to pop-up factories, PESTLE helps to identify how regulatory environments, economic conditions, societal dynamics, technological developments, legal frameworks, and environmental considerations shape the feasibility and design of localized manufacturing solutions.
Building Information Modelling (BIM)	A digital methodology for planning, designing, constructing, and managing buildings and infrastructure. It integrates detailed 3D models with rich data, allowing stakeholders to simulate and coordinate all phases of a project more efficiently. In the context of pop-up factories, BIM supports the alignment of off-site production with on-site assembly and enhances traceability and collaboration through the use of shared digital environments. This integration is especially relevant for enabling circular practices, lifecycle tracking, and more sustainable construction workflows.

Executive summary

This report provides a comprehensive overview of the development and implementation of the local Pop-up Factory (PuF) concept within the BuildUPspeed (BUPS) project. The BUPS project addresses the urgent need for deep renovation of European buildings to meet the EU's 2050 decarbonization targets. Within this context, the PuF concept is presented as a promising solution to overcome supply and demand challenges in the construction sector by enabling flexible, localized, and industrialized renovation approaches.

The core objectives of this report are to assess the market readiness for industrialised renovation solutions, including local Pop-up Factories, across the five BuildUPspeed ecosystems of Austria, France, Italy, the Netherlands, and Spain; to develop the methodological basis and implementation matrix for PuF deployment; to present tailored local factory concepts and ecosystem-specific implementation plans; to analyse supporting activities and business-model implications; to assess the feasibility of applying PuF concepts in other or remote locations in the Netherlands, Italy, and Spain; and finally, to consolidate the results into BIM-based digital blueprints and factsheets for the main PuF scenarios.

Pop-up factories are temporary, rapidly deployable facilities for manufacturing and assembly, designed to accelerate construction and renovation efforts. Five conceptual models are identified: **Mobile On-site Factory**, temporary units located directly on construction sites to reduce logistics and delays; **Satellite Factory**, local hubs supported by a central facility enabling off-site production with local assembly; **District Factory**, centralized facilities serving multiple regional projects with shared resources and customization; **Assembly Factory**, facilities near project sites focused on assembling prefabricated components; and **Service Factory**, centres providing advisory and support services to strengthen local capacity.

The report outlines a structured methodology consisting of: **(i) concept characterization**, a framework for identifying and detailing PuF scenarios informed by literature and industry analysis; and **(ii) digital management tools**, including the RE Suite platform, which creates digital passports and unique identifiers for each PuF scenario, ensuring traceability and lifecycle management.

For the market potential and feasibility understanding, a PESTLE analysis (Political, Economic, Social, Technological, Legal, Environmental) was conducted across the five target ecosystems:

- Netherlands: high readiness for assembly and district factories, supported by a mature renovation market.
- France: moderate readiness; promising for assembly and service factories, though stakeholder coordination and cultural buy-in need improvement.
- Austria: strong potential for mobile, district, and assembly factories, supported by favourable political and social contexts.
- Italy: moderate readiness, especially for service factories; technological and social barriers remain.
- Spain: high potential for service factories, though political support and social acceptance require strengthening.

In general, pop-up factories offer significant benefits: (i) to involve local labour, offer traineeships, and strengthen skills in the construction workforce; (ii) to reduce transport-related emissions and increase use of local materials; and (iii) to be able to adapt to diverse local contexts and project scales. Potential limitations are: (i) the limited access to detailed market data in some regions; (ii) the varied uptake of advanced construction technologies across countries; and (iii) the cultural resistance may hinder the adoption of PuF models in some areas.

Important to note that the PuF concept aligns with the values of the New European Bauhaus by promoting sustainability, inclusiveness, and aesthetic improvement in the built environment. It supports community involvement, environmentally responsible practices, and the enhancement of public spaces.

1. Introduction

Achieving Europe's 2050 decarbonization targets demands a deep and widespread renovation of the existing building stock. Yet, barriers ranging from fragmented supply chains and labour shortages to high costs and logistical inefficiencies continue to hinder large-scale implementation. In response, the BuildUPspeed (BUPS) project explores the transformative potential of local pop-up factories (PuFs), an innovative and flexible manufacturing approach designed to accelerate renovation efforts.

PuFs offer a sustainable and adaptive alternative to conventional construction supply chains. These temporary, modular facilities can be rapidly deployed and locally operated, enabling efficient production and reducing environmental impacts. Their proximity to renovation sites minimizes transportation needs, lowers emissions, and facilitates just-in-time (JIT) delivery of prefabricated components. At the same time, they allow for greater customization based on regional contexts and local building practices.

More than simple production units, PuFs function as dynamic platforms for innovation. They support modular construction, integrate advanced technologies such as digital design tools and Building Information Modelling (BIM), and offer opportunities for workforce training in circular construction and life cycle assessment methods. By involving local actors—municipalities, small and medium-sized enterprises (SMEs), and research institutions, these factories help strengthen regional supply chains and foster shared learning environments.

The versatility of the PuF concept allows for various implementations depending on local needs: on-site mobile units, district-serving facilities, satellite hubs, assembly centres, and service-oriented platforms. These diverse configurations are explored in the following sections, along with a typology framework developed to support decision-making and contextual adaptation within the BUPS ecosystems.

This report provides a structured overview of the PuF concept and its application within the five BuildUPspeed ecosystems: Austria, France, Italy, the Netherlands, and Spain. After introducing the PuF concept and the overall approach, the document structure follows the sequential logic of the WP4 tasks from Chapter 3 onwards. In this way, the report guides the reader from market-readiness assessment, through tailored design

development and implementation plans, towards feasibility studies and BIM-based digital blueprints.

Chapter 1 introduces the Pop-up Factory concept. Chapter 2 presents the methodological approach, including the categorisation framework for PuF scenarios and the digital PuF data-management environment established through RE Suite. Chapter 3 presents the mapping of market readiness for local PuFs across the five ecosystems. Chapter 4 then focuses on the design of tailored local factory concepts, combining the theoretical foundation, literature insights, and stakeholder workshops, through which ecosystem partners translated generic PuF typologies into context-specific design concepts. Chapter 5 builds on these designs by presenting the implementation plans and scenarios for local PuFs, including strategic mapping, structured implementation planning, and ecosystem-specific implementation summaries.

Chapter 6 addresses supporting activities for PuF implementation, including theoretical underpinnings, methodology, comparative analysis across national ecosystems, and Business Model Canvas-based analysis. Chapter 7 presents feasibility studies for applying BuildUPspeed local factory concepts in other or remote locations, with specific attention to the Dutch, Italian, and Spanish ecosystems. Chapter 8 consolidates the design and implementation knowledge into BIM-based digital blueprints and factsheets for the District Factory, Assembly Factory, Mobile On-Site Factory, and Satellite Factory. Finally, Chapter 9 provides the overall conclusion of the deliverable.

Since each main chapter from Chapter 3 onwards corresponds to a complete WP4 task or major task output and includes its own dedicated conclusion, the final conclusion in Chapter 9 is intentionally concise. Rather than repeating the detailed findings of each chapter, it synthesises the overall contribution of the deliverable and highlights how the combined WP4 outputs support future PuF replication and implementation.

1.1 The pop-up factory concept

This section outlines the core concept of the PuF and its role in reshaping renovation and construction practices across Europe. It begins by contrasting the PuF model with traditional supply chain approaches, highlighting key differences in flexibility, efficiency, and environmental impact. Various types of PuFs are then introduced—ranging from mobile on-site units to district and service-oriented factories—each tailored to specific local needs and project scales. To illustrate their practical relevance, the section also presents application scenarios, benefits, and real-life examples across Europe. Together, these elements provide a comprehensive understanding of how PuFs contribute to a more agile, sustainable, and inclusive built environment.

1.1.1. Traditional Supply Chain and Pop-Up Factory Comparison

Traditional supply chains in the construction industry (see Figure 1) rely heavily on centralized factory methods, where components are produced in a single, often remote location and then transported to the construction site for assembly. This model allows for consistent quality control through centralized production, benefits from labour

specialization, and takes advantage of dedicated equipment and established logistics networks. The use of standardized components and modular systems can simplify some phases of construction, and the involvement of skilled personnel often results in higher precision and product quality.

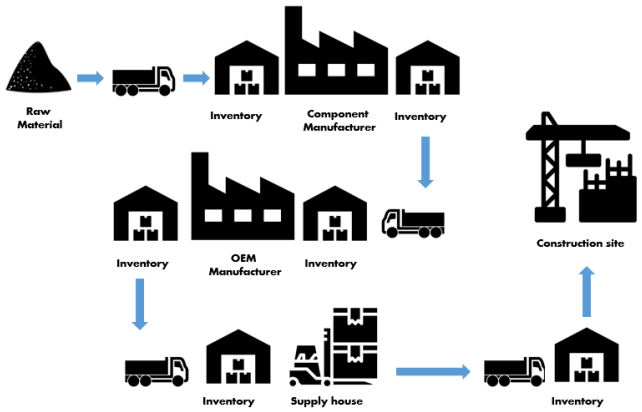


Figure 1 - Traditional supply chain in construction project

Despite these advantages, the centralized model introduces several inefficiencies. Transportation alone can account for 20–30% of total project costs, with significant CO_2 emissions from fuel use and logistics operations. The supply chain is often fragmented, as architects, engineers, contractors, and suppliers operate in silos, leading to miscommunication, quality issues, and delays that can stretch project timelines by 10–15%. On-site work adds further complications—labour accounts for 40–50% of total renovation costs, and construction activities frequently cause disruptions through noise, dust, and restricted access, affecting both residents and surrounding communities. In addition, variable on-site conditions and inconsistent skill levels lead to defect rates of 5–10%, while safety incidents contribute to further delays and increased costs. Sequential workflows inherent to the traditional process tend to prolong construction periods by 20–30% compared to more modern, modular alternatives.

In contrast, pop-up factories (see Figure 2) offer a more agile and decentralized approach. By shifting production closer to or even directly onto the construction site, they drastically reduce the need for transportation, cutting both costs and emissions. The co-location of design, production, and assembly teams promotes better communication and coordination, helping to overcome fragmentation and improve quality control. Operating within a modular, controlled environment also enhances worker safety and reduces the likelihood of defects. JIT production models streamline project execution and contribute to significantly shorter timelines. Furthermore, pop-up factories support broader sustainability goals by lowering emissions, promoting circularity, and integrating digital tools such as BIM into construction workflows.

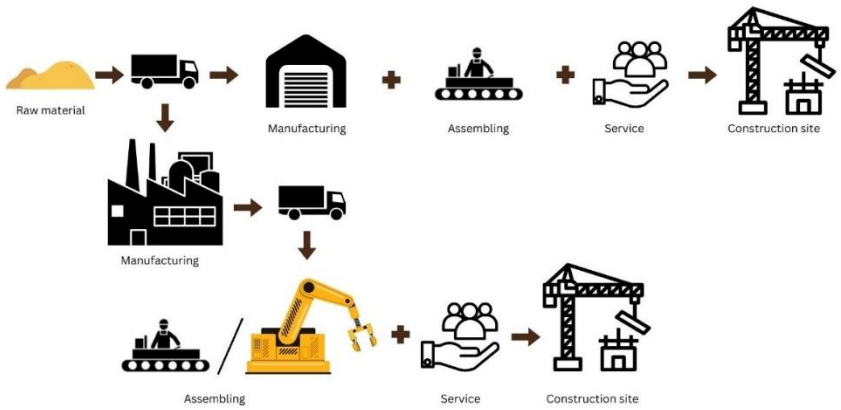


Figure 2 - Pop-up factory concept for constructions schema

By rethinking both the location and organization of production, the PuF approach addresses the structural inefficiencies of traditional construction supply chains and provides a flexible, scalable solution aligned with Europe's renovation and decarbonization goals.

1.1.2. Types of Pop-Up Factories

PUFs can take various forms, depending on the constraints and goals of a construction or renovation project. All types share a common goal of bringing manufacturing, assembly, or services closer to the building site, but differ in permanence, function, and stakeholder engagement. The most common types include mobile on-site, satellite, district, assembly, and service factories. Table 1 provides a comparative overview of these five types.

Table 1 - Overview of Pop-Up Factory Types

Term	Definition
Mobile On-Site Factory	A movable production cell deployed directly on or near the construction site.
Satellite Factory	A temporary facility near the site that collaborates with a central production hub.
District Factory	A semi-permanent facility serving multiple nearby projects, acting as a system integrator.
Assembly Factory	A location focused solely on assembling prefabricated components from other sources.
Service Factory	A knowledge and facilitation hub that supports sustainable renovation through advice and coordination.

The scenarios of the pop-up factory (see Figure 3) developed by partner DEMO Consultants in the context of the BuildUPspeed project, illustrates six different types of production and service arrangements within the construction and renovation sector, highlighting their spatial organization and functional components. Each model is classified by where key processes (manufacturing, assembling, and service) occur either off-site (in centralized or remote facilities) or on-site (at or near the location of construction activity). A color-coded scheme simplifies the comparison:

- Blue indicates manufacturing activities (e.g., component production).
- Yellow represents assembling tasks (e.g., joining components).
- Green denotes service-oriented functions (e.g., planning, logistics, or local engagement).

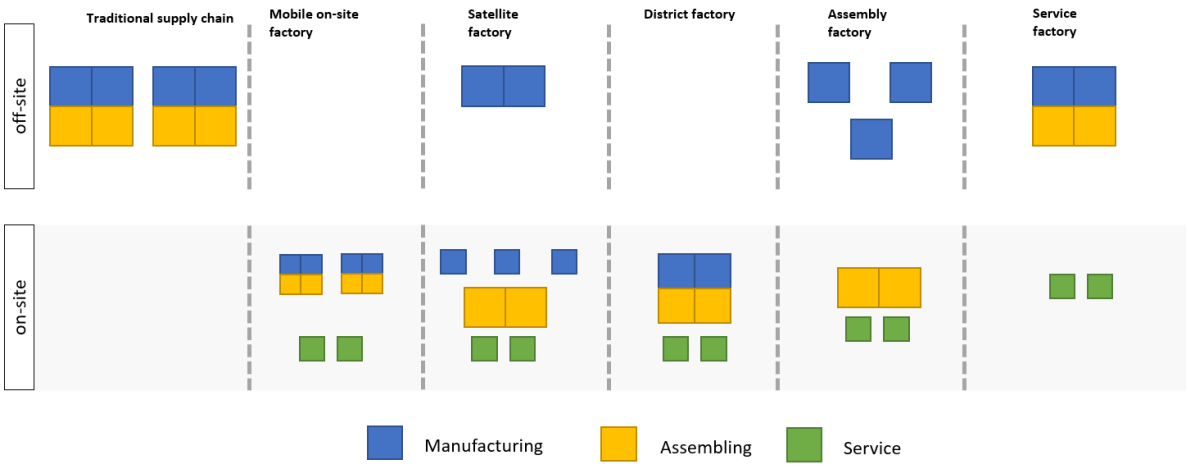


Figure 3 The scenarios of the pop-up factory concept

Going through (left to right) the schema Figure 3 provides, it is important to note that the Traditional Supply Chain (shown before in Figure 1) serves as the baseline. In this model, both manufacturing and assembling are centralized in off-site facilities. Construction sites are mainly passive receivers of finished components, which may be less adaptive to local needs and timelines.

In contrast, Mobile On-Site Factories (see Figure 4) bring a share of manufacturing and assembling directly to the construction site, often through modular or transportable units. This hybrid model improves responsiveness, reduces transportation emissions, and increases adaptability, especially in time-sensitive or spatially constrained projects.

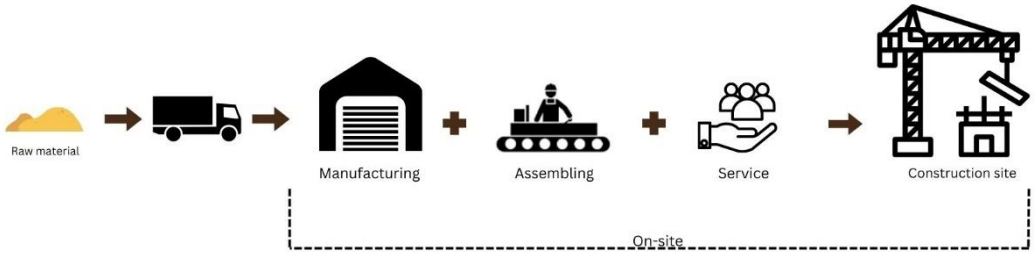


Figure 4 - Mobile on-site factory schema

Satellite Factories (see Figure 5) extend this decentralization by keeping manufacturing off-site but distributing assembling and service functions across multiple small, local hubs. These facilities support a more agile response to urban renovation demands, particularly in dense or hard-to-access neighbourhoods.

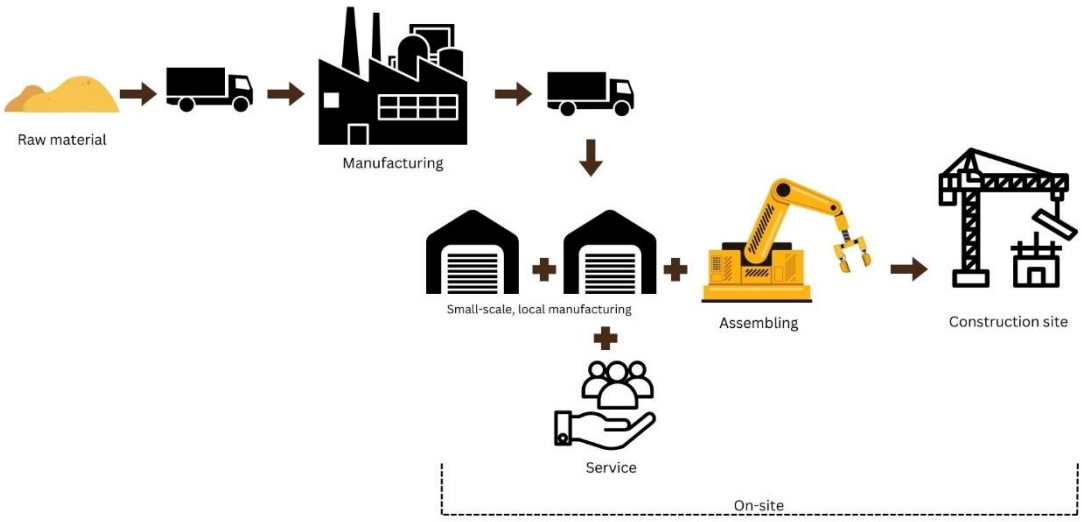


Figure 5 - Satellite factory schema

A more integrated model is the District Factory (see Figure 6), which combines off-site manufacturing and assembling with strong on-site service and assembling capabilities. This configuration supports coordinated renovation across a district, enabling economies of scale while remaining sensitive to local complexities.

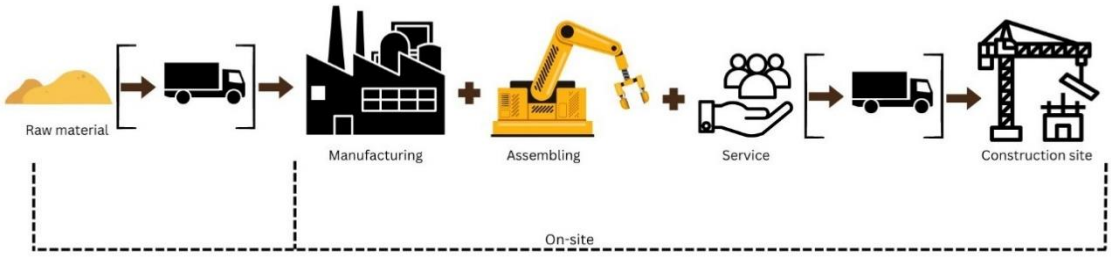


Figure 6 - District factory schema

The Assembly Factory (see Figure 7) focuses on off-site manufacturing and on-site assembling, serving as an intermediary that streamlines final construction stages. It is ideal for JIT assembly approaches where logistics and space efficiency are critical.

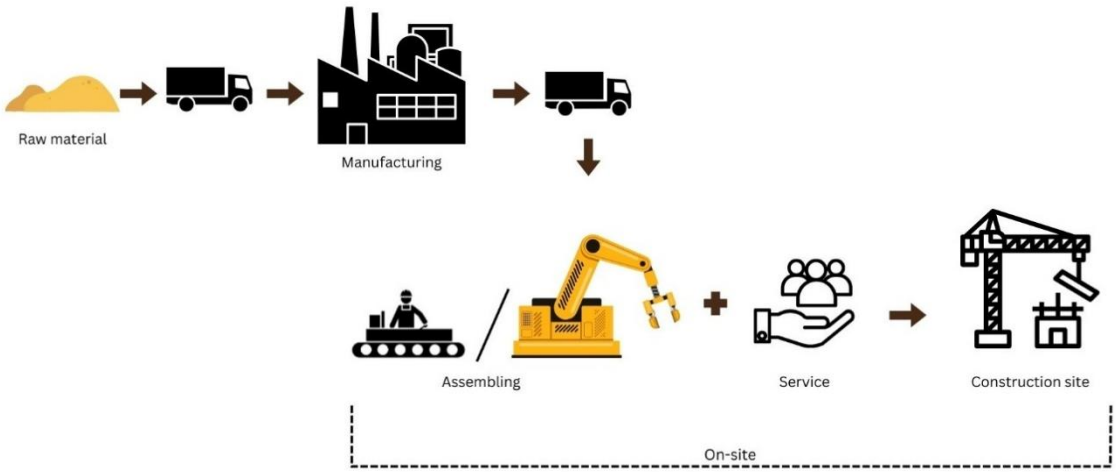


Figure 7 - Assembly factory schema

The Service Factory (see Figure 8) diverges from the physical production logic altogether. Here, all manufacturing and assembling are outsourced, while on-site service nodes take the lead in coordination, stakeholder engagement, and project facilitation. This model is well suited for enabling localized innovation, participation, and context-aware planning.

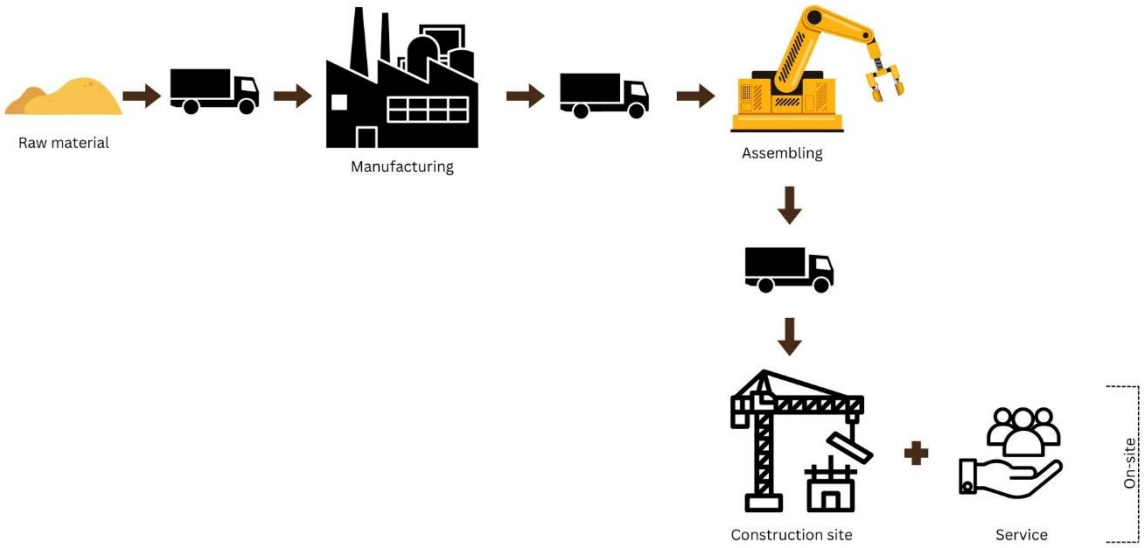


Figure 8 - Service factory schema

Together, these models illustrate an evolving shift from centralized, production-driven paradigms to distributed, hybrid, and service-enhanced systems that better support sustainable and resilient urban transformation. Table 2 condenses the key features of the analysed PuF types to facilitate comparison and improve clarity on what are the differences between the different types of PuFs, see below.

Table 2 – Pop-up Factories Key Features Comparison

Feature	Mobile On-Site	Satellite	District	Assembly	Service
Location	On or very near site	Near site	Regional/district	Near site or district	In community areas
Main Function	Manufacturing & assembly	Adaptation & assembly	Full integration	Assembly only	Support & guidance structure
Type	Modular units	Warehouses/containers	Industrial facilities	Warehouses	Community spaces
Permanence	Temporary	Semi-permanent	(Semi-)permanent	Temporary/semi-perm.	Temporary/semi-perm
Scalability	High (modular setup)	Medium (region-based)	High (multi-project)	Medium	Context-dependent

To further refine the understanding and application of different PuF types, Table 3 presents a detailed characterization of the key aspects that define each scenario. This table breaks down the four main features—purpose, design, scale, and location—into specific descriptors, which are then mapped to the PuF types (**m**obile on-site, **s**atellite, **d**istrict, **a**ssembly, and **se**rvice). By identifying which characteristics align with each

PuF model, this overview supports stakeholders in evaluating trade-offs, recognizing opportunities, and selecting the most context-appropriate factory setup.

Table 3 - Aspects to characterise the different PuF scenarios

No.	Description	Scenarios
Purpose		
P1	Provides localised manufacturing and assembly of construction components and systems in a specific region or district	(d)
P2	Supports more extensive manufacturing facilities by producing components or products in a more decentralised manner on a local scale	(s)
P3	Assembles (pre)fabricated components locally	(a)
P4	Provides specific services related to construction and renovation projects	(se)
P5	Produces customised components on-site	(m)
P6	It aims to create jobs and boost economic growth locally.	(d,se)
P7	Provides JIT delivery for specific projects	(m)
Design		
D1	Mobile, easily transportable structure	(m,s)
D2	Semi-permanent structure	(d, a,se)
D3	Temporary structure	(m,s, a,se)
D4	Permanent structure	(d, a,se)
D5	Uses innovative and flexible manufacturing processes	(m,s)
D6	High level of automation and precision	(s,d, a)
D7	Uses sustainable and eco-friendly solutions	(d)
Scale		
S1	Large-scale manufacturing	(s,d)
S2	Small-, medium-scale manufacturing	(m,s)
S3	Large-scale assembling	(s,d, a)
S4	Small-, medium-scale assembling	(m, a)
Location		
L1	Near the construction site (on-site)	m, a,se)
L2	District level	(s,d, a,se)
L3	Within proximity (regional level)	(s,d,se)
L4	Off-site (away from the construction site)	(s)

1.1.3. Scenarios and Applications

Pop-up factories are flexible solutions that can be deployed across a wide range of construction and renovation contexts. Their modular nature and adaptability make them suitable for various project scales and types, from small community-led initiatives to large-scale urban redevelopments.

In remote or hard-to-reach locations—such as islands, mountainous areas, or rural environments—transporting prefabricated elements over long distances often incurs high costs and complex logistics. In such cases, establishing mobile or satellite factories closer to the project site significantly reduces heavy freight expenses and CO_2 emissions, while also overcoming infrastructure limitations. Temporary pop-up

factories are especially valuable in emergency housing situations, as they enable the rapid production of essential building components in disaster-affected areas.

For high-volume or urgent projects, such as rapid infrastructure expansions or commercial developments, pop-up factories support lean construction techniques by enabling JIT production. This approach compresses timelines, minimizes on-site storage, and accelerates delivery without compromising quality. District factories, in particular, can handle large-scale demand by integrating automation and multi-line assembly processes, facilitating swift turnaround while maintaining production control.

When it comes to customization needs, pop-up factories provide a practical solution for adapting to specific local conditions. Whether addressing historical preservation guidelines, building codes, or extreme climate factors, mobile on-site or satellite factories allow for tailored production. Their flexibility supports the use of advanced manufacturing technologies—such as 3D printing, robotics, and Computer Numerical Control (CNC) milling—which are especially useful for fabricating components for heritage buildings, unique façade systems, or non-standard geometries.

Pop-up factories also play a crucial role in community-focused construction. By involving local SMEs, residents, and stakeholders, these factories help build a collaborative ecosystem that fosters job creation, skill development, and social inclusion. Community-driven construction or deep renovation projects can benefit from on-site or nearby assembly lines, especially when integrating reclaimed or recycled materials—promoting environmental responsibility and circular building practices. District and service factories often double as living labs, offering live demonstrations, educational workshops, and pilot programs to enhance building performance and engage local communities.

In mixed-use or multi-phased developments, an on-site PuF can be relocated as construction progresses across building clusters. This mobility minimizes downtime and transport needs, offering flexibility and efficiency throughout the project lifecycle. District factories are particularly well-suited for such developments, as they centralize resources and services for housing, offices, and public spaces within a neighbourhood. This promotes synergy between architects, builders, and local authorities, enabling coordinated and adaptable urban regeneration strategies.

The purpose category highlights the primary objectives of each project, ranging from localized manufacturing to JIT delivery and job creation. Design features describe how the factory is configured, including whether it is mobile or semi-permanent, the extent of technological integration, and its alignment with sustainable practices. Scale refers to whether the project operates at a large or small/medium manufacturing or assembly level, while the location classification indicates whether activities take place on-site, at a district level, within a regional scope, or completely off-site.

1.1.4. Benefits and Advantages

Pop-up factories offer more than just a novel approach to construction, they bring tangible benefits across the entire project lifecycle. By decentralizing production and bringing it closer to the point of use, these flexible setups address some of the construction sector’s most pressing challenges, including sustainability, efficiency, and

community development. Table 4 outlines the key advantages that pop-up factories can deliver to projects, stakeholders, and local economies.

Table 4 – Pop-up Factories Key Benefits

Category	Key Benefits
Transport & Emissions	Manufacturing close to or on-site cuts fuel use and logistics costs
	Fewer vehicle trips reduce emissions and support climate goals
Quality Control	Controlled factory environments increase precision and reduce errors
	Automated processes ensure consistency across components
Communication	Co-location of teams enables faster decision-making
	Real-time collaboration between designers, engineers, and builders streamlines workflows
Project Timelines	On-demand production shortens delivery times and reduces inventory
	Rapid prototyping accelerates design iterations
Flexibility	Factories can be scaled, reconfigured, or relocated based on project needs
	Easily adapt to changing market or design demands
Local Impact	Engages and trains local workers, boosting regional employment
	Supports SMEs and strengthens local supply chains
	Encourages community involvement and knowledge sharing

1.1.5. Real-Life Examples Across Europe

Across Europe, PuF concepts are being adapted to local contexts, supporting renovation efforts at multiple scales. These projects vary from mobile units producing bespoke components directly on-site to more permanent hubs coordinating large-scale district retrofits.

Initiatives often combine technical innovation with local engagement. Some serve as service hubs, offering training and technical support to boost deep-renovation uptake in communities. Others function as district factories, overseeing bundled renovation projects from a centralized base. Satellite setups complement larger production systems by decentralizing component manufacturing for quicker delivery and fewer logistical demands.

To better understand these diverse applications, this subsection draws on the typology introduced before. Each identified project is mapped against five core factory scenarios (district, satellite, assembly, mobile, and service), based on its primary types (purpose, design, scale, and location) of operation.

Table 5 provides a comparative overview of PuF–related projects implemented across Austria (AT), Italy (IT), the Netherlands (NL), and Spain (SP). A total of twenty seven relevant projects were identified. Each row in the table presents a specific project and categorizes it according to the main types. The final column identifies the overarching scenario each project aligns with based on its combined characteristic. The comparative helps to clarify how different forms of pop-up manufacturing are being implemented across Europe.

Table 5 - European existing factories analysis.

Country	Project name	Purpose							Design							Scale				Location				Factory scenario
		P1	P2	P3	P4	P5	P6	P7	D1	D2	D3	D4	D5	D6	D7	S1	S2	S3	S4	L1	L2	L3	L4	
AT	Neuland 3P					X		X																Mobile
	Baukarussell					X																		Mobile
	Ferry Dusika Stadium					X																		Mobile
	Smart Balkon					X		X																Mobile
	Aspern Seestadt	X					X			X					X			X			X			District
	Beustoff Holz			X							X			X		X		X		X				Assembly
	WoodRocks			X							X			X		X		X		X				Assembly
	MyBlock			X							X			X			X		X	X				Assembly
	Re-use-box				X					X							X		X	X				Service
	Materialnomaden				X					X						X		X			X			Service
IT	4RinEU	X								X				X	X			X				X		District
	Infinite			X							X			X		X				X	X			Assembly
	Passeggiata dei Castan			X							X			X		X				X	X			Assembly
NL	Kerkrade					X		X	X								X		X	X				Mobile
	Takkenkamp							X	X				X				X			X				Mobile
	WEBO		X								X		X	X			X	X			X	X	X	Satellite
	mobile buurtfabriek	X					X			X					X			X			X	X		District
	BAM's system			X						X	X			X				X		X	X			Assembly
	Reimarkt Woonzijnwinkle				X		X			X		X				X					X	X		Service
SP	Aislahome					X		X	X				X				X		X	X				Mobile
	Okambuva.coop		X										X	X			X	X			X	X		Satellite
	CREE system		X										X	X			X	X			X	X		Satellite
	Cadersa	X					X			X				X	X	X					X	X		District
	Inhaus			X						X				X		X					X			Assembly
	Arguima			X						X				X		X					X			Assembly
	Xaloc Network				X		X			X		X				X		X			X	X		Service

2. Approach

This section presents the approach used to define, assess, and manage the feasibility of the PuF concept within the BUPS project. To establish a working definition for the PuF concept, scientific literature and relevant reports were reviewed which will later be again touched upon. From this, a framework was developed to categorize PuF scenarios, which was then applied to validate the concept in each ecosystem. Based on these validated scenarios, a digital platform was used to support the management of tailored designs throughout their lifecycle.

2.1 Categorization Framework

PuFs vary significantly in their setup and purpose, depending on the specific needs of construction projects. To support effective planning and deployment, a categorization framework has been developed based on four defining features and these provide a practical reference for identifying and selecting the most suitable factory model for a given context,

- Purpose: PuFs fulfil a range of functions within the construction value chain. While some are focused on the production of specific components or entire systems, others offer services such as consultancy, design, engineering, installation, maintenance, or end-of-life processing. This includes contributions to circular economy practices, such as repair, reuse, and recycling—aligned with the R-imperatives.
- Design: this refers to the physical configuration and technological setup of the factory. Factors such as mobility, equipment type, automation level, and sustainability measures define the flexibility and complexity of each PuF. Setups can range from compact, fully mobile units to semi-permanent installations with advanced capabilities.
- Scale: the scale dimension considers both production capacity and physical size. Some PuFs are small and portable, ideal for localized or temporary tasks, while others are designed for high-throughput operations and larger footprint requirements.
- Location: the factory's geographical positioning is a key operational consideration. PuFs may be deployed directly on construction sites, at nearby district hubs, or in regional or off-site facilities. Location affects logistics, accessibility, and cost-efficiency.

To facilitate consistent evaluation and comparison of different PuF setups, Table 5 presents classification criteria under each of these four dimensions. It also introduces a fifth element, Factory Scenario, which summarizes the combination of features into the five PuF types: mobile, satellite, district, assembly, and service factories. This categorization tool (see Table 6) serves as a decision-making aid, enabling stakeholders to match factory models with project requirements. By encouraging flexible and context-specific configurations, the framework supports more efficient, scalable, and sustainable construction practices.

Table 6 - Checklist criteria for Pop-up Factory scenarios

Criteria / Pop-up factory		Mobile on-site factory (m)	Satellite factory (s)	District factory (d)	Assembly factory (a)	Service factory (se)
Purpose						
P1	Provides localised manufacturing and assembly of construction components and systems in a specific region or district			☑		
P2	Supports more extensive manufacturing facilities by producing components or products in a more decentralised manner on a local scale		☑			
P3	Assembles (pre)fabricated components locally				☑	
P4	Provides specific services related to construction and renovation projects					☑
P5	Produces customised components on-site	☑				
P6	It aims to create jobs and boost economic growth locally.			☑		☑
P7	Provides JIT delivery for specific projects	☑				
Design						
D1	Mobile, easily transportable structure	☑	☑			
D2	Semi-permanent structure			☑	☑	☑
D3	Temporary structure	☑	☑		☑	☑
D4	Permanent structure			☑	☑	☑
D5	Uses innovative and flexible manufacturing processes	☑	☑			
D6	High level of automation and precision		☑	☑	☑	
D7	Uses sustainable and eco-friendly solutions			☑		
Scale						
S1	Large-scale manufacturing		☑	☑		
S2	Small-, medium-scale manufacturing	☑	☑			
S3	Large-scale assembling		☑	☑	☑	
S4	Small-, medium-scale assembling	☑			☑	
Location						
L1	Near the construction site (on-site)	☑			☑	☑
L2	District level		☑	☑	☑	☑
L3	Within proximity (regional level)		☑	☑		☑
L4	Off-site (away from the construction site)		☑			

Using the framework and supporting literature, five main PuF types were identified. These categories are based on the four defining features: purpose, design, scale, and location. While each factory type has a general profile, the location is often influenced by local ecosystem conditions. Therefore, we defined proximity thresholds tailored specifically for the BUPS project rather than based on external sources. These thresholds help classify the factories according to their distance from the construction site (see Figure 9).

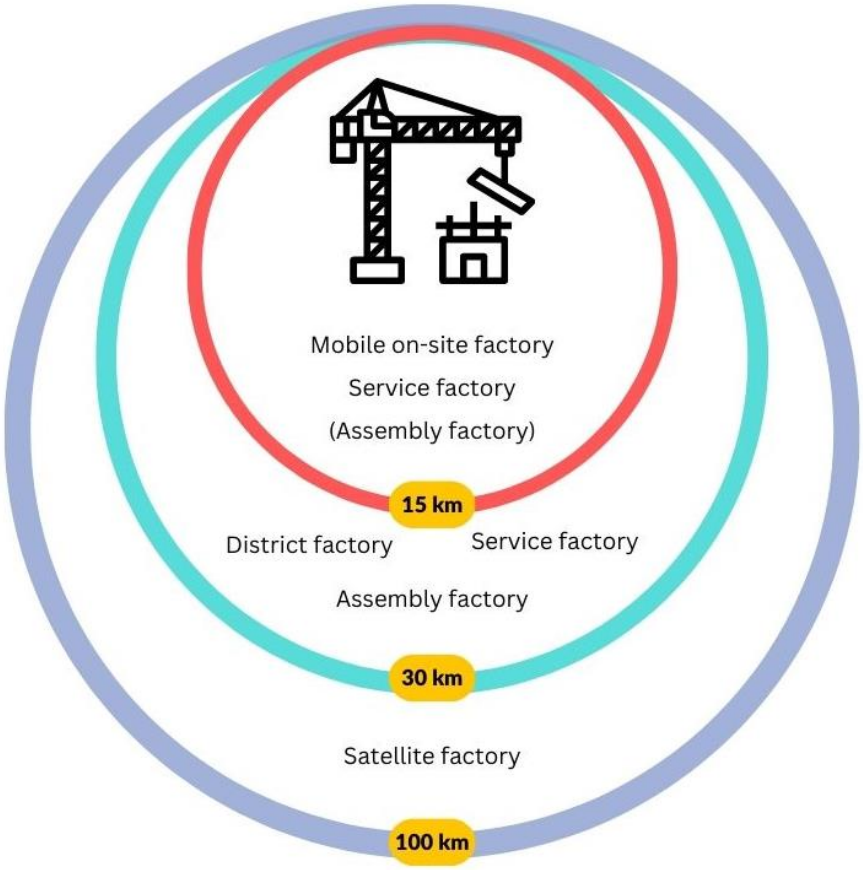


Figure 9 - Proximity of pop-up factories to the construction site

- On-site factories: these include mobile on-site, service, and assembly factories. "On-site" may refer to the exact project location, but due to practical constraints, we consider any location within 15 km as on-site. At this distance, transportation costs and logistics are negligible compared to conventional supply chains.
- District-level factories: located within 30 km of the site, these typically include manufacturing, assembly, or service operations. They strike a balance between mobility and production capacity.
- Regional-level factories: these are usually satellite factories, placed between 30 and 100 km from the site. While still relatively accessible, they may require some logistics coordination.
- Beyond 100 km: at this distance, factories operate as part of a traditional supply chain, with significant reliance on transportation, storage, and logistics infrastructure.

Building on the framework used to characterise and distinguish between different PuF scenarios, the next step is to translate these insights into a practical management tool.

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This involves setting up a digital environment that supports the design, planning, and coordination of PuFs across their lifecycle. By integrating the checklist criteria into a digital platform, it becomes possible to streamline the configuration and monitoring of tailored factory setups, ensuring they respond effectively to project-specific goals and local conditions. The following section outlines the development of this digital PuF management environment.

2.2 Setting up a Digital Pop-up Factory Data Management Environment

Transitioning to a digital environment for managing PuFs is essential to ensure their scalability, flexibility, and long-term integration within renovation ecosystems. Given the complexity of coordinating mobile and decentralized production systems—each involving multiple stakeholders, products, locations, and timelines—traditional, paper-based or fragmented digital tools are no longer sufficient. A digitally integrated approach provides not only greater operational efficiency but also transparency and traceability across the entire product life cycle. This is especially important in the context of sustainable construction, where data-driven decision-making and circularity are becoming industry standards.

The BUPS approach to digitalization is closely aligned with BIM-driven factory and production system planning (Forte et al., 2024). Their work presents a robust reference architecture for integrating Building Information Modeling (BIM) with advanced data management capabilities—including a Common Data Environment (CDE) and Product Lifecycle Management (PLM) functionalities—to support all phases of factory and process planning. This methodology enables seamless collaboration, synchronized data exchange, and multidisciplinary coordination between all stakeholders, from initial design through to operation and decommissioning. By adopting these principles, the BUPS project ensures that data flows remain standardized, interoperable, and future-proof across all PuF implementations.

Before introducing the specific tool used in this project, it is important to outline the concept guiding the digitalization of PuF operations. At its core, the approach relies on digitally representing each construction product and assigning it a unique identity, referred to as a digital product passport. These digital identities enable full traceability across all stages of the lifecycle, including manufacturing, logistics, on-site assembly, usage, maintenance, and ultimately, disassembly or reuse. This continuous flow of data supports the transition to circular business models, enhances resource efficiency, and is increasingly necessary to meet evolving regulatory frameworks such as the EU's Eco-Design for Sustainable Products Regulation (ESPR) under the Circular Economy Action Plan. Digital Product Passports (DPPs) are also aligned with Industry 4.0 technologies and can be integrated with Building Information Modelling (BIM) platforms to enable dynamic material tracking, facilitate life cycle-type analysis (assessment and costing, for example), and inform end-of-life strategies. Such integration is essential for operationalizing circularity in construction and closing material loops at scale.

Within BUPS, this digital strategy is operationalized through the RE Suite, and selected not only for its technical capabilities but also because of the partner's in-depth expertise

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in managing real estate and construction-related data environment. This ensures that the platform is tailored to the specific needs of pop-up factory manufacturing scenarios.

To enable full traceability and efficient coordination across PuF scenarios, each construction product is digitally represented and assigned a unique identity within the RE Suite platform. This digital identity forms the backbone of a data-driven management approach, allowing for real-time tracking of components throughout their entire life cycle—from manufacturing and logistics to installation, after-service, and end-of-life processes. The following section introduces the RE Suite in more detail, highlighting its core functionalities and how it supports the implementation and scaling of PuFs across diverse contexts.

2.2.1. Digital Management Tool: RE Suite

To support the digital management of PuFs in BUPS, the project utilizes the RE Suite[1] (Figure 10 shows the interface), a modular software solution designed to structure, analyse, and share information about the built environment. Developed by DEMO Consultants, RE Suite provides a cohesive environment for managing real estate data and suited for overseeing dynamic and distributed manufacturing setups like PuFs.



Figure 10 - RE Suite's interface for Built-Up-Speed Project

RE Suite's architecture emphasizes flexibility and interoperability. Its modular structure allows the platform to be adapted to different use cases, from traditional building management to mobile factory operations. For BUPS, this adaptability enables the platform to act as a digital backbone for organizing factory-related data and ensuring interoperability between components, workflows, and stakeholders. In the context of the BUPS project, RE Suite serves several key purposes:

- Digital Representation of PuF Components: RE Suite supports the creation of detailed digital representations of the various elements that constitute a PuF.

[1] https://www.demobv.nl/en/re-suite

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These representations provide a structured, visual overview of all components involved—facilitating setup, planning, and system integration across different use case contexts.

- Common Data Environment (CDE): RE Suite consolidates all relevant information into a single interface, supporting clear oversight and reducing fragmentation. This centralized approach improves coordination, ensures consistency of data, and allows different actors (manufacturers, operators, and decision-makers) to work from a shared source of truth.
- Template Functionality for Standardization: through its configurable data fields and modules, RE Suite helps define a standardized information structure for PuF setups. This ensures that each implementation is based on a replicable and adaptable framework, enhancing scalability across diverse geographic and operational contexts.

In summary, the RE Suite enables the generation of ecosystem-specific digital factory designs and related information flows. These digital structures serve not only to document components but also to support ongoing decision-making, traceability, and optimization throughout the lifecycle of a PuF. In BUPS, RE Suite therefore provides the BIM-based layer of the PuF blueprints, while the consolidated blueprint structure itself is presented in Chapter 8.

Figure 11 illustrate examples of how PuFs are represented within the RE Suite environment, including a preview of the dedicated passport module used in the BUPS project (see section below).

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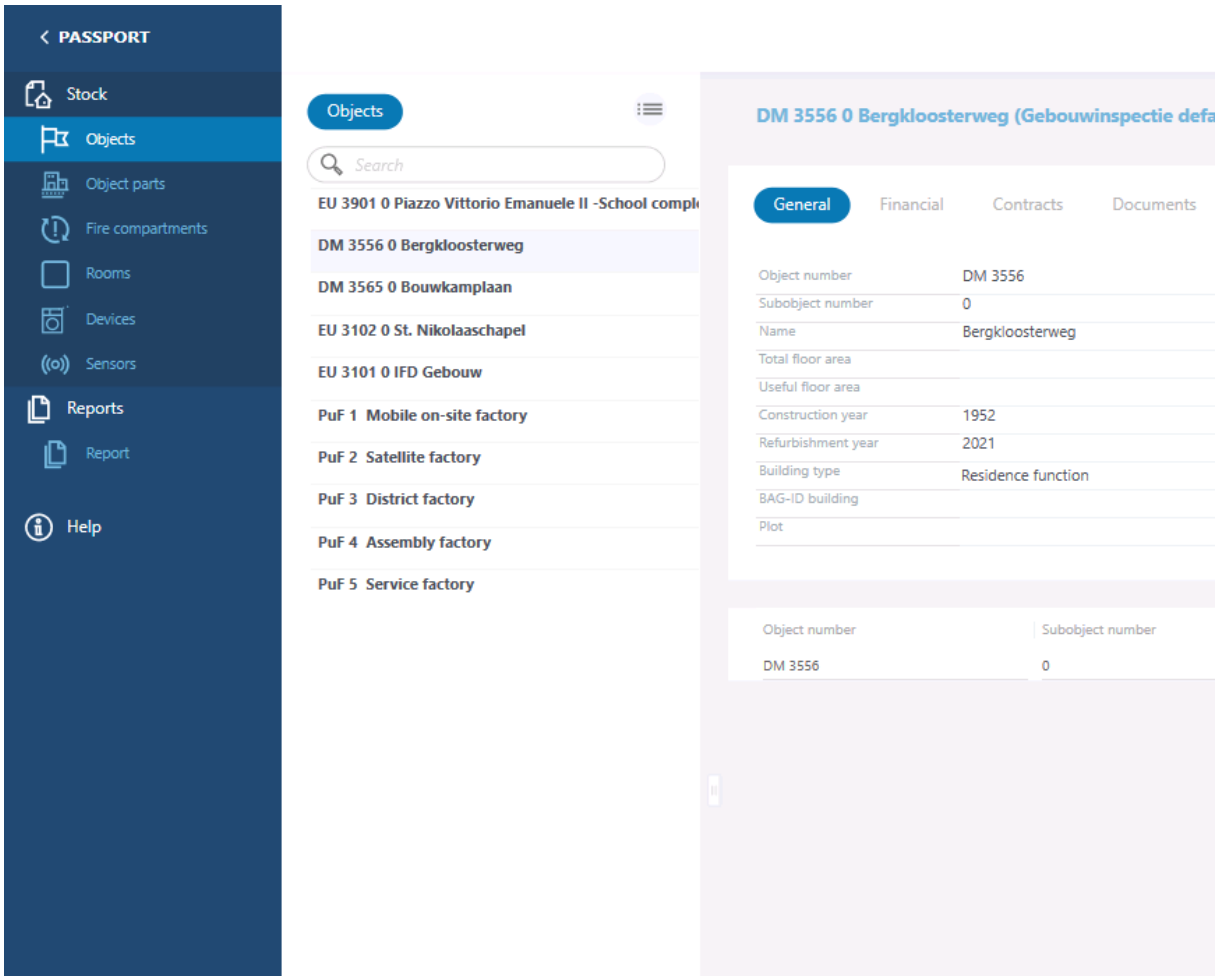


Figure 11 - PuF scenario management environment.

2.2.2. Integration of Digital Passports

As PuFs contribute to a more sustainable and circular construction ecosystem, the integration of digital product passports becomes a key enabler for traceability, transparency, and informed decision-making. In the BUPS project, digital passports are used to record and manage detailed information about each component involved in the manufacturing and assembly processes. This approach supports the creation of a comprehensive, lifecycle-oriented data environment in which materials and components can be tracked, assessed, and reused. A digital passport is essentially a structured data container linked to a physical product, material, or system. It includes essential attributes such as:

- Origin and material composition.
- Manufacturing and installation details.
- Energy Performance characteristics.
- Maintenance (history and planned activities) usage information.
- Environmental impact indicators.
- End-of-life strategies (reuse, recycling, disposal options).

By embedding these digital records within the RE Suite platform, each product in the PuF setup gains a unique digital identity, enabling real-time updates and lifecycle documentation. This supports circular construction strategies by facilitating reuse scenarios, verifying compliance with sustainability standards, and reducing waste during renovations or deconstructions.

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In practice, digital passports in BUPS are managed through dedicated modules in RE Suite (such as the Passport Module) which allow for the creation, editing, and retrieval of passport data. These modules are directly connected to the digital representations of PuF components, ensuring integration and easy access for stakeholders across the project's lifecycle stages. The benefits of integrating digital passports include:

- Enhanced traceability of components across different PuF deployments.
- Data-driven decision-making for sustainable material selection and system optimization.
- Regulatory compliance with emerging requirements in circular construction and building documentation.
- Knowledge preservation for future renovations or adaptive reuse scenarios.

Within BUPS, the digital passport framework provides a practical basis for linking PuF components with lifecycle information, material characteristics, environmental indicators, and end-of-life options within the RE Suite environment. This completes the BIM-based data management layer of the PuF blueprint approach. Chapter 8 builds on this foundation by presenting the consolidated PuF factsheets and digital blueprints that are made accessible through the Market Activation Platform (Service Factory)[2].

[2] https://busmap.demobv.nl/platform

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3. The Mapping Of The Market Readiness For Industrialized Solutions And Local Pop-Up Factories

Europe is experiencing fewer new building constructions coupled with insufficient building stock refurbishment. However, to achieve its climate change policies by 2050, the acceleration of building renovation actions is crucial (D'Oca et al., 2018). This proves to be a multi-faceted, wicked problem for which there are no simple panaceas. Therefore, multiple actors across industries need to collaborate to provide tangible scenarios for speeding up renovations. Since there is no one-size-fits-all solution for the whole of Europe, research and analysis are taken from various viewpoints, combining technical, financial, social and legal perspectives. Following this line of argument, it is part of the problem statement and identification to analyse the current market condition within the construction sector to introduce innovation that will have a chance to be uptaken and utilized. Within BuildUpSpeed, five ecosystems across Europe have fairly distinctive market and industrial characteristics that are highly influential for product and service design processes. Market research, feasibility studies and, etc., are inherent parts of research & innovation actions. In this case, an early-stage market potential is researched to lay the foundation for further actions with the project. Amongst the various methods to conduct market potential, PESTLE analysis proved to be the suitable one.

Further details about the methodology of conducting PESTLE analysis and the market feasibility analysis of the different PuF scenarios are described in the following section below.

3.1 Methodology

This section details the systematic approach taken to assess the market readiness for local pop-up factories (PuF) across the BuildUPspeed ecosystems. The methodology combined both qualitative and quantitative elements, using multiple data collection and analysis methods to ensure a comprehensive evaluation.

3.1.1. PESTLE Analysis

A **PESTLE analysis** (Political, Economic, Social, Technological, Legal, and Environmental) formed the backbone of the assessment. This framework was chosen for its ability to systematically capture the broad set of external factors influencing the feasibility and market potential of PuF concepts in the construction sector. The PESTLE approach enabled the identification of supporting and hindering factors within each ecosystem.

3.1.1.1. Data Collection

The data collection took place during a Miro Board–based workshop at Consortium Meeting 2 in Bordeaux on 31 May 2023.

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- Stakeholder workshops were held as part of the data collection process, engaging project partners and ecosystem stakeholders to discuss and complete structured questionnaires based on the PESTLE framework. Complete list of participants is provided in Appendix I.
- Questionnaires were designed to address each PESTLE dimension, informed by literature review and expert consultation (see Appendix I)
- Additional qualitative insights were gathered through workshop discussions and post-workshop follow-up with participants.
- A desk study supplemented the primary data, providing further background and triangulating findings.

3.1.1.2. Data Analysis

The collected data were analysed using a structured five-tier scale (see Appendix I for explanation of the scoring system and assessment criteria). For each ecosystem, the PESTLE factors were reviewed to determine their level of support, hindrance, or alignment with pop-up factory implementation.

- **Qualitative and Quantitative Approach**: Each factor was first qualitatively assessed based on workshop input, questionnaire results, and desk research. Factors such as the presence of direct or indirect policies, funding mechanisms, social acceptance, technological infrastructure, legal frameworks, and environmental regulations were systematically examined.
- **Assessment Criteria for Each PESTLE Dimension:**
    - *Political*: The presence or absence of policies and regulations directly supporting pop-up factories was assessed. In some ecosystems, no specific policies were found, indicating a lack of direct political support, but indirect support such as incentives, demands, or environmental/social programs was noted. New initiatives, such as an R&D center for industrialization, were also considered as potential sources of future support.
    - *Economic*: The analysis considered economic conditions and support mechanisms, including funding opportunities and backing from economic agencies. Barriers such as inflation, interest rates, and decision-making complexity were also taken into account.
    - *Social*: Social acceptance and relevance were explored, including variations in cultural acceptance, the perceived benefits of sustainability and local employment, as well as awareness and support for pop-up factory concepts.
    - *Technological*: The level of technological readiness and adoption was assessed by considering available production tools, advanced design systems (e.g., BIM), 3D printing, and warranty issues that might affect implementation.
    - *Legal*: Regulatory frameworks and compliance requirements were reviewed, with attention to laws on recycling, energy/resource efficiency, and construction products. The need for clearer legislative frameworks and social/political acceptance was also recognized.
    - *Environmental*: Environmental challenges and opportunities were considered, including factors such as noise, dust, water management, and the impact of stricter urban regulations on factory location and operations.

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- **Scoring**: Each factor was rated on a five-tier scale (Figure 12), ranging from "Not Ready" to "Ideal," providing a relative measure of ecosystem readiness. The overall readiness for each ecosystem was calculated as the average of the PESTLE scores (rounded to the nearest whole number). The detailed explanation and rationale for the scale are provided in Appendix I.
- **Interpretation**: This structured assessment enables the identification of key opportunities and challenges for PuF adoption in each context, informing subsequent scenario analysis and implementation planning that will be discussed in the following sections.

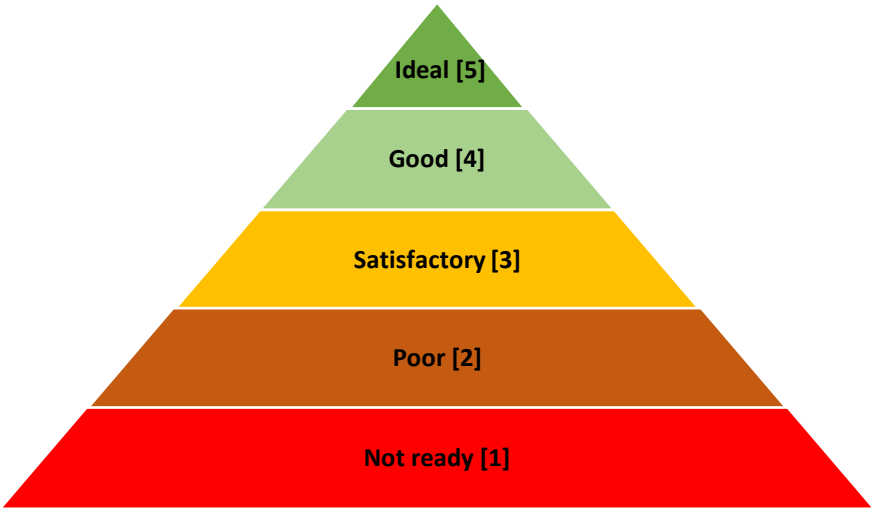


Figure 12: Five-tier Assessment Criteria

3.1.2. Scenario Analysis

The scenario analysis complements the PESTLE assessment by systematically evaluating the suitability of different PuF concepts for each ecosystem. This methodology was designed to determine the feasibility and readiness of five PuF scenarios—mobile on-site factory, satellite factory, district factory, assembly factory, and service factory—across the pilot countries.

3.1.2.1. Data Collection

Scenario-specific questionnaires were developed and distributed to project stakeholders and local experts within each ecosystem to capture context-rich insights for each PuF scenario. These questionnaires addressed four key assessment criteria: the **maturity** of each scenario in the local market, perceived **market potential** and attractiveness, primary **drivers** or enablers supporting uptake, and main **barriers** hindering adoption or scalability. Responses were gathered through both direct survey returns and, where relevant, follow-up clarifications. This approach ensured that the analysis captured both quantitative and qualitative perspectives on the suitability and feasibility of each PuF scenario. The full list of scenario assessment questions can be found in Appendix II.

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3.1.2.2. Data Analysis

Stakeholder responses to the scenario-specific questionnaires were compiled and analyzed for each ecosystem. For every PuF scenario, input on maturity, market potential, drivers, and barriers was carefully reviewed to identify critical factors influencing feasibility and uptake. Responses were qualitatively assessed and mapped onto a standardized scale (low, moderate, high) to indicate the overall potential for implementation within each context (see Appendix II). This comparative approach enabled the identification of both scenario-specific opportunities and systemic challenges, providing a clear basis for scenario prioritization and subsequent implementation planning. The summarized results of this analysis are presented in the following Results section, with ecosystem- and scenario-specific details provided in the corresponding tables and charts.

3.1.3. Implementation Matrix

To arrive at the final implementation matrix, results from both the PESTLE assessment and the scenario-specific evaluation were brought together. This approach allowed for a holistic synthesis of external ecosystem readiness and the practical feasibility of each pop-up factory scenario across the five pilot contexts. The matrix visually consolidates which PuF scenarios align best with each ecosystem, based on combined insights from stakeholder input and systematic analysis. This mapping serves as a practical tool for identifying where certain PuF concepts are most likely to succeed and where targeted interventions may be required, providing a foundation for the ecosystem-specific recommendations detailed in the following sections.

The results are presented in a table (see Table 7, on page 41), which provides a summary of the identified potential for each PuF scenario across the five national ecosystems. A checkmark indicates where a given scenario was assessed as suitable for implementation within that specific context.

3.2 Results

This section presents the results of the PESTLE analysis and scenario assessment as applied to each ecosystem, and lastly the Implementation Matrix, which brings together the preceding analyses to map the potential alignment of PuF scenarios with each ecosystem.

3.2.1. PESTLE Analysis

This section presents the results of the PESTLE analysis, summarized in Figure 13 and Figure 14. Detailed answers to the questions along with scores and individual plots, can be found in Appendix III.

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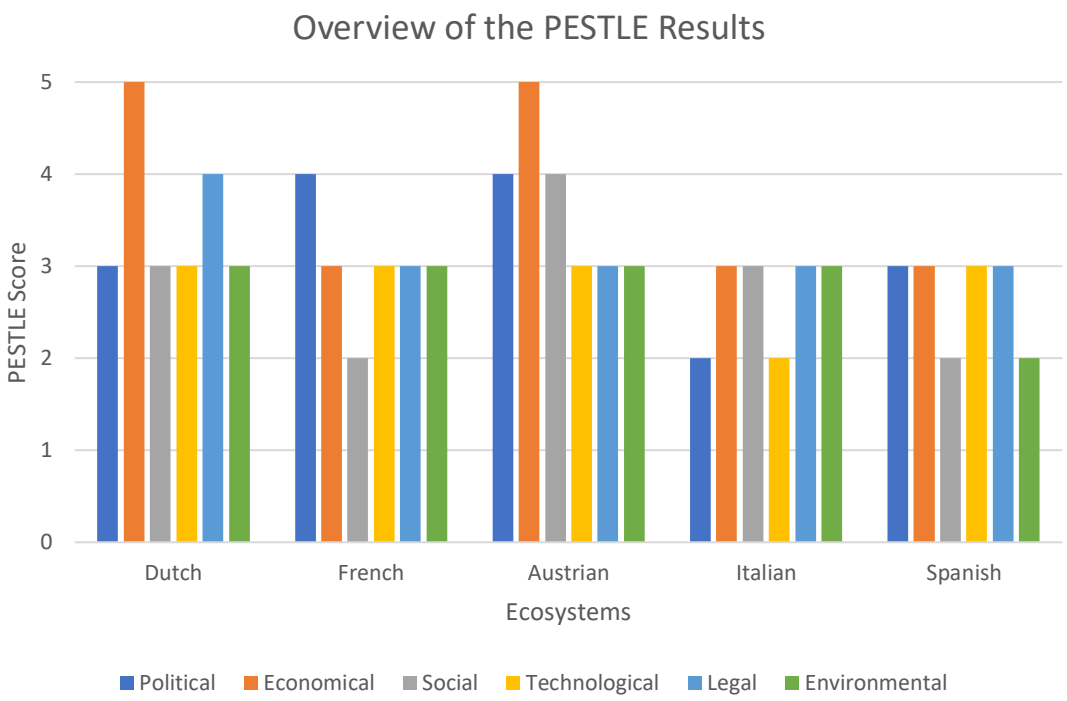


Figure 13: Comparison of the results of PESTLE in each ecosystem

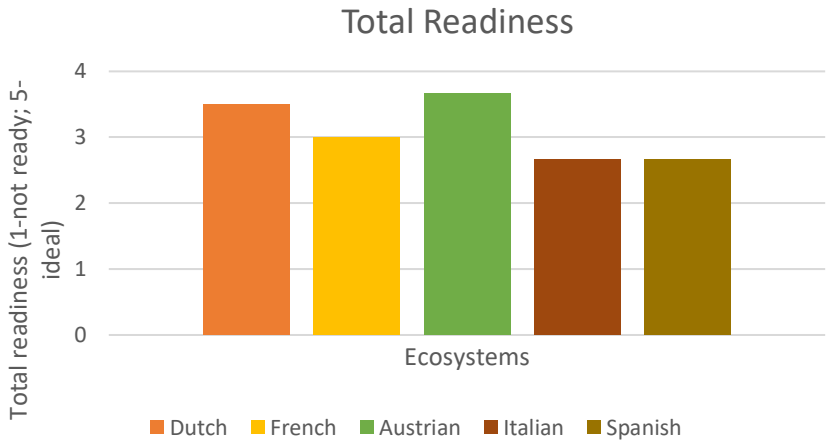


Figure 14: Overall readiness of the ecosystems taking an average value of PESTLE scores

3.2.1.1. Dutch Ecosystem

From a political perspective, there are currently no specific policies directly involving pop-up factories, with the market being responsible for determining the delivery approach. However, there is indirect influence through incentives and project-specific demands set by local governments, which can pave the way for the adoption of pop-up factories. Economically, the DEI regulation serves as a stimulus fund, while factors such as inflation and energy/logistics costs can also impact market readiness. Socially, the traditional construction process and business case are considered key lock-ins, but there is a growing trend of raising awareness and support for pop-up factory technologies, especially in terms of their potential to create local employment and utilise local resources. Technologically, while some innovative solutions are emerging, they are still relatively scarce, with commercial rental companies and digital printing

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being notable examples. Legally, conformity with CE marking and local regulations is crucial, and greater enforcement of norms across the EU is needed to integrate pop-up factories into local building culture. Finally, from an environmental perspective, considerations such as noise regulations for mobile factories and incentives related to nitrogen reduction policies can further drive the adoption of offsite construction and pop-up factories (see Appendix III for complete results).

Overall, the Dutch ecosystem demonstrates a **good (4)** readiness for the implementation of pop-up factories (PuFs). There is political recognition, economic support, growing social acceptance, technological readiness, favourable legal conditions, and environmental considerations in place. However, continuous efforts in addressing technological challenges, promoting social acceptance, and ensuring sustainable practices will be crucial for the further advancement and success of PuFs in the Dutch construction industry.

3.2.1.2. French Ecosystem

Politically, initiatives such as REP (Responsabilité Elargie du Producteur) and local facilitation platforms promote waste recycling and reuse, while laws encourage building renovation and temporary land use for activities. Economically, regional support and the national energy agency's involvement provide job creation opportunities, but inflation and interest rate fluctuations pose barriers. Socially, there is a need to overcome the cultural resistance to pop-up factories and promote local employment and social responsibility. Technologically, while production tools exist, challenges arise from limited available land, heterogeneous architectural contexts, and opposing trends favouring concentrated production sites. Legally, temporary occupation permits are required but attainable, with the main barriers being social and political acceptance. Environmental risks include noise, dust, and water management, necessitating effective mitigation measures (see Appendix III for complete results).

Overall, the French ecosystem demonstrates **satisfactory (3)** readiness for the implementation of PuFs. While there is political recognition and support for circular economy practices, low cultural acceptance, limited economic data, and barriers in social and technological aspects might hinder the widespread adoption of PuFs. However, the presence of specific sustainability standards, experience with mobile factories, and strict environmental regulations create opportunities for PuFs to contribute to more sustainable construction practices in France.

3.2.1.3. Austrian Ecosystem

Politically, research funding, economic agencies, energy efficiency bills, and waste directives support circularity and promote the concept. Economically, there are assumptions of funding by the Austrian Economic Chamber, with both hindrances and benefits due to decision-making. Socially, Austria's strong social democracy can benefit systems that incorporate pop-up factories. Technologically, there are no major limitations except for warranty issues, but challenges exist with different BIM systems and technology expertise. Legally, laws related to recycling, waste management, energy efficiency, and construction products govern the industry, and local pop-up factories aim to improve resource and energy efficiency. Environmental considerations include water treatment, energy supply, noise, air pollution, and potential regulatory requirements (see Appendix III for complete results).

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Overall, the Austrian ecosystem demonstrates a **good (4)** readiness for the implementation of PuFs. The favourable political and social environment, along with supportive regulations and a strong focus on sustainability, create opportunities for PuFs to contribute to the circular economy and sustainable construction practices in Austria. However, further data and information are needed to fully assess the economic, social and technical factors and identify specific initiatives that can drive the adoption of PuFs in the Austrian construction industry. In addition to that, the whole legal system was never intended to use outputs of the economy as inputs. This is specifically true for waste management legal acts. In line with that, it is necessary to develop the legal frame to enable and, even better, support circular economy.

3.2.1.4. Italian Ecosystem

From a political perspective, there is interest in work safety regulations and quality certifications, primarily driven by EU directives, while local regulations are yet to be explored comprehensively. Although not directly linked to pop-up factories, economic considerations show promising energy and seismic renovation incentives. However, high-interest rates pose challenges to the return on investment. Socially, there is a historical reluctance to automation, but sustainability aspects could enhance acceptance. Technologically, Italy faces barriers in finding suitable locations, limited use of advanced design systems, and a need for professional training. Legally, adherence to specific building codes is crucial, although no explicit legal risks are identified. Environmental factors necessitate exploring regulations, especially concerning pollution in urban areas and carefully analysing the impact and benefits of temporary pop-up factories in non-industrial areas (see Appendix III for complete results).

Overall, the Italian ecosystem shows **satisfactory (3)** readiness for the implementation of pop-up factories (PUFs). While economic incentives for energy and seismic renovations are significant, challenges such as high interest rates and technological barriers, particularly in identifying suitable places, are cause for concern. There has always been a social aversion to automation, yet sustainability factors offer potential acceptability. Legal concerns, such as compliance to certain construction codes could help streamlining the operation of PuF. Environmental factors such as pollution rules and site impact must be thoroughly investigated. The collective assessment indicates that the viability of PuFs in the Italian environment is moderate.

3.2.1.5. Spanish Ecosystem

Politically, there is currently no specific support for pop-up factories, but there are plans to create a new R&D national centre focused on industrialisation. Economically, there are funding options available for circular economy initiatives, which can be aligned with pop-up factories. Socially, there is a negative perception of factories due to noise, dust, and other disturbances, but there is some awareness of sustainability standards. Technologically, there is experience with mobile factories in civil works that can potentially be adapted for pop-up factories, with pre-cast concrete being a commonly used technology. Legally, construction is highly regulated in Spain, and environmental regulations, particularly in urban areas, can pose challenges for pop-up factories. Mitigating noise, dust, and traffic impacts is crucial.

Overall, the Spanish ecosystem shows **satisfactory (3)** readiness for the implementation of pop-up factories (PuFs). While there are some positive aspects such

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as available funding options and existing regulations in the construction sector, there are significant gaps in political support, social acceptance, and environmental readiness. It is essential to engage policymakers, raise awareness among the public, and establish clear regulations and frameworks to overcome these barriers and foster a more favourable environment for the development and adoption of PuFs in Spain (see Appendix III for complete results).

3.2.2. Scenario Analysis

The results, presented in Figure 15, provide a cross-ecosystem comparison of implementation potential for the five scenarios, while more detailed results for each ecosystem are provided in the following sub-sections.

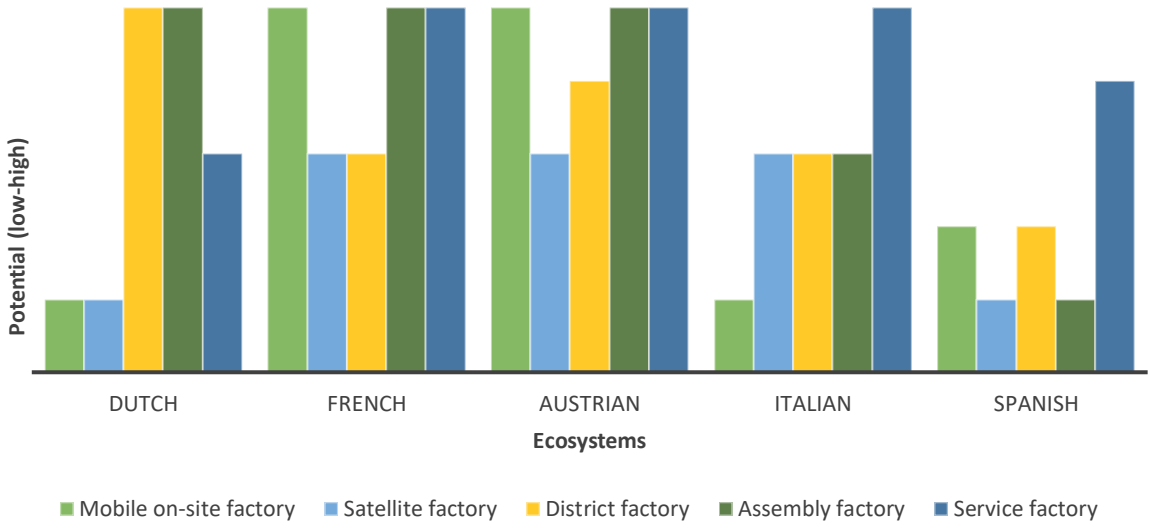


Figure 15: Cross-ecosystem comparison of implementation potential. all the factors in each ecosystem to further aid comparison among the factors and ecosystems.

3.2.2.1. Dutch Ecosystem

The Dutch ecosystem has a lot of potential for assembly factory and district factory scenarios. The assembly factory scenario benefits from its established position in deep-renovation activities, as well as the availability of a repetitive building portfolio. The district factory holds promise for individual home repairs and capitalises on the possibilities for mass customisation. Due to different hurdles and market limits, the mobile on-site factory, satellite factory, and service factory models have limited potential in the Dutch environment.

3.2.2.2. French Ecosystem

Mobile on-site factories are well-prepared, with existing demonstrator sites and companies introducing comparable concepts, driven by demand from construction actors and a desire to reduce traffic and noise. Satellite factories are in a moderate state of readiness, primarily suited to large rehabilitation regions, with continuous research into their benefits. District factories are still in their early stages, requiring public institution support and stakeholder participation. Assembly factories have

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significant potential and are currently being used in construction projects, but they need new approaches to the construction chain and investment. While undeveloped, service factories have significant potential, particularly for single-family households, and could benefit from governmental financial assistance and awareness-building activities.

3.2.2.3. Austrian Ecosystem

Pop-up factories have tremendous potential in the Austrian ecosystem particularly in mobile on-site, assembly and service factories. Mobile on-site factories show significant promise, with more than half of the market believing they are viable due to effective resource usage and reduced labour requirements. District factories have a high potential for resource-efficient construction, but they necessitate collaboration and the removal of resource allocation bottlenecks. With over 70% market demand, assembly factories are generally desired, particularly for balcony retrofitting. Although service factories are relatively obscure, they have the potential to significantly benefit professionals and users once awareness grows. Long-term strategies, such as satellite factories, have significant promise if further developed. Overcoming obstacles and raising awareness will be critical to fully fulfilling this promise.

3.2.2.4. Italian Ecosystem

Scenarios of PuF show a diverse potential for application in the Italian ecosystem. The mobile on-site factory is still in its developmental stage and faces challenges in considering temporary manufacturing locations due to a lack of readiness for such concepts. The satellite factory is an interesting model but requires exploration regarding the types of components produced on-site and those prefabricated elsewhere. The district factory, although not yet developed, holds potential in areas requiring urban regeneration but faces challenges in finding solution providers willing to invest in temporary renovation factories. The assembly factory, explored for new offsite construction, is contingent on the evolving supply chain and faces coordination challenges among manufacturers and suboptimal transport optimisation. Finally, the service factory, with a few examples, aligns with the emerging concept of offsite renovation, emphasising services for tenant engagement and training for construction companies, but questions of feasibility and coordination remain. Overall, each scenario presents varying levels of maturity, market potential, drivers, and barriers.

3.2.2.5. Spanish Ecosystem

Pop-up factories have a wide range of potential in the Spanish ecosystem, with service factories in the front showing particular promise. Mobile on-site factories have varied degrees of potential, depending on the solution. Satellite factories are viewed as cost-effective options, however market maturity and perceptions must be improved. District factories rely on public investment, and there is a small market for prefabricated construction, necessitating project aggregation. Assembly plants gain awareness through public administration projects, which are motivated by shorter lead times and lower environmental effect, however there is a scarcity of experienced actors. With future renovation subsidies, service factories have a lot of potential, especially for middle-income homes. To realise these potentials, it will be necessary to break down obstacles, raise market knowledge, and create collaboration.

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3.2.3. Implementation Matrix

The consolidated analysis presents how each ecosystem aligns with specific PuF models, based on the synthesis of PESTLE and scenario analysis outcomes. The cross-case analysis culminated in the implementation matrix shown below, which indicates the most suitable PuF scenarios for each ecosystem.

Table 7: Potential implementation matrix of PuF scenarios for each ecosystem.

	Dutch ecosystem	French ecosystem	Austrian ecosystem	Italian ecosystem	Spanish ecosystem
Mobile on-site factory		☑	☑		
Satellite factory				☑	
District factory	☑				
Assembly factory	☑	☑	☑		☑
Service factory		☑	☑	☑	☑

In the **Netherlands**, strong market conditions and advanced digital infrastructure align most effectively with District and Assembly Factory models. The **French** ecosystem is characterized by moderate readiness but substantial political and societal support, making Mobile On-Site and Service Factory scenarios the most suitable. In **Austria**, favourable regulatory frameworks and high social acceptance support the viability of Mobile On-Site, District, and Assembly Factories. The **Italian** ecosystem demonstrates potential for Service Factories and, to a lesser extent, Satellite Factories; however, the latter will require further feasibility studies to confirm their effectiveness, while Service Factories are almost market-ready. Finally, **Spain**, with mixed readiness and challenges in public perception and regulatory complexity, shows that Service Factory models are the most feasible starting point.

In Table 7, the potential implementation matrix is presented, which can also considered as a decision matrix for guiding ecosystem choices and aligning PuF concepts with local conditions. The final selection of the PuF scenarios for each ecosystem will be detailed in Section 3.3.3.

3.3 Discussion

3.3.1. PESTLE

This section will systematically explore and compare the implications of PESTLE factors across the Spanish, Italian, Austrian, French, and Dutch ecosystems. Each ecosystem's results of the political landscape, economic considerations, societal dynamics, technological readiness, legal frameworks, and environmental factors will be critically examined. The focus is on drawing comparative insights to understand the unique challenges and opportunities for pop-up factories in each context.

In the **political** realm, Spain is in the early stages, lacking explicit support for pop-up factories but with intentions for a new R&D centre in industrialisation. Italy faces a need for heightened awareness of work safety regulations, signalling a political gap. Austria enjoys robust political backing with support from research funding, energy efficiency

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bills, and waste directives. France showcases explicit political support through initiatives like REP and facilitation platforms for waste recycling. In the Netherlands, policies directly involving pop-up factories are absent, relying on market-driven approaches influenced indirectly by incentives and local government demands.

From an **economic** perspective, the Netherlands benefits from the DEI regulation, which serves as a significant economic stimulus, but faces potential challenges such as inflation and rising energy and logistics costs. In contrast, France showcases regional support and active engagement by the national energy agency, providing favourable conditions for job creation. Austria operates on assumptions of funding from the Austrian Economic Chamber, with both hindrances and benefits associated with decision-making. Italy, despite presenting promising incentives for energy and seismic renovation, faces challenges posed by high-interest rates, significantly impacting the return on investment. Notably, economic considerations are not directly tied to pop-up factories. Meanwhile, Spain offers funding options that align with circular economy initiatives, presenting potential economic support for pop-up factories.

In the realm of **social** dynamics, the Netherlands witnesses a burgeoning awareness and backing for pop-up factory technologies, particularly in their capacity to generate local employment, while France grapples with the imperative to surmount cultural resistance to these factories and amplify efforts to endorse local employment and social responsibility. Austria can potentially provide a conducive environment for systems incorporating pop-up factories. Contrarily, Italy confronts historical reluctance to automation, but there is a promising avenue for increased acceptance, especially when emphasising sustainability aspects. Spain, on the other hand, contends with a negative social perception attributed to noise, dust, and disturbances, albeit with some level of awareness regarding sustainability standards.

Even though almost all ecosystems have scored similarly within the **technological** realm, there are some notable differences. The Netherlands – for example - stands out with relatively scarce but emerging innovative solutions, spotlighting commercial rental companies and digital printing as noteworthy examples. France, on the contrary, grapples with challenges stemming from limited available land, diverse architectural contexts, and conflicting trends favouring concentrated production sites. Austria showcases no major technological impediments yet contends with challenges tied to different Building Information Modelling (BIM) systems and varied technology expertise. Italy faces hurdles in identifying suitable locations for pop-up factories, coupled with restricted usage of advanced design systems and a pronounced need for professional training. In Spain, the experience with mobile factories in civil works presents an intriguing foundation that holds promise for potential adaptation to pop-up factories.

From a **legal** perspective, the Netherlands emphasizes the critical importance of compliance with CE marking and local regulations, underscoring the need for stronger enforcement of standards across the EU. France underlines the necessity of navigating temporary occupation permits, with primary barriers rooted in social and political acceptance. Austria is governed by laws that span recycling, waste management, energy efficiency, and construction products, shaping the legal framework for pop-up factories. In Italy, adherence to specific building codes takes precedence in the legal landscape, although no explicit legal risks have been identified. On the contrary,

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Spain's construction industry is highly regulated, with stringent environmental regulations underscoring the imperative for meticulous planning and compliance which could pose significant challenges for the implementation of PuF.

In the **environmental** sphere the Netherlands factors in considerations like noise regulations for mobile factories and incentives linked to nitrogen reduction policies. France faces strict environmental risks, including challenges related to noise, dust, and water management, necessitating effective mitigation measures. Austria's environmental considerations extend to water treatment, energy supply, noise, air pollution, and potential regulatory requirements. Italy stresses the need for exploration of regulations, especially regarding pollution in urban areas. Additionally, careful analysis of the impact and benefits of temporary pop-up factories in non-industrial areas is crucial. Spain, operating in an environmentally sensitive context, prioritises the mitigation of noise, dust, and traffic impacts.

3.3.1.1. Key Takeaways

The overview PESTLE plot (see Figure 13, on page 36) highlights the key differences in ecosystem readiness for the implementation of pop-up factories. The main findings are as follows:

- The Dutch ecosystem demonstrates the strongest economic foundation, with the highest score in economic factors supporting pop-up factory uptake.
- The French ecosystem is characterized by significant political and social support, creating particularly favourable conditions for pop-up factory initiatives.
- The Austrian ecosystem shows robust political and economic backing, tying with the Dutch ecosystem for the highest combined score in these categories.
- The Italian ecosystem lags in political and economic factors but stands out for promising social acceptance and technological capacity.
- The Spanish ecosystem maintains a balanced profile, with moderate scores across all PESTLE factors, indicating steady but non-differentiated readiness.

In summary, the Dutch and French ecosystems are best positioned for the successful implementation of pop-up factories, while the remaining ecosystems display varying levels of preparedness that call for context-specific approaches.

3.3.2. Scenario Analysis

When it comes to the potential of the **Mobile On-site factory**, both the French and Austrian ecosystems resulted in a high potential due to being well-prepared, boasting existing demonstrator sites and ongoing initiatives aimed at reducing traffic and noise. The Austrian context holds significant promise as well, as more than half of the market envisions viability owing to effective resource usage. However, the Italian ecosystem is in a developmental stage, grappling with challenges related to the consideration of temporary manufacturing locations. Meanwhile, the Spanish ecosystem presents varied potential contingent on specific solutions, entangled in challenges related to perception and maturity, while the Dutch ecosystem exhibits limited potential, constrained by market limits and hurdles similarly to Spain.

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In the realm of **Satellite factories**, the Dutch environment faces limited potential, encountering constraints due to market limitations and hurdles. The French scenario exhibits moderate readiness, particularly suited for large-scale rehabilitation regions, necessitating ongoing research for optimisation. Austria holds long-term potential for satellite factories, dependent on further development and the need to overcome obstacles and raise awareness. The Italian landscape views the satellite factory as an intriguing model, requiring exploration regarding on-site and prefabricated components, and grappling with associated challenges. In the Spanish context, satellite factories are perceived as cost-effective, yet their realisation demands an enhancement in market maturity and a shift in perceptions.

The results regarding **District factories** show that the Dutch ecosystem considers this scenario as a promising option, particularly for individual home repairs and mass customisation, capitalising on its robust economic foundation. The French ecosystem is in the early stages, necessitating public institution support and active stakeholder participation for further development for this scenario. Austria holds high potential for resource-efficient construction within its district factories, contingent on collaboration and the removal of resource allocation bottlenecks. The Italian landscape, while not yet developed, holds potential in areas requiring urban regeneration, yet faces challenges in finding solution providers willing to invest in temporary renovation factories. In the Spanish context, district factories rely heavily on public investment, confronting a small market for prefabricated construction and necessitating project aggregation for viability.

In the domain of **Assembly factories**, the Dutch ecosystem stands out with high potential, leveraging its established position in deep-renovation activities and a repetitive building portfolio while the French ecosystem demonstrates significant potential as well, however, it necessitates new approaches to the construction chain and increased investment. Austria sees assembly factories as generally desired, boasting over 70% market demand, especially for balcony retrofitting. In Italy, assembly factories have been explored for new offsite construction, dependent on the evolving supply chain, but they face coordination challenges. The Spanish ecosystem highlights assembly plants gaining awareness through public administration projects, driven by the prospect of shorter lead times and lower environmental impact.

Service factories generally show good potential across the ecosystems. In the Netherlands, such concepts are already established; however, service factories are not considered the most suitable solution for accelerating renovation actions. To the contrary, in the French ecosystem, although undeveloped, it has a significant promise, especially for single-family households, indicating potential benefits that could be realised with governmental support. Austria's potential for service factories is relatively obscure, but it presents potential benefits for both professionals and users as awareness grows. In Italy, service factories align with the emerging concept of offsite renovation, but questions of feasibility and coordination persist. The Spanish ecosystem leads with a high potential of service factories, particularly for middle-income homes, emphasising the need to overcome obstacles and enhance market knowledge.

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3.3.2.1. Key Takeaways

- **The Dutch and French ecosystems** exhibit strengths in different scenarios, with the Dutch focusing on assembly and district factories, while the French shows readiness in mobile on-site and service factories.
- **The Austrian ecosystem** demonstrates broad potential across various scenarios, with significant market demand for mobile on-site, district, assembly, and service factories.
- **The Italian ecosystem** faces developmental challenges across scenarios, with potential in satellite and service factories once coordination and feasibility issues are addressed.
- **The Spanish ecosystem** presents a mix of potential, with service factories standing out, but challenges in perception and market maturity across other scenarios.

3.3.3. Implementation Matrix

According to the results presented in Section 3.2.3, the implementation matrix not only identifies the optimal PuF models for each ecosystem but also guides the design of context-sensitive implementation strategies. For instance, regions with **high technological readiness** and **favourable economic conditions**—such as the Netherlands—are positioned to leverage centralized production models (District and Assembly Factories). These models enable the delivery of systemic deep retrofits involving tightly coupled renovation measures, which require high levels of coordination and integration.

In digitally mature environments, advanced tools like **Building Information Modelling** (BIM) and **automation technologies** further enhance coordination and standardization, supporting the deployment of high-performance PuF models. The Netherlands' leadership in BIM adoption serves as a case in point, illustrating the benefits of such digital maturity for implementing advanced PuF solutions.

In contrast, ecosystems facing **market fragmentation** and **lower stakeholder coordination** (e.g., France, Spain, and Italy) may benefit from Service Factory models. These approaches focus on capacity building, knowledge transfer, and providing support services, which are particularly relevant in large countries with geographic dispersion and technological diversity. In such contexts, retrofit strategies that rely on loosely coupled technologies—requiring less stringent synchronization—are more adaptable and feasible.

Overall, the implementation matrix supports strategic decision-making by highlighting where different PuF concepts are most likely to succeed and what contextual adaptations are required for effective deployment. Based in ecosystem reflections on the potential PuF scenarios, and the results presented through the entire chapter, a final selection of scenarios has been made by the ecosystems. These are consolidated in the final implementation matrix presented in Table 8, which marks the transition from potential scenarios to real concepts by addressing their design and implementation aspects, as further elaborated in the following chapters.

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Table 8: Final Implementation Matrix.

	Dutch ecosystem	French ecosystem	Austrian ecosystem	Italian ecosystem	Spanish ecosystem
Mobile on-site factory		☑			
Satellite factory				☑	
District factory	☑				
Assembly factory			☑		☑
Service factory	☑	☑	☑	☑	☑

3.4 Conclusion

Pop-up factories are becoming increasingly important in the building and renovation sector due to their ability to provide flexible and efficient solutions for a variety of projects. Although the concept is relatively new, real-world examples demonstrate its practical applicability.

This report offers an in-depth overview of the various types of pop-up factories—mobile on-site factories, assembly factories, satellite factories, service factories, and district factories. These types have been explored to provide innovative solutions for accelerating renovation activities as part of the BuildUPspeed project. Each type of pop-up factory is characterized by distinct traits such as purpose, design, scale, and location, which are extensively analyzed using previous research and practical examples.

Framework and Decision-Making

A framework in the form of a checklist has been created to differentiate between these types of factories based on specific criteria. This framework helps stakeholders in the construction and renovation industry understand the options available and make informed decisions about which type of pop-up factory best meets their needs. It also provides the foundation for developing a decision-tree or implementation matrix for renovation projects, contributing to the exploration of available concepts and scenarios, which can later be matched with specific use cases to provide tailor-made solutions for circular, sustainable, and industrialized practices.

Analysis of Pop-Up Factory Scenarios

Examining pop-up factory scenarios across different European ecosystems reveals a complex landscape influenced by political, economic, social, technological, legal, and environmental factors. The PESTLE analysis highlights the varying degrees of support and readiness for pop-up factories in different countries:

- **Political:** Support ranges from developing plans in Spain to concrete initiatives in France and Austria.
- **Economic:** Funding aligns with circular economy initiatives, with incentives for energy and seismic renovations in several ecosystems.
- **Social:** Overcoming historical resistance and fostering acceptance through sustainability is crucial.

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- **Technological:** Challenges include location issues, limited use of advanced design systems, and the need for professional training.
- **Legal:** Adherence to building codes and regulations is essential.
- **Environmental:** Each ecosystem must navigate unique challenges, emphasizing meticulous planning and compliance.

Ecosystem-Specific Insights

A detailed look at specific ecosystems provided deeper insights into the driving and hindering factors for pop-up factory scenarios:

- **Dutch Ecosystem:** High readiness for assembly and district factories due to an established renovation approach and supportive market conditions.
- **French Ecosystem:** Moderate readiness with potential in assembly and service factories, but cultural acceptance and stakeholder coordination need improvement.
- **Austrian Ecosystem:** High potential for mobile on-site, district, and assembly factories, supported by strong political and social environments.
- **Italian Ecosystem:** Moderate readiness with significant potential for service factories, though technological and social barriers must be addressed.
- **Spanish Ecosystem:** High potential for service factories, but political support and social acceptance need enhancement.

Recommendations

To maximize the potential of pop-up factories, the report recommends:

- **Enhancing Stakeholder Collaboration:** Foster cooperation among various stakeholders to streamline operations and ensure effective implementation.
- **Addressing Technological Challenges:** Invest in technology to overcome logistical and manufacturing challenges.
- **Promoting Cultural Acceptance:** Increase awareness and acceptance of pop-up factories through education and demonstration projects.
- **Leveraging Regulatory Frameworks:** Utilize existing regulations and financial incentives to support the deployment of pop-up factories.
- **Continuous Monitoring:** Regularly assess and adapt strategies based on evolving market conditions.

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4. Designs For Tailored Local Factory Concepts

This chapter presents conceptual designs for PuFs that are tailored to the specific local contexts of Austria, France, Italy, The Netherlands and Spain, drawing on the insights gained from previous analyses. The aim is to translate the strategic and analytical groundwork (particularly the assessment of market readiness, the PESTLE framework, and the exploration of various PuF scenarios) into practical design propositions that align with localized needs, capacities, and constraints.

Building upon the typologies and operational models detailed in the earlier chapters, this section focuses on the spatial, functional, and technological configurations that different types of PuFs can adopt when adapted to specific neighbourhoods, urban environments, or renovation project typologies. The tailored local factory concept refers to flexible, scalable setups that integrate the technical and logistical dimensions of renovation processes within the immediate context where they are implemented. These configurations are not static blueprints, but adaptable frameworks developed to accommodate local demands (for example: workforce availability, stakeholder ecosystem, spatial constraints, or renovation urgency).

By synthesizing systemic understanding with on-the-ground design thinking, this chapter lays the foundation for prototyping, piloting, or scaling up factory concepts that are not only technically feasible but also locally responsive. Each design responds to both the strategic rationale and operational detail needed to support sustainable, industrialized renovation at the neighbourhood level. This chapter aims to:

- Ground the concept of PuFs in relevant literature, identifying key theoretical principles and methodologies that shape tailored, localized applications;
- Document and analyse participatory design processes, particularly insights gained from a Workshop conducted at Consortium Meeting 2 in Vienna, focusing on stakeholder input, contextual challenges, and co-created PuF ideas;
- Translate user needs and contextual parameters into a set of adaptable factory typologies, integrating findings from both literature and workshop-based exploration;
- Point towards the development and visualization of conceptual designs for local PuFs that address renovation market dynamics, spatial constraints, and technological integration needs;
- Define evaluation and design criteria for assessing the proposed factory concepts, including sustainability, modularity, ecosystem fit, and local stakeholder alignment;
- Compare and reflect on the performance of each design, identifying trade-offs and guiding principles for choosing factory configurations per market scenario; and
- Formulate strategic recommendations for piloting, prototyping, and adapting tailored PuF models across varied European renovation contexts, serving as input for implementation and scenarios (Chapter 5).

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4.1 Approach

To structure the development of tailored Pop-up Factories (PuFs) concepts across the ecosystems, we drew inspiration from the field of Corporate Real Estate Management (CREM) — particularly the application of multi-perspective frameworks for aligning spatial configurations with organizational and societal needs.

CREM traditionally focuses on how real estate (buildings, infrastructure, and spatial assets) can best support core business processes and strategic goals. In this context, real estate is not merely a physical asset, but a tool to create value across multiple dimensions: organizational performance, user satisfaction, financial feasibility, and long-term adaptability.

This multi-dimensional logic has been further operationalized in the 4-view framework (Vande Putte & Jylhä, 2023). The framework views real estate through four interconnected lenses: the **strategic view**, which considers how the physical environment contributes to broader organizational or societal goals; the **functional view**, which focuses on how users interact with the environment and the functional demands that shape its configuration; the **physical view**, which addresses the spatial, technical, and architectural qualities of the environment; and the **financial view**, which encompasses the management of investments, operational costs, and long-term value over time.

Building on this adaptation of the CREM model, we developed a bespoke 4-view framework to guide the design and evaluation of PuFs tailored for large-scale renovation. While inspired by the strategic-functional-physical-financial logic of corporate real estate, our version explicitly integrates both the organizational and technical dimensions relevant to factory deployment in the built environment.

Our framework distinguishes between **strategic** vs. **operational levels**, and between **organization focus** vs. **factory focus,** resulting in the four views shown in Figure 16:

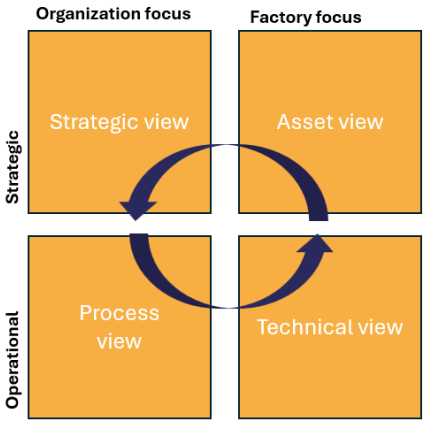


Figure 16: Pop-up Factory 4-view framework.

- **Strategic View**
  Defines the overarching ambition and planning logic for deploying the PuF. It covers the factory's purpose (e.g. supporting renovation targets, boosting local employment), its

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intended impact on regional strategies, and integration into public-private innovation agendas.

- **Asset View**
  Addresses long-term considerations tied to the factory as an asset — including mobility, reusability, adaptability to different renovation waves, and its contribution to industrial capacity building.

- **Process View**
  Describes the workflows and functions within the factory — such as manufacturing, assembling, warehousing, and service provision — as well as how these workflows are planned and operated to meet renovation goals efficiently.

- **Technical View**
  Focuses on the physical configuration, equipment, digital tools, spatial footprint, and temporary infrastructure requirements that enable the factory to function in specific urban or district contexts.

This framework provides a common language to align the strategic ambitions of renovation programs with the physical and operational realities of factory design. It has been used as the backbone for developing context-specific PuF configurations in the countries involved in this project.

4.2 Theoretical Foundation and Literature Insights

In this chapter, we aim to address the **operational layer** of the four-view framework while drawing on both the **organisation and factory focus** to identify the requirements related to the process view and technical view, as illustrated in Figure 17. These views guide the exploration of how on-site manufacturing approaches can be configured, both in terms of organisational setup and physical factory design.

To inform the conceptual design of PuFs, we draw from three key academic contributions that examine mobile, on-site manufacturing approaches from different disciplinary perspectives. Together, these works highlight emerging strategies for embedding flexibility, efficiency, and digital integration into localized production systems. While their focus areas vary (from timber construction to distributed manufacturing) their collective insights underpin the design principles applied in this project.

The first study (Gee & Brown, 2022), presents the development of a mobile system for the on-site assembly of timber frame components. Designed as an agile and low-cost alternative to off-site prefabrication, this system leverages digital tools like Computer Numerical Control (CNC) and on-site fabrication to produce timber frames directly at construction locations. The project followed an iterative prototyping methodology, integrating practical experimentation with digital modelling to develop a compact, efficient setup. For PuFs, this case

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exemplifies how lightweight, mobile fabrication units can reduce transport costs and support decentralized, sustainable construction.

Figure 18 visualizes the integration of value stream principles into mobile setup design, identifying process flows, bottlenecks, and spatial constraints. This user-centred and craft-oriented model demonstrates how design can be both lean and context-sensitive. For the PuF concept, their study illustrates the importance of tailoring factory setups not only to scale and technology but also to material flows and local labour conditions.

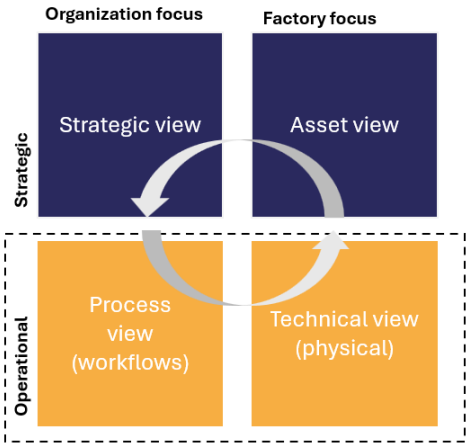


Figure 17: Focus of Task 4.3.



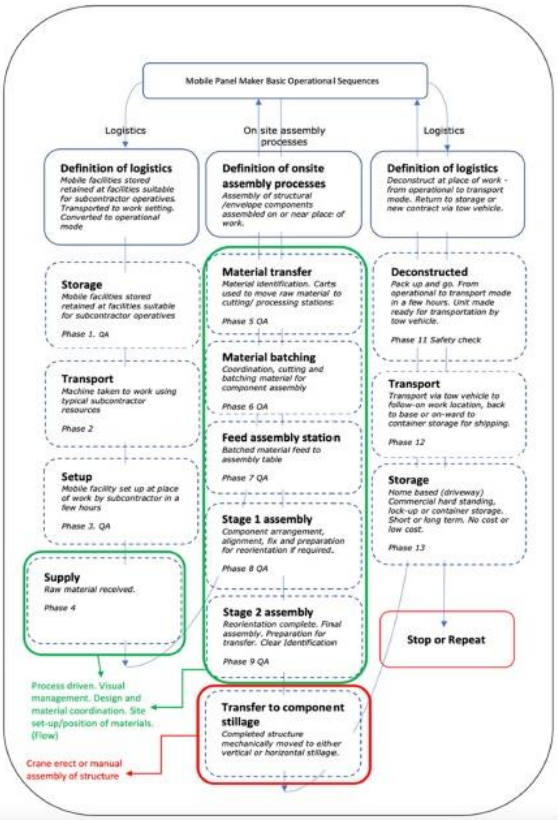


Figure 18 – Facit Home: machine in a container; components are made ready for onsite assembly; and Considerations for a mobile timber frame process using the Value Stream (Source: Gee & Brown, 2022).

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The second paper (Rosarius & García De Soto, 2021), provides a broader conceptual foundation for on-site factories, focusing on how they can support lean principles and industrialized construction. Through a review of relevant literature and case studies of "flying factories" across Europe and the Middle East, the authors explore how integrating Design for Manufacture and Assembly (DfMA) with on-site production can optimize workflows, reduce waste, and enhance efficiency. This framework directly aligns with the PuF objective of creating scalable and responsive production systems tailored to project-specific demands.

The key visual representation of their model is shown in Figure 19, which encapsulates their lean and modular design approach, showing how digital tools can facilitate rapid reconfiguration and planning of factory setups. The relevance to PuFs lies in the integration of digital design environments and the alignment with lean construction goals (factors that are crucial for efficient deployment in diverse scenarios).

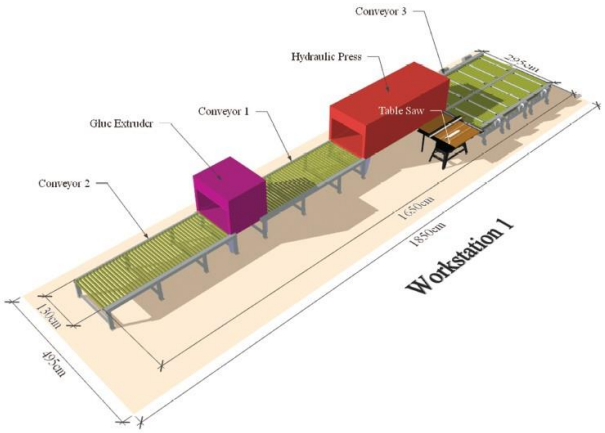


Figure 19 - 3D model of AL-1 consisting of a single assembly line with a low-mid level of automation (Source: Rosarius & García De Soto, 2021).

The third paper (Rauch et al., 2015), delves into the design of mobile, distributed manufacturing systems based on cyber-physical integration. Their conceptual framework and prototyping work investigate how factories can enable scalable, modular, and digitally supported on-site production. With a strong focus on technological adaptability and knowledge-based systems, this study contributes critical insights on how mobile factories can evolve beyond static infrastructure into intelligent, connected nodes within broader production ecosystems.

Figure 20 illustrates the modular thinking behind the design, focusing on how industrialized processes can be adapted for mobile implementation. This approach is particularly relevant for PuFs, as it emphasizes flexibility, integration with local supply chains, and minimizing transport and setup costs. The study's structured and systemic approach informs the way we think about scalable typologies in different urban or remote contexts.

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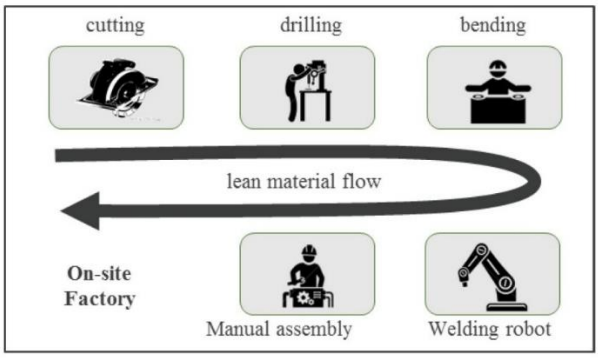


Figure 20 – Industrialized and efficient processes (Source: Rauch et al., 2015).

Table 9 summarizes and compares the three studies in terms of methodology, key concepts, and their specific relevance to PuF design.

Table 9 - Comparative Summary of Key Literature.

Paper	Methodology	Key Concepts	Relevance for PuFs
Gee & Brown (2022)	Iterative prototyping and digital modelling of a mobile timber assembly system.	Agile manufacturing; low-cost setups; digital fabrication (CNC); sustainable on-site construction.	Demonstrates feasibility of compact, mobile fabrication systems for local use; highlights affordability and flexibility.
Rosarius & García de Soto (2020)	Literature review and case studies of on-site/flying factories.	Lean principles; DfMA; hybrid prefabrication models; process optimization.	Emphasizes scalability and waste reduction; provides operational strategies for temporary on-site manufacturing.
Rauch et al. (2015)	Conceptual modelling and prototyping of cyber-physical mobile factory systems.	Modular systems; distributed production; cyber-physical integration; scalability.	Offers systemic, digitally integrated framework for PuFs; supports adaptive and intelligent local production networks.

Across these three studies, several shared principles emerge:

- Modularity is consistently emphasized as a key enabler for flexible deployment;
- All papers recognize the importance of minimizing onsite disruption and reducing waste;
- Digital tools are central for visualizing, simulating, and optimizing mobile factory configurations; and
- There is a strong concern for contextual adaptation, whether in terms of scale, materials, or automation.

These studies significantly informed the conceptual design approach of this project. Rauch et al. contributed to the systemic, modular design thinking. Rosarius and Garcia de Soto demonstrated the power of digital simulation for planning and evaluating factory layouts. Gee and Brown grounded the factory design in tangible material workflows and user-centred efficiency. By triangulating these insights, the tailored PuF concepts proposed later in this chapter aim to balance standardization with local adaptability (enabling meaningful application across various geographies, technologies, and production goals).

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4.3 Tailor-made designs: Imagine your Pop-up Factory Workshop

4.3.1. Context and Process

In the rapidly evolving construction sector, the push for sustainable, adaptive, and efficient solutions is more urgent than ever. PuFs have gained prominence as an innovative model to meet this demand. These mobile and flexible production units have the potential to streamline construction workflows, minimize transportation-related emissions, reduce costs, and support efficient renovation efforts. Against this backdrop, the BUPS project conducted a workshop in Vienna during its 3rd Consortium Meeting, which served as a milestone in further shaping the conceptual and practical direction of PuFs.

The workshop was designed to gather ecosystem-specific input from stakeholders and co-develop initial tailored designs for PuFs across the five regional ecosystems (Austria, France, Italy, The Netherlands, and Spain). Its outcomes not only reflect the collective knowledge and insights of participants but also help translate theoretical research into grounded, practical configurations for implementation.

The goal of the Vienna session was to explore a birds-eye view design, with spatial awareness and operational functions of the scenarios created. The format encouraged open-ended yet grounded discussion, leveraging both imagination and prior experience. A strong emphasis was placed on balancing creativity with feasibility, enabling the generation of viable, actionable solutions tailored to each ecosystem's conditions.

Participants, who represented a mix of industry professionals, researchers, and ecosystem stakeholders, were first oriented to the implementation matrix (see Figure 21 - PuFs Implementation matrix). This tool helped guide discussions toward the primary PuF scenario envisioned for each specific context, acting as a springboard for design ideation.

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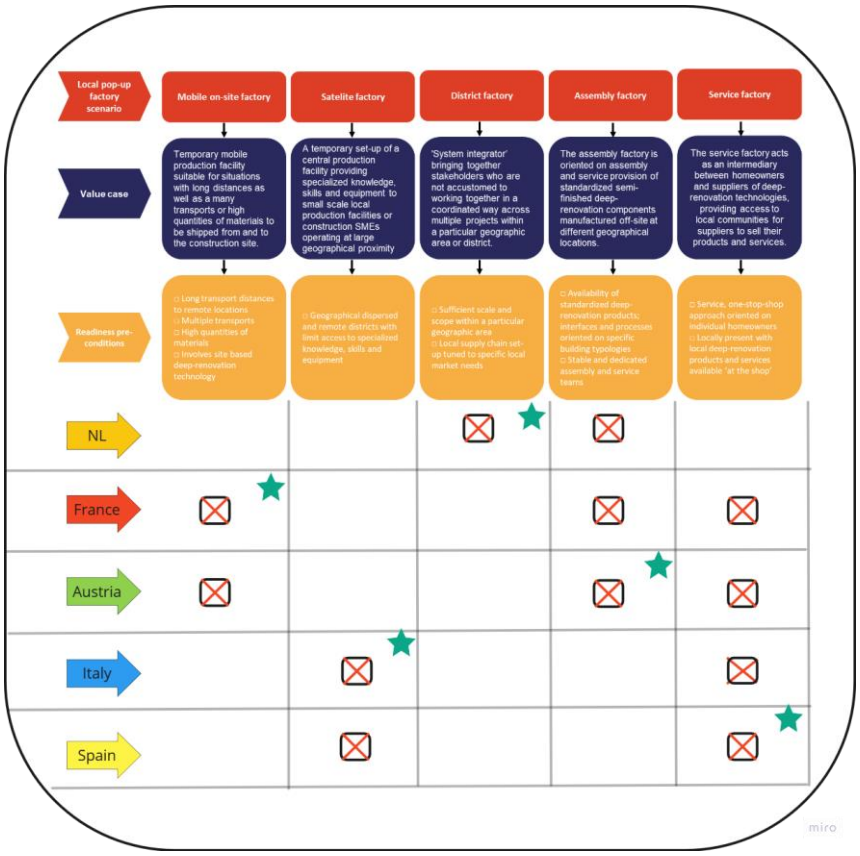


Figure 21 - PuFs Implementation matrix.

The workshop unfolded in three structured phases:

- Scenario Matching: participants matched their ecosystem's needs with one of the five predefined PuF scenarios. This activity grounded the discussion in localized challenges and opportunities;

- Creative Design Ideation: the second stage was focused on free-flow brainstorming around potential PuF layouts, production processes, necessary equipment, and logistical requirements. Visual references (including case studies and examples of existing mobile manufacturing systems) were presented to inspire thinking while underscoring the novel and experimental nature of the PuF concept.

- Categorization and Visualization: finally, the groups organized their ideas into "must-have" and "nice-to-have" categories. This step aimed to prioritize core functional elements while acknowledging desirable but non-essential features. Participants were encouraged to use sketches, diagrams, and visual storytelling to articulate their visions, and each PuF scenario was developed sequentially, ensuring equal attention across the five ecosystems.

This methodical yet flexible approach ensured that the final workshop outcomes were not only grounded in stakeholder insight but also rich in visual and conceptual depth. In doing so, the Vienna workshop played a critical role in shaping the future form and function of the PuFs envisioned within BUPS broader framework.

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4.3.2. Matching Needs

Aligning PuF scenarios with the specific needs of each ecosystem is comparable to tailoring a tool for a precise task, therefore, an essential step in ensuring effectiveness and impact. As part of the co-creation process, participants were provided with a structured template to guide their input and reflection. This template (see Figure 22) helped them define the use case within their ecosystem, articulate the contextual needs, and assess the feasibility of implementing PuFs[3].

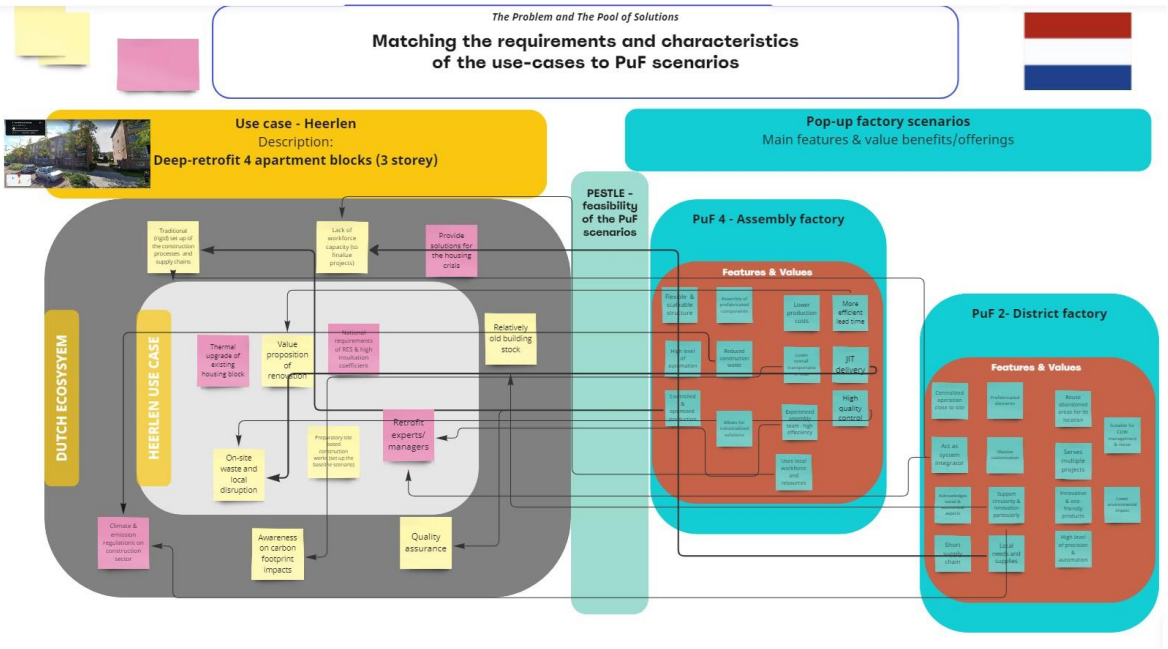


Figure 22 - First section ("match") of the Workshop.

The process began with participants filling in a description of their selected use case, capturing relevant typologies, goals, and any unique local challenges. They then identified the main needs arising from their ecosystem (both generally and in relation to the specific use case). In an earlier workshop, a PESTLE (Political, Economic, Social, Technological, Legal, Environmental) analysis was conducted to evaluate the external conditions influencing feasibility – which was described in Chapter 3.

Building on this foundation, participants were asked to match the identified ecosystem needs with two primary PuF scenarios previously identified for their context. This matching process involved identifying how each PuF scenario's key features, production focus, and value offerings aligned with the local needs and constraints. Participants were encouraged to view the problem landscape holistically and consider the full pool of ecosystem-specific solutions, ultimately aligning these with the operational possibilities offered by the PuF scenarios.

By systematically linking ecosystem requirements with appropriate PuF characteristics, this process allowed for a demand-driven, context-aware approach to innovation. It enabled the strategic calibration of PuF solutions, helping to optimize resource use, streamline renovation processes, and enhance stakeholder acceptance. Ultimately, this

[3] For participants' detailed answers, please refer to the Miro board: https://miro.com/app/board/uXjVNZ1L1y0=/?share_link_id=642946723162

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tailored alignment reinforces the potential of PuFs as effective, flexible, and sustainable solutions within diverse renovation ecosystems.

Following the matching of ecosystem needs with two main PuF scenarios, the next step of the process focused on gathering ideas to further define the functional and spatial configuration of these factory types (see Figure 23). Building on the identified challenges, value offerings, and context-specific requirements, participants were invited to explore how each of the selected PuF scenarios could operate in practice. This phase aimed to translate abstract matches into tangible concepts by detailing production processes, physical layouts, equipment needs, and potential user interactions. By drawing from both real-world references and creative input, participants began shaping tailored designs that not only respond to their ecosystem's demands but also reflect the unique identity, scale, and technological capacity of each scenario.

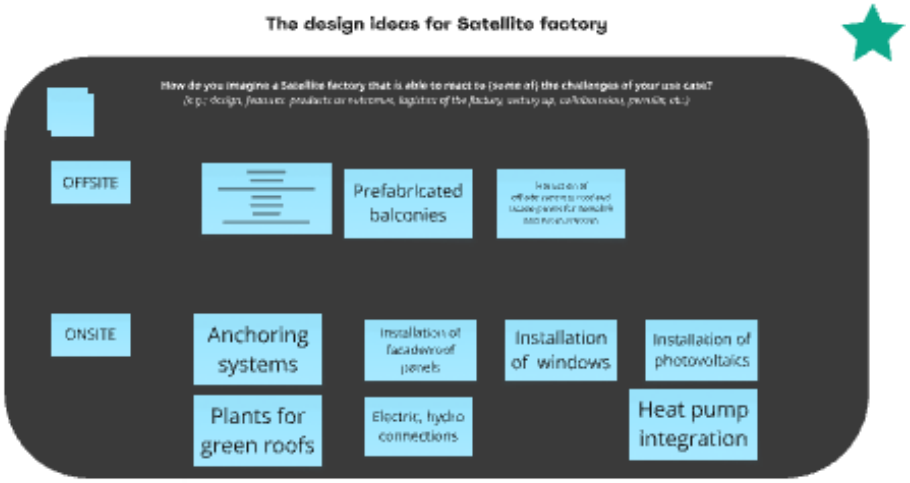


Figure 23 – Second section ("gather") of the Workshop.

In the third stage of the design exercise, participants moved from idea gathering to more detailed mapping and design of their two selected PuF scenarios. This phase (see Figure 24) involved structuring their concepts around key operational dimensions, including main features and purpose, spatial layout and design, materials and equipment (both physical and digital) workflows and production processes, as well as logistics and supply chain coordination. By addressing these elements, participants began to define how each factory type could be configured to deliver value efficiently within their ecosystem. This hands-on design approach helped translate earlier discussions into actionable insights, setting a foundation for context-specific factory models that are both operationally viable and aligned with local renovation goals.

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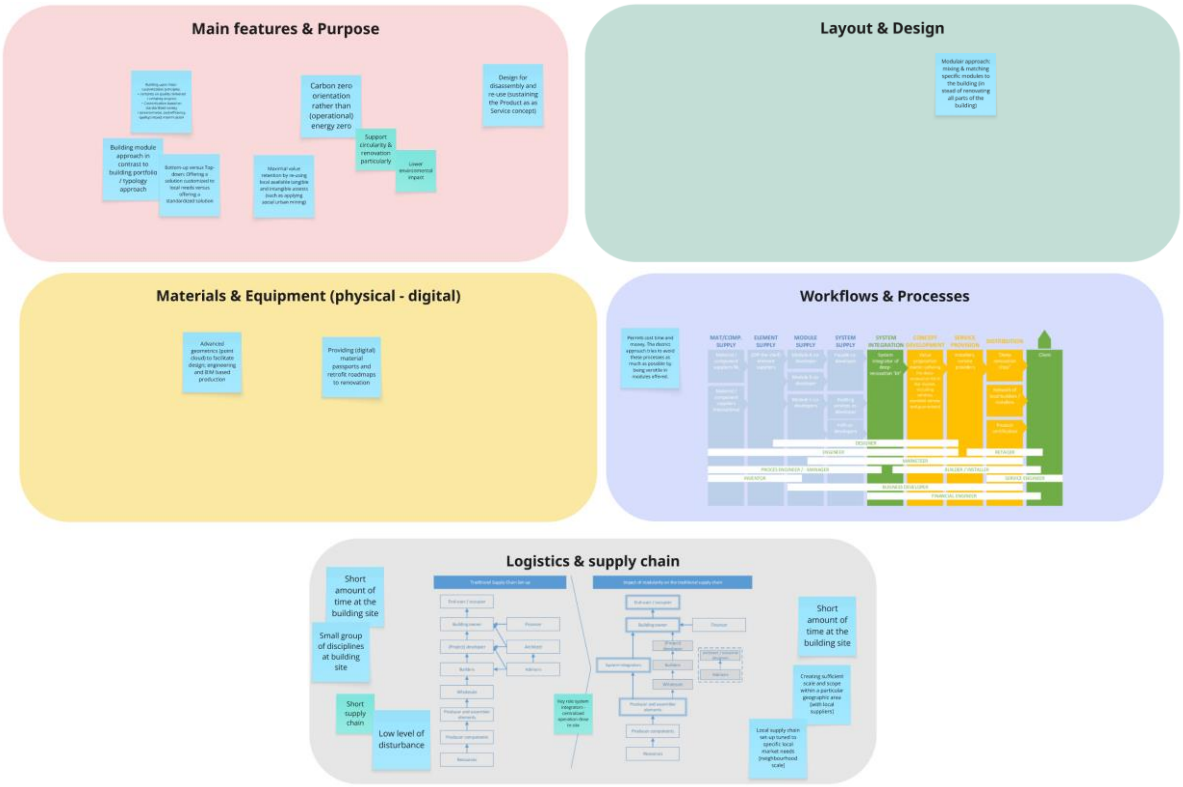


Figure 24 - Third section ("map") of the Workshop.

To conclude the workshop, participants engaged in a more structured design activity that aimed to visually articulate the internal logic and operational flow of each PuF scenario (further details in Key Outcomes). Using a simplified flowchart method, they created rough spatial and process diagrams to map out the sequence of actions, functional zones, and interactions within the factory layout. This exercise was supported by a predefined legend (see Figure 25), which included visual elements representing key operational components such as quality control checkpoints, waste collection and separation units, material and unit movement pathways, storage areas (e.g. ISO containers), designated work zones for assembly or production, and specialized workstations for specific processes. By mapping these elements, participants could simulate and better understand the operational dynamics of their PuF concept—how resources, materials, and activities move through space—and identify potential bottlenecks, redundancies, or opportunities for optimization. This final step helped ground earlier conceptual ideas in spatial and procedural realities, enabling a clearer vision for implementation.

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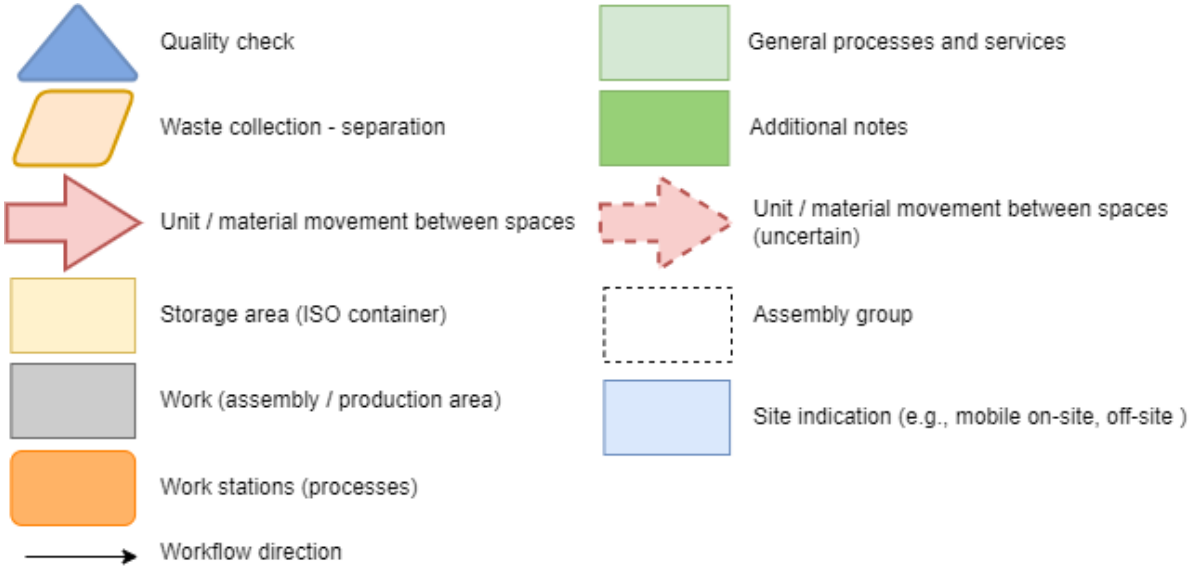


Figure 25 – Workshop design legend.

4.3.3. Key Outcomes

The visual flowcharts developed by participants during the final stage of the workshop provided concrete insights into the envisioned operational models of PuFs across different European ecosystems – Figure 26 shows the example provided during the workshop. These diagram, although preliminary and exploratory in form, offered valuable perspectives on how factory processes, material flows, and logistical sequences could be structured to serve specific renovation use cases (for the detailed design sketches see Section 4.3.4).

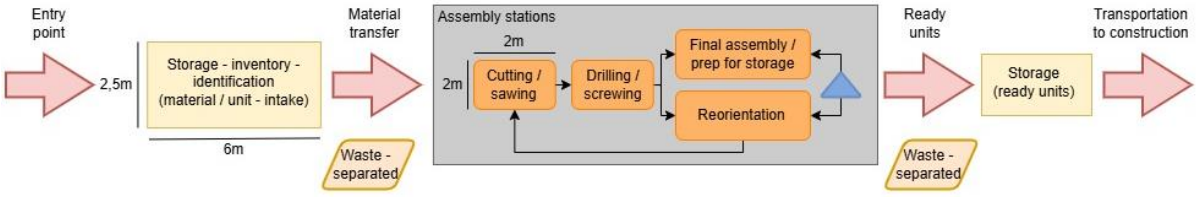


Figure 26 - Assembly factory example (abstract) design.

Key Insights from Participants

A consistent theme across the diagrams was the emphasis on closed-loop processes and on-site integration. For instance, many participants mapped pathways for waste separation, reuse, or redirection to recycling streams—suggesting a clear intention to embed circular economy principles into PuF workflows. The integration of quality control checkpoints throughout the process flow also indicated strong awareness of maintaining product standards, especially when dealing with reused or reclaimed materials.

Participants showed a preference for modular layouts that accommodate real-time decision-making and material variability. For example, the French and Austrian teams emphasized diagnostics and

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material audits at the beginning of the process, ensuring that reuse decisions are informed by technical assessments. In Spain and Italy, workflows were aligned with just-in-time (JIT) delivery strategies and included detailed breakdowns of prefabrication, wiring, and green technology installations, demonstrating their focus on minimizing on-site disruptions.

Challenges and Opportunities Identified

A recurring challenge noted—either explicitly or through process design—was the complexity of logistics management. Coordinating material movement, temporary storage, and repackaging across tight spatial and time constraints posed difficulties, particularly in urban or constrained construction sites. The concept of "limited-time storage" in the Spanish case highlighted the logistical tension between JIT flows and material availability.

On the opportunity side, several diagrams revealed untapped potential in combining technical workflows with user engagement. For instance, references to tenant involvement, financing schemes, and knowledge-sharing platforms in the Spanish and Dutch diagrams illustrated a broader vision for PuFs not just as production facilities, but as participatory hubs for renovation culture and stakeholder collaboration.

Ideas and Concept Sketches Proposed

The diagrams reflected detailed and diverse design thinking. In the Netherlands, a full material flow for window retrofitting—from cutting and framing to glazing and installation—was laid out, complete with specific waste streams (e.g., sawdust, glue, packaging). France's concept included a decision matrix for material reuse and integration with diagnostics, suggesting the use of digital tools for circularity planning. Austria's model revolved around containerized logistics and certified repackaging processes, revealing a hybrid model involving both mobile units and regional service providers. In Spain, the design was centred on pre-cutting, JIT repackaging, and green building components, supported by stakeholder engagement across multiple buildings.

Alignment with the Literature Review

The design logic presented by the workshop participants strongly aligns with the principles outlined in the literature review. Similar to the mobile timber frame system discussed by Gee & Brown (2022), the Dutch and Spanish flowcharts emphasized modular production zones and embedded feedback loops (e.g., quality checks, iterative installation). The process optimization and low-mid automation levels seen in Rosarius & García de Soto's (2020) AL-1 model were echoed in Austria's and Italy's emphasis on semi-automated repackaging and on-site assembly. Rauch et al. (2015) had highlighted the potential of distributed, scalable manufacturing models, and this was evident in the Austrian and French cases, where decentralized logistics and reuse strategies were central.

However, some divergences were also present. For instance, while the academic literature tends to focus on technical integration and operational efficiency, participants placed relatively more emphasis on stakeholder engagement and the socio-economic role of PuFs (e.g., job creation, community participation), suggesting a broader understanding of value beyond throughput and precision. This reflects a more holistic perspective—consistent with the goals of the

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New European Bauhaus—where sustainability is combined with inclusivity and local empowerment.

4.3.4. Ecosystem Overview & Design Visualizations

4.3.4.1. Dutch Ecosystem

The Dutch PuF scenario is anchored in two different pilot projects, which resonate with the development of a district/assembly Pop-up Factory (PuF) model, and it is further supported by a feasibility study for remote areas (here explored in Chapter 7). Their hybrid condition allows for a more informed understanding of the actual state of a PuF and on its possible implementation.

The first pilot relates to the deep renovation[4] of four portico-style[5] apartment blocks constructed in 1957 and located in the neighbourhood of Hoesnbroek in the Dutch city of Heerlen (Limburg). The renovation of the 36 apartments, owned by a local Housing Association is managed through a formal tendering process, followed by the execution phase, with apartments renovated over multiple months. Works are planned under occupied conditions, meaning tenants remain in their homes during renovation and are supported by temporary arrangements to accommodate those who stay at home during the day. The renovation scope includes façade upgrades, new window frames, additional insulation in roof and storage areas, and broader building-technology improvements such as (partial) asbestos removal. In addition, the renovation of kitchen and bathroom/toilet unit is also carried out, in accordance with the tenants.

The second pilot relates to the renovation of a residential building block of Quirinaalhof located in the neighbourhood of Daalhof in Maastricht and owned by a local Housing Association. The renovation includes the replacement of the façade systems with a new prefabricated façade, in addition to wall, floors, and roof insulation, the installation of replaced by individual heat pumps and PV-thermal panels. This renovation related to 145 apartments and is structured according to a formal tendering process, followed by an execution phase, with apartments renovated over multiple months. Also in this case, works are planned under occupied conditions with temporary arrangements to accommodate residents who are at home during the day. The renovation scope includes prefabricated façade upgrades, heating system upgrade, ventilation system installation, and internal kitchen/bathroom/toilet renovation, with

[4] Although Deep Renovation (or Deep Energy Renovation) concept doesn't reach a shared agreement on its core definition, we adopt the definition developed by GDPN, which sees this concept as "is a term for a renovation that captures the full economic energy efficiency potential of improvement works, with a main focus on the building shell, of existing buildings that leads to a very high-energy performance. The renovated buildings energy reductions are 75% or more compared to the status of the existing building/s before the renovation. The primary energy consumption after renovation, which includes, inter alia, energy used for heating, cooling, ventilation, hot water and lighting after the deep renovation of an existing building is less than 60 kWh/m2/yr. (GBPN, 2013, p.19)

[5] The authors refer to the Dutch housing typology of *portiek etageflat*, defined as a multi-family dwelling with several floors, where the flats are accessible via a communal, covered and lockable porch, which is centrally located at the main entrance of the building. Unlike a gallery block (*galerijflat*, in Dutch), where the flats are located along an open corridor on the outside of the building, the front doors of a porch block are located around a central stairwell. For more information, see: https://kennis.cultureelerfgoed.nl and https://www.tudelft.nl/beyondthecurrent/benadering/typologie

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(partial) asbestos removal. The renovation of this building is planned around a collaboration between different stakeholders which exchange knowledge around process and technical manufacturers, in a sustainable idea of PuF (Figure 27).[6]

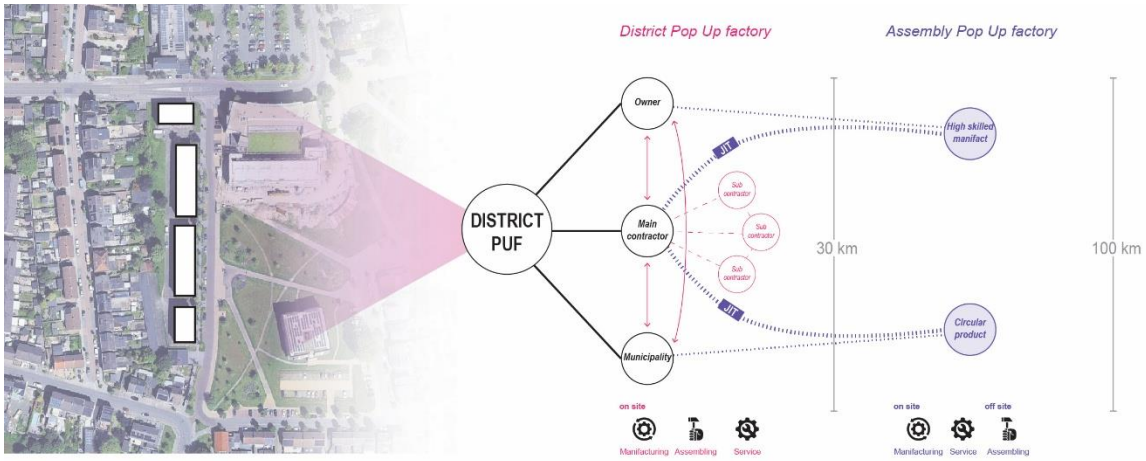


Figure 27: Organisation of the hybrid District/Assembly PuF.

In parallel to defining the renovation scope, the Dutch ecosystem positions the Pop-up Factory concept as a way to address the ecosystem's **maturity gap**: while many housing associations currently renovate toward **energy label B**, deeper renovation ambitions require more systematic and scalable approaches. To frame this, the ecosystem develops a **complexity matrix** (Figure 28) and proposes that pop-up factories could support deep renovation by **bundling demand across larger building portfolios** and organizing renovation in a more systemic way.

[6] As the Quirinaalhof building is part of a larger complex of three buildings built within the same plot, years, and type, the renovation need of these complex happened at the same time. However, the three buildings now belongs to different Housing Association, meaning that different procedures, actors, services and processes will happen. Seen the local dimension of the renovation though, a stream of communication between Housing Association happened and allowed for the replication of a model through two of the buildings, involving some of the same actors in the renovation. This reflects the spirit of the PuF of being a platform for facilitating the renovation also through a knowledge and services exchange.

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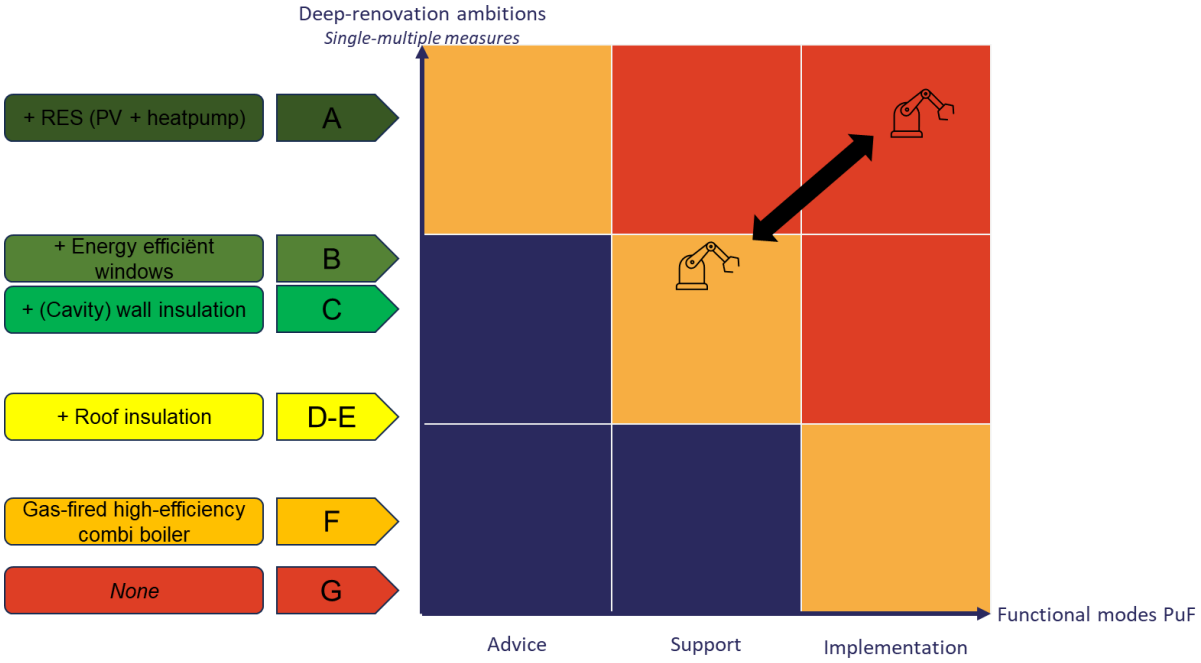


Figure 28: Complexity Matrix

A distinctive feature of the Dutch context is the influence of procurement procedures on the feasibility and organisational structure of renovation projects. Dutch housing corporations (woningcorporaties), although legally private foundations, operate within a highly regulated framework due to their public mandate in the provision of social housing. For large renovation projects they often apply procurement procedures aligned with the Dutch Public Procurement Act (Aanbestedingswet 2012), which implements the EU Public Procurement Directive 2014/24/EU (European Commission, 2014; Rijksoverheid, 2012). When contract values exceed the European threshold for works contracts (approximately €5.5 million for the 2024–2025 period), competitive tendering procedures are generally required and contracts must be published at the European level. These rules aim to ensure transparency, equal treatment, and fair competition, but they can also limit the possibility of directly selecting local firms or establishing pre-defined supply chains—an approach that would typically underpin a local Pop-up Factory ecosystem. As a result, industrialised renovation models such as Pop-up Factories should be structured through procurement-compatible mechanisms, including framework agreements, innovation partnerships, or integrated design–build contracts, which allow long-term collaboration while remaining compliant with European and national procurement regulations (European Commission, 2014).
Based on the characteristics of the Dutch building stock—particularly the repetition and standardization of many apartment blocks and row houses from the 1960s and 1970s—the ecosystem proposes a PuF based on a district/assembly model. The core logic is to identify groups of similar buildings within an area, develop a repeatable renovation approach, and place a larger bundled renovation package on the market in a single tender. This front-loaded organization is expected to reduce investment and

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execution inefficiencies and to enable faster renovation delivery once implementation begins.
Figure 29 illustrates the District/Assembly Factory concept for the Dutch ecosystem. The process begins with the Manufacturing phase in which the (raw) material is

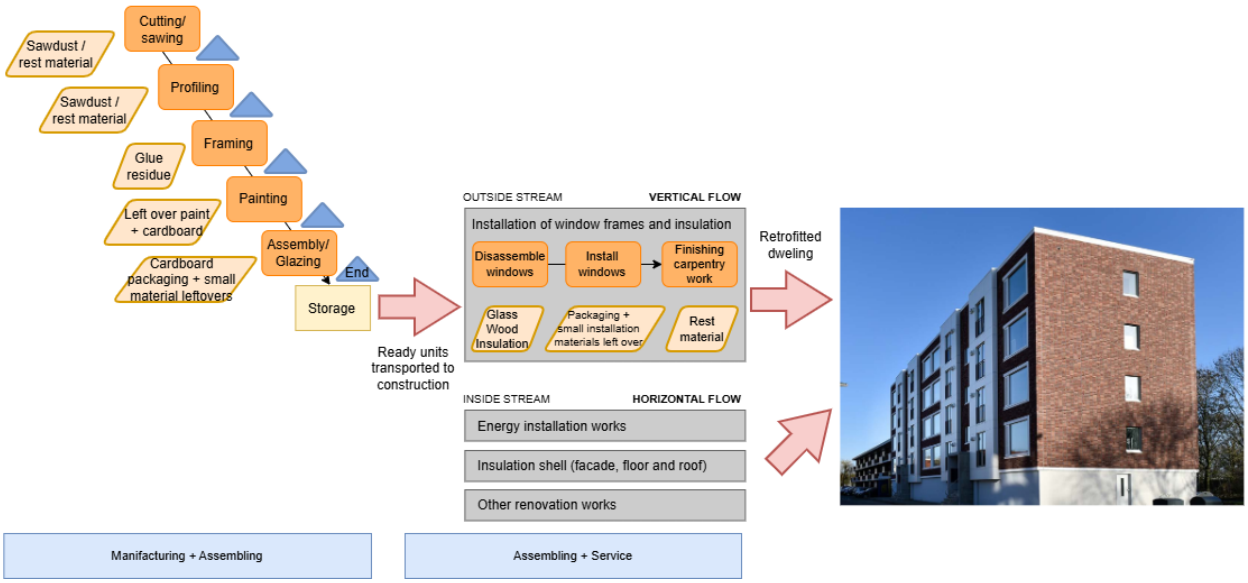


Figure 29: District Factory Sketch (for the legend see Figure 25)

collected and prepared. For the Dutch pilots we reckon three main workflows, related to the Insulation shell (façade and roof), the Installation of the window frames/façade system, and the Energy works. In addition, these cases show the added value of using the occasion of the deep-renovation for intervening on smaller portion of the building blocks, such as the interior systems and finishing. In both pilots, not all these work flows are executed within the PuF logic, with the exception of the window frames/façade system work flow which will be further discuss below. In this way, The reason for this difference lays on the opportunities for mass production and repetition of elements (higher in repetitive façade, lower in insulation installation), as well as the specific type of work required for the other processes, such as those energy-related.
The Dutch pilots also show how these different work flows are operated simultaneously in the building but proceedings at two different speeds (Figure 30). The first stream is related to the outside works, which is organised vertically on the facades, requiring for the pilot in Maastricht around 1 day per apartment, and for the pilot in Heerlen around 28 days per block (9 apartments) for the façade system and the roof insulation; the second one, instead, is a horizontal type and it refers to works that happen inside the building and the apartments. It usually takes around 18 days per apartment, as in the Heerlen pilot.
Within this PuF model flow, the works related to the instalment of the window frames can be divided into two blocks of actions: the first related to Manufacturing and the initial Assemblage of the part (which happens off-site), and the second related to Assemblage and Service, which takes place on-site.

The first block includes also activities such as cutting of profiles, framing, painting, glazing and finally assembly: all these steps results in a waste streams (e.g., leftover paint, cardboard packaging) and a final check necessary to proceed to the following step. Completed units are then moved to storage before being transported to the construction site. Once at the

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construction site, the second block includes the preliminary activity of disassembling the windows, then installing the new (prefabricated) facade, and finishing the carpentry work. Also these actions will result in related waste stream.
In parallel, other actions are happening within the **horizontal flow** in the inside of the building and the apartments, namely the insulation of the basements, the renovation of gas/boiler, the (partial) removal of asbestos in the wc pipes, the upgrade of fire compartments (in the Hoensbroek pilot), the installation of ventilation system, and the renovation of kitchen and bathrooms with the related finishing. A relatively small portion of the site environment is dedicated to storing the construction material (partially o pre-assembled), in a variable range between 60-100 sm. The sum of these two streams result in the final (deep) renovation of the building blocks and the related dwellings.



Figure 30: Sequence of works within the Horizontal and the Vertical Flows



Figure 32: Building complex in Maastricht

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4.3.4.2. French Ecosystem

The French PuF scenario is built around **selective deconstruction linked to rehabilitation**, with a specific focus on the **reuse of sanitary equipment** recovered through careful removal. Building on a pilot rehabilitation activity in social housing, the ecosystem demonstrated that reused sanitary elements can be integrated into a rehabilitation process, with reported cost savings (e.g., around €8,000 for 20 flats). The ecosystem highlights sanitary equipment as a high-potential reuse stream due to the durability of ceramic materials, limited technological evolution over recent decades, and the practical feasibility of cleaning and maintenance, while noting the significant impacts associated with manufacturing and transporting new equipment.

Within the BuildUPspeed PuF typology, France primarily adopts a *Mobile On-site Factory* concept, developed as a **"truck for reused equipment."** The intent of this mobile unit is to connect reuse operations directly to deconstruction sites by enabling reconditioning steps—such as checking, cleaning, and preparation for re-employment—within a mobile setup, rather than relying solely on fixed facilities. This concept is being defined through technical and economic feasibility work, and is motivated by current barriers in the market, including the complexity of careful removal and checking procedures, logistics, a lack of specialized companies able to deliver the full chain, and unresolved insurance considerations.

Depending on site conditions and sequencing between deconstruction and rehabilitation, the reconditioned equipment may be returned to the same project (where intermediate storage or staging is possible), transferred directly to another receiving site, or distributed via marketplace-type platforms. The concept is intended to serve project owners such as social landlords, property developers, and public authorities, and can be extended beyond sanitary equipment to other reusable product streams where feasible.

The project could also be carried out by an organisation from the Social and Solidarity Economy (SSE), involving people in professional integration pathways. This approach would reinforce the social impact of the initiative while contributing to the creation of an innovative and locally rooted economic model.

Key implementation needs identified include a workable business model defining ownership and transfer of recovered equipment between project owners and reuse operators, clarity on transport and handling constraints (notably where chemical cleaning processes are involved), and an insurance approach that covers the risks of the reuse process. The French PuF scenario is therefore positioned as a scalable mobile implementation model aimed at strengthening the sanitary equipment reuse chain and supporting circular renovation practices by bridging selective deconstruction and reuse in a more operationally integrated way.

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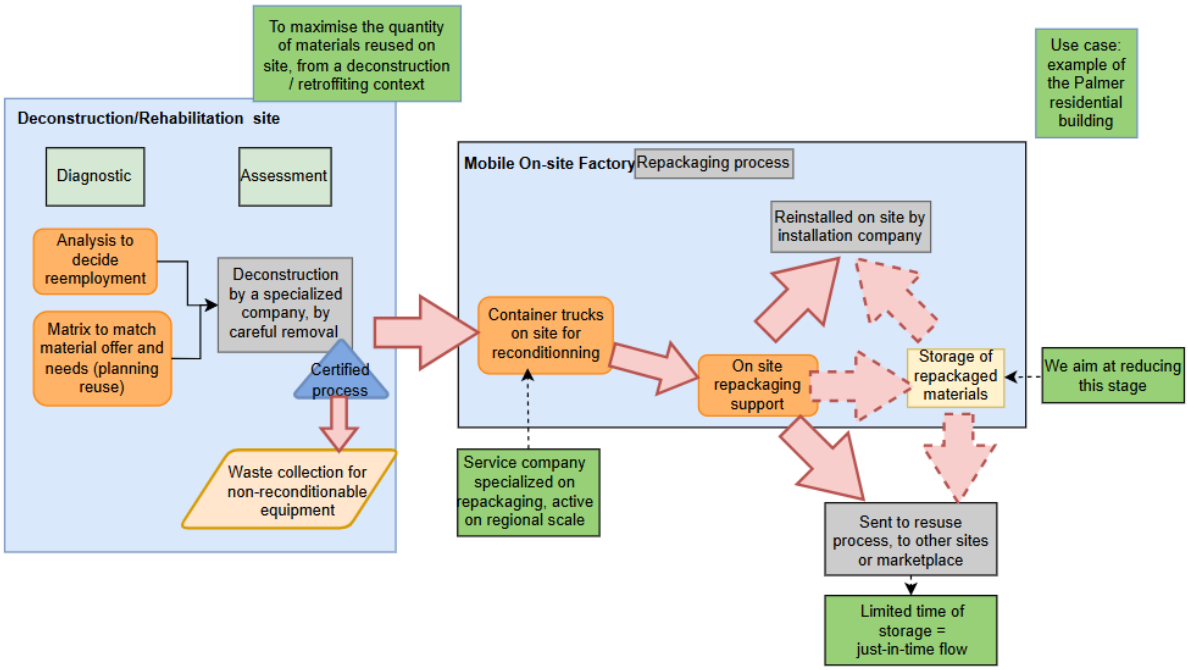


Figure 33: French Ecosystem - Mobile On-site Factory Sketch (for the legend see Figure 25)

The Mobile On-Site Factory concept for the French ecosystem, shown in Figure 33, which brings repackaging and reuse processing directly to the construction or deconstruction site. The operational functioning of the mobile factory is as follows: the workshop truck is mobilised on demand, depending on the construction site schedule. It can be requested by a project owner (social housing provider, local authority), a reuse platform, a specialised marketplace, or directly by a project manager seeking to valorise existing equipment on site.

Once deployed on site, the mobile unit performs the following operations:

- careful removal of sanitary equipment previously identified during the preparation phase;
- cleaning, disinfection, and refurbishment of the equipment;
- packaging and temporary storage directly within the truck or in dedicated modules;
- transport of the refurbished equipment, either to a temporary storage area or directly to a receiving construction site.

The refurbished sanitary equipment can therefore be reused directly on the same site (when the construction schedule allows it) or integrated into local reuse channels for other renovation or construction projects.

To ensure efficient operations, the mobile factory must be easily transportable and adaptable, with modular configurations depending on the specific needs of each site.

The mobile unit is based on container modules that can be transported by truck (see Figure 34 and Figure 35). Two standard sizes can be considered:

- 6.06 × 2.44 × 2.59 m (30m2)
- 12.19 × 2.44 × 2.59 m (15m2)

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A first module is fitted out for refurbishment activities, providing approximately 30 m² of working space. Additional units can then be added to provide storage capacity for refurbished equipment, depending on site requirements, typically ranging from 15 to 50 m².

The use of containers offers several advantages, including ease of transport and the possibility of stacking modules, which allows better optimization of the available space on site.

Based on previous experimental sites, the mobile factory is expected to handle an average processing capacity of approximately three apartments per day, corresponding to around 10 to 15 sanitary elements (toilets, sinks, bathtubs).

The mobile factory must include the equipment and tools necessary for the refurbishment of sanitary equipment, including:

- a workbench;
- an indoor layout with shelving, power supply and wastewater evacuation;
- lifting and handling equipment;
- various tools (high-pressure cleaner, hand tools, etc.);
- consumable supplies (personal protective equipment, cleaning products, etc.).

Electrical connection and wastewater evacuation should be facilitated through a plug-and-play connection system. The deconstruction site manager must anticipate the arrival of the mobile factory by ensuring that construction site utility connections (electricity and wastewater) are available.



Figure 34: French Ecosystem: Mobile On-Site Factory

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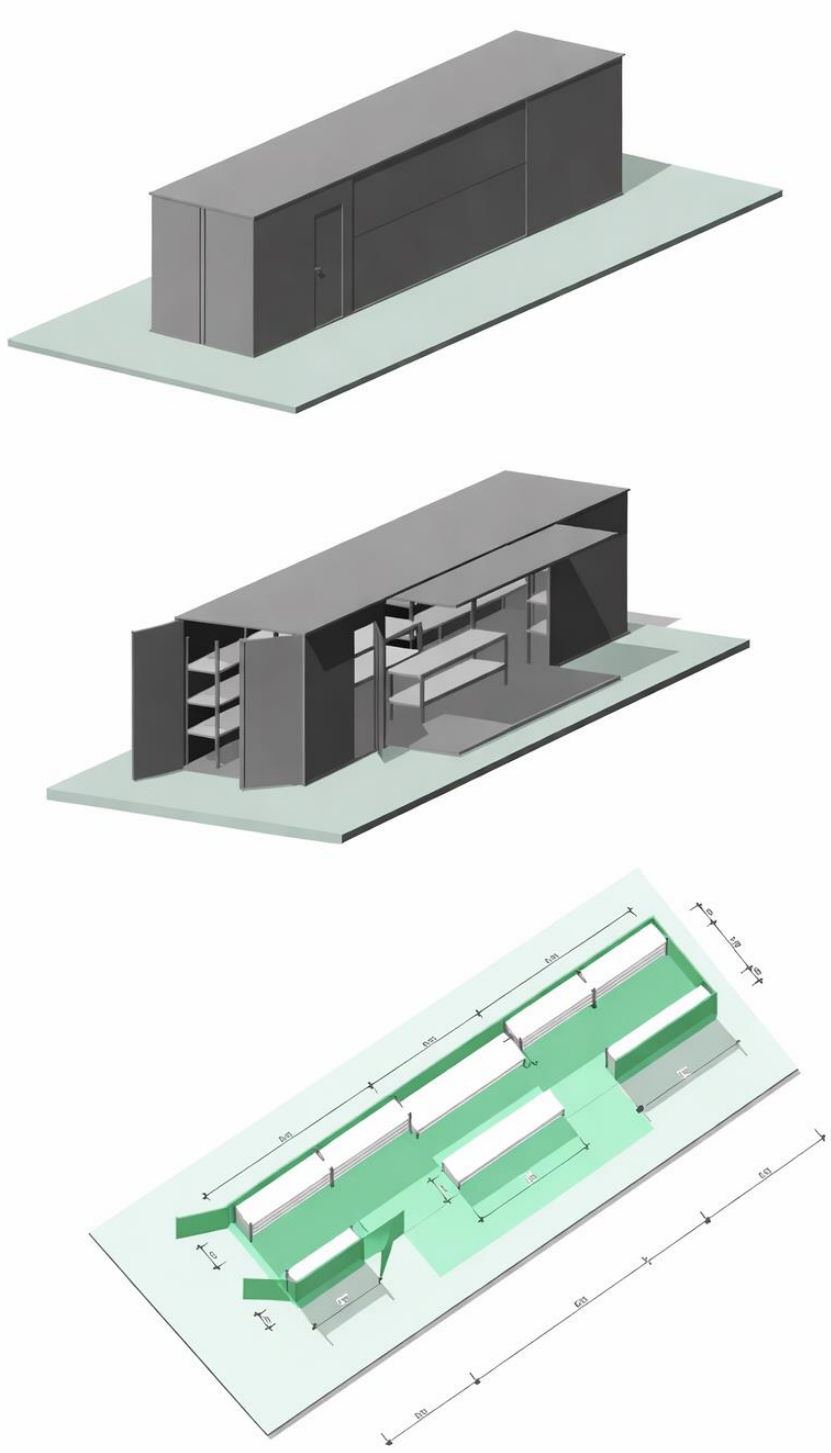


Figure 35: French Ecosystem: Mobile On-Site Factory Drawing

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4.3.4.3. Austrian Ecosystem

The Austrian PuF scenario is centred on the innovative concept of social urban mining, with a focus on systematically identifying, documenting, deconstructing, and reusing building components prior to demolition. The approach is applied across multiple pilot activities, ranging from former shops and hotels to industrial parks and training facilities, and is designed to be replicated across several sites. **Within the BuildUPspeed PuF typology, the Austrian ecosystem primarily adopts an *Assembly Factory* concept, referred to as the "Re-Use Box," to support the organization and execution of reuse-oriented deconstruction and redistribution activities.** Rather than relying on a single fixed installation, the Austrian ecosystem implements reuse through locally organized "Re-Use boxes" and operational dismantling activities that are adapted to each building context.

A core element of the PuF concept is the development and continuous refinement of a screenbook, which functions as a structured planning and checklist tool to guide reuse activities before, during, and after deconstruction. The screenbook supports early coordination with real estate developers, clarifies negotiation points, identifies technical and logistical constraints (such as lack of electricity or reliance on elevators), and enables post-activity documentation and evaluation. This planning framework is applied iteratively across all pilots and is considered a key outcome of the ecosystem's work.

To address the high effort and cost associated with manual documentation of reusable elements, the Austrian ecosystem is also developing a digital recording and stock documentation tool. Reusable products were identified through on-site inspections, photographs, and manual notes that were later compiled into catalogues. In the meanwhile a digital tool accelerates this process, reduces back-office workload, and enables trained representatives of social economic partners to support documentation activities, rather than limiting this task to experts only.

Operationally, the Austrian PuF scenario is implemented through a portfolio of pilots, including completed and ongoing projects such as community shops, hotels, large industrial parks, and a former training center in Vienna where a new reuse box is being established. These pilots demonstrate different levels of engagement, from conceptual urban mining studies to active dismantling and reuse operations, often in cooperation with social economic enterprises. While not all projects result in on-site reuse boxes, linkages to operational dismantling and reuse pathways are systematically explored.
In parallel, the Austrian PuF scenario connects the BuildUPspeed activities with national R&D projects to address structural barriers to reuse, particularly in relation to testing, auditing, warranty, and insurance of reused building products. These efforts include developing testing procedures for reused steel and reinforced concrete elements and exploring insurance models that could cover risks associated with placing reused products on the market. Through this combination of practical pilots, planning tools, digital support, and regulatory experimentation, the Austrian PuF scenario positions social urban mining as a scalable and knowledge-driven approach to embedding reuse within standard deconstruction and redevelopment practices.



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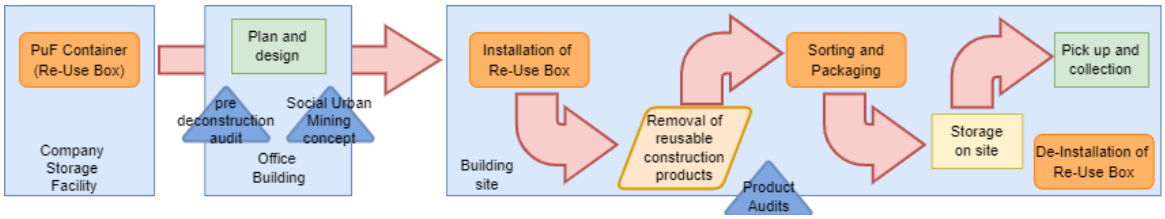


Figure 36: Austrian Ecosystem - Assembly Factory Sketch (for the legend see Figure 25)

Figure 36 illustrates the Assembly Factory concept developed within the Austrian PuF scenario, referred to as the "Re-Use Box." The core element of the concept is the idea, that the deconstruction site itself functions as an operational and organizational place for reuse activities. In the building itself a Social Urban Miner installs a deconstruction office to serve as a central contact point for reuse-related activities and stakeholder coordination. The need for infrastructure is minimal.

Prior to operational activities a pre-deconstruction audit and a Social Urban Mining concept define the scope of reuse and deconstruction works. Both documents define a framework to embed reuse mining. Limitations occur due to hazardous substances in products, the state of materials and components, warranty issues, the potential for deconstruction and the acceptance of reused components. These preparatory steps determine the type and quantity of reusable products and allow estimation of the required production time. Depending on previously described framework conditions the social urban mining concept summarises the kind and number of reuseable products and proposes a time slot to trade and sell those products. In average the concepts show potentials for reuse between zero EUR for devastated vacant buildings and up to 350.000 EUR for large building complexes still in use. The previous studies show that properties larger than 2,000 square meters, in particular, have significant potential. The Social Urban Mining concepts presents potentially reuseable components in three categories: The category green stand for easily realisable potential like doors, furniture, floorings or wand coverings. The category yellow is linked to some kind of special certificates like electric products, installations or cooling units. The highest efforts are linked to the category orange that is often used for windows, façade elements, or for static elements like beams, concrete elements or roof trusses.

Once the operational agreement is concluded with the building owner, responsibility for the entire building is transferred to the Re-Use Box operator. The whole building is used as the operational disassembly zone. Reusable products are typically distributed throughout the building rather than concentrated in a single fixed assembly area. Therefore, a specific gross floor area for an on-site assembly zone is not defined. The operational setup includes:

- A clearly defined central contact point (like an office room)
- Installation or definition of toilets and washing facilities for the employees
- One controlled entry point
- Designated "No-Go" areas for safety reasons (clearly marked)
- Secured building access (no external access without operator knowledge)

Experience so far includes projects in buildings ranging between app. 1,000 m² and 60,000 m². Storage capacity on-site depends on the building and project scope. However, a minimum of approximately 100 m² storage space is recommended. Below this threshold, operations become

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difficult. Suitable access infrastructure, such as a ramp for lorries, is required to support loading and unloading processes.

The dimensions of key site facilities depend on project size and team composition. The typical team size is one head and four to five worker. If the size of the object needs more work force the Re-Use Miner organises teams from different social partner organisations. As a rough guideline:

- One mobile toilet is provided per five workers.
- A social room (e.g., classroom-style space) between approximately 20 m² and 100 m² is required, depending on team size.

The entire building is locked during operations for safety and security reasons. Utility requirements are project-specific and not defined by fixed capacity values. However, the organization of both water supply and electricity is mandatory. Site power is particularly required for lighting and operational activities (240V, better 400V three phase, 5kW), while water and greywater solutions are necessary to ensure sanitation and basic site functionality.

Once installed, operations include the removal of reusable construction materials, sorting and packaging activities, and additional recycling-oriented processes. Recovered reuse products are temporarily stored on-site before being collected. The final transport and integration into new construction or refurbishment projects is task of the new owner (Figure 37 and Figure 38).

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Figure 37: Re-Use Box in Vienna 2025 (©Joanna Pianka)



Figure 38: Re-Use Box 9501 Villach ©BauKarussell

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4.3.4.4. Italian Ecosystem

The Italian PuF scenario focuses on the **pre-feasibility of a satellite factory** to support large-scale, industrialized renovation of residential buildings, particularly in the public social sector. Due to the significant industrial investment required, the pop-up factory itself is explored through a feasibility study rather than direct deployment within the project timeframe. However, the analysis has been done considering the offsite deep renovation of a pilot involving six large public social housing buildings constructed in the 1960s–1970s in Milan, northern Italy, which serves as a real-world reference for impact evaluation and methodological testing. Indeed, the Municipality expressed the willingness to retrofit them, and this study could help to consider prefab solutions from a technical and economical perspective.

The reference pilot demonstrates an **industrialized façade renovation approach** based on offsite concrete prefabricated insulated panels combined with re-roofing solutions and replacement of heat generation systems. Precast intervention enables the improvement of seismic performance, while keeping the cost relatively low with respect to wood solutions. The energy class improvement foreseen is from class G to A2, while fully maintaining residential continuity. Installation is carried out without scaffolding and reached an average productivity of around 200 m² per day with a small workforce.

The satellite factory is conceived as a **hybrid production model**, capable of manufacturing components for both renovation and new construction to maximize the capacity and lowering the risk on down picks of demand. Beside the main factory, a **close-to-site manufacturing** capability is also in place for producing or integrating certain components near the building site, which is the assembly location of the panels on the buildings. The analysis includes comparing renovation scenarios with demolition-and-reconstruction alternatives (both prefabricated vs traditional) and assessing the added value of using a dedicated offsite satellite factory for this and future projects. Replication potential is also explored, considering the need for more localized production units if similar interventions were to be implemented in other regions of Italy. Through a structured feasibility study applied to a possible real building implementation, the Italian PuF scenario establishes a knowledge base for evaluating the technical, economic, and organizational conditions required to deploy satellite factory models for public building renovation at scale.

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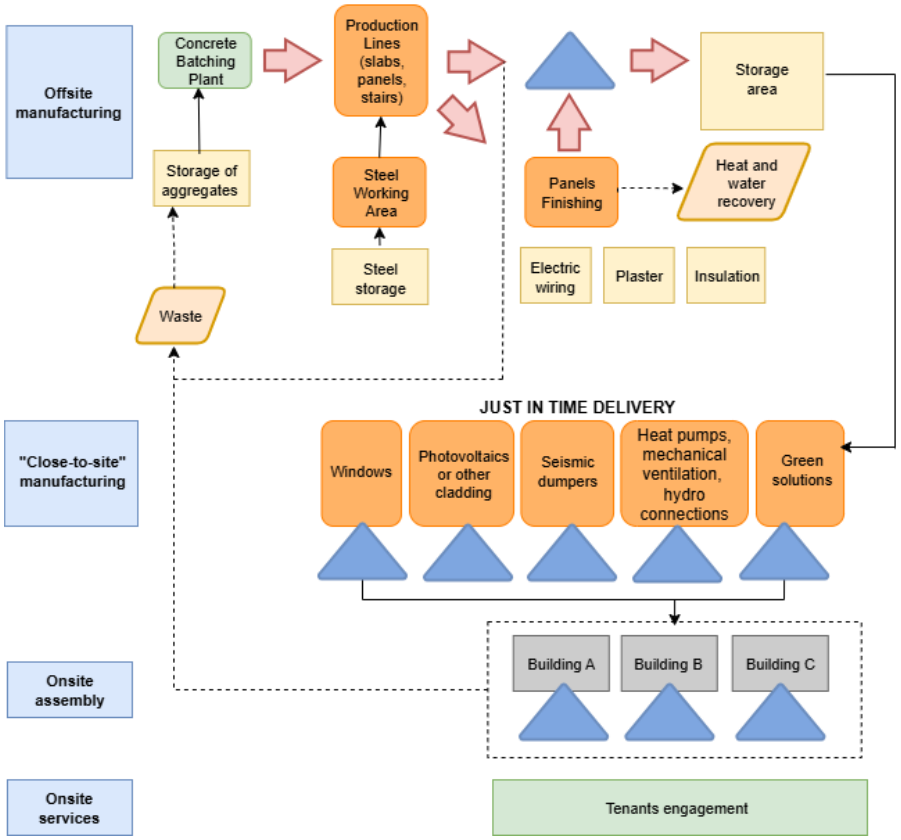


Figure 39: Italian Ecosystem - Satellite Factory Sketch (for the legend see Figure 25)

The Satellite Factory concept for the Italian ecosystem, shown in Figure 39, was developed as a hybrid offsite facility capable of producing elements for both renovation and new construction. Precast concrete panels with low-impact binders and recycled aggregates were chosen because they are cheaper than wood or steel for social housing and allow flexible conversion of production lines. Since not all competences were available among the Italian partners, Structurama[7] was selected as subcontractor and LAB member to develop the factory layout, investment plan, and validation of the model.

The factory covers the full workflow—from aggregate storage and batching to production, finishing, and storage—and is equipped to manufacture wall panels, hollow-core slabs, precast stairs, and reinforcement cages, operated by about 50 workers. Complementary components such as windows, photovoltaics, heat pumps, and seismic dampers are produced close to site and delivered through Just-in-Time (JIT) logistics. RECOskeletron technology enables rapid façade installation (about 200 m²/day), as shown in the Viale Omero social housing case, while tenant engagement ensures smooth integration in occupied buildings.

Further details on the layout, equipment, workforce, production capacities, and factory photos are provided in the Appendix IV.

[7] https://www.structurama.com/

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4.3.4.5. Spanish Ecosystem

The Spanish PuF scenario is framed around the development of a roadmap for industrialized renovation, reflecting the specific characteristics and maturity of the Spanish construction market. **Across the pilots, the PuF concept is predominantly realized as an *Assembly Factory* approach**—i.e., maximizing off-site value creation in a factory setting and limiting on-site work to necessary assembly and complex details. Rather than starting from a predefined pop-up factory model, the ecosystem used two completed renovation pilots as analytical anchors to identify the features, constraints, and boundary conditions that shape how a PuF concept can be realistically applied in Spain. Both pilots are based on CLT (cross-laminated timber) industrialized construction, yet they differ significantly in their spatial, organizational, and supply-chain conditions.

The two pilots—student housing in Zaragoza and a public body headquarters in Pamplona—were fully executed and analyzed, providing a robust empirical basis for evaluating industrialized renovation strategies. In Pamplona, the lack of available space on site led to a solution where nearly all value-adding activities were concentrated in a local CLT factory, with only the most complex construction details executed on site by a specialized and itinerant team. The demolition process also offered the opportunity to reuse and reintroduce existing raw materials back into the construction cycle. This **factory-led assembly model** minimized on-site operations and disruption while relying on the proximity of the factory, availability of raw materials, and prior experience of the teams with the technology.

By contrast, in the Zaragoza pilot, different regional and operational conditions—including the absence of local suppliers, limited availability of raw materials, and lack of prior experience with CLT—necessitated the creation of a temporary on-site workshop. In this case, pre-assembled CLT elements were completed and adapted close to the building to be renovated, allowing uncertainties related to design and execution to be managed while still applying industrialized principles. Although not initially conceived as a pop-up factory, this temporary workshop functioned as a **temporary on-site assembly unit**, established to complete and adapt components when a purely factory-based approach was not feasible.

Through the analysis of these two contrasting implementations, the Spanish ecosystem concluded that the closest functional equivalent to a pop-up factory in Spain is **an Assembly Factory configuration**, typically anchored in a local CLT factory and complemented—only when required—by a temporary workshop to finalize assembly near the site. Rather than a single canonical PuF typology, the Spanish scenario emphasizes flexibility in how assembly capacity is organized across off-site and near-site settings, while maintaining the overarching goal of maximizing factory-based work and minimizing on-site activities whenever conditions allow.

The ongoing work focuses on consolidating these lessons into a structured roadmap, generalizing the results to the broader Spanish market, and aligning the PuF concept with emerging national renovation strategies. Particular attention is given to dissemination and training, as the

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concept of pop-up factories remains unfamiliar to many construction professionals. Open questions remain regarding the applicability of canonical PuF models in dense urban contexts and neighborhood-scale renovation programs, especially where minimizing on-site disruption is a primary objective.

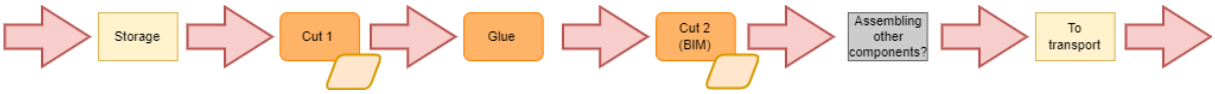


Figure 40: Spanish Ecosystem - Assembly Factory Sketch (for the legend see Figure 25)

The Assembly Factory concept for the Spanish ecosystem is provided in Figure 40. The Spanish PuF operates according to two complementary process flows that together define its full value chain.

The first is the **Assembly PuF workflow**, which handles newly supplied industrialised components. Incoming wood materials are received and stored, then undergo an initial cutting stage to prepare them for gluing, where components are bonded and any required adaptations are incorporated. A second, precision cutting stage follows, guided by BIM documentation to ensure accurate sizing and fitting at complex junctions. The finished assemblies are then completed by integrating the remaining building components into the industrialised solution, before being transported to their final installation position.

The second is the **Material Reuse workflow**, which runs in parallel and is specific to the Spanish pilot. Reusable structural elements are recovered from the demolition area — identified on the site plan in red — which corresponds to the zone that has undergone selective deconstruction. These materials are inventoried, assessed against quality standards, and any sections deemed unsuitable for reuse are discarded at this stage. The usable elements are then cut to specification using BIM-based documentation and subsequently assembled on site for installation.
Together, these two flows illustrate the circular character of the Spanish Assembly Factory: new industrialised components and reclaimed materials converge within the same on-site production logic, each following a tailored process path before being integrated into the final construction.

The material recovered through the reuse workflow consists of **timber beams** extracted from the demolished structural floor of the building. As can be seen in the photographs below, an initial visual and structural assessment revealed a significant reuse potential in a substantial portion of the beams. Following a first inspection, classification, and cleaning process, the beams were confirmed as suitable for reintegration into the new construction, contributing directly to the circular material approach that characterises the Spanish ecosystem.

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Figure 41: Timber beams following initial identification, classification and cleaning on site

The project site is located on the edge of the historic city centre, in an urban setting characterised by its medieval layout — narrow, elongated streets with severely limited vehicular access and no possibility of establishing large on-site storage yards. As a result, it was necessary to apply for a temporary occupation of the public right-of-way in order to accommodate material storage and site facilities.

The crane, however, was successfully installed within the building's inner courtyard, avoiding any additional encroachment on the surrounding public space. As illustrated in the site access photographs, the restricted street widths significantly limited the ability of delivery vehicles to manoeuvre and deposit materials freely. This constraint required a reduction in on-site stockpiling and a tightening of logistics coordination, with deliveries scheduled in a staggered sequence and adapted to local access regulations governing noise levels, permitted hours, and traffic management.

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Figure 42: Site access conditions and PuF layout within the constrained urban context. Overview of the work areas, material storage zones, crane position, and relationship to the public right-of-way.

During the construction phase, the PuF is organised into four distinct work areas (see Figure 43), in which assembly activities take place alongside other tasks inherent to the construction process:

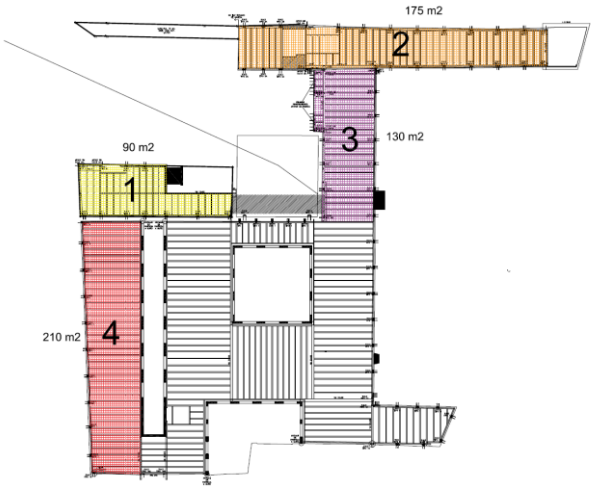


Figure 43: Spanish Assesmbly Factory - Work areas

During the construction phase, the PuF is organised into four distinct work areas, where assembly activities take place alongside other tasks inherent to the construction process. The spatial distribution of these areas is as follows:

- Area 1: 90 m² Beam storage, precedence of raw material
- Area 2: 175 m² Other works
- Area 3: 130 m² Assempbly of CLT and elements
- Area 4: 210 m² PuF
- Total area: 605 m²

The team has extensive experience working with CLT elements in refurbishment projects, which enables both development and assembly to be carried out with a high degree of operational autonomy. The average recorded output is **52.5 m²/day**, at a unit cost of **€159.65/m²**.

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Execution of the tasks required access to electrical supply, measuring and cutting machinery, digital documentation support (BIM tools), and auxiliary machinery for the transport and lifting of elements. Since the fabrication and adaptation of components takes place on a demand-driven basis — responding to the specific requirements of each construction junction as they arise — it is not possible to establish standardised unit production values for this phase of the process.

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4.4 Conclusion

This chapter brought together the main inputs developed so far and translated them into tailored Pop-up Factory concepts for the five BuildUPspeed ecosystems. The results show that a PuF should not be understood as one standard solution that can simply be copied from one context to another. Instead, each factory concept needs to respond to the local renovation market, available space, stakeholder setting, logistics, procurement conditions, and technical capacity.

The ecosystem examples illustrate this clearly. The Dutch case points towards a district/assembly approach based on bundling similar renovation needs, while the French concept focuses on a mobile on-site factory for the reuse of sanitary equipment. The Austrian Re-Use Box shows how social urban mining can be organised directly within deconstruction sites, whereas the Italian case explores the feasibility of a satellite factory for large-scale prefabricated renovation. In Spain, the assembly factory model demonstrates how off-site production and near-site adaptation can be combined, especially where urban constraints and material reuse play an important role.

Across these different examples, some shared principles can be identified. PuFs need to be modular, flexible, close to the renovation activity where possible, and well integrated with logistics and stakeholder coordination. They also need to support circular material flows and make use of digital tools where these can improve planning, documentation, and execution. At the same time, the cases also show that there are important trade-offs, especially between scalability, investment requirements, site limitations, and the complexity of organising local supply chains.

Overall, the tailored factory concepts developed in this chapter provide a practical step between the strategic PuF framework and future implementation. They help clarify what different PuF models could look like in practice and what conditions need to be considered before piloting or scaling them. In this way, the chapter forms a basis for the following implementation and scenario work, while supporting the broader BuildUPspeed aim of accelerating industrialized, sustainable, and locally adapted renovation across Europe.

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5. Implementation Plans And Scenarios For Local Pop-Up Factories In The Ecosystems

As the PuF concepts matured through the activities presented in Chapter 4, in parallel, implementation plans under **Task 4.4** were initiated. Following the four-view framework introduced in Section 4.1, this task addresses the *strategic* and *asset* views with an organization and factory focus (see Figure below).

Two main activities have been conducted so far, each designed as workshops: the first during **Consortium Meeting 4** in Milan, and the second during **Consortium Meeting** 6 online. The methodology, results, and analysis related to the first workshop are provided in Section 5.1, while those of the second are covered in Section 5.2.

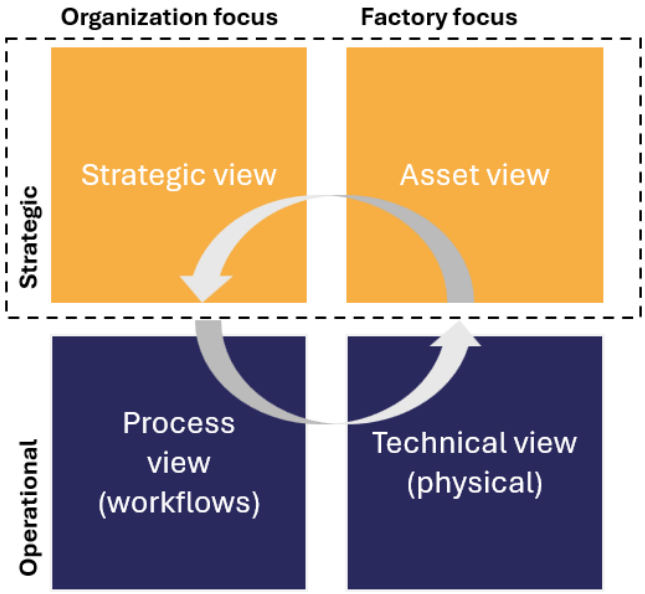


Figure 44: Focus of T4.4: implementation

5.1 Workshop: Strategic Mapping for Pop-Up Factories

We ran a structured, evidence-first workshop to turn each tailored factory concept into an implementable local scenario. Participants captured verifiable facts, linked them causally, and aligned actions with partners, schedules, costs, and risks. The workshop took place in Consortium Meeting 4 in Milan in person and then the canvases (see Figure 45) digitized in Miro for further analysis[8].

[8] **Miro board link**: https://miro.com/app/board/uXjVKCstFsI=/?share_link_id=484967294260

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Teams worked on a balanced-scorecard style canvas (see Figure 35) with four perspectives and guiding questions. Each cell was populated with fact-level entries (numbers, dated statements, observed outcomes).

- **Financial** — "How did we appear to our shareholders?" Examples: project cost and funding split (e.g., Cost of assembly project for 397 units: EUR 1,378,849; Federal co-funding: 52%), margin/gross profit (e.g., 5% gross profit).
- **Customer** — "To achieve our vision, how did we appear to our customers?" Examples: delivery quality/status (e.g., Project duration: 2 years without complaints), market share (50% in 2023 in Tirol), perceived quality.
- **Activities** — "To satisfy shareholders and customers, what processes did we excel at?" Examples: lead times, defect rates, supply dependencies, process changes (additional storage space → defect rate decrease by x; less dependency on wood due to local partnerships).
- **Learning & Growth** — "How did we sustain our ability to improve?" Examples: workforce numbers/skills, training, capability building (x workers able to diagnose/repair defects; JIT supply-chain training; local training module established).

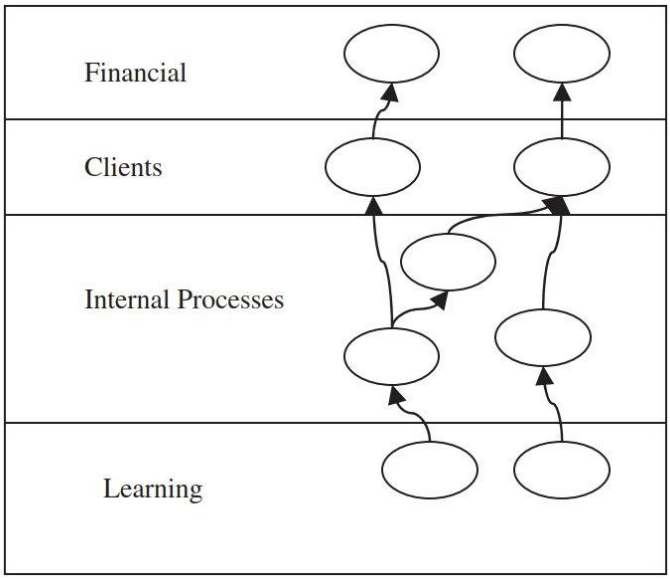


Figure 45: Workshop canvas

Teams filled each quadrant with concrete financial, customer, activity, and learning/growth facts relevant to their local factory concept and ecosystem. Using arrows on and above the canvas, teams connected notes to highlight interrelations between different aspects.

Each pilot produced a completed canvas (see full results in Appendix V), a causal map linking capabilities/activities to customer outcomes and financial results, and a structured evidence sheet. The outcome of this workshop was then processed through the requirements analysis of each PuF scenario to identify missing requirements that should be collected (see sub-section below).

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5.1.1. Results

The Netherlands

The Dutch District Factory concept targets scaling renovation in an urban region through a single case, with the aim of connecting projects into a broader portfolio to build both skill and scope. Financially, the baseline renovation cost was estimated at about €125,000 per apartment, with new construction in the same building costing around €250,000. By leveraging portfolio effects, the approach seeks to lower renovation costs by up to 25% below the baseline. Customers are primarily social housing associations, highlighting the need to align the district factory concept with organizational models to achieve price reductions. Activities draw on lessons from the Horizon Drive 0 project, stressing that the factory approach should be applied to projects naturally suited to it, while reducing dependency on expensive, customized technologies. Learning aspects focus on building local partnerships and strengthening organizational capacity to support a scalable, cost-efficient district model.

France

The French Mobile Factory concept involves transporting social sanitary equipment via trucks from selective reconstruction sites, allowing about 50% of equipment to be reused for rehabilitation at other sites. Financially, this reemployment approach can reduce costs by around €8,000 compared to new sanitary equipment. For customers such as co-ops, project managers, and social housing associations, the model promises lower expenses, timely delivery, and improved quality outcomes. Activities center on just-in-time storage and shipping, which respect project schedules and help achieve volume goals. Learning and growth emphasize training local workers in reemployment processes to maintain high standards and create local employment opportunities, which in turn support energy savings and decarbonization.

Spain & Austria

The Assembly Factory builds on shared experience from pilot projects in Spain and Austria, which were noted as remarkably similar. The approach prioritizes minimal impact on surroundings, both environmentally and on-site, with activities such as maintaining clean work environments and actively promoting solutions to stakeholders. Customers demand green, clean, and low-carbon solutions, but these priorities were paired with tight construction deadlines, creating financial challenges such as high upfront costs. Nevertheless, the model benefited from subsidies due to its innovative solutions, which also allowed owners to gain more square meters from the work. Learning and growth included leveraging expertise across both countries, reinforcing the transferability of solutions and the ability to demonstrate benefits to diverse stakeholders.

Italy

The Italian Satellite Factory operates in close linkage with a Gigafactory, where advanced machinery produces panels later transported to smaller, regionally distributed factories. With a production capacity of 100,000 m², this model allows both new construction and renovation, reducing transportation needs through decentralization. Financially, funding sources vary by region and include national Manufacturing 4.0 funds, European innovation funds, and private real estate investments, with up to 40% of investment costs covered for machinery and facilities. Customers value the flexibility to serve both renovation and new construction while keeping solutions aligned with

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local contexts. Activities focus on panel assembly, transport logistics, and integration with local suppliers. Learning and growth emphasize training the local workforce, knowledge transfer from the Gigafactory, and fostering adoption of new technologies within the ecosystem.

5.2 Workshop: Implementation Plans & Scenarios for Pop-Up Factories

The second workshop built on the outcomes of the first by shifting the focus from causal mapping toward implementation-oriented perspectives for each PuF scenario. While the earlier exercise identified missing requirements, this follow-up aimed to address them systematically. Eight requirement categories were considered: **Partnerships and Stakeholders**, **Legal and Regulatory Requirements**, **Costs and Financing Plans**, **Time Schedules**, **Risks and Contingency Plans**, **Site Requirements** and **Logistics**, **Sustainability Considerations**, and **Scalability and Adaptability**.

Participants worked in dedicated Miro workspaces, where they addressed targeted questions under each requirement to refine their PuF scenarios and capture ecosystem-specific insights. This exercise enabled a structured evaluation of both design and implementation aspects and supported the identification of gaps to be resolved in subsequent tasks. The workshop content and methodology documented in Appendix VIII.

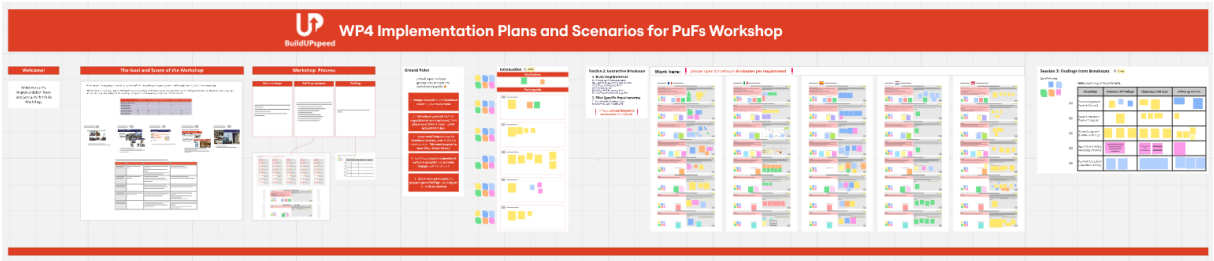


Figure 46: Workshop Environment[9]

5.2.1. Data Collection

Following the tailored PuF design activities, a structured post-workshop data collection process was carried out to support the development of ecosystem-specific implementation plans for local PuFs. The objective was to translate the qualitative workshop outcomes into comparable implementation data across the BuildUPspeed ecosystems and PuF scenarios.

A common requirement-based data collection framework was developed for this purpose. The framework was structured around the implementation requirements identified for Task 4.4, covering the main aspects needed to establish, operate, and replicate local PuF concepts: scenario definition, partnerships and stakeholders, legal and regulatory requirements, costs and financing plans, time schedules, risks and contingency plans, site requirements and logistics, sustainability considerations, and scalability and adaptability.

[9] Miro board link:
https://miro.com/app/board/uXjVIP75a9k=/?share_link_id=979816129400

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Each requirement was translated into a dedicated table with a consistent structure: *ID/category, definition, guiding questions, structured answer field, and evidence/supporting material*. An example of the requirement-table structure is shown in Table 10, using R1 Partnerships and Stakeholders as an example. The full set of completed requirement tables for each ecosystem is provided in Appendix IX.

The use of common data fields ensured that partner inputs could be compared across ecosystems, while still allowing each PuF scenario to reflect its local implementation context. Where possible, the tables were pre-filled using information collected during the workshop and from the tailored PuF design activities. Partners were asked to review the pre-filled content and complete the missing fields.

This structured approach enabled the implementation plans to move from workshop-level ideas toward operational descriptions of each PuF scenario. The resulting tables form the basis for the ecosystem-specific implementation plan summaries presented in the following sections and provide detailed input for the PuF digital blueprints developed as reusable outputs (see Chapter 8).

Table 10: R1 – Partnerships and Stakeholders (Example from the Austrian Ecosystem)

ID / Category	R1 – Partnerships and Stakeholders
Definition	Identifying the key stakeholders involved in the pilot projects, including demand-side partners (housing companies, governments) and supply-side (local SMEs, contractors).
Question (s)	Demand-side partners: ○ Who are the key stakeholders (e.g., housing companies, local governments) currently involved in the pilot project? ○ What additional partnerships are needed to move forward? Supply-side partners: ○ Which local SMEs, manufacturers, or constructors can support the factory? ○ Are there any collaboration gaps on the supply-side?
Answer	**Client / contracting authority:** Building owners, public or private ones. **Who signs contracts:** Building owners and BauKarussell **Who pays:** The Building Owner, but the contract is co-financed by the urban mine (=the building) due to the revenues of the reuse sales. **Decision-maker / governance lead:** Building owner **Demand-side partners (name + role):** • **Name**: Public and non-profit housing organisations, ; **Role**: building owner / client **Supply-side partners (name + role):** • **Name**: Building owner and their general contractors; **Role**: decision taking

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	• **Name**: BauKarussell **Role**: plan, design, run, manage and evaluate the Re-Use Box • **Name**: local social economic enterprises **Role**: act as subcontractors to perform operational deconstruction work for purchasers at local level • **Name**: Original producers and Circular Economy Startups ; **Role**: legally and technically experienced companies for checking component functionality (e.g., PV panels or HVAC systems, electrical equipment) **Regulatory / assurance partners (name + role):** • **Name**: authorised professionals for building or other products; **Role**: certification / conformity in case needed • **Name**: Insurance companies; **Role**: insurance coverage **Missing roles/trades needed (tick):** ☒ electrician ☐ HVAC ☐ façade/insulation ☐ logistics/transport ☐ crane ☐ QA/QC ☐ O&M ☒ other: higher potential possible in cooperation with producers, manufacturing partner, dismantling companies
Evidence / supporting material	

5.3 Ecosystem-specific Implementation Plans

5.3.1. Dutch Ecosystem

The Dutch ecosystem implementation plan focuses on a District Factory model in which renovation activities are coordinated at district or portfolio scale through a housing-association-led delivery structure. The implementation logic is based on bundling similar residential buildings into repeatable renovation packages, with the strongest PuF potential linked to façade, window, roof, envelope, ventilation, PV, and selected interior renovation streams. The model combines off-site or near-site preparation with on-site assembly and installation, coordinated through the main contractor and specialised subcontractors.

The main demand-side actor is the local housing association, with Woonpunt identified in the Dutch pilot context. The housing association acts as client, asset owner, payer, and governance lead. Contracts are signed between the housing association and the main contractor selected through tendering, while the main contractor coordinates subcontractors and suppliers. Relevant supply-side actors include the main contractor, architecture studio, circular façade-system suppliers, carpentry, masonry, PV, insulating glass, ventilation, tile, and kitchen subcontractors. Tenants are included as end users, while technical advisors support the housing association on structural, fire-safety, asbestos, roofing, maintenance, and concrete-related issues.

The legal and regulatory pathway is centred on the Omgevingsvergunning, issued by the local municipality, with an indicative lead time of 8–14 weeks where no zoning or heritage complications occur. Additional requirements include asbestos

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notification and work planning, site layout and traffic management approval through a Bouwplaatsinrichtingsplan, and notification to local building supervision before structural or special construction activities. Potential public support may be available through Dutch rental-housing sustainability and gas-free housing schemes, although availability and eligibility depend on the specific project context.

Cost information remains limited due to confidentiality. No CAPEX, OPEX, or €/m² values were provided. The financial logic is therefore described through the Dutch housing-association model, where benefits are mainly indirect and linked to asset value, rental-income stability, subsidy access, and improved energy performance. Investments may be financed through WSW-guaranteed loans, with equity components included in some recent housing-association business schemes.

The implementation schedule indicates around 50 weeks for a 36-apartment case, including work preparation and construction-site setup. On-site operations are estimated at around 20 days per apartment, although this varies by project conditions. Procurement can take approximately 3–6 months, and key dependencies include permit sequencing, available space near the building, tenant management, product availability, and workforce capacity.

Site requirements include 60–100 m² of storage, truck and car access, 3-phase power, water, preferably drainage, two containers for materials and team facilities, and crane access for buildings above four floors. Main risks include limited storage space, product supply delays, asbestos presence, and limited access to skilled circular-product manufacturers. Mitigation relies on early municipal coordination, site planning, asbestos evaluation, and timely supplier integration. Sustainability measures include energy-label improvement, circular glass and window-frame strategies, PV, smart ventilation, selective demolition, and nature-inclusive façade elements. Scalability depends on regional clustering, standardised processes, modular products, BIM use where feasible, and coordination by the main contractor.

Further details on the full requirement tables and supporting ecosystem inputs are provided in The Dutch Ecosystem in Appendix IX.

5.3.2. French Ecosystem

The French ecosystem implementation plan focuses on a Mobile On-Site Factory for the reconditioning and reuse of sanitary equipment in residential renovation projects. The implementation logic is based on bringing the reconditioning process close to the construction or rehabilitation site, supporting just-in-time reuse flows where sanitary equipment can be carefully removed, cleaned, checked, refurbished, repackaged, and either reinstalled, transferred to another site, or prepared for reuse through other channels.

The main demand-side actor is Domofrance, acting as the social landlord and pilot client by providing residential buildings and sanitary equipment to be reconditioned. FAVRE is identified as the mobile-unit leader, concept developer, investor, and expected operator of the first unit. The contractual logic foresees the project owner, such as Domofrance, contracting the mobile-unit service, while FAVRE develops and operates the concept. Ecominéro is identified as a potential funding supporter for reuse initiatives, while

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Compagnons Bâtisseurs and plumber companies may contribute to implementation capacity and sanitary-related works. Transport of the container-factory is expected to be outsourced to standard container transport providers.

The legal and regulatory requirements relate mainly to chemical-product handling and site deployment. Chemical products used for descaling or disinfection must comply with relevant REACH-related requirements, while the concept aims to avoid hazardous substances where possible. Deployment of the mobile unit requires authorization from the public authority, site owner, or project owner, with an indicative lead time of around one month. Key conditions include access to power and water, a dedicated installation area, and no disruption to ongoing site operations. No direct subsidy was identified, although French circular-economy regulations, including reuse-oriented policy drivers and extended producer responsibility for construction products, provide a favourable context.

Indicative financial data was provided for the mobile unit. CAPEX is estimated at approximately EUR 62,000 for the container-based factory setup, including the container, workbench, shelving, power supply, wastewater evacuation, lifting and handling equipment, tools, PPE, cleaning products, and other consumables. OPEX is estimated at approximately EUR 1,200 per housing unit, while revenue assumptions are around EUR 1,800 per housing unit. FAVRE is identified as investor and owner of the reuse-related revenue and inventory.

The implementation schedule indicates approximately three months for project leadership, funding, truck adaptation, and operational preparation, with a prototype already built and under testing. On-site operation depends on the number of dwellings and is estimated at around six months for a representative project. Decommissioning is expected to be short due to the light mobile setup, requiring around half a day for removal and up to two days to clear or refurbish the unit.

Site requirements include container-truck access, around 50 m² of storage/staging space around the truck, clean water, drainage, and power-grid access. Main risks include chemical handling, workforce availability, and variability in the quantity and quality of equipment streams. Mitigation relies on limiting hazardous products, HSE procedures, operator training, dedicated refurbishment training, flexible planning, and contracts with housing providers or deconstruction actors. Scalability depends on local source and demand sites, an indicative 20 km reuse radius, one to two months of storage where needed, approximately 60 units per week per mobile unit, and digital traceability tools for FDES documentation and coordination between units.

Further details on the full requirement tables and supporting ecosystem inputs are provided in The French Ecosystem in Appendix IX.

5.3.3. Austrian Ecosystem

The Austrian ecosystem implementation plan focuses on an Assembly Factory logic closely linked to the Re-Use Box approach. The implementation scenario is oriented toward reuse-oriented dismantling, documentation, temporary organisation, and redistribution of building components before demolition or major redevelopment. Instead of a conventional production factory, the PuF is implemented as a locally organised

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reuse operation that depends on early planning, buyer matching, suitable site conditions, and compliance with reuse-product and waste-related regulations.

The demand side is represented mainly by public and non-profit housing organisations or other building owners that can decide to integrate reuse activities into deconstruction planning. The building owner acts as the key decision-maker and client. Supply-side actors include general contractors, planning experts, manufacturing or product-related partners, and organisations responsible for certification and conformity of building products. Insurance companies are also identified as relevant assurance partners, especially because reuse products may involve uncertainty related to liability, warranty, and product performance.

The legal and regulatory requirements include pre-demolition audits, waste-management-act compliance, trade licence requirements, chemical-regulation-related requirements such as REACH where relevant, and certification by licensed or authorised organisations for building products. The pre-demolition audit is important for defining safe working conditions and identifying limitations related to waste legislation and material condition. Regional public funding schemes for sustainable business are identified as potential support mechanisms, although specific eligibility conditions, values, and deadlines remain to be clarified.

Cost information depends strongly on building size, condition, location, and reuse potential. The implementation data indicate a cost range of approximately EUR 7,000–150,000 for planning and execution, depending on the size and state of the building. Cost estimates are based on approximately EUR 1–2/m² for analysis activities and EUR 1.5–2.5/m² for operational activities. Running the legal entity requires approximately EUR 1,800 per month to cover rent, insurance, accounting, phone and internet services, devices, software, hand tools, fees, and taxes. Operational expenditures are estimated at approximately EUR 1,000 per month and include travel, certification, and subcontracting costs. A detailed exploration phase is considered an essential prerequisite for implementing a Re-Use Box, with the Social Urban Mining concept typically costing between EUR 5,000 and 10,000 depending on the size and location of the building. The financial model is contract-based and can be supported through revenue generated from the sale of reuse products. The building owner and the buyers of reuse components form the main payment chain. The Re-Use Box organiser temporarily takes possession of the recovered components and inventory before transferring ownership to the final buyer. The completion date for the Re-Use Box is agreed with the client and aligned with the overall construction schedule.

The time schedule is driven by the deconstruction timeline and the duration needed for reuse matchmaking. Implementation requires months rather than weeks, as buyer identification and operational planning need to start during the planning phase. The Re-Use Box itself may only be open for a few days up to one week, but the broader preparation, negotiation, and matchmaking process can take weeks to months. Key dependencies include the willingness of the building owner to pursue an innovative reuse process, alignment with deconstruction planning, and sufficient time to identify buyers.

Site requirements include construction-site electricity, sanitation, a construction office, fencing, parking and entrance access, road

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access, lockable storage or security, packaging materials such as pallets, and documentation or traceability materials. Greywater handling and packaging-related waste need to be managed, while the building owner is identified as a key provider of site utilities. Main risks include high negotiation effort without realisation, legal restrictions, long lead times, product-function failure, and the need for continuity of operations. Scalability depends on process standardisation, digital tools for documentation, sales and stock control, multi-site coordination, and continuous clarification of legal compliance for new product groups.

Further details on the full requirement tables and supporting ecosystem inputs are provided in The Austrian Ecosystem in Appendix IX.

5.3.4. Italian Ecosystem

The Italian ecosystem implementation plan focuses on a Satellite Factory model based on a main hybrid precast factory supported by close-to-site finishing and integration facilities. The implementation logic combines industrial production of main concrete panels with local integration of more fragile components, such as windows, PV, MEP systems, cladding, and other technical elements, before final on-site assembly. The model is intended for large-scale renovation programmes where buildings are geographically clustered, typologically similar, and suitable for repeatable façade and envelope solutions.

The demand side is represented by public authorities and public housing actors, including Comune di Milano, Regione Lombardia, MM S.p.A., and ALER Milano. These actors may act as building owners, contracting authorities, demand aggregators, or funders. Private regeneration developers can also act as demand drivers for high-performance interventions. Supply-side partners include precast manufacturers such as LOMBARDA SpA, Camuna Prefabbricati, Bianchi Precast, and Progress Srl, together with local SMEs for windows, PV, MEP, and cladding integration. STRUCTURAMA is identified as a system integrator and consultant for satellite precast PuF design. ESCOs and energy providers such as A2A, E.ON, and Enel X may support PPP/EPC-based operation and maintenance, while financing actors may include crowdfunding, banks, and social-impact investors.

The legal and regulatory pathway includes factory building permits under regional regulation, environmental authorisation, general building-code compliance, safety and health regulations, and noise-level requirements. Building permits are issued through the Municipality / Sportello Unico per l'Edilizia or SUAP, with an indicative lead time of 3–6 months. Environmental authorisation may follow AUA or AIA procedures, depending on thresholds and plant activities. Potential support instruments include national digital and green-transition incentives, Transition 5.0 tax credits, and regional Lombardy grant schemes, subject to eligibility and call-specific conditions.

The financial plan indicates a CAPEX estimate of approximately EUR 35 million for land acquisition, civil works, factory and office buildings, batching plant, production lines, automation, digital systems, installation, testing, and commissioning. The implementation data also reports approximately EUR 59.4 million in operating costs, although the reporting period should be verified. Production costs are estimated at approximately EUR 510/m² for retrofit panels and EUR 335/m² for new-construction elements, with

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corresponding price assumptions of EUR 790/m² and EUR 450/m². Financing can combine grants, loans, equity/SPV structures, PPPs, and ESCO models.

The time schedule includes approximately three months from panel production to component integration and pre-installation checks. Full on-site retrofit works are estimated at around three months, while RECOskeletron panel installation can reach approximately 200 m²/day. The satellite model relies on permanent industrial structures, so decommissioning is not applicable for the main factory. Key risks include financing delays, workforce availability, factory underutilization, rigid production sequencing, energy and material price volatility, JIT logistics disruption, and installation-phase interruptions. Mitigation measures include multiple financing channels, demand aggregation, standardised interfaces, local finishing factories, long-term energy and material agreements, backup logistics routes, and phased quality checks.

Site and logistics requirements include large storage yards at the main factory, heavy-truck access, high-capacity three-phase power, water, drainage, internet, internal overhead cranes, security, and fencing. Local finishing SMEs may require up to 1,000 m² for component integration and 80–100 m² for JIT buffer storage. Sustainability targets include reduced logistics-related CO_2e, waste diversion, lower energy use per m² of panel, renewable electricity use, routing optimisation, and consolidated deliveries. Scalability depends on a 100 km logistics envelope, 1–3 days of JIT storage, annual factory-capacity thresholds, multi-site coordination, and digital tools such as BIM/CDE, WMS, TMS, and CNC-supported production.

Further details on the full requirement tables and supporting ecosystem inputs are provided in The Italian Ecosystem in Appendix IX.

5.3.5. Spanish Ecosystem

The Spanish ecosystem implementation plan focuses on an Assembly Factory model for the local assembly of prefabricated components in deep renovation projects. The scenario addresses whole-building deep retrofit measures, including façade and envelope works, window and door replacement, roof and floor insulation, ventilation, HVAC upgrades, renewable energy systems, electrical controls, and selected interior modules. The model is particularly relevant for public and heritage buildings where limited on-site space, urban constraints, reuse objectives, and the need to preserve architectural or historical elements influence the implementation process. The main materials identified include CLT components, recovered timber beams from the construction site, new timber beams, and related timber-based joint completion works.

The governance structure is organised around private companies and public bodies. The client may be a public body, while the construction company signs contracts and the construction manager acts as governance lead. Demand-side actors include private companies, architects, and public clients. Supply-side actors include technology providers for demolition, logistics, transport, and carpentry, construction workers for measuring and cutting, and local installers responsible for assembling elements on site. This reflects a project-based delivery model in which the Assembly Factory logic depends on coordination between design, construction management, suppliers, and local installation capacity.

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Legal and regulatory requirements are linked to sustainability requirements, local standards, space constraints, public-space use, and health and safety. Relevant authorities include the national technical building code, regional government, and local government. Key constraints include the balance between heritage requirements and energy-performance requirements, lighting and local standards, limited available space, surrounding buildings, residents, dust, noise, and safety. Next Generation funding is identified as a potential support mechanism for integral refurbishment, although detailed values, deadlines, and eligibility conditions were not available.

Cost and financing information remains limited. CAPEX and OPEX were not defined, as the model relies on subcontractors rather than a separately costed factory operation. A cost basis of approximately EUR 27/m² for CLT panels was provided, while no direct revenue stream was identified. The workshop input indicates that public grants are essential for implementation, industrialised plug-and-play solutions may be more expensive than conventional alternatives, and a business plan or sustainability objective is needed to justify the use of prefabricated solutions.

The implementation schedule indicates a setup duration of approximately one to two months, an on-site operational duration of around 24 months, and a wrap-up or decommissioning duration of around four months. Permit approval may take around six months, while procurement was reported as 28 months. Main dependencies include public permits, access permission, energy-resource connections, demolition and building permits, heritage-related definitions, historical-element classification, design definition, available site space, and the possibility of using public space.

Site and logistics requirements include approximately 130 m² for assembly, 223 m² for storage, crane-based staging and loading, truck and car access, working hours from 9:00 to 16:00, public-space use, power above 35 kW, water, drainage, internet, four containers, crane access, and lockable security space. Main risks include unclear requirements, provider capability limitations, raw-material shortages, temporary regulations linked to political priorities, and insufficient skilled workers for assembling prefabricated components. Mitigation relies mainly on planning, alternative workflows, storage, and familiar or trusted workers. Sustainability measures include material reuse, especially wood, logistics optimisation, and technical evaluation of reused components. Scalability depends on standardised processes, modular equipment, digital tools such as Revit, a 130 m² allocated-space threshold, one day of storage, and an indicated capacity of approximately 200 m²/day.

Further details on the full requirement tables and supporting ecosystem inputs are provided in The Spanish Ecosystem Appendix IX.

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5.4 Conclusion

The ecosystem-specific implementation plans show that the PuF concept cannot be treated as a single standardized factory model. Instead, each ecosystem translates the PuF logic into a different operational configuration, shaped by the local renovation market, building stock, governance structure, regulatory context, available partners, and supply-chain maturity. Across the five ecosystems, the implementation plans demonstrate four distinct PuF scenario logics: district-level coordination in the Netherlands, mobile on-site reuse in France, reuse-oriented assembly in Austria, satellite production and integration in Italy, and project-based assembly in Spain. A common finding is that the practical feasibility of PuFs depends less on the factory type alone and more on the alignment between demand, governance, logistics, and implementation timing. In the Dutch and Italian ecosystems, scalability is strongly linked to demand aggregation, repeated building typologies, and coordinated portfolio or programme-level renovation. In France and Austria, the PuF logic is more closely connected to circular material flows, reuse matchmaking, and local operational flexibility. In Spain, implementation is strongly shaped by site constraints, public permits, heritage conditions, and the availability of skilled workers for assembly of prefabricated components.

The implementation plans also show that partnerships and governance are central to PuF deployment. In all ecosystems, a clear client or demand-side actor is needed to initiate the process, while the operational role is typically carried by a main contractor, factory operator, system integrator, reuse organiser, or specialised supplier network. This confirms that PuFs require not only technical design, but also a defined coordination model, decision-making structure, and contractual chain. Legal and regulatory requirements form another recurring implementation condition. Permitting, public-space use, construction-site safety, environmental compliance, product certification, asbestos handling, chemical handling, and reuse-product liability appear with different intensity across the ecosystems. These requirements are highly context-specific and therefore need to be addressed early in each local implementation process.

Cost and financing information varies significantly between ecosystems. Italy provides the most quantified industrial investment model, while the Netherlands and Spain remain more project- and procurement-dependent. France and Austria show reuse-oriented models where revenue or avoided costs may partly support implementation. This variation confirms that PuF business models must be adapted to the specific scenario type, ranging from capital-intensive production infrastructure to service-based, reuse-oriented, or project-based coordination models.

Overall, the requirement tables provide a structured basis for comparing implementation conditions across ecosystems while preserving local specificity. They identify the key operational requirements, dependencies, risks, and scalability conditions needed to move from PuF concepts toward deployable local implementation plans. These findings also form the basis for translating the ecosystem-specific implementation knowledge into reusable PuF factsheets and digital blueprints for replication beyond the BuildUPspeed pilot contexts

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6. Implementation Plans and Scenarios for Supporting Activities

6.1 Background and objectives

Innovative techniques are required to address the increased need for sustainable and efficient building practices in today's quickly expanding construction market. Within this context, Pop-up factories emerged as a potential way to meet these demands and support sustainable and circularity transition within the construction sector. These adjustable and flexible production units represent a new path for optimizing construction processes, lowering costs, and improving sustainability building upon the concept of modularity.

Recognizing the importance of pop-up factories in the built environment, especially within the deep-renovation market, highlights the necessity for a thorough examination of their commercial potential and practicality, i.e. market feasibility and viability, with a focus on early-stage market potential. Therefore, this study assesses market feasibility and viability of pop-up factories by providing a thorough examination of the opportunities and problems connected with the implementation of local pop-up factories within the ecosystem under the umbrella of BuildUPspeed project. Therefore, this paragraph documents an implementation plan oriented on supportive actions guiding the introduction of the local pop-up factory.

6.2 Theoretical underpinnings

In order to industrialize and boost the deep-renovation of the EU housing stock by applying local pop-up factories, certain basic pre-conditions need to be met inherent to the nature of modular deep-renovation solutions being offered. These pre-conditions are often overlooked in developing and implementing relevant modular deep-renovation solutions in projects.

Modularity is seen as a key strategy to improve both production and resource efficiency in constructing and retrofitting housing (Ellen MacArthur Foundation, 2015a, b). Modularity in itself is a concept that is observed as a major beneficiary in numerous industries. Modular product systems are developed with an one-to-one mapping between functions and physical technical subsystems with standardized interfaces (Salvador, 2007; Ulrich, 1995). Modular product systems balance the demand for customization in order to meet specific project needs and client demands as well as providing opportunities to improve the level prefabrication and industrialization. This results in a mutually beneficial setting where the client is able to obtain benefits in the form of a well customized product that perfectly adheres to the client's specific needs. In addition to this, the client is able to procure the product at a relatively lower cost benefitting from economies of scale.

Modular Zero Energy Renovation Kits are seen as a specific type of modular products systems for retrofitting housing. Modular Zero Energy Renovation Kits have been introduced to step up the pace of building renovation to achieve European Union (EU) climate change policies for 2050. In fact, industrial building and modularity and related technological

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innovations are at the core of boosting the Renovation Wave (Renz and Zafra Solas, 2016; Saheb, 2016). Following Salvador (2007), a Zero Energy Renovation Kit is seen as modular when it has separable subsystems that can be combined in different ways to provide 'standardized variety'. In addition to Saheb's (2016) definition, a modular Zero Energy Renovation Kits is typically characterized by a one-to-one mapping between functions and physical subsystems and have standardized, decoupled interfaces (Ulrich, 1995). Decoupling reflected by its disassembly potential, implies that changes in one subsystem do not require changes in other interfacing subsystems (Baldwin and Clark, 2000). Modular Zero Energy Renovation Kits have the potential to substantially improve product and process sustainability by facilitating access to individual modules and components of the product system, thereby facilitating refurbishing, re-use and recycling (Chung et al., 2014; Kimura et al., 2001; Ma and Kremer, 2016; Okudan Kremer et al., 2013). This is especially relevant for modules that age more rapidly than parts they interface with, or that improve faster, for example due to higher innovation clock speeds, than other parts leading to an opportunity for modular upgrades of the system.
Previously conducted research revealed various preconditions which are found crucial in the adoption and uptake of modular product systems (van Oorschot, 2020):

Relative advantage	• Relative advantage is an important aspect in enhancing the adoption of modular products and in particular advantages linked to improved quality, production efficiency and energy efficiency. • Also, if the product is a highly visible element in the building envelope, making it stand out and be architecturally appealing will enhance its adoption, end users will feel encouraged to adopt the product as it improves the architectural appearance of their dwelling.
Lowest cost orientation	• Modular products most often have higher initial costs but lower operational costs than tradition products which have lower initial costs and higher operational costs. • The long-term benefits of these modular products are not perceived by clients, and this keeps them from adopting the product because it is perceived as initially too expensive. • Similarly, if the criteria used by contractors in selecting suppliers are based on lowest initial costs, then the innovations will not be adopted.
Supply chain integration	• The creation of stable and long-lasting partnerships (i.e. supply chain integration) between the stakeholders involved is crucial in achieving adoption. • It is crucial to have trustful and transparent relationships between the partners involved in order to establish the necessary agreements that will lead to adoption. • Stable relationships should not only be bounded for the adoption and implementation phase of the product (within and across projects) but rather that they should be extended throughout the operational lifecycle phase of the modular product.

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	• However, the larger the number of organizations and trades involved, the more complex partnering becomes.
Boundary spanning & task interdependency	• Some modular products have more than one function coupled to the product. On the one hand, this brings the advantage of providing solutions to multiple problems in a single product. On the other hand, it has the disadvantage that, by integrating functions in one product, the supply chain of the product is reshaped, and this is not always positively viewed. • Function integration should diminish complexity in the construction process by reducing the number of stakeholders the contractor should need to collaborate with in a project. The successful adoption of a product in the housing sector will only occur if the adoption of a product developed by a supplier is attractive to both the contractor and the end-user.
Design rules & standards	• A key principle of modularity is the existence of an architecture and a set of standard design rules that function as a stable base on which to manage boundaries in the development and implementation of modular products. • Establishing agreements about the boundaries between modules and the installation of the module in a dwelling requires intense collaboration between supplier and contractor. Although, from a technical perspective, boundaries are not difficult to establish; from a managerial perspective they are a time-consuming activity. For this reason, developing stable relationships enhances a product's potential adoption. • Adoption is mostly hindered by the absence of design rules and standards and the complexity of boundary crossing activities to resolve technology misalignments.
Adequate skills & knowledge	• Implementing innovative modular products in housing projects requires adequate skills and knowledge. This includes basic knowledge about the overall system and in-depth knowledge about the module itself. • Further, knowledge and skills related to the full life cycle of the modular product are required, ranging from modular design and engineering to pre-production, installation, maintenance and removal. • Currently - Early stage of market introduction and the installation of the modular products are highlighted as crucial in terms of required knowledge and skills. • Additionally, modular innovations are typically not installed by the suppliers but are subcontracted to specialized installers. These installers need to be multiskilled to successfully install the products in a dwelling. • In addition, the composition of the team that conducts the installation should not vary since repeating the process several times with the same team enables improvements to the installation process.
Regulatory	• Current regulations require contractors to adopt and implement innovative products in order to improve the energy performance of housing. However, they do not encourage contractors to implement solutions that surpass the basic requirements mandated in the Building Code. Contractors tend to view the basic requirements of the Building Code as the maximum performance levels they should achieve.

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	• However, many modular energy efficient technologies outperform mainstream energy technologies and, for example in the Netherlands, they are not required to meet the basic energy efficiency requirements of the Building Code; • In addition, end-users have not been motivated to adopt energy efficient technologies. End-users are not aware of the potential savings that can be achieved through improvements in the energy performance of their dwellings. • If contractors are being required to develop new energy efficient technologies then end- users should also be encouraged to improve the energy performance of their dwellings. Otherwise there will be an imbalance in the supply of and demand for modular products, which hinders adoption.
Product branding	• The implementation of modular product strategies represents a change to the traditional industry and market culture. Modular products are developed to be adopted across projects, resulting in a shift from a project-oriented construction sector to a product-oriented construction sector. Here, companies with a known brand are perceived as more reliable parties to collaborate with. • Further, when companies have a known brand, the uncertainties and risks associated with adoption appear lower, and the product is implicitly of good quality. The importance of product branding was found in many cases of modular products.
Market maturity	• Within traditional housing projects, clients are used to translating their demands into product specifications rather than specifying a specific performance level that needs to be met. Presenting performance specifications is seen as a barrier to the adoption of modular products. • The immaturity of the market conducting housing projects based on performance specifications, rather than specifying all the components, hinders a modular product's adoption. Most contractors do not have sufficient experience to work with these practices, and the market in general is also not used to this.
Innovation maturity, guarantees and liabilities	• Providing a guarantee to cover the life cycle of a product reduces the uncertainties that are linked to the adoption of a modular innovation. From the perspective of the client, guarantees and liabilities ensure that certain safety and performance standards are met and indicate who can be held responsible in the event of any deficiencies. Two other aspects fundamentally linked to product guarantees and liabilities also affect adoption. • First, the perception of uncertainties diminishes as the number of completed projects increases. To some extent, this serves as a 'proof of concept' of the innovative modular product. • Second, the maturity of an innovative modular product is also reflected by the ability of contractors and/or suppliers to convey the benefits of the product to other involved stakeholders. This was often reported as challenging, and therefore a barrier against adoption.

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Figure 47 presents a conceptual framework which includes the pre-conditions which need to be met to enhance the overall efficiency of deep-renovation processes on four aspects, project lead time, cost, quality and circularity respectively. As suggested in the conceptual framework, in order to improve the overall performance and quality delivered for deep renovation projects applying modular products, the working hypothesis and pre-conditions have to be met in order to enhance deep renovation projects applying modular product systems. In sum, in developing an implementation plan for the local pop-up factories it is of utmost importance to take these working hypothesis and pre-conditions into account.

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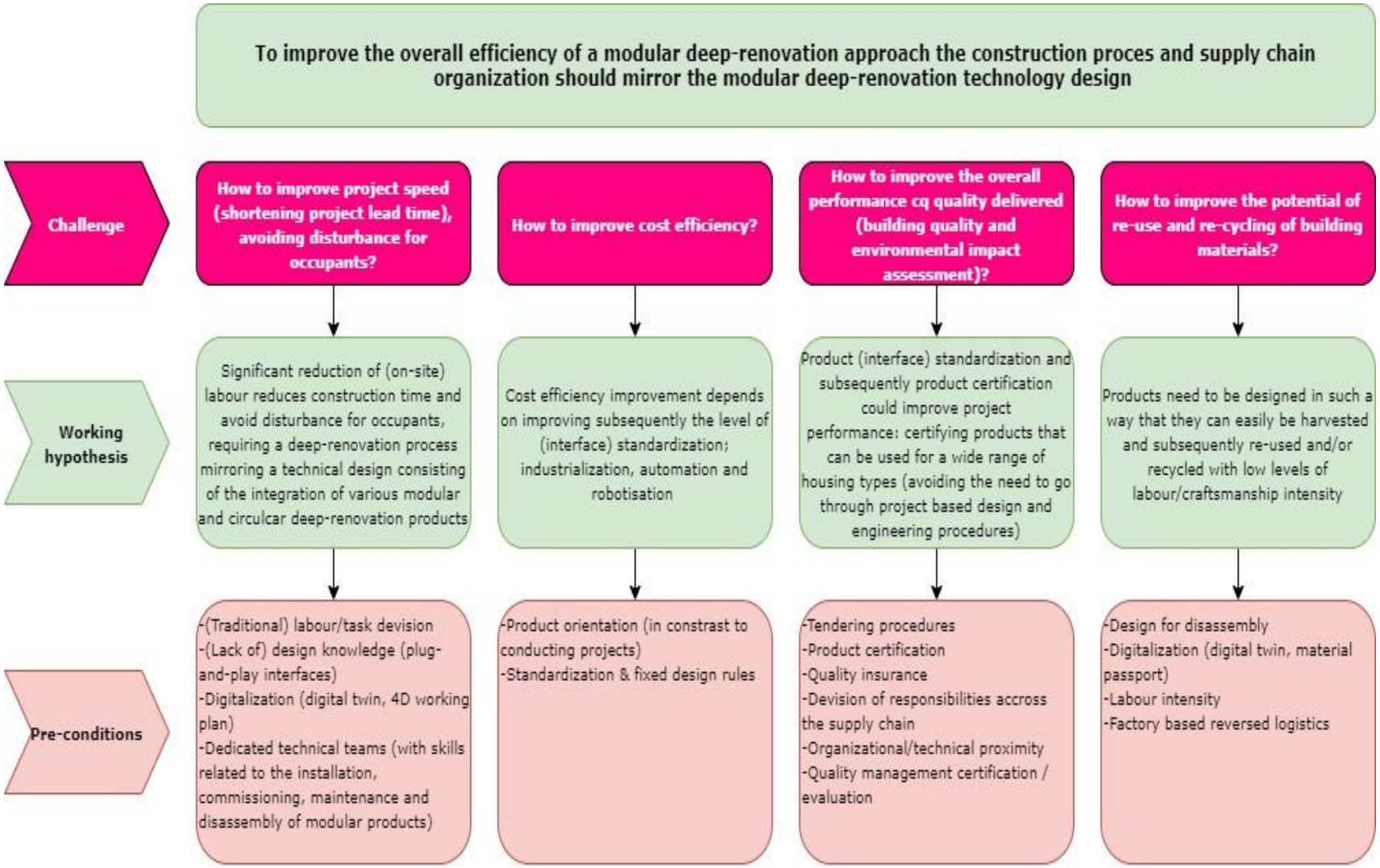


Figure 47: Conceptual model presenting the pre-conditions to enhance the overall efficiency of deep-renovation process on four key aspects concerning project lead time; cost; quality and circularity

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6.3 Methodology

The development of the implementation plans builds on the results of other tasks carried out within the BuildUPSpeed project. In particular, the pre-selected favourable concept and the insights obtained from the national ecosystems. The Business Implementation Plans focus on investigating the business capabilities for bringing the pre-selected favourable local pop-up factory concept to the market.
The implementation plan consists of the following elements, which are explored through each Ecosystem:

- Step 1: A description of the local pop-up factory concepts;
- Step 2: External framework analysis;
- Step 3: Business case
- Step 4: Internal business analysis;
- Step 5: SWOT analysis;

The collected information is structured through a sequential analytical framework. First, the proposed Local Pop-up Factory concept and the key insights emerging from the national ecosystem are summarized. Subsequently, an external framework analysis is conducted, drawing on the expertise of both industrial and academic partners, and comprising market, customer, competition, and trend analyses. This is followed by a an introduction to the business case, and an internal business analysis focusing on the employed technologies, products, sales and distribution channels, partnerships, and organizational capabilities.

The results of these analyses are then integrated into a SWOT framework, through which strengths, weaknesses, opportunities, and threats are systematically examined. The outcomes provide the basis for assessing market opportunities, defining market strategies, and identifying potential cost optimization measures. Finally, a brief outlook is presented regarding the future development and market implementation of the approach. The information underpinning these analyses can be primarily gathered through interviews with local stakeholders and experts. These interviews contribute both to a deeper understanding of the topic and to the development of a shared knowledge base concerning the Local Pop-up Factory concept.

Following this methodology, each ecosystem produced a dedicated report documenting its specific context and findings. These reports are provided as Annexes (Appendix VII) and may be consulted individually for a more detailed understanding of each ecosystem. The comparative analysis and conclusions presented in this document build upon the knowledge generated through these ecosystem-specific reports, synthesizing their findings to identify common patterns, differences, opportunities, and challenges across the various contexts.

6.3.1. Step 1: Description of the Local Pop-up Factory Concept

The first step of the methodology consists of defining and contextualizing the Local Pop-up Factory (PuF) concept within each ecosystem. This phase aims to establish a common understanding of

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the proposed implementation model while accounting for the specific characteristics, needs, and opportunities of the local context. To this end, three complementary elements are addressed.

6.3.1.1. Addressing ecosystem needs: offering a deep-renovation kit through a Local Pop-up Factory scenario

The first element focuses on identifying how the Local Pop-up Factory concept can respond to the specific needs and challenges of each ecosystem. While numerous theories, strategies, and technological concepts have been developed to improve the efficiency and scalability of deep renovation processes, a major challenge remains their effective implementation and adoption beyond pilot and demonstration projects. Therefore, this section presents the preferred Local Pop-up Factory scenario(s) developed for each ecosystem, illustrating how they can contribute to delivering deep-renovation solutions adapted to local conditions and market demands.

6.3.1.2. Multiple value creation: matching the Local Pop-up Factory scenario with local needs

The second element examines the extent to which the proposed Local Pop-up Factory scenario aligns with local priorities and stakeholder expectations. Particular attention is given to the different forms of value that can be generated, including economic, environmental, social, and organizational benefits. This section discusses the type or combination of Pop-up Factory scenarios considered most suitable for each ecosystem and, where available, reflects on the modifications, optimizations, and lessons learned emerging from their development, testing, and refinement processes.

6.3.1.3. From the Local Pop-up Factory scenario to ecosystem-specific application

To understand the conditions that would enable the transition from the conceptualization of Pop-up Factories (PuFs) to their practical realization, an initial collaborative and interactive workshop has been organized[10]. The workshop "BuiltUPspeed: state of play real time demonstrators & implementation plans" aimed to assess the state of play of the BUPS demonstrators and to explore the passage from the concepts of PuFs and the Project status. To achieve this, the workshop adopted a methodological tool inspired by Monika Sznel's Actant Mapping Canvas, reconfigured into a "wheel" that supported an environmental- rather than solely human-centred perspective. This structured method guided participants through a phased process. From the identification of key needs within each ecosystem, to the recognition of human actants and non-human actants, the

[10] The workshop has been developed and hosted by ZUYD and DEMO online on 11th October 2024. The results of the workshop are available in a separate Report, here included as Appendix VI. The workshop has been supported by a Miroboard here accessible: https://miro.com/app/board/uXjVMjKsr2s=/?moveToWidget=3458764564501484087&cot=14

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participants have identified barriers connected to these actants, as well as potential solutions.
The process demonstrated that PuFs function not only as technical infrastructures but as socio-technical mediators able to reshape relations among stakeholders, regulations, and resources. The activity thus provided both an analytical framework and practical insights for developing the Implementation plans.

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6.3.2. Step 2: External Business Environment of the local pop-up factory

Following the definition of the Local Pop-up Factory concept and its adaptation to the specific characteristics of each ecosystem, the second step of the methodology consists of an external framework analysis. The purpose of this phase is to assess the external conditions that may influence the feasibility, market uptake, and long-term development of the proposed Local Pop-up Factory scenario.

To achieve this, the analysis is structured around four complementary components: a market demand analysis, a customer analysis, a competitor analysis, and a trend analysis. Together, these elements provide a comprehensive understanding of the external environment in which the Local Pop-up Factory is expected to operate, highlighting key opportunities, challenges, and factors that may affect its implementation and future development within each ecosystem.

6.3.2.1. Market demand analysis

This part focuses on analyzing the market demand for the local pop-up factory, with the aim of identifying and defining the most suitable target market in terms of building types, renovation potential, and geographic scope. It will evaluate which categories of buildings (e.g., single-family, multi-family, or specific construction periods) are most appropriate for circular, industrialized deep-renovation technologies, and estimate their market share and volume within the national ecosystem. The analysis will also explore the geographic proximity required to ensure efficient operation, and quantify the potential supply of buildings (in gross floor area) over the next 1, 5, and 10 years. Furthermore, the section will assess the suitability of the pop-up factory to respond to specific renovation demands, its potential expansion to other markets, and its competitive positioning compared to other renovation approaches. Finally, it will conclude with a concrete plan detailing which building types and regions will be prioritized in the short, medium, and long term, based on demand potential, available ecosystem partners, and opportunities for large-scale adoption. This work is ongoing and will be further expanded in the final version of the deliverable.

6.3.2.2. Customer analysis

This section examines the customer analysis for the local pop-up factory, focusing on identifying the key owner categories in the targeted market and understanding their behavior, decision-making processes, and motivations regarding deep-renovation projects. It will describe the customer journey, the role of decision makers and influencers, and highlight which groups are likely to act as early adopters. The analysis will also assess potential barriers and drivers to adoption, identify the most convincing selling points to be emphasized in communication strategies, and propose a plan for how different customer groups will be addressed. Finally, it will provide an estimation of sales potential segmented by building type and ownership structure, considering factors such as price sensitivity and economies of scale. This work is ongoing and will be further expanded in the final version of the deliverable.

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6.3.2.3. Competitor analysis

This section analyzes the competitive landscape of the local pop-up factory by identifying its main competitors and evaluating their position in the targeted market. It will compare products, services, customer bases, and the most competitive aspects of existing deep-renovation solutions, highlighting both similarities and differences with the pop-up factory approach. Furthermore, the section will examine how competitors are expected to evolve over the next 1, 5, and 10 years, considering whether the market will be dominated by a few large players or many smaller ones, and anticipating the entry of new solutions. This work is ongoing and will be further expanded in the final version of the deliverable.

6.3.2.4. Trend analysis

This section investigates the key trends that influence the introduction and long-term development of the local pop-up factory, identifying both opportunities and threats across economic, political, technological, and socio-cultural dimensions. It will analyze factors such as energy prices, labour market dynamics, and regulatory frameworks, alongside technological advancements and evolving societal preferences. The analysis will highlight how these trends are expected to shape the market, customers, and competitors over the next 1, 5, and 10 years, providing a forward-looking perspective on the conditions that will support or challenge the adoption of the pop-up factory approach. This work is ongoing and will be further expanded in the final version of the deliverable.

6.3.3. Step 3: Business case

In order to support the development of business models for the different Local Pop-up Factory (PuF) scenarios, an initial workshop was organised at Consortium Meeting 4 with ecosystem stakeholders to identify and discuss the key elements required for their implementation and market uptake. The workshop methodology was based on the *Business Innovation Kit* developed by the German research and consultancy agency UXBerlin[11] and was adapted to the specific objectives and context of this research (Figure 48).

[11] The Business Innovation Kit is a structured, workshop-based facilitation tool designed to empower entrepreneurial teams and seasoned moderators in leveraging shared values as a catalyst for innovation. Through a modular toolkit—including diverse card sets for ideation, revenue modelling, customer journey mapping, and sustainability orientation—participants collaboratively explore, articulate, and refine values-based business models, whether for new ventures or existing enterprises (Brauer, 2014). The model is accessible also online at: https://www.uxberlin.com/business-innovation-kit/

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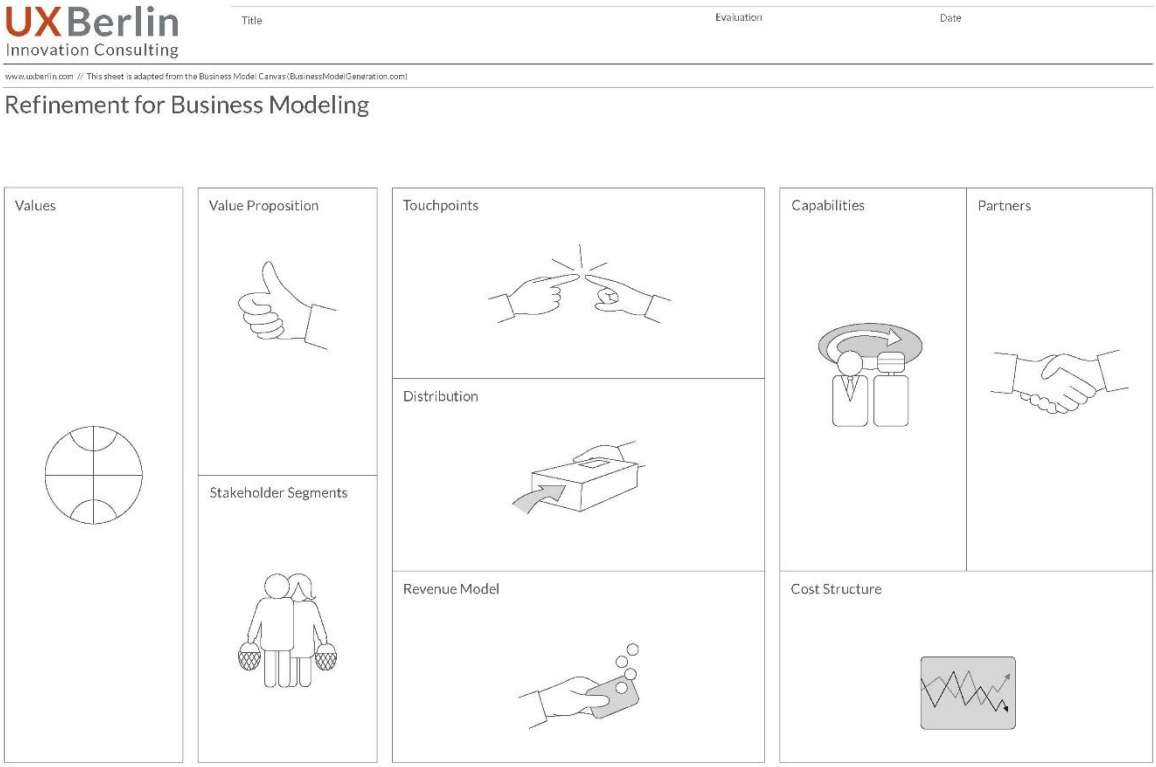


Figure 48: Model used during the CM 4 for discussing the Business Model with the different ecosystems (Source: Refinementsheet_UXBerlin).

Building upon the analyses conducted in the previous phases, this section introduces the Business Model for the Local Pop-up Factories, integrating the main findings related to market conditions, stakeholders, value creation, and implementation requirements. The insights are summarised in a table following the structure presented in Table 11, which represents an adaptation of the UXBerlin *Business Innovation Kit* with the Business Model Canvas Model (further discussed in the following paragraph), which allow for structuring different building blocks of Business Models for all the ecosystems and compare them.

Table 11: The general deduction of all ecosystem's business model canvasses, retrieved from the ecosystem's 4.5 report.

		Pop-up Factory
Value creation	**Value proposition**	*The core value delivered by the PuF, typically improving efficiency, reducing waste, enabling circular construction, and delivering renovation or construction services closer to the site.*
	Customer relationships	*The way the PuF interacts with clients (e.g. housing associations, contractors), often involving long-term*

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		collaboration, co-creation, and close coordination during projects.
	Channels	*The means through which the PuF delivers its services and communicates its value, including direct project partnerships, procurement processes, and digital tools or platforms.*
	Customer segments	*The main users of PuF services, such as housing associations, construction companies, municipalities, and developers involved in renovation or new-build projects.*
Value delivery	**Key activities**	*The main operations of the PuF, including prefabrication, assembly, logistics coordination, material recovery, and on-site or near-site production.*
	Key resources	*The essential assets required, such as skilled labour, temporary manufacturing facilities, digital tools (e.g. BIM), machinery, and access to materials or components.*
	Key partners	*The organisations involved in delivering the PuF model, including contractors, suppliers, SMEs, logistics providers, housing associations, and public authorities.*
Value Capture	**Revenue streams**	*The ways the PuF generates income, typically through project-based contracts, service fees, or integrated renovation and construction services.*
	Cost structures	*The main cost drivers, including labour, equipment, logistics, temporary facility setup, and coordination across the supply chain.*

Building on the experience and data collection, each ecosystem has then established both the scale and the urgency of renovation through a market analysis. In this section their financial fit for the local market is evaluated and the beneficial circumstances for the financial viability of the popup factory underpinned.

6.3.3.1.Research Design

A phase of Research Design is then introduced through the definition of four parameters, to dive into the examined business case. Based on literature related to the evaluation of innovations for the redesign of the construction sector as well as the opinion of experts in the field, the main criteria selected are: the required financial investment, the fit to the project scale, and the ecosystem's fits to the region. These also depend on the type of ownership that is involved. Below, the criteria and ownership model will be explained and explained through the application in Dutch Ecosystem in Table 12.

Financial Investment refers to the financial resources required to acquire and make the PUF operational (Teece, 2010). This is broader than upfront capital expenditure and includes physical assets, facility set-up, digital tooling where relevant, and organisational capacity such as training and process development.

This criterion is considered high when the PUF requires a substantial, partly irreversible commitment in assets and capabilities that cannot easily be redeployed without loss. It implies dedicated facility requirements, specialised equipment/tooling, a stable operating team, and non-trivial training and process development. This criterion is considered low

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when it can be started with minimal physical commitment and relies mainly on mobile capacity, digital tools, or reconfigurable resources.

Fit to project scale assesses whether the PUF type and ownership model are compatible with the scale and structure of the renovation work in the region. This includes the expected volume of dwellings, the degree of repeatability in typologies, the ability to cluster projects into batches, and the predictability of the pipeline required to achieve stable utilisation (Lessing et al., 2015). In other words, this criterion evaluates whether the PUF can be operated efficiently at the programme size that is realistically available.

This criterion is considered strong when the PUF matches the expected programme structure in the region: there is sufficient repeatability in typologies, the work can be clustered into batches, and the pipeline can be sequenced to maintain flow. The implication is that the model can maximize learning and repetition and as a result is able to scale. It can be considered weak when it is too fragmented, too bespoke, or too unpredictable to sustain the operating logic of the PUF type being assessed. The implication is that throughput and learning effects are unlikely to be realized and the PUF risks becoming a nuisance rather than a tool for increased efficiency.

Ecosystem fit describes the degree to which the PUF and ownership model can be embedded within the broader network of actors in the Dutch renovation market. This includes alignment with housing corporations, municipalities, contractors, suppliers and residents, as well as compatibility with governance and procurement arrangements, trust and neutrality considerations, and the coordination capacity needed to deliver and scale the approach. The innovation network and ecosystem literature repeatedly treats this alignment/orchestration as essential to value creation and capture. (Adner & Kapoor, 2010).

The criterion is considered strong when PUF can be embedded with relatively low friction into the multi-actor setting: roles are clear, governance is feasible, procurement routines can accommodate it, and key complementarities (suppliers, contractors, housing corporations, municipalities, installers, resident interface) can align. The implication is that the PUF has a credible path to adoption and routinisation. It is considered weak when it likely struggles to embed due to misaligned incentives, unclear roles, procurement barriers, or insufficient coordination capacity. The implication is that even if technically feasible, implementation will stall because the ecosystem cannot align around the required activity configuration.

Ownership model

We set-up four scenarios regarding the ownership status of the PUF since the ownership of the PUF is crucial in understanding the risks involved. Within the business case, we identify four scenarios: (1) a local construction company can set-up, own, and maintain the PUF itself; (2) a group of local construction companies can set-up, own, and maintain the PUF. By spreading the costs and risks, the risk of down-time is reduced; (3) a neutral third party, such as an industry association, can set up, own and maintain the PUF and act as a facilitator; (4) the housing corporation itself can set-up, own, and maintain the PUF.

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Table 12: Example table for the Dutch Ecosystem, related to the Assembly PUF.

Ownership scenario	Assembly PUF		
	Tool investments	**Project scale fit**	**Ecosystem fit**
Single construction company	High	Strong	Moderate
Consortium of construction companies	Medium	Strong	Strong
Industry Association	Medium	Strong	Strong
Housing corporations	High	Weak	Very strong

6.3.4. Step 4: Internal Business Analysis of the local pop-up factory

In this step, the elements of a business model (value proposition, value creation, value delivery, and value capture) are discussed following Richardson (2008), Osterwalder & Pigneur (2005, 2010), Nielsen and Lund (2014), and Teece (2010). Osterwalder and Pigneur (2005) developed the Business Model Canvas (BMC), a 9-block template, as a visual tool for describing a business model (Table 13). The nine blocks comprises of three components:

Value creation

Value creation refers to how the core offering creates value. In BMC terms, value creation is primarily explained through key resources (e.g., skilled labour, equipment, digital tools, facility space), key activities (e.g., planning, assembly operations, quality assurance, coordination, and continuous improvement), and key partnerships (e.g., suppliers, logistics partners, technology providers, installers, housing corporations, and municipalities). These blocks describe the operational and organisational capabilities required to transform inputs into outputs and to establish repeatable routines, which is particularly relevant for industrialised renovation concepts such as the Assembly PUF and the District PUF.

Value delivery

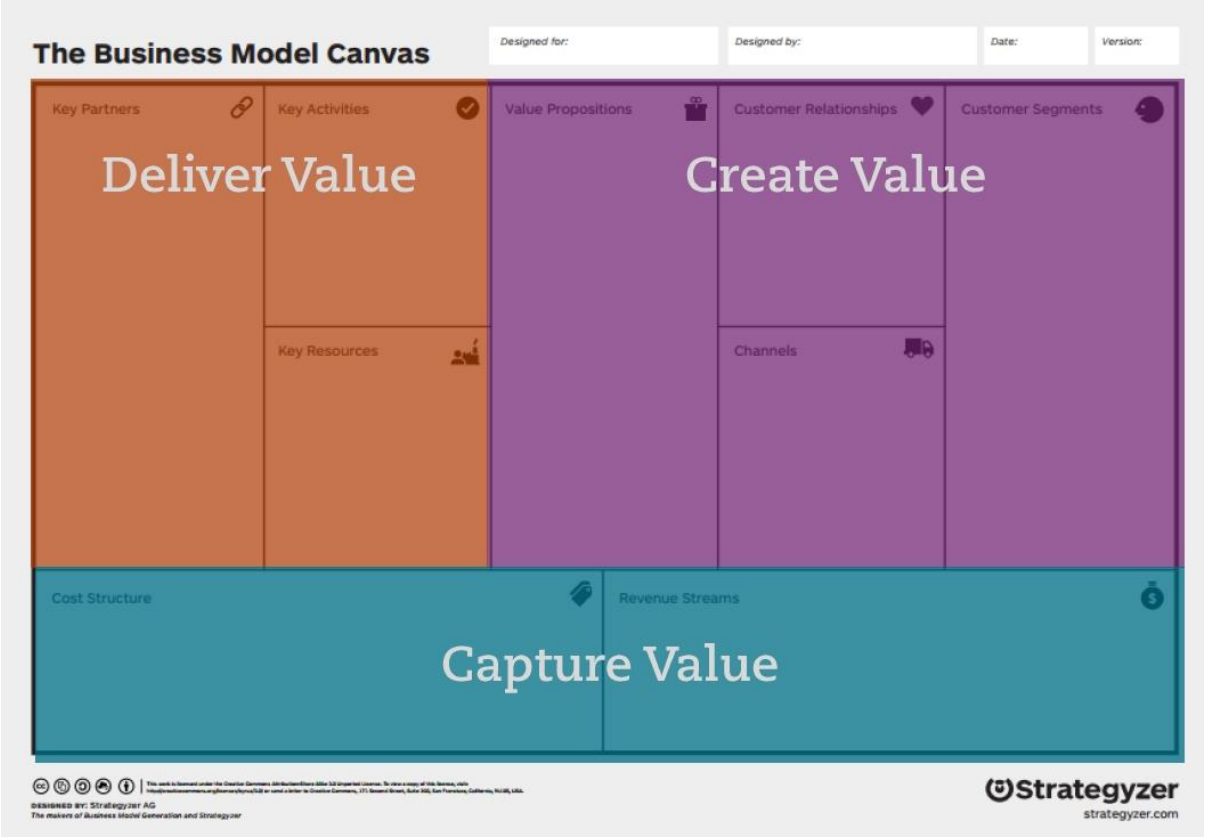
Value delivery describes how the created value reaches customers, users and other stakeholders. In BMC terms, value delivery is mainly expressed through customer segments (such as social housing corporations), channels (such as procurement routes and logistics), and customer relationships (how interaction, coordination, communication, and aftercare are organised). In a renovation context, value delivery also includes how disruption is managed in occupied dwellings, how stakeholders are aligned, and how standardised processes and information (e.g., BIM, quality documentation) are communicated across parties.

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Value capture

Value capture focuses on how the PUF sustains itself economically and how benefits and costs are distributed across actors. Within the BMC, value capture is represented by revenue streams (how income is generated, for example through service fees, assembly charges, framework-based payments, subscriptions, or performance-linked contracts) and cost structure (the main cost drivers such as labour, energy, facility set-up, tooling, logistics, governance, and digital infrastructure). In addition to direct financial capture, the PUF context often involves broader value outcomes—such as reduced lifecycle costs, social value, or circular material gains—yet the BMC helps ensure that even these broader outcomes are connected to a viable operational and funding logic.

Table 13: The nine building blocks of the BMC divided in three components. Image from Social Enterprise: How to Uncover Original Ideas Using the Social Business Model Canvas



6.3.5. Step 5: SWOT Analysis

Albert Humphrey developed SWOT analysis in the 1960s as a framework for corporate planning that analyzes a firm's internal strengths, weaknesses, opportunities, and threats. It is a strategic planning tool that identifies and assesses a project or organization's internal strengths and weaknesses, as well as external opportunities and threats. It is used to gain a better understanding of a company's market position and to develop

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strategies by leveraging strengths, mitigating weaknesses, exploiting opportunities, and guarding against threats. In this section, a SWOT analysis of the pop-up factory (PUF) project is conducted.

6.4 Comparative Analysis of Pop-up Factory Concepts across National Ecosystems

This section focuses on learning from the experiences from the ecosystem partners on the analysis and implementation of the pop-up factory (PUF).
Table 14 provides a comparison of the PUFs across the consortium ecosystems, and summarizes their value based on three aspects of the *Business Model Canvas*: value creation, value delivery, and value capture.[12]

Table 14: high-level results of the PUF application in the various ecosystems

Country	Factory Type	Value Creation	Value Delivery	Value Capture
Netherlands	Assembly Factory	Near-site assembly of prefabricated renovation modules using standardized workflows.	Just-in-time site integration minimizing disruption and lead time.	Service fees per unit combined with efficiency gains and reduced rework.
	District Factory	Regional coordination and aggregation of projects and stakeholders.	Programmatic delivery through standardized processes and shared logistics.	Coordination fees and system-level cost savings through scale.
France	Mobile On-site Factory	On-site reconditioning and reuse of recovered building components.	Direct integration with deconstruction and renovation sequences.	Service fees plus cost avoidance from reduced procurement and waste.
France	Service Factory	Coordination, knowledge sharing, and facilitation of circular renovation practices.	Stakeholder alignment, advisory services, and platform-based interaction.	Consultancy and facilitation fees, supported by ecosystem efficiency gains.
Italy	Satellite Factory	Centralised production combined with decentralised SME integration and on-site installation.	Coordinated logistics linking factory, SMEs, and construction sites.	Programme-based contracts and scale-driven efficiency gains.
Spain	Assembly Factory	Local assembly of industrialised	Near-site production combined with local	Service revenues linked to renovation

[12] These insights are collected through the contributions of all the Ecosystem which have filled in a Report following the methodology explained in this Chapter. The five Ecosystem's reports are included in this deliverables as Appendix VII.

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		components and integration of reused materials in renovation projects.	supply chain integration and reduced logistics complexity.	projects and cost savings through industrialisation and reuse.
Austria	Assembly Factory	Systematic identification, dismantling, and reuse of building components through Social Urban Mining.	On-site reuse operations integrated directly within demolition and renovation processes.	Service contracts combined with revenue from resale of reused components and avoided waste costs.

What can be observed is that the objectives and approach of the various PUFs worked on by the ecosystem partners differ. For example, the Dutch ecosystem focuses on renovating with a focus on reducing operational energy. Within the Austrian ecosystem, the focus lies on re-using materials and thereby reducing embedded carbon. In the following paragraphs, the different approaches are highlighted and the three elements of value creation, value capture, and value delivery analysed.

6.4.1. NL: District and Assembly PUF

Context and Project Summary
The District PUF reflects the Dutch need for coordination across multiple renovation projects and stakeholders. The fragmented nature of construction supply chains combined with large-scale renovation ambitions requires system-level organisation. The approach focuses on aggregation, standardization, and regional coordination to unlock economies of scale.

The Assembly PUF is particularly relevant in the Dutch context due to the high share of standardized post-war housing, which enables repetition and industrialization at scale. In addition, national policies impose minimum energy performance requirements on social housing corporations, creating a strong and predictable demand for renovation solutions. The Dutch ecosystem is therefore characterized by a combination of standardized building typologies, institutional demand aggregation, and policy-driven urgency.

Value Creation
The Dutch District PUF creates value by functioning as a regional system integrator that aggregates demand and coordinates multiple projects and stakeholders. Through process standardization and supply chain alignment, it reduces fragmentation and transportation costs.

The Dutch Assembly PUF creates value through the near-site assembly of prefabricated renovation modules within a controlled environment. By standardizing workflows and concentrating activities in a dedicated facility, the model increases productivity, reduces on-site complexity, and enhances quality consistency across projects.

Value Capture
In the case of the District PuF, Value is captured through coordination and facilitation fees embedded in programme-based arrangements, as

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well as indirect efficiency gains achieved through economies of scale and improved resource allocation.

In the case of the Assembly PuF, Value is captured through service-based fees per apartment or renovation package, complemented by efficiency gains such as reduced rework, lower labor intensity, and decreased transport-related costs. Economic viability is closely linked to sustained utilization and program scale.

Value Delivery
In the case of the District PuF, Value delivery is realised through programmatic coordination, including shared logistics, standardised quality assurance, and structured collaboration mechanisms across projects, resulting in increased predictability and scalability.

In the case of the Assembly PuF, Value delivery is organized through just-in-time logistics and tight integration with ongoing renovation works. This enables shorter on-site durations, predictable execution, and minimized disruption for residents.

6.4.2. FR: Mobile On-site Factory

Context and Project Summary
The French Mobile On-site Factory responds to opportunities for circular construction by integrating re-use directly into construction sites. The ecosystem emphasises reducing waste and improving material circularity by linking deconstruction and renovation processes.

Value Creation
The French Mobile On-site Factory creates value by enabling on-site renovation and reuse of building components recovered during selective deconstruction, particularly sanitary equipment. It directly links deconstruction and renovation activities within a single operational chain.

Value Capture
Value is captured through service fees for reconditioning and reuse operations, combined with cost avoidance related to reduced procurement of new materials and lower waste handling costs.

Value Delivery
Value delivery is achieved through direct integration with construction site sequencing, allowing immediate or near-immediate reuse of components, thereby reducing logistics complexity and enabling efficient material flows.

6.4.3. FR: Service Factory

Context and Project Summary
The Service Factory in France reflects the need for coordination and knowledge integration in emerging circular ecosystems. The project focuses on enabling collaboration across stakeholders and supporting the adoption of circular practices.

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Value Creation
The French Service Factory creates value by facilitating coordination, knowledge integration, and alignment across stakeholders involved in circular renovation processes. It strengthens the organisational capacity required to implement reuse strategies at scale.

Value Capture
Value is captured through consultancy and facilitation fees, often embedded in programme or platform-based services, alongside system-level efficiency gains generated across the ecosystem.

Value Delivery
Value delivery takes place through stakeholder engagement, advisory services, and the use of digital platforms to align supply and demand, supporting coordinated and scalable implementation of circular practices.

6.4.4. IT: Satellite PUF

Context and Project Summary
The Italian Satellite PUF is developed in response to large-scale public renovation programmes, particularly in social housing. The ecosystem combines centralised industrial production with decentralised execution by local SMEs, enabling both scale and flexibility. The approach is especially suited to dense urban areas where logistics and coordination are important.

Value Creation
The Italian Satellite PUF creates value through the industrialised production of prefabricated components in a central facility, combined with decentralised integration by local SMEs and on-site installation. This hybrid model enhances standardisation, enables batch production, and supports efficient coordination across large renovation programmes.

Value Capture
Value is captured through programme-based contracts and framework agreements linked to large-scale public renovation initiatives, particularly in social housing. The model relies on long-term pipeline stability to recover high upfront investments and achieve cost efficiency through scale and continuous utilisation.

Value Delivery
Value delivery is organised through a coordinated logistics system linking central production, local SME contributions, and just-in-time on-site installation. This configuration reduces execution time, minimises disruption for residents, and improves predictability in dense urban contexts such as Milan.

6.4.5. ES: Assembly PUF

Context and Project Summary

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The Spanish ecosystem is characterised by a large, ageing building stock with very low energy performance, with around 83% of buildings classified as inefficient. Renovation rates are currently far below required levels, creating strong policy-driven demand for scalable renovation solutions.
The project focuses on the Salesas pilot in Pamplona, where industrialised construction is applied in a heritage building context. The ecosystem relies on local SME networks and explores near-site assembly approaches to support industrialised renovation.

Value Creation
The Spanish Assembly PUF creates value by combining near-site assembly of prefabricated components with the re-use of recovered materials within the same process chain. This dual approach supports both industrialisation and circularity.

Value Capture
Value is captured through construction and assembly services, supported by cost reductions in logistics, improved efficiency, and reduced reliance on new materials.

Value Delivery
Value delivery is based on integrating assembly activities close to the construction site, leveraging local supply chains and reducing disruption, while enabling adaptation to complex building contexts such as heritage structures.

6.4.6. AU: Assembly PUF

Context and Project Summary
The Austrian ecosystem focuses strongly on circular construction and material reuse, supported by national ambitions to increase renovation rates and reduce resource consumption. The concept of Social Urban Mining reframes buildings as material banks, using the re-use box.
The project includes pilots, demonstrating how reuse can be systematically integrated into demolition and renovation processes, supported by tools such as the “screenbook” for planning and coordination.

Value Creation
The Austrian Re-Use Box creates value by identifying, dismantling, and redistributing reusable building components directly from demolition sites. This transforms waste into valuable resources while generating environmental and social benefits. The museum-like exhibition communicates their work to external parties.

Value Capture
Value is captured through service contracts with building owners and through revenue generated from the resale of reusable components. Additional value is created through avoided disposal costs and measurable sustainability impacts.

Value Delivery
Value delivery is fully integrated into the construction site, where materials are catalogued, marketed, dismantled, and transferred to

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new users. The process involves coordination with buyers, social enterprises, and logistics directly on site.

6.4.7. Findings

Assembly PUF

The comparison of Assembly Pop-up Factories across the Netherlands, Spain, and Austria reveals that while the underlying concept remains structurally similar: the relocation of value-creating activities closer to the construction site. The purpose and configuration of the assembly process differ significantly across ecosystems.

A first key similarity lies in the hybrid nature of the Assembly PUF. In all cases, production activities are relocated away from purely on-site construction and reorganised in a more controlled, semi-industrialised environment. This results in increased control over quality, improved process predictability, and reduced logistical complexity.

However, a difference emerges in the primary objective of the assembly function. In the Dutch case, the Assembly PUF is primarily oriented towards efficiency and standardisation, driven by the need to industrialise renovation processes for large volumes of similar dwellings. In Spain, the Assembly PUF serves a dual role: it enables industrialised production while maintaining flexibility to adapt to complex and heterogeneous building contexts, including heritage structures. In contrast, the Austrian Re-Use Box application of the assembly PUF reinterprets the Assembly PUF entirely, placing circularity at its core. Here, assembly is not about combining new prefabricated components, but about extracting, processing, and redistributing existing materials.

These differences are closely linked to the type of input materials. The Dutch model is based almost exclusively on new, (pre)fabricated components. The Spanish model combines new components with reused materials, while the Austrian model relies almost entirely on extracting reclaimed materials. This progression reflects a continuum from linear to circular production systems.

A further distinction can be observed in the degree of physical centralisation. The Dutch Assembly PUF is typically organised in a dedicated, semi-permanent facility. In Spain, the assembly function is more project-based and locally embedded. In Austria, the concept is fully decentralised, with the entire construction or demolition site effectively functioning as the factory. This suggests that the degree of “factory-ness” decreases as circularity increases.

Energy Performance

Sustainable renovations can be achieved through two means; lowering the embodied carbon of the materials, and by decreasing the operational carbon. The embodied carbon relates to the emissions of building materials in the production process. This is reduced by using materials with a lower carbon footprint, and by ensuring re-use of the outgoing materials. Operational carbon is related to the energy usage of the inhabitants of dwellings. This is decreased by improving the energy performance of buildings, such as improving insulation and using a less polluting way to heat the dwelling.

Across the analysed ecosystems, energy performance emerges as a dominant driver in some contexts, while being largely absent in others. The Netherlands and Spain are characterised by strong policy-driven demand for energy-efficient renovation, in line with European

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directives and national regulations. In these contexts, improving operational energy performance is a primary objective, which directly shapes the design and implementation of pop-up factory concepts.
In both countries, the push for energy efficiency encourages standardisation and repeatability. This aligns well with Assembly PUF models, as these enable the efficient deployment of standardised renovation packages at scale. As a result, energy performance improvements and industrialisation are closely intertwined.
In contrast, the Austrian case is not primarily driven by operational energy performance, but by material circularity and resource efficiency. While energy efficiency remains relevant at the broader policy level, it is not a central driver of the Re-Use Box concept. This highlights the coexistence of different renovation logics within Europe.
The Italian and French cases demonstrate partial relevance. While energy performance is an important background driver, it is not the primary determinant of the selected PUF configurations. Instead, these cases combine energy objectives with other priorities, such as scalability (Italy) or circularity and coordination (France).
Overall, two parallel renovation logics can be identified: one focused on operational energy reduction and standardisation, and another focused on material circularity and value recovery. These logics do not necessarily conflict, but they lead to different design requirements for pop-up factory concepts.

Material Reuse
Material reuse constitutes a key differentiator across the analysed ecosystems, revealing significant variation in the extent to which circular principles are integrated into pop-up factory concepts.
In the Dutch case, material reuse does not play a central role in the Assembly or District PUF concepts. The focus is predominantly on efficiency gains through industrialisation and standardisation of new components. As such, the model remains largely embedded within a linear production logic.
Spain represents an intermediate position, where reuse is selectively integrated into the Assembly PUF. The Spanish case demonstrates how reused materials can be combined with industrialised construction processes, particularly in complex renovation contexts. However, reuse remains a complementary rather than dominant element.
In Austria, material reuse is the core of the PUF concept. The Re-Use Box fundamentally restructures the value chain by transforming demolition sites into sources of valuable materials. This shifts the logic of value creation and capture from production efficiency towards resource valorisation.
France also demonstrates partial integration of reuse, particularly in the Mobile On-site Factory model, where recovered components are reconditioned and reintegrated into construction processes. However, reuse is not institutionalised to the same extent as in Austria.
These differences indicate a clear transition from linear to circular construction models. Importantly, the integration of reuse not only affects production processes, but also transforms business models, stakeholder roles, and revenue streams.

Institutional Organisation of Renovation Markets
The organisation of national renovation markets plays a decisive role in shaping the emergence and configuration of pop-up factory concepts. The comparative analysis reveals that PUF models are not

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universally applicable, but instead emerge as context-specific responses to market conditions.
In the Netherlands, the renovation market is characterised by a high degree of organisation and demand aggregation, particularly through social housing corporations. This enables programmatic approaches and large-scale implementation, which in turn favour standardised and industrialised PUF models such as the Assembly and District factories.
In Spain, the market is more fragmented, with a significant share of privately owned dwellings and homeowner associations. Decision-making processes are therefore more complex and slower, limiting the feasibility of highly standardised approaches. As a result, the Assembly PUF in Spain is designed to be more flexible and locally embedded.
The Austrian market, particularly in the context of reuse and demolition, is less oriented towards mass renovation and more characterised by project-based innovation. The emergence of the Re-Use Box reflects a bottom-up approach, driven by niche actors and aligned with circular economy objectives rather than large-scale renovation programmes.
Italy represents a hybrid model, where large-scale public renovation programmes coexist with strong local SME networks. This combination favours the Satellite PUF, which links centralised production with decentralised execution.
Finally, the French ecosystem emphasises coordination and knowledge integration across stakeholders, reflecting a need to align fragmented actors in emerging circular markets. This results in the development of both Mobile and Service PUF configurations.

6.4.8. Conclusion

The comparative analysis shows that pop-up factory configurations are not uniform solutions, but vary systematically depending on both the organisation of the renovation market and the main objectives driving renovation activities.
A first key observation is that Assembly PUFs appear in multiple ecosystems, but are used for different purposes and under different circumstances. In the Netherlands, the Assembly PUF is primarily used to increase efficiency and enable large-scale renovation through standardisation. In Spain, the same concept is adapted to deal with more heterogeneous building types, requiring a balance between standardisation and flexibility. In Austria, the Assembly concept is fundamentally reinterpreted to support material reuse, where the focus shifts from assembling new components to recovering value from existing buildings.
A second observation concerns the role of energy performance and circularity as drivers of innovation. In ecosystems where energy performance is the main driver, such as the Netherlands and Spain, PUFs are used to support scalable and repeatable renovation processes. In contrast, in Austria, where circularity and material reuse are central, the PUF concept becomes more decentralised and site-based, reflecting the variability and uncertainty of reuse processes.
Third, the organisation of the renovation market strongly influences which PUF configurations are feasible. Highly organised markets with aggregated demand, such as in the Netherlands, support standardised and programmatic approaches. More fragmented markets, such as in Spain, require more flexible and locally embedded solutions. In

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Austria, where renovation is less programmatic and more project-based, innovation emerges through niche applications such as the Re-Use Box. Italy demonstrates a hybrid structure, where centralised production is combined with decentralised execution through SMEs.
Overall, the analysis indicates that there is no single optimal pop-up factory model. Instead, different configurations are appropriate under different conditions. The main implication is that the design of PUFs should start from the characteristics of the local ecosystem (including market structure, policy drivers, and project types) rather than from a predefined technological model.

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6.5 Business Model Canvas-Based Comparative analysis

This paragraph provides a detailed, component-level comparison of the Business Model Canvasses (BMCs) across the different PUF ecosystems. Each subsection presents a comparison per PUF type. Characteristics are linked to the applied cases in each ecosystem and the role of the PUF therein.

6.5.1. Value proposition

The comparison shows that value propositions differ fundamentally depending on the national context and strategic focus. In the Netherlands, both Assembly and District PUFs are strongly oriented towards large-scale efficiency and programme delivery. In Spain, the Assembly PUF adapts this model to more heterogeneous building stock, requiring flexibility. In Austria, the Assembly logic is reframed around circularity through the Re-Use Box. France introduces both Mobile and Service factories, shifting the focus towards circular material flows and ecosystem coordination. Italy's Satellite PUF complements industrialization with decentralized execution through SMEs.
In practice, this results in a spectrum of value propositions, ranging from efficiency and scalability (NL, IT), to flexibility (ES), and circularity (AT, FR).
The main conclusion is that value propositions are not transferable as standalone concepts, but are closely tied to national priorities such as energy performance, circularity, or market organization.

Table 15: an overview of the value proposition per PUF type

PUF type	Value Proposition
Mobile On-site Factory	On-site integration of deconstruction, processing, and reuse, enabling circular material flows, reduced logistics, and shorter renovation cycles
Satellite Factory	Scalable renovation through centralised industrial production combined with flexible local SME-based execution
District Factory	System-level optimisation by aggregating demand, aligning stakeholders, and reducing fragmentation across projects
Assembly Factory	Fast, repeatable and standardised renovation processes, with variants ranging from efficiency-driven to circular assembly
Service Factory	Enabling ecosystem coordination, knowledge integration, and alignment of

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	circular renovation practices across stakeholders

6.5.2. Customer segments

Across all cases, PUFs operate within the same renovation sector, yet the primary customer differs substantially. In the Dutch and Spanish Assembly PUFs, the focus lies on contractors and housing organisations executing renovation projects. In Italy, the Satellite PUF targets both public programme clients and SMEs, reflecting a hybrid system. In France, the Service Factory targets a broad ecosystem, including public authorities and knowledge actors, rather than a single project-level client.

This demonstrates that customer segments evolve from project-level actors (NL Assembly, ES Assembly, FR Mobile) towards programme-level (IT Satellite, NL District) and eventually system-level stakeholders (FR Service). Identifying the correct primary customer is critical and depends on the level on which the PUF operates.

Table 16: an overview of the customer segments per PUF type

PUF type	Customer segments
Mobile On-site Factory	Contractors, demolition companies, and actors focused on circular reuse and waste reduction
Satellite Factory	Public programme clients, large developers, and local SMEs involved in execution
District Factory	Housing associations, municipalities, and institutional asset owners with aggregated portfolios
Assembly Factory	Contractors, developers, and housing organisations executing renovation projects
Service Factory	Public authorities, housing organisations, and broader ecosystem stakeholders involved in systemic change

6.5.3. Customer Relationships

Customer relationships reflect the organisational maturity of the PUF. In execution-oriented models such as Assembly (NL, ES, AT) and Mobile (FR), relationships are largely transactional and project-based. In contrast, the Dutch District PUF builds long-term programme relationships with housing organisations, while the Italian Satellite model combines long-term contracts with local execution partnerships. The French Service Factory operates at a strategic level, focusing on long-term stakeholder alignment.

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This shows a clear scaling pattern in which relationships become longer-term and more strategic as PUFs move from execution to coordination and system roles. Business continuity and scaling potential depend on the ability to transition from short-term project relationships to long-term partnerships.

Table 17: an overview of the customer relationships per PUF type

PUF type	Customer Relationships
Mobile On-site Factory	Short-term, project-based collaboration focused on specific demolition or renovation sites
Satellite Factory	Combination of long-term programme agreements with local short-term execution contracts
District Factory	Long-term programme-based partnerships with institutional clients enabling continuity and scaling
Assembly Factory	Primarily project-based operational relationships with contractors and housing organisations
Service Factory	Strategic, long-term relationships aimed at stakeholder alignment and ecosystem coordination

6.5.4. Channels

Channels differ strongly in spatial and organisational terms. In France, the Mobile factory is fully embedded on site, while Assembly factories in the Netherlands and Spain operate near-site to optimise logistics. Italy's Satellite model connects a central facility with decentralised actors. The Dutch District PUF relies on programme-level coordination rather than physical channels, and the French Service Factory shifts towards digital and organisational delivery.

This represents a continuum from physical proximity (on-site, near-site) to organisational coordination (platforms, governance structures). The choice of channel shapes the operational model and must be aligned with the structure and organisation of the renovation system.

Table 18: an overview of the channels per PUF type

PUF type	Channels
Mobile On-site Factory	Fully embedded on-site delivery, directly integrated into demolition and renovation activities

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Satellite Factory	Coordinated logistics linking central production facilities with decentralised construction sites
District Factory	Programme-level coordination structures, often supported by governance frameworks and digital tools
Assembly Factory	Near-site logistics with just-in-time delivery integrated into construction workflows
Service Factory	Non-physical channels including digital platforms, workshops, and structured stakeholder engagement processes

6.5.5. Key Activities

Key activities vary significantly depending on the function of the PUF. Assembly factories (NL, ES, AT) and Mobile factories (FR) are dominated by physical operations, although with different goals (efficiency vs reuse). The Italian Satellite combines production with coordination across SMEs. The Dutch District factory focuses primarily on organising processes, while the French Service factory operates almost entirely through facilitation and knowledge activities.

This shows a gradual shift from production activities towards coordination and enabling activities. Defining the correct activity profile determines both required capabilities and organisational structure.

Table 19: An overview of the key activities per PUF type

PUF type	Key activities
Mobile On-site Factory	Selective deconstruction, sorting, reconditioning, and immediate reuse of materials on site
Satellite Factory	Industrial production, supply chain coordination, and logistics management across multiple actors
District Factory	Demand aggregation, planning, standardisation, and coordination of multiple projects and stakeholde
Assembly Factory	Assembly of prefabricated components, installation, and coordination of site logistics
Service Factory	Facilitation, advisory, stakeholder coordination, and knowledge transfer across projects and organisations

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6.5.6. Key Resources

Resource requirements clearly differ between models. Execution-based PUFs rely heavily on physical resources such as facilities, labour, and materials (NL Assembly, ES Assembly, AT Re-Use Box). The Italian Satellite adds network resources through SME integration. The Dutch District PUF depends more on governance structures and coordination systems, while the French Service factory is primarily based on knowledge and network resources.

This represents a transition from tangible to intangible resource bases. Different PUF types require different investment strategies, ranging from physical infrastructure to organisational capacity.

Table 20: an overview of the key resources per PUF type

PUF type	Key resources
Mobile On-site Factory	Reclaimed materials, local labour, temporary infrastructureRecovered building materials, skilled local labour, and temporary site-based infrastructure
Satellite Factory	Central production facilities, logistics systems, and networks of local SMEs
District Factory	Governance mechanisms, digital coordination platforms, and stakeholder networks
Assembly Factory	Assembly facilities, trained labour force, and digital tools such as BIM
Service Factory	Intangible assets including knowledge, expertise, digital platforms, and stakeholder networks

6.5.7. Key Partners

The structure of partnerships reflects the ecosystem in which each PUF operates. Assembly factories rely on relatively traditional supply chains. The Italian Satellite expands this to include networks of SMEs. The Dutch District PUF and French Service factory operate in more complex ecosystems involving public actors, while the Mobile factory introduces social enterprises linked to circularity.

This shows an increase in partnership complexity and institutional involvement at higher system levels. The PUF's success depends heavily on the ability to build and maintain the appropriate partner network for its role.

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Table 21: an overview of the key partners per PUF type

PUF type	Key partners
Mobile On-site Factory	Demolition firms, social enterprises, contractors and circular economy actors
Satellite Factory	SMEs, manufacturers, logistics providers and public programme clients
District Factory	Housing associations, contractors, municipalitiesHousing organisations, contractors, municipalities and regulatory bodies
Assembly Factory	Prefabrication suppliers, contractors and logistics providers
Service Factory	Public authorities, NGOs, knowledge institutesPublic authorities, NGOs, research institutes and knowledge organisations

6.5.8. Revenue Streams

Revenue streams reflect the type of value delivered. Assembly factories in the Netherlands and Spain rely on project-based revenues, while the Austrian Re-Use Box introduces circular income streams through material recovery. The Italian Satellite and Dutch District factories are embedded in programme-based funding structures. The French Service factory uses consultancy-based revenues.

This shows a shift from production-based revenues to service- and coordination-based income streams, with circularity enabling additional revenue opportunities. The financial viability depends on aligning revenue models with the type of value created, particularly when introducing circular strategies.

Table 22: an overview of the revenue streams per PUF type

PUF type	Revenue streams
Mobile On-site Factory	Service-based revenues from reuse operations combined with income from resale of recovered materials
Satellite Factory	Programme-based contracts and production-related revenues linked to large-scale renovation programmes
District Factory	Fees for coordination, programme management and system-level services
Assembly Factory	Per project or per dwelling service feesProject-based or per-dwelling service

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	fees linked to assembly and installation activities
Service Factory	Consultancy fees, facilitation services, and platform-based revenue streams

6.5.9. Cost Structures

Cost structures vary significantly. Assembly factories in the Netherlands and Spain are driven by labour and facilities, while the Austrian Re-Use Box remains labour-intensive due to manual processes. The Italian Satellite requires substantial upfront investment in production capacity. The Dutch District and French Service factories shift costs towards organisational and coordination activities.
This reflects a transition from asset-intensive to organisation-intensive cost structures. Different PUF types require different financial planning approaches, particularly regarding upfront investment versus operational costs.

Table 23: an overview of the cost structures per PUF type

PUF type	Costr structures
Mobile On-site Factory	Labour-intensive operations, site setup, and logistics linked to material handling and reuse
Satellite Factory	High upfront investment in production facilities combined with ongoing coordination and logistics costs
District Factory	Costs related to governance, coordination, programme management and digital infrastructure
Assembly Factory	Labour, facility setup, transport and logistics costs for assembly operations
Service Factory	Personnel, coordination activities, and maintenance of digital platforms and networks

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6.5.10. Summary

The previous paragraph explains how every PUF application operates based on the building blocks of the BMC. The table below provides a summarized overview showing how the PUFs operate across the BMC per PUF type.

Table 24: overview of the BMC building blocks per PUF type

		Mobile on-site factory	**Satellite factory**	**District Factory**	**Assembly Factory**	**Service Factory**
Value creation	Value proposition	On-site integration of deconstruction, processing, and reuse, enabling circular material flows, reduced logistics, and shorter renovation cycles	Scalable renovation through centralised industrial production combined with flexible local SME-based execution	System-level optimisation by aggregating demand, aligning stakeholders, and reducing fragmentation across projects	Fast, repeatable and standardised renovation processes, with variants ranging from efficiency-driven to circular assembly	Enabling ecosystem coordination, knowledge integration, and alignment of circular renovation practices across stakeholders
	Customer segments	Contractors, demolition companies, and actors focused on circular reuse and waste reduction	Public programme clients, large developers, and local SMEs involved in execution	Housing associations, municipalities, and institutional asset owners with aggregated portfolios	Contractors, developers, and housing organisations executing renovation projects	Public authorities, housing organisations, and broader ecosystem stakeholders involved in systemic change
	Customer relationships	Short-term, project-based collaboration focused on specific demolition or renovation sites	Combination of long-term programme agreements with local short-term execution contracts	Long-term programme-based partnerships with institutional clients enabling continuity and scaling	Primarily project-based operational relationships with contractors and housing organisations	Strategic, long-term relationships aimed at stakeholder alignment and ecosystem coordination
	Channels	Fully embedded on-site delivery, directly integrated into demolition and renovation activities	Coordinated logistics linking central production facilities with decentralised construction sites	Programme-level coordination structures, often supported by governance	Near-site logistics with just-in-time delivery integrated into construction workflows	Non-physical channels including digital platforms, workshops, and structured stakeholder

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				frameworks and digital tools		engagement processes
Value delivery	Key activities	Selective deconstruction, sorting, reconditioning, and immediate reuse of materials on site	Industrial production, supply chain coordination, and logistics management across multiple actors	Demand aggregation, planning, standardisation, and coordination of multiple projects and stakeholders	Assembly of prefabricated components, installation, and coordination of site logistics	Facilitation, advisory, stakeholder coordination, and knowledge transfer across projects and organisations
	Key resources	Recovered building materials, skilled local labour, and temporary site-based infrastructure	Central production facilities, logistics systems, and networks of local SMEs	Governance mechanisms, digital coordination platforms, and stakeholder networks	Assembly facilities, trained labour force, and digital tools such as BIM	Intangible assets including knowledge, expertise, digital platforms, and stakeholder networks
	Key partners	Demolition firms, social enterprises, contractors and circular economy actors	SMEs, manufacturers, logistics providers and public programme clients	Housing organisations, contractors, municipalities and regulatory bodies	Prefabrication suppliers, contractors and logistics providers	Public authorities, NGOs, research institutes and knowledge organisations
Value Capture	Revenue streams	Service-based revenues from reuse operations combined with income from resale of recovered materials	Programme-based contracts and production-related revenues linked to large-scale renovation programmes	Fees for coordination, programme management and system-level services	Project-based or per-dwelling service fees linked to assembly and installation activities	Consultancy fees, facilitation services, and platform-based revenue streams
	Cost structures	Labour-intensive operations, site setup, and logistics linked to material handling and reuse	High upfront investment in production facilities combined with ongoing coordination and logistics costs	Costs related to governance, coordination, programme management and digital infrastructure	Labour, facility setup, transport and logistics costs for assembly operations	Personnel, coordination activities, and maintenance of digital platforms and networks

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6.5.11. Generalization of PUF applications

The value proposition across the various PUF applications remains similar whereas the approach differs. All PUFs are designed to improve renovation efficiency in order to realize more energy friendly or more circular renovations. Maintaining relationships with various customers and other stakeholders is crucial for its success. For a district factory this is more on a practical level, whereas the satellite factory requires more long-term partnerships. The stakeholders determine the position of the PUF in the renovation projects and therby its key activities. Some PUFs focus more on the physical execution, whereas others focus more on the coordination (planning or logistics) of the building materials. Revenue is obtained from the execution of the PUF; these are primarily service-based revenues. Depending on the PUF type, these also contain programme contracts or coordination fees. Table 25 below shows the building blocks of the Business Model Canvas related to the generalized PUF.

Table 25: The general deduction of all ecosystem's business model canvasses,

		Pop-up Factory
Value creation	**Value proposition**	Improved renovation efficiency combined with scalable delivery, system coordination, and/or circular value creation depending on configuration
	Customer relationships	Combination of project-based and programme-based relationships, evolving towards long-term and strategic stakeholder engagement
	Channels	Integration into construction processes through on-site, near-site or coordinated programme-based logistics and delivery structures
	Customer segments	Actors within the renovation ecosystem, including contractors, housing organisations, public authorities, and broader ecosystem stakeholders
Value delivery	**Key activities**	Mix of physical execution (assembly, reuse), coordination (planning, logistics), and facilitation (knowledge transfer, alignment)
	Key resources	Combination of physical assets (facilities, materials, labour) and intangible assets (knowledge, data, networks)
	Key partners	Multi-actor networks including contractors, suppliers, public institutions, SMEs, and knowledge organisations
Value Capture	**Revenue streams**	Primarily service-based revenues, complemented by programme contracts, coordination fees, and circular revenue streams (e.g. material reuse)
	Cost structures	On-site labour costs on running the PUF, coordination costs in facilitating the collaboration of various stakeholders, logistics across working fields.

6.5.12. Conclusions

The BMC-based comparison demonstrates that differences between pop-up factory concepts are most clearly visible at the level of individual business model components. While all PUFs operate within

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the same sector, they represent fundamentally different configurations depending on their role in the renovation system.
Across the cases, a consistent pattern emerges: Assembly (NL, ES, AT), Mobile (FR), and Satellite (IT) PUFs operate primarily at the execution level; the District PUF (NL) operates at the coordination level; and the Service PUF (FR) operates at the system level.
This distinction is reflected across all BMC components, including customers, activities, resources, and revenue models. As PUFs move from execution to system level, there is a clear shift from physical production towards coordination and knowledge-based activities, from project-based customers to ecosystem stakeholders, and from production revenues to service-based income.
Effective PUF design requires aligning all Business Model Canvas components with the intended operational level (execution, coordination, or system) and the specific characteristics of the national renovation ecosystem.

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7. Feasibility studies for implementation of the BuildUPspeed local factory concepts on other locations

Chapter 5 presented the ecosystem-specific implementation plans developed under Task 4.4. These plans structured the main requirements for implementing local Pop-up Factory (PuF) concepts in the BuildUPspeed ecosystems, including scenario definition, stakeholder roles, legal and regulatory conditions, costs and financing, time schedules, risks, site logistics, sustainability, and scalability. The same requirement logic was used as the basis for the feasibility studies in Task 4.6.

The purpose of this chapter is to describe how the implementation plan framework was extended into a feasibility study format for assessing whether a selected PuF concept could be applied in another location. Whereas Task 4.4 focused on defining implementation conditions within the original ecosystem context, Task 4.6 uses the same requirement categories to test transferability to a new local context. The feasibility study therefore does not repeat the implementation plan, but reuses its structure as a diagnostic tool: the same types of information are collected again, but now for a different location, building stock, stakeholder setting, regulatory environment, and logistical context.

To support this process, a dedicated feasibility study template was developed. The template consists of three main parts. Part A collects the implementation requirements for the selected PuF concept in the new location, using the requirement categories derived from Task 4.4. Part B translates these inputs into a structured feasibility assessment across technical, operational, legal/regulatory, market, and financial dimensions. Part C consolidates the main blockers, mitigation actions, assumptions, and an overall feasibility judgement. The final judgement is expressed as a GO, CONDITIONAL GO, or NO-GO decision, depending on whether the PuF concept can be implemented directly, requires additional conditions to be met, or is not considered feasible under the assessed circumstances (Appendix X).

This structure enables the feasibility study to remain comparable with the implementation plans described in Chapter 5 while adding a decision-oriented layer. The completed feasibility study inputs and supporting material are included in Appendix X.

7.1 The Dutch Ecosystem

The feasibility assessment indicates that the District/Assembly-type Pop-up Factory is explored in a pilot case in the Dutch city of Groningen, provided that several operational and market constraints are carefully managed. The renovation concept of the Van Heemskerckflat is well defined, supported by an industrialised workflow using prefabricated façade elements, bathroom pods, and a lightweight steel substructure. A strong governance ecosystem of housing association, contractor, and local

municipality underpins the project, complemented by specialised suppliers. Regulatory requirements are predictable within Dutch permitting procedures, and EU innovation funding reduces financial exposure.

Technical feasibility is high, as demonstrated by the successful deployment of complex prefabricated systems in a peripheral region. Operational feasibility is more sensitive due to strict sequencing requirements, the need for a fully vacant building, and reliance on subcontractor availability. Financial feasibility remains challenging, with limited short-term ROI and dependence on equity and grants. Market feasibility is mixed: demand for deep renovation is strong, but Groningen's remote position leads to longer lead times, limited specialised labour skills, and dependence on external suppliers. Nonetheless, the long-standing collaboration between the main contractor Van Wijnen and the owner of the building, the Housing Association Lefier, suggests that stable demand could strengthen regional capacity over time, including opportunities for coordinated material reuse across multiple renovation sites.

Key blockers include subcontractor capacity, asbestos-related delays, workflow disruptions, and long component lead times. Mitigation focuses on early subcontractor engagement, strict pre-construction planning, and buffering critical components. The study supports a **CONDITIONAL GO**, with next steps including formalising subcontractor commitments, validating lead times, coordinating district-level renovation cycles, and refining the production rhythm to ensure reliable throughput (The Dutch Ecosystem Feasibility Report in Appendix X).



Figure 49: The Van Heemskerckflat building in its context in the city of Groningen (left) and the installation of the façade blocks (right).

7.2 The Italian Ecosystem

The assessment examined a Pop-up Factory (PuF) model for offsite retrofit in Catania (Sici-ly), using the IACP-owned Acquicella building — representative of Italy's pre-seismic-code reinforced-concrete stock — as pilot. Given the island (remote) context, the configuration keeps the centralized precast main factory in Campania, serving the wider southern catch-ment, with local Sicilian SMEs integrating components before on-site installation.

The analysis confirms that this configuration is essentially identical to the validated main-land model (T4.5); the difference is concentrated in the transport and logistics dimensions introduced by the mainland-to-island leg. Governance is interregional, the permitting path-way feasible

(mediated by Sicily's special-statute institutions), and quality requirements include NTC seismic compliance.
The feasibility assessment scored 77%, with strong outcomes in process definition, technol-ogy readiness, governance, regulatory compliance and demand potential. The main condi-tional issues are maritime-logistics reliability, workforce preparation (against a structural Sicilian brain drain), production saturation and demand continuity — the latter constrained by chronic ERP underfunding and the fragmentation of nine provincial IACP, though the combined Campania–Sicily public-housing stock approaches Lombardy scale. ZES Unica (Southern Italy supply-side investment tax credit) and the Sismabonus (demand-oriented seismic-retrofit tax deduction) support the financial case; IACP Catania's role in the H2020 e-SAFE project evidence local readiness and engagement in offsite renovation projects.
Final decision: **FEASIBLE – GO**, conditional on securing an anchor client, a multi-year pipeline and a confirmed logistics setup (The Italian Ecosystem Feasibility Report in Appendix X).

7.3 The Spanish Ecosystem

The Assembly Pop-up Factory (PuF) assessed in this study is located in **Pamplona, Navarra (Spain)**, targeting the complete deep renovation of public and heritage buildings through on-site assembly of prefabricated CLT-based components, at a target throughput of 52.5 m²/day. The remote context doesn't reply in this case rather than the viability study is developed for this PuF where a heritage sensitivity, strict noise/working-hours regulations, and urban crane restrictions, though proximity to logistics infrastructure (5 km to nearest hub) is adequate.

Part A findings indicate a technically workable process relying on subcontracted skilled trades with low equipment CAPEX, but a notable absence of confirmed clients, financing structures, or defined stakeholder partnerships. Market demand data is unavailable, and no pipeline of renovation projects has been identified.
Part B assessments yield strong results for Technical (90%), Operational (75%), and Legal/Regulatory (80%) dimensions, but Financial feasibility is only Conditional (62.5%) due to an undefined revenue model, and Market/Demand feasibility scores 0% — all four rows rated Not Feasible — representing the critical blocker.

The **final decision is CONDITIONAL GO**. Progression requires: (1) identifying and confirming anchor clients or a renovation demand pipeline; (2) defining a viable revenue and contracting model; and (3) securing at least one committed public or private project to validate operational assumptions. These conditions must be resolved before pilot implementation begins (The Spanish Ecosystem Feasibility Report in Appendix X).

8. General script and guidelines for designing BIM-based digital blueprints for local PuF concepts and their implementation

This section translates the outcomes of the tailored PuF design activities and ecosystem-specific implementation planning into a set of reusable digital blueprints for local Pop-up Factory concepts. The blueprints build on the design logic developed in Task 4.3, see Section 4.3.4, and the implementation requirements collected in Task 4.4 (see Section 5) and 4.5 (see Section 6). Together, these tasks provided both the conceptual design basis of each PuF scenario and the practical implementation conditions needed for replication, including stakeholder roles, site requirements, legal and regulatory conditions, cost and financing logic, time schedules, risks, sustainability considerations, scalability conditions, and required skills.

The blueprint format was developed as a structured factsheet rather than as a heavy interactive design tool. This choice reflects the intended use of the outputs: the factsheets are not marketing flyers, but practical general scripts that provide enough detail for replication, policy discussion, expert interpretation, and further BIM-based development. Each factsheet consolidates ecosystem-specific knowledge into a generalised PuF scenario description, while preserving the main operational lessons derived from the pilots and workshops. In this way, the factsheets act as an intermediate layer between detailed ecosystem documentation and future implementation by other users, regions, or project teams.

The factsheets have two defining features. First, they are **BIM-based**, as each PuF type is supported by a Common Data Environment (CDE) in RE Suite (see Section 2.2), which enables BIM-based information management and expert-level workflows. Second, they are **digital**, as they are integrated into the BuildUPspeed Market Activation Platform (MAP) as dedicated platform pages. Together, these two features position the factsheets as BIM-based digital blueprints: structured, reusable references that connect general PuF implementation knowledge with digital, BIM-enabled renovation workflows.

Five PuF scenarios were identified in the BuildUPspeed framework: Mobile On-Site Factory, Satellite Factory, District Factory, Assembly Factory, and Service Factory. This section presents four physical or production-oriented PuF blueprints: Mobile On-Site Factory, Satellite Factory, District Factory, and Assembly Factory. The fifth scenario, the Service Factory, is addressed through the BuildUPspeed Market Activation Platform[13] itself, which supports users through guidance, matchmaking, and access to related renovation and implementation workflows. Further information on the

[13] https://busmap.demobv.nl/platform

Service Factory logic and platform-related functionalities is provided in Deliverables D3.1 and D3.2.

Each PuF scenario is represented by one consolidated factsheet, even where the underlying knowledge was validated or informed by multiple ecosystem contexts. The factsheets therefore do not reproduce individual pilot storylines. Instead, they generalise the main design and implementation conditions into a common structure. This structure covers the PuF type, purpose, deep-renovation scope, design intent, scale, location logic, operational lifetime, production capacity, production workflow, space allocation, required resources and utilities, digital infrastructure, logistics and site requirements, actors and governance, labour force and skills, legal and regulatory requirements, cost structure, lifecycle and time schedule, risks and contingencies, scalability, and expected impact. The Assembly Factory blueprint is based primarily on the Austrian Re-Use Box / Social Urban Mining pilot, as this ecosystem delivered one of the physical PuFs within the project lifetime. This selection does not reduce the relevance of the Spanish ecosystem outputs. The Spanish Assembly Factory work contributed a substantial body of knowledge on industrialised renovation, prefabrication, heritage constraints, urban site limitations, public-permit conditions, and the assembly of prefabricated components in complex renovation contexts. These insights remain important for the broader Assembly Factory logic, while the Austrian case was selected as the main basis for the consolidated blueprint because of its physical implementation maturity.

As mentioned above, the factsheets have been integrated into the BuildUPspeed Market Activation Platform[14] as dedicated static pages under the Pop-Up Factories section of the platform (Figure 50). Users can access the consolidated PuF scenario pages directly through the dedicated Pop-Up Factories tab. In addition, the platform includes a tailored PuF wizard based on the PuF checklist criteria, see Table 6. By answering the wizard questions, users are guided toward the PuF scenario that is most relevant to their context, renovation needs, and implementation conditions. The anticipated users are stakeholders interested in exploring or deploying a PuF for deep renovation, such as housing providers, public authorities, contractors, suppliers, renovation consultants, or other ecosystem actors.

The factsheets themselves are not intended to be edited by end users. Instead, they provide a stable reference structure for understanding when a PuF scenario is suitable, what resources and partners are required, which site and logistics conditions need to be considered, and which implementation requirements should be checked before replication. In this way, the MAP acts as the digital access point for the PuF blueprints, while the factsheets provide the underlying scenario-specific guidance.

[14] The Pop-Up Factories section of the BuildUPspeed Market Activation Platform is available at: https://busmap.demobv.nl/platform/popup-factories

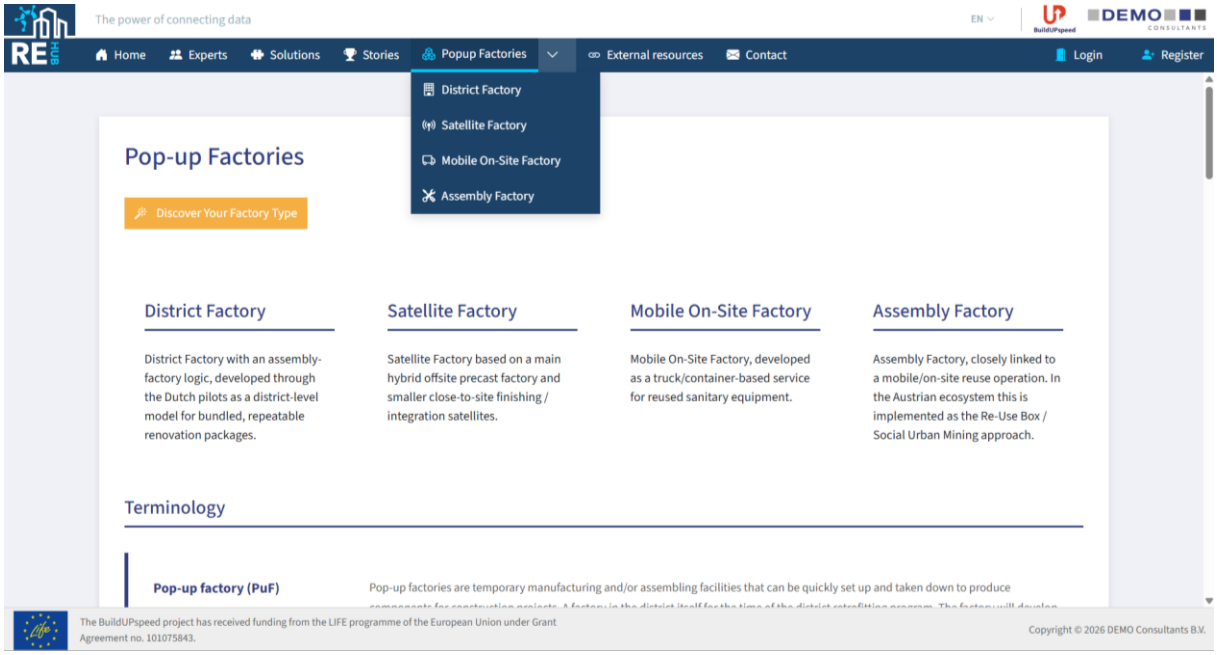


Figure 50: Pop-Up Factories section in the BuildUPspeed Market Activation Platform, showing the dedicated PuF overview page, access to the PuF wizard, and navigation links to the four consolidated PuF scenario blueprints.

8.1 District Factory Factsheet

8.1.1. Scenario & Strategy

PuF type	District Factory with an assembly-factory logic, developed through the Dutch pilots as a district-level model for bundled, repeatable renovation packages.
PuF purpose	Localised manufacturing, assembly and coordination of prefabricated renovation components for groups of similar buildings. The concept aims to aggregate demand, standardise repeatable modules, reduce site time and support deeper renovation ambitions in the Dutch housing-association context.
Deep renovation / reuse scope	Whole-building deep retrofit package. The scope includes façade/envelope upgrades, window and door replacement, roof insulation or roof refurbishment, floor/basement insulation, ventilation, heating-system upgrades, renewable energy/PV, and interior kitchen, bathroom and toilet works. Partial asbestos removal can also be part of the renovation works.
Priority components	Prefabricated façade systems and timber-frame (HSB) wall elements, integrated window and door systems with glazing and airtight/fire-resistant detailing, multi-layer roof insulation modules, prefab ventilation roof caps, modular kitchen units, bathroom/toilet finishes, PV components and selected circular material streams such as flat glass and partly window frames.
Target building typology	Repeated residential building typologies, especially post-war multi-family apartment blocks and row houses. The pilots include four portico-style apartment blocks from 1957 in Hoensbroek/Heerlen with 36 apartments, and a residential block in Daalhoff/Maastricht with 145 apartments. The source typology is described as a building block with brick and sand-lime-brick structure and external cavity walls.
Design intent	Create sufficient scale and scope within a district or region by bundling similar buildings into a larger renovation package. The concept combines mass-customisation, modular renovation packages, local supply-chain coordination, digital geometry/BIM support, low disturbance on site and shorter construction time at the building.
Best-fit conditions	Best suited to repeated building typologies, clustered renovation demand, limited on-site space, occupied housing renovation, local suppliers that can deliver standardised components, and procurement-compatible project structures such as framework agreements, innovation partnerships or integrated design-build contracts.

8.1.2. Factory Layout & Production Logic

Factory typology	Semi-permanent or permanent district/assembly setup rather than a small mobile container. The PuF logic is distributed between off-site manufacturing, district-level assembly/coordination and on-site assembly/service activities.
Production workflow	1) Identify similar buildings and define a bundled renovation package; 2) carry out point-cloud/BIM-supported design and engineering; 3) manufacture or pre-assemble façade, window, roof and selected interior modules off-site; 4) stage and coordinate materials through a district/local supply-chain setup; 5) deliver components just in time; 6) remove existing windows/facade elements; 7) install prefabricated façade/window systems and finish carpentry; 8) execute parallel interior, ventilation, heating, PV and asbestos-related works where required.
Main production streams	Three main workflows are identified: insulation shell works for façade and roof, installation of window frames or prefabricated façade systems, and energy-related works. Interior systems and finishing are also included, although not all workflows are equally suited to PuF logic; the window-frame/facade-system stream has the strongest repetition and mass-production potential.
Dimensions / space allocation	The pilot data does not define a fixed factory footprint. On site, assembly space depends on the product and building. Storage or buffer space near the building is typically about 60-100 m². A site setup may also include two containers, one for materials and one for the team, plus crane or hoist access for buildings above four floors.
Operational scale	Pilot reference scales are 36 apartments in Hoensbroek/Heerlen and 145 apartments in Daalhof/Maastricht. The intended scale-up logic is not one building at a time, but a district or portfolio of similar buildings offered as a larger renovation package.
Production / installation cadence	Vertical outside works are reported as about 28 days per block of 9 apartments in Heerlen, or about 1 day per apartment for the Maastricht façade system. Horizontal inside-apartment works are reported at around 18 days per apartment, while the R4 implementation table summarises the on-site operation as about 20 days per apartment depending on conditions.

8.1.3. Resources & Utilities

Power & electricity	Three-phase electricity is required on site. The exact kW requirement is not specified in the pilot data and depends on the selected products, hoisting/cutting equipment and temporary construction-site setup.
Water & sanitation	Water is required for site and interior works, especially bathroom/toilet/kitchen-related renovation. Drainage is preferred where wet works are carried out. Exact water volumes are not specified in the pilot data.
Heating, cooling & ventilation	No dedicated factory HVAC system is defined. Building-side renovation can include heating-system upgrades and mechanical/balanced ventilation installation. Occupied-building working conditions and temporary resident arrangements remain important operational constraints.
Digital infrastructure	BIM software is used where possible; point-cloud or advanced geometric surveys can support design, engineering and production. The concept also highlights digital material passports, retrofit roadmaps, predesigned BIM catalogues and coordination tools for standardised renovation packages.
Equipment and materials	Cutting/gluing equipment, work benches, material storage, transport/loading areas, crane or hoist equipment, PPE and product-specific installation tools.

8.1.4. Site & Logistics

Site preconditions	A coordinated site layout is required with space near the building for storage, staging/loading, team facilities and safe resident circulation. Works are often performed in occupied buildings, so low disturbance, clear communication with tenants and careful sequencing are essential.
Access constraints	Truck and car access are needed. Typical working hours in occupied buildings are 7:00-16:00; in some cases the practical noise window may be 9:00-15:00. Public-space use is normally avoided, but in narrow sites a permit for public-space occupancy may be required.
Supply chain integration	The model links housing-association demand, a main contractor/system integrator, off-site or district assembly, and specialised subcontractors for façade systems, carpentry,

	masonry, PV, insulating glass, ventilation, tiles and kitchen components. JIT coordination is important because onsite storage is limited.
Storage & buffer strategy	On-site storage is typically around 60-100 m². The approach relies on small local buffers and early site planning rather than large intermediate storage areas. A private apartment or lockable space in the block may be used by contractors for personal items.
Waste handling	Waste streams include packaging, cardboard, leftover paint, old façade/window elements, selective demolition waste, and asbestos-related waste where applicable. The main contractor is responsible for waste management and coordinates specialist handling for asbestos and regulated streams.
Last-mile logistics	Prefabricated or partially pre-assembled components are moved from the off-site/district setup to the construction site by truck and then handled by the main contractor and subcontractors. Crane access is required for works above four floors.

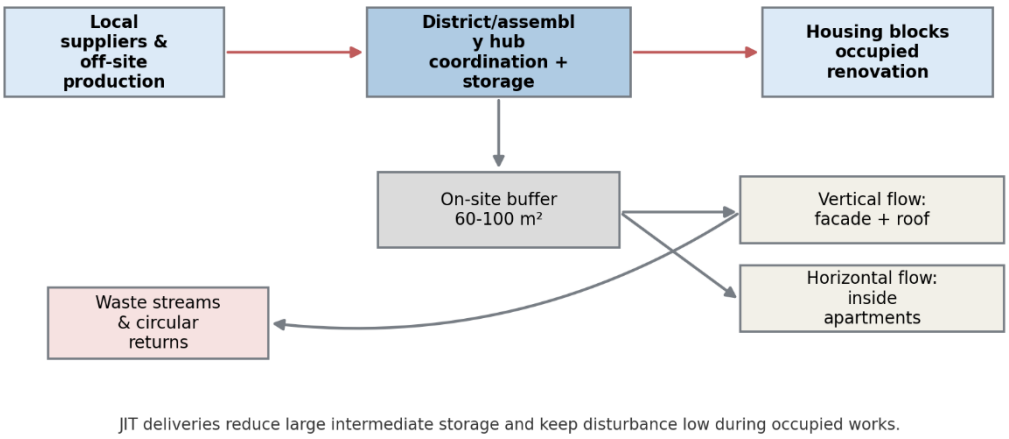


Figure 51: Indicative District Factory site and logistics setup

8.1.5. Actors, Roles & Governance

Factory owner / operator	No single dedicated factory owner is defined in the pilot data. Operationally, the main contractor acts as the central coordinator/operator for site and supply-chain activities, supported by subcontractors and suppliers.
Client / contracting authority	Local housing associations, with Woonpunt identified in the Dutch pilot context, act as the client, asset owner, demand-side partner and governance lead.
Contracting and payment	The housing association signs contracts with the architect and the main contractor selected through tendering. The main contractor then contracts or coordinates the subcontractors and suppliers. The housing association pays for the renovation works.
Demand-side partners	Housing association as owner/client, tenants as end users, structural advisors, fire-safety and asbestos advisors, roofing-system and maintenance advisors, and concrete-component advisors.
Supply-side partners	Main contractor BCG, architecture studio, circular façade-system subcontractor, carpentry subcontractor, masonry subcontractor, PV subcontractor, insulating-glass subcontractor, ventilation-system subcontractor, tile subcontractor and kitchen-component subcontractor.
Governance lead	The housing association leads strategic decisions and procurement. The main contractor leads operational coordination, subcontractor management, site logistics, safety and resident-facing execution planning.

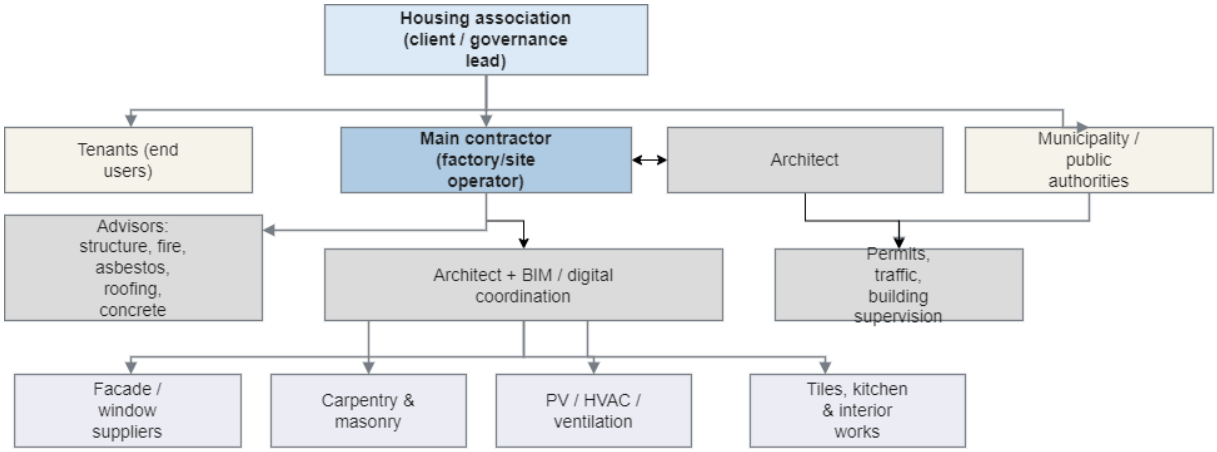


Figure 52: Stakeholder and governance structure of the Dutch District Factory

8.1.6. Labour Force & Required Skills

Typical team	No fixed PuF team size is specified. Labour is organised through the main contractor and product-specific subcontractors. The site model favours a small group of disciplines at the building site, supported by off-site or district-level preparation.
Core roles / indicative FTE	Site/factory supervisor, installer team lead, façade/window installers, carpentry and masonry workers, PV installers, HVAC/ventilation technicians, crane/hoist operators, BIM/CAD or digital-production coordinator, tenant liaison/resident manager, H&S officer, and specialist asbestos contractors where required.
Skills and certifications	Project-management experience, product-specific design-to-installation skills, façade/window installation, airtight/fire-resistant detailing, glazing, timber-frame and carpentry work, lifting/hoisting competence, asbestos-removal certification where needed, BIM/CAD coordination and occupational safety skills.
Training needs	Training depends on the product and supplier. Recommended training areas include energy-neutral building and renovation, integral construction budgeting, risk management, quality management, construction-process communication, and product-specific operator/installer training.
Labour sourcing	Main contractor selected by competitive tender, supported by subcontractors and local/regional suppliers. Workforce availability is a key dependency in smaller regional markets.
Shift model	One shift is indicated for occupied buildings, typically around 7:00-16:00, with shorter noise-sensitive windows possible depending on tenant conditions and local agreements.

8.1.7. Legal & Regulatory Requirements

Omgevingsvergunning	The environmental/building permit is the overarching permit for renovation. It is issued by the local municipality and has an indicative lead time of 8-14 weeks where the renovation does not deviate from the zoning plan and is not heritage-protected. It includes the demolition permit component. An environment and planning permit for flora and fauna activities (Omgevingsvergunning voor een flora- en fauna-activiteit) is often also needed as the construction/renovation works might disturb or harm protected animals and plants. Although the time to receive a flora and fauna permit is 8 weeks, some measures need to take place one year prior the beginning of the works.
Asbestos notification / work plan	Asbestos-containing materials require formal notification and an approved work plan through the relevant inspection authority. Indicative lead time is about one week without complications. Risk Class 2 and 2A works require specialised certified contractors and an asbestos-free declaration after completion.
Terrain and traffic management	A Bouwplaatsinrichtingsplan (BIP) or site layout plan is required for transport, waste disposal and emergency routes. It is approved by the municipality, fire department and traffic police. Indicative lead time is 1-3 weeks, longer for complex cases.

Local building supervision	The contractor must notify local Building and Housing Supervision before structural or special activities. Under the Omgevingswet and Wet kwaliteitsborging voor het bouwen context, the start notification includes a quality-assurance plan and risk assessment and is submitted two days before the start.
Procurement and contracting	Housing corporations operate in a regulated procurement environment. Larger projects may require competitive tendering aligned with Dutch and EU public-procurement rules, so local PuF ecosystems need procurement-compatible structures such as framework agreements, innovation partnerships or integrated design-build contracts.
Incentives / subsidies	Desk-researched support options include SAH for gas-free rental housing, with approximately EUR 1,200-5,000 per dwelling, and related rental-housing sustainability subsidies. Earlier SPOR-type support is noted as no longer a standalone national scheme name; reported support levels are around EUR 4,000-7,000 per dwelling in larger gas-free renovation programmes.

8.1.8. Cost Structure

CAPEX	No CAPEX range is provided in the pilot data. Main cost elements are expected to relate to product-specific manufacturing or pre-assembly capacity, design/BIM coordination, site setup, containers/team facilities, crane or hoist access, and contractor/subcontractor mobilisation.
OPEX	No monthly OPEX range is provided in the pilot data. Operating costs are project-specific and include contractor and subcontractor labour, logistics, temporary site utilities, site facilities, tenant coordination, waste management and specialist works such as asbestos removal.
Cost basis	No €/m² value is reported for the District Factory model in the available data. Costs should therefore be treated as project-based and dependent on building typology, façade/system scope, number of apartments, site constraints and procurement outcome.
Revenue / value logic	For the housing association, value is mainly indirect and regulated rather than a direct factory revenue stream. Benefits may include asset-value improvement, rental-income stability, subsidy access, reduced disturbance, improved energy performance and potentially lower transaction cost through bundled demand.
Financing model	Dutch housing-association investments can be financed through WSW-guaranteed loans, reducing risks and interest rates. Equity is partially included in recent housing-association business schemes. Grant support may be available through relevant sustainability or gas-free housing schemes.
Payment chain	Housing Association -> Architect; Housing Association -> Main Contractor -> Subcontractors. No reuse-sales inventory owner is defined in the pilot data.
Value Creation	District Factory creates value by functioning as a regional system integrator that aggregates demand and coordinates multiple projects and stakeholders. Through process standardization and supply chain alignment, it reduces fragmentation and transportation costs
Value Capture	Value is captured through coordination and facilitation fees embedded in programme-based arrangements, as well as indirect efficiency gains achieved through economies of scale and improved resource allocation.
Value Delivery	Value delivery is realised through programmatic coordination, including shared logistics, standardised quality assurance, and structured collaboration mechanisms across projects, resulting in increased predictability and scalability.

8.1.9. Business Model Canvas

Value proposition	System-level optimisation by aggregating demand, aligning stakeholders, and reducing fragmentation across projects
Customer relationships	Housing associations, municipalities, and institutional asset owners with aggregated portfolios
Channels	Long-term programme-based partnerships with institutional clients enabling continuity and scaling
Customer segments	Programme-level coordination structures, often supported by governance frameworks and digital tools

Key activities	Demand aggregation, planning, standardisation, and coordination of multiple projects and stakeholders
Key resources	Governance mechanisms, digital coordination platforms, and stakeholder networks
Key partners	Housing organisations, contractors, municipalities and regulatory bodies
Revenue streams	Fees for coordination, programme management and system-level services
Cost structures	Costs related to governance, coordination, programme management and digital infrastructure

8.1.10. Lifecycle & Time Schedule

Setup & commissioning	The 36-apartment case reports an overall setup duration of around 50 weeks, including 2 weeks of work preparation and about 3 days for construction-site setup. Procurement can take approximately 3-6 months, including preparation/publication, tendering, evaluation and award.
Permits and preparation	Permit approval is indicated at around 8 weeks, with additional time where environmental aspects, heritage protection, asbestos removal or zoning-plan issues are involved. Start of operations is indicated about 2 weeks after preparation milestones are completed.
Operational phase	On-site duration is approximately 20 days per apartment depending on project-specific conditions. For outside works, the Dutch narrative gives about 28 days per block of 9 apartments in Heerlen and about 1 day per apartment for the Maastricht façade system. Interior horizontal flow is around 18 days per apartment.
Decommissioning / wrap-up	No specific decommissioning duration is defined. Because the model is a district/assembly coordination setup rather than a temporary mobile factory, wrap-up is expected to consist mainly of removing temporary site facilities, clearing storage/staging areas and completing handover documentation.
Main dependencies	Permit sequencing, sufficient space near the building, management of inhabitants during occupied works, product and material availability, subcontractor coordination, workforce availability and design freeze conditions.

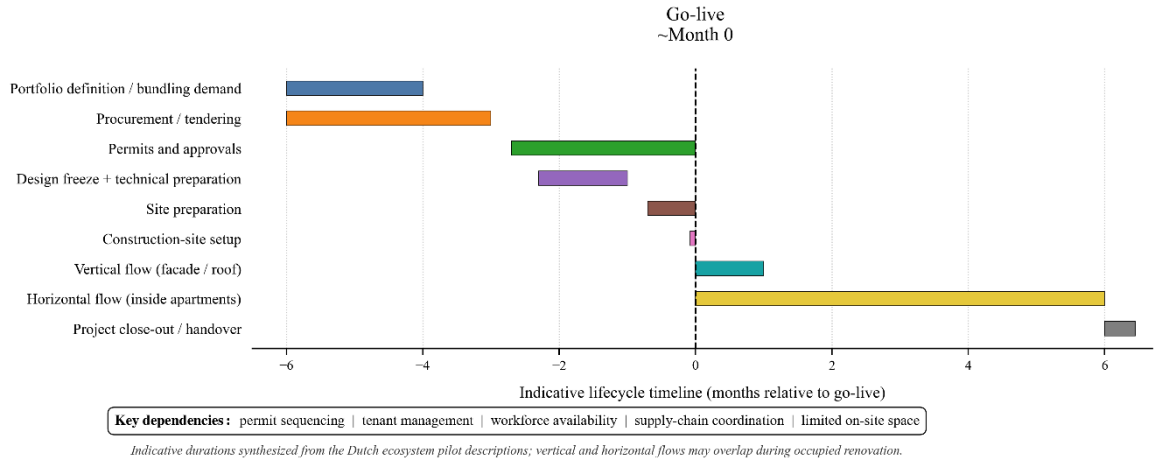


Figure 53: Indicative District Factory Life-cycle Timeline

8.1.11. Risks & Contingencies

Limited storage near building	Mitigation: early coordination with the municipality and careful site planning. Owner: contractor.
Product supply delays	Mitigation: early site-plan setup and supply-chain coordination. Trigger: component delivery delayed by more than 1-2 weeks from plan. Owner: supply-chain coordinator or contractor.

Presence of asbestos	Mitigation: request asbestos evaluation early, ideally directly after tender or before tender where possible. Owner: main contractor.
Shortage of skilled circular-product manufacturers	Mitigation: plan early integration of suppliers from outside the region when needed and use training incentives. Trigger: inability to secure the right workforce to respond properly to the tender. Owner: main contractor.
Procurement constraints	Mitigation: use procurement-compatible structures such as framework agreements, innovation partnerships, or integrated design-build contracts rather than relying on direct selection of predefined local supply chains.
Occupied-building disruption	Mitigation: clear tenant communication, temporary arrangements for residents who remain at home, careful noise-window planning, phased apartment-by-apartment sequencing and low-disturbance logistics.

8.1.12. Scalability & Impact

Scalability approach	Scale through bundled district or regional renovation packages, repeated building typologies, standardised processes, modular products, increasing use of digital tools and coordination by the main contractor.
Distance threshold	The source document describes the scaling distance as within the region. The general BUPS framework defines district-level factories within about 30 km and regional-level factories up to about 100 km, so the Dutch model is best understood as a district/regional clustered approach rather than a long-distance supply chain.
Storage / volume threshold	No fixed storage duration, production volume or district-size threshold is provided. The practical limits are site space, workforce availability, product supply, tenant coordination, crane/access constraints and the availability of similar buildings within a coherent renovation package.
Adaptability mechanism	Adaptability is achieved through standardised processes, modular products, mass-customised variation, BIM/point-cloud-supported design, local supply-chain coordination and a building-module approach rather than a purely one-off project approach.
Environmental impact	Expected impacts include improved energy labels from below D toward A/B, thermal-envelope improvement, PV installation, smart ventilation, reuse of flat glass, circular wooden window-frame strategies, selective demolition, reduced transport through efficient planning and lower embodied-carbon material choices.
Social impact	The model supports occupied social-housing renovation with lower disturbance, improved comfort and energy performance, local/regional supply-chain participation, and more predictable delivery for housing associations and tenants.
Digital tools	BIM software is used where possible. Required features include geometry capture, design coordination, product/module catalogues, retrofit roadmaps, material-passport information and schedule/logistics coordination.

8.2 Assembly Factory Factsheet

8.2.1. Scenario & Strategy

PuF type	Assembly Factory, closely linked to a mobile/on-site reuse operation. In the Austrian ecosystem this is implemented as the Re-Use Box / Social Urban Mining approach.
PuF purpose	Identification, documentation, dismantling, sorting, temporary storage, matchmaking, and sale/redistribution of reusable building components before demolition.
Deep renovation / reuse scope	Not a conventional whole building deep retrofit package. The Re-Use Box deals with all potentially reusable components in buildings scheduled for demolition or major redevelopment.
Priority components	Furniture, doors, flooring, wall coverings, sanitary and interior components, electrical products, installations, cooling units, windows, facade elements, steel beams, concrete elements, roof trusses, and other reusable construction products.
Target building typology	Buildings larger than roughly 2,000 m² are preferred, especially office buildings, factory buildings, healthcare facilities, educational buildings, hotels, shops, and large redevelopment assets.

Design intent	Turn the demolition site into a temporary reuse operation, supported by a Social Urban Mining concept, screenbook/checklist, documentation tool, and local social economic partners.
Best-fit conditions	A client willing to engage in reuse planning; a sufficiently large building; at least 3 months for exploration and planning; at least 2 weeks of operational time; truck access; construction power; sanitary facilities; and temporary storage space.

8.2.2. Factory Layout & Production Logic

Factory typology	The current concept is less dependent on one fixed container. The building itself becomes the operational disassembly zone, with a defined contact point/office and controlled access.
Production workflow	1) Social Urban Mining concept and pre-demolition audit; 2) inventory and quality categorisation; 3) buyer/matchmaking process; 4) controlled dismantling; 5) sorting, packaging, documentation and temporary storage; 6) collection by new owner/buyer; 7) evaluation.
Component categories	Easy reuse: doors, furniture, flooring, wall coverings, and interior items. Reuse with checks: electrical products, installations, cooling units, and sanitary components. High-effort reuse: windows, façade elements, beams, concrete elements, and roof trusses.
Dimensions / space allocation	The whole building is used for dismantling. Recommended minimum storage: around 100 m²; site specific storage examples indicate around 200 m². Staging/loading area: around 20 m². Site office/contact point: around 20 m². Social room: about 20–100 m² depending on team size.
Operational scale	Experience covers buildings from roughly 1,000 m² to 60,000 m². Potential reuse value can range from 0 EUR in devastated vacant buildings to up to about 350,000 EUR in large building complexes still in use.

8.2.3. Resources & Utilities

Power & electricity	Construction site power is mandatory. Typical requirement: 240 V minimum; 400 V three-phase preferred; around 5 kW indicated for lighting and operational activities. Generator use may be considered where site power is unavailable.
Water & sanitation	Water and greywater solutions are required for social/sanitary needs. Rule of thumb: 1 mobile toilet per 5 workers.
Digital infrastructure	Internet/WiFi is required for documentation, sales, payment, coordination, and inventory processes. Tablet based documentation and a digital tool based on Odoo/open source database logic are indicated.
Equipment and materials	Documentation devices/camera, PPE, emergency equipment, tools and working materials, packaging materials/pallets, barrier tape, construction diary, legal information package, waste bins and separated collection facilities.

8.2.4. Site & Logistics

Site preconditions	Controlled building access, one defined entry point, secured/no-go areas, construction road or truck access, parking/entrance area, sanitary facilities, storage area, office/contact point, and building/site fencing where needed.
Access constraints	Best case: truck/lorry access. Public space use may require permits and additional lead time. Time windows are agreed with the building owner and must fit the deconstruction schedule.
Supply chain integration	Reusable components are identified and matched with buyers during planning. The PuF operator avoids long term storage and generally stores only already sold components temporarily until delivery/collection.

Waste handling	Reuse activities improve waste separation quality. Residual waste, packaging waste, and specific dismantled materials are separated on site; responsibility is assigned to the PuF operator and/or building owner framework depending on contract.
Last mile logistics	Final transport and integration into new construction or refurbishment projects is normally the responsibility of the buyer/new owner, not the Re-Use Box operator.

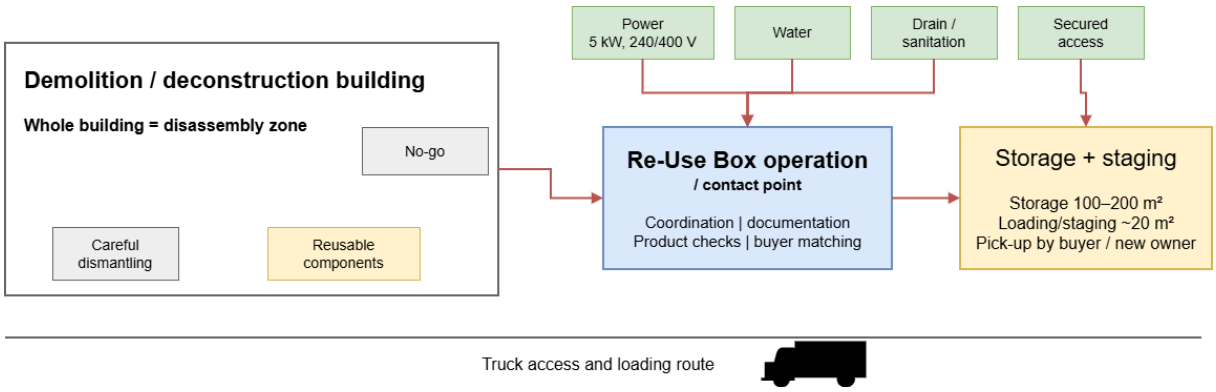


Figure 54: Indicative Re-Use Box site setup showing the whole-building disassembly zone, controlled entry, no-go areas, storage, office/contact space, loading/staging area, and required truck access.

8.2.5. Actors, Roles & Governance

Factory owner / operator	The Re-Use Box is operated by BauKarussell or the responsible Social Urban Mining organiser.
Client / contracting authority	Building owners, public or private, can decide on reuse oriented deconstruction and commission the Re-Use Box process.
Contracting and payment	Contracts are signed between the building owner and the Re-Use Box organiser. The building owner pays, with co-financing potential through revenues from reuse sales.
Demand side partners	Building owners, public and non-profit housing organisations, buyers of reused components, redevelopment actors, and clients interested in circular construction.
Supply side partners	BauKarussell, local social economic enterprises, general contractors, planning experts, dismantling companies, original producers, circular economy start-ups, certification bodies, authorised professionals, and insurance companies.
Governance lead	Building owner for project decisions; Re-Use Box organiser for operational planning, documentation, dismantling coordination, sales/matchmaking, and evaluation.

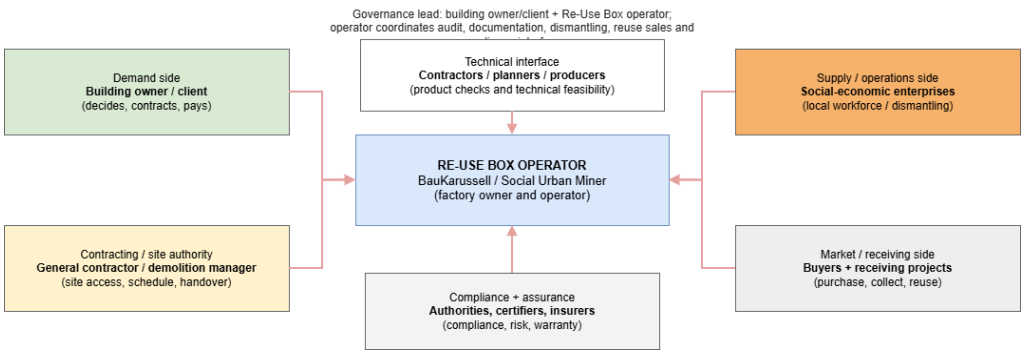


Figure 55: Stakeholder and governance structure of the Re-Use Box

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8.2.6. Labour Force & Required Skills

Typical team	Typical operational team: one lead/head and around 4–5 workers. Additional teams from different social partner organisations can be organised for larger buildings.
Core roles / indicative FTE	Site/factory supervisor: 0.2 FTE; production/assembly operative: 0.1 FTE; logistics/warehouse handler: 0.3 FTE; electrician: 0.05 FTE; unskilled labourers through socioeconomic partners.
Skills and certifications	Reliability is important because workers may handle cash and customer interaction. Product specific certificates may be required for electrical, technical, HVAC, cooling, facade, or structural components.
Training needs	Training as Social Urban Miner is strongly recommended; approximate duration: 3 days. Retail/customer contact onboarding is also needed for public Re-Use Box operation.
Labour sourcing	Mixed models using local social economic enterprises, subcontracting, and partner workforce.
Shift model	One shift. Opening hours comparable to retail, adjusted to site and client conditions.

8.2.7. Legal & Regulatory Requirements

Pre-demolition audit	Required according to Austrian waste management and recycling material rules. It defines safe working conditions, waste law limitations, and documentation requirements. Lead time: at least 3 months for building evaluation and chemical analysis.
Other legal acts	Relevant rules may include waste management law, recycling building materials ordinance, Austrian standard ONORM B 3151, trade regulation, electrical engineering law, REACH/chemical regulation, F gas rules, product certification and CE-related requirements.
Compliance issue	The legal framework is not fully designed for reuse products. Testing, certification, warranty, insurance, and end of waste questions can limit the sale of certain reused components.
Incentives / subsidies	Possible regional public funding schemes for sustainable business and circular economy support, such as WIN, OKOPLUS, OekoBusiness Wien, and KPC circular economy related programs. Eligibility and value are region and call specific.

8.2.8. Cost Structure

CAPEX / company baseline	Approximately 1,800 EUR/month for the legal entity to run the company; Re-Use Box is one service of this company. Includes rent, insurance, accounting, phone/internet, IT devices, software, hand tools, fees, and taxes.
OPEX	Approximately 1,000 EUR/month of operation, including travel costs, certifications, and subcontracting costs.
Project personnel cost range	Approx. 15,000–30,000 EUR depending on building size and condition, mainly for personnel costs to organise and operate the Re-Use Box.
Cost basis	Analysis: around 1–2 EUR/m² depending on size and state of the building. Operation: around 1.5–2.5 EUR/m².
Social Urban Mining concept	Detailed exploration/Social Urban Mining concept: approximately 5,000–10,000 EUR depending on building size and location.
Revenue / value logic	Reuse sales can create “negative cost” or co-financing potential. The building owner and buyers of reused components form the payment/revenue chain. Reuse value depends on product quality, demand, certification effort, and buyer matching.
Value creation	The Austrian Re-Use Box creates value by identifying, dismantling, and redistributing reusable building components directly from demolition sites. This transforms waste into valuable resources while generating environmental and social benefits. The museum-like exhibition communicates their work to external parties.

Value capture	Value is captured through service contracts with building owners and through revenue generated from the resale of reusable components. Additional value is created through avoided disposal costs and measurable sustainability impacts.
Value delivery	Value delivery is fully integrated into the construction site, where materials are catalogued, marketed, dismantled, and transferred to new users. The process involves coordination with buyers, social enterprises, and logistics directly on site.

8.2.9. Business Model Canvas

Value proposition	Fast, repeatable and standardised renovation processes, with variants ranging from efficiency-driven to circular assembly
Customer relationships	Contractors, developers, and housing organisations executing renovation projects
Channels	Primarily project-based operational relationships with contractors and housing organisations
Customer segments	Near-site logistics with just-in-time delivery integrated into construction workflows
Key activities	Assembly of prefabricated components, installation, and coordination of site logistics
Key resources	Assembly facilities, trained labour force, and digital tools such as BIM
Key partners	Prefabrication suppliers, contractors and logistics providers
Revenue streams	Project-based or per-dwelling service fees linked to assembly and installation activities
Cost structures	Labour, facility setup, transport and logistics costs for assembly operations

8.2.10. Lifecycle & Time Schedule

Setup & commissioning	Minimum 3 months, ideally 6 months. Includes Social Urban Mining concept, pre-demolition audit, contract, permits/compliance, buyer search and operational planning.
Operational phase	Typically 2 weeks to 2 months depending on building size, available schedule, storage allowance and buyer matching.
Decommissioning / wrap up	Approx. 2 days for removal of temporary setup, close-out documentation, remaining sold items and site handover.
Main dependencies	Owner mindset, demolition timeline, matchmaking duration, local social-economic partners, storage permission, power, water, sanitation and access.

8.2.11. Risks & Contingencies

High negotiation effort without realisation	Mitigation: standardise offer, screen opportunities early, and stop quickly where reuse potential or client commitment is too low.
Legal restrictions and misunderstandings	Mitigation: training, structured communication with authorities, clear documentation and compliance strategy.
Long lead time from negotiation to operation	Mitigation: focus on promising projects, define decision gates, and align early with deconstruction schedule.
Product failure / quality uncertainty	Mitigation: written quality checks, product specific testing/certification where needed, and clear communication of acceptance criteria.
Continuity of operations	Mitigation: portfolio management of multiple projects, operational planning, and workload monitoring.
Reuse sales below estimates	Mitigation: present sales values as estimates, agree liability boundaries, and evaluate against the Social Urban Mining concept.

8.2.12. Scalability & Impact

Scalability approach	Multi-site coordination, process standardisation, digital documentation/sales tools, second-hand material market platforms, and continuous clarification of legal compliance for new product groups.
Distance threshold	Local to regional level; roughly up to 50 km is indicated as a practical estimate aligned with building sector logistics.
Storage threshold	No fixed maximum, but long-term storage should be avoided. The operator generally stores only already sold components temporarily until collection/delivery.
Volume threshold	Limited mainly by building site conditions, available reusable products, workforce, storage, buyer matching, and available operational time.
Environmental impact	Reuse of building components increases resource efficiency, reduces waste, and improves separation quality for remaining waste streams.
Social impact	Cooperation with social economic enterprises supports reintegration of long-term unemployed people and creates local social value.
Digital tools	Tablet based documentation and placement/sales/stock control tool based on Odoo/open-source database logic; required features include documentation, sales, stock control, traceability, and payment support.

8.3 Mobile On-Site Factory Factsheet

8.3.1. Scenario & Strategy

PuF type	Mobile On-Site Factory, developed as a truck/container-based service for reused sanitary equipment.
PuF purpose	Careful removal, checking, cleaning, disinfection, refurbishment, packaging, temporary storage and re-employment of sanitary equipment directly linked to rehabilitation projects.
Deep renovation / reuse scope	Not a conventional whole-building deep retrofit package. The PuF focuses on the interior sanitary-equipment stream within rehabilitation works, especially bathrooms/toilets in social housing.
Priority components	WC units, sinks, baths, stainless sinks and other ceramic or sanitary elements that can be cleaned, checked and prepared for reuse.
Target building typology	Residential buildings and public housing, especially multi-family apartment blocks, social housing and similar community/public residential assets.
Design intent	Bring reconditioning close to the deconstruction or rehabilitation site, reduce intermediate storage, support just-in-time local reuse, and maximise the quantity of sanitary equipment re-employed.
Best-fit conditions	Occupied or fast-track renovation where apartments are renovated sequentially, sanitary equipment must be removed/replaced quickly, local storage is limited, and nearby receiving projects or marketplaces can absorb reusable equipment.

8.3.2. Factory Layout & Production Logic

Factory typology	Mobile workshop truck or ISO-container module transported to site. A 20-foot container provides roughly 15 m² and a 40-foot container roughly 30 m²; additional modules can be added for storage.
Production workflow	1) Diagnostic and assessment; 2) analysis to decide re-employment; 3) careful removal by a specialised company; 4) cleaning, disinfection, checking and refurbishment; 5) packaging and temporary storage; 6) reinstallation, transfer to another site or marketplace distribution.
Component handling	The process replaces or checks items such as flush mechanisms, drains, siphons and mounting kits where required, while equipment that is too deteriorated is routed to recycling or waste treatment.
Dimensions / space allocation	Indicative working module: approx. 30 m². Storage modules can range from about 15 to 50 m². A storage and staging area of about 50 m² around the truck is identified for on-site operation.
Operational scale	Expected processing capacity is about 3 apartments per day, corresponding to roughly 10-15 sanitary elements per day. A scalable threshold of about 60 units per week per mobile unit is indicated.

8.3.3. Resources & Utilities

Power & electricity	Connection to the construction-site power grid is required. A plug-and-play electrical connection is recommended; no fixed kW value is specified in the available pilot data.
Water & sanitation	Clean water access and water drainage/wastewater evacuation are required for washing, disinfection and operational hygiene.
Digital infrastructure	Internet is not mandatory for basic operation, but digital traceability, FDES documentation and communication between mobile units are needed for scaled deployment.
Equipment and materials	Workbench, shelving, power supply, wastewater evacuation, lifting and handling equipment, high-pressure cleaner, hand tools, PPE, cleaning/disinfection products and replacement mounting/plumbing kits.

8.3.4. Site & Logistics

Site preconditions	Dedicated area for truck/container deployment without disrupting site operations, access for container truck, power grid connection, clean water access, drain/wastewater route and around 50 m² storage/staging area.
Access constraints	The site must allow container-truck access. Authorisation to deploy the mobile unit on the site may be required from the public authority, site owner or project owner, with around one month indicated as lead time.
Supply chain integration	The model links local source sites and local demand sites through just-in-time matching. Reconditioned equipment can return to the same project, go to another receiving site or be distributed through marketplace-type platforms.
Waste handling	Waste from refurbishment is treated as construction waste and should be integrated into the project owner's waste-management plan. Equipment too deteriorated for refurbishment is handled by the refurbishment company through an appropriate recycling route.
Last-mile logistics	The mobile-unit operator provides the reconditioning equipment; the construction/project owner provides power and water access. Container transport is outsourced to transport companies where needed.

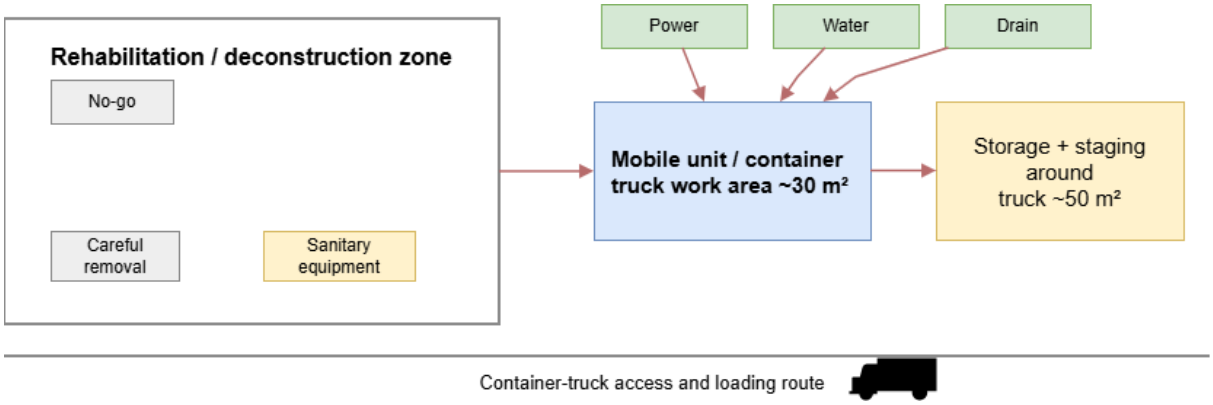


Figure 56: Indicative mobile-unit site setup showing the rehabilitation zone, truck/container work area, storage/staging space, utilities and access route.

8.3.5. Actors, Roles & Governance

Factory owner / operator	FAVRE / the mobile-unit leader is indicated as the concept developer and initial operator of the mobile on-site factory.
Client / contracting authority	Domofrance acts as the pilot social-landlord client and provides the residential building and sanitary equipment to be reconditioned.
Contracting and payment	The intended contract chain is between the project owner, such as Domofrance, and the mobile-unit leader. FAVRE invests financially in the concept and is indicated as owner of revenue/inventory.

Demand-side partners	Social landlords, housing companies, public authorities, property developers and other project owners with residential renovation assets suited to sanitary-equipment reuse.
Supply-side partners	Plumber companies / FAVRE, rehabilitation specialists, Compagnons Bâtisseurs for workforce or implementation capacity, transport companies, installation companies and reuse marketplaces.
Governance lead	FAVRE leads the mobile-unit operation; Domofrance leads the pilot demand side; Ecominéro is identified as a potential funding supporter for reuse initiatives.

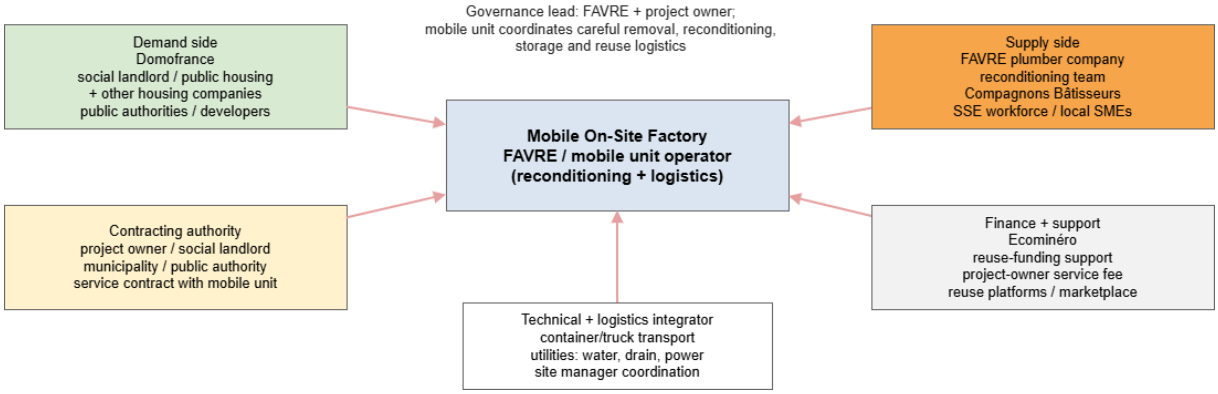


Figure 57: Stakeholder and governance structure of the French Mobile On-Site Factory.

8.3.6. Labour Force & Required Skills

Typical team	One site/factory supervisor per project or deployment, supported by about four technicians per unit depending on demand and building size.
Core roles / indicative FTE	Supervisor: 1 per deployment. Maintenance/refurbishment technicians: about 4 per unit, with two for careful removal and two for reconditioning. QA/QC inspector: periodic checks.
Skills and certifications	Manual handling and lifting, plumbing and sanitary-equipment maintenance, refurbishment process knowledge, quality control and traceability, logistics/project management and ADR awareness if chemical products are transported or stored.
Training needs	Initial onboarding and safety training: about 2 days. Process and tooling training for refurbishment operations: about 1 week. Periodic HSE refresher training depending on regulations and cleaning products used.
Labour sourcing	Mixed model using local hires, subcontractors, partner workforce and potentially Social and Solidarity Economy organisations or professional-integration pathways.
Shift model	One-shift / flexible deployment model adjusted to the construction-site schedule and apartment-by-apartment renovation cadence.

8.3.7. Legal & Regulatory Requirements

Chemical transport / use	Transport or storage of cleaning/disinfection products must comply with relevant chemical-safety requirements, including REACH and ADR awareness where applicable. The concept seeks to avoid hazardous chemical products where possible.
Site deployment authorisation	Deployment of the truck/container on a specific site area may require authorisation by the public authority, site owner or project owner. Lead time: around one month. Conditions include utility access and no disruption to site operations.
Construction and labour rules	Temporary construction-site structures may be exempt from building permits under defined conditions, but the working area remains subject to labour-code health and safety requirements.
Electrical / product documentation	Power supply must follow applicable electrical standards such as NF C 15-100. Disinfectant products and reused components may require documentation through FDES/INIES and traceability procedures.
Incentives / policy context	No direct subsidy is identified in the pilot data. However, French circular-economy policy, AGEC/PEMD diagnostic requirements, PMCB extended producer

	responsibility, RE2020 and CSRD/taxonomy create a favourable reuse-policy context.

8.3.8. Cost Structure

CAPEX	Approx. 62,000 EUR for the container/mobile factory, including container, workbench, interior layout, shelving, power supply, wastewater evacuation, lifting/handling equipment, tools, PPE and consumables.
OPEX	Approx. 1,200 EUR per housing unit for reconditioning-related work, including careful removal, disinfectant application, replacement of flush mechanism/drain/siphon and mounting kit.
Cost basis	No €/m² basis is used. Costs are expressed per housing unit / per mobile unit and depend on number of dwellings, equipment condition and the amount of reconditioning required.
Revenue / value logic	Revenue assumption: approx. 1,800 EUR per housing unit. Value is generated through avoided purchase of new sanitary equipment, reuse sales/service fees and reduced disposal/waste impacts.
Financing model	Grant and equity-type financing are indicated, with FAVRE identified as investor/operator. The final business model and payback logic require validation.
Value creation	The French Service Factory creates value by facilitating coordination, knowledge integration, and alignment across stakeholders involved in circular renovation processes. It strengthens the organisational capacity required to implement reuse strategies at scale.
Value capture	Value is captured through consultancy and facilitation fees, often embedded in programme or platform-based services, alongside system-level efficiency gains generated across the ecosystem.
Value delivery	Value delivery takes place through stakeholder engagement, advisory services, and the use of digital platforms to align supply and demand, supporting coordinated and scalable implementation of circular practices.

8.3.9. Business Model Canvas

Value proposition	On-site integration of deconstruction, processing, and reuse, enabling circular material flows, reduced logistics, and shorter renovation cycles
Customer relationships	Contractors, demolition companies, and actors focused on circular reuse and waste reduction
Channels	Short-term, project-based collaboration focused on specific demolition or renovation sites
Customer segments	Fully embedded on-site delivery, directly integrated into demolition and renovation activities
Key activities	Selective deconstruction, sorting, reconditioning, and immediate reuse of materials on site
Key resources	Recovered building materials, skilled local labour, and temporary site-based infrastructure
Key partners	Demolition firms, social enterprises, contractors and circular economy actors
Revenue streams	Service-based revenues from reuse operations combined with income from resale of recovered materials
Cost structures	Labour-intensive operations, site setup, and logistics linked to material handling and reuse

8.3.10. Lifecycle & Time Schedule

Setup & commissioning	Approx. 3 months for project leader/funding, mobile-unit or truck adaptation and operational preparation. Earlier workshop input noted up to one year as an optimistic period for project leader/funding and adaptation.
Operational phase	On-site/project duration depends on the number of housing units in the building; approx. 6 months is indicated for a representative project.

Decommissioning / relocation	Approx. 0.5 day to remove the mobile unit from site, plus about 0.5-2 days to clear out or renovate the interior of the module.
Milestones	Funding secured and permits approved are indicated as done; design freeze/testing around May 2026; procurement around June 2026; start of operations around July 2026.
Main dependencies	Funding/project leader, worker motivation and availability, site authorisation, utility readiness, transport scheduling, equipment stream availability and insurance/business-model clarification.

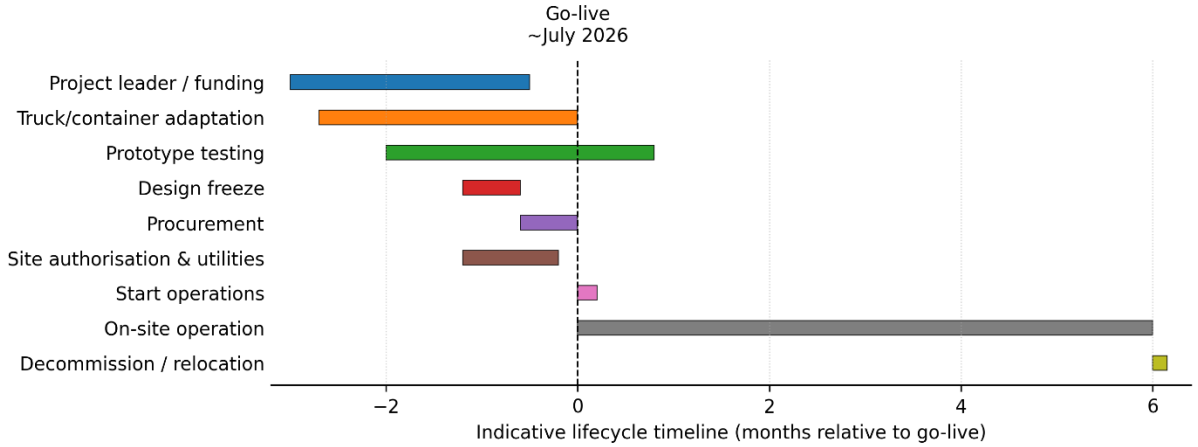


Figure 58: Indicative lifecycle timeline for the French Mobile On-Site Factory, from preparation and testing to on-site operation and relocation.

8.3.11. Risks & Contingencies

Chemical handling	Risk: transport and handling of cleaning/disinfection products. Mitigation: avoid hazardous chemicals where possible, use only easily transportable products, apply strict HSE procedures and operator training.
Workforce availability	Risk: limited availability or motivation of skilled workers. Mitigation: dedicated refurbishment-process training, multi-skilled teams, local partners and social-integration pathways.
Equipment-stream variability	Risk: variable quantity or quality of recovered sanitary equipment. Mitigation: early assessment, contracts with housing providers/deconstruction actors, flexible planning and recycling route for unsuitable items.
Site access / utilities	Risk: insufficient space, truck access, power, water or drain connection. Mitigation: pre-check deployment area, define responsibility for utilities, and make site deployment authorisation a decision gate.
Business / insurance uncertainty	Risk: unclear ownership, liability or insurance coverage for reused products. Mitigation: define inventory ownership, acceptance criteria, traceability and liability boundaries in the service contract.

8.3.12. Scalability & Impact

Scalability approach	Replicate mobile units, increase capacity by adding supplementary modules, and coordinate multiple sites through local just-in-time matching between source and demand sites.
Distance threshold	Approx. 20 km between deconstruction site and receiving site is indicated as a practical local-reuse threshold; no fixed limit is defined between different PuF units.
Storage threshold	Around one to two months of storage is indicated, depending on storage price. The model aims to avoid large-scale or long-distance storage by using JIT flows.
Volume threshold	Approx. 60 sanitary-equipment units per week per mobile unit. Throughput can increase with additional or stacked modules, but site space becomes the key limiting factor.
Environmental impact	Reuse of sanitary equipment improves material efficiency, diverts waste, reduces the need for new ceramic/sanitary products and supports CO2e, waste-diversion and reuse-rate KPIs.

Social impact	The model can involve Social and Solidarity Economy actors and professional-integration pathways, while creating local skills and a locally rooted circular renovation service.
Digital tools	Digital traceability, FDES documentation, stock/control records and communication between units are needed to support replication and multi-site coordination.

8.4 Satellite Factory Factsheet

8.4.1. Scenario & Strategy

PuF type	Satellite Factory based on a main hybrid offsite precast factory and smaller close-to-site finishing / integration satellites.
PuF purpose	Produce the main concrete panels in major hybrid factories and integrate more fragile components close to the building site before onsite assembly.
Deep renovation / reuse scope	Multi-measure deep renovation focused on the building envelope and its interface with building systems. The scope includes prefabricated facade panels with integrated insulation, windows, ventilation, HVAC upgrades, renewable-energy systems and smart electrical controls; roof insulation can be handled by a dedicated subcontractor where required.
Priority components	RECOskeletron insulated facade panels; external wall panels, internal walls, hollow-core slabs, stairs and balconies; close-to-site integration of windows, PV or cladding, heat-pump / mechanical-ventilation components, electric and hydro connections and seismic dampers.
Target building typology	Large multi-storey residential buildings from the 1950s-1990s, especially public/social housing blocks with extensive facade surfaces, seismic-improvement needs and a requirement to maintain residential continuity.
Design intent	Combine industrialized low-impact concrete panel production with local finishing satellites to support fast, repeatable, scaffold-free renovation and reduce logistical risk for fragile integrated components.
Best-fit conditions	Renovation programmes concentrated in a limited geographic area, with similar building typologies and facade dimensions, sufficient demand aggregation, skilled local SMEs for component integration and a logistics radius of roughly 100 km.

8.4.2. Factory Layout & Production Logic

Factory typology	Hybrid offsite precast factory for renovation and new construction, supported by close-to-site satellites for finishing and component integration. The factory is conceived as a permanent/semi-permanent industrial facility rather than a temporary container.
Production workflow	1) Raw material storage and concrete batching; 2) steel reinforcement and carpentry preparation; 3) production of wall panels, hollow-core slabs and stairs; 4) panel finishing and storage; 5) transport to close-to-site integration facilities; 6) JIT delivery to the building site; 7) onsite panel installation and tenant services.
Production lines / component handling	Main lines include tilting tables and battery moulds for panels, hollow-core slab lines, stair production, carpentry and steel-working areas. Close-to-site facilities integrate fragile elements such as windows, PV/cladding, MEP connections and seismic components.
Dimensions / space allocation	Indicative main factory: about 12,000 m² production area, plus about 20,000 m² storage for panels. Working areas include batching plant (1,500 m²), steel working (1,500 m²), tilting tables (2,000 m²), battery moulds (2,000 m²), hollow-core slabs (3,000 m²), stairs (500 m²), panel finishing (2,000 m²) and storage with overhead cranes (19,300 m²).
Operational scale	Annual capacity: about 80,000 m² retrofit/internal insulated walls, 85,000 m² new-construction external walls, 40,000 m² hollow-core slabs, 3,400 m² staircases with landing and 9,000 m² balconies.
Installation productivity	RECOskeletron panels are expected to be installed at about 200 m²/day. A 2,000 m² facade, such as the Viale Omero reference building, can therefore be renovated in roughly 10 installation days, excluding preparation and finishing works.

8.4.3. Resources & Utilities

Power & electricity	High-capacity three-phase power is required for the main factory, including batching plant equipment, production machinery, overhead cranes, forklifts, CNC/automation and storage-yard operations.
Water & sanitation	Water is required for concrete mixing, cleaning and plant operation. Washing-water treatment and recycling are included in the batching-plant logic; drainage is required for industrial wastewater streams.
Heating, cooling & ventilation	Natural gas, steam or equivalent curing energy may be required for concrete curing. Industrial ventilation and workplace environmental controls are needed across production and finishing areas.
Digital infrastructure	BIM / Common Data Environment for design freeze and interface control; WMS for panel sequencing and micro-stock; TMS or delivery scheduler for JIT routing and time-window management within the 100 km logistics envelope; CNC-controlled production for repeatability.
Equipment and materials	Batching plant, aggregate hoppers, conveyor belts, mobile scales, mixers, steel silos, dosing systems, casting bucket, washing and recycling plant, tilting tables, battery mould, concrete pumps, levelling beam, carpentry and steel-working equipment, overhead cranes, forklifts, transport carts and quality-control equipment.

8.4.4. Site & Logistics

Site preconditions	A suitable industrial site for the main factory, fixed utility connections, storage yards, truck loading bays, secure/fenced areas and industrial road access. Close-to-site SMEs require enough space for panel handling and component integration without disrupting their ordinary operations.
Access constraints	Heavy trucks of about 16-18 m and 32-40 tonnes are expected. Industrial roads suitable for long vehicles are required. The maximum renovation-panel size is about 3.2 m x 12 m, with common panels around 9 m long.
Supply chain integration	The model links the main hybrid factory, local finishing satellites and the renovation site. Fragile components are integrated close to the site to reduce travel by each component supplier and to support JIT delivery.
Storage & buffer strategy	Large panel storage is located at the main factory. Local finishing satellites work with small JIT buffers, typically around 80-100 m² and 1-3 days of storage, to avoid large intermediate stock.
Waste handling	Low-waste precast production is expected through reusable formwork, controlled batching and standardised components. Steel scraps, formwork residues, packaging/pallets, concrete scraps and washing water are handled by the factory operator or the responsible local partner.
Last-mile logistics	One truck can usually carry 4-6 panels of about 28 m² each. Handling on and off trucks is the most delicate step, so fragile components should be integrated late in the process and protected through coordinated delivery slots.

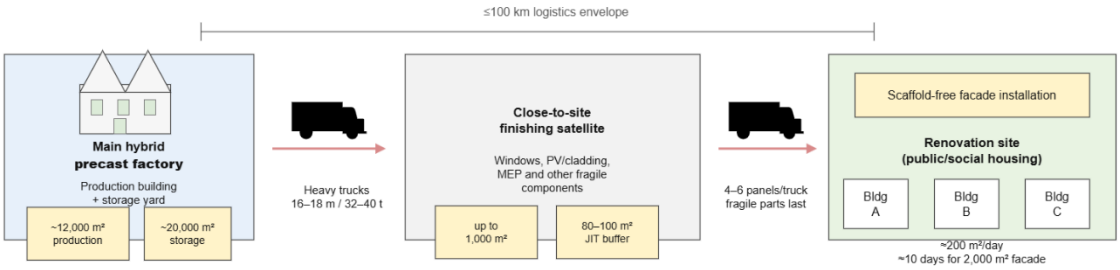


Figure 59: Indicative satellite-factory logistics setup linking the main hybrid precast factory, close-to-site integration facilities and the renovation site.

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8.4.5. Actors, Roles & Governance

Factory owner / operator	The main precast manufacturer or a dedicated SPV is the likely owner/operator of the main hybrid factory. The operator coordinates industrial production, storage, quality control and logistics.
Client / contracting authority	Comune di Milano, Regione Lombardia and/or public social housing agencies such as MM S.p.A. or ALER Milano may act as public owner, asset manager, contracting authority or demand aggregator.
Contracting and payment	Typical chain: public authority or housing owner -> general contractor / ESCO in PPP, or SPV -> precast manufacturer -> suppliers and local integrated SMEs. In an SPV model, cash flow is linked to delivery milestones rather than single product sales.
Demand-side partners	Milan Municipality, Lombardy Region, MM S.p.A., ALER Milano and private urban-regeneration developers such as COIMA, Lendlease, Hines, Prelios, Near SGR, DeA Capital SGR and Kryalos SGR.
Supply-side partners	Precast manufacturers such as LOMBARDA SpA, Camuna Prefabbricati, Bianchi Precast and Progress Srl; local SMEs for windows, PV, MEP and cladding; STRUCTURAMA as system integrator and consultant for satellite precast PuF design.
Financing / O&M partners	A2A, E.ON, Enel X and similar ESCOs or energy providers can support EPC/PPP operation and maintenance. Ener2Crowd, Intesa Sanpaolo, Unicredit and Fondazione Cariplo are identified as potential financing or social-impact actors.

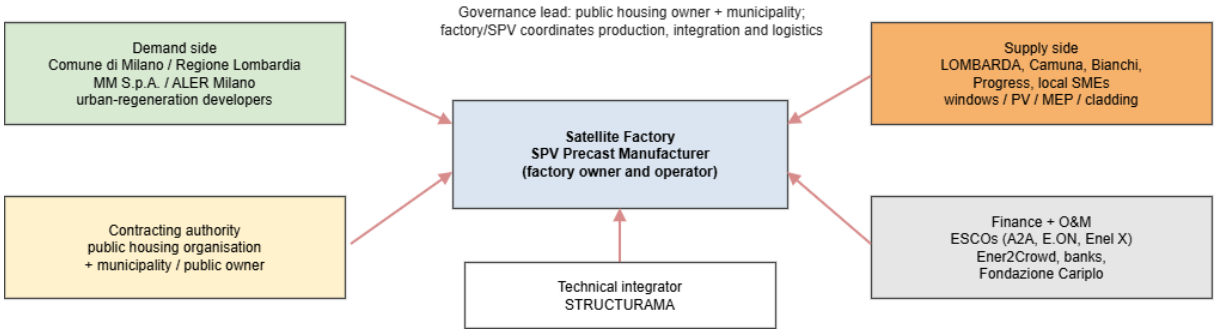


Figure 60: Stakeholder and governance structure of the Italian Satellite Factory.

8.4.6. Labour Force & Required Skills

Typical team	The main offsite hybrid factory requires around 50 workers per shift, excluding indirect administrative, management and communication roles. Additional local SME and onsite installation teams are required for component integration and building-site works.
Core roles / indicative FTE	Production manager/factory supervisor; batching-plant operators; panel-production workers; battery-mould workers; panel-finishing and insulation-assembly workers; hollow-core slab and stair-production workers; carpentry and steel-working workers; storage/logistics handlers; quality-control workers; installer team lead; DfMA designer; maintenance technician.
Skills and certifications	Precast production, concrete batching/casting/curing, formwork and finishing, steel reinforcement, crane and forklift operation, CNC/digital production, DfMA/BIM coordination, QA/QC, logistics planning and mandatory workplace safety training.
Training needs	Mandatory safety training according to Italian workplace rules, equipment-specific training for overhead cranes and forklifts, process training for precast production and targeted onboarding for DfMA, quality control and JIT logistics.
Labour sourcing	Combination of factory employees, external HR recruitment, local SMEs, subcontractors for windows/PV/MEP/cladding and specialised installation teams.
Shift model	Industrial shift model. Annual capacity depends on the number of shifts; additional shifts, extra production lines or additional factories are required once the capacity threshold is exceeded.

8.4.7. Legal & Regulatory Requirements

Factory building permit	A building permit according to regional regulation is required. The issuing route is through the Municipality / Sportello Unico per l Edilizia or SUAP under DPR 380/2001. Lead time is about 3-6 months, longer if seismic, fire-safety or landscape authorisations are required.
Environmental authorisation	AUA under DPR 59/2013 may apply for non-AIA plants, with ARPA technical review. AIA under D.Lgs. 152/2006 may apply if thresholds or activities fall under IPPC/EID annexes. Lead time is about 3-4 months for AUA and 6 months or more for AIA.
Building, safety and noise rules	The factory must comply with national/regional building rules, structural and seismic codes, accessibility and fire safety. Construction and operation are governed by D.Lgs. 81/2008. Noise is regulated through municipal noise zoning, UNI 11728:2018, law 447/1998 and D.P.C.M. 14/11/1997.
Compliance responsibility	The project developer / future plant operator applies for factory and environmental approvals with support from certified designers, the general contractor and environmental consultants. The operator remains responsible for permit conditions and monitoring.
Incentives / subsidies	Potential instruments include Invitalia/MIMIT Digital Transformation incentives, the Transition 5.0 tax credit for digital and green industrial investment, and regional Lombardy grants such as Bando Nuova Impresa 2026. Eligibility and amounts are call-specific.

8.4.8. Cost Structure

CAPEX	Approx. 35 million EUR, including land acquisition, civil works, production and office buildings, batching plant, precast production lines for panels/slabs/stairs, automation and machinery, digital control systems, installation, testing and commissioning.
OPEX	The pilot data reports approx. 59.4 million EUR for direct and indirect operating costs, including about 50 factory employees, energy, mechanical/electrical maintenance, consumables, factory-side logistics, transport, operational coordination and management. The exact reporting period should be verified.
Cost basis	Reported production cost basis: about 510 EUR/m² for retrofit panels and 335 EUR/m² for new-construction elements.
Price / value basis	Reported price basis: about 790 EUR/m² for retrofit panels and 450 EUR/m² for new-construction elements, understood as the price per m² of precast piece exiting the main factory and including transport to local facilities. The whole energy and seismic retrofit intervention is estimated around 1,400 EUR/m² of floor area.
Revenue / value logic	Revenue is linked to programme-based renovation contracts, often through PPP structures. Cash flow comes from selling integrated panels to the general contractor or from delivery milestones in an SPV model.
Financing model	Mixed financing is possible: grant, loan, equity/SPV, PPP and ESCO models. Example loan assumption: 25 million EUR, 6% interest, 5 years, including credit institutions and crowdfunding up to 5 million EUR. In an SPV, the precast manufacturer holds the majority share, with housing organisations and external investors as co-investors.
Value creation	The Italian Satellite PUF creates value through the industrialised production of prefabricated components in a central facility, combined with decentralised integration by local SMEs and on-site installation. This hybrid model enhances standardisation, enables batch production, and supports efficient coordination across large renovation programmes.
Value capture	Value is captured through programme-based contracts and framework agreements linked to large-scale public renovation initiatives, particularly in social housing. The model relies on long-term pipeline stability to recover high upfront investments and achieve cost efficiency through scale and continuous utilisation.
Value delivery	Value delivery is organised through a coordinated logistics system linking central production, local SME contributions, and just-in-time on-site installation. This configuration reduces execution time, minimises disruption for residents, and improves predictability in dense urban contexts such as Milan.

8.4.9. Business Model Canvas

Value proposition	Scalable renovation through centralised industrial production combined with flexible local SME-based execution
Customer relationships	Public programme clients, large developers, and local SMEs involved in execution
Channels	Combination of long-term programme agreements with local short-term execution contracts
Customer segments	Coordinated logistics linking central production facilities with decentralised construction sites
Key activities	Industrial production, supply chain coordination, and logistics management across multiple actors
Key resources	Central production facilities, logistics systems, and networks of local SMEs
Key partners	SMEs, manufacturers, logistics providers and public programme clients
Revenue streams	Programme-based contracts and production-related revenues linked to large-scale renovation programmes
Cost structures	High upfront investment in production facilities combined with ongoing coordination and logistics costs

8.4.10. Lifecycle & Time Schedule

Setup & commissioning	Approx. 21 months overall for project funding, permitting, detailed design and engineering, procurement, factory construction, production-line installation, commissioning and start-up.
Main setup milestones	Funding secured: about 3 months. Permits approved: about 4 months. Design freeze: about 3 months. Factory construction, machinery installation and commissioning: about 14 months.
Panel production and integration	Approx. 3 months from panel production to component integration and pre-installation checks, including dispatch from the main precast factory, JIT integration by local finishing factories and routing within the 100 km envelope.
Operational phase	A full onsite retrofit phase is estimated at about 3 months, including site setup, demolitions/surface preparation, foundation works, RECOskeletron panel installation, roof/balcony/basement works and MEP connection. Panel installation itself is around 200 m²/day.
Decommissioning / relocation	Not applicable for the main satellite factory because it relies on permanent industrial structures. Close-to-site buffers and temporary staging areas are cleared after project completion.
Main dependencies	Project leader and funding partners, permit approval, factory construction, machinery testing, workforce availability, local finishing-SME coordination, lead times for windows/MEP/cladding, renovation permits, site preparation, installer availability, weather and final testing/commissioning.

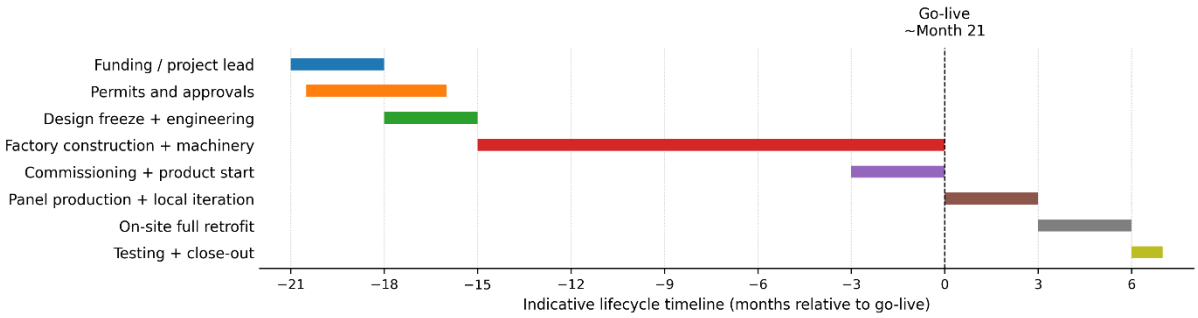


Figure 61: Indicative lifecycle timeline for the Italian Satellite Factory, from funding and permitting to production, onsite retrofit and close-out.

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8.4.11. Risks & Contingencies

Financing / project leadership delay	Risk: difficulty securing a project lead and financing partners. Mitigation: activate multiple funding channels, including institutional investors, banks and crowdfunding; define a decision gate if no project lead is identified within about 6 months.
Workforce availability	Risk: difficulty finding enough qualified workers for the hybrid factory. Mitigation: targeted recruitment, short intensive training and worker incentives; trigger if workforce cannot be secured within 2-3 months.
Capacity under-utilisation	Risk: insufficient or discontinuous renovation pipeline and poor geographic clustering. Mitigation: aggregate demand through multi-year framework agreements, align with public renovation programmes and keep production lines convertible between new build and renovation.
Production rigidity	Risk: reduced operational flexibility due to rigid layout and sequencing. Mitigation: standardise interfaces, lock designs and production batches early, and use local finishing factories to absorb variability.
Energy and material price volatility	Risk: cost fluctuations affect operating margins. Mitigation: long-term energy contracts, onsite renewable generation where feasible, framework agreements for key materials and cost pass-through clauses.
JIT logistics and installation disruption	Risk: windows, MEP, cladding or panel deliveries are delayed, or installation tolerances create interruptions. Mitigation: multiple SME frameworks, backup transport routes, daily coordination meetings, phased quality checks and installer training.

8.4.12. Scalability & Impact

Scalability approach	Scale by replicating sites, increasing capacity at one site, adding shifts or production lines, and coordinating multiple close-to-site finishing partners.
Distance threshold	Approx. 100 km maximum panel-transport distance from the main factory to the building site, including deviations for component integration.
Storage threshold	Close-to-site storage is intended to remain minimal: around 1-3 days of JIT buffer and about 80-100 m² local storage where possible.
Volume threshold	Indicative maximum annual capacity: 80,000 m² retrofit panels, 85,000 m² new-build external walls and 40,000 m² new-build slabs. Above this, a new factory, extra line or additional shift is needed.
Adaptability mechanism	Concrete production can be reconfigured with standardized processes and modular equipment to produce different precast elements for renovation, housing, infrastructure, tertiary or industrial buildings.
Digital / coordination tools	BIM/CDE for design and interface control, WMS for sequencing and micro-stock, TMS or delivery scheduling for JIT routing, and CNC machinery for accurate, repeatable production.
Environmental and social impact	Targets include -20% logistics-related CO2e per building, at least 15% waste diversion for packaging/pallets/concrete scraps, -10% kWh per m² of panel produced and at least 60% renewable electricity across involved factories. The model also supports public/social housing renovation, local SME participation and tenant engagement.

9. Conclusion

This deliverable has developed the Pop-up Factory (PuF) concept from an initial typology into a structured set of ecosystem-specific designs, implementation plans along with the supporting activies, feasibility studies, and BIM-based digital blueprints. Within the BuildUPspeed project, PuFs are positioned as flexible and localised configurations that can support industrialised deep renovation by bringing production, assembly, coordination, or reuse-related activities closer to renovation demand. In doing so, they can help address logistical inefficiencies, reduce unnecessary transport, improve coordination between actors, and support more adaptable renovation delivery models.

A central finding of the report is that PuFs should not be understood as a single standard factory model. The five scenarios identified in the BuildUPspeed framework -Mobile On-Site Factory, Satellite Factory, District Factory, Assembly Factory, and Service Factory- respond to different market conditions, building typologies, supply-chain structures, stakeholder roles, and regulatory contexts. The ecosystem work confirmed that successful PuF deployment depends on the alignment between local demand, governance, logistics, available partners, site conditions, financing logic, and implementation timing.

The tailored design and implementation-planning activities also showed that PuFs can play different roles within renovation ecosystems. In some cases, such as the Dutch and Italian ecosystems, the PuF logic is closely linked to demand aggregation, repeatable renovation packages, and coordinated production or assembly capacity. In others, such as the Austrian and French ecosystems, the concept is more strongly connected to reuse, reconditioning, and circular material flows. The Spanish ecosystem further demonstrated the relevance of assembly-based approaches in constrained urban and heritage contexts, where prefabrication, limited site space, and careful logistics coordination are central implementation conditions.

Across the ecosystems, the report highlights the importance of partnerships, early planning, and clear governance structures. PuFs require more than technical production capacity; they depend on coordinated roles between clients, public authorities, contractors, suppliers, factory operators, reuse organisers, technical advisors, and end users. Legal and regulatory conditions, including permitting, public-space use, health and safety, environmental compliance, product certification, reuse-related liability, and funding eligibility, also need to be addressed early in the process.

Additional insights from supporting activities reinforce these findings. Three key learnings stand out. First, the objective of a PuF must align with its type; a small assembly factory and a regional district factory address different challenges, and their business models cannot be directly transferred from one to the other. Second, partners and stakeholders are decisive; these models rely on effective collaboration and communication across housing corporations, municipalities, and delivery partners; without this alignment, even a well-designed PuF is unlikely to succeed. Third, understanding the market and future project pipeline is critical; anticipating demand allows a PuF to scale its operations strategically rather than reacting on a project-by-

project basis. Together, these learnings highlight what distinguishes a Pop-Up Factory that works in theory from one that performs effectively in practice.

The digital layer developed through RE Suite provides the BIM-based data-management foundation for the PuF approach. By supporting Common Data Environment logic, structured component information, and digital passport functionality, RE Suite enables traceability and lifecycle-oriented management of PuF-related components and workflows. Building on this foundation, the factsheets and blueprints presented in Chapter 8 consolidate the design and implementation knowledge into practical digital references for the District Factory, Assembly Factory, Mobile On-Site Factory, and Satellite Factory. The Service Factory logic is represented through the BuildUPspeed Market Activation Platform, where the PuF factsheets are integrated as dedicated static pages and supported by a tailored PuF wizard.

Overall, D4.1 shows that PuFs offer a flexible framework for connecting industrialised renovation, local implementation capacity, circularity, and digital information management. While further validation and market uptake will depend on local conditions and future project development, the combined WP4 outputs provide a structured basis for replicating, adapting, and implementing PuF concepts beyond the original BuildUPspeed ecosystems.

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Appendix I

Table 26: Questions of PESTLE analysis

Factors	Questions
Political	What are the main national / regional / local policies and governmental action plans that support pop-up factories?
	Are there any upcoming changes or proposed regulations that could impact the adoption of pop-up factories?
	How do local governments and municipalities view the use of pop-up factories in their communities? Are they receptive to the idea or sceptical?
Economical	Are there any financial subsidies, incentives or grants available from the government to support the implementation of pop-up factories?
	How do the current economic factors (such as interest and inflation rate) influence the establishment of pop-up factories?
	To what extent could pop-up factories boost the local economy and improve the current unemployment rate in your country?
Social	Are there any cultural or social factors that could impact the acceptance of pop-up factories in your country?
	Are there any social trends, such as a growing interest in sustainability, that could make pop-up factories more appealing to customers and partners?
Technological	What is the level of technological infrastructure in your country regarding pop-up factories? Are there any limitations or challenges that could impact the implementation of pop-up factories?
	To what extent is it common to use innovative solution in pop-up factories in your country (e.g. 3D printing, BIM, prefabrication with robotics, AI, etc.)?
	Are there any technological barriers, such as the need for specialized equipment or software to the adoption of pop-up factories?
Legal	Are there any legal barriers to setting up a pop-up factory in your country, such as zoning regulations or building codes?
	Are there any legal risks associated with using pop-up factories, such as liability or insurance concerns?
Environmental	What are main environmental regulations and policies affecting pop-up factories (e.g. in terms of noise, air, water, soil pollution)?
	What are the potential environmental risks associated with the installation of pop-up factories, and how can these be mitigated?

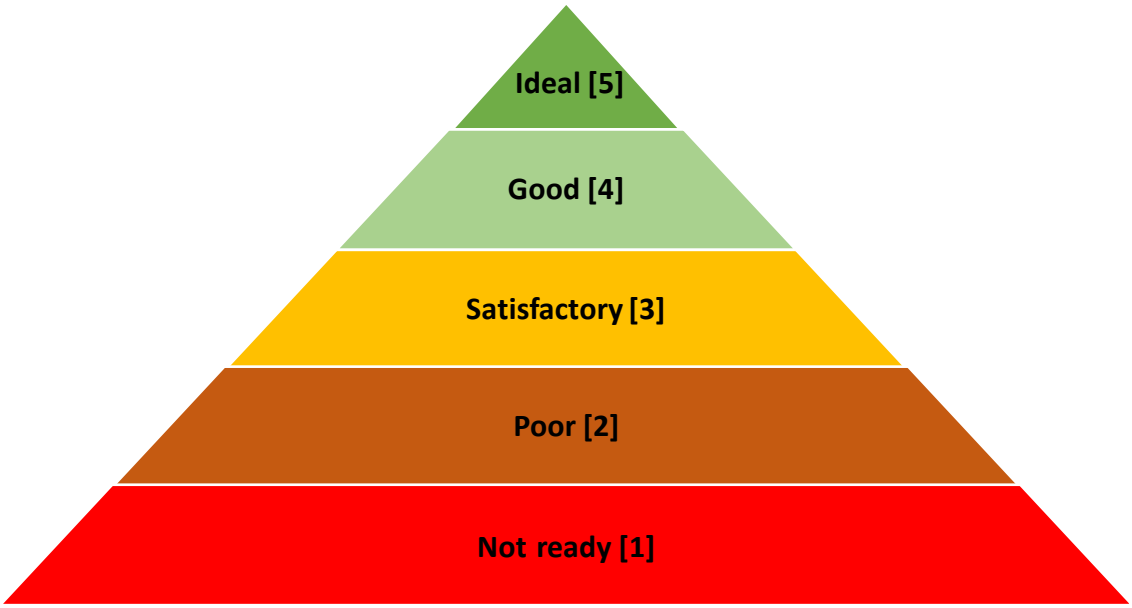


Figure 62: Assessment criteria

The scoring system provides a relative assessment of the readiness and potential of an ecosystem to embrace and implement pop-up factories.

A "Not Ready" score indicates that the ecosystem is not adequately prepared or supportive of pop-up factories. A lack of policies, initiatives, or awareness regarding pop-up factories may hinder their implementation and acceptance.

A "*Poor*" score suggests significant challenges or barriers within the ecosystem that impede the successful implementation of pop-up factories. These challenges could include social perceptions, limited economic opportunities, technological limitations, or legal and regulatory hurdles. However, with specific strategies that offer broad benefits, the chances of overcoming these barriers are significantly higher.

A " Satisfactory " score signifies moderate progress or potential within the ecosystem for pop-up factories. There may be some existing initiatives, funding options, or regulations that support the concept. However, there are still areas for improvement or enhancement to fully leverage pop-up factories' benefits.

A "*Good*" score indicates a favourable environment within the ecosystem for pop-up factories. There may be supportive policies, funding opportunities, positive social perceptions, advanced technological infrastructure, and conducive legal frameworks that enable pop-up factories' successful implementation and operation.

An "*Ideal*" score represents an exceptionally well-suited ecosystem for pop-up factories. There is extensive political support, favourable economic conditions, widespread social acceptance, advanced technological capabilities, and comprehensive legal and regulatory frameworks that facilitate the seamless establishment and operation of pop-up factories.



Figure 63: PESTLE Miro Board: Output of the workshop via the interactive board

Table 27: List of participants of the workshop

Name		Country	Organization
Ruben	Veneklaas	the Netherlands	HI&A

André	Beckers	the Netherlands	HI&A
Peter	op 't Veld	the Netherlands	HI&A
Maria Sara	di Maggio	the Netherlands	HI&A
Ana	Tisov	the Netherlands	HI&A
John	van Oorschot	the Netherlands	Zuyd
Bart	Voortman	the Netherlands	WEBO
Emmanuelle	Causse	Belgium	IVE
Maria	Figueira	Belgium	UIPI
Ana	Sanchis	Spain	IVE
Miriam	Navarro Escudero	Spain	IVE
Tobias	Weiss	Austria	AEE
Sebastian	Casalderry Díaz	Spain	ACR
Sylvian	Durand	France	IBS
Carlos	Martinez	Spain	PTEC
Jesús	Alonso Pérez	Spain	ACR
María	Ibanez Puy	Spain	ACR
Giulia	Paoletti	Italy	EURAC
Niccolo	Sovico	Italy	E2C
Zeno	Gorini	Italy	E2C
Raj	Mailaram	Austria	RB
Elisa	Estaún Atarés	Spain	ACR
Andre	van Delft	the Netherlands	DMO
Daniel	Orth	Austria	AIE
Benjamin	Varela	France	NBK
Fred	Andre	France	DOMO
Markus	Meissner	Austria	AEE
Mohamed	Elagiry	the Netherlands	DMO
Anna	Kloepper	Belgium	UIPI
Riccardo	Pinotti	Italy	EURAC
Paula	Menéndez	Spain	PTEC
Aurélien	Henon	France	NBK
Thomas	Garnesson	France	NBK
Paolo	Alberico	Italy	E2C
Maia	Louvard	France	NBK
Vera	Valero Escribano	Spain	IVE
Julia	Semeniuk	Italy	E2C
Cornelia	Ninaus	Austria	AEE
Paul	Rasper	Austria	RB
Christoph	Rohrigner	Austria	AEE
Julien	Dijol	Belgium	HE

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Appendix II

Table 28: Questions for PuF Scenario Analysis.

	Maturity	Market potential	Drivers	Barriers	Potential for application in ecosystem
Mobile on-site factory	How well-established is the market for mobile on-site factories?	How does the market perceive the viability of the mobile on-site factory approach?	What are the main drivers to the uptake of mobile on-site factory?	What are the main barriers to the uptake of mobile on-site factory?	Low-moderate-high
Satellite factory	How well-established is the market for satellite factories?	How does the market perceive the viability of the satellite factory approach?	What are the main drivers to the uptake of satellite factory?	What are the main barriers to the uptake of satellite factory?	Low-moderate-high
District factory	How well-established is the market for district factories?	How does the market perceive the viability of the district factory approach?	What are the main drivers to the uptake of district factory?	What are the main barriers to the uptake of district factory?	Low-moderate-high
Assembly factory	How well-established is the market for assembly factories?	How does the market perceive the viability of the assembly factory approach?	What are the main drivers to the uptake of assembly factory?	What are the main barriers to the uptake of assembly factory?	Low-moderate-high
Service factory	How well-established is the market for service factories?	How does the market perceive the viability of the service factory approach?	What are the main drivers to the uptake of service factory?	What are the main barriers to the uptake of service factory?	Low-moderate-high

Appendix III

PESTLE Results

The Dutch Ecosystem

Factors	Responses	Overall result
Political	None, no policies which directly involve LPFs - it's up to the market to decide how to deliver the project.	Satisfactory (3)
	Brief Minster Hugo de Jonge - biobased and circular building.	
	Indirect incentives effect; local governments, through project-specific demands & policies, could pave the way for LPFs (environmental zone; Paris proof indicators, social programs)	
Economical	Yes, DEI regeling (Demonstratie Energie- en Klimaatinnovtie regeling - stimuleringsfonds)	Ideal (5)
	Inflation none, interest none other than the general consequences; energy and logistics could be influenced	
	Examples: social return programs and environmental zones are driving PuFs. In addition, because of small construction sites, PuFs are gaining momentum. PuF give the potential to involve local labourers/ offer traineeships to the unemployed. The use of social urban mining could boost the employment rate.	
Social	The traditional set-up of the construction process - the business case - is considered a key lock-in.	Satisfactory (3)
	There are methods/ intermediation needed to connect the demand and supply site better. Raise awareness and support for these kinds of technologies. Trends are arising on the carbon footprint impact, more awareness on using local resources and outsourcing less.	
Technological	Commercial rental companies (like Boels) are addressing this already and making propositions to large contractors	Satisfactory (3)
	Innovative solutions like this are still scarce.	
	Some examples of digital printing for construction components, but on a small scale	
Legal	CE marking, local regulations, and national guidelines. Conformity of norms across the EU should be enforced more in local building culture.	Good (4)
	Yes. Risk of quality assurance.	

Environmental	Noise regulations for the mobile factory.	Satisfactory (3)
	Nitrogen reduction policies can incentivise the use of offsite construction and pop-up factories.	
TOTAL		Good (4)

The French Ecosystem

Factors	Responses	Overall result
Political	(National). REP Responsabilité Elargie du Producteur. Collecting points for waste and then various classification and recycling/reuse stages.	Good (4)
	Local initiatives facilitated (Platform NOE: for logistic services). Public entities, such as public urban developers, can play an important part in making the deployment of such initiatives (e.g. EPA, Etablissement Public d'Aménagement, in the French context) available with the support of private stakeholders.	
	-RE2020, the national energy and environmental regulation for the built environment. -Current laws preventing from renting/selling buildings with low EPC indicators. Encouraging renovation. Will to use the unused land opportunities for temporary activity (transitory urbanism)	
Economical	The local Region is the main support. Case by case, opportunity to create activities and jobs (e.g. industrial conversion of specific facilities). National energy agency to support through dedicated projects.	Satisfactory (3)
	Inflation and the rise of interest rates are an additional barrier (as a new investment)	
	Improving the employment rate is a strong ambition, as well as having more people trained. However, there is no awareness that pop-up factories are a solution.	
Social	Low cultural acceptance of the pop-up factory. In a business-as-usual context, the factory is asked to be hidden.	Poor (2)
	"Circuit court", "indice de réparabilité", local employment. Activities that make sense for people: renovation, local. RSE, social responsibility of the company	

Technological	Technological production tools exist. There are barriers to moving them as LPF (companies are not so keen on displacing their production means; very few lands are available due to high land value in urban areas, and heterogeneous architectural contexts make it harder to reach high productivity).	Satisfactory (3)
	Recent trends are opposite to LPF: massification of production sites, concentrated in dedicated production sites.	
	No major technological barriers were identified.	
Legal	Autorisation d'Occupation Temporaire is required but possible (decision at the local scale)	Satisfactory (3)
	No major legal barriers, but social and political acceptance issues. The LPF is to be considered as a "construction site".	
Environmental	"Loi de la transition écologique et de croissance verte" could facilitate.	Satisfactory (3)
	Risks related: Noise, dust, water management. Important to manage well to avoid counter references.	
TOTAL		Satisfactory (3)

The Austrian Ecosystem

Factors	Responses	Overall result
Political	- Research Fundings (FFG, circularity) - Economic agencies for regions (Ecoplusin lower Austria, ...)	Good (4)
	- New energy efficiency bill - taxonomy (E adopted) - Waste Framework Directive (EU)	
	- Not very well known, circularity is promoted by politicians	
Economical	Yes, examples: – Funding Initiative Circular Economy by the Austrian Research Promotion Agency (FFG) – Austrian Promotion Bank (AWS - Austria Wirtschaftsservice) – Regional Funding programs such as Ökobusiness Wien, also in other regions	Ideal (5)

	The economic factor supports the establishment due to a positive impact on EU taxonomy regulation.	
	We expect a positive boost because it creates employment on a local level. Regarding reuse in the construction sector, we estimate 5 – 30 jobs per 1000 tons of reused products [Reuse Austria 2021].	
Social	There are cultural barriers to adopting new business models, therefore slowing down the acceptance of new processes.	Good (4)
	Yes. Examples: – Growing interest in sustainability – The growing number of building curricula connected to sustainability or circular economy – Sensitivity regarding heavy traffic	
Technological	In principle, no limitations, but warranty issues are addressed and must be solved.	Satisfactory (3)
	One of the biggest challenges is the use of different BIM systems and their exchange (Autodesk, Graphisoft, etc.). AI implementation in BIM has not yet been fully/positively tested.	
	More technology expertise needed: - Automation and robotics is strong in automotive and many industries - Prototype construction is prevalent in buildings. Each building is new and different - 3D printing in buildings is occasional - In Austria, it is mainly about renovation. Austria is already heavily built up, and in the future, little new construction.	
Legal	*No.* No specific legal barriers to PuF. But building codes are the same as for usual construction sites or factories. Laws in Austria regarding recycling management and energy/resource efficiency: - Recycling Building Materials Ordinance - Waste Management Act (2002) - Ecodesign Ordinance (2007) - energy efficiency through A, B, C...F, G - Construction Products Ordinance (2013) LPFs (local Pop-up Factories) support the resource/energy efficiency of construction processes - which, however, has hardly been reflected in the characteristic values of buildings	Satisfactory (3)

	so far. Mostly standardised values are used, but possibly a more efficient process can be rewarded. Many cities have rules for larger construction sites, so that they do not burden the residents so much.	
	The trade regulations regulate the impairment of neighbourhoods regarding emissions. This could prevent PuF.	
Environmental	- Trade regulations - Waste law - Building codes - Water rights act - Noise and air pollution - Federal Act on Environmental Impact Assessment - Temporary is also problematic	Satisfactory (3)
	Stricter regulations due to situation within non-factory areas.	
TOTAL		Good (4)

The Italian Ecosystem

Factors	Responses	Overall result
Political	Work safety regulations and quality certifications of building components and technologies are some areas of interest that could indirectly boost pop-up industrialised factories.	Poor
	EU directives mainly. Local regulations are to be explored (e.g., regulation changes in managing working times and using waste and production in Brenner Tunnel).	
	It's not yet their priority since they see more urgent issues related to construction.	
Economical	Not directly related to pop-up factories, but there are a lot of incentives to increase energy and seismic renovation.	Satisfactory
	High interest rates do not help the return of investment of such factories. Inflation, on the contrary, stimulate productivity to save on materials and other costs.	
	Difficult to say how the PuF concept could impact on employment rate but for sure it will make the sector younger and more attractive.	

Social	Reluctance to automation and prefabrication as it was intended in 1970s.	Satisfactory
	Surely sustainability aspects can increase PuF acceptance, and vice-versa.	
Technological	Probably the main barrier in Italy could be finding a near area to set up the factory, as well as the rent cost of those areas	Poor
	Use of BIM and advanced design systems is not so common but it is increasing	
	The main limitation is the lack of knowledge of professionals that should be trained. Cost for licenses is also an issue	
Legal	There are very specific building codes related to the area of construction, which must be respected for PuF.	Satisfactory
	There are not explicit legal risks for the concept of PuF in general.	
Environmental	Specific regulations are to be explored but for sure there are some restrictions regarding the production of pollution in urban areas.	Satisfactory
	Risks regarding the installation of pop-up factories in non-industrial areas so their impact and benefits must be properly analysed. The fact that they are temporary can have both pros and cons.	
TOTAL		Satisfactory

The Spanish Ecosystem

Factors	Responses	Overall result
Political	None at the moment. It is expected to create a new R&D national centre focused on industrialisation and probably they will deal this concept	Satisfactory
	yes, there is a new legislation related to circular economy that will be mandatory soon	
	They do not know the concept of "pop-up" factory, however some of them are promoting local recycling areas for construction materials	
Economical	Yes. Currently there are different options such as PERTE for circular economy which has a funding line for something that can be close to pop-up factory	Satisfactory
	Not enough info to have an opinion	

	It has a great potential if someone decide to promote it (see the previous point)	
Social	Yes, in general the social perception is not good, due to people associate the factory with noise, dust, traffic, disturbances, etc.	Poor
	some, associated to sustainability standards such as BREEAM, LEED, WELL	
Technological	Despite the fact that we do not use the pop-up concept, we have some experience working with "mobile factories" (concrete, pre-cast concrete, asphalt, etc.) mainly associated with civil works. So, we could try to adapt this experience and apply it to pop-up factories	Satisfactory
	Not too much, probably pre-cast concrete is the most used among the technologies of the question	
	Lack of knowledge and specific training	
Legal	Yes, construction is highly regulated in Spain	Satisfactory
	yes, all of them	
Environmental	Yes, the environmental regulation is very restrictive in particularly urban areas.	Poor
	Noise, dust and traffic are the main issues to deal with. Mitigation is complicated and probably could affect the location of the factory	
TOTAL		Satisfactory (3)

Scenario Analysis Results

The Dutch Ecosystem

Dutch Ecosystem	Maturity	Market potential	Drivers	Barriers	Potential for application
Mobile on-site factory	Mobile technologies are still under development. Approach could be mandatory for specific deep-renovation interventions such as cavity wall insulation and mining resource materials from existing buildings.	Not seen as a main approach relative to the other local pop-factory scenarios. As a deep-renovation approach the market potential is low due to quality management issues and cost.	For some specific deep-renovation interventions there are no alternative technological solutions to a) effectuate an energy efficiency measure and b) reuse local mined materials	-Quality management issues -Perceived costs -Limited scale and scope -Labor intensive	Low
Satellite factory	Not applied because of the low geographical proximity between suppliers and projects.	Not seen as a main approach relative to the other local pop-factory scenarios.	Availability: of interest for exporting / importing deep-renovation technologies and some firms are exploring this opportunity.	-High organisational cost -Availability of competitive or alternative technological solutions	Low
District factory	Concept is still under development in solving the issue of balancing supply and demand, i.e. setting up the value chain	Seen as a competitive scenario for the dominant assembly factory approach especially for individual home renovations.	Maximises the mass-customisation potential and eventually cost benefit.	-Maturity barrier: radical different deep-renovation process and supply chain set-up	High
Assembly factory	Dominant deep-renovation approach	Especially relevant for building owners and social housing	High level of repetition in portfolio of buildings which are financially	-If the level of customisation increases the	High

	since 2013 supported by the 'Stroomversnelling'	associations with high level of repetition in their portfolio.	interesting to be renovated relative to other scenarios like selling or demolishing.	potential of the assembly factory decreases	
Service factory	Service shops have been established across the Netherlands to inform and support private homeowners about how to improve energy efficiency	Especially relevant for private, middle-income homeowners.	Especially relevant for homeowners who face an anyway renovation and/or like to reduce the energy costs.	-Low upscaling potential	Moderate

The French Ecosystem

	Maturity	Market potential	Drivers	Barriers	Potential for application
Mobile on-site factory	Concept has existing examples with the demonstrator site.	Some companies launch similar concept on demonstrator site	-the demand from the actors of the construction -reduce traffic, noise etc	-psychological barrier: relocation factories in situ. -cost -requirement on the product -motivation is still in the massification in large production centres	High
Satellite factory	Companies exist with similar concepts but with	Needed for large rehabilitation area, as GIPGPV	Companies explore this concept and are showing that is benefic	The time to develop a satellite factory.	Moderate

BuildUPspeed

	permanent production centres.				
District factory	Concept exists for the waste management but still under developed for the construction/rehabilitation	Specific to each construction sites	-should be supported by national/regional public institution	-Complicated due to the difference and specification of each construction project -Synergies between stakeholders must take place	Moderate
Assembly factory	They are already in place in construction projects and some companies are specialised on prefabrication/assembling	High potential	-Advantages for stakeholders	-New organisation of the construction chain -Need investments	High
Service factory	Undeveloped	-interest in single-family houses' owner	-state financial aid -requires not too much effort -solution exists, it "just" needs to share knowledge and inform stakeholders	-lake of awareness	High

The Austrian Ecosystem

	Maturity	Market potential	Drivers	Barriers	Potential for application

BuildUPspeed

Mobile on-site factory	- urban mining possibility - managed on-site deconstruction -> 5%	The potential of buildings applicable for deep renovation is very high with more than 50%. **Or** The approach is highly favored by the market, with more than 50% considering it viable.	Key drivers for the adoption of mobile on-site factories include efficient resource utilisation, streamlined transport, and reduced manpower requirements.	The main barriers are limited space in dense cities and challenges in areas with significant existing structures and population.	High
Satellite factory	Very low – development needed	In the short term, the potential of satellite factories is low, but in the long term, it holds high potential.	Use synergies to use know-how in several construction projects	The potential barriers regarding the duration of adoption (long/short term) have not been specified, therefore suitable locations cannot be identified.	Moderate
District factory	The maturity of the central logistics facility approach is around 15%.	The applicability of district factories is highly dependent on the relatively close vicinity of several construction sites.	- Usage of local resources - knowledge exchange - social aspects - cost savings (e.g. transportation costs)	The main barriers include the necessity for coordination among various stakeholders and the presence of large barriers in terms of resource allocation.	High (but large barriers)
Assembly factory	Retrofit of balconies holds a maturity of 40-50%.	The market potential for assembly factories is high, with over 70% of the market showing interest.	Time constraints drive the uptake of this approach.	The adaptation of existing facilities to the assembly factory	High

				approach is the main barrier to its uptake.	
Service factory	The concept of service factories is not known in the market yet. Participation in construction conferences and fairs is considered mandatory for awareness.	They are highly relevant for professionals to spread their knowledge and insights, benefiting both buyers and users of construction services.	Effective knowledge transfer/sharing from experts around countries, which should also be accessible to buyers and users.	The main barriers include lack of awareness about the concept and resistance to change within the industry.	High

The Italian Ecosystem

	Maturity	Market potential	Drivers	Barriers	Potential for application
Mobile on-site factory	Not yet developed	not ready yet to think to temporary manufacturing locations	Flexibility to move the factory around, close to building sites	too densely populated areas to move all the production on-site.	Low
Satellite factory	Not yet developed	Interesting model but it's to be explored what type of components/finishing are produced close to the site and which ones are prefabricated further.	JIT process, possibility to have higher level of flexibility in the final production stages. Another driver is geographical; indeed, the model could fit well for those	Big cities are too densely populated areas to find space for different production sites close by the renovation works. It really depends on the area and a cost-benefit analysis	Moderate

BuildUPspeed

			area that are far away from main prefabrication production facilities but still have valid local craftmanship to complete the retrofit element.	is needed to assess the impact of transportation and dislocation of manufacturing.	
District factory	Not yet developed	It could work in areas when urban regeneration is needed	One production site serving an area where both new construction and renovation interventions occurs	Hard to find solutions providers ready to invest in temporary renovation factories, moving away from the idea of fixed production site.	Moderate
Assembly factory	Something has been explored for new offsite construction	The supply chain is evolving and could be ready for such collaborative model where only assembly is moved on-site	Possibility to use and invest in current production facilities	High coordination from different manufacturers and low transport optimisation.	Moderate
Service factory	Few examples, but with the service part to be improved and explored	It's similar to the concept of offsite renovation that is currently developing: one location for manufacturing and assembly, then delivered on-site.	Services for tenant engagement and training for construction companies.	Feasibility of the business model: who pays / coordinate such services?	High

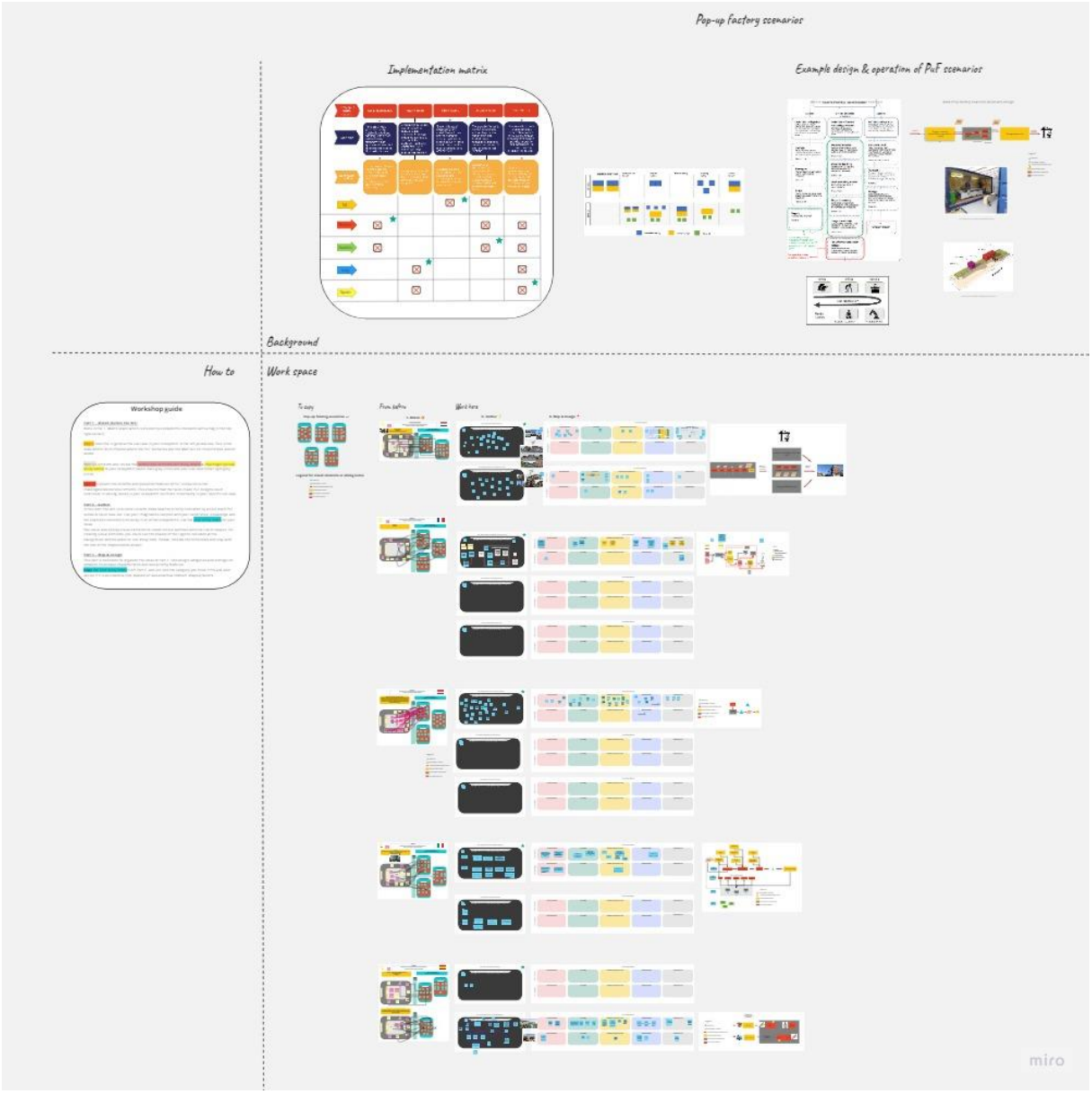
The Spanish Ecosystem

	Maturity	Market potential	Drivers	Barriers	Potential for application
Mobile on-site factory	High	Although there is already supply on the market for certain "services", e.g. blown-in thermal insulation, the potential is relative depending on the solution, e.g. thermal insulation blown-in has some drawbacks: existing thermal bridges are not eliminated and its application is limited to houses/buildings built between 1920-1979, besides the thickness of insulation required may be greater than the thickness of the cavity.	For some solutions or "services" is the only available option.	Lack of space next to the building to be renovated. The disturbance to neighbours: noise, dust, etc.	Low-moderate
Satellite factory	Medium	As a general comment, Nowadays, the market only is concerned about the cost of the project. So, if it is cheaper, the market will accept it without problems. As we understand it is not mature enough to ensure the cost, the perception is not very good	Interest for importing deep-renovation technologies offering competitive advantages (price, execution time, no inconvenience for tenants) compatible with existing building typologies and construction systems.	High barriers to entry: high initial investments, adequate economy of scale	Low

BuildUPspeed

District factory	Low		As a general comment, investment by public bodies is the best driver nowadays	The market for prefabricated construction in Spain is very small, less than 1%, and the market for industrialised renovation is even smaller. This type of factory requires a certain volume or aggregation of projects and agents that is still very difficult to find in the Spanish market.	Low-moderate
Assembly factory	Low	The use of this type of industrialised solutions in constructions (investments) promoted by the public administration has a clear exemplary role and give them high visibility.	The need to develop projects with short lead times and reduced environmental impact can be catalysts.	The lack of actors with sufficient knowledge, experience and resources in the market to provide these solutions.	Low
Service factory	High	Especially relevant for private, middle-income homeowners.	They may benefit from the pull of the "next generation" subsidies available in the coming years to encourage housing renovation.	Services with low profit margins.	Medium-High

Appendix IV



Italian Ecosystem

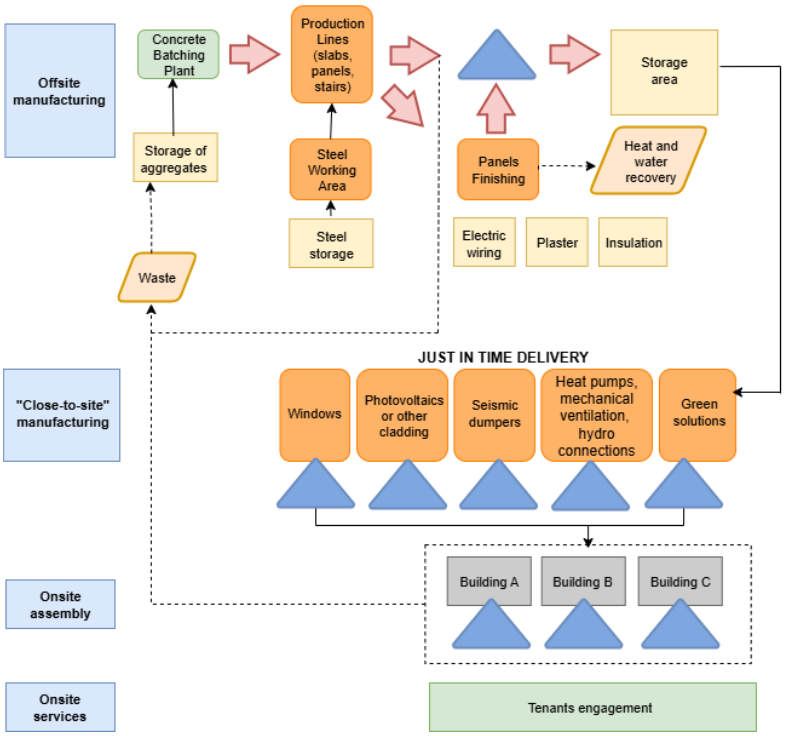
Idea board

OFFSITE (main hybrid factory)	Production of offsite roof and facade panels for renovation: - structure - insulation - plaster finishing - predisposition for cables and pipes – anchoring systems
	Prefabricated balconies
	Production of concrete roofs, façades, internal walls, slab and stairs for new construction or demolish and reconstruction

CLOSE-TO-SITE (smaller satellites factories)	Windows
	Other finishing rather than plaster (photovoltaics, green roof or facades, cladding)
	Heat pump or mechanical ventilation integrations
	Electric, hydro connections
	Seismic dumpers or other components
ONSITE (building location)	Provisional works
	Assembly of panels
	Technical systems not integrated
	Reinforcement for the foundation (if needed)
	Services to tenants and owners

Categorization

Main features & purpose	Main hybrid factory for both new construction and renovation through offsite panels
	Close-to-site factories (satellites) to integrate more fragile components such as windows, photovoltaics, green, etc.
	Onsite assembly and services
Layout & design	Typical factory producing precast elements of around 12.000 m2
	20.000 m2 storage only for panels, smaller components delivered JIT
Materials & equipment	Batching plant
	Carpentry and steel working
	Tilting tables and battery mould for panels
	Hollow core slabs and stairs production
	Forklifts and overhead cranes
	Close-to-site specific facilities
Workflow & processes	Continuous flow production for concrete panels
	LEAN management from satellites factories to sites
	Tenant engagement planned onsite for effectiveness of the works
Logistics & supply chain	Truck transportation of panels till satellites factories
	Maximum size of panels defined to optimize logistics
	High level of coordination among supplier to integrate components and delivery



Workshop Results: Design visualizations & Missing Requirements

The flow diagram in the figure above illustrates the Satellite Factory concept for the Italian ecosystem. In this configuration, **offsite manufacturing** refers to the hybrid factory producing elements both for renovation and new construction. Its layout strictly depends on the structural material used. It this study, panels are made of concrete with low-environmental impact binders and recycled aggregates. It has been selected for 2 main reasons:

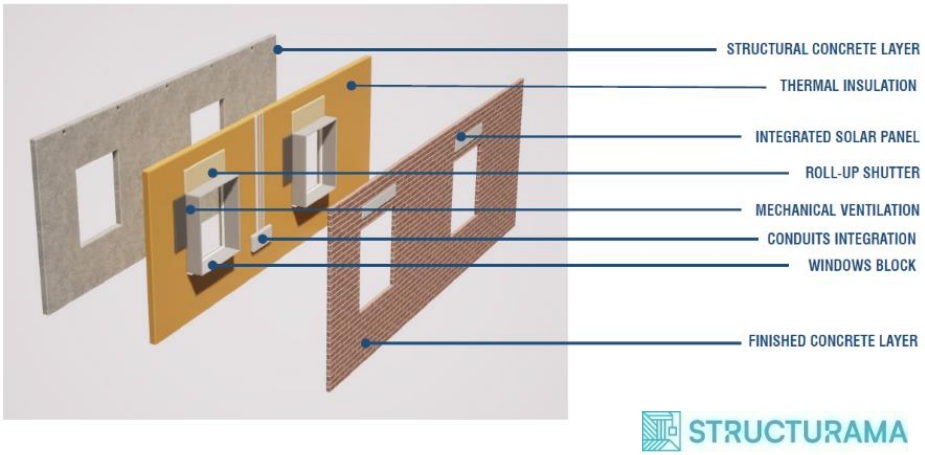
- it's cheaper than wood and steel-based offsite elements which is a relevant parameter when dealing with social housing
- it has production lines that can easily convert to produce renovation panels due to the casting process.

Having chosen concrete, Structurama (precast engineering expert) was selected as subcontractor and LAB member for factory layout, investment plan activities and validation of the satellite model, since not all the competences needed were present within the Italian Partners.

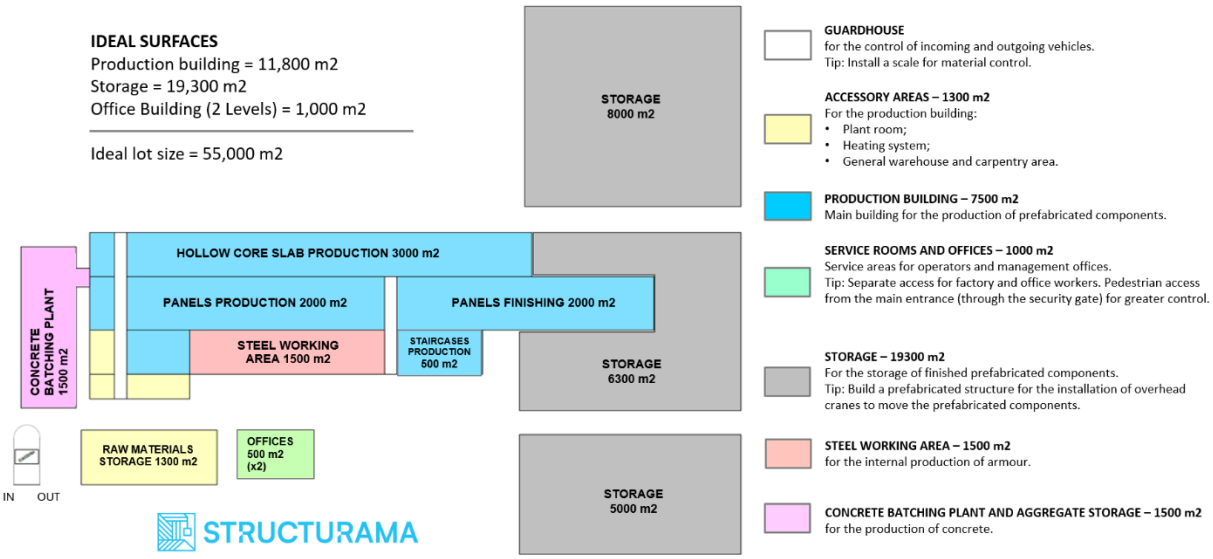




The technology proposed by Structurama is called RECOskeletron and it's represented in the diagram and pictures at the left and below.



The Offsite factory layout with the ideal dimension of each area is shown in the picture below. From left to right it has an area for storing aggregates (raw materials) that are moved into the batching plant, where the binders are mixed and then pumped into the main building which is divided in three different lines: production of hollow core slabs (for new construction only), production of wall panels (with a dedicated area for the finishing operations) and production of precast stairs. In addition, there are also the carpentry and the steel working area to produce reinforcement bars and cages. At the end of the process there are 3 storage areas for different elements.



The needed production equipment and workforce depends on the working station:

- Batching plant requires galvanized hoppers for storing aggregates, conveyors belts, mobile scale, planetary mixers, steel silos, dosing systems, automatic casting bucket, washing system and recycling plant for the treatment and reuse of wastewater, pre-wired control cabin (mainly for humidity and plasticity). The equipment is highly automatized and needs 2 workers only.
- Panels production requires 16 workers for the 8 tilting tables (3 x 24 meters each, mainly for insulated panels) and 5 for the battery mould with concrete pump and levelling beam (mainly for internal walls). In addition, a machine for tracking, one for oiling and surface treatment with 2 workers is needed together with 1 worker for cleaning the magnetic banks. Panels finishing implies 6 workers, plus 2 for insulation assembly. It clearly emerges that panels production is the working station requiring more manpower, having a lower level of automation.
- Stairs production requires 2 formworks, controlled by 1 worker each.

- Hollow core slab production requires 3 standard production lines and 1 line for special pieces managed by 4 workers
- Carpentry requires wood machines and 2 workers, while steel working requires a production plant for cages and machines that cut, extrude and fold steel, plus a conveyor cart for transportation.
- Storage of finished goods has 4 workers dedicated, beside forklifts and transport carts.
- Quality control implies 2 workers plus one production manager and one maintenance technician.

Overall, around 50 workers are needed to manage the offsite main factory.

Each section is equipped with overhead cranes which move the pieces to the next working station. In total there are 6 in the production area with a loading capacity of 5 to 15 tons each and 6 in the storage areas in the centre and bottom with a loading capacity of 20 tons each. For the storage on the top, instead, the handling is made through forklifts only. All these machines and equipment require utilities including electricity, water for concrete mixing and cleaning, compressed air for equipment and forms, natural gas or steam for curing, and robust communication systems. Proper management of these utilities supports efficient production of high-quality panels, ensuring the consistency and durability needed for construction applications.

The set up of the factory promotes a rapid and continuous production, and its sectionalization makes it possible to produce both products for new buildings and panels for renovations. Indeed, the hybrid offsite factory has an annual capacity for new construction of around:

- Internal walls = 85.000 m2 of which 21.000 m2 can be stored
- Internal insulated walls = 25.000 m2 of which 6.000 m2 can be stored
- External walls = 85.000 m2 of which 21.000 m2 can be stored
- Hollow core slabs = 100.000 m2 of which 25.000 m2 can be stored
- Full slab for common areas = 12.000 m2 of which 3000 m2 can be stored
- Staircase with landing = 380 pieces of which 95 can be stored
- Balconies = 9.000 m2 of which 2000 m2 can be stored

This quantity allows to demolish and rebuild 10 buildings such as the one of Viale Omero, the Milanese social housing which has been used as reference case for the feasibility study and cost comparison between traditional and prefab concrete technologies. In addition, since slabs are longer to be produced, considering the same number of shifts, the line for walls panels can have an overproduction of around 13.000 m2, which are sufficient for the external renovation of around 7 buildings such as the one of Viale Omero (having a façade surface of 2000 m2).
The sizing of each prefabricated component is developed taking into account not only the required production capacity, but also road transport constraints, onsite construction cranes characteristics and also the organization of the storage area. For the renovation panels the maximum dimension is around 3.2 m x 12 m, but the most common ones are 9 m long. The data demonstrates how the factory's production capacity, combined with the efficiency of RECOskeletron technology, enables not only the systematic construction of new buildings, but also a significant opportunity for the renovation of existing buildings.

Concrete batching plant (1500 m2)



Steel working area (1500 m2)



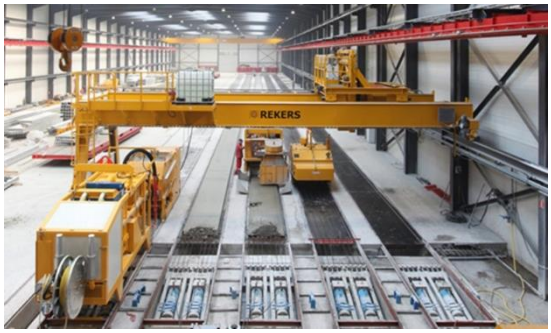
tilting tables for panels production (2000 m2)



Battery mould for panels production (2000 m2)



Hollow core slabs production (3000 m2)



Staircase production (500 m2)



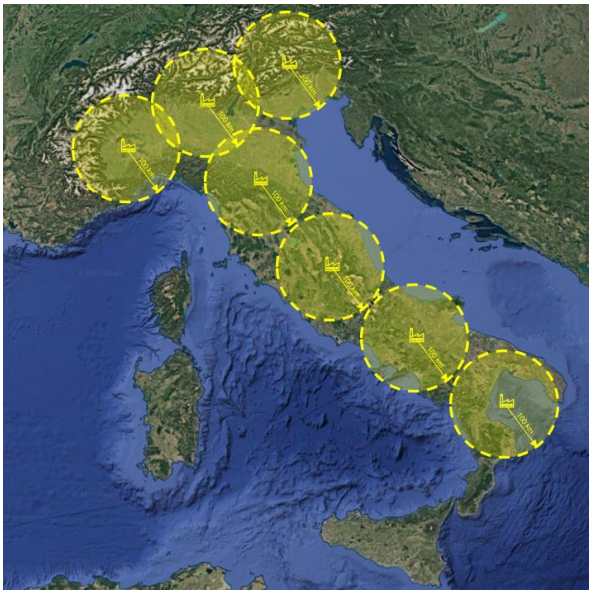
Panels finishing (2000 m2)



Storage area with overhead cranes (19300 m2)



Beside the main hybrid factory, a **close-to-site manufacturing** capability is also in place for producing or integrating certain components near the building site, which is the assembly location of the panels on the fabric. While the offsite factories have big storage space, the close-to-site ones are smaller and more locally oriented, so the logistic need to be adapted to their needs and constraints. For this reason, a Just-in-Time (JIT) delivery process, which coordinates the supply and integration of windows Other finishing rather than plaster (photovoltaics, green roof or facades, cladding), heat pump or mechanical ventilation components, electric, hydro connections and seismic dumpers. These arrive precisely when needed for **onsite** assembly or onsite temporary storage at multiple building sites. Finally, the installation of renovation panels on the façade takes place. RECOskeletron has an average installation time of 200 m2/day, so for a building such has the one of Viale Omero, the façade can be renovated in 10 days (excluding the onsite preparation works). In addition, onsite tenant engagement services are provided since they are crucial in social housing context. Indeed, residents' cooperation ensures smooth installation, minimizes disruptions, and helps adapt behaviours to maximize the benefits of new technologies. Continued engagement after renovation fosters correct use and maintenance of systems, securing long-term energy savings and comfort improvements, especially among energy poor tenants.

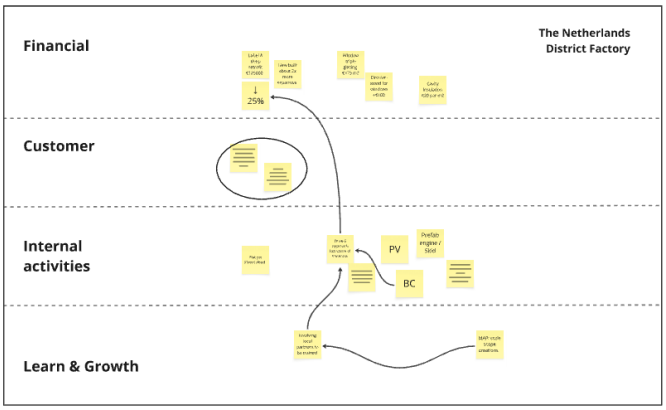


Considering a maximum radius of 100 km, in Italy around 7 main offsite factories are needed to cover the whole peninsula (excluding remote locations such as Sicily and Sardinia that are tackled in T4.6).
An economic analysis will follow to assess the cost-benefit ratio in terms of transport costs, opening of multiple factories and the related requirements with respect to more traditional scenarios.

Appendix V

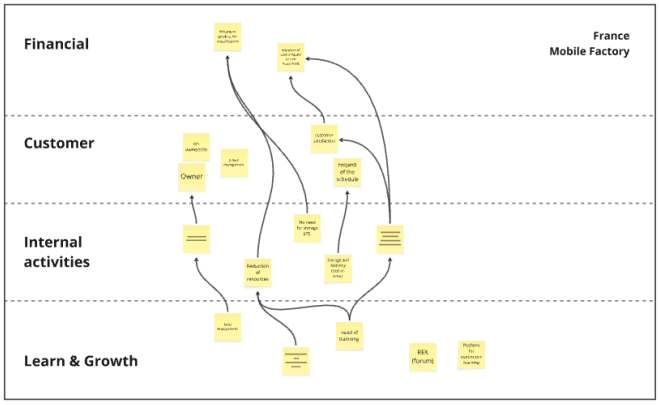
The Dutch ecosystem

District Factory
We are focusing on the District factory concept, particularly in an urban region with one single case at the moment. One of our main goals is to build both skill and scope. In that region, we try to connect projects to a larger portfolio to increase skill and scope, which is a prime focus of the district concept. This approach aims to accelerate the renovation wave at a local level.
Our starting point for this effort is a base concept developed in previous projects, particularly with Drive 0. This renovation approach provides a baseline that we must follow to avoid excessive costs from customising solutions. We need to select projects that naturally fit with the district factory approach and the portfolio we want to create, depending heavily on the business case.
We will discuss this further in our next workshop this afternoon, as it is crucial to communicate our story to our initial customer, a social housing association. From the Drive 0 project, we learned the importance of aligning the project organizational model with the district factory concept to achieve price reductions. Currently, our technologies are too expensive.
We asked the housing association to estimate renovation costs for properties in our project. They calculated about €125,000 per apartment for renovation. Building a new apartment in the same building would cost around €250,000. By leveraging skill and scope potential in the region, we aim to reduce renovation costs by up to 25% below €125,000 per apartment.



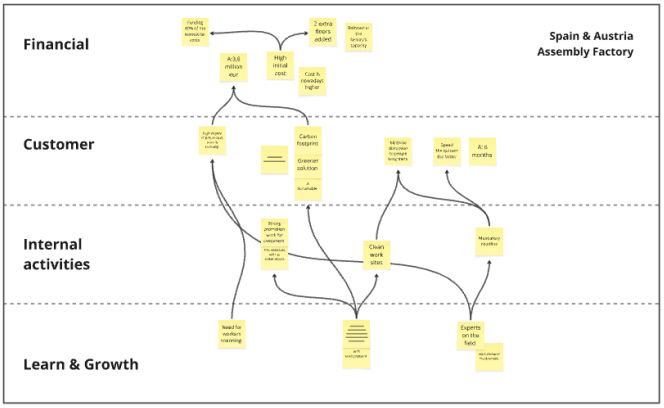
The French ecosystem

Mobile Factory
We are developing an innovative process for our pilot project involving an mobile on-site factory. This concept involves using a truck to transport social sanitary equipment from selective reconstruction sites. The equipment can be stored on the truck and reused for rehabilitation at other sites.
To ensure success, we need proper training to maintain high standards of work, which will positively impact local employment. This local employment can lead to energy savings and decarbonization of the work.
The development of this reemployment sector can reduce resource usage and requires training to utilize about 50% of the existing equipment from selective reconstructions. This approach is applicable for various owners, including co-op ownership, project managers, and social housing associations.
A key aspect of this process is just-in-time storage and shipping, which helps manage expenses and ensures timely delivery to the site. This method respects the project schedule and aims to achieve the project's volume goals through reemployment.
Project managers specify requirements for reemployment, and our process helps meet these specifications. For example, this approach can reduce costs by approximately €8000 compared to new sanitary equipment.
Thank you.



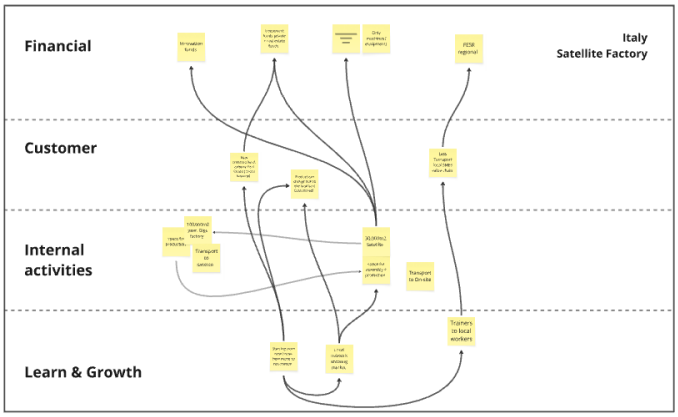
The Austrian & Spanish ecosystem

Assembly Factory
Our assembly factory draws from our extensive experience with pilot projects in Spain and Austria, which have proven to be remarkably similar. This shared experience has led us to develop a cohesive concept. Let me share the central story, focusing on our initial needs.
At the outset, we prioritized having a minimal impact on the surroundings, both on-site and environmentally. This requirement led to specific activities on-site, including maintaining a clean work environment and actively promoting our solutions to all stakeholders to demonstrate their benefits.
Next, we integrated these priorities with our customers' demands for green, clean, and low-carbon solutions, all within a tight construction deadline. This combination posed financial challenges, such as high initial costs and short deadlines. However, we also had the opportunity to access additional funds from subsidies due to our innovative solutions. Additionally, the nature of these solutions allowed us to build more square meters, benefiting the site owner.



The Italian ecosystem

Satellite Factory
Our factory operates as a satellite facility, primarily focusing on internal processes that define our operations. This satellite factory is linked to a Gigafactory where components requiring the most advanced high-tech machinery are produced. In Italy, we have a production capacity of 100,000 m2. Due to the need for ample production space, panels are manufactured at the Gigafactory and transported to the satellite factory. To avoid inconvenient off-site construction over distances exceeding 100 kilometers, smaller factories are strategically located throughout Italy. The satellite facilities are primarily used for assembly and production, with local suppliers contributing some components that are integrated with the panels. To foster learning and growth, we aim to train the local network in new technologies, supply chain creation, and integration. By leveraging the local network's knowledge of the building stock, the Gigafactory produces through the satellite factory, which possesses the necessary market expertise to implement the technology.
Our factory's uniqueness lies in its dual focus on new construction and renovation. The Gigafactory's production machinery can produce new component walls and retrofit components without significant changes, allowing the satellite factory to adapt them to the local context. However, our primary expertise is in new construction, and we recognize a gap in renovation skills. To address this, our customer value proposition emphasizes real estate and social housing renovation, involving both renovation and deconstruction.
The ecosystem's value is its ability to produce the same technology for both new construction and renovation, with customization based on location while using the same basic panels. We have also reduced transportation needs by leveraging local manufacturing expertise.
The satellite factory primarily receives funds from regional sources, as it is regionally located, with funding varying from region to region. The larger Gigafactory, which invests more in machinery, can secure funding from European innovation funds. Additionally, private real estate funds may invest in the factory to renovate their areas and resell apartments, recognizing the benefits of contributing to and investing in a satellite factory. In Italy, the Manufacturing 4.0 financial fund can be used for both the machinery of the Gigafactory and satellite factories, covering up to 40% of the investment cost.



Appendix VI

Overview & Objectives

This report summarizes the activities developed within the collaborative and interactive workshop “BuiltUPspeed: state of play real time demonstrators & implementation plans”, organized by ZUYD and DEMO on 11th October 2024.
The workshop was attended by all the Ecosystems, and aimed at exploring the state of play of the BUPS real-time demonstrators. Moreover, the workshop focused on understanding the conditions (barriers, limits, and opportunities) which would or would not allow the transition from the theoretical concepts of PuFs to their actual and practical realisation.
The insights developed within the workshop contribute to the development of the Implementation plan, included in Deliverable D 4.1.

The activities here described were held online by using a the Miroboard here accessible:
https://miro.com/app/board/uXjVMjKsr2s=/?moveToWidget=3458764564501484087&cot=14

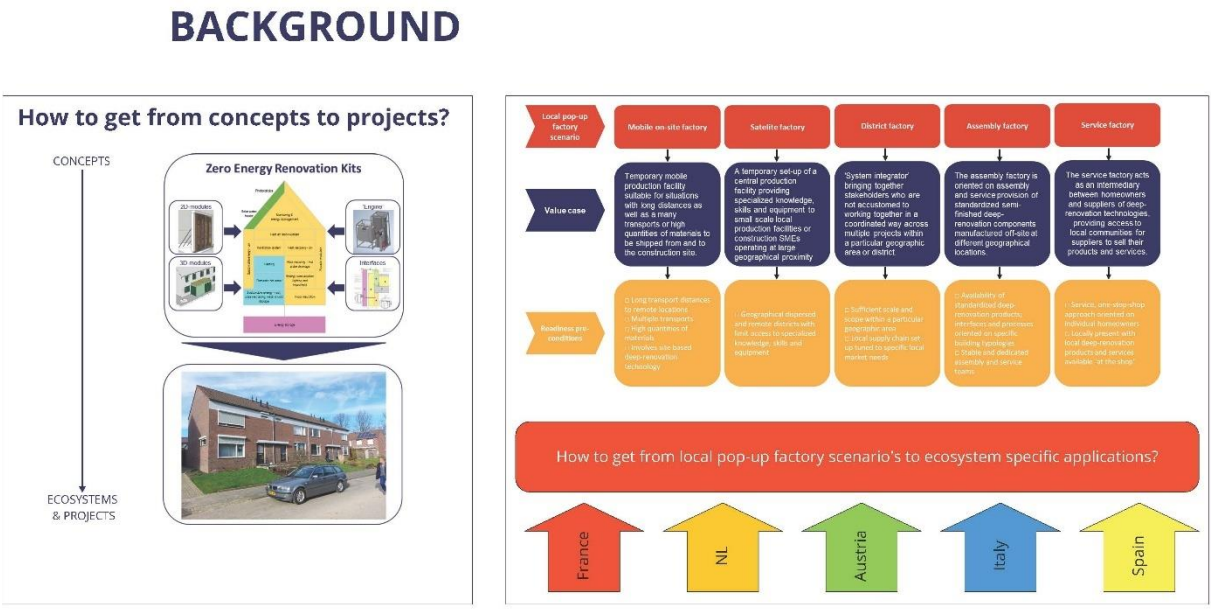


Figure 64: PuFs: from Concepts to Projects

Introduction and scope

The rapid growth of the construction sector has intensified the demand for sustainable and efficient building practices, calling for innovative approaches. In this context, Pop-up Factories (PuFs) have emerged as a promising solution to advance both sustainability and circularity within the industry. As adaptable and flexible production units, PuFs open new pathways for optimizing construction processes, reducing costs, and enhancing environmental performance through modularity. Their relevance is particularly evident in the deep-renovation market, where assessing their commercial

potential and practical feasibility—especially in terms of early-stage market viability—becomes essential.

Pop-up factory scenarios

As developed during the previous phases of the BuildUpSpeed research project, several Pop-up Factories scenarios have been defined, responding to the need of the different partners' Ecosystems.
Table 1 summarises the main traits of each PuF, as well as their Value cases and elements of readiness pre-conditions.

Table 29: Different PuF's scenarios showing Value cases and readiness pre-conditions

Local pop-up factory scenario	Mobile on-site factory	Satelite factory	District factory	Assembly factory	Service factory
Value case	Temporary mobile production facility suitable for situations with long distances as well as a many transports or high quantities of materials to be shipped from and to the construction site.	A temporary set-up of a central production facility providing specialized knowledge, skills and equipment to small scale local production facilities or construction SMEs operating at large geographical proximity	'System integrator' bringing together stakeholders who are not accustomed to working together in a coordinated way across multiple projects within a particular geographic area or district.	The assembly factory is oriented on assembly and service provision of standardized semi-finished deep-renovation components manufactured off-site at different geographical locations.	The service factory acts as an intermediary between homeowners and suppliers of deep-renovation technologies, providing access to local communities for suppliers to sell their products and services.
Readiness pre-conditions	- Long transport distances to remote locations - Multiple transports - High quantities of materials - Involves site based deep-renovation technology	- Geographical dispersed and remote districts with limit access to specialized knowledge, skills and equipment	- Sufficient scale and scope within a particular geographic area - Local supply chain set-up tuned to specific local market needs	- Availability of standardized deep-renovation products; interfaces and processes oriented on specific building typologies; - Stable and dedicated assembly and service teams	- Service, one-stop-shop approach oriented on individual homeowners - Locally present with local deep-renovation products and services available 'at the shop'

Methodology

The activities developed for the workshop "BuiltUPspeed: state of play real time demonstrators & implementation plans" are built around a methodological tool, inspired by the *Actant Mapping Canva*, by the design anthropologist and researcher Monika Sznel[15]. This tools allow for a more precise shape of stakeholder mapping, which envisions 'human' and 'non-human' actant. The problem that the tool aims to approach is then explored by defining the related 'direct actants', who affect the problem and can be affected by the solution to the it; and the 'indirect actants', who affect the direct actants and can be affected by them.



Figure 65: Methodological scheme developed and used in the workshop

Being inspired by this tool, which supports then an environmental-centered perspective, instead of a mere human-centered one, a specific wheel has been developed for the workshop. This, shown in Figure 2, allows to discuss shared needs, in two distinct phases:

PART I

- Phase 1: in this phase the users work in the central part of the circle, recognising key needs that need to be met in the ecosystem. They answer to questions such as "what are the needs and wishes of the involved end-users and other stakeholders?"
- Phase 2: in this phase the users work in the left side of the middle and outer circles. They aim to recognise the direct and indirect human actants (stakeholders) involved in the ecosystem.
- Phase 3: in this phase the users work in the right side of the middle and outer circles. They aim to recognise the direct and indirect non-human actants

[15] The Actant Mapping Canva, developed by Monika Sznel, is available at: https://uxdesign.cc/tools-for-environment-centered-designers-actant-mapping-canvas-a495df19750e

(technical, financial, legal etc), such as building characteristics/elements being subject to the renovation.

PART II

- Phase 4: In this phase the users work with the information filled in in the middle and outer circles. They aim to identify the barriers related to the human and non-human actants.
- Phase 5: In this phase the users aim to identify possible solutions to the previously identified barriers.

PART III

- Phase 6: In this phase the users organize the barriers and solutions in three categories:
    - 1) barriers and solutions to be addressed in the BuiltUPSpeed WPs;
    - 2) barriers and solutions to be addressed in the Local Advisory Board;
    - 3) barriers and solutions beyond the scope of the project.

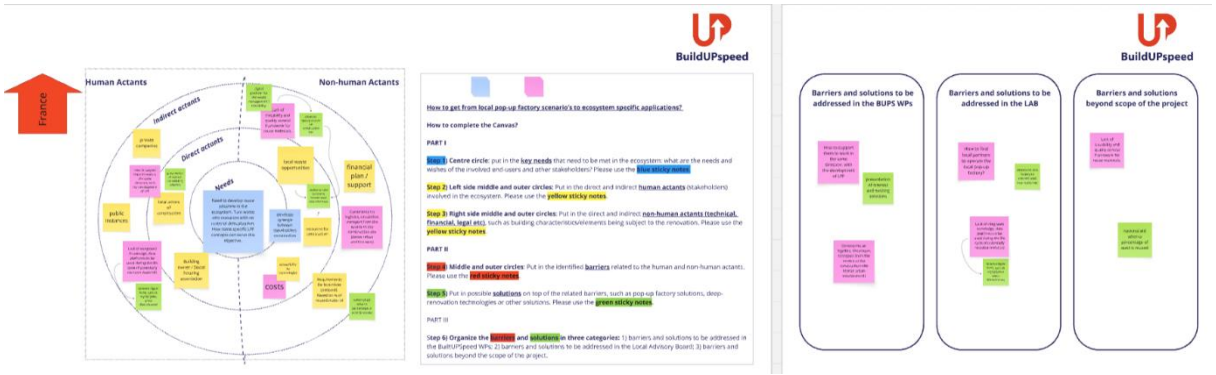


Figure 66: Complete layout of the workshop, as example of the French Ecosystem

The Workshop

The Dutch Ecosystem

Building on the methodological framework, the application of the Actant Mapping Canvas during the workshop made it possible to generate a structured overview of the ecosystem surrounding the deployment of local Pop-up Factories (PuFs). The process began with the identification of key needs, which highlighted fundamental gaps in the renovation market, such as the lack of transparent communication of real performances to end-users, the persistence of a divide between research and market application, and the need for universal access upgrades. Specific technical and social priorities emerged, including the thermal upgrading of existing housing blocks, better awareness of the non-financial benefits of retrofitting, the demand for clarity around renovation processes, and the introduction of a dedicated “retrofit manager” role to mediate between stakeholders.

Mapping of human actants revealed a constellation of both direct and indirect stakeholders shaping the renovation ecosystem. Among the direct actants, occupants, building owners, social housing associations, and ZUYD were central, while indirect actants included decision-makers at local and national levels, construction companies, local partners, and WEBO. On the non-human side, the mapping process recognized the importance of technical and regulatory dimensions, such as EU regulations, preparatory site-based works, waste management, material stock locations, local environmental quality, and the Market Activation Platform linking supply and demand.

The workshop then advanced to the identification of barriers and solutions. Barriers were reported across institutional, technical, and financial domains: the difficulty of persuading decision-makers to prioritize renovation over new construction, short guarantee contracts that fail to comply with regulations, insufficient labour capacity, quality issues with existing materials, and the persistent lack of financial or human resources to challenge “business-as-usual” approaches. In response, participants proposed a range of solutions. These included: strengthening value propositions to decision-makers beyond cost-benefit logic; appointing system integrators to ensure continuity of PuFs; adopting new business models such as leasing systems for façades and services; promoting automation and industrialization of the renovation process; and applying circular strategies like material equivalence principles, local material stocks for value retention, and risk funds to mitigate uncertainties. Additional measures, such as training programmes to improve retrofitting skills and better integration with existing local One-Stop Shops (OSSs), were also seen as key enablers.

Overall, the exercise confirmed that PuFs are not only technical infrastructures but also socio-technical mediators that can reconfigure relationships among stakeholders, resources, and regulatory frameworks. By articulating needs, actants, barriers, and solutions in a single ecosystem view, the workshop provided a roadmap for addressing early-stage market feasibility, underscoring the potential of PuFs to accelerate sustainable deep renovation while embedding circularity principles at multiple scales.

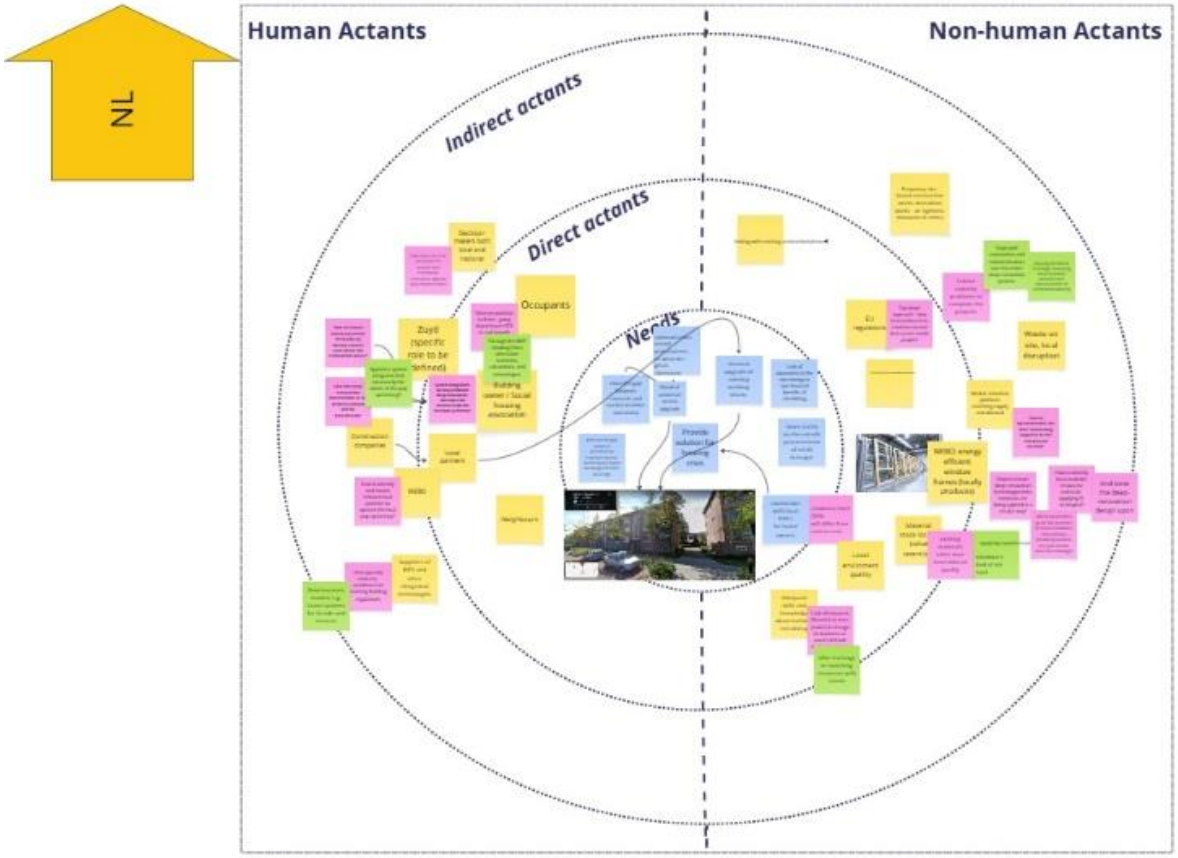


Figure 67: The Actant Map, Dutch Ecosystem

Table 30: Workshop result of the Dutch Ecosystem

Needs
Communication of real performances (i.e.: what do I get as a citizen/user?)
Close the gap between research and market
Address the gap between architectural tradition (typical dutch house) & energy efficient buildings
Need of universal access upgrade
Thermal upgrade existing building blocks
Lack of awareness in the non-energy or non-financial benefits of retrofitting
More clarity on the retrofit process
Need for retrofit manager

Human Actants	
Indirect Actants	**Direct Actants**
Decision-makers (local and national)	Occupants
ZUYD	Building owner
Construction companies	Social housing association
WEBO	Local partners
	Neighbourhood
	WEBO

Barrier	Solutions	Barrier	Solutions
How could decision makers be persuaded to support and emphasize renovation against new constructions?	-	Value proposition to them - going beyond pure ROI or cost-benefit analysis	Through the MAP showing them alternative scenarios, calculations, and technologies

How to ensure continuity of the local pop-up factory (and as such boost the renovation wave)?*	Appoint a system integrator (not necessarily the owner of the pop up factory)?	System integrators are key to holistic deep-renovation: who initiates/leads the local pop up factory?	-
How the deep-renovation intervention or set of interventions will be determined?			
How to identify and involve relevant local partners to operate the local pop-up factory?	-		
Short garanty contracts, conditions not meeting Building regulations	New business models e.g. Lease systems for facade and services		

Non-Human Actants			
Indirect Actants		**Direct Actants**	
Preparatory site-based construction works (demolition works, air-tightness, measurements, …)		EU Regulations	
Waste on site		Material stock location	
Market Activation Platform (to match supply and demand)		Local environment quality	
Barrier	**Solutions**	**Barrier**	**Solutions**
Labour capacity problems to complete the projects	Improved automation and industrialization over the entire deep-renovation process	Top-down approach - how to transform it to a bottom-uo one that serves needs people?	Linking with existing actions/initiatievs
	Applying the Rethink R-strategy: developing deep-renovation scenario's with reduced number of components/handling	Readiness level OSSs will differ from case to case	Connection with local OSS's
Existing materials often dont have label of quality	applying equilance priniples and introduce a kind of risk fund	Existing materials often dont have label of quality	Material stock locally (value retention)
Lack of resources (financial or man-power) to change on business-as-usual methods and technologies	Offer trainings or matching resources with needs	Lack of resources (financial or man-power) to change on business-as-usual methods and technologies	Adequate skills and knowledge about building retrofitting
How to operationalize the MAP connecting suppliers to the ecosysteem [needs]?	-		
How to ensure deep-renovation technologies/interventions are being applied in a circular way?	-		
How to identify local available resources/	-		

materials (applying R-strategies)? And how to base the deep renovation upon them?			
Which parameters guide the selection of deep-renovation interventions [following a whole life cycle carbon reduction strategy]?	-		

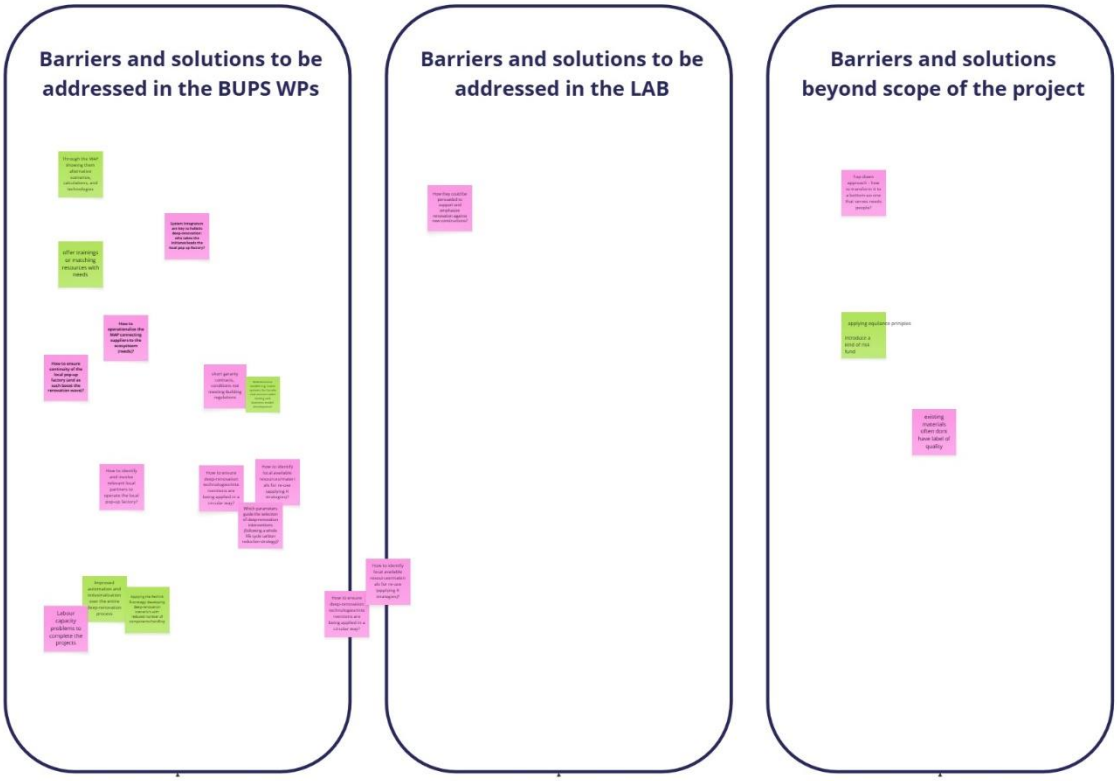


Figure 68: Different destination of Barriers and Solutions, Dutch Ecosystem

Table 31: Different destination of Barriers and Solutions, Dutch Ecosystem

Barriers and solutions to be addressed in the BUPS WPs	
Barriers	*Solutions*
System integrators are key to holistic deep-renovation: who takes the initiates/leads the local pop up factory?	
How to operationalize the MAP connecting suppliers to the ecosysteem [needs]?	
How to ensure continuity of the local pop-up factory (and as such boost the renovation wave)?	
short garanty contracts, conditions not meeting Building regulations	New business models e.g. Lease systems for facade and services>pilot testing and business model developemnt
How to identify and involve relevant local partners to operate the local pop-up factory?	

How to ensure deep-renovation technologies/interventions are being applied in a circular way?	
Which parameters guide the selection of deep-renovation interventions [following a whole life cycle carbon reduction strategy]?	
How to identify local available resources/materials for re-use (applying R strategies)?	
Labour capacity problems to complete the projects	Improved automation and industrialization over the entire deep-renovation process
	Applying the Rethink R-strategy: developing deep-renovation scenario's with reduced number of components/handling
How to ensure deep-renovation technologies/interventions are being applied in a circular way?	
	Through the MAP showing them alternative scenarios, calculations, and technologies
	Offer trainings or matching resources with needs
Barriers and solutions to be addressed in the LAB	
How they could be persuaded to support and emphasize renovation against new constructions?	
How to identify local available resources/materials for re-use (applying R strategies)?	
Barriers and solutions beyond scope of the project	
Top-down approach - how to transform it to a bottom-uo one that serves needs people?	
existing materials often dont have label of quality	
	Applying equilance priniples and introduce a kind of risk fund

The Austrian Ecosystem

The workshop session developed for the Austrian ecosystem focused on identifying the needs, stakeholders, barriers, and enabling solutions related to industrialized renovation processes, reuse strategies, and circular construction practices. The activity explored the conditions required to improve renovation processes through more integrated value chains, reuse-oriented approaches, and enhanced collaboration between actors involved in the construction sector. Particular attention was given to the challenges associated with regulations, information availability, reuse processes, and the operational organization of stakeholders across the renovation and construction chain.

Through the mapping exercise, participants identified a broad range of human and non-human actants involved in the ecosystem. Human actants included authorities, the Federal Ministry for Climate Protection, building consultants, consumers and

companies, building owners, residents, real estate operators, Burgenland mobilien gesellschaft, and other stakeholders involved in planning, construction, and renovation processes. Non-human actants included building and national regulations, business models, standards, value-chain processes, financing models, information systems, and reuse-related procedures.

The workshop activity highlighted several central needs within the Austrian ecosystem. These included the necessity for affordable and fast renovation solutions, the development of financing models, improved availability of information, increased awareness among stakeholders, and the establishment of “One Stop Shop” approaches capable of simplifying renovation and reuse processes. Participants also identified the need to develop solutions for end-of-waste issues concerning reuse elements and to better connect processes across the actual value chain. Fixed rents and rental contracts emerged as additional structural conditions influencing renovation possibilities and investment capacities.

A number of barriers were identified during the activity. Participants emphasized the complexity of administrative and regulatory frameworks, including cumbersome regulations, strict conditions, legal frameworks for waste management, standards, and market procedures affecting SMEs. Additional barriers concerned the lack of knowledge among building owners and stakeholders regarding renovation benefits and reuse possibilities, as well as insufficient information about reuse products and responsibilities within the process chain. Planning processes not being finalized until execution stages, warranty and business insurance issues, time limitations, and the costs associated with urban mining and reuse practices were also identified as major constraints. The ecosystem further highlighted operational difficulties linked to differing standards and procedures, as well as limited integration between stakeholders across the value chain.

Alongside these barriers, the workshop mapped several potential solutions and enabling strategies. These included simplifying administrative procedures, developing exchange platforms and collaborative spaces, promoting awareness of renovation benefits, and creating guidelines for end-of-waste preparation for reuse. Participants also identified the importance of pilot projects for reuse materials and standards, earlier integration of BIM processes, improved information regarding subsidies, and the creation of platforms capable of connecting stakeholders and technologies. Additional solutions focused on reducing administrative burdens, supporting cheaper energy costs, and strengthening coordination between actors involved in renovation and reuse processes.

The workshop session further distinguished between barriers and solutions that could be addressed within the BUPS Work Packages, those requiring additional development within the LAB environment, and those extending beyond the scope of the project. Within the project framework, actions such as pilot projects, awareness raising, and process experimentation were considered feasible. In contrast, broader issues linked to regulatory frameworks, standards, insurance systems, administrative procedures, and market structures were recognized as challenges requiring intervention at institutional and policy levels. Overall, the activity demonstrated that the Austrian ecosystem requires an integrated approach combining regulatory adaptation, stakeholder coordination, reuse-oriented governance, digital and organizational

innovation, and financial support mechanisms in order to accelerate circular and industrialized renovation processes.

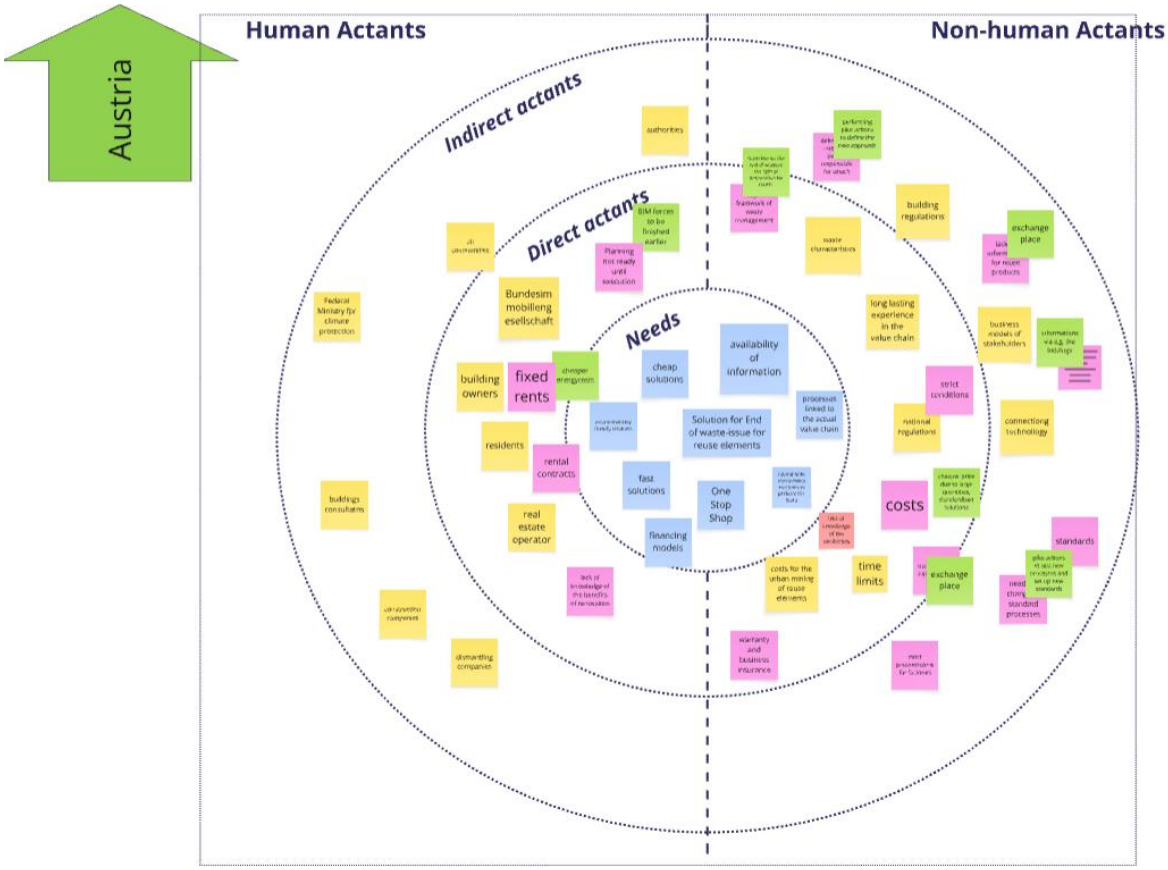


Figure 69: The Actant Map, Austrian Ecosystem [Miro Canva]

Table 32: Workshop result of the Austrian Ecosystem

Needs
Fixed rents
Cheap solutions
Availability of information
Solution for End of waste issue for reuse elements
Fast solutions
One Stop Shop
Financing models
Awareness raising for stakeholders
Processes linked to the actual value chain

Human Actants			
Indirect Actants		**Direct Actants**	
Authorities		Building owners	
Federal Ministry for climate protection		Residents	
Building consultants		Real estate operators	
Consumers / companies		Burgenland Mobilien Company	
All stakeholders			
Barrier	**Solutions**	**Barrier**	**Solutions**

Framework of cumbersome regulations	Simplify the administrative burden for all stakeholders	Rental contracts	Energy cooperatives
		Lack of knowledge of benefits of renovation	Awareness raising
		Planning not ready until execution	BIM forms to be finished
		Fixed rents	Cheaper energy costs

Non-Human Actants			
Indirect Actants		**Direct Actants**	
Building regulations		Long lasting experience in the value chain	
National regulations		Business models of stakeholders	
		Standards	
Barrier	**Solutions**	**Barrier**	**Solutions**
legal framwork of waste management	Guideline for the end of waste in the ligth of preparation for reuser	legal framwork of waste management	Guideline for the end of waste in the ligth of preparation for reuser
Costs	cheaper price due to large quantities, standardized solutions	definition of interfaces (who is responsible for what?)	performing pilot actions to define the new approach
Strict conditions		lack of information for reuse products	exchange place
warranty and business insurance		lack of knowledge of the buildung owner. dependence of the gereal contractor.	informations via e.g. the biddings
start a market supply/demand	exchange place	standards	pilot actions to test new processes and set up new standards
		need for change of standatd processes	
		start a market supply/demand	exchange place
		strict precondicions for factories	

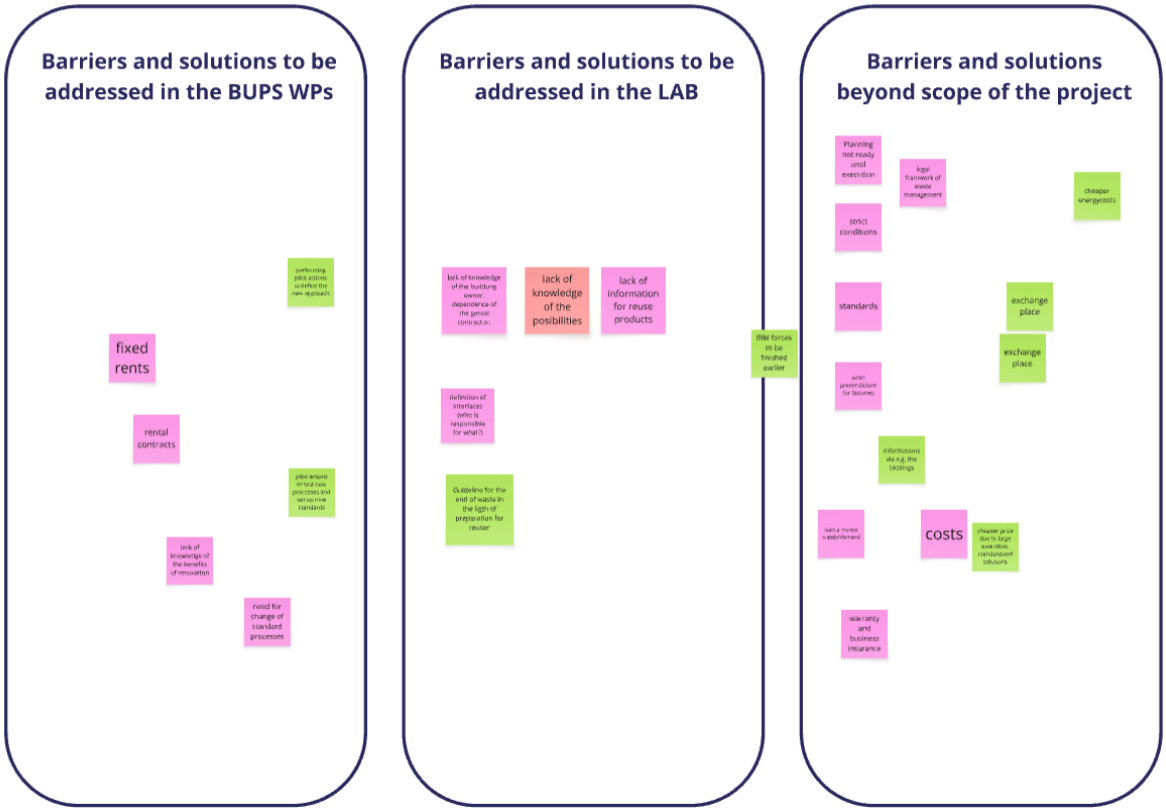


Figure 70: Different destination of Barriers and Solutions, Austrian Ecosystem [Miro Canva]

Table 33: Different destination of Barriers and Solutions, Austrian Ecosystem

Barriers and solutions to be addressed in the BUPS WPs	
Barriers	*Solutions*
Fixed rents	Partnering pilot actors to define the app process
Rental contracts	Pilot projects with reuse and reuse material standards
Lack of knowledge of the benefits of renovation	
Need for change of standard processes	
Barriers and solutions to be addressed in the LAB	
Lack of knowledge of the building owner, dependence of the general contractor	BIM forces to be finished earlier
Lack of knowledge of the possibilities	Guideline for the end of waste in the light of preparation for reuse
Lack of information for reuse products	
Definition of interfaces (who is responsible for what?)	
Barriers and solutions beyond scope of the project	
Planning not ready until execution	Cheaper energy costs
Strict conditions	Exchange place
Legal framework of waste management	
Standards	Information about the subsidies
Strict procedures for SMEs	Cheaper price due to less cumbersome administrative solutions
Costs	
Market procedures for SMEs	
Warranty and business insurance	

The French Ecosystem

The workshop activity developed for the French ecosystem focused on mapping the actors, needs, barriers, and potential solutions related to the implementation of reuse-oriented construction processes and Local Factory Processes (LFPs). The activity aimed to identify the conditions necessary to transform waste into resources while reducing material delocalization and strengthening localized circular construction ecosystems. Through the mapping exercise, participants identified both human and non-human actants involved in the process, distinguishing between direct and indirect actors as well as the barriers and enabling solutions associated with each of them.

The activity highlighted the central role of private companies, public institutions, local construction actors, and building owners or social housing associations in supporting the transition toward reuse-based construction practices. At the same time, several non-human actants were identified, including local waste opportunities, construction resources, financial support mechanisms, incentives linked to reused materials, logistics systems, and digital platforms for waste management and traceability.

The workshop session revealed a number of critical barriers affecting the implementation of reuse processes. Among the main organizational barriers identified was the difficulty of aligning stakeholders toward shared objectives connected to the development of LFPs. In parallel, participants emphasized the lack of integrated knowledge systems and data platforms capable of supporting the tracking and management of reusable materials throughout their life cycle. Additional operational barriers concerned logistics, circulation, and transport constraints between waste sources and construction sites, particularly within dense urban environments. The lack of traceability systems and quality-control frameworks for reused materials was also identified as a structural challenge extending beyond the direct scope of the project.

Alongside the barriers, the workshop activity also mapped a series of possible solutions and enabling strategies. These included the dissemination and presentation of existing reuse solutions, the development of material digital banks and traceability platforms such as myUpcycle space (Domofrance), and the implementation of mobile on-site factories capable of transforming waste into reusable construction resources. Participants also identified the importance of improving access to technologies, strengthening synergies between stakeholders, and introducing national financial incentives linked to the percentage of reused materials.

Finally, the workshop exercise distinguished between barriers and solutions that could be addressed directly within the BUPS Work Packages, those requiring further development within the LAB activities, and those remaining beyond the project scope. While stakeholder coordination, local partnerships, logistics strategies, and digital tools could be explored within the project framework, broader regulatory and certification challenges related to traceability and quality-control standards were recognized as issues requiring intervention at institutional and policy levels. Overall, the activity demonstrated that the development of circular and reuse-oriented construction

ecosystems depends on the integration of technical, organizational, financial, logistical, and regulatory dimensions within a coordinated local framework.

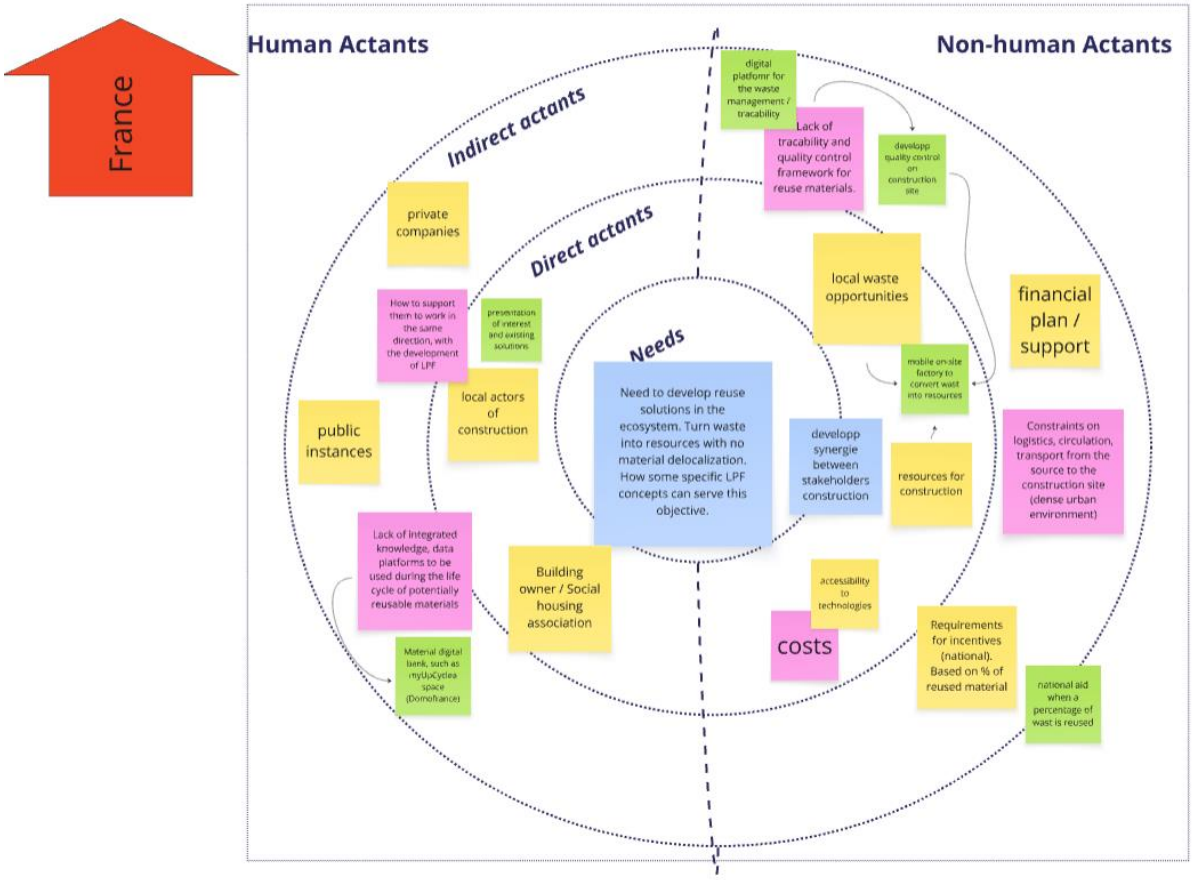


Figure 71: The Actant Map, French Ecosystem [Miro Canva]

Table 34: Workshop result of the French Ecosystem

Needs			
Need to develop reuse solutions in the ecosystem. Turn waste into resources with no material delocalization. Explore how specific LFP concepts can serve this objective.			
Develop synergies between stakeholders in construction.			
Human Actants			
Indirect Actants		**Direct Actants**	
Private companies		Local actors of construction	
Public instances		Building owner	
		Social housing association	
Barrier	**Solutions**	**Barrier**	**Solutions**
How to support them to work in the same direction, with the development of LFP	Presentation of interest and existing solutions	How to support them to work in the same direction, with the development of LFP	Presentation of interest and existing solutions
Lack of integrated knowledge and data platforms to be used during the life cycle of	Material digital bank, such as myUpcycle space (Dornfolen)	//	//

potentially reusable materials			

Non-Human Actants			
Indirect Actants		**Direct Actants**	
Financial plan / support		Local waste opportunities	
		Resources for construction	
		Requirements for incentives (national), based on percentage of reused material	
Barrier	**Solutions**	**Barrier**	**Solutions**
Constraints in logistics, circulation, transport from the source to the construction site (dense urban environment)	National aid when a percentage of waste is reused	Costs	Accessibility to technologies
Lack of traceability and quality control framework for reuse materials	Digital platform for the waste management / traceability		
	National aid when a percentage of waste is reused		

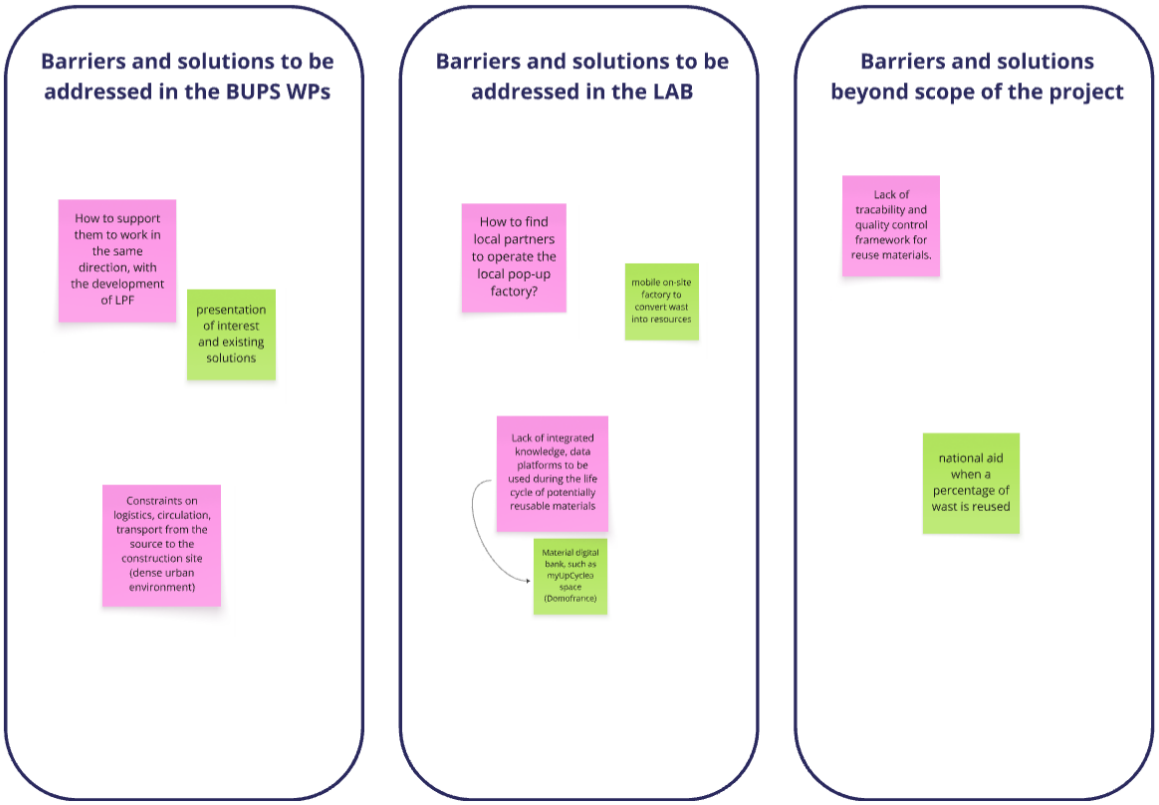


Figure 72: Different destination of Barriers and Solutions, French Ecosystem [Miro Canva]

Table 35: Different destination of Barriers and Solutions, French Ecosystem

Barriers and solutions to be addressed in the BUPS WPs	
Barriers	*Solutions*
How to support them to work in the same direction, with the development of LFP	Presentation of interest and existing solutions

Constraints on logistics, circulation, transport from the source to the construction site (dense urban environment)	
Barriers and solutions to be addressed in the LAB	
How to find local partners to operate the local pop-up factory?	How to find local partners to operate the local pop-up factory?
Lack of integrated knowledge, data platforms to be used during the life cycle of potentially reusable materials	Lack of integrated knowledge, data platforms to be used during the life cycle of potentially reusable materials
Barriers and solutions beyond scope of the project	
Lack of traceability and quality control framework for reuse materials	Lack of traceability and quality control framework for reuse materials

The Spanish Ecosystem

The workshop session developed for the Spanish ecosystem focused on identifying the needs, stakeholders, barriers, and potential solutions related to the implementation and diffusion of industrialized construction processes. The activity explored the conditions required to support the transition from traditional construction approaches toward more industrialized and technologically integrated systems, while also addressing the increasing demand for housing and the current limitations in supply. Particular attention was given to the low percentage of industrialized construction currently implemented in Spain, estimated at approximately 1–2%, and to the limited cultural and educational background associated with industrialized construction practices.

Through the mapping exercise, participants identified both human and non-human actants involved in the ecosystem. Human actants included public administrations, professional associations, developers, promoters, construction companies, public housing developers, and suppliers of industrialized products and solutions. The activity highlighted the importance of collaboration between these actors in order to strengthen the industrialization process and improve awareness, skills, and implementation capacity across the sector.

Several barriers emerged during the workshop activity. One of the main issues identified concerned the limited availability of specific training opportunities related to industrialized construction. Participants also emphasized the persistence of resistance to change within the sector, particularly regarding established ways of working and conventional construction practices. Additional structural barriers included the little digitization of the sector, the absence of specific regulations supporting industrialized construction, difficulties in accessing traditional financing mechanisms, and the lack of public incentives capable of supporting the transition toward industrialized building systems.

Alongside these barriers, the activity mapped a series of potential solutions and enabling strategies. The development of specific training programs and the possibility of influencing official educational and training curricula were identified as important actions to strengthen sectoral knowledge and skills. Participants also proposed making the benefits of industrialization more visible through the dissemination of good

practices and successful examples. Additional solutions included promoting the digitization of the sector through grants and training initiatives, as well as increasing awareness among public administrations regarding the benefits of industrialized construction and the necessity of supporting it through dedicated policies and incentives.

The workshop session further distinguished between barriers and solutions that could be addressed directly within the BUPS Work Packages, those requiring further exploration within the LAB environment, and those extending beyond the scope of the project. Actions such as training development, dissemination of good practices, and awareness-building activities were considered manageable within the project framework. In contrast, broader issues related to educational reforms, sector-wide digitization, financing systems, and regulatory development were recognized as challenges requiring intervention at institutional and policy levels. Overall, the activity demonstrated that the transition toward industrialized construction depends not only on technological innovation, but also on cultural change, training, governance support, and the development of enabling regulatory and financial frameworks.

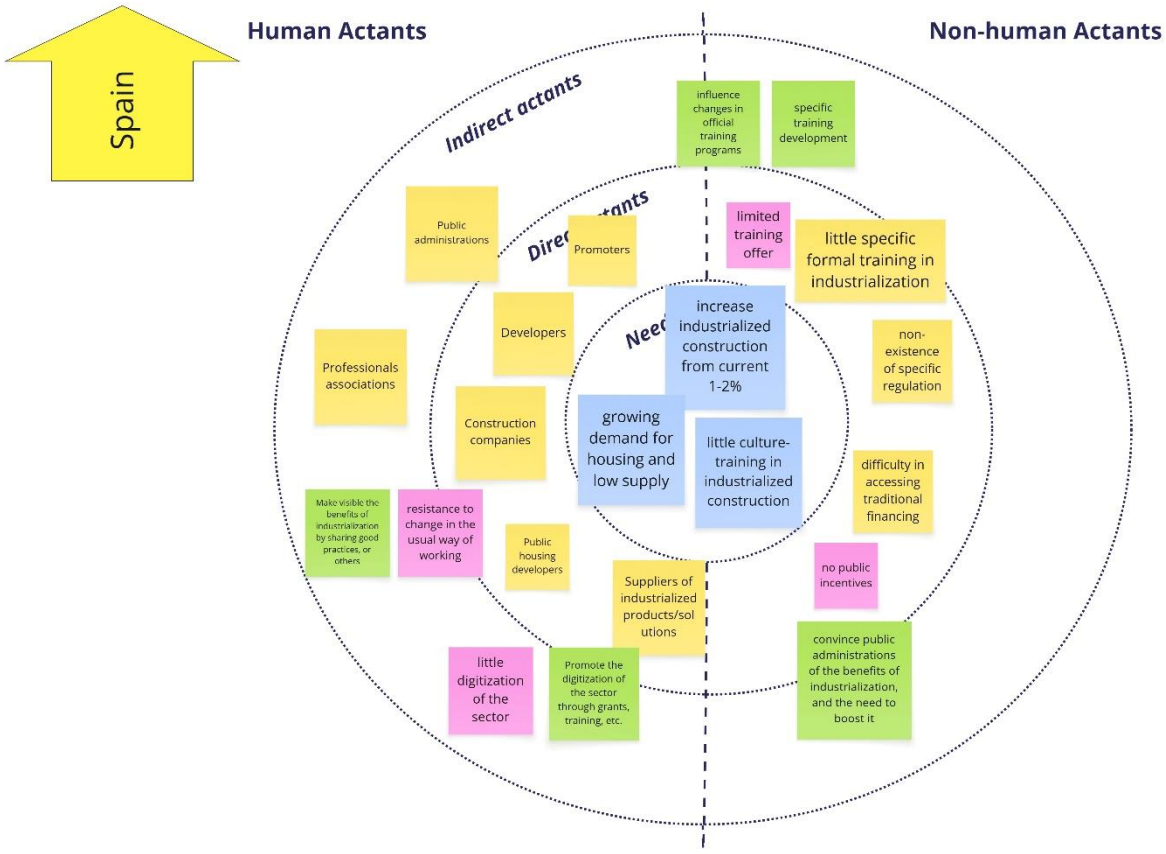


Figure 73: The Actant Map, Spanish Ecosystem [Miro Canva]

Table 36: Workshop result of the Spanish Ecosystem

Needs
Increase industrialized construction from the current 1–2%
Growing demand for housing and low supply

Little culture and training in industrialized construction

Human Actants

Indirect Actants	Direct Actants
Public administrations	Promoters
Professionals associations	Developers
	Construction companies
	Public housing developers
	Suppliers of industrialized products/solutions

Barrier	Solutions	Barrier	Solutions
Resistance to change in the usual way of working	Make visible the benefits of industrialization by sharing good practices, or others	Resistance to change in the usual way of working	Make visible the benefits of industrialization by sharing good practices, or others
Little digitization of the sector	Promote the digitization of the sector through grants, training, etc.		

Non-Human Actants

Indirect Actants	Direct Actants
Little specific formal training in industrialization	Difficulty in accessing traditional financing

Barrier	Solutions	Barrier	Solutions
Non-existence of specific regulation		No public incentives	Convince public administrations of the benefits of industrialization, and the need to boost it
		Limited training offer	Influence changes in official training programs
			Specific training development

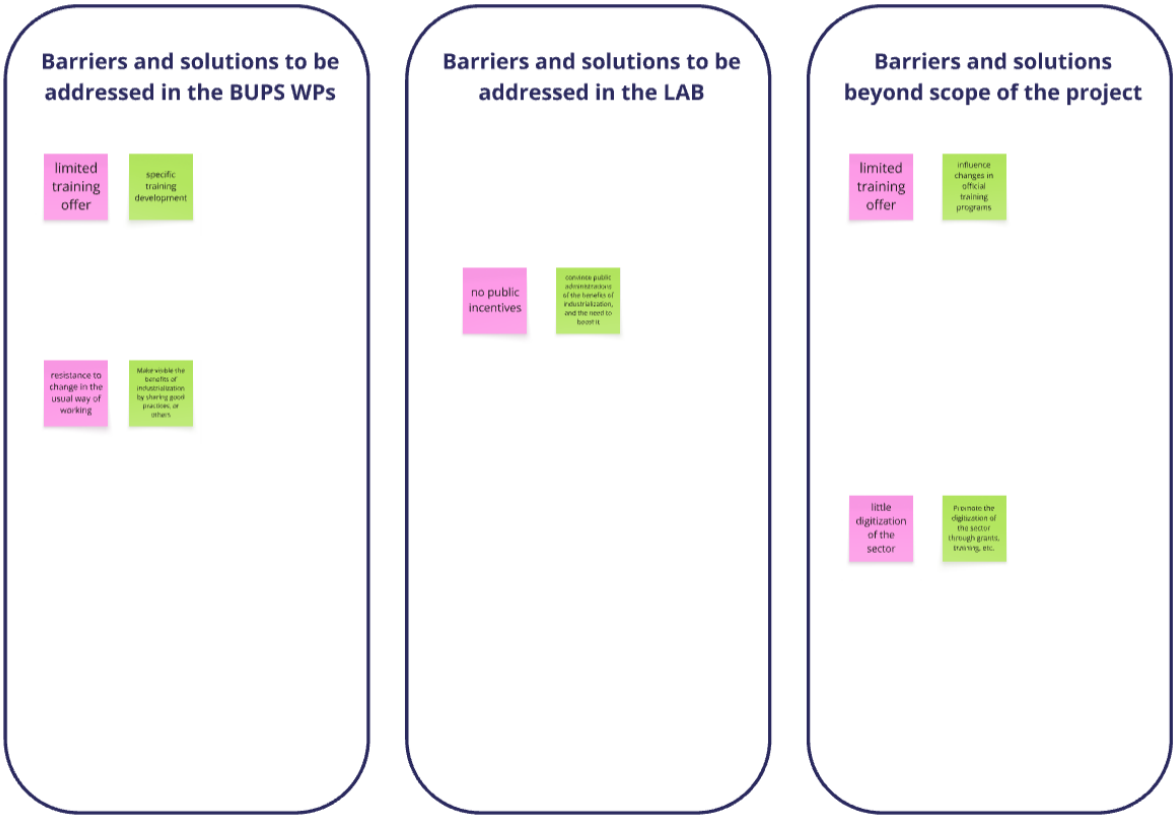


Figure 74: Different destination of Barriers and Solutions, Spanish Ecosystem [Miro Canva]

Table 37: Different destination of Barriers and Solutions, Spanish Ecosystem

Barriers and solutions to be addressed in the BUPS WPs	
Barriers	*Solutions*
Limited training offer	Specific training development
Resistance to change in the usual way of working	Make visible the benefits of industrialization by sharing good practices, or others
Barriers and solutions to be addressed in the LAB	
No public incentives	Convince public administrations of the benefits of industrialization, and the need to boost it
Barriers and solutions beyond scope of the project	
Limited training offer	Influence changes in official training programs
Little digitization of the sector	Promote the digitization of the sector through grants, training, etc.

The Italian Ecosystem

The discussion on the Italian ecosystem highlighted a complex network of human and non-human actants involved in the implementation of industrialized energy renovation processes. The workshop identified tenants, social housing owners and managers, design teams, ESCOs, suppliers, financing institutions, local authorities, and national and European regulatory bodies as key actors influencing the transition. Within the central needs emerging from the session, participants stressed the necessity for clearer information on renovation processes, accessibility improvements, reduction of noise and disturbance during interventions, stronger financial support mechanisms,

and better monitoring of energy consumption. Several barriers were identified, particularly related to fragmented and unorganized information, lack of financial and fiscal knowledge, unclear national and local regulations, high renovation costs, and the complexity of the energy renovation sector from economic, technical, and social perspectives. The Italian ecosystem was also described as highly fragmented, especially regarding SMEs operating in the Milan surrounding area, where actors often struggle to organize themselves into coordinated supply chains. Additional concerns regarded low tenant engagement in retrofitting processes, insufficient knowledge of incentives due to continuous regulatory changes, lack of industrialized construction know-how, and limited information on existing building stock and manufacturing potential. In response, participants proposed several possible solutions, including improved access to information on financing methods, clarification of national regulations, training and simplification of incentive procedures, stronger involvement of financial stakeholders, the development of innovative financial and business models involving SMEs, and ongoing training activities led by front-edge players. The workshop also emphasized the importance of fast and solid energy renovation strategies based on industrialized and human-centered approaches, together with the need for more coordinated governance structures capable of supporting collaboration between stakeholders.

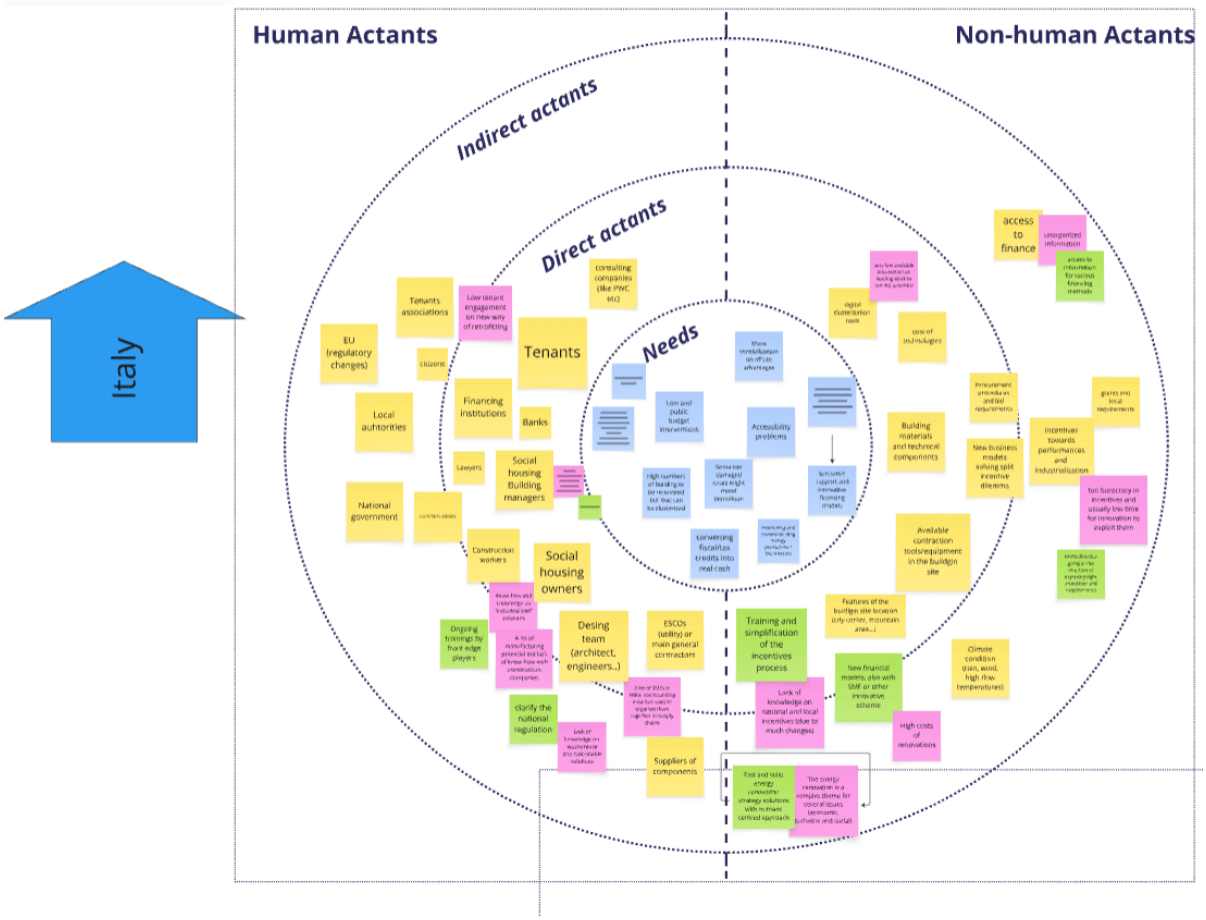


Figure 75: The Actant Map, Italian Ecosystem [Miro Canva]

Table 38: Workshop result of the Italian Ecosystem

Needs
More information on the process
Low and public budget limitations
Accessibility problems
High barriers of talking to the European level and to be involved
Some tax barriers / permissions
Increase comfort and minimize noise
Convincing financial institutions on real costs
Managing and monitoring energy consumption

Human Actants	
Indirect Actants	**Direct Actants**
EU (regulatory changes)	Tenants
Local authorities	Social housing building managers
National government	Social housing owners
Tenants associations	Design team (architects, engineers…)
Financing institutions	ESCOs (utility or main general contractors)
Banks	Construction workers
Lawyers	Consulting companies (like PVC etc.)
Construction workers	Lawyers
Citizens	Financing institution
Accountants	
Suppliers of components	

Barrier	Solutions	Barrier	Solutions
Know-how and knowledge on "industrialized" solutions	Ongoing trainings by front edge players	lack of knowledge on incentives (law / fiscal and economic)	Consultancy
Lack of knowledge on waste/reuse and susteinable solutions	clarify the national regulation	Low tenant engagement on new way of retrofitting	
A lot of SMEs in Milan sourrounding area but need to organize them together in supply chains			

Non-Human Actants	
Indirect Actants	**Direct Actants**
Climate condition (rain, wind, high /low temperatures)	digital clusterization tools
Incentives towards performances and industrialization	cost of technologies
grants and local requirements	Building materials and technical components
access to finance	Procurement procedures and bid requirements
	New business models solving split incentive dilemma
	Available contraction tools/equipment in the buildgin site
	Features of the buidlgin site location (city center, mountain area...)

Barrier	Solutions	Barrier	Solutions

		very few available information on buiding stock to see ind. potential	
Lack of knowledge on national and local incentives (due to much changes)	New financial models, also with SME or other innovative scheme	Lack of knowledge on national and local incentives (due to much changes)	Training and simplification of the incentives process
High costs of renovations			
unorganized information	access to information for various financing methods		
	access to finance		
too burocracy in incentives and usually low time for innovation to exploit them	EPBD directive going in the direction of imposing right incentives and requirements		
High costs of renovations	New financial models, also with SME or other innovative scheme		
The energy renovation is a complex theme for several issues (economic, technical and social)	Fast and solid energy renovation strategy solutions with humanc centred approach		



Figure 76: Different destination of Barriers and Solutions, Italian Ecosystem [Miro Canva]

Table 39: Different destination of Barriers and Solutions, Italian Ecosystem

Barriers and solutions to be addressed in the BUPS WPs	
Barriers	*Solutions*
unorganized information	access to information for various financing methods
no financial / fiscal knowledge	access to information
Lack of knowledge on waste/reuse and susteinable solutions	clarify the national regulation
A lot of SMEs in Milan sourrounding area but need to organize them together in supply chains	
High costs of renovations	New financial models, also with SME or other innovative scheme
The energy renovation is a complex theme for several issues (economic, technical and social)	Fast and solid energy renovation strategy solutions with humanc centred approach
Barriers and solutions to be addressed in the LAB	
Access to finance	have financial stakeholders
Lack of knowledge on national and local incentives (due to much changes)	Training and simplification of the incentives process
A lot of SMEs in Milan sourrounding area but need to organize them together in supply chains	
Low tenant engagement on new way of retrofitting	
Barriers and solutions beyond scope of the project	
Know-how and knowledge on "industrialized" solutions	Ongoing trainings by front edge players
A lot of manufacturing potential but lack of know-how with construction companies	
very few available information on building stock to see ind. potential	

Conclusions

The workshop activity developed by the all ecosystems demonstrated that the implementation of Pop-up Factories and industrialized deep-renovation processes depends on the interaction between technical, social, financial, organizational, and regulatory dimensions. Through the Actant Mapping methodology, the workshop enabled participants to identify shared needs, direct and indirect human and non-human actants, as well as the barriers and opportunities affecting the deployment of local renovation ecosystems. Across all ecosystems, recurring themes emerged, including the need for improved access to information, stronger stakeholder coordination, training and awareness raising, development of innovative financial and business models, simplification of administrative and regulatory frameworks, and better integration between local supply chains and industrialized construction processes.

The workshop also highlighted the importance of reuse-oriented approaches, circularity strategies, digital platforms, and collaborative governance structures capable of supporting the transition from theoretical Pop-up Factory concepts toward practical implementation.

Comparing the Dutch, Austrian, French, Spanish, and Italian ecosystems, it is possible to note that, despite the different local conditions and priorities, many barriers are shared across contexts. These include fragmented knowledge systems, limited training opportunities, difficulties in stakeholder coordination, lack of incentives, regulatory complexity, financial constraints, and insufficient integration between construction actors and industrialized processes. At the same time, the potential of Pop-up Factories as socio-technical mediators is clearly shown, as they can connect stakeholders, technologies, materials, and governance frameworks within localized renovation ecosystems. The activities confirmed that accelerating circular and industrialized renovation processes requires integrated approaches combining technological innovation, organizational adaptation, financial support, regulatory evolution, and human-centered strategies.

Overall, the workshop outcomes provide a valuable foundation for the further development of the BuildUPspeed Implementation Plan and for the identification of future actions within the BUPS Work Packages, Local Advisory Boards, and broader policy and institutional frameworks.

Appendix VII

Dutch Ecosystem Report

This Annex presents the analysis of the Dutch ecosystem with regard to the market potential and feasibility of Pop-up Factory (PuF) concepts, with the aim of informing the development of implementation plans, scenarios, and supporting activities. The methodological framework adopted for this assessment is described in detail in Deliverable D4.1 of Work Package 4. The findings presented in this Annex are subsequently compared and discussed alongside the results from the other national ecosystems in the main report, contributing to a broader cross-ecosystem evaluation of the opportunities and challenges associated with the deployment of PuF models.

Addressing ecosystem needs: Offering a deep-renovation kit by a local pop-up factory scenario

Various theories and concepts have been developed to boost the efficiency of deep retrofits. One of the key challenges is to turn these theories and concepts into real-world implementations being adopted beyond demonstration. In this chapter the preferred local pop-up factory scenarios are being presented for each Ecosystem.

The Dutch Ecosystem deep-renovation needs

The Dutch housing stock encompasses over 8 million dwellings. Characteristic to the Dutch housing stock are the so called detached or terraced single-family dwellings which encompass about 3.4 million dwellings. Apartments form the second largest typology in the Netherlands facilitating close to 3 million housing units. From the perspective of scale and scope two potential housing typologies are of specific interest for the implementation of a local pop-up factory informed by the following selection criteria:

- Repetition - number of housing units of which the energy efficiency need to be improved) significantly towards all-electric ready, zero energy buildings according Dutch policy
- Standardized variety – number of housing units that can be serviced by the local pop-up factory within a limited variety i.e. level of customization
- Proximity – number of housing units clustered in a specific geographic area, normally at the level of neighbourhoods
- Local presence – visibility of the suppliers in a specific geographic area

1) Terraced housing constructed in the period 1965-1974



Housing units that fall into this category often have 4 to 5 rooms spread over 3 levels. Terraced housing constructed during this period represents about 606,000 units, almost 9% of the Dutch housing stock. Almost half (47%) is in property of private homeowners. An equally large part is owned by social housing associations and 6% by private investors. Since 1965 requirements have been set for the energetic quality of homes. Nevertheless, compared to current standards these apartment buildings are not very well insulated with an average yearly energy consumption of 91.097 MJ and an average natural gas consumption of 2030 m^3 yearly. Most dwellings are equipped with gas heaters. Over the years, some dwellings have been energetically improved at the level of single components (double glazing, cavity and/or insulation, more efficient gas heaters).

Table 40: characteristics reference building

Component	Dimension [m^2]	Rc-value [m^2 K/W]	U-value [W/m^2 K]
Ground floor	52	0,17	2,33
Roof (pitched)	65,5	0,86	0,89
Façade (back & front)			
— **Closed**	40,5	0,43	1,45
— **Single glazing**	4,3		5,20
— **Double glazing**	21,3		2,90
— **HR++ glazing**	-		-
Head façade			
— **Closed**	58,3	0,43	1,45
— **Single glazing**	-		-
— **Double glazing**	1,8		2,90
— **HR++ glazing**	-		-

2) Apartment building constructed in the period 1965-1974



Housing units that fall into this typology often classify 2 to 4 bed room apartments. Typically, the apartments are part of a residential building with multiple stories without elevator. The homes are accessible via a closed porch. This specific building typology represents about 112,000 housing units, about 1.7% of the Dutch housing stock. The majority, 76%, is owned by the social housing sector and 7% by the private sector, the remaining 17% are owner-occupied apartments. Again, compared to current standards these apartment buildings are not very well insulated with a primary energy consumption of 45.934 MJ and a natural gas consumption of about 981 m^3 yearly, calculated on average

for apartments or about 70 m². Thermal bridges near balconies are a typical and complex issue to be encountered. Many apartments are equipped with (local) gas heaters and electric water heaters or collective block heating systems. The apartments are mainly ventilated naturally. Over the years, some apartment buildings have been energetically improved at the level of single components.

Table 41: characteristics reference building

Component	Dimension [m^2]	Rc-value [m^2 K/W]	U-value [W/m^2 K]
Ground floor	71	0,17	
Roof	75,1	0,86	
Façade (back & front)			
— **Closed**	38,3	0,43	1,45
— **Single glazing**	1,3		5,20
— **Double glazing**	16,8		2,90
— **HR++ glazing**	-		-
Head façade			
— **Closed**	23,2	0,43	1,45
— **Single glazing**	-		-
— **Double glazing**	1,4		2,90
— **HR++ glazing**	-		-

The local pilots of the Dutch Ecosystem

Hoensbroek: the District Factory pilot

The Dutch pilot in Hoensbroek focuses on the sustainable and circular renovation of four portico-style apartment blocks built in 1957, comprising 36 social housing units. The buildings are in poor condition, with outdated installations, inadequate insulation, and low energy labels (E/F/G). The renovation aims to extend the service life by 30 years, improve liveability, and achieve energy label A through upgraded insulation, new technical systems, and circular construction practices. The project also addresses environmental challenges such as heat stress and flooding, while enhancing social cohesion and accessibility.

This pilot was selected because portico-style apartment buildings are highly prevalent in the Netherlands. According to WoON (2024), 34% of all housing consists of apartment buildings, while CBS (2023) reports that 42% of the housing stock comprises terraced homes. The majority of these dwellings were mass-produced and share similar construction characteristics. This uniformity offers significant potential for scalable renovation solutions, making them well-suited for standardized, industrialized renovation approaches within the broader renovation wave.



Figure 77: Building complex under renovation, Hoensbroek, Heerlen

See *Annex VIII* for more information.

Maastricht: the Assembly Factory pilot

The Quirinaalhof renovation in Maastricht is an industrialized project led by the housing association Woonpunt and the contractor Smeets Bouw, emulating a successful pilot at the neighboring Palatijnhof complex owned by a different housing association and the same building contractor. The comprehensive scope of work focuses on the building envelope, featuring a new roof with 30 cm of insulation, wall and floor insulation, and a specialized strategy of mounting new wooden window frames over existing ones to bypass hazardous asbestos while minimizing waste. Internal interventions include the complete replacement of vertical water and waste pipelines alongside the modernization of kitchens, bathrooms, and toilets using prefabricated tile panels from local manufacturer Mosa. A primary improvement is the transition from an

obsolete collective system to individual heat pumps for all 144 units, supported by roof-mounted PV-thermal panels that generate electricity and capture outside warmth to pre-heat water. These measures are designed to extend the building's functional lifespan by 50 years and elevate its energy performance to Label A, ensuring compliance with regulatory mandates to eliminate poor energy labels by 2028.



Figure 78: Quirinaalhof building in Maastricht.

See Appendix VIII for more information.

Multiple value creation: Matching local pop-up factory scenario with local needs

This paragraph provides a discussion on the type(s) of pop-up factory scenario which best suits each Ecosystem, including, when possible, insights obtained through the modifications and optimizations made while developing it and testing it.

Local pop-up factory scenario: District Factory

A *district factory* is a subcategory of pop-up factories that involves the creation of a centralized manufacturing and assembly facility that serves multiple construction projects within a particular geographic area or district. District factories are typically located in industrial areas or other locations with easy access to transportation networks and are designed to produce a variety of prefabricated components for use in different construction projects. One of the key advantages of district factories is that they enable greater collaboration and coordination between designers, manufacturers, and construction teams. A *district factory* acts as a 'system integrator', typically working on individual projects and bringing together stakeholders who are not accustomed to working together in a coordinated way across multiple projects. Acting as a system integrator, it enables the application of mass customization principles and accelerates the wave of renovation. This local district-focused approach is not only important for eco-efficiency, but also efficient, inclusive and circular by identifying and leveraging local socio-economic and/or technological factors. It is also important for achieving cost-effective refurbishments. However, the success of this approach depends on the buy-in and participation of key stakeholders such as residents, building owners, managers and investors. These stakeholders play a key role in accelerating the transition to deep and circular renovations. By bringing these different stakeholders together in a single location, district factories can facilitate more effective communication and help to ensure that prefabricated components are designed and

manufactured to meet the specific needs of each construction project. In addition, the whole supply chain is considerably shorter due to the elimination of long-distance transportation and consequently results in reduced waste production.
A generic district retrofitting configurator allowing to select the best options from a range of relevant retrofitting for specific local conditions, accompanied with descriptions of the most efficient logistic delivery methods and construction techniques, as well as health and safety protocols.
A set of action plans for establishing a 'district retrofitting factory' with generic features as well as adaptable set-ups depending on the district characteristics, most relevant technical solutions for retrofitting, and level of skill of local workers. As construction projects – including retrofitting of existing buildings - continue to become more complex and demand greater levels of customization and precision, district factories are likely to become increasingly important.
In a district factory, all three elements – manufacturing, assembling and services – are centralized in the local context as a more permanent solution (Figure 79). According to these, the key features of district factories are:

- Local, centralized, large-scale manufacturing and assembling.
- Depending on the local needs, small-scale design is possible as well.
- Usually, a permanent solution located in industrial or abandoned areas.
- Serves regional construction projects in a proximity of 30 km.

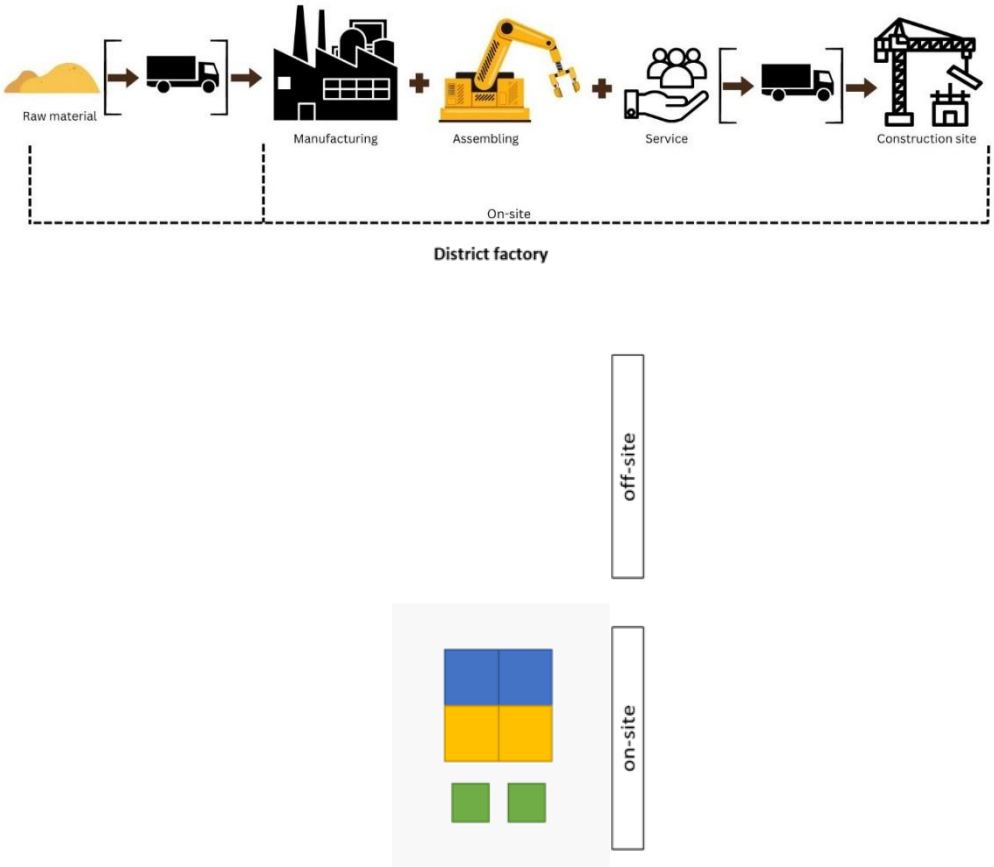


Figure 79 Schematic diagram of the District Factory

District factories could offer a sustainable and community-based solution as an alternative to traditional supply chains of building materials. District factories also give suppliers the chance to collaborate with local stakeholders to develop novel, tailored solutions that address the particular requirements of the neighborhood. Suppliers can

gain from decreased transaction costs, increased supply chain efficiency, and increased client loyalty by working with district factories. In general, it provides a distinctive value proposition by fostering a cooperative ecosystem that permits extensive renovation at scale and addresses the complicated issues of energy poverty, social inclusion, and sustainable development.

The Mobile District Factory (*In Dutch*: Mobiele Buurtfabriek)

Private homeowners form the largest target group to be motivated to improve the energy efficiency of their dwellings. Decision making about energy efficiency measures tends to be limited to certain events such as the purchase of a new property, family expansion or dilution. For each household these events take place at different points in time, complicating a collective deep-renovation approach.

This specific market characteristic, reflecting about 4,5 million single family households, requires an affordable and individual based deep-renovation approach, consisting of separate renovation modules which can be mixed and matched in various configurations. As an essential pre-condition suppliers need to provide warranties and quality insurances for their modules and the modules need to be easily financed (Van Oorschot et al., 2020). Despite these complex conditions an industrialized approach is possible for this 'pixel approach' in which individual homes are tackled one by one. This is possible because the Dutch housing stock has a high degree of repetition of housing types, which can be linked to a select number of building component families. Renovation modules can be developed for each of these families and can be mixed and matched in various ways.

To exploit this potential the ‘Mobiele Buurtfabriek' has been developed, a standardized deep-renovation process supported by a digital platform (Figure 80). Homeowners digitally map their dwelling themselves and then receive a home passport, a digital report in which the baseline conditions of the dwelling are bundled with their personal housing demands. With the home passport homeowners put together their renovation needs in a (virtual) renovation shop with direct insights in the financial implications. As soon as enough of a specific type of renovation modules have been ‘sold’ in a specific neighborhood - about 20-25 dwellings – these specific modules can be collectively purchased.

Essential to the ‘Mobiele Buurtfabriek’ is that industrialization for scaling up home renovations at the mobile neighborhood factory is not about 'prefab' technologies, but rather standardizing the deep-renovation process and orchestrating the supply chain: simplifying the entire deep-renovation process to a few 'smart' steps with 'digital' support where the home owner can take control themselves. Depending on actual demand, direct contact is sought with relevant system integrators and module suppliers, i.e. specialists who are able to provide quality insurance up-front the deep-renovation.

Note that the ‘Mobiele Buurtfabriek' contrasts with the usual governmental deep-renovation programs. The business case central to these programs are based on repetition and scale, assuming uniformity at the level of building blocks. However, building blocks are often not as uniform as assumed, and residents showcase a high variety of demand which may change over time. The success of these deep-renovation programs heavily depends on scale and scope, which until now are hardly achieved. For this reason, the ‘Mobiele Buurtfabriek' focuses on building blocks of multiple housing units, but on the scale of a neighborhood so that 'production flows' can arise within that neighborhood: groups of people who want an improvement of the same type at the same time.

When applying the ‘Mobiele Buurtfabriek' scenario, a (traditional) renovation process, from initiative to realization and management, can be reduced from 10-15 years for all dwellings in a neighborhood to just 1-2 years for a production round through the neighborhood of at least one module per dwelling. The ‘Mobiele Buurtfabriek' can be replicated from neighborhood to neighborhood, and just like a traveling circus, the factory is moved when there is not enough ‘audience’ to keep the production going. Although many modules and deep-renovation technologies most likely consist of industrial produced off-the-shelf products, system integration and the on-site assembly will be done by local dedicated renovation professionals.

The ‘Mobiele Buurtfabriek' becomes affordable as about 20-25 households in a neighborhood participate to install a deep-renovation module of the same type.

The ‘Mobiele Buurtfabriek' operates in various neighborhoods within a district with a maximum distance of about 50 km from the key module supplier(s).



Figure 80 The ‘Mobiele Buurtfabriek' scenario relative to two dominant deep-renovation approaches: different paths of customer journey co-existing next to each other (adopted from H2020 Save the Homes)

Table 42 Overview of Dutch district factory example

	District factory
Purpose	
Provides localized manufacturing and assembly of construction components and systems in a certain region or district	☑
Aims to create jobs and boost economic growth locally	☑
Design	
Semi-permanent structure	☑
Uses sustainable and eco-friendly solutions	☑
Scale	
Large-scale assembling	☑
Location	
District level	☑
Within proximity (regional level) – max 50 km from key suppliers	☑

Local pop-up factory scenario: Assembly Factory

Within the Dutch ecosystem, and particularly in the Limburg region, the Assembly Factory represents one of the most feasible and immediately deployable Pop-up Factory (PuF) scenarios to support the growing demand for deep renovation of the social housing stock. Unlike manufacturing-oriented models, the Assembly Factory does not focus on the production of building components, but rather acts as an intermediary hub between manufacturers, suppliers, and construction sites. Prefabricated elements such as façade systems, roof modules, technical installations, and circular or reused components are produced off-site by specialised suppliers and delivered to the Assembly Factory, where they are received, inspected, sorted, temporarily stored, pre-assembled when necessary, and prepared for installation.

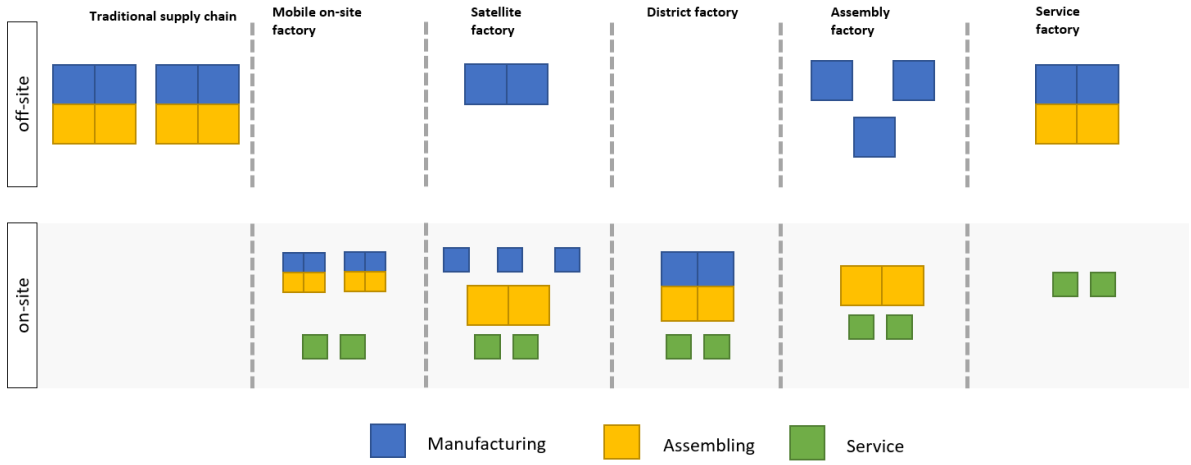


Figure 81: The scenarios of the pop-up factory concept

The facility coordinates logistics, manages Just-in-Time deliveries, creates installation kits, and can also support reverse material flows, facilitating the recovery, storage, refurbishment, and redistribution of reusable building components. This configuration is particularly suited to industrialised renovation approaches, as it reduces construction time, minimises disruption for residents, improves quality control, standardises workflows, and enables the efficient coordination of multiple renovation projects. In the Limburg context, where housing associations are facing significant challenges related to ageing housing stock, energy transition targets, circularity ambitions, and large-scale renovation programmes, the Assembly Factory can offer a pragmatic solution that builds upon existing regional capacities without requiring substantial investment in manufacturing infrastructure.

Beyond its operational role, the Assembly Factory can also function as a regional collaboration and innovation hub, bringing together housing associations, contractors, manufacturers, municipalities, circular economy actors, SMEs, and knowledge institutions to strengthen cooperation across the renovation value chain. Its focus on assembly, logistics, and installation makes it particularly suitable for workforce development and reskilling initiatives, supporting the acquisition of new competencies in modular construction, digital coordination, circular material management, and industrialised renovation processes. Furthermore, by concentrating preparation and coordination activities within a dedicated facility, the Assembly Factory contributes to greater predictability, scalability, and efficiency across renovation programmes,

allowing lessons learned from individual projects to be transferred across housing portfolios.

Table 43 - Overview of Pop-Up Factory Types

Term	Definition
Mobile On-Site Factory	A movable production cell deployed directly on or near the construction site.
Satellite Factory	A temporary facility near the site that collaborates with a central production hub.
District Factory	A semi-permanent facility serving multiple nearby projects, acting as a system integrator.
Assembly Factory	A location focused solely on assembling prefabricated components from other sources.
Service Factory	A knowledge and facilitation hub that supports sustainable renovation through advice and coordination.

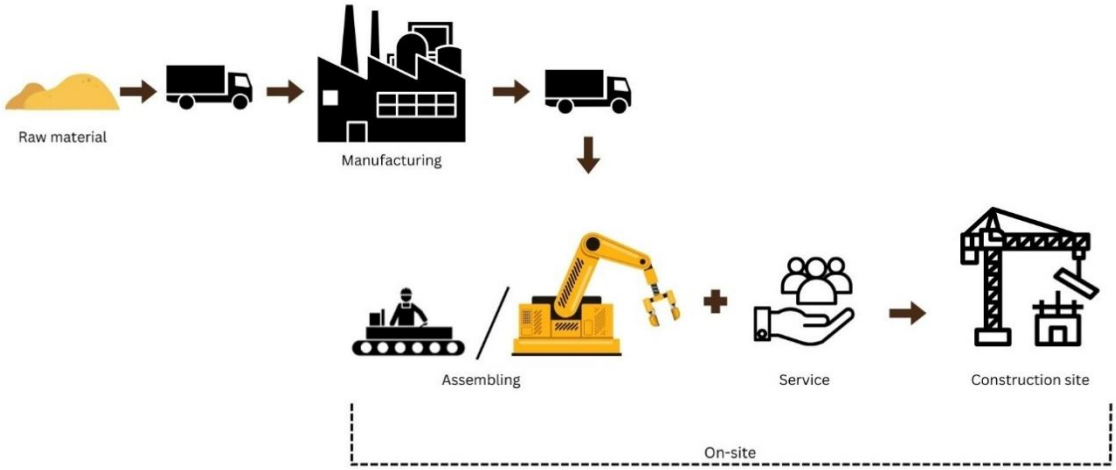


Figure 82 - Assembly factory schema

From a circular economy perspective, it can act as a local material exchange and recovery hub, helping to retain material value within the region and supporting Limburg's ambition to become fully circular by 2050. Although the model remains dependent on external manufacturers and therefore generates less local added value than more integrated factory concepts, its flexibility, relatively low implementation costs, compatibility with existing supply chains, and ability to foster ecosystem development make it particularly relevant for the Dutch ecosystem. As such, the Assembly Factory can be considered both a practical mechanism for accelerating deep renovation projects and a strategic stepping stone towards more integrated district-scale renovation ecosystems in the future.

Local pop-up factory scenario: a comparison

The Assembly Factory and District Factory represent two distinct but complementary Pop-up Factory (PuF) configurations within the renovation ecosystem. While the Assembly Factory focuses primarily on supporting the efficient assembly and installation of prefabricated components for specific projects or clusters of projects, the District Factory adopts a broader role by coordinating multiple actors, services, and renovation activities at the district or regional scale. As a result, the two models differ in terms of objectives, scale of operation, stakeholder involvement, governance requirements, investment needs, and potential impact on the local ecosystem. Table 44 provides a comparative overview of the main characteristics of both scenarios, highlighting their respective strengths, limitations, and suitability for different renovation contexts within the Dutch ecosystem. In practice, however, the boundaries between the two models are often blurred. Within the Dutch ecosystem, and particularly in the context of large-scale housing renovation programmes, Assembly and District Factory functions are frequently combined to better respond to the needs of stakeholders and the dynamics of the renovation market, integrating the operational efficiency of assembly-oriented activities with the broader coordination, service provision, and ecosystem-building functions characteristic of the District Factory model.

Table 44: Comparison between Assembly and District PUFs

Aspect	Assembly PUF	District PUF
Primary Purpose	Assemble prefabricated components close to the construction site and prepare them for installation. The core contractor may operate multiple Assembly PUFs simultaneously and allocate skilled personnel and workforce resources across them as demand and project schedules require.	Serve as a semi-permanent regional hub integrates, coordinates, and supports mu renovation or construction projects. Uses m prefabricated components.
Operational Focus	Physical assembly and preparation of components.	System integration, coordination, logistics, quality assurance, planning, and standardisation.
Geographic Scope	Located near the final construction site, typically within the project area.	Covers a wider geographic territory and serves multiple nearby projects.
Project Coverage	Usually serves one project at a time.	Simultaneously serves multiple projects and clients.
Facility Size	Smaller facility with a limited range of tools, instruments, and equipment.	Larger hub with broader infrastructure, storage, material handling, and coordination capabilities.
Work Variety	Optimised for a specific set of assembly activities.	Supports a greater variety of activities, functions, and job types.
Complexity of Work	Lower project complexity and less variation in tasks.	Suitable for more complex projects requiring coordination across multiple stakeholders and workstreams.
Flexibility	Highly responsive and adaptable to changing project requirements ("quick change of shoes").	More structured, standardised, and regulated, less flexible
Production Approach	Repeatable assembly workflows in a controlled environment close to site.	Regional programme management, pipeline aggregation, logistics coordination, and process standardisation.

Supply Chain Role	Receives prefabricated components from external suppliers and assembles them.	Acts as a regional backbone connecting suppliers, contractors, housing corporations, municipalities, and logistics providers.
Factory	Temporary or semi-temporary facility established for a project or project cluster. The factory is build based on the reusable materials.	Semi-permanent facility with scalable infrastructure that can evolve according to regional demand.
Key Value Proposition	Faster installation, reduced site disruption, predictable quality, and local responsiveness.	Stable project flow, reduced transaction costs, standardisation, quality governance, and ecosystem coordination.
Workforce Requirements	Trained assembly teams focused on production efficiency and assembly operations.	Coordination teams combined with operational staff managing planning, logistics, quality, and stakeholder interfaces.
Planning Requirements	Strong dependence on careful planning and sequencing of tasks.	Strong dependence on regional programme planning, pipeline aggregation, and multi-project sequencing.
Resource Allocation	Requires flexible workforce allocation to respond quickly to changing project needs.	Requires coordination of resources across multiple projects and organisations.
Scalability	Scales through replication across project clusters.	Scalable operation capable of serving several clients and projects simultaneously.
Utilisation Dependency	Highly dependent on sufficient pipeline volume to justify set-up and maintain utilisation. Operational advantages diminish without clustering and sequencing jobs.	Highly dependent on continuous regional throughput and aggregated demand to justify semi-permanent facilities and staffing.
Main Risk	Underutilisation caused by insufficient project volume, poor sequencing, or discontinuous demand.	Underutilisation caused by failure to aggregate projects, weak governance, or insufficient regional flow.

External Business Environment of the local pop-up factory

In a first step the external business environment of the pre-selected local pop-up factory will be defined in detail. Different fields of external factors which influence the operation of the pop-up factory are considered, such as the market demand and existing alternatives, the customers and competitors as well as influence of environmental, economic, technological, socio-cultural and political trends.

Market demand analysis

The Dutch construction industry registered strong growth in 2019–24, according to MarketLine Advantage (2025). Industry growth is driven primarily by an expanding population that demands more residential, commercial, and infrastructure building. CBS (2024a), i.e., the Central Bureau of Statistics of the Netherlands, estimates the Dutch population reached 18.13 million in 2025, with a 0.6 percent annual growth rate. The rise in population has intensified demand for new housing, schools, hospitals, and transportation networks. The growth in residential and construction activities is

supported by the Dutch government's commitment to sustainability and energy-efficient green building.

According to MarketLine Advantage (2025), the Dutch construction industry comprises two segments: residential and non-residential buildings. The focus of this report, though, will be on residential construction, where the local pop-up factory (PUF) business model will be introduced. *Residential construction*, by definition, refers to the process of building structures intended primarily for people to live in. This involves extensive renovations of residential buildings, such as facade renovations, insulation renovations, or kitchen-bathroom-toilet renovations. It accounts for an average market share of 51,1% of the industry's total value from 2019 to 2024. The non-residential segment, in turn, includes commercial, energy and utilities, industrial, infrastructure, and institutional construction, with an average share of 48,9% of the industry's total value from 2019 to 2024.

The Dutch residential construction market comprises four market segments, namely: (i) *new construction*, which covers the installation of new structures; (ii) *refurbishment*, which covers the upgrade of any building or structure; (iii) *repair and maintenance*, which involves restoring a deteriorated or damaged structure or building; and (iv) *demolition*, which includes the planned destruction of a building or its parts. According to MarketLine Advantage (2024), the total market value reached 83.3 million USD in 2023, up from 68.8 million USD in 2018, with a compounded annual growth rate (CAGR) of 3.9% over the five years (Table 1). Repair and maintenance show the highest CAGR at 5.5%, followed by demolition at 5.0% and refurbishment at 4.4%. New residential construction has a CAGR of 3.2%.

Table 45: Netherlands residential construction sector: USD million, 2018-2023.

Category	2018	2019	2020	2021	2022	2023	2018-23 CAGR(%)
New Construction	41,121.7	41,847.0	43,681.5	49,181.2	47,767.1	48,032.8	3.2%
Refurbishment	13,381.3	13,595.1	14,164.1	15,914.3	15,431.4	16,605.2	4.4%
Repair & Maintenance	11,746.1	12,038.8	12,601.4	14,317.8	14,114.7	15,365.9	5.5%
Demolition	2,552.7	2,593.7	2,703.8	3,056.7	2,985.0	3,250.3	5.0%
Total	68,801.8	70,074.6	73,150.8	82,470	80,298.2	83,254.2	3.9%

Source: MARKETLINE

MARKETLINE

In terms of market share, Table 2 shows that new residential construction, although showing the smallest CAGR, accounts for the largest share, averaging 59.3% from 2018 to 2023, or close to three-fifths, followed by refurbishment at 19.4% and repair and maintenance at 17.5%. Demolition had the lowest average market share of 3,7% during the five years. Note that we can combine refurbishment, repair, and maintenance, as refurbishment involves renovation, into the repair and maintenance and renovation market (henceforth called RMR), with a combined share of 36.9%.

Table 46: Netherlands residential construction, % share of market value, 2018-2023

Category	2018	2019	2020	2021	2022	2023
New Construction	59.8%	59.7%	59.7%	59.6%	59.5%	57.7%
Refurbishment	19.4%	19.4%	19.4%	19.3%	19.2%	19.9%
Repair & Maintenance	17.1%	17.2%	17.2%	17.4%	17.6%	18.5%
Demolition	3.7%	3.7%	3.7%	3.7%	3.7%	3.9%
Total	100%	100%	100%	100%	100%	100%

Source: MARKETLINE

MARKETLINE

While the available data is as of 2023, MarketLine Advantage (2025) and Sante, M. (2025a) indicate a recovery in 2025 following a slight 3% slump in residential construction in 2024. In December 2024, at the Dutch housing summit “Woontop”, the Dutch Ministry of Housing and Spatial Planning signed an agreement with housing corporations, developers, and their investors to accelerate the construction of new homes. This aligns with the government’s target of 100,000 residential units per year. Of this housing target, about two-thirds will be affordable rentals or owner-occupier properties. Another 30,000 social housing units are intended to be built by 2029. According to the Cabinet, the available resources over the next five years will be sufficient to cover most costs if municipalities finance half of them. However, the question is whether municipalities will have the financial resources to do so in the coming years.

According to Sante. M. (2025a) and Glocker & Gonne (2025), a common argument against the two-thirds affordable rule is that it limits movement within the housing market. This is because building more expensive owner-occupied homes allows people to move up the property chain, freeing up more affordable homes. Focusing on affordable housing restricts this movement, resulting in fewer affordable homes becoming available. Hence, an agreement was reached to amend or eliminate regulations that hinder home construction (the STOER programme: Scrapping Contradictory and Unnecessary Regulations) to enable cheaper and more efficient construction.

In the Dutch province of Limburg, where the pilot Dutch pop-up factory is to be installed, a construction boom is emerging amid ambitious housing targets and significant infrastructure projects. As of 2025, the Limburg region has a population of 1,135 million inhabitants (All Charts.Info, 2025). The region is focusing on innovation and sustainability, building on its historical transition from a mining region to a chemical circular hub (Brightlands Chemelot Campus, n.d.).

Figure 1 illustrates the percentage distribution of dwellings by various housing characteristics in Limburg. Available categories include ownership, occupancy, dwelling type, building type, and construction period (All Charts.Info, 2025).

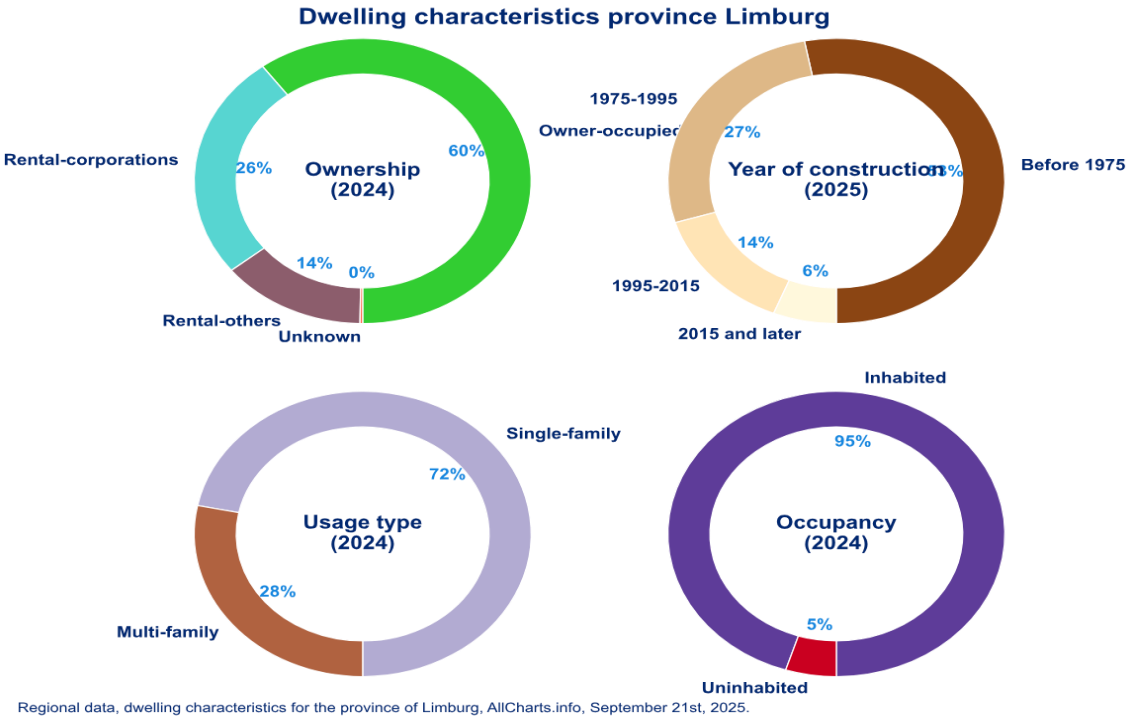


Figure 83: Dwelling characteristics in Limburg [Source: AllCharts.Info (2025).]

By type of dwelling, Table 47 shows that apartments are the most common in Limburg, with 160,409 addresses with house type apartments. The data on dwelling types are based on the Kadaster housing classification and Kadaster records of fixed and mobile residential units. The dwelling type is determined using a geographic-algorithmic method for buildings that contain a residential unit (buildings with a residential use function). The data reflect the situation as of 1 July 2025 (All Charts.Info, 2025).

Table 47: Type of Dwelling in Limburg, 2025 [Source: AllCharts.Info (2025).]

None	Types of houses in Province Limburg	Percent Share
Apartments	160,409	28,5%
Terraced houses	150,621	26,7%
Corner dwelling type	80,000	14,2%
Semi-detached houses	78,506	13,9%
Detached houses	94,119	16,7%
Unknown dwelling type	3	-

In residential construction, “Woondeal Limburg" plans to build 26,550 new homes by 2030. In addition, during the conclusion of the deal, the ambition for an additional 20,000 homes was expressed. Three thousand housing units increased the Woondeal

number by the end of 2023. Limburg offers space, making it one of the Dutch regions best positioned to help address the Netherlands' growth challenges. A specific plan, "Limburg Centraal," aims to add more than 30,000 homes by 2040 near six major railway stations in cities such as Maastricht and Heerlen (Bouwbeurs, 2024). Projects like "Le Sud" on the Groene Loper in Maastricht demonstrate ongoing construction of new housing. Le Sud is a new, high-quality residential area in Maastricht, Netherlands, part of the larger *De Groene Loper* (The Green Carpet) urban development. The project emphasizes sustainable, green living with a mix of housing types and has received an international award for sustainable development (Ballast Nedam Development, 2021). In a parallel move, another initiative in Maastricht involving the Blauwe Loper (the Blue Carpet), where 115 social housing units in Blauwdorp and Mariaberg in Maastricht, was commissioned by Servatius, a leading housing corporation in Maastricht, to BAM Wonen and Van Wijnen to make these units more energy-efficient and remove damps and drafts (BAM Wonen, n.d.; BAM, 2021).

Following the contraction in 2024, ING expects modest growth in construction output in 2025–2026; the RMR market in housing remains a supporting factor, driven by retrofitting and quality upgrades to the existing stock (Sante, M., 2024, 2025a). The RMR market within housing is a stable pillar of the Dutch construction sector. After a contraction year (krimpjaar) in 2024 with total construction output of around €97 billion (EIB, 2025), RMR continues to account for a large share of sector turnover; recent sector insights estimate the RMR share at around 25%, implying an order of magnitude of roughly €21–24 billion in 2024 (Sante, M., 2023, 2024, 2025a, 2025b; Doelen, J., 2025a, 2025b, 2025c, 2025d, 2025e; EIB, 2025, 2023; CBS, 2025).

The main engine behind housing renovation is the energy retrofitting of the existing housing stock. The EIB (Economisch Instituut voor de Bouw) shows that retrofit activities have grown relatively strongly in recent years and are more labor-intensive than average, meaning that, also when newly built structures underperform, they keep a significant share of activity going (EIB, 2023; EIB, 2025). The most common energy labels in Province Limburg are C (136,824 addresses) and A (106,713 addresses), as shown in Table 4. The chart above shows the number of addresses by energy label type in the province of Limburg. For this purpose, data at the address level from the EP-Online system of the RVO was used. EP-Online is the official national database that contains energy labels and energy performance indicators for buildings. The data used applies to the situation as of July 1st, 2025. An energy label indicates a building's energy efficiency. G is the worst energy label, and A+++++ is the best. Energy label C is most common in Province Limburg: 136,824 addresses have energy label C.

Table 48: Energy Labels in Limburg Province [Source: AllCharts.Info (2025)]

Energy label	Number of energy labels in the province of Limburg
A+++++	124
A++++	2,150
A+++	5,912
A++	4,303
A+	9,123
A	106,713
B	89,251

Energy label	Number of energy labels in the province of Limburg
C	136,824
D	70,561
E	39,193
F	54,340
G	49,400

In addition, the need for housing remains high, and conversions of existing real estate add several thousand dwellings each year; in 2024, this amounted to 7.9 thousand homes, roughly 10% fewer than in 2023 (CBS, 2025). Policy also bolsters renovation and improvement via the implementation of the EPBD IV: the Netherlands will transpose this European directive in 2026, with tightening measures intended to accelerate improvements to existing homes as well (Rijksoverheid, 2025a, 2025b). However, the housing renovation market is hampered by structural shortages of skilled workers. The EIB reports highlight high vacancy pressure and a continued need for inflow, particularly in housing activities crucial to the energy transition (EIB, 2023). Moreover, costs and project complexity weigh on deliverability and margins; after the peaks of 2022–2023, the cost picture has stabilized, but the sector enters 2025 on a cautious recovery path, with RMR acting as the lagged stabilizer, less cyclical than new construction (Sante, M., 2024; 2025a).

Another key part of market demand is the threat of substitutes. For individuals, rented accommodation is the main substitute for buying a home from a construction company. According to Eurostat, the share of people living in their households was 70.6%, and the share renting their home was 29.4% in 2022. The Dutch housing market consists of approximately 4.4 million owner-occupied homes and 2.9 million rental homes. This indicates that a significant portion of the population rents.

In general, only in times of economic uncertainty does leasing or renting an existing property become more attractive than buying (or renting or leasing) a new one. Accordingly, the value of the residential construction industry is negatively correlated with renting or leasing existing properties, since the demand for the latter has price-sensitive characteristics, as the value of new properties is usually higher than that of existing (similar) ones, while build-to-rent activities are not prevalent.

Assessing the relative costs and benefits of these substitutes is difficult. It will depend on factors such as market rent levels, the fitness-for-purpose of the available buildings, mortgage interest rates, etc. Most importantly, though, the benefits of leasing or renting a property are determined by the affordability of buying it, especially for residential properties. According to the Organisation for Economic Co-operation and Development (OECD), as cited in Trading Economics (n.d.), the price-to-rent ratio in the Netherlands averaged 101.34 from 1970 until 2025, reaching an all-time high of 167.47 in Q2 of 2025 and a record low of 59.54 in Q3 of 1985. Hence, renting has become less affordable. Furthermore, the switching costs between buying and renting a residential property are determined by mortgage interest rates, which are crucial demand factors for residential construction. Historically low interest rates have helped stimulate demand for purchasing property rather than renting in recent years.

Some buyers may choose to build their own home, but they will have to go through a complicated regulatory process and have the necessary skills and time to do so. In the

Netherlands, with the popularity of prefab housing, one in three houses is self-built (Research and Markets, 2025; USP Marketing Consultancy, n.d.). There is even a site dedicated to self-build homes in Almere, covering 250 acres and planned to accommodate 3,000 units (MVRDV, n.d.). Finally, it should also be noted that individuals may be dissuaded from renting if the law favors landlords or if landlords themselves are unwilling to offer long-term rental agreements. Overall, the threat of substitutes is assessed as moderate.

Customer analysis

There is a wide range of buyers in this market, from individuals looking to buy residential property to property developers and governments that may engage in large-scale residential projects. In 2022, according to the Housing Ministry, the twelve Dutch provinces have agreements with the Cabinet to create and build around 917,000 new housing units by the end of 2030 (NL Times, 2022). In Zuid-Holland, more than 25% of them will be constructed, with around 600,000 units regarded as affordable.

These different categories of buyers have widely differing amounts of power. Government-funded housing projects are usually put out to tender, where price is the most crucial determinant. Construction contractors have limited control over the tender procedures typically used for government projects as buyer price sensitivity increases. Nevertheless, price-setting by cartels of contractors could still occur (MarketLine Advantage, 2024).

Project developers deliver the largest share of new-build homes (56.7k in 2023); housing associations follow (14.3k in 2023). Private individuals are included within “other owners” and are smaller than developers as a group, and municipalities hardly build themselves (CBS, 2024b, 2025). Property developers represent the most influential customer segment in the Netherlands, particularly in urban and high-growth regions. These developers often undertake large-scale residential and commercial projects, including apartment complexes, retail spaces, and commercial developments. Their bargaining power stems from their ability to negotiate with multiple contractors for favorable pricing and delivery timetables, given the frequency and volume of projects. In 2024, the urban real estate landscape, particularly in Amsterdam, Rotterdam, and Utrecht, is dominated by leading developers such as AM Real Estate Development, BPD (Bouwfonds Property Development), and Synchroon. These firms have substantial leverage in procurement due to their scale and strategic landholdings. Despite their size, they are still reliant on the technical expertise and operational capacity of construction contractors. Property developers also have significant bargaining power because they leverage their market size. A high concentration of real estate activities among a few large property developers dilutes the power of construction contractors. In the Netherlands, some of the largest real estate developers are Meyer Bergman and Unibail-Rodamco (MarketLine Advantage, 2024).

The largest group of buyers in the industry is prospective homeowners, who purchase property through real estate agents. However, the most significant projects are often the result of local governments tendering for contractors to build multi-property residential developments, usually with additional non-residential elements. In these

situations, the organization that plans and tenders the work can be considered the primary buyer before the end consumer comes into play.

Another significant customer is social housing associations (SHAs), which own almost a third of the housing stock. As of 1 January 2024, housing associations accounted for 28% of the Dutch housing stock (≈2.3 million dwellings), the private rental sector for 14% (≈1.2 million), and owner-occupied homes for 57% (≈4.7 million) (CBS, 2024b). Project developers deliver the largest share of new-build homes (56.7k in 2023), housing associations follow (14.3k in 2023), and private individuals are included within "other owner". They are smaller than developers as a group (Dutch News, 2024; CBS, 2025b). Municipalities hardly build themselves (CBS, 2025c).

No data breaks down renovation turnover directly by ownership. However, for social housing associations, annual expenditure on maintenance, improvement, and decarbonization is well-documented via the Aedes benchmark—around €10.5 billion in 2023 (+15.5% y/y) (Aedes, 2024).

Individual consumers hold the least buyer power in the construction industry, especially in custom-built residential construction (MarketLine Advantage, 2024). These homeowners engage directly with contractors to build or renovate dwelling units. Their negotiating position is reduced by their limited technical knowledge, smaller budgets, and dependence on contractors for materials and labor. Individuals cannot control costs because pricing in residential construction is opaque and varies by region, architectural preferences, and local permitting. As in many developed countries, Dutch housing prices follow the basic economic principles of supply and demand. Individual consumers find it challenging to enforce significant pricing power given the large number of both buyers and sellers in cities like Amsterdam, The Hague, and Eindhoven. The country's high urbanization rate, which generates demand for new housing and infrastructure, also reinforces the role of the supplier construction firms in limiting individual consumer leverage.

Competitor analysis

The Dutch construction industry, although highly fragmented, is characterized by intense rivalry with a mix of dominant firms and small and medium-sized enterprises (SMEs). In the residential construction industry, sustainability concerns, workforce challenges, technological advancements, and government policy shape the competitive landscape.

The leading players in the entire Dutch residential construction market are Ferrovial SA, Royal BAM Group, and Koninklijke Heijmans (MarketLine Advantage, 2024). Based on this source, Ferrovial SA, aside from civil engineering, provides services in building refurbishment and the construction of residential, non-residential, and industrial structures for both public and private-sector clients. Ferrovial focuses on the development, construction, and operation of sustainable infrastructure through a combination of organic growth and selective acquisitions, with a focus on four areas: sustainable growth, operational excellence, innovation, and people. Royal BAM specializes in providing construction contracts and property development, with construction services for the residential and non-residential sectors, including commercial and technical development, project development, design and engineering, maintenance and renovation, and facility management. It focuses on restructuring its

portfolio of businesses to serve the growing demand for sustainable solutions in the construction sector by maintaining a strong position in public-private partnerships. Koninklijke Heijmans is one of the leading players in the Dutch residential construction market, focusing on the design, development, and sale of residential buildings and non-residential building projects. Its strategy lies in creating a healthy living environment.

In the Dutch province of Limburg, the notable players in the residential construction industry are listed on the Dun and Bradstreet website (see https://www.dnb.com/business-directory/company-information.residential_building_construction.nl.limburg.html) and shown in Table 49, arranged by annual revenue in million USD as of 2023.

Table 49: Residential Building Construction Companies in Limburg, Netherlands by Annual Revenues in USD Million as of 2023 [Source:https://www.dnb.com/business-directory/company-information.residential_building_construction.nl.limburg.html.]

	Company	Location	Sales Revenue 2023	Website
	(Large companies)		(USD million)	
1	Hanab DEC B.V.	Nederweert	873.9	https://www.hanab.nl
2	LAUDY Bouw & Ontwikkeling B.V.	Sittard	490.6	www.laudybouw.nl
3	Bouwbedrijven Jongen B.V.	Roermond	203.9	www.jongen.com
4	Wijnen Bouw Horst B.V.	Melderslo	198.9	http://www.wijnenbouw.com/
5	Henvas B.V.	Schinnen	196.0	http://www.henssen.nl/
6	Smeets Vastgoedservice B.V.	Maastricht	96.4	http://www.smeetsvastgoedservice.nl/
7	Wegenbouw van de Kreeke N.V.	Nuth	96.4	http://www.vandekreekegroep.com/
8	Habenu-van de Kreeke Projecten B.V.	Nuth	96.4	http://www.habetsbouwgroep.nl/
9	van de Kreeke Bouw B.V.	Nuth	96.4	http://www.vandekreekegroep.com/
10	Christiaens Construction B.V.	Melderslo	67.8	http://www.christiaensgroup.com/
11	Smeets Bouw B.V.	Maastricht	62.9	http://www.smeetsbouw.nl/
12	Willems Bouwbedrijf B.V.	Venlo	51.5	http://www.wbbv.nl/
	SMEs (< 50M ER turnover)			
1	Ammerlaan Kassenbouw B.V.	Melderslo	43.8	http://www.kassenbouw.com/
2	Maurice Produkties B.V.	Melderslo	43.8	http://www.kassenbouw.com/
3	Bouwmij Janssen B.V.	Venray	41.3	http://www.bouwmij-janssen.nl/
4	Raedts B.V.	Venray	27.7	http://www.raedtsbv.nl/
5	MTB Regio Maastricht N.V.	Maastricht	16.4	http://www.mtb-maastricht.nl/
6	Van Lipzig Aluminium- en Kunststof-Systemen B.V.	Venray	5.9	http://www.vanlipzig.nl/
7	Habenu-van de Kreeke Vastgoedservice B.V.	Nuth	5.0	http://www.vandekreekegroep.com/
8	Holding M.J. Teunissen B.V.	Ysselsteyn	5.0	http://www.teunissen-bv.nl/
9	Aannemers- en Timmerbedrijf P. Smeets B.V.	Maastricht	4.0	not available
10	Camp B.V.	Haelen	3.0	http://www.camp.nl/
11	IZO Bouw	Kerkrade	2.6	not available
12	Bouwbedrijf Henk Schnackers B.V.	Kerkrade	1.8	http://www.schnackers.nl/
13	Gebrs. Kurvers B.V.	Heerlen	1.7	http://www.wegenbouwkurvers.nl/
14	Mergelbouwsteen Kleijnen B.V.	Valkenburg	1.4	http://www.mergel.nl/
15	D.E.G. Maar Beheer B.V.	Margraten	1.4	not available
16	Derckx Weert B.V.	Weert	1.2	http://www.derckx.nl/
17	Bohaco B.V.	Meijel	1.2	http://www.bohaco.nl/
18	Ulantech B.V.	Sittard	1.2	http://www.ulantech.com/
19	Rijs Infra B.V.	Baexem	1.0	not available
20	FrigoFriends OG B.V.	Ittervoort	1.0	not available

Since the pilots for the BUPS project for the Netherlands will be located in Heerlen and Maastricht, the top residential construction companies from the same Dun and Bradstreet database are shown in Table 50. This matters for the possible ownership of the local PUFs for the BUPS project.

Table 50: Top 10 Residential Construction Companies in Heerlen and Maastricht [Source:https://www.dnb.com/business-directory/company-information.residential_building_construction.nl.limburg.html.]

	Top 10 SMEs Heerlen			
1	Gebrs. Kurvers B.V.	Oude Rooderweg 28, 6422 PE	1.7	http://www.wegenbouwkurvers.nl/
2	24/7 The Transporter B.V.	Wannerplein 8, 6413 ET	0.92	not available
3	Maaiveld+ B.V.	Grasbroekerweg 65, 6412 BC	0.75	http://www.mvplus.nl/
4	Oostwegel en Kowollik B.V.	Schaesbergerweg 129, 6415 AE	0.5	http://www.ateliersier.nl/
5	Feisan Vastgoed B.V.	Nieuwhuisstraat 1, 6417 AG	0.38	not available
6	R-Con B.V.	Valkenburgerweg 9, 6411 BM	0.25	http://www.r-con.nl/
7	Bouwbedrijf Peeters B.V.	Esschenweg 46, 6412 PV	0.25	http://www.bouwbedrijfpeeters.nl/
8	Connessa Projecten B.V.	Kruisstraat 56, 6411 BW	0.25	not available
9	Bouwservice van Tilborg	Dr Kuyperstraat 41, 6415 HB	0.25	not available
10	MW Bouw B.V.	Beersdalweg 93, 6412 PE	0.25	not available
	Top 10 SMEs Maastricht			
1	Smeets Vastgoedservice B.V.	Kotterweg 20, 6222 NR	96.37	http://www.smeetsvastgoedservice.nl/
2	Smeets Bouw B.V.	Kotterweg 20, 6222 NR	62,89	http://www.smeetsbouw.nl/
3	MTB Regio Maastricht N.V.	Watermolen 1, 6229 PM	16.4	http://www.mtb-maastricht.nl/
4	Aannemers- en Timmerbedrijf P. Smeets B.V.	Heugemerweg 57 a, 6221 GG	4.02	not available
5	Schilderwerken Beere B.V.	Franciscus Romanusweg 34, 6221 AG	0.67	http://www.beere.nl/
6	F.S.A B.V.	Scharnerweg 137 a02, 6224 JD	0.63	not available
7	V.A.L. Vastgoed B.V.	Meerssenhoven 202, 6222PD	0.38	http://www.v-a-l.nl/
8	R.P.C. Habets Beheer B.V.	Laan van Brunswijk 77, 6212 HD	0.36	http://www.mvplus.nl/
9	Laro Bouwbedrijf B.V.	Rekoutweg 13, 6229 RB	0.25	http://www.larobouw.nl/
10	Service Buro Zuid B.V.	Posthoornstraat 75, 6219 NV	0.25	http://www.serviceburozuid.nl/

Based on MarketLine Advantage (2024), despite the presence of some large companies, the residential construction market is highly fragmented, which tends to increase rivalry. The macroeconomic situation in the Netherlands can significantly impact the market, for example, during an economic recession, when construction is hit by funding constraints, or during inflation, when consumers tend to postpone renovation or property-buying decisions. Depending on the availability of construction workers, contractors and construction companies can recruit additional workers to meet increased demand. Exit costs are low because market players' competencies are transferable to non-residential construction, and even a complete exit from the construction industry does not require divesting large amounts of fixed assets, especially if the equipment is rented or leased. This decreases the degree of rivalry as companies may choose to leave the market if a more profitable venture becomes available.

Both fixed and storage costs are low for residential construction players because the primary input is the workers' building skills (MarketLine Advantage, 2024). The typical market players are not very diversified in their business models and revenue streams. Geographical diversification is more common among larger contractors.

A key part of the competitor analysis is the threat of new entrants. The economies of scale in the construction industry are usually the most significant barrier to entry for new players. Barriers to entry also include a considerable capital outlay for acquiring capital items. However, construction companies can be relatively asset-light, as on-site work can be outsourced to subcontractors and equipment can be hired or leased rather than purchased, making the residential construction market susceptible to new, small-scale players (MarketLine Advantage, 2024).

The same report cites that the differentiation of construction companies by the range of services (vertical integration) they provide, from design to project management to specific building skills, allows the entry of new players. Moreover, the existence of different market segments (horizontal differentiation), such as houses, apartments, and condominiums, leaves room for specialized niche markets.

Construction markets in developed economies like the Netherlands commonly share two features: a shortage of skilled labor and slender margins, pushing players to find new ways to do more with less. Technology is beginning to change how construction projects are undertaken, creating opportunities for new players and forcing existing players to adapt. The emergence of this new trend in the market could prove lucrative for potential new entrants specializing in this form of construction. There is currently a push for sustainable building in the Netherlands, in part due to a need to use space more efficiently as the country's urban population grows and in part due to government efforts to be more environmentally friendly. New entrants offering skills in this area would be highly favored.

Regulation is typically stringent and complex. It covers planning permission and zoning, building site health and safety, and the safety and security of the buildings themselves. In the Netherlands, the main building code is defined in the Buildings Decree 2012, while municipal authorities each have their own additional codes. Compliance with this government regulation increases costs. Building restrictions limit supply, having a devastating effect on housing affordability and demand. The construction permit process is considered slow in the Netherlands, hindering the supply of new housing. This housing shortage should drive market growth, further aided by the government's Action Agenda, which plans to build 1 million new homes over the next 10 years.

Government policies also affect the industry outside of the regulatory framework. For example, tax deductions for mortgage payments or other tax incentives and subsidies can positively affect demand in the construction industry. According to De Nederlandsche Bank (n.d.), the Bank Lending Rate in the Netherlands decreased to 4.21% in February from 4.24% in January of 2024. Bank Lending Rate in the Netherlands averaged 2.89 % from 2003 until 2024, reaching an all-time high of 6.26% in October of 2008 and a record low of 0.26% in May of 2022. This will further slow residential construction demand and slow the market.

Another aspect considered by construction companies when entering a particular industry is access to and the cost of construction materials. Specifically, the scarcity of construction materials within a country leads to imports, which increase production costs. At the same time, those costs are also affected by fluctuations in the local currency. Notably, the Netherlands is a net importer of cement and aggregates; domestic production is only sufficient for building bricks.

Switching costs in this market are low. For example, suppose a local authority wants a block of low-cost apartments built. In that case, it will put the contract out to tender,

and the fact that one company has bid successfully in the past is no guarantee that it will win this particular contract: the buyer is free to choose a competitor. Similarly, individuals buying newly built houses are not tied to the company that built their current home. This is a benefit for new entrants.

Furthermore, the likelihood of new entrants is dependent on the macroeconomic outlook of the country market, as residential construction is one of the most vulnerable sectors to the macroeconomic environment and is highly correlated with economic growth. Overall, the threat of new entrants is strong.

Trend analysis

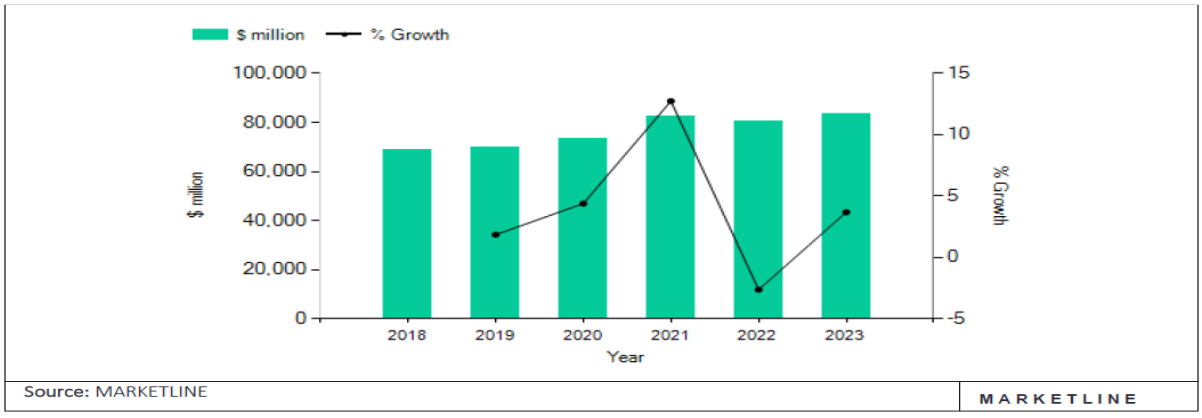
The Dutch residential construction sector grew by 3.7% in 2023, reaching $83,254.2 million. The sector's compound annual growth rate for 2018–23 was 3.9%.

Table 51: Netherlands residential construction sector value in USD million, 2018-2023.

Year	$ million	€ million	% Growth
2018	68,801.9	58,259.5	
2019	70,074.6	62,596.0	1.8%
2020	73,150.8	64,044.0	4.4%
2021	82,470.0	69,727.9	12.7%
2022	80,298.2	76,193.3	(2.6%)
2023	83,254.2	76,996.7	3.7%
CAGR: 2018–23			3.9%

Source: MARKETLINE MARKETLINE

Figure 9 illustrates the market value with the annual growth rates.



Source: MARKETLINE MARKETLINE

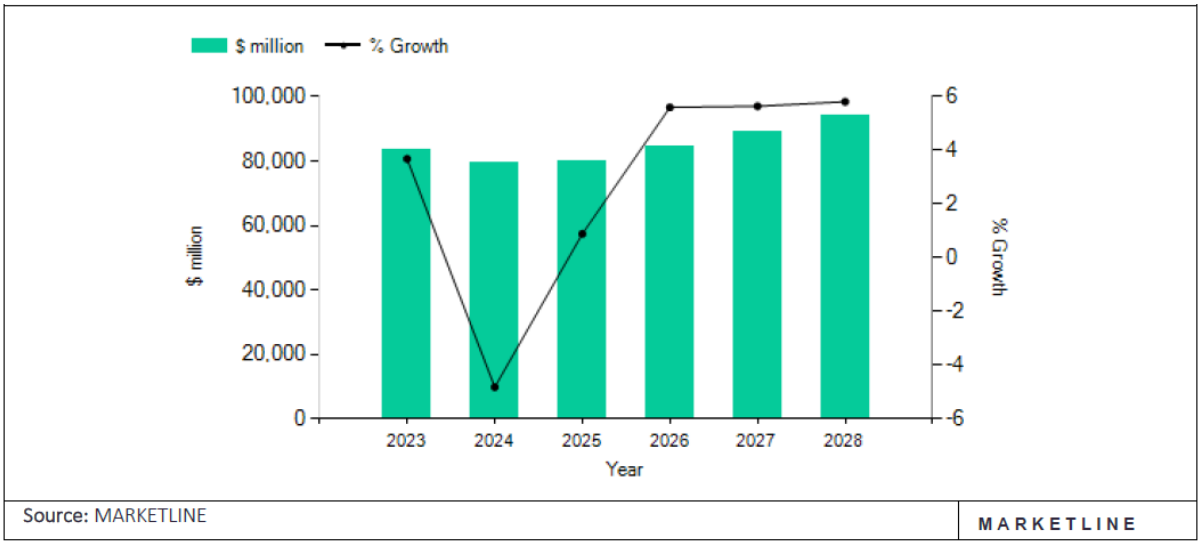
Figure 84: Netherlands residential construction value in USD million vs. growth rates

In 2028, the Dutch residential construction sector is forecast to be valued at $94,361.3 million, an increase of 13.3% since 2023. The sector's compound annual growth rate for 2023–28 is predicted to be 2.5%.

Year	$ million	€ million	% Growth
2023	83,254.2	76,996.7	3.7%
2024	79,241.1	74,755.8	(4.8%)
2025	79,945.2	75,174.4	0.9%
2026	84,419.8	79,243.5	5.6%
2027	89,182.7	83,609.4	5.6%
2028	94,361.3	88,371.2	5.8%
CAGR: 2023–28			2.5%

Source: MARKETLINE MARKETLINE

Figure 85: Netherlands Residential Construction Sector Value Forecast USD million,



Source: MARKETLINE MARKETLINE

Figure 86: Netherlands Residential Construction Sector Value Forecast

For the major residential construction market segments, the RMR market, which is most relevant to local PUFs, will be discussed. The Dutch residential repair, maintenance, and renovation (RMR) market is expected to see a stable-to-slight growth outlook toward 2030, as shown in Figure 3, primarily driven by significant government targets for energy efficiency upgrades and the need to maintain an aging housing stock (FIEC, 2025).

In 2024, residential renovation saw a minor decrease, mainly due to saturated demand for some sustainable improvements, such as solar panels, and a previous surge in activity leveling off. In 2025, the RMR market is expected to stabilize, with a slight increase in non-residential renovation activity. Overall construction output is expected to grow by 2.4%. For the medium term (2026-2030), the outlook is more optimistic. Total construction output is projected to rise with a moderate annual average growth across segments, driven by regulatory requirements and strong future demand for energy-efficient solutions. For example, higher energy prices in the installation and maintenance market create additional demand for energy-saving construction works. These include installing (hybrid) heat pumps, installing solar panels, and installing insulation. Specific volume figures are not available for the installation sector, but 2022 turnover figures indicate that this sector is showing much higher growth than the rest of the construction sector (Sante, M. 2022; Atradius, 2024; CBRE, n.d.).

The major market drivers for the growth of the RMR market, based on the following sources: Koopal, H. (2025); Rijkwaterstaat Ministerie van Infrastructuur en Waterstaat (2023); Langen, M. (2025); Carter, A. (2024); and Sante, M. (2022), are:

1) *Government Mandates*: A primary driver is the European Energy Performance of Buildings Directive (EPBD), which the Netherlands is incorporating into national law.
    a. The national goal is to renovate 2.5 million homes by 2030 to improve energy efficiency.
    b. By 2027, homes with an energy label of G or worse must be upgraded to at least label C; by 2030, all homes with label F or worse must reach label C.
2) *Decarbonization and Sustainability*: The broad push towards a circular economy and reducing CO2 emissions means a strong focus on insulation, heat pumps, and expanding district heating networks.
3) *Housing Stock Age*: Over 50% of the housing stock was built before 1980 and is not inherently energy efficient, presenting a large market for retrofitting.
4) *Shift from New Construction*: While new construction has faced headwinds (nitrogen issues, high material costs, labor shortages, permit delays), the RMR sector is viewed as a more environmentally friendly and feasible way to improve the housing situation, with some reports suggesting renovation could create up to 120,000 new homes by 2030 through division and transformation of existing buildings.

Business case

The market analysis established both the scale and the urgency of residential renovation in the Netherlands and the specific characteristics of the Limburg ecosystem that call for modular, industrialized approaches. In this section we evaluate their financial fit for the Dutch market and underpin what circumstances would be most beneficial for the financial viability of the popup factory. The two pop-up factory types that fit this ecosystem are the *Assembly Factory* and the *District Factory*. Table 7 (below) presents the research design applied to examine the evaluation of the two PUFs.

Table 52: Types of PUFs

Term	Definition	Netherlands Ecosystem
Mobile On-Site Factory	A movable production cell deployed directly on or near the construction site.	No

Satellite Factory	A temporary facility near the site that collaborates with a central production hub.	No
District Factory	A semi-permanent facility serving multiple nearby projects, acting as a system integrator.	Yes
Assembly Factory	A location focused solely on assembling prefabricated components from other sources.	Yes
Service Factory	A knowledge and facilitation hub that supports sustainable renovation through advice and coordination.	No

1.1.1.1 Simplified Business Process Model

The Pop-up Factory business process begins when a client identifies the need for a deep energy renovation of a residential property. The client engages an energy efficiency consultant, who assesses the building, develops a renovation concept, and prepares an action plan in compliance with applicable regulations, standards, and energy performance requirements.
Based on the approved action plan, the client places an order for the required renovation measures. The model focuses on four standardised residential sustainability interventions that contribute to improving the building's energy performance and energy label:

- Roof insulation, delivered by a roofing contractor;
- Floor and wall insulation, delivered by an insulation contractor;
- Energy efficient window frames, delivered by a system integrator and OEM;
- HVAC upgrades, delivered by a specialised HVAC installer.

Each supplier receives the relevant order, manufactures or prepares the required energy-efficient products and components, and delivers them to the construction site.
A dedicated installation team coordinates the logistics, quality control, and installation of prefabricated components. The use of standardised and prefabricated solutions helps reduce on-site construction time and improves process efficiency.
For renovation measures that require specialised equipment or technical expertise, installation is carried out directly by the responsible contractor. Examples include cavity wall insulation using injection or foam systems and the installation and commissioning of heat pumps and other HVAC systems.
Upon completion of all renovation activities, the energy efficiency consultant verifies the achieved performance and prepares the required documentation. During the final stage of the project, the consultant issues an EnerPHit certification and provides the client with a Progress and Validation Report documenting the completed measures, achieved performance improvements, and compliance with project requirements.
Following final verification and acceptance, the renovation project is formally delivered to the client, and the associated activities within the Pop-up Factory are concluded. The temporary production and coordination resources can then be redeployed to the next renovation project.

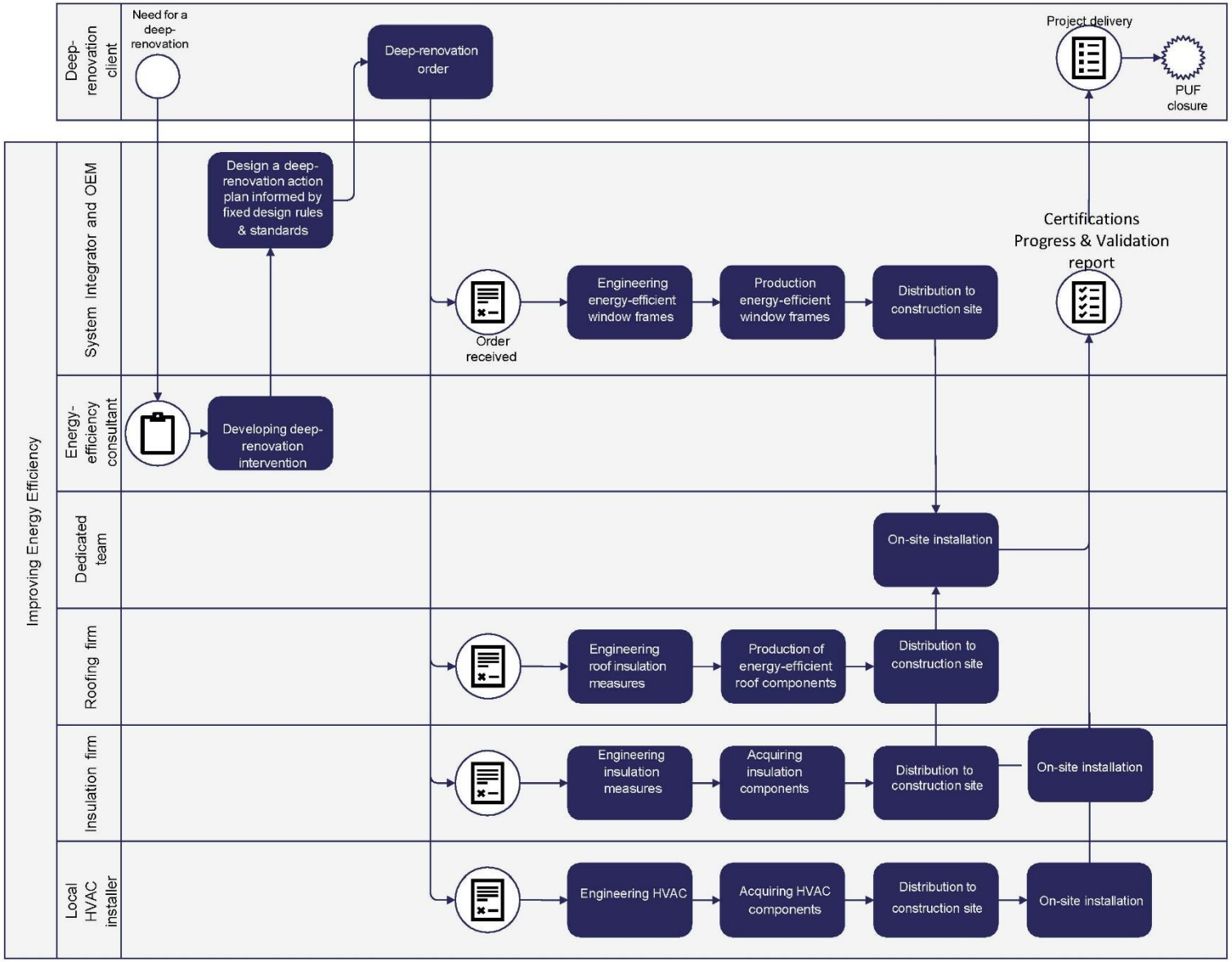


Figure 87: Business Process Model

Research Design

In this section, we present the steps followed to dive into the examined business case. Based on literature related to the evaluation of innovations for the redesign of the construction sector as well as the opinion of experts in the field, the main criteria selected are: the required financial investment, the fit to the project scale, and the ecosystem's fits to the region. These also depend on the type of ownership that is involved. Below, the criteria and ownership model will be explained.

PUF Application in the Netherlands

Based on key assumptions and relevant risk considerations from experts, we elaborate on each ownership scenario and evaluate it against the 3 main evaluation criteria. Below, we elaborate on key assumptions and risk considerations from experts for the PUF assembly and service. Finally, we present the reasoning of this business case in the sub-section 1.4.2 and further.

Table 53: The Assembly and District PUF compared across four ownership scenarios

Ownership scenario	**Assembly PUF**			**District PUF**		
	Tool investments	**Project scale fit**	**Ecosystem fit**	**Tool investments**	**Project scale fit**	**Ecosystem fit**
Single construction company	High	Strong	Moderate	Medium	Strong	Moderate
Consortium of construction companies	Medium	Strong	Strong	Medium	Strong	Strong
Industry Association	Medium	Strong	Strong	Medium	Strong	Strong
Housing corporations	High	Weak	Very strong	High	Moderate	Very Strong

Overall, the comparison suggests that the Assembly PUF is most viable when there is sufficient programme scale to justify the higher tool investments. This is reflected in consistently strong project scale fit for single-company, consortium, and industry association scenarios, while housing corporation ownership shows a weaker scale fit despite very strong ecosystem fit. In contrast, the District PUF shows low tool investment requirements across ownership scenarios and performs particularly well in scale and ecosystem fit under consortium and industry association arrangements. The single-company District option remains moderate in both scale and ecosystem fit, indicating a more bounded role linked to one pipeline, while housing corporation ownership shows very strong ecosystem fit but only moderate scale fit, suggesting strong alignment with local objectives but a more portfolio-bound operational reach. Taken together, the table indicates that Assembly capacity is primarily a scale- and utilisation-driven choice, whereas District capacity appears more robust as a multi-

actor regional mechanism, especially where neutrality and cross-project aggregation are important.

Assembly PUF – Key assumptions and risk implications

The Assembly PUF is treated in this business case as an approach that accelerates renovation primarily through physical process control, proximity, and repeatable assembly workflows. The central assumption is that assembly benefits become meaningful only when the PUF operates at sufficient utilisation and when projects can be sequenced in a programmatic manner, because assembly requires set-up effort, production discipline, and a trained workforce. This is why the “project scale fit” dimension in the table is interpreted as the key feasibility driver for the Assembly type, and the reasoning that the “tool investments” dimension is interpreted as the main exposure to underutilisation: the higher the investments and the weaker the scale fit, the more the Assembly PUF becomes vulnerable to idle capacity and organisational drag rather than creating acceleration.

Under single construction company ownership, the table assigns high tool investments, strong scale fit, and moderate ecosystem fit. This configuration assumes that a single contractor can mobilise equipment, organise labour, and integrate the Assembly PUF into its delivery chain, which explains the strong scale fit. The trade-off is that investment exposure and utilisation risk are concentrated in one actor, and the ecosystem fit is moderated by the fact that an asset owned by one contractor is less likely to be perceived as a shared ecosystem instrument by other firms and stakeholders. The associated risk is therefore not primarily technical feasibility but rather concentration risk: the Assembly PUF can work well when the owner has a stable pipeline, but it becomes fragile if the pipeline fluctuates or if wider ecosystem participation is needed to secure volume and legitimacy.

Under consortium ownership, the table shows medium tool investments, strong scale fit, and strong ecosystem fit. The underlying assumption is that shared ownership can spread tool commitments across partners and improve the ability to aggregate and sequence projects across a broader network, which strengthens both scale fit and ecosystem fit. The corresponding risk is not lack of capability, but coordination risk: the Assembly PUF remains dependent on disciplined pipeline alignment, scheduling, and standardisation across firms that may otherwise compete. In practice, this means that consortium ownership only yields the “strong” ratings in the table if governance mechanisms ensure that shared ownership translates into shared utilisation and consistent methods, rather than becoming a passive arrangement where each partner prioritises its own projects and the shared asset becomes underused.

Under industry association ownership, the table also shows medium tool investments, strong scale fit, and strong ecosystem fit. The assumption here is that an association can play a non-competing stewardship role that increases neutrality and reduces friction through standardisation of processes, specifications, and logistical routines, while leaving execution responsibility and delivery know-how with construction companies. The scale fit is rated strong because association stewardship can support aggregation through frameworks and shared access rules, and the ecosystem fit is rated strong because neutrality tends to improve stakeholder buy-in. The risk in this configuration is not primarily operational execution, but conversion of convening power into throughput: the Assembly PUF’s viability still depends on whether member contractors and anchor clients actually commit projects into the shared pipeline. In

other words, the association model can lower barriers to participation and strengthen legitimacy, but it must still be coupled to programme commitments to avoid the Assembly PUF becoming a well-designed concept with insufficient utilisation.

Under housing corporation ownership, the table indicates high tool investments, weak scale fit, and very strong ecosystem fit. This combination reflects a structural assumption that housing corporations are strongly aligned with Limburg's ecosystem priorities—social housing quality, affordability, energy poverty and neighborhood stability—which explains the very strong ecosystem fit. At the same time, owning a physical assembly operation implies a high tooling commitment and operational responsibilities that are not typically core to a housing corporation, which explains the high investment rating. The weak scale fit reflects practical barriers rather than lack of renovation need: procurement rules, risk aversion, and dependence on contracted contractors can slow mobilization and reduce the ability to run assembly at the pace and sequencing discipline that make it effective. The implied risk is therefore implementation complexity and slow ramp-up, not lack of local relevance. In this scenario, housing corporations are assumed to be strongest as anchor clients and programme owners that secure volume, rather than as direct owners of assembly operations.

Across all ownership scenarios, the table implies that the Assembly PUF's dominant vulnerability is utilization and sequencing. If the high production volumes can not be met, the efficiency and ROI of the PUF will decline. The more the ownership model can ensure predictable batches and operational discipline, the more the Assembly PUF behaves like an accelerator; the more it depends on ad hoc project intake, the more it behaves like a costly add-on that struggles to realise its intended benefits.

District PUF – Key assumptions and risk implications

The District PUF is a regional delivery and system-integration hub that accelerates renovation by combining coordination with a semi-permanent operational capability. Whereas the Assembly PUF is centred on near-site assembly for a defined programme, the District PUF is assumed to serve multiple projects within a geographic area and to function as a shared backbone for logistics, quality assurance, standardisation, and processing activities. The central assumption is therefore that the District PUF is not tool-light. Its feasibility depends on a level of physical and organisational capacity that exceeds a purely advisory function, including space, material handling, storage, digital planning and tracking, and the routines needed to run repeatable flows across multiple projects. For that reason, the "financial investment" dimension is expected to be higher than for a Service PUF and closer to the Assembly PUF, although the investment profile is typically more modular and scalable than a permanent central factory.

The District PUF is expected to be most sensitive to regional throughput and utilisation. This approach requires a stable pipeline across multiple projects to justify semi-permanent set-up, staffing, and coordination structures. This makes "fit to project scale" decisive: the District PUF performs best where the regional projects have sufficient volume, where typologies are repeatable enough to standardise packages, and where sequencing can be organised to maintain continuous flow. At the same time, ecosystem fit remains important because the District PUF is multi-actor: it depends on trust, governance arrangements, and procurement compatibility, but also

on practical embedding conditions such as site availability, local regulations, and logistics connectivity.

Under single construction company ownership, the District PUF is assumed to be implementable relatively quickly because a contractor can mobilise operational capability and integrate the hub into its regional delivery chain. However, the hub may become primarily aligned with that contractor's pipeline, which can constrain ecosystem participation and reduce the ability to aggregate projects across the broader market. The risk in this configuration is that utilisation becomes dependent on one pipeline, and the District PUF may perform well operationally while remaining bounded in ecosystem value because other contractors or clients may hesitate to rely on a hub owned by a direct competitor. The implication is that single-company ownership can work where the contractor controls a sufficiently large regional portfolio, but it is less robust if the ambition is ecosystem-wide scaling or cross-contractor aggregation.

Under consortium ownership, the District PUF is assumed to benefit from pooled pipelines and shared capacity, which can strengthen project scale fit by smoothing demand variability and enabling better sequencing across multiple programmes. Ecosystem fit is also expected to improve because shared ownership signals broader access and reduces the perception of a proprietary asset. The associated risk shifts from investment exposure to coordination and governance risk: the District PUF only realises its potential if consortium partners align operational standards, scheduling rules, and allocation mechanisms, and if shared utilisation is actively managed rather than left to voluntary participation. Without such governance, the District PUF risks becoming underutilised despite having sufficient theoretical demand in the region.

Under industry association ownership, the District PUF can be positioned as a non-competing regional backbone that standardises processes and logistics while allowing construction companies to remain responsible for execution. In this configuration, ecosystem fit can be strong because neutrality supports broad participation and reduces friction in a fragmented market. The scale fit can also be strong, but only if the association's convening role is translated into programme commitments and an operational model that ensures continuous throughput. The central risk is therefore not technical feasibility but the conversion of convening power into sustained utilisation. If pipeline aggregation is not secured through framework agreements or anchor programmes, a semi-permanent hub risks carrying fixed coordination and facility costs without sufficient flow.

Under housing corporation ownership, ecosystem fit is typically very strong because corporations are anchored in the region, have direct portfolio visibility, and can align the District PUF with social objectives such as reducing energy poverty and minimising disruption for tenants. However, the District PUF still requires operational capability that corporations may prefer not to own or operate directly. The risk is that ownership concentrates responsibility for a semi-permanent operational hub in an organisation whose core competencies and procurement structures are not designed for running logistical/production functions. A more feasible interpretation of this scenario is therefore that housing corporations act as anchor clients providing pipeline certainty and performance requirements, while operational responsibility remains with contractors or an independent operator.

Across all ownership scenarios, the table implies that the District PUF's dominant vulnerability is not whether stakeholders see it as useful in principle, but whether the model can be kept continuously productive through aggregated regional flow. Where

ownership and governance arrangements enable multi-project sequencing and shared access, the District PUF can stabilise renovation delivery and reduce friction across programmes. Where pipeline aggregation fails or governance is slow, the District PUF risks becoming an underutilised asset that delivers coordination benefits but does not achieve the throughput needed to justify semi-permanent capacity.

Internal Business Analysis of the local pop-up factory

Assembly PUF - Value proposition

The Assembly PUF is positioned as a local, project- and portfolio-oriented operational set-up that assembles prefabricated components close to renovation sites. Its value proposition is centred on speed, predictable quality, and reduced on-site disruption by shifting critical assembly work from the construction site into a controlled environment, while still keeping delivery geographically close to the end location. In Business Model Canvas terms, the primary customer segments are housing corporations and contractors delivering programmatic renovation, municipalities and district programmes commissioning clustered upgrades, and (indirectly) residents who benefit from shorter time-in-home interventions. The Assembly PUF creates a clear offer for customers seeking reliable throughput in repeatable typologies, because it translates standardised components into a coordinated assembly output that can be delivered just-in-time.

Value Creation

For the Assembly PUF, value creation is driven by the ability to transform inbound prefabricated components into assembled packages with stable quality and takt-based productivity. The key resources include a temporary or semi-temporary facility space, assembly tooling and material-handling equipment, a trained assembly workforce, and digital assets such as BIM-enabled work instructions and QA documentation. The key activities focus on production planning, inbound logistics coordination, assembly operations, quality checks, and continuous improvement of standard work routines. The key partnerships include component suppliers and manufacturers, logistics providers, installers (particularly for retrofit packages that integrate building envelope and building services), local labour and training partners, and programme owners who can provide stable sequencing. The assembly model creates the most operational value when it can run repeatable workflows across a clustered set of dwellings, because repetition reduces errors and stabilises output. The core assumption is that the Assembly PUF requires sufficient pipeline volume to justify set-up and to maintain utilisation; without clustering and sequencing discipline, the operational advantages diminish.

Capabilities: ‘upskilling’ to operate the local pop-up factory

Assembly PUF focuses on coordination of assembly operations, workforce flexibility, digital production control, and integration of specialist expertise from external partners. Assembly PUF depends on a core contractor coordinating multiple assembly operations while integrating specialist subcontractors and high-tech manufacturing

partners. A successful Assembly PUF requires a combination of technical, organisational, and digital competences. Many of these capabilities are not yet widely available in the traditional construction workforce and therefore require targeted upskilling and continuous training programmes.

The Assembly PUF operates through three complementary competence groups:

Core team (main contractor)
Responsible for planning, coordination, assembly operations, logistics, quality control, and workforce allocation.
May operate multiple Assembly PUFs simultaneously and redistribute labour and skills between projects.

Specialist subcontractors
Provide unique technical expertise and customised solutions that cannot be standardised within the Assembly PUF.
Examples include building services integration, windows systems, energy systems, and specialist installations.

External high-tech manufacturers
Supply prefabricated building components and industrialised solutions.
Responsible for advanced manufacturing capabilities, product development, robotics, automation, and product engineering.

Job descriptions for abovementioned competence groups are the following:

Job description: Assembly Coordinator (Core Contractor)

Tasks and responsibilities:

- Planning and sequencing each Assembly PUF activities.
- Coordinating deliveries and material flows.
- Managing workforce allocation across multiple Assembly PUFs.
- Monitoring productivity and quality.
- Hiring and Coordinating subcontractors and installation teams.

Capabilities:

- > 5 years of experience in construction-related project management
- Experience with planning and project management, affinity with integrated construction processes and lean management
- Highly skilled in communication (project management and mediation)
- Certified Passive House professional or equivalent qualification (renovation expert), and/or
- Experience in this or a similar role in one or more successful (certified) EnerPHit renovation, Passive House, or WNR projects, and/or
- Certificate of participation in the Quality Assurance Course for Performance-based Renovations

Recommended training:

- Course on Lean Construction
- Course on Takt Planning
- Course on Last Planner System
- Course on Digital Production Management

- Course on Energy-neutral Building and Renovation
- Course on Quality Assurance in Performance-based Renovations
- Course on Project Budgeting in Integral Construction
- Course on Chain Collaboration
- Course on Risk Management
- Course on Quality Management
- Course on Continuous Improvement
- Course on Communication in the Construction Process

Job description: Digital Production Planner (Core Contractor)

Tasks and responsibilities:

- Coordinate BIM-based (Building Information Model) production and assembly planning for prefabricated building components.
- Translate engineering designs and BIM models into practical assembly sequences and digital work instructions for assembly teams.
- Develop and maintain production schedules, ensuring that materials, equipment, workforce, and information are available at the right place and time.
- Coordinate logistics and material flows between external manufacturers, suppliers, subcontractors, and Assembly PUF operations.
- Monitor assembly progress, productivity, quality performance, and resource utilisation through digital planning and tracking systems.
- Manage digital project information, including BIM models, digital twins, quality documentation, and renovation dossiers.
- Support workforce planning and allocation across multiple Assembly PUFs operated by the core contractor.
- Identify bottlenecks, delays, and resource constraints and implement corrective actions to maintain workflow continuity.
- Analyse production and operational data to improve productivity, reduce waste, and support continuous improvement.
- Act as the digital interface between designers, manufacturers, specialist subcontractors, and assembly teams to ensure coordinated execution.
- Support quality assurance processes through digital inspection records, traceability systems, and performance monitoring.
- Contribute to the implementation of lean construction and industrialised construction methodologies.

Capabilities:

- Strong understanding of BIM and digital construction workflows.
- Experience with production planning, scheduling, and resource management.
- Knowledge of prefabrication and industrialised construction methods.
- Familiarity with digital quality assurance and document management systems.
- Ability to analyse operational and production data.
- Strong communication and coordination skills across multidisciplinary teams.
- Understanding of lean construction principles and continuous improvement methodologies.

Recommended training:

- Course on BIM and Digital Construction

- Course on Industrialised / Modular Construction
- Course on Lean Construction and Takt Planning
- Course on Construction Logistics and Supply Chain Coordination
- Course on Quality Assurance and Performance Verification
- Course on Data-driven Production Planning
- Course on Multi-disciplinary Collaboration and Communication

Job description: Project Leader PUF

Tasks and responsibilities:

- Point of contact for both client and project team
- Organizing the engineering team, delegating tasks and responsibilities
- Organizing meetings and decision lists
- Managing project execution
- Organizing execution planning and process monitoring
- Organizing cost estimation and procurement according to Customer Requirements Specification (CRS)
- Organizing quality assurance according to the Validation and Verification (V&V) plan
- Organizing toolkit discussions
- Organizing execution documentation for the renovation dossier (EnerPHitcertification and BENG reporting)
- Organizing final cost calculations
- Organizing and participating in project evaluations

Capabilities:

- > 5 years of experience in construction-related project management
- Experience with planning and project management, affinity with integrated construction processes and lean management
- Highly skilled in communication (project management and mediation)
- Certified Passive House professional or equivalent qualification (renovation expert), and/or
- Experience in this or a similar role in one or more successful (certified) EnerPHit renovation, Passive House, or WNR projects, and/or
- Certificate of participation in the Quality Assurance Course for Performance-based Renovations

Recommended training:

- Course on Energy-neutral Building and Renovation
- Course on Quality Assurance in Performance-based Renovations
- Course on Project Budgeting in Integral Construction
- Course on Chain Collaboration
- Course on Risk Management
- Course on Quality Management
- Course on Continuous Improvement
- Course on Communication in the Construction Process

Job description: Assembly Technicians and Craftspeople (Core Contractor)

Tasks and responsibilities:

- Assembly of prefabricated components
- Component inspection

- Installation preparation
- Rework and adjustments

Capabilities:

- Modern construction techniques
- Understanding of prefabricated systems
- Quality awareness
- Ability to work with digital instructions

Recommended training:

- Course on Energy-neutral Building and Renovation
- Course on Quality Assurance in Performance-based Renovations
-

Job description: Specialist Integration Experts (Subcontractors)

Tasks and responsibilities:

- Deliver unique technical solutions
- Support assembly of complex systems
- Commissioning and testing
- Technical troubleshooting

Examples:

- HVAC specialists
- Energy system specialists
- Windows engineers
- Insulation specialists
- Smart building specialists
- Circular construction experts

Job description: Manufacturing and Product Engineering Experts (External Manufacturers)

Tasks and responsibilities:

- Design, engineer, and manufacture specialised prefabricated building components and systems that require advanced technical expertise and manufacturing capabilities.
- Develop customised solutions for project-specific requirements that cannot be delivered through standard Assembly PUF processes.
- Ensure manufacturability, quality assurance, and compliance with technical and regulatory requirements.
- Support the integration of prefabricated products into Assembly PUF workflows and installation processes.
- Provide technical guidance and product-specific training to Assembly PUF teams and subcontractors.
- Contribute to product innovation, industrialisation, automation, and continuous improvement of construction systems.
- Support commissioning, testing, and performance verification of specialised building systems.

Capabilities:

- Advanced product engineering and design-for-manufacture expertise.
- Deep understanding of prefabricated and industrialised construction systems.

- Expertise in manufacturing technologies, automation, and quality control.
- Ability to work within BIM-enabled and digital construction environments.
- Knowledge of performance-based renovation requirements and building regulations.
- Experience with product testing, certification, and performance verification.
- Strong collaboration skills to coordinate with contractors, subcontractors, and Assembly PUF teams.

Note:
These specialist capabilities are typically developed within dedicated manufacturing organisations rather than within the Assembly PUF itself. However, as industrialised renovation and construction become more widespread, selected members of the core PUF team should be upskilled in:

- Design for Manufacture and Assembly
- BIM-based (Building Information Model) product engineering
- Industrialised and modular construction methods
- Digital fabrication and manufacturing technologies
- Quality assurance for prefabricated construction systems
- Integration of advanced building systems (HVAC, energy systems, smart controls)
- Circular and bio-based construction solutions

While the most advanced manufacturing expertise will continue to reside with specialised external manufacturers, increasing demand for industrialised renovation is expected to require greater knowledge transfer and capability development within Assembly PUF core teams to improve coordination, integration, and innovation capacity.

Value Delivery

Value delivery in the Assembly PUF hinges on translating controlled assembly output into predictable on-site installation and reduced disruption for occupants. In Business Model Canvas terms, channels are primarily programme procurement routes (framework agreements, district tenders, portfolio contracts) and operational delivery channels that include scheduled transport, just-in-time delivery to sites, and coordinated handovers to site teams. Customer relationships are characterised by high coordination intensity and performance-based expectations, because the Assembly PUF must align with project planning, resident communication, and site readiness. The proximity of the assembly location to the renovation sites reduces long-haul transport dependencies and enables rapid issue resolution. Quality is delivered through standardised inspection routines, traceable documentation, and the ability to make controlled adjustments when tolerances or site conditions require it. The social dimension of value delivery is visible through local employment opportunities and training pathways created by the assembly workflow, as well as the potential to build trust through visible local presence and demonstrated craftsmanship.

Touchpoints and market activation

For an Assembly PUF serving the Dutch renovation market, the customer journey starts long before actual assembly activities begin. Since the factory operates primarily in a B2B/B2G environment, the onboarding phase focuses on awareness, engagement, qualification, and project preparation. Residents are generally indirect customers but become important stakeholders during project implementation. For the Dutch Assembly factory, the following touchpoints will be considered as part of the sales strategy and the first stage ('onboarding') of the customer journey:

Touchpoint	Onboarding and sales activity
1) Knowledge & awareness raising campaign	Local knowledge and awareness raising campaign to inform the local community about deep-renovations.
2) Informal info meetings (evening)	Creating collective awareness and an essential touchpoint in motivating a collective deep-renovation.
3) Industry events and demonstration projects: exhibitions,conferences, municipality meetings	Create awareness of Assembly Factory capabilities, reaching out to stakeholders, addressing industry and municipality concerns.
4) Professional networks and industry associations	To increase awareness, market presence and identify PUF's opportunities.
5) Energy Box	Providing an 'gift' box with do-it-yourself energy saving products; handing over the energy box to the "customers" - housing corporations and contractors delivering programmatic renovation, municipalities and district programmes commissioning clustered upgrades, and (indirectly) residents - provide an essential 'first contact' touchpoint.
6) Door-to-door campaigns, information letters	Organizing a door-to-door campaign to inform and activate single households to conduct a deep-renovation (including follow-up in time). Alternatively, information letters can be distributed with explanation of renovation benefits and references to the agenda of community meetings, and residence support channels.
7) Neighbourhood scan with thermal imaging	Offering of a thermal image annex heat scan. This is organised at a district level and directed by the local municipality with the aim to raise awareness. The follow-up consists of a home visit to discuss the findings and suggest deep-renovation interventions.
8) Energy coaches	Providing access to energy coaches, mostly local volunteers, who, on the basis of short training and often also own experiences, inform residents about the energy bill and low-tech do-it-yourself energy-saving measures.
9) 'Open house' visits	Organizing open house visits allowing "customers" to visit an already renovated and comparable dwelling.

	This involves sharing experiences by the occupants of the renovated dwelling.
10)Local pop-up store	Establishing a physical store, located in popular and regular spots (like a shopping mall), easily accessible and where people can ask their questions about energy efficiency. There are various mock-ups of deep-renovation interventions showcased.
11)Community mobilisation (in Dutch: opbouwwerk)	Key touchpoint oriented on getting people into action and getting them organised to make collectively choices to create a collective offering building upon the principles of standardized variety.
12) Purchasing campaigns	Offering multiple purchasing campaigns for various deep-renovation interventions. These campaigns are offered in close cooperation with local intermediaries (Woonwijzerwinkel), the municipality and (local) contractors.
13) Residence support channel	To support smooth onboarding into renovation programme a helpdesk, a digital communication platform or a dedicated contact person are recommended.

Value Capture

Value capture for the Assembly PUF is shaped by a combination of service revenues and cost savings that arise from reduced transport complexity, improved productivity, and lower rework. In Business Model Canvas terms, revenue streams are primarily assembly services billed per dwelling, per package, or per programme, potentially complemented by premiums for accelerated delivery, defined quality performance, or integrated package solutions. Cost structure includes facility set-up and operation, labour, energy, tooling and maintenance, inbound/outbound logistics, and quality management. Because the Assembly PUF is more asset- and workforce-intensive than a purely advisory model, its economic viability is sensitive to utilisation and programme continuity. Non-financial value capture includes measurable social value from local jobs and upskilling, reputational benefits for partners seen as accelerating renovation with less disruption, and sustainability benefits from reduced transport distances and controlled waste handling. In practice, the Assembly PUF captures value most reliably when it is attached to programmatic pipelines where repeatability and scale reduce volatility.

District PuF – Value Proposition

The District PUF is positioned as a regional backbone that supports multiple renovation projects within a geographic catchment area and creates value by stabilising flow, standardising processes, and coordinating the ecosystem of actors required to deliver renovation at scale. Its value proposition is less about a single assembly line and more about enabling consistent delivery across many projects by reducing transaction costs, aligning stakeholders, and institutionalising standard routines for logistics, quality, procurement, and increasingly circular flows such as reverse logistics and reuse. In Business Model Canvas terms, the primary customer segments include housing corporations running multi-year programmes, municipalities coordinating

neighbourhood approaches, contractors and installers participating in clustered delivery, and supply-chain partners that benefit from predictable demand and clearer specifications.

Value Creation

For the District PUF, value creation is anchored in system integration rather than only physical assembly. Key resources typically include a regional hub location (or a network of temporary hubs), digital planning and coordination tools, standard specifications and process playbooks, quality assurance routines, and a coordination team that can manage interfaces across contractors, suppliers, housing corporations, and municipalities. Key activities include pipeline aggregation and clustering, programme planning and sequencing, coordination of inbound/outbound logistics, quality governance across projects, standardisation of packages and documentation, and management of circular streams such as returns, sorting, and redistribution of reusable materials where applicable. Key partnerships are central because the district model only works as an ecosystem instrument: partners commonly include housing corporations as anchor clients, contractors and SME supply-chain participants, logistics providers, technology and data partners (e.g., BIM libraries, tracking systems), training institutions, and local authorities facilitating placement and permitting. The district model creates value by making renovation easier to execute repeatedly across projects; it reduces fragmentation by turning dispersed demand into organised programmes.

Capabilities: 'upskilling' to operate the local pop-up factory

A local pop-up factory can be considered as an ecosystem on its own as it brings together the capacity of local SME's, addresses unemployment of local construction workers. This requires supporting training and upskilling programs for involved craftsmen, designers, engineers, architects, and operational construction workers, etc, using outcomes and methods of the BUS and Construction Skills projects. All in all it is important to consider the required competences, skills and know-how of (future) employees. Complementary, the processing of information, data and systems; institutional and legal conditions, and financial, technical and material resources to instate and operate the local pop-up factory are key capabilities to take into consideration.

For the District factory the following human capital is envisioned: project leader, system integrator, energy consultant, project engineer, cost engineer, prefabrication employee (construction), construction assembly team member (e.g., carpenter, bricklayer), project engineer HVAC | DHW | RES, assembly team member HVAC | DHW | RES, communication officer annex Housing Consultant, local ambassador annex Account Manager.

Job descriptions for abovementioned team members are the following:

Job description: Project Leader

Tasks and responsibilities:

- Point of contact for both client and project team

- Organizing the engineering team, delegating tasks and responsibilities
- Organizing meetings and decision lists
- Managing project execution
- Organizing execution planning and process monitoring
- Organizing cost estimation and procurement according to Customer Requirements Specification (CRS)
- Organizing quality assurance according to the Validation and Verification (V&V) plan
- Organizing toolkit discussions
- Organizing execution documentation for the renovation dossier (EnerPHit certification and BENG reporting)
- Organizing final cost calculations
- Organizing and participating in project evaluations

Capabilities:

- > 5 years of experience in construction-related project management
- Experience with planning and project management, affinity with integrated construction processes and lean management
- Highly skilled in communication (project management and mediation)
- Certified Passive House professional or equivalent qualification (renovation expert), and/or
- Experience in this or a similar role in one or more successful (certified) EnerPHit renovation, Passive House, or WNR projects, and/or
- Certificate of participation in the Quality Assurance Course for Performance-based Renovations

Recommended training:

- Course on Energy-neutral Building and Renovation
- Course on Quality Assurance in Performance-based Renovations
- Course on Project Budgeting in Integral Construction
- Course on Chain Collaboration
- Course on Risk Management
- Course on Quality Management
- Course on Continuous Improvement
- Course on Communication in the Construction Process

Job description: System Integrator

Tasks and responsibilities:

- Partner selection
- Organizing and coordinating the research/design team, delegating tasks and responsibilities to experts (streamlining expert work related to CRS, V&V plan, feasibility analysis, including assessment, baseline measurement, renovation and MJOP/MJOB scenarios, and TCO analysis)
- Chairing and organizing meetings, decision lists
- Setting up a communication structure for sharing information (keeping it up to date and accessible)
- Developing a value proposition, including expectation management for involved stakeholders

- Drafting Customer Requirement Specifications (CRS): prioritizing customer needs and translating them into functional specifications with corresponding performance indicators
- Preparing the Verification and Validation (V&V) plan
- Organizing the renovation plan using morphological design sessions
- Estimating construction costs and performing TCO calculations for various renovation scenarios as part of the feasibility analysis
- Coordinating contact with the municipality and other relevant authorities, such as governments and grid operators, for support and approvals
- Developing an execution plan, including budgeting, scheduling, and process monitoring
- Designing the customer journey
- Establishing performance contracts/purchase agreements

Capabilities:

- > 5 years of experience in construction-related project management
- Experience with process management and/or lean management
- Experience in guiding homeowners' associations or other collective private clients
- • Basic knowledge of preparing long-term maintenance plans
- Highly skilled in communication (project management and mediation)
- Certified Passive House tradesperson, consultant, or designer, or equivalent qualification, and/or
- Experience in a similar role in the execution of one or more successful (certified) EnerPHit renovation, Passive House, or WNR projects
- Experience with integrated project budgeting from conceptual design to completion
- Knowledge of subsidies, regulations, etc.

Recommended training:

- Course on Energy-neutral Building and Renovation
- Course on Acquisition for Cost-neutral Renovation of Homeowners' Associations
- Course on Project Budgeting in Integral Construction
- Course on Feasibility Studies for Energy-efficient Renovation
- Course on Chain Collaboration
- Course on Risk Management
- Course on Quality Management
- Course on Continuous Improvement
- Course on Quality Assurance in Performance-based Renovations
- Course on Communication in the Construction Process

Job description: Energy Consultant

Tasks and responsibilities:

- Developing functional specifications for energy, comfort, and indoor climate, along with corresponding performance indicators in relation to the renovation project

- Assessing the current situation and conducting an energy design/calculation of energy performance for renovation scenarios using DesignPH/nZEB calculations
- Calculating heating and cooling demand and providing recommendations on technical installation requirements
- Providing input parameters for TCO calculations
- Supporting the technical development of the selected renovation design and aligning it with the energy (balance) calculation
- Providing documentation for EnerPHit certification, energy efficiency (in Dutch: BENG) calculations, and the renovation dossier

Capabilities:

- > 5 years of experience as an energy or installation consultant
- Knowledge of energy-related laws and regulations (to assess their implications), and/or
- Certified Passive House Designer, or
- Certified Passive House Tradesperson with demonstrable experience in designing (certified) Passive Houses
- > 2 years of demonstrable work experience with nZEB calculations and heat flow calculations
- Basic knowledge of TCO calculations.

Recommended training:

- Passive House Designer Course
- Course on Energy-neutral Renovation and Construction
- Course on Calculating with the nZEB Tool
- Course on Thermal Bridge Calculations
- Course on Energy Balance with DesignPH

Job description: Project Engineer

Tasks and responsibilities:

- Engineering and work preparation for deep-renovation renovation tasks based on the Customer Requirement Specification (CRS)
- Assisting with quality assurance
- Conduct project evaluations

Capabilities:

- (Vocational) education in work preparation, with experience in energy renovation projects
- Certified Passive House Tradesperson or an equivalent qualification, and/or
- Involvement in this or a similar role in the execution of one or more successful (certified) EnerPHit renovation, Passive House, or WNR projects, and/or
- Certificate of participation in the Quality Assurance Course for Performance-based Renovation

Recommended training:

- Course on Energy-neutral Building and Renovation
- Course on Quality Assurance in Performance-based Renovations
- Course on Chain Collaboration
- Course on Continuous Improvement

Job description: Cost Engineer

Tasks and responsibilities:

- Conduct cost estimations
- Conduct post-cost calculations
- Conduct project evaluations

Capabilities*:*

- (Vocational) education in cost estimation, with experience in energy renovation projects
- Proven experience with transparent project budgeting, element-based renovation cost estimation, and/or
- Certificate of participation in the Course on Integral Construction Project Budgeting.

Recommended training:

- Course on Integral Construction Project Budgeting

Job description: Prefabrication Employee (Construction)

Tasks and responsibilities:

- Participation in toolbox meeting(s)
- Working on the production line (window frames)
- Performing quality control

Capabilities:

- (Vocational) education in construction

Recommended training:

- Relevant (health & safety) toolbox meetings

Job description: Construction Assembly Team Member (Carpenter, Bricklayer)

Tasks and responsibilities:

- Participation in kick-off meeting(s)
- Performing quality control
- Specific tasks include:
    - Post-insulation ground floors
    - Post-insulation cavity walls
    - Post-insulation roof
    - Installing window frames and glazing
    - Preventing thermal bridges
    - Applying airtight sealing
- Ensuring:
    - Airtight construction
    - Preventing thermal leaks
    - Preventing condensation formation in structures
- Optimal performance within an integrated construction process (lean, customer-focused, efficient, and multidisciplinary collaboration according to schedule)
- Conduct project evaluations

Capabilities:

- (Vocational) education in construction, with experience in energy renovation projects
- Certified Passive House Tradesperson with a specialization in construction or an equivalent qualification, and/or
- Involvement in this or a similar role in the execution of one or more successful (certified) EnerPHit renovation, Passive House, or WNR projects, and/or
- Certificate of participation in the Quality Assurance Course for Performance-based Renovations (Part 2).

Recommended training:

- Course on Integral Construction Project Budgeting
- Course on Energy-neutral Building and Renovation
- Course on Quality Assurance in Performance-based Renovations.

Job description: Project Engineer HVAC | DHW | RES

Tasks and responsibilities:

- Engineering and work preparation for installation work in renovations based on the Customer Requirement Specification (CRS)
- (Project management) execution of installation technology
- Defining minimum requirements for maintenance measures and providing recommendations for the Multi-Year Maintenance Plan
- Organizing and participating in toolkit discussions
- Quality assurance of execution according to the Verification & Validation (V&V) plan
- Organizing commissioning
- Organizing customer service
- Conducting project evaluations

Capabilities:

- Participation in kick-off meetings
- Certified (Passive House) tradesperson in installation technology or an equivalent qualification, and/or
- Involvement in this or a similar role in the execution of one or more successful (certified) EnerPHit renovation, Passive House, or WNR projects, and/or
- Certificate of participation in the Quality Assurance Course for Performance-based Renovations (Parts 3+4)

Recommended training:

- Course on Energy-neutral Building and Renovation
- Course on Quality Assurance in Performance-based Renovations

Job description: Assembly Team Member HVAC | DHW | RES

Tasks and responsibilities:

- Participation in kick-off meeting(s)
- Performing quality control
- Assembly of installations (quiet, energy-efficient, airtight, maintenance-friendly):
    - Ventilation system
    - Tap water distribution system
    - Heating distribution system

    - Monitoring installation
    - Insulation of riser pipes and other penetrations in contact with cold outside air
- Optimal functioning within the integral construction process (lean, customer-oriented, efficient and multidisciplinary collaboration, planning)
- Aftercare, customer service for problems after delivery
- Conduct project evaluations

Capabilities:

- (Vocational) education in installation technology, experience with energy renovation projects
- Certified (passive house) installation technician or similar qualification, and/or
- Involvement in this or a similar role in the execution of one or more successful (certified) EnerPHit renovation, passive house, or WNR projects, and/or
- Participation certificate Course Quality Assurance in performance-oriented renovations (part 4)

Recommended training:

- Course Energy-neutral building and renovating
- Course Quality Assurance in performance-oriented renovations

Job description: Communication Officer annex Housing Consultant

Tasks and responsibilities:

- Supporting the project leader in researching resident preferences (developing surveys, attending meetings)
- Customer communication, point of contact
- Resident guidance (smooth process)
- Community building
- Project evaluation

Capabilities:

- Over 5 years of construction-related work experience in the renovation market
- Strong communication skills: socially competent, reliable, good listener, network
- Experience in sales and acquisition
- Detailed knowledge of the PuF model

Recommended training:

- Basic knowledge of the PuF model
- Course Energy-neutral building and renovating
- Course Acquisition of cost-neutral renovation for homeowners' associations
- Additional training in customer communication (Participation certificate Training Introductory meeting cost-neutral renovation)

Job description: Local Ambassador annex Account Manager

Tasks and responsibilities:

- Establishing contact with the municipality and neighborhood representatives
- Preparing and conducting introductory meetings

- Presenting the (PuF) District Factory model, explaining the renovation model in detail to the municipality and local stakeholders
- Providing neutral information about renovation to residents and conveying the main points of the renovation approach
- Gathering important data, understanding the current situation, the renovation history of the building, and conducting a rough assessment of the construction and technical state
- Estimating whether the neighborhood/district fits within the scope of PuF

Capabilities:

- Over 5 years of construction-related work experience in the renovation market
- Strong communication skills: socially competent, reliable, good listener, network
- Experience in sales and acquisition
- Detailed knowledge of the PuF model

Recommended training:

- Basic knowledge of the PuF model
- Course Energy-neutral building and renovating
- Course Acquisition of cost-neutral renovation for homeowners' associations
- Additional training in customer communication (Participation certificate Training Introductory meeting cost-neutral renovation)

Value delivery

Value delivery in the District PUF is primarily expressed through the coordination mechanisms that allow multiple projects to run more predictably. Channels include programme-level frameworks, procurement and contracting routes that allow repeated call-offs, shared logistics booking and scheduling processes, and standardised documentation channels for quality and compliance. Customer relationships tend to be long-term and programme-based, because the District PUF is designed to work across multiple project cycles rather than a single deployment. The district approach delivers value by improving reliability and transparency for clients and delivery partners: projects become easier to plan, suppliers face less variability, and contractors can participate in stable rhythms. It also supports resident-facing value delivery through better scheduling discipline, clearer communication routines, and improved aftercare processes, because coordination is structured at a programme level instead of reinvented project by project.

Touchpoints and market activation

To further develop the research, and in line with the suggestions of Broers et al. (2022), for the PuF a detailed customer journey needs to be developed specifically addressing the touchpoint with the residents requiring some level of action. For the Dutch District factory, the following touchpoints will be considered as part of the sales strategy and the first stage (‘onboarding’) of the customer journey:

Touchpoint	**Onboarding and sales activity**

14) Knowledge & awareness raising campaign	Local knowledge and awareness raising campaign to inform the local community about deep-renovations.
15) Informal info meetings (evening)	Creating collective awareness and an essential touchpoint in motivating a collective deep-renovation.
16) Energy breakfast	Idem, but morning sessions.
17) Energy Box	Providing an 'gift' box with do-it-yourself energy saving products; handing over the energy box to the residents provide an essential 'first contact' touchpoint.
18) Door-to-door campaigns	Organizing a door-to-door campaign to inform and activate single households to conduct a deep-renovation (including follow-up in time).
19) Neighbourhood scan with thermal imaging	Offering of a thermal image annex heat scan. This is organised at a district level and directed by the local municipality with the aim to raise awareness. The follow-up consists of a home visit to discuss the findings and suggest deep-renovation interventions.
20) Energy coaches	Providing access to energy coaches, mostly local volunteers, who, on the basis of short training and often also own experiences, inform residents about the energy bill and low-tech do-it-yourself energy-saving measures.
21) 'Open house' visits	Organizing open house visits allowing residents to visit an already renovated and comparable dwelling. This involves sharing experiences by the occupants of the renovated dwelling. This is also a key touchpoint to initiate touchpoint 1-3.
22) Local pop-up store	Establishing a physical store, located in popular and regular spots (like a shopping mall), easily accessible and where people can ask their questions about energy efficiency. There are various mock-ups of deep-renovation interventions showcased.
23) Community mobilisation (in Dutch: opbouwwerk)	Key touchpoint oriented on getting people into action and getting them organised to make collectively choices to create a collective offering building upon the principles of standardized variety.
24) Purchasing campaigns	Offering multiple purchasing campaigns for various deep-renovation interventions. These campaigns are offered in close cooperation with local intermediaries (Woonwijzerwinkel), the municipality and (local) contractors.

Value Capture

Value capture for the District PUF is typically based on facilitation and coordination value rather than direct production output. Revenue streams may consist of coordination fees embedded in programme frameworks, subscription-like participation models for access to shared tools and standards, service fees for planning/quality/logistics support, and potentially performance-based arrangements

linked to delivery reliability, reduced failure costs, or circularity outcomes. The cost structure includes coordination staff, digital infrastructure, governance and standardisation work, facility or hub costs where applicable, and ongoing quality management and data handling. Non-financial value capture is substantial in district models because the benefits often materialise as lower transaction costs for the ecosystem, reduced delivery risk, improved resident outcomes, and a stronger capacity to scale renovation in line with policy targets. The district approach captures value most effectively when it secures broad participation and is embedded in procurement routines so that it becomes the default way projects are initiated and delivered rather than an optional overlay.

Cost structure and revenue model

This section discusses the cost structure and revenue model associated with the deep-renovation offered by the Dutch local district factory. Our approach to collective neighbourhoods deep-renovations involve categorizing deep-renovation and home improvement interventions into three main groups:

A) Upgrades – Offers the greatest economies of scale.

B) Maintenance – Provides moderate economies of scale due to greater variation in work scope.

C) Other / Custom Requests – Limited economies of scale but benefits from reduced organizational costs.

Category A products and services supplied by the local district factory:

Module	Supply chain partner
Deep-renovation intervention	Energy efficiency consultant
Deep-renovation action plan	System integrator in close collaboration with all value chain partners
Window frames	OEM manufacturer
Floor insulation	Local insulation company
Cavity wall insulation	Local insulation company
Roof insulation	Local roofing company
HVAC system	Local HVAC installer

Category B products and services supplied by the local district factory:

Module
Renew rainwater drainage system
Clean masonry, repair masonry locally; renew masonry joints
Improve fire safety (compartmentalization)
Renew window sills
Renew balcony railings
Repair balcony floors
Install fall protection where necessary
Concrete repairs
Replace mailboxes and doorbell panels

Renovate common areas including painting
Renew paint (wood – steel)
Renew garage doors
Remove asbestos
Implement nature-inclusive measures

Category C products and services supplied by the local district factory:

Module
Renewal bathroom and toilet
Renewal kitchen

Homeowners who opt for a combination of **A, B, and C** benefit the most from economies of scale. However, the challenge lies in defining the **scope of category C**—finding the right balance between **standardization and variety** to maintain efficiency. The feasibility of scaling category C depends on **willingness to pay** and should be integrated into **pricing, customer, and sales strategies** to optimize cost efficiency while meeting demand.

Below the characteristics of the Category A distribution channel is enlisted. As the local district factory will be located in specific city neighbourhoods, we estimated the potential (maximum) number of deep-renovations based on housing type classification and capacity.

Characteristics Category A distribution channel:	
220	Working days/yearly
5	Working days/renovation:
	T1: 2-3 working days RES, DHW & HVAC
	T2: 2-3 working days openings
	T3: 1-2 working days insulation
40-45	Renovations yearly - single production line
6	Production lines
250	Renovations yearly with 6 production lines
	Dedicated teams consisting of :
	1 coordinator,
	12 reno specialists,
	6 operators (crane)
1650	Person working hours yearly
€ 60,00	Hour rate
€ 2M	Yearly labour cost PuF
€ 8.000,00	Labour cost per renovation (based on 250 renovations/yearly)

The direct cost of a category A deep-renovation is estimated below. Following the principles of a Housing Cost-Neutral Renovation (HCNR) [in Dutch: Woonlasten Neutrale Renovatie – WNR] and an average yearly energy bill of €2,400.- the return on investment of the direct renovation costs associated with category A is about 17 years. This is without:

- The start-up cost of the local district factory
- The overhead cost associated with the local district factory
- Asbestos removal costs (subsidies available)
- Structural – foundation – improvement costs
- Environmental costs, i.e. costs associated with measures that must be taken from an ecological perspective, such as relocating nesting opportunities for birds
- Other direct costs associated with category B or C

The renovation costs are billed to the client, who is also the building owner. The costs and affordability are strongly influenced by local market conditions, economies of scale, and external factors such as the availability of green loans and government subsidies.

Direct cost of deep-renovation		
Material cost:		
— **Building service module**	€	15.000,00
— **Openings module**	€	15.000,00
— **Insulation module**	€	2.000,00
Labour cost:	€	8.000,00
Reno cost/dwelling	€	40.000,00
> = cost that need to be retrieved via energy savings		
Exclusive:	Overhead costs	
	Start-up costs	
	Asbestos removal costs	
	Structural improvements costs	
	Environmental (ecology)costs	
	Home improvements costs	

1.1.1.2 PUF Comparison and recommendation

The Assembly PUF and the District PUF create, deliver, and capture value through different mechanisms. The Assembly PUF is an execution-focused model that generates value primarily through controlled, repeatable assembly routines, short on-site time, and predictable quality when there is sufficient programme volume to keep the facility utilised. It is therefore most appropriate when the renovation pipeline can be organised into stable, repeatable batches, such as a housing-corporation portfolio,

a district programme with consistent typologies, or a multi-year framework with clear sequencing. In this setting, the Assembly PUF can be justified as a dedicated production-like capability, because its key resources (facility, tooling, trained workforce) and its cost structure become economically and operationally viable only when throughput is reliable and downtime is limited.

The District PUF, by contrast, is a regional backbone model that generates value primarily through system integration across multiple projects and actors. It is most appropriate when the main constraint is fragmentation—many small projects, mixed ownership, diverse suppliers, and coordination burdens that slow down delivery—because the District PUF can institutionalise standard processes, planning routines, logistics coordination, and quality governance across a catchment area. In that setting, the District PUF is justified as a permanent or semi-permanent operational capability whose value comes from stabilising regional flow and reducing transaction costs, rather than from producing output through a single assembly line. While the District PUF can be less dependent on one specific programme, it is more dependent on governance design and sustained participation, because its viability rests on being embedded into procurement routines and being perceived as legitimate and neutral by multiple stakeholders.

The tables below (Table 10 and Table 11) show the assembly and district PUF respectively of the Dutch ecosystem summarized through the Business Model Canvas. The three areas depict the three types of value as seen in the business model canvas; value creation (value proposition, customer relationships, customer segments, channels), value delivery (key partners, key activities), and value capture (cost structures, revenue streams).

Table 54: Business Model Canvas summarizing the assembly PUF of the Dutch ecosystem.

<table>
<tr>
<td rowspan="2">Key partners

Key partners include component suppliers, logistics providers, installers, and local labour or training organisations. Housing corporations and programme owners are also important partners, as they provide the pipeline and scale required to ensure economic viability.</td>
<td>Key Activites

Core activities include production planning, inbound logistics coordination, assembly of prefabricated components, quality control, and continuous optimisation of workflows. These activities focus on establishing repeatable and standardised assembly processes that can be scaled across multiple dwellings.</td>
<td rowspan="2">Value Proposition

The Assembly PUF delivers value through faster and more predictable renovation by relocating assembly activities to a controlled, near-site environment. This results in higher quality, reduced on-site disruption, and improved efficiency. Its strength lies in executing repeatable renovation processes at scale, provided that projects can be clustered and sequenced effectively.</td>
<td>Customer Relationships

Customer relationships are highly operational and coordination-intensive. The Assembly PUF requires close alignment with contractors and clients regarding planning, sequencing, and performance expectations. Interactions are largely project- or programme-based, with strong emphasis on reliability, efficiency, and minimising impact on residents.</td>
<td rowspan="2">Customer segments

The Assembly PUF primarily serves housing corporations and contractors involved in programmatic renovation projects, as well as municipalities coordinating clustered upgrades. Residents form an important indirect segment, benefiting from reduced disruption and improved quality. The model is particularly suited to contexts with repeatable housing typologies and sufficient scale to enable standardisation.</td>
</tr>
<tr>
<td>Key Resources

The model depends on physical and operational resources such as assembly facilities, tooling, and a trained workforce. Digital tools, including BIM-based work instructions and quality documentation systems, are also critical in ensuring consistency and efficiency across projects.</td>
<td>Channels

The Assembly PUF operates through programme-based procurement channels such as framework agreements and district-level tenders. Operational delivery is organised through just-in-time logistics, scheduled transport, and coordinated handovers to construction sites.</td>
</tr>
<tr>
<td colspan="3">Cost Structure

The Assembly PUF has a relatively asset- and labour-intensive cost structure, including facility setup and operation, labour, energy, tooling, logistics, and quality management. Its financial viability is highly dependent on utilisation and stable project pipelines.</td>
<td colspan="3">Revenue Streams

Revenue is primarily generated through assembly services, typically priced per dwelling, per package, or within programme contracts. Additional value may be captured through premiums for speed, quality, or integrated solutions.</td>
</tr>
</table>

Table 55: Business Model Canvas summarizing the district PUF of the Dutch ecosystem.

<table>
<tr>
<td rowspan="2">Key partners

Key partners include housing corporations (as anchor clients), municipalities, contractors, logistics providers, SMEs, and technology and data partners. Training institutions and local authorities also play an important role in supporting workforce development and implementation.</td>
<td>Key Activites

Key activities include pipeline aggregation, programme planning and sequencing, logistics coordination, quality assurance, and the standardisation of processes and documentation. In addition, the District PUF can manage circular flows such as reverse logistics and material reuse.</td>
<td rowspan="2">Value Proposition

The District PUF delivers value as a regional coordination and system integration mechanism. It aggregates demand, aligns stakeholders, and stabilises renovation flows across multiple projects. By reducing fragmentation and enabling standardisation, it supports large-scale renovation and improves efficiency at the system level rather than at the level of individual projects.</td>
<td>Customer Relationships

Customer relationships are long-term and programme-based, focusing on sustained collaboration between housing corporations, municipalities, and delivery partners. The model relies on structured communication, governance arrangements, and ongoing coordination to ensure alignment across multiple projects and actors.</td>
<td rowspan="2">Customer segments

The District PUF targets housing corporations as primary clients, alongside municipalities coordinating neighbourhood-level renovation programmes. Contractors, installers, and supply chain partners also act as key user groups. Compared to the Assembly PUF, the District PUF serves a broader ecosystem of stakeholders involved in multi-project and regional renovation processes.</td>
</tr>
<tr>
<td>Key Resources

The District PUF relies primarily on organisational and coordination resources, including regional hubs, digital platforms, process standards, quality assurance systems, and dedicated coordination teams. These resources enable the orchestration of multiple projects and stakeholders.</td>
<td>Channels

Channels are primarily programme-based and coordination-oriented, including framework agreements, procurement systems, and shared logistics and planning platforms. Standardised documentation and communication structures are used to coordinate activities across multiple projects and stakeholders.</td>
</tr>
<tr>
<td colspan="3">Cost Structure

The cost structure is primarily organisational, including coordination staff, digital infrastructure, governance, and (where applicable) facility or hub-related costs. The model depends on sustained regional activity and stakeholder participation rather than individual project throughput.</td>
<td colspan="3">Revenue Streams

Revenue is generated through coordination-based models, including programme management fees, service fees for logistics and planning, and potentially subscription-like models for access to shared infrastructure and services. Performance-based contracts linked to delivery outcomes may also be applied.</td>
</tr>
</table>

SWOT analysis: Strategic orientation for the introduction of the local pop-up factory

Albert Humphrey developed SWOT analysis in the 1960s as a framework for corporate planning that analyzes a firm's internal strengths, weaknesses, opportunities, and threats. It is a strategic planning tool that identifies and assesses a project or organization's internal strengths and weaknesses, as well as external opportunities and threats. It is used to gain a better understanding of a company's market position and to develop strategies by leveraging strengths, mitigating weaknesses, exploiting opportunities, and guarding against threats. In this section, a SWOT analysis of the pop-up factory (PUF) project is conducted.

SWOT on District PUF

Strengths

DS1. Strong alignment with the Netherlands as a logistics and coordination hub.

A District PUF leverages national infrastructure to coordinate multiple projects within a region, stabilising flow across suppliers, contractors, and sites.

DS2. High ecosystem value as a system integrator across multiple projects and actors. Unlike a single-project facility, a District PUF supports multiple programmes and creates common routines for procurement, planning, QA, and logistics across stakeholders.

DS3. Better potential for continuous utilisation through portfolio aggregation. Because it serves several projects, it can buffer project-to-project variability more effectively than an assembly set-up tied to one programme.

DS4. Strong platform for digital standardisation and technology integration. District hubs can institutionalise BIM object libraries, QA protocols, booking systems, and tracking across multiple contractors and suppliers.

DS5. Circularity enablement through reverse logistics and material hubs. A District PUF is well positioned to function as a local collection, sorting, refurbishment, and redistribution point for reusable materials, supporting circular renovation at scale.

DS6. Social value and skills development at regional level. A semi-permanent hub can sustain training programmes, local employment pathways, and partnerships with education providers more easily than short-lived project pop-ups.

Weaknesses

DW1. Higher organisational complexity and governance requirements. District PUFs must coordinate multiple actors, contracts, and pipelines; this increases transaction costs unless governance is well designed.

DW2. Dependence on regional throughput rather than single-project demand. While more resilient than a project-only model, a District hub still needs a stable regional flow; if programmes are not aggregated, the hub risks underutilisation.

DW3. Greater exposure to site/location constraints. A district facility requires suitable space, access, permits, and community acceptance, which may be challenging in dense urban areas.

DW4. Potential bureaucracy if ownership is collective or association-led. Multi-actor ownership can slow decisions on prioritisation, investment, and allocation of capacity unless operational authority is delegated.

DW5. Interface complexity with supply chains. Managing inbound/outbound logistics across many projects increases the need for robust planning, data exchange, and standardisation; without it, variability can create inefficiencies.

Opportunities

DO1. Regional renovation acceleration programmes linked to EPBD-driven targets. A District PUF can support municipality and housing-association programmes by acting as a shared backbone for planning, logistics, and QA.

DO2. Cross-project standardisation and procurement frameworks. The District PUF can institutionalise framework contracts, standard packages, and supply partnerships to reduce lead times and variability.

DO3. Circular hubs and urban mining infrastructure. District hubs can become focal points for material reuse ecosystems, enabling measurable circularity outcomes and reducing waste.

DO4. Integration with broader energy transition initiatives (heat networks, insulation campaigns). The District PUF can coordinate renovation activities with installation partners and utilities to increase delivery coherence.

DO5. Replication across provinces once proven. A District model that works in Limburg can be copied to other regions with similar housing typologies and policy pressures.

Threats

DT1. High energy and operating costs for semi-permanent hubs. Running a district-level facility can become expensive, especially with energy-intensive processes or heating requirements.

DT2. Local permitting and zoning challenges. District hubs may face longer and more complex approvals than short-term project setups, particularly if the facility includes storage, handling, or processing of materials.

DT3. Supply chain vulnerabilities and material shortages. As an integrator, a district hub may become a “single point of coordination,” meaning upstream disruptions can cascade across multiple projects.

DT4. Market pushback from incumbents or fragmentation dynamics. If contractors or suppliers view the district hub as shifting bargaining power or standardising too aggressively, participation may weaken.

DT5. Economic downturns that reduce renovation budgets across multiple clients simultaneously. A district hub is exposed to correlated demand drops if multiple programmes pause at once.

1.1.1.3 SWOT on Assembly PUF

Strengths

AS1. Controlled assembly environment improving quality and reducing disruption. Assembly activities move from a weather-dependent building site into a controlled setting, improving consistency and reducing rework compared with purely on-site assembly.

AS2. Strong fit with the Dutch logistics baseline for inbound components and outbound "just-in-time" delivery. The Netherlands' dense infrastructure enables predictable inbound flows of prefabricated elements and rapid delivery to nearby sites, which supports takt-based sequencing.

AS3. Flexibility and relocatability for project- or portfolio-specific programmes. Assembly PUFs can be deployed close to a cluster of renovation sites and moved once the programme is completed, avoiding long-term fixed-factory lock-in.

AS4. Good potential for rapid learning curves and standard work routines. Assembly lines benefit from repetition across similar typologies (e.g., terraced housing, apartment blocks), enabling process optimisation and stable quality routines.

AS5. Sustainability gains through reduced heavy transport of large modules and improved waste handling. Compared with transporting fully volumetric units over longer distances, assembling from delivered subcomponents can reduce logistics constraints and facilitate controlled material management.

AS6. Workforce development potential via training for assembly-specific roles. Assembly work can be structured into repeatable tasks, enabling faster onboarding and targeted upskilling in a labour-scarce market.

Weaknesses

AW1. High dependence on local demand volume and sequencing discipline. The Assembly PUF becomes inefficient if the pipeline is fragmented, the order book is unstable, or projects are not clustered sufficiently to sustain utilisation.

AW2. High operating costs sensitivity (energy, labour, and temporary facility costs). Even when "temporary," an assembly set-up still carries energy and staffing costs; high Dutch energy prices can erode the economic advantage.

AW3. Need for adaptable and reliable inbound supply chains. Assembly relies on timely delivery of components; delays or variability in prefabricated input supply directly disrupt output rhythm and on-site delivery commitments.

AW4. Perception risk: "temporary facility equals lower quality." Even with quality systems, clients and residents may initially associate temporary or pop-up facilities with reduced reliability, requiring strong QA transparency.

AW5. Skill gaps in industrialised assembly methods. Traditional trades do not automatically map to industrial assembly routines; training and supervision load can be substantial early on.

AW6. Customisation constraints when standardisation is required for efficiency. Assembly PUF performance depends on repeatability; atypical designs and one-off solutions reduce the advantages and increase coordination overhead.

Opportunities

AO1. Programmatic renovation and retrofit in social housing portfolios. Housing associations' portfolio approach aligns with repeatability and clustering, creating conditions for stable Assembly PUF throughput.

AO2. Digitalisation (BIM, digital QA, digital work instructions). Dutch BIM adoption supports standard packages, better tolerances, and smoother handovers between design, prefabrication, assembly, and site.

AO3. Circular renovation via controlled disassembly and material sorting. An assembly setting enables structured reuse streams (windows, insulation materials, façade elements) when linked to reverse logistics.

AO4. Partnerships with suppliers and installers to standardise "kit-of-parts" solutions. Assemblers can work with manufacturers and MEP partners to predefine packages suited to common Dutch typologies.

AO5. Urban regeneration and neighbourhood-scale renovation where disruption must be minimised. Assembly allows faster on-site installation windows (shorter time in the dwelling), improving resident experience.

Threats

AT1. Persistent inflation and high energy costs. These increase assembly operating costs and can reduce clients' willingness to commit to programmes.

AT2. Regulatory and permitting frictions for temporary facilities. Local approvals and compliance burdens may slow deployment, undermining the speed advantage.

AT3. Supply chain disruptions (materials and prefabricated inputs). Assembly is exposed to upstream manufacturing bottlenecks and cross-border disruptions.

AT4. Competition from established prefab and traditional renovation delivery chains. Large incumbents may respond through pricing, capacity scaling, or integrated offers that reduce differentiation.

AT5. Economic volatility affecting renovation investment decisions. If households or landlords delay upgrades, the clustered pipeline required for utilisation becomes harder to secure.

Comparison and conclusion

The most important difference between the two concepts is that the Assembly PUF is primarily a delivery and throughput instrument that creates value through a controlled, repeatable assembly environment close to renovation sites, which improves quality and speed when projects can be clustered into stable batches, whereas the District PUF is primarily an ecosystem and scaling instrument that creates value by providing a regional backbone for coordinating multiple projects and actors through logistics, standardisation, quality routines, and increasingly circular flows such as reverse logistics and reuse; as a result, the Assembly PUF is most sensitive to utilisation and sequencing discipline (with key risks around idle capacity, inbound component reliability, and the need for specialised assembly skills), while the District PUF is most sensitive to governance and coordination capacity (with key risks around multi-actor decision-making, site and permitting constraints for a semi-permanent hub, and the challenge of converting convening power into sustained regional throughput).

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Austrian Ecosystem Report

This Annex presents the analysis of the Dutch ecosystem with regard to the market potential and feasibility of Pop-up Factory (PuF) concepts, with the aim of informing the development of implementation plans, scenarios, and supporting activities. The methodological framework adopted for this assessment is described in detail in Deliverable D4.1 of Work Package 4. The findings presented in this Annex are subsequently compared and discussed alongside the results from the other national ecosystems in the main report, contributing to a broader cross-ecosystem evaluation of the opportunities and challenges associated with the deployment of PuF models.

Addressing ecosystem needs: Offering a deep-renovation kit by a local pop-up factory scenario

Various theories and concepts have been developed to boost the efficiency of deep retrofits. One of the key challenges is to turn these theories and concepts into real-world implementations being adopted beyond demonstration. In this chapter the preferred local pop-up factory scenarios are being presented for each Ecosystem.

The Austrian Ecosystem needs

In the Austrian ecosystem, PuF activities concentrated on the reuse of construction materials which is an important topic because the annual renovation rate in Austria is targeted to be increased from currently around 1% to 2 or 3% of the housing stock. In Vienna alone, around 400 demolition projects are estimated.

Reuse of construction materials is important during renovation because renovation creates large material flows at exactly the moment when valuable components can still be identified, removed carefully, and kept in use. In the Austrian ecosystem, a PuF scenario was developed that makes use of these materials by implementing the concept of the ‘Re-Use Box’ which is integrated in the broader concept of social urban mining.

The PuF can be applied not only to renovation projects but also to all demolition projects. Social urban mining is a circular construction approach that views existing buildings as sources of valuable materials, components, and products, and combines their recovery with social value creation, for example through training and employment in dismantling, sorting, and reuse activities. Rather than treating a building at the end of a renovation or demolition process mainly as waste, it starts with identifying reusable elements early, carrying out selective deconstruction, separating materials carefully, and creating pathways for reuse and high-value recycling.

The local pilots of the Austrian Ecosystem

The Re-Use Box, as part of the concept Social Urban Mining, is realised by the cooperative BauKarussell. The cooperative was co-founded by the authors of AIE. The concept Social Urban Mining rewrites the phase of renovation and /or deconstruction.

The change of the existing value chain comes along with new processes, interfaces and responsibilities. In order to convince building owners and their representatives to realize Social Urban Mining, it is necessary to define clear new processes and tasks. The pilots and activities in the frame of BuildUPspeed therefore developed a core element of the PuF concept “Re-Use Box”: A screenbook, which functions as a structured planning and checklist tool to guide reuse activities before, during, and after deconstruction **(see attachment).** The screenbook supports early coordination with real estate developers, clarifies negotiation points, identifies technical and logistical constraints (such as lack of electricity or reliance on elevators), and enables post-activity documentation and evaluation. This planning framework is applied iteratively across all pilots and is considered a key outcome of the ecosystem’s work.

Within the BuildUpSpeed project, AIE has delivered 20 Social Urban Mining concepts. The negotiations with the clients led to four implemented projects. The screenbook was developed and refined within the following four operational “Re-Use Boxes”:

- Military barrack in Villach (Carinthia)
- Former training center Vienna
- Office Building in Loosdorf (Lower Austria)
- Renovation of an Education Academy in Graz (Styria)

Military barrack in Villach (Carinthia)

Client: Federal Ministry of Defence (Austria)
Project period: Nov 2023 – Mar 2024
Partners: Schindel+Holz, forschen planen bauen Romm ZT
Impact: 109 tonnes (1,088 units) put to re-use

Overview
The Austrian Armed Forces commissioned BauKarussell to carry out the circular deconstruction of defined objects of the Hensel Barracks in Villach. In cooperation with Schindel & Holz, ten buildings were prepared for demolition, with a strong focus on maximizing the re-use of materials. A considerable re-use potential was identified, and the cataloguing, sale and redistribution of building components, fittings and furniture were implemented. As a result 60% of the processed mass was channelled into re-use, including vehicle shelters, equipment, fittings and furniture.

As part of the project, a Re-Use Box event was organized, during which the building complex was opened to the public for two days. The target groups included regional businesses, associations and farmers. The aim of the event was to bundle planned inspections and dismantling activities and to foster direct exchange with regional stakeholders and potential recipients.

In line with the five identified core areas for organizing a Re-Use Box, the following **activities** were implemented within this project:

1. Coordination with Client & Administration

The Re-Use Box was scheduled for two days following the completion of the project. The objective of PuF (opening the building to regional businesses) was coordinated and agreed with the client.

2. Target Group & Communication

Communication about the event was carried out via multiple channels. Flyers were distributed in the region, and information and invitations were shared through specific emailings and the BauKarussell Re-Use newsletter. In addition, the Re-Use Box was continuously promoted, also bilateral, during ongoing re-use sales.

3. Building Components

The sale of available building components had already started in advance of the event, meaning that some elements were already reserved or sold. During the Re-Use Box, participants were able to inspect the remaining inventory, purchase items on site, and carry out dismantling and removal.

4. Logistics & Infrastructure

To enable the on-site implementation of the concept, a central entrance, designated parking areas and a sales desk were jointly defined and set up. An overview map was created to support orientation across the extensive site and the large number of items available.

5. Safety

In coordination with site supervision, specific areas were closed off and secured in advance. Inspections and dismantling activities were only permitted when accompanied. A total of at least five supervisors were present on site over the two days. All visitors were required to register upon entering the construction site and to read an information leaflet.

Learnings

Bundling dismantling and collection activities by third parties proved to be good practice. At the same time, the on-site presence and increased visitor numbers during the Re-Use Box enabled additional re-use products to be sold.



Figure 88: Mapping of the premises. © BauKarussell



Figure 89: Removal of an entrance gate. © BauKarussell



Figure 90: Markus (AIE) with partners from the local social enterprise ARGE Soziales Villach. © BauKarussell



Figure 91: Entrance area with the welcome desk at the former military barrack © BauKarussell

Former training center (Vienna)

Client: Chamber of Labour and Employees for Vienna (Arbeiterkammer Wien)
Project period: Jan 2025 – Jul 2025
Partners: Die KÜMMEREI (Job-TransFair), Volkshilfe Wien, Start Working, Burgenländisches Schulungszentrum, materialnomaden, forschen planen bauen Romm ZT
Impact: 14.5 tonnes (2,200 units) put to re-use

Overview
From January to July 2025, BauKarussell was active on behalf of the Chamber of Labour for Vienna at the Technical and Commercial Evening School (Technisch-Gewerbliche Abendschule, TGA) located at Plößlgasse 13, 1040 Vienna. The aim was to retain as many resources as possible within material cycles and to prepare the building for mechanical demolition. At the end of the project, a Re-Use Box, with materials from the building itself, was set up and operated by social economy organisations, with Start Working responsible for the setup and Volkshilfe Wien and Start Working jointly managing operations. The testing of electrical appliances was carried out by the Burgenländisches Schulungszentrum (BUZ).

The Re-Use Box implemented as part of this project was designed as a one-week event with daily opening hours, with a strong focus on awareness-raising. The format included an exhibition of building components recovered from the site, workshops and guided tours, and was aimed at a broad public audience. The objective was to make re-use and urban mining visible as relevant topics in an urban context and to reach diverse target groups through low-threshold access.

Activities
1. Coordination with Client & Administration

The PuF was conceived as an awareness-raising event, incorporating workshops, an exhibition and guided tours. At the same time, it was possible to inspect, dismantle and purchase movable assets directly on site. For the first time, both the setup and the ongoing operation of the Re-Use Box were carried out by socio-economic partners. These partners were responsible for exhibition setup, supervision, sales, transport services and the testing of electrical appliances.

2. Target Group & Communication

In line with the awareness-raising objective, a broad target group was addressed, including architects and planners, employees of the Chamber of Labour, students and local residents. Communication was conducted exclusively via BauKarussell channels. Flyers and posters were distributed, social media events were created, and a newsletter was issued. All promotional materials were designed by BauKarussell in coordination with the client. A professional photographer documented the event to support follow-up communication.

3. Building Components

All available building components were catalogued in advance, and re-use sales were already well underway. The current component catalogue was available in print, and the exhibition showcased re-use components recovered directly from the building.

4. Logistics & Infrastructure

All movable assets were collected in a storage room with ground-floor access to ensure easy collection. Sold components were clearly marked and temporarily stored in a designated area within the storage space.

5. Safety

The safety concept was developed in close coordination with all involved parties. Specific areas were cordoned off for visitors, and supervisory staff were deployed. Access to the site was managed centrally via the main entrance, and all visitors received a safety briefing upon entry.

Learnings

The key learning from this Re-Use Box was the importance of a clearly defined objective agreed jointly with the client. In this case, the focus was placed on awareness-raising and public outreach rather than on maximising re-use quantities. This clear orientation proved essential for project planning, communication and the evaluation of overall project success.



Figure 92: Guided tours through the building. © Joanna Pianka



Figure 93: An exhibition showcasing the potential of the urban mine. © Joanna Pianka


Figure 94: Please do touch! An interactive exhibition. © Joanna Pianka



Figure 95: The entrance area of the Re-Use Box at the former training center in Vienna © Meissner

Commercial Site in Loosdorf (Lower Austria)

Client: SPAR AG
Project period: Dec 2025 – Mar 2026
Partners: Emmausgemeinschaft St. Pölten, Gemeinnützige Sanierungs- und Beschäftigungs GmbH (GESA), forschen planen bauen Romm ZT
Impact: 26.1 tonnes (2,900 units) put to re-use

Overview
From December 2025 to March 2026, BauKarussell was commissioned by SPAR AG to plan and implement a Social Urban Mining project at Wiener Straße 24 in Loosdorf. The site, comprising office spaces, storage areas and workshops, had been adapted several times over the years to meet the evolving needs of previous owners. For the newly acquired property, SPAR decided not to pursue a conventional demolition approach. Instead, the company utilised the preparatory hazardous and interfering material removal in accordance with ÖNORM B 3151 as an opportunity to simultaneously carry out the selective, non-destructive dismantling of reusable building components through Social Urban Mining.

The Re-Use Box was designed as a one-day event and was specifically aimed at the local population, neighbouring residents and other interested parties from the surrounding region. The objective was to bundle site visits, provide information about the construction project and enable low-threshold access to the initiative.

Activities
1. Coordination with Client & Administration

The event date and all communication activities were coordinated with the client. The socio-economic partners were primarily involved in the preparation and safeguarding of the building.

2. Target Group & Communication

The client announced the Re-Use Box via a press release and local posters. The primary target group consisted of nearby residents. In addition, former employees of

the site became aware of the project through the event and took the opportunity to revisit their former workplaces.

3. Building Components

For the documentation of available components, a central merchandise management system was used for the first time. This enabled the parallel implementation of two projects (see subsequent project). Furthermore, the presentation format—similar to that of an online shop—increased interest and supported wider dissemination of the project.

4. Logistics & Infrastructure

Access was organised via the courtyard to the warehouse hall, where all movable assets and door leaves were collected during the dismantling phase. Reception and registration were also set up in this area. Guided inspections of the remaining building areas were possible when accompanied.

5. Safety

To ensure safety, visitors were received via the workshop hall. Two supervisors were present on site, and no other dismantling works were carried out in parallel. Potential trip hazards were secured in advance, and the building was disconnected from the power supply.

Learnings

Although this Re-Use Box was implemented at very short notice, it achieved a strong impact due to the support of the building owner, particularly with regard to promotion and communication. In addition to re-use sales, the PuF informed and raised awareness among local residents about the construction project. Furthermore, the introduction of digital infrastructure for re-use management proved essential, as it was the only way to successfully manage two projects in parallel.



Figure 96: Mayor Thomas Vasku, Sonja Zumpfe (BauKarussell), Christina Gsenger (SPAR Construction Project Manager), and Alois Huber (SPAR Managing Director). © SPAR



Figure 97: The warehouse hall with all the inventory. © BauKarussell



Figure 98: Re-Use Box entry with SPAR-branded advertisement for the PuF. © BauKarussell

Renovation of an Education Academy in Graz (Styria)

Client: Chamber of Labour and Employees for Styria (Arbeiterkammer Steiermark)
Project period: Nov 2025 – Apr 2026
Partners: Employment project of bfi Bildungszentrum Graz-Süd, Burgenländisches Schulungszentrum, forschen planen bauen Romm ZT
Impact: Project ongoing at the time of reporting; as of 12 March 2026, approximately 20 tonnes and 800 units had been put to re-use.

Overview
The Education Academy of the Chamber of Labour for Styria, located in the Stiftingtal area of Graz, is undergoing extensive renovation from January 2026 onwards. The objective is to keep as much of the high-quality and well-maintained interior fit-out as possible within material cycles and to enable its re-use. BauKarussell is responsible

for re-use brokerage and, in cooperation with bfi Graz-Süd, is carrying out key dismantling and decontamination works in accordance with ÖNORM B 3151.
Within this project, the Re-Use Box was implemented over a period of several weeks. Once per week, interested parties were able to visit the building and inspect available components by prior appointment. At the end of March, third-party dismantling activities were bundled over a two-week period. The objective was to achieve the greatest possible impact over the full duration of the project while ensuring a safe and well-regulated process.

Activities

1. Coordination with Client & Administration

Inspections, collections and general access for third parties were permitted exclusively by appointment. The building was opened once per week over a six-week period, followed by a two-week dismantling window for third parties.

2. Target Group & Communication

Using the newly available digital infrastructure, the project was communicated via Re-Use News and cooperative members. In addition, the opportunity spread widely among employees of the Chamber of Labour over the course of the project. No printed materials or dedicated promotional tools were used.

3. Building Components

For the systematic cataloguing of building components and inventory, the digital tool BauKrecord was deployed. This resulted in a component catalogue comprising more than 400 different products. Prior to public sale, the client reserved selected components for internal re-use.
The documentation and tracking of all re-use materials—both for re-deployment within the client's own stock and for sale to third parties—were centrally managed by BauKarussell.

4. Logistics & Infrastructure

Thanks to the digital inventory management system, a wide variety of re-use products could be effectively managed within a highly complex and segmented building layout. Dismantling activities by third parties were bundled and scheduled for the end of March following full disconnection of the power supply. The Re-Use Box at the Otto Möbes Academy operated entirely cash-free, enabled by a mobile card terminal and the digital inventory system.

5. Safety

Access for inspections of building components was only permitted following prior registration. This was partly due to the extended duration of the Re-Use Box and the limited on-site supervision capacity of one to two supervisors per opening day. All visitors received a safety briefing upon entry. Third-party dismantling was carried out in a bundled manner and only after complete power disconnection. Following dismantling works, certain areas—such as balconies, shafts and light wells—were secured by the socio-economic partner.

Learning

This project demonstrated that a Re-Use Box can also be successfully implemented in an unbundled format over an extended period of several weeks. In combination with high-quality and well-structured cataloguing, this significantly improves the communication of re-use potential. This approach not only facilitates documentation but also enhances the scalability of the re-use model and increases the likelihood of subsequent re-use of building components.

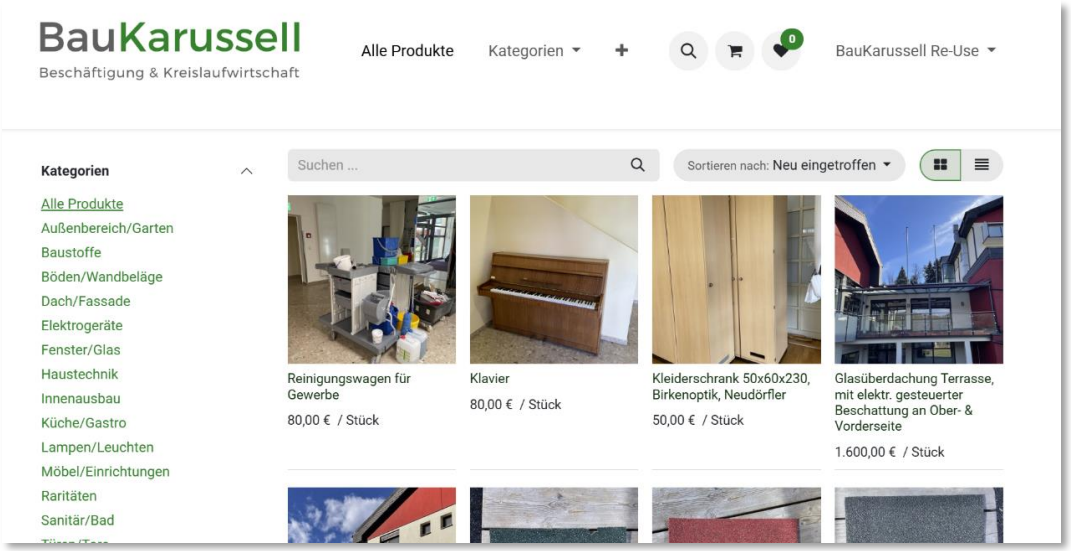


Figure 99: The digital inventory management and re-use catalogue.



Figure 100: Removal of windows for re-use as part of the Re-Use Box. © BauKarussell



Figure 101: Logistics of flag poles. © BauKarussell



Figure 102: Planning meeting regarding the operation of the Re-Use Box as part of Social Urban Mining at the education academy in Graz © AIE/Baukarussell

1.1.1.4 Multiple value creation: Matching local pop-up factory scenario with local needs

This paragraph provides a discussion on the type(s) of pop-up factory scenario which best suits each Ecosystem, including, when possible, insights obtained through the modifications and optimizations made while developing it and testing it.

Local pop-up factory scenario: Assembly factory

Within the BuildUPspeed PuF typology, the Austrian ecosystem primarily adopts an Assembly Factory concept, referred to as the “Re-Use Box,” to support the organization and execution of reuse-oriented deconstruction and redistribution activities. Rather

than relying on a single fixed installation, the Austrian ecosystem implements reuse through locally organized “Re-Use boxes” and operational dismantling activities that are adapted to each building context.
A “Re-Use Box” assembles components in a specific interpretation of the term “assembling”: The “assembling” is the dismantling of potential re-useable building parts and products without causing damage on site. The building itself is the source of the products. The “Re-Use Box activates this urban mine. The Re-Use Box requires temporary infrastructure. The pilot actions show that an optimal duration for planning and performing is between three to six months. In principle, there is no limitation for the kind of products. All building parts of the dismantled building can show a re-use potential. This depends on contaminations/hazardous substances, state of quality, number, interconnections, warranty issues, logistic issues and economic issues.

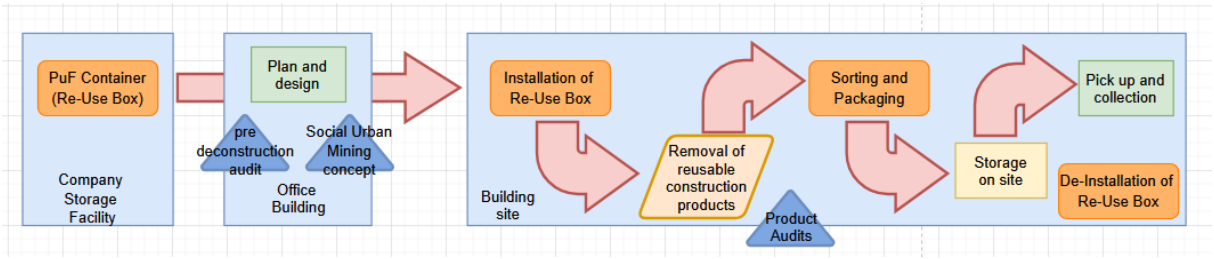


Figure 103: The Assembly Factory “Re-Use Box”

Figure 16 illustrates the Assembly Factory concept “Re-Use Box.” It reflects the idea, that the deconstruction site itself functions as an operational and organizational place for reuse activities. In the building itself, a deconstruction office serves as a central contact point for reuse-related activities and stakeholder coordination. The need for infrastructure is minimal and temporal.

In the first phase of a Re-Use Box the specific deconstruction site is analysed to evaluate what materials have potential for re-use. The respective documents are two preparatory audits: a pre-deconstruction audit and a Social Urban Mining concept. Both define the scope of reuse and deconstruction works as well as a framework to embed the mining/assembling of reuse products. Limitations occur due to hazardous substances in products, the state of materials and components, warranty issues, the potential for deconstruction and the acceptance of reused components. These preparatory steps determine the type and quantity of reusable products and allow estimation of the required production time. Once the operational agreement is concluded with the building owner, responsibility for the entire building is transferred to the Re-Use Box operator. The whole building is used as the operational assembly zone. Reusable products are typically distributed throughout the building rather than concentrated in a single fixed assembly area. Once a buyer has been found for a reuse product, it is dismantled, packed and, if necessary, temporarily stored directly on the premises. The operational setup includes amongst others one controlled entry point. From a legal point of view, a box is a construction site, including all specific rules governing access to it.

External Business Environment of the local pop-up factory

In a first step the external business environment of the pre-selected local pop-up factory will be defined in detail. Different fields of external factors which influence the

operation of the pop-up factory are considered, such as the market demand and existing alternatives, the customers and competitors as well as influence of environmental, economic, technological, socio-cultural and political trends.

Market demand analysis

The Re-Use Box and the concept of Social Urban Mining change the steps of planning and execution of building demolition and renovation. This value chain has been well-established for decades. The stakeholders involved are familiar with their roles, and the interfaces between them are well understood. Standardized, widely recognized tools and software exist for the planning, tendering and execution of demolition works. Based on years of experience, the view is that risks and opportunities are known and can be assessed. At the same time, the current implementation does not meet circular-economy standards. The circular economy as a requirement is only now finding its way into this value chain. Consequently, this means Stakeholders must break away from the well-trodden paths which brings uncertainties, but also opportunities. The integration demands a change to existing processes.
AIE promotes and develops the Re-Use Box and Social Urban Mining as one concept to integrate circular economy requirements into that value chain. One of the key tasks for those driving these changes is therefore to ensure that these changes are compatible with existing systems. To encourage building owners to cooperate, their concerns must be addressed with potential solutions. The project BuildUPspeed enabled to address these risks by supporting the formulation and standardization of the measure “Re-Use Box”.
AIE, the cooperative BauKarussell, currently completes between two and four Re-Use Boxes a year. Given the thousands of demolition and renovation projects under way in Austria, the potential market appears virtually ‘endless’. In Vienna alone, there are an estimated 400 projects a year.
The cooperative BauKarussell aims to grow slowly and steadily. The expertise in implementation is growing within the organization. Growth in terms of more Re-Use Boxes requires new staff, whom the cooperative must train. No curricula teach this specific knowledge.

Customer analysis

At strategic level the integration of circular economy in the building sector is of high concern. Austria’s Circular Economy Strategy and Federal Waste Prevention Programme includes specific sections dedicated to the construction sector. In terms of environmental legislation, reducing resource consumption is a high priority. With the Recycling materials ordinance and the mandatory standard ON B 3151, a legal framework already exists in Austria to comprehensively analyze the building stock as part of the planning process. Re-Use is already mentioned in these documents. The PuF “Re-Use Box” uses this framework to start negotiations with building owners.
Efforts by the construction sector to increase the renovation rate are primarily aimed at reducing energy consumption.
The industry is currently undergoing a period of upheaval, as changes in material flow management resulting from the landfill bans on gypsum and artificial mineral fibres are already leading to changes in how operations are carried out.

In summary, stakeholders in the demolition and renovation sector are facing far-reaching changes. The "Re-Use" Box is, in the broad context of deconstruction/renovation, a service that can and will help shape this change.

Competitor analysis

A number of startups and organisations are dedicated to brokering building components (e.g. materialnomaden, concular, madaster, aurena, historischeFliesen). Still the Re-Use Box is unique in this regard. Within the Re-Use Box, the cooperative temporarily assumes ownership. Brokers do not, the building owner acts as the seller, assuming the associated warranty obligations. The Re-Use Box identifies value within the building and seeks to realize it. Sales are credited to the building owner as part of Social Urban Mining. The "Mine Building" thus generates revenue. Additionally, social enterprises are integrated into the work. This is another aspect not found among any competitors.

Trend analysis

The PuF Re-Use Box, embedded in Social Urban Mining, is unique and has no direct competitors or market. It is rooted in efforts to integrate circular economy principles into the demolition phase. These changes were initiated by the EU Green Deal and are irreversible. Stakeholders are embracing these challenges to varying degrees. AIE (BauKarussell) conducts around 50 initial negotiation talks per year. While we quickly begin to explore with some building owners how we can move toward implementation, we also encounter building owners who have no interest in changing their approach. Anyhow, we see that the split of the Business in planning (concept) and operation (inkl. Re-Use Box) allows to start cooperating with building owners.

Business case

The market analysis in section 1.3 established both the scale and the urgency of dismantling and renovation in Austria and the specific characteristics of the deconstruction sector. In this section we evaluate their financial fit for the Austrian market and underpin what circumstances would be most beneficial for the financial viability of the popup factory. The two pop-up factory types that fit this ecosystem: the Assembly Factory and the District Factory. Table 7 (below) presents the research design applied to examine the evaluation of the two PUFs.

Table 7. Types of PUFs

Term	Definition	Austrian Ecosystem
Mobile On-Site Factory	A movable production cell deployed directly on or near the construction site.	No
Satellite Factory	A temporary facility near the site that collaborates with a central production hub.	No

District Factory	A semi-permanent facility serving multiple nearby projects, acting as a system integrator.	No
Assembly Factory	A location focused solely on assembling prefabricated components from other sources.	YES
Service Factory	A knowledge and facilitation hub that supports sustainable renovation through advice and coordination.	No

Research Design

In this section, we present the steps followed to dive into the examined business case. Based on literature related to the evaluation of innovations for the redesign of the construction sector as well as the opinion of experts in the field, the main criteria selected are: the required financial investment, the fit to the project scale, and the ecosystem's fits to the region. These also depend on the type of ownership that is involved. Below, the criteria and ownership model will be explained.

PUF Application in Austria

Based on key assumptions and relevant risk considerations from experts, we elaborate on each ownership scenario and evaluate it against the 3 main evaluation criteria. Below, we elaborate on key assumptions and risk considerations from experts for the PUF assembly and service. Finally, we present the reasoning of this business case in the sub-section 1.4.2 and further.

Table 56: The Assembly PUF compared across four ownership scenarios

Ownership scenario	**Assembly PUF**		
	Tool investments	**Project scale fit**	**Ecosystem fit**
Single construction company	low	Strong	Moderate
Consortium of construction companies	low	Weak	low
Industry Association	low	Strong	Strong
Housing corporations	low	Weak	low

PuF type - Key assumptions and risk implications

The Re-Use Box, embedded within Social Urban Mining, fits into the PuF concept as an assembly factory. The demolition site itself is classified as a production site, as used

building components are produced there. These are manufactured only once a buyer has been found. «Assembly» therefore takes place on-site. In terms of infrastructure, temporary facilities are installed directly within the demolition project. The equipment materials are stored until their next use. In principle, this measure can be implemented in any building. Experience from projects since 2016, and particularly from pilot implementations, shows that realistic implementation can achieve results starting at approximately 1,000 m² of floor area of building.
The concept of Social Urban Mining, including the Re-Use Box, is designed in an open source context. The owners have already published the main principles, challenges and impacts in many publications and reports. In parallel the first start up that realizes Social Urban Mining has been founded, the cooperation Baukarussell. It is defined will of the active stakeholders to create a new market. To create impact a functional market situation is key, which implies followers and competitors to start operation. Due to the project BuildUPspeed BauKarussell, via AIE, was able to take further steps on the road towards a new understanding of deconstruction, urban production and Urban mining.

Internal Business Analysis of the local pop-up factory

ReUse Box - Value proposition

The value proposition of the Re-Use Box, embedded in a Social Urban Mining concept, lies in making the value within the urban mine visible to the client / the building owner and to use it within the renovation / deconstruction. Standard procedures for demolition and renovation focus on completing the task as quickly as possible, so that the building is gutted or removed.

Value Creation

In standard demolition or renovation procedures, all building assets are destroyed or, at the very least, taken away from the client/the building owner. A Re-Use Box and Social Urban Mining changes that. The planning phase of Social Urban Mining identifies where valuable building components are located and to what extent they are present. At the same time, it outlines a way in which this potential can be realised. All proceeds from the sale of re-used components via the Re-Use Box are credited to the client. This economic aspect is combined with ecological benefits through the reuse of components and with social benefits through the involvement of social enterprises. Overall, this results in a service that demonstrably achieves impacts across all pillars of sustainable development.
All impacts are documented, quantified and communicated to the client. This information can be incorporated into the areas of CRSD, EU Taxonomy and national building certification schemes. The specific challenge lies in persuading people to break away from familiar paths and help shape the fundamental shift towards circular economy practices. Too many clients are stuck in their standard processes, areas of responsibility and interfaces. The challenge is to find those who are willing to move forward and to find them efficiently.

Capabilities: ‘upskilling’ to operate the local pop-up factory

A local pop-up factory can be considered as an ecosystem on its own as it brings together the capacity of local SME's, addresses unemployment of local construction workers. This requires supporting training and upskilling programs for involved craftsmen, designers, engineers, architects, and operational construction workers, etc, using outcomes and methods of the BUS and Construction Skills projects. All in all it is important to consider the required competences, skills and know-how of (future) employees. Complementary, the processing of information, data and systems; institutional and legal conditions, and financial, technical and material resources to instate and operate the local pop-up factory are key capabilities to take into consideration.

For the Re-Use Box the following human capital is envisioned:

Job description: project manager, operational leader

Tasks and responsibilities:

- Set up offers
- Cost calculation
- Compiling a list of reuse potential
- Project management
- Designing the Re-Use Box process
- Liaising with customers during the matching process
- Coordinating social enterprises
- Invoicing
-

Capabilities:

- Experience in construction site management
- Customer focus
- Willingness to travel
- Ability to work under pressure
- Knowledge of waste management legislation
- Experience of working with social economic enterprises
-

Recommended training:

- A comprehensive package combining construction and waste management
- Architects, builders, waste management specialists
- Experience in construction site management
- Relevant environment-focused degree programmes

Value Delivery

The Re-Use Box sources used building components from the 'urban mine', the demolition site, and allows the buyer to collect them directly from the PuF. As part of the concept development, the reuseable components are added to our database along with photos and a product description. The concept also involves clarifying with the client when the Re-Use Box will be launched and how long it can run. The products are then made publicly available in the component catalogue in accordance with the

agreed timeframe (https://katalog.baukarussell.at/). A prospective buyer can select products. After entering contact details, the prospective buyer receives an offer. BauKarussell then get in touch promptly to clarify details and, if the offer is accepted, the collection terms. At the agreed time, the products are dismantled by the buyers themselves, provided they have the necessary expertise. Where necessary, this is carried out by social enterprises commissioned by us. Once dismantling begins, ownership of the components passes to the buyer. Removal takes place immediately after dismantling. Temporary storage must be explicitly agreed. Our generally observation is, that the goods are transported directly to their new location.

Touchpoints and market activation

To further develop the research, and in line with the suggestions of Passlack (2021) and Broers et al. (2022), for the PuF a detailed customer journey needs to be developed specifically addressing the touchpoint with the residents requiring some level of action.

For the Re-Use Box Assembly factory, the following touchpoints will be considered as part of the sales strategy and the first stage ('onboarding') of the customer journey:

Touchpoint	Onboarding and sales activity
1) Knowledge & awareness raising campaign	not applicable
2) Informal info meetings (evening)	not applicable
3) Energy breakfast	not applicable
4) Energy Box	not applicable
5) Door-to-door campaigns	not applicable
6) Neighbourhood scan with thermal imaging	not applicable
7) Energy coaches	not applicable
8) 'Open house' visits	not applicable
9) Local pop-up store	not applicable
10) Community mobilisation	not applicable
11) Purchasing campaigns	not applicable
12) PR and media relations by BauKarussell e.Gen.	The cooperative Baukarussell performs active PR and media relation. We reach our clients through presentations at relevant events, publications in professional and scientific journals as well as through media appearances. All implementation projects are covered by the media. We provide our clients with the relevant data and also make our own appearances. We rely on word-of-mouth promotion through our corporate network and our newsletter. We also reach potential clients via our network, via newsletter

Value Capture

Cost structure and revenue model

In principle, services such as the Re-Use Box and Social Urban Mining are provided on behalf of the client, the building owner as part of their deconstruction or renovation process. The client is therefore also the primary point of contact for financing in the form of contracts. As described, a Re-Use Box (and Social Urban mining) is developed in two phases: the planning phase takes place as part of a contract for a feasibility study. The result is the Social Urban Mining concept that includes the list of potential reuseable products. The client is responsible for bearing the full cost of these planning expenses.
In case the building owner wants to realize the concept, a further contract is concluded for the implementation of the operational phase. This contract sets out the costs for the Re-Use Box and offsets them against the expected reuse revenues. The costs of implementation are therefore co-financed by the value contained in the building stock. This reflects the approach of urban mining.
Through the Re-Use Box, building components that would otherwise have to be disposed of as waste at a cost during standard demolition are transformed into used building products that are reused and generate revenue. This combines ecological and economic benefits.
The involvement of socioeconomic enterprises extends the impact in the social sphere. The primary aim of socioeconomic organisations is the reintegration of people who have dropped out of the labour market. The long-term unemployed receive support, qualification and partial training within the framework of a temporal contract, with the aim of integrating them into the primary labour market. The organisation receives funding by jobcentres. In the collaboration with BauKarussell, the target sector is the construction industry.

As the concept proves itself, revenue will grow through service fees, training and consulting packages, and potential licensing or franchising of the model. In the longer term, a broader ecosystem of reuse service providers will emerge, building on the groundwork laid by BauKarussell and its partners.

Summary of findings or PuFs comparison

In Austria, the legal framework has established the resource-oriented demolition as a binding standard for integrating circular economy principles. The Re-Use Box is a concrete measure that puts this principle into practice. Identifying components that can be reused and ensuring their sale with quality assurance safeguards functionality and thereby increases resource efficiency. At the same time, value is made visible within the ‘building’ as an urban mine and realised in the form of sales revenue. This revenue helps to finance the overall project. Embedded within the overall concept of Social Urban Mining, the Box also has a social impact through the involvement of social economy organisations.
A Re-Use Box can be installed in any construction site and needs proper planning to gain reliable data about potential reuseable components in the respective building. Based on the report, a building owner can make an informed decision as to whether or

not to proceed with the project. In general, a Re-Use Box can be installed in any larger demolition project. It requires sufficient lead time for assessment and implementation and a client that has the mind set to start changing his business model towards more circularity. Provided work begins in good time, there are generally no delays to the construction schedule and the benefits can start to pay off for the client.

The Table 1below shows the Austrian ecosystem summarized through the Business Model Canvas. The three areas depict the three types of value as seen in the business model canvas; value creation (value proposition, customer relationships, customer segments, channels), value delivery (key partners, key activities), and value capture (cost structures, revenue streams).

Table 57: Business Model Canvas summarizing the Austrian ecosystem.

<table>
<tr>
<td rowspan="2">Key partners
The Re-Use Box relies on a network of partners to function effectively. The BauKarussell cooperative plays a central role as operator, while social enterprises contribute labour-intensive dismantling activities. Additional partners include construction and demolition companies, clients (building owners), and knowledge institutions supporting the development and scaling of the concept. This multi-actor collaboration is essential for integrating circularity into existing value chains.</td>
<td>Key Activites
The core activities of the Re-Use Box include pre-demolition audits, identification and assessment of reusable building components, and the development of Social Urban Mining concepts. During implementation, activities focus on project management, coordination of dismantling processes, logistics, and the cataloguing and sale of recovered components. A key feature is that dismantling and reuse operations are closely integrated and managed directly on site.</td>
<td rowspan="2">Value Proposition
The value proposition of the Re-Use Box lies in the on-site integration of deconstruction, identification, and reuse of building components. By identifying reusable materials early and facilitating their recovery and resale, the model creates combined economic, ecological, and social value. It reduces disposal costs, generates revenue from reused components, and supports compliance with circular economy regulations. The uniqueness of the model lies in its ability to embed circularity directly into the demolition and renovation process.</td>
<td>Customer Relationships
Relationships with building owners are typically formalised through contracts covering both the planning phase and the operational implementation of the Re-Use Box. Relationships with buyers of reused components are more transactional and project based. At the same time, strong collaborative relationships are established with social enterprises and implementation partners to ensure effective execution of circular activities.</td>
<td rowspan="2">Customer segments
The Re-Use Box primarily targets building owners as the main clients, as they commission both the planning and operational phases of the concept. In addition, the model serves demolition and renovation contractors involved in execution, as well as buyers of reused building components, including SMEs, organisations, and private actors. Social enterprises also act as important stakeholders, participating in dismantling and logistics activities, while public authorities and sustainability-driven organisations form a broader ecosystem around the implementation.</td>
</tr>
<tr>
<td>Key Resources
The model relies on a combination of technical, organisational, and physical resources. These include expertise in construction, waste management, and circular economy practices, as well as digital tools for inventory management and component cataloguing. Temporary on-site infrastructure is required to operate the Re-Use Box, while access to networks of buyers and partners is essential for matching supply and demand.</td>
<td>Channels
The delivery of the Re-Use Box is organised through a combination of digital and physical channels. Engagement starts with feasibility studies and the development of a Social Urban Mining concept. Reusable components are then made available through a digital catalogue, while the physical construction site acts as the main touchpoint for inspection, purchase, and dismantling. Additional contact points include on-site events and communication activities that support awareness and market activation.</td>
</tr>
<tr>
<td colspan="3">Cost Structure
The cost structure is dominated by labour-intensive activities related to dismantling and coordination, as well as planning and analysis costs for identifying reuse potential. Additional costs arise from temporary infrastructure, logistics, and overall project management. However, these costs are partly offset by avoided disposal expenses and the generation of new revenue streams from reused materials.</td>
<td colspan="3">Revenue Streams
Revenue is primarily generated through service contracts with building owners, covering both the planning phase (feasibility study) and the operational phase (implementation of the Re-Use Box). Additional value is created through the sale of reused building components, with the generated revenues typically credited to the client. Over time, further revenue streams may emerge through consultancy services, training activities, and replication or scaling of the model.</td>
</tr>
</table>

SWOT analysis for the PuF “Re-Use Box”: Strategic orientation for the introduction of the local pop-up factory

Strength

A strength of the Re-Use Box is that…

- ..it visualizes the incorporated values of deconstruction buildings
- ..it respects and uses the fact that construction sector is a local one for materials
- ..it offers a measure to realize those values to the building owner’s benefit
- ..it creates positive documented ecological impact due to the reuse of building components
- ..it creates positive and documented social impacts due to the engagement of local based socioeconomic enterprises
- ..it is embedded in the broader concept of Social Urban Mining. This concept combines several measures to use the values of the urban mine “deconstruction building” in favour of the building owner.
- ..it combines the expertise of the team of BauKarussell. In the team are architects, advocates and waste managers. This reflects the approach to develop a concept that is compatible with the actual value chain.
- ..it is applicable to a broad range of building products

Weakness

A weakness of the Re-Use Box is that…

- ..it is not a standardized, generally accepted process.
- ..there are no standardized tender texts.
- ..there are no benchmarks and little experience on the identification of the property “reuseable”.
- ..the question of liability issues are not solved finally and in detail.
- ..the availability of local socioeconomic enterprises to act as subcontractors is questionable for some regions.
- ..there is so far no trustworthy method to evaluate the impact for reusing building components regarding Greenhouse gas emissions.

Opportunities

An opportunity of the Re-Use Box is that…

- ..the measure contributes to several strategic documents like the EU taxonomy, ESG and CSRD.
- ..reusing of building products is an act of waste prevention.
- ..it directly reduces resource need and impact on climate change due to lifetime extension.
- ..reuse preserves economic values and this helps to get the attention of the decision makers.

- ..it gathers knowledge in two axes: Firstly, to deal with the resources of existing buildings and secondly, to use the learning to educate stakeholders to build new ones in a way that those will come up with higher circular potentials.
- ..it makes use of the current legal national framework and offers building owners the opportunity to develop their business operations towards circular economy.

Threats

A threat for the Re-Use Box is that ..

- ..the matter of reusable products is mentioned to be examined there exists no further regulation on how to deal with that potential.
- ..a contact for a potential project happens far too late which reduces the chances simply due to a lack of time no matter of the real potential of the building.
- ..reusing a broad spectrum of building components relates to a wide range of legal acts for example trade regulations, chemicals legislation, building regulations, electrical engineering regulations, consumer protection acts, warranty and insurance laws.
- ..there is a general lack of knowledge to identify reusability by experts that do the pre demolition audits.
- ..existing curricula have only started to embed this shift towards circularity. No vocational training, no school curricula, no degree programme has included this topic accordingly in its curricula.
- ..in case reusable products are identified, there is no standardized process or team in place to handle them.
- ..it needs high investments in negotiation phase as many negotiations last very long and still do not lead to contracts.
- ..sold reuse products might have a failure of function
- ..that it needs a continuity of operations to secure sufficient business for the engaged companies.
- still the lack of market (Matchmaking)
- ..reusing is, in terms of volume, still irrelevant to waste management statistics which might lead to marginalisation.
- ..the prices for reusable products compete with the prices for new products.
- ..the persons in charge, the decision-makers are not willing to even consider changing their approaches. The established processes in the deconstruction phase of a renovation or development project are simply too well-established.

Conclusions

In the current construction and demolition sector, there is a significant gap between the potential for reuse and the systems in place to enable it. In light of evolving regulations such as the Austrian ordinance on recycled building materials there is a growing interest of building owners to that new idea. Still most are not willing to change well established processes. Thus, in future high efforts are needed to explain the potential benefits and impacts.
While these regulations mention recycling-oriented deconstruction and the reuse of products during the pre-demolition audit, the experts conducting these assessments

are not trained to identify reuse potential. The next generation of experts has to be trained and educated already within their education career. Therefore, the curriclula have to be reworked to reflect reuse and more widely circular economy in the construction and demolition sector.
Furthermore, even when reusable products are identified, there is no standardized process or team in place to handle them. This results in a fragmented approach, where materials are often discarded or reused inefficiently, leading to increased waste, higher costs, and missed environmental targets. Processes have to be developed to reduce risks and create the confidence that the new approach meets the needs of the stakeholders.

The Re-Use Box is defined as a full-service package that facilitates the reuse of construction materials on-site, directly where deconstruction takes place. It includes physical infrastructure—a pop-up store—as well as a suite of supporting services. This package shows high potential for other users to adopt. It can be operated by different actors (not only BauKarussell), from SMEs to larger firms, and is designed to be seamlessly integrated into existing deconstruction workflows. It professionalizes reuse, making it scalable, predictable, and valuable for the whole industry.

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French Ecosystem Report

This Annex presents the analysis of the French ecosystem with regard to the market potential and feasibility of Pop-up Factory (PuF) concepts, with the aim of informing the development of implementation plans, scenarios, and supporting activities. The methodological framework adopted for this assessment is described in detail in Deliverable D4.1 of Work Package 4. The findings presented in this Annex are subsequently compared and discussed alongside the results from the other national ecosystems in the main report, contributing to a broader cross-ecosystem evaluation of the opportunities and challenges associated with the deployment of PuF models.

Addressing ecosystem needs: Offering a deep-renovation kit by a local pop-up factory scenario

Various theories and concepts have been developed to boost the efficiency of deep retrofits. One of the key challenges is to turn these theories and concepts into real-world implementations being adopted beyond demonstration. In this chapter the preferred local pop-up factory scenarios are being presented for each Ecosystem.

The French Ecosystem deep-renovation needs

Bordeaux and its metropolitan area face a twofold challenge: sustained population growth and an aging housing stock that struggles to meet today's standards for comfort, energy efficiency, and livability.

The residential building stock reflects the weight of older construction. Among single-family homes, 54% were built before 1975 — a generation of buildings that systematically underperforms on energy criteria and concentrates the highest shares of F and G DPE ratings (Caillière, 2026). The situation is even more pronounced in the apartment segment, where 61% of dwellings predate 1975, with nearly a third dating from the 1949–1974 period alone — the era of large-scale social housing construction that is now at the heart of deep-renovation programs. Bordeaux Métropole is classified as a Zone A housing market, meaning demand pressure is high, which makes the urgency to bring this aging stock up to standard all the more acute.

In the tertiary sector, three building categories — offices, commercial premises, and education establishments — together account for 65% of the total floor area. These typologies represent the primary targets for deep energy renovation in the non-residential segment, given both their surface area dominance and the increasing regulatory obligations applying to public and commercial buildings.

The distribution of the stock of one-dwelling houses by construction date, based on broadly defined construction periods, is as follows:

Construction period	Before 1948	1949-1974	1975-1999	>2000
Share of one-dwelling houses	36%	18%	30%	16%

The distribution of the stock of apartment dwellings by construction eras is as follows:

Construction period	Before 1948	1949-1974	1975-1999	>2000
Share of apartments	29%	32%	25%	14%

At the urban scale, the most emblematic renovation effort is the *Grand Projet de Villes Rive Droite* (GPV Rive Droite), a large-scale, multi-year restructuring program grouping four municipalities — Bassens, Cenon, Floirac, and Lormont — within Bordeaux Métropole. Covering approximately 3,200 hectares and home to around 65,000 inhabitants on the northern right bank of the Garonne, this territory concentrates some of the most significant deep-renovation needs of the metropolitan area, spanning both housing and public infrastructure.

The local pilots of the French Ecosystem

The GPV Rive Droite project, representing the French ecosystem, combines two strategic priorities that define the specificity of this use case within BuildUPspeed: the deep renovation of social housing at scale, and the development of circular economy practices through the reuse of local material flows, primarily sourced from the construction and demolition (C&D) sector.

To ground this work in operational reality, the French ecosystem has access to the housing portfolio of DOMOFRANCE, a major social housing landlord operating in the Bordeaux metropolitan area with 59,000 dwellings under management. In 2025 alone, DOMOFRANCE is delivering approximately 1,900 new units and rehabilitating around 1,000 existing ones — illustrating both the scale of the challenge and the pace at which renovation programs must be accelerated. This stock provides an ideal testbed for developing, trialling and scaling the methods and tools explored within BuildUPspeed.

The main pilot project consists of two selected buildings within the Palmer Residence, in Cenon (33150), currently undergoing extensive deep renovation alongside a new building extension. A central feature of these renovations is the emphasis placed on material reuse and circular economy principles, making them directly aligned with the project's core research agenda. The Palmer pilot thus serves as a concrete, real-scale demonstration of how deep renovation and circularity can be integrated within a social housing context.



Figure 104 : Residential building PAM P, Palmer's residence, CENON (33) FR

These pilots are not isolated experiments. They are designed to reflect and illustrate the national and local policy frameworks to which the French ecosystem is subject, while addressing a structural challenge: the need to develop a mature material reuse supply chain capable of supporting the large-scale renovation of the existing housing stock. In this respect, the Pop-Up Factory model — described in the following sections — is particularly well suited to these conditions, offering a flexible, proximity-based production approach that can be mobilised and replicated across renovation programs of varying scales.

Multiple value creation: Matching local pop-up factory scenario with local needs

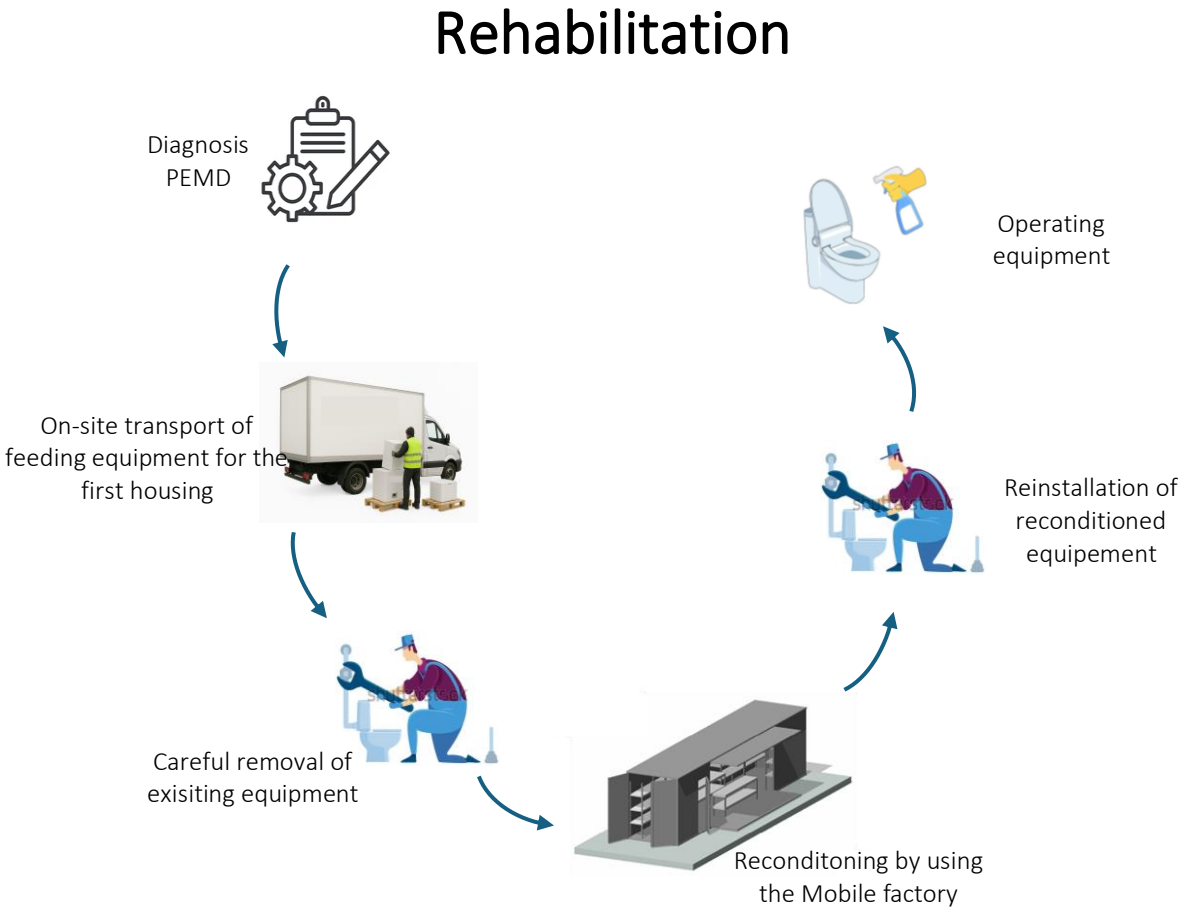
This paragraph provides a discussion on the type(s) of pop-up factory scenario which best suits each Ecosystem, including, when possible, insights obtained through the modifications and optimizations made while developing it and testing it.

Local pop-up factory scenario: Mobile on site factory

The French PuF scenario is built around **selective deconstruction linked to rehabilitation**, with a specific focus on the **reuse of sanitary equipment** recovered through careful removal. Building on a pilot rehabilitation activity in social housing, the ecosystem demonstrated that reused sanitary elements can be integrated into a rehabilitation process, with reported cost savings (e.g., around €8,000 for 20 flats). The ecosystem highlights sanitary equipment as a high-potential reuse stream due to the durability of ceramic materials, limited technological evolution over recent decades, and the practical feasibility of cleaning and maintenance, while noting the significant impacts associated with manufacturing and transporting new equipment.

Within the BuildUPspeed PuF typology, France primarily adopts a *Mobile On-site Factory* concept, developed as a **"truck for reused equipment."** The intent of this mobile unit is to connect reuse operations directly to deconstruction sites by enabling reconditioning steps—such as checking, cleaning, and preparation for re-employment—within a mobile setup, rather than relying solely on fixed facilities. This concept is being defined through technical and economic feasibility work, and is motivated by current barriers in the market, including the complexity of careful removal and checking procedures, logistics, a lack of specialized companies able to deliver the full chain, and unresolved insurance considerations.

Depending on site conditions and sequencing between deconstruction and rehabilitation, the reconditioned equipment may be returned to the same project (where intermediate storage or staging is possible), transferred directly to another receiving site, or distributed via marketplace-type platforms. The concept is intended to serve project owners such as social landlords, property developers, and public authorities, and can be extended beyond sanitary equipment to other reusable product streams where feasible.



The project could also be carried out by an organisation from the Social and Solidarity Economy (SSE), involving people in professional integration pathways. This approach would reinforce the social impact of the initiative while contributing to the creation of an innovative and locally rooted economic model.

Key implementation needs identified include a workable business model defining ownership and transfer of recovered equipment between project owners and reuse operators, clarity on transport and handling constraints (notably where chemical cleaning processes are involved), and an insurance approach that covers the risks of the reuse process. The French PuF scenario is therefore positioned as a scalable mobile implementation model aimed at strengthening the sanitary equipment reuse chain and supporting circular renovation practices by bridging selective deconstruction and reuse in a more operationally integrated way.

External Business Environment of the local pop-up factory

In a first step the external business environment of the pre-selected local pop-up factory will be defined in detail. Different fields of external factors which influence the operation of the pop-up factory are considered, such as the market demand and existing alternatives, the customers and competitors as well as influence of environmental, economic, technological, socio-cultural and political trends.

Market demand analysis

The potential market for refurbished sanitary equipment in Bordeaux Metropole is substantial. The total collective housing stock in the region reaches approximately 290,000 units, of which 74,000 are social housing. Roughly 40% of these dwellings predate 1975, meaning around 115,000 units are potentially energy-intensive and in need of renovation. Large-scale ongoing or planned projects involve more than 1,500 units, including major refurbishments and demolitions. In the private condominium sector, there are an estimated 210,000 dwellings, with one in three considered fragile or substandard. Energy Performance Certificates indicate that around 40% of these condominiums are rated E, F, or G, representing roughly 80,000 to 90,000 units requiring renovation. Across France, the regulatory framework - including AGEC law, RE2020, and the mandatory Waste Audit for Demolition Works (PEMD) - favors the reuse of construction materials, further expanding the addressable market. Refurbished sanitary equipment is sold at 40% to 60% lower than new equivalents, creating a commercially attractive price point for buyers.
With regard to Domofrance, the forecasted activity volume is as follows:

- 1,000 rehabilitated dwellings per year,
- 1,500 new social rental dwellings per year,
- 200 to 300 new dwellings per year through affordable homeownership schemes.

By the end of the year, Domofrance aims to scale up reuse across its construction, rehabilitation, and development projects, targeting:

- 2% of construction costs for building works,
- 5% of construction costs for outdoor spaces.

All these elements are expected to support the implementation of this solution and contribute to strengthening the local reuse ecosystem.

Customer analysis

The target market comprises several key segments in France. First are social housing providers, including local authorities and government-funded housing organizations, which undertake large-scale renovations and refurbishments. Second are private developers and condominium associations, especially those managing older or energy-inefficient buildings seeking cost-effective refurbishment solutions. Third, reuse marketplaces such as Cycle Up act as both distribution channels and partners, sourcing refurbished equipment and connecting it with receiving sites. Finally, there is a smaller but growing segment of construction project managers and contractors interested in integrating circular economy practices and reducing waste on-site. Each segment has unique needs: social housing providers prioritize cost savings and regulatory compliance; private developers emphasize quality and reliability; marketplaces focus on traceability and supply chain efficiency; and project managers value operational flexibility and on-site logistics efficiency.

Competitor analysis

The main competitors are centralized refurbishment facilities and online marketplaces that sell guaranteed refurbished sanitary equipment. Notable examples include Cycle Up and Réempro. These actors have strengths in visibility, standardized processes, and quality assurance. Though their model depends on transporting equipment from sites to centralized facilities, which results in high logistical costs, longer processing times, and limited scalability. Additionally, sourcing raw materials relies on deconstruction projects where the equipment owner decides to resell, creating unpredictability in supply. The mobile workshop truck model differentiates itself by operating directly on-site, eliminating multiple transport steps, reducing carbon footprint, improving efficiency, and allowing immediate refurbishment and reuse. This operational innovation addresses the key weaknesses of existing competitors while aligning with regulatory incentives and circular economy goals.

Trend analysis

The French construction industry generated an estimated €161.6 billion in output in 2024. Despite near-term challenges, the sector is projected to grow at a CAGR of 2.8% between 2024 and 2028, reaching €180.5 billion by 2028 (Research and Markets, 2024). However, this aggregate figure masks a sharp divergence between segments: new residential construction fell by 8.8% in 2025, following a 12.2% collapse in housing starts in 2024, (FFB Nationale, 2026), while renovation has become the sector's primary growth engine.

The renovation market reached approximately €40 billion in 2024, with energy renovation alone exceeding €25 billion and representing nearly a quarter of total construction activity. Growth in energy renovation is forecast at 6.1% per year through 2030, driven by strong demand, public support schemes, and regulatory pressure (Picariello, 2024). This pressure is structural: G-rated dwellings have been banned from the rental market since January 2025, with F-rated properties to follow in 2028 and E-rated in 2034, (Koffel, 2025), mobilizing renovation activity across the entire existing stock. The building sector accounts for 27% of national CO2 emissions and

nearly 45% of final energy consumption, making deep renovation a national priority with long-term visibility.
In this context, the Bordeaux metropolitan area — with its GPV Rive Droite program, the DOMOFRANCE rehabilitation pipeline, and the Grand Parc convention — represents a concentrated and predictable renovation demand that directly supports the viability of the Pop-Up Factory model.

Business case

Research Design

In this section, we present the steps followed to dive into the examined business case. Based on literature related to the evaluation of innovations for the redesign of the construction sector as well as the opinion of experts in the field, the main criteria selected are: the required financial investment, the fit to the project scale, and the ecosystem's fits to the region. These also depend on the type of ownership that is involved. Below, the criteria and ownership model will be explained.

PUF Application in the French ecosystem

Based on key assumptions and relevant risk considerations from experts, we elaborate on each ownership scenario and evaluate it against the 3 main evaluation criteria. Below, we elaborate on key assumptions and risk considerations from experts for the PUF mobile on site. Finally, we present the reasoning of this business case in the sub-section 1.4.2 and further.

Table 58: The mobile on site PUF compared across four ownership scenarios

Ownership scenario	**Mobile on-site PUF**		
	Tool investments	**Project scale fit**	**Ecosystem fit**
Single construction company	High	Medium	Strong
Consortium of construction companies	Medium	Strong	Strong
Industry Association	Medium	Strong	Moderate
Housing corporations	High	Strong	Weak

PuF type - Key assumptions and risk implications

The mobile on-site PUF concept appears most viable under the single construction company and consortium scenarios. In the single company case, the higher upfront investment — covering acquisition or rental of the mobile unit, team training, and process development — is offset by a real strategic advantage: the ability to specialize rapidly, refine the reconditioning process, and position the company directly on the sanitary equipment reuse market. This model implies a clear strategic shift toward renovation and reconditioning as a core activity — a natural opportunity for firms already engaged in reuse, and a credible entry point for those seeking to establish themselves in this growing segment. Access to projects is facilitated by the unit's

mobility and operational flexibility, which strengthens fit within the local ecosystem. That said, a smaller company may not have access to large-scale renovation programs, which can limit throughput and slow the return on investment.

The consortium scenario directly addresses this limitation. By pooling investment and spreading risk across several firms, it reduces individual financial exposure while opening access to larger markets. Combining order books improves pipeline predictability and unit utilization, thereby maximizing learning and repetition effects. Ecosystem fit is also strengthened: a group of companies brings greater coordination capacity and increased legitimacy in the eyes of project owners and housing corporations.

A professional or industry association could act as a neutral third-party facilitator, carrying the investment and making the unit available to its members. While fit to project scale remains strong, ecosystem embeddedness is more moderate: coordinating members with potentially diverging interests requires robust governance, and unclear roles — around site deployment, material stream management, and day-to-day operations — risk becoming significant friction points.

Housing corporations, despite owning large portfolios with repetitive typologies — conditions that are in principle well-suited to this type of mobile unit — are not naturally positioned as owners of such a facility. As project owners rather than construction professionals, their business model is not adapted to operating an industrial production unit, which explains the weak ecosystem fit in this scenario. Their role is more naturally that of an informed client, capable of creating the conditions that make a mobile PUF viable — clustered programs, repeated typologies, structured procurement — rather than assuming direct ownership and operation of the unit.

Internal Business Analysis of the local pop-up factory

Puf Type - Value proposition

The core product is a fully equipped workshop truck/container designed for on-site refurbishment. Services include careful dismantling of sanitary equipment, cleaning and disinfection using eco-friendly processes, refurbishment of components (including replacement of flush systems, seals, and seats), and packaging for direct reuse or temporary storage. The truck also enables on-demand transport to receiving sites, reducing multiple handling steps in cases where the receiving site is different from the deconstruction site. Beyond the physical service, the project offers an integrated operational model, coordinating upstream identification of reusable equipment, quality control, traceability, and sales through established reuse platforms. This dual offering of tangible refurbishment capabilities and operational management differentiates the venture from traditional refurbishment facilities and marketplaces.

Value Creation

The core value creation of the French Pop-Up Factory rests on three interlocking elements: a specialised mobile unit, a dedicated reconditioning process, and a set of

strategic partnerships. The key resource is the mobile factory itself — a truck-based unit equipped for the selective removal, checking, cleaning, and preparation for reuse of building components recovered from buildings undergoing rehabilitation. While sanitary equipment represents the primary and most mature reuse stream — given the durability of ceramic materials, the limited technological evolution of these products, and the practical feasibility of their reconditioning — the model is deliberately designed to be extensible. Other product categories present comparable reuse potential, including electrical equipment and fittings, balustrades and guardrails, door and window frames, and various fixed interior components, provided that condition assessment and quality verification procedures can be established. Key activities include the coordination of selective deconstruction sequences, on-site reconditioning operations, quality control, logistics management between donor and receiving sites, and where relevant, temporary storage. Key partnerships structure the entire chain: social landlords and project owners such as DOMOFRANCE provide access to donor buildings and represent the primary demand; construction companies and site managers ensure operational coordination; and Social and Solidarity Economy (SSE) organisations may operate the factory itself, integrate professional reintegration pathways and reinforce the local economic model. Marketplace platforms or material reuse networks may additionally serve as distribution channels when direct site-to-site transfer is not possible.

Capabilities: 'upskilling' to operate the local pop-up factory

A local pop-up factory can be considered as an ecosystem on its own as it brings together the capacity of local SME's, addresses unemployment of local construction workers. This requires supporting training and upskilling programs for involved craftsmen, designers, engineers, architects, and operational construction workers, etc, using outcomes and methods of the BUS and Construction Skills projects. All in all it is important to consider the required competences, skills and know-how of (future) employees. Complementary, the processing of information, data and systems; institutional and legal conditions, and financial, technical and material resources to instate and operate the local pop-up factory are key capabilities to take into consideration.

For the mobile on site factory, the following human capital is envisioned:

Job description: Field manager
Tasks and responsibilities: • identify potentially reusable deposits • Identify receiver site • manage the entire process, from identification through to reinstallation or delivery to another recipient's site
Capabilities: • Organisational and reporting skills • Management and coordination abilities • Logistic expertise • Stakeholder network development
Recommended training: • Training of logistic expertise

Job description: Reuse Technician

Tasks and responsibilities:

- careful removal
- reconditioning
- installation of sanitary equipment

Capabilities:

- Precise and meticulous hand skills
- Dexterity and attention to detail
- Physical resilience and ability to handle demanding manual tasks

Recommended training:

- Training for careful removal.
- Training in building trades / construction crafts

Job description: Software developer

Tasks and responsibilities:

- Develop a supply chain planning tool tailored to building renovation needs
- Develop a web marketplace Platform
- Integrate data flows between the two tools to ensure consistency between material availability and site planning
- Develop user interfaces adapted to non-technical users (site managers, social landlords, ESS operators)
- Ensure data security, platform maintenance and continuous improvement based on user feedback

Capabilities:

- Full-stack web development (front-end and back-end)
- Database design and management
- API development
- Knowledge of supply chain or logistics planning systems

Recommended training:

- Degree in computer science, software engineering or information systems
- Knowledge of circular economy or materials traceability tools
- Training in developing marketplace or logistics planning platforms

Job description: Professional reintegration coordinator

Tasks and responsibilities:

- Recruit and select candidates eligible for professional integration pathways
- Assess individual situations, skills gaps and employment barriers
- Design and monitor personalised integration pathways for each worker
- Support workers in their transition toward sustainable employment at the end of the pathway

Capabilities:

- Organisational and reporting skills
- Ability to work with vulnerable and diverse populations

Recommended training:

- Degree in social work, human resources, or education sciences

Value Delivery

The primary customer segment is the project owner — typically a social housing landlord or public authority — who commissions the reconditioning service as part of a broader rehabilitation program. Value is delivered through a dual substitution logic: the mobile factory replaces both conventional destructive demolition (by enabling careful selective removal) and the procurement of new equipment (by supplying reconditioned alternatives). This logic applies across the full range of recoverable components: just as reconditioned sanitary ware avoids the environmental and financial cost of new ceramic production, reused guardrails, electrical panels or joinery elements avoid the equivalent costs associated with their manufacturing and transport. Delivery is organised around the sequencing of construction timelines: where deconstruction and rehabilitation occur simultaneously within the same project or across adjacent sites, the mobile unit enables direct transfer of reconditioned components with minimal intermediate handling. When planning constraints prevent immediate reuse, temporary storage provides continuity. The receiving site — whether the same project or a separate one — benefits from a ready-to-install supply of quality-checked components at reduced cost. Customer interaction is built around close coordination with site managers and project owners throughout the deconstruction and rehabilitation phases, requiring alignment on scheduling, logistics, and technical specifications. The pilot at Residence Palmer has demonstrated the practical feasibility of this delivery model, with reported cost savings of approximately €8,000 across 20 flats for sanitary equipment alone — a figure that could scale significantly as additional product streams are integrated.

Touchpoints and market activation

To further develop the research, and in line with the suggestions of Passlack (2021) and Broers et al. (2022), for the PuF a detailed customer journey needs to be developed specifically addressing the touchpoint with the residents requiring some level of action.

For the French type of PuF factory, the following touchpoints will be considered as part of the sales strategy and the first stage (‘onboarding’) of the customer journey:

Touchpoint	Onboarding and sales activity
1) Knowledge & awareness raising campaign	Raising awareness among end users (tenants and homeowners) is key to making reuse a more mainstream practice. Construction companies also need to be engaged, to help them understand the market opportunity that reconditioning represents.
2) Informal info meetings (evening)	Not applicable
3) Energy breakfast	Not applicable
4) Energy Box	Not applicable
5) Door-to-door campaigns	Not applicable

6) Neighbourhood scan with thermal imaging	Not applicable
7) Energy coaches	Not applicable
8) 'Open house' visits	Open days can take several forms. One option is a visit to a renovated apartment fitted with reconditioned equipment, aimed at future residents (it has already been tested during a pilot project). Another is an open day at the mobile unit itself, targeted more specifically at construction companies.
9) Local pop-up store	Not applicable
10) Community mobilisation	Not applicable
11) Purchasing campaigns	Not applicable
12) other	Not applicable

Value Capture

The economic model is built around a service fee paid by the project owner to the reconditioning operator. Rather than bearing the full cost of conventional deconstruction on one side and new equipment procurement on the other, the client pays for an integrated reuse service that is economically competitive with the traditional alternative. This value proposition strengthens as the range of recoverable product categories expands: each additional reuse stream — whether sanitary fittings, electrical components, or structural elements such as guardrails — adds to the overall cost avoidance and increases the economic attractiveness of the service relative to conventional approaches. The cost structure of the operator includes the acquisition or rental of the mobile unit, labour for selective removal and reconditioning, transport and logistics, temporary storage where needed, insurance, and compliance costs associated with handling and cleaning procedures. Revenue streams may evolve as the model matures: beyond direct service fees, the operator could develop income from component resale through reuse platforms, framework agreements with social landlords covering multiple sites and multiple product categories, or performance-linked contracts tied to measured cost savings and circular economy outcomes. The involvement of SSE structures introduces the possibility of additional public funding or integration subsidies, improving the economic viability of the model in its early deployment phases. At portfolio scale — given DOMOFRANCE's annual rehabilitation volume of approximately 1,000 units — even modest per-unit savings across a growing range of reusable components generate a compelling and scalable economic case for systematic adoption.

Cost structure and revenue model

Example for Sanitary equipment :

Direct cost of mobile on site factory deep-renovation		
Material cost:		
— **Mobile Unit (container, interior layout, various tools)**	€	62.000,00

— **Reconditioning sanitary equipment (Per equipment)**	€	300,00
Labour cost:	€	8.000,00
Reno cost/dwelling	€	40.000,00
> = cost that need to be retrieved via energy savings		
Exclusive:	Overhead costs	
	Start-up costs	
	Asbestos removal costs	
	Structural improvements costs	
	Environmental (ecology)costs	
	Home improvements costs	

Summary of findings or PuFs comparison

The tables below (table X and X) show the Mobile on-site and Service PUFs respectively of the French ecosystem summarized through the Business Model Canvas. The three areas depict the three types of value as seen in the business model canvas; value creation (value proposition, customer relationships, customer segments, channels), value delivery (key partners, key activities), and value capture (cost structures, revenue streams).

Table 59: Business Model Canvas summarizing the Mobile On-site PUF of the French ecosystem.

<table>
<tr>
<td rowspan="2">Key partners

Key partners include social housing organisations (pipeline providers), contractors and site managers, SSE organisations operating the unit, and reuse platforms supporting redistribution.</td>
<td>Key Activites

Key activities include selective dismantling, on-site cleaning and reconditioning of components, quality control, logistics coordination, and preparation for reuse or transfer. These activities are directly embedded in construction workflows and linked to renovation sequencing</td>
<td rowspan="2">Value Proposition

The value proposition is the provision of an on-site refurbishment service that enables selective deconstruction, reconditioning, and direct reuse of building components. By replacing both demolition and new material procurement, the model delivers cost savings, reduced environmental impact, and improved circularity within renovation projects</td>
<td>Customer Relationships

Customer relationships are based on close operational coordination with project owners, contractors, and site managers. The model requires alignment on planning, logistics, and technical requirements throughout the renovation process, leading to collaborative and project-integrated relationships.</td>
<td rowspan="2">Customer segments

The mobile on-site factory primarily serves social housing providers, public authorities, and developers involved in renovation programmes. Contractors and project managers act as operational users, while reuse platforms function as secondary stakeholders when redistribution of components is required</td>
</tr>
<tr>
<td>Key Resources

The central resource is the mobile factory unit (truck/container) equipped for reconditioning operations. Additional resources include skilled labour, digital tools for coordination, and access to reusable material streams from demolition</td>
<td>Channels

The model operates mainly through project-based procurement within renovation programmes. Value is delivered directly on construction sites, while additional distribution takes place via reuse platforms when components are transferred between projects.</td>
</tr>
<tr>
<td colspan="3">Cost Structure

Costs include investment in the mobile unit, labour for dismantling and reconditioning, logistics, storage, insurance, and coordination. Cost efficiency depends on integration into ongoing renovation projects and utilisation across multiple sites.</td>
<td colspan="3">Revenue Streams

Revenue is primarily generated through service fees paid by project owners for integrated reuse services. Additional revenues may arise from resale of refurbished components and framework agreements covering multiple projects</td>
</tr>
</table>

Table 60: Business Model Canvas summarizing the Service PUF of the French ecosystem.

<table>
<tr><td rowspan="2">Key partners

Key partners include reuse marketplaces (Cycle Up), social housing organisations, contractors, digital platform providers, and SSE organisations. These actors collectively form the reuse ecosystem.</td><td>Key Activites

Key activities include supply–demand matching, planning of material flows, coordination between donor and receiving sites, data management, and integration of reuse within programme-level planning.</td><td rowspan="2">Value Proposition

The value proposition lies in coordinating the reuse chain by matching supply (recovered components) with demand (receiving projects), ensuring traceability, quality assurance, and efficient logistics across multiple sites.</td><td>Customer Relationships

Relationships are long-term and network-based, focusing on coordination, trust, and data sharing between multiple actors. The service layer enables ongoing collaboration across projects rather than single project interactions.</td><td rowspan="2">Customer segments

The service layer targets social housing organisations, developers, and contractors managing multiple renovation projects, as well as reuse platforms and supply chain actors requiring coordination of material flows between sites</td></tr>
<tr><td>Key Resources

Key resources include digital platforms, data management systems, supply chain planning tools, and knowledge of reuse processes and regulations. Human resources include coordinators and developers managing the system.</td><td>Channels

Channels consist of digital platforms (e.g. Cycle Up), supply chain tools, and project coordination structures. These channels enable communication, matching, and distribution between stakeholders in the reuse ecosystem</td></tr>
<tr><td colspan="3">Cost Structure

Costs relate to platform development, coordination staff, data systems, and governance of the network.</td><td colspan="2">Revenue Streams

May include service fees for coordination, commissions on resale via platforms, and agreements linked to services.</td></tr>
</table>

SWOT analysis: Strategic orientation for the introduction of the local pop-up factory

Strengths	Weaknesses
reduces logistics, lowers costs, and cuts carbon footprint; social impact through SSE partnerships; aligned with French reuse regulations; strong distribution via Cycle Up.	Coordination across multiple sites is complex; relies on early identification of reusable equipment; requires skilled, insured labor; untested at scale. Coordination between the various stakeholders through a viable and effective economic and operational model
Opportunities	**Threats**
Large market of aging housing needing renovation; growing demand for circular economy solutions; replicable and scalable model; access to public funding and subsidies. mandatory percentage of reused materials in renovation and construction projects	Contractor or client reluctance; variability in available equipment; competition from established marketplaces; economic or regulatory risks in the construction sector.

Strength

The Pop-Up Factory model offers a compelling set of internal advantages. By deploying the mobile unit directly at or near the renovation site, it significantly reduces logistics costs and transport-related carbon emissions compared to conventional supply chains. The emphasis on material reuse — starting with sanitary equipment and extendable to other product categories — positions the model as both economically competitive and environmentally responsible. Its alignment with French regulations on reuse and circular economy in construction reinforces its credibility with public project owners. The potential involvement of Social and Solidarity Economy (SSE) structures as operators adds a meaningful social impact dimension, creating local employment and professional integration pathways in urban renewal territories. Distribution is further strengthened through partnership with established platforms such as Cycle Up, providing immediate access to an existing network of buyers and reuse operators.

Weakness

The model's operational complexity represents its main internal challenge. Coordinating selective deconstruction, reconditioning, and reuse across multiple sites simultaneously requires precise planning and strong stakeholder alignment — between project owners, site managers, reconditioning operators, and receiving projects. The process depends heavily on the early identification and assessment of reusable equipment, which is not always possible given the variability of building stock and renovation timelines. The labour required is specialised: workers must combine

building craft skills with the precision and care demanded by selective removal and reconditioning, and insurance coverage for reused components remains an unresolved barrier. Finally, the business model itself — defining ownership, transfer, and liability of recovered equipment between actors — has yet to be tested and validated at operational scale.

Opportunities

The French ecosystem offers a particularly favourable external environment for this model. The sheer volume of aging housing stock requiring deep renovation — concentrated in territories such as GPV Rive Droite — represents a large and sustained pipeline of potential donor and receiving sites. Societal demand for circular economy solutions is growing, supported by an increasingly robust regulatory framework: the introduction of mandatory minimum percentages of reused materials in renovation and construction projects creates a structural market pull that directly benefits the Pop-Up Factory model. The model is also inherently replicable and scalable, with the potential to be deployed across other ecosystems and social housing portfolios beyond Bordeaux. Access to public funding — through ANAH, MaPrimeRénov', OPAH programs, and European mechanisms — further improves the economic conditions for adoption.

Threats

The primary external risks relate to market adoption and operational variability. Contractor or client reluctance — whether due to unfamiliarity with reuse processes, concerns about quality and liability, or resistance to changing established procurement habits — could slow uptake. The variability of available equipment from one building to the next makes it difficult to guarantee a consistent and reliable supply of reconditioned components, which in turn complicates planning and commercial commitments. The model also faces competition from established digital marketplaces and reuse platforms that already operate at scale. Finally, broader economic and regulatory risks in the construction sector — including funding cuts to renovation incentive schemes, rising material and labour costs, or shifts in public policy — could affect both the volume of renovation activity and the financial viability of the model.

Findings and Conclusion

The SWOT analysis, when read through a TOWS lens, reveals four strategic directions for the French Pop-Up Factory.

S+O — Leverage strengths to capture opportunities. Formalising framework agreements with social landlords such as DOMOFRANCE across multiple renovation sites would transform the GPV Rive Droite pipeline into a recurring revenue stream, while the alignment with reuse regulations opens access to public funding and positions the model as a national circular economy reference.

S+T — Use strengths to mitigate threats. The model's cost competitiveness and integrated service offer — combining removal, reconditioning, and on-site delivery — differentiates it from digital-only marketplaces. Documented savings such as those

achieved at Palmer Residence are the most effective lever to overcome client reluctance and build procurement confidence.

W+O — Address weaknesses through regulatory momentum. Growing policy pressure around mandatory reuse percentages creates the right conditions to resolve unresolved barriers around insurance and quality certification. Public funding can also finance the digital tools needed to manage multi-site coordination complexity.

W+T — Consolidate before scaling. The priority is to document and standardise the operational protocol — site assessment, selective removal, reconditioning, logistics — before broader deployment, reducing dependence on individual expertise and making the model insurable and transferable.

Strategic fit and priority actions

The Pop-Up Factory is well suited to the Bordeaux context, where aging housing stock, an active urban renewal program, a committed social housing operator, and a supportive regulatory environment are rarely as aligned. Three actions are critical to its success: securing additional documented pilots; resolving the insurance and liability framework for reused components; and developing the digital supply chain and marketplace tools required for systematic multi-site deployment.

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Spanish Ecosystem Report

This Annex presents the analysis of the Spanish ecosystem with regard to the market potential and feasibility of Pop-up Factory (PuF) concepts, with the aim of informing the development of implementation plans, scenarios, and supporting activities. The methodological framework adopted for this assessment is described in detail in Deliverable D4.1 of Work Package 4. The findings presented in this Annex are subsequently compared and discussed alongside the results from the other national ecosystems in the main report, contributing to a broader cross-ecosystem evaluation of the opportunities and challenges associated with the deployment of PuF models.

Addressing ecosystem needs: Offering a deep-renovation kit by a local pop-up factory scenario

Various theories and concepts have been developed to boost the efficiency of deep retrofits. One of the key challenges is to turn these theories and concepts into real-world implementations being adopted beyond demonstration. In this chapter the preferred local pop-up factory scenarios are being presented for each Ecosystem.

The Spanish Ecosystem deep-renovation needs

The Spanish building stock faces a critical challenge in terms of energy efficiency. Approximately 83% of the Spanish building stock has very low energy quality, a situation aggravated by the accelerated aging of buildings, threatening to make obsolete a building stock that represents the main source of savings for Spanish households due to the importance of homeownership in our country.

Historical context of the building stock:
Approximately 25 million homes (60% of the residential stock) were built before the first national regulation that established regulatory requirements in energy matters: the Basic Building Standard NBE-CT/79, which required a minimum level of thermal insulation in the building envelope.
95% of the primary housing stock predates the Technical Building Code approved in 2006, which establishes energy efficiency conditions for buildings and transposed European Directive 2002/91/EC on the energy performance of buildings (subsequently amended in 2010 and 2018).
Housing currently under construction (approximately 80,000-100,000 homes per year) is assumed to meet the definition of Nearly Zero Energy Buildings and has adequate energy performance.

Energy certification of the existing stock:
By the end of 2019, approximately 4 million energy performance certificates for existing buildings had been registered. Analysis of certificate evolution shows that the existing building stock is based on rating E, with a clear but slow evolution toward higher ratings. Half of the existing building stock is in category E, with a small evolution observed from categories G and F.

Renovation rate and climate objectives:

The turning point in which we are immersed relates to the transformation of the Spanish economy: renovation is a strategic political strategy to economically revolutionize our country, modernize it, improve the sustainability of our cities, and reduce energy dependence.
The building renovation rate should be around 2-3% annually to meet climate neutrality objectives by 2050. However, the European average currently stands at around 1%, and Spain, with a rate below 0.3%, is in the lowest positions.
Investment in improving the building stock has never been part of consumer spending priorities, a cultural barrier that we must all begin to eliminate. Renovation is a central strategy for mobilizing EU funds until 2026. If this is the turning point, we can only grow now.

The local pilots of the Spanish Ecosystem

Case Pilot: Public Body Headquarters – Salesas, Pamplona
The Salesas pilot represents one of the most complex and nuanced renovation scenarios within the BuildUPspeed Spanish ecosystem. It involves the transformation of a former monastery building into a fully operational public body headquarters — a typology that sits at the intersection of heritage conservation, adaptive reuse, and industrialized construction.
A Heritage-Constrained Renovation
The building is a protected, listed asset, meaning that the renovation must comply with strict heritage regulations governing the preservation of specific original architectural elements. This constraint introduces a layer of complexity that goes beyond standard renovation projects: the construction system selected cannot simply be optimized for efficiency or performance in isolation, but must be capable of adapting to the unique geometries, materials, and structural conditions imposed by the existing building. Far from being a limitation, this condition becomes a key test for the flexibility and adaptability of industrialized solutions — demonstrating that these approaches are not exclusively suited to standardized or repetitive building typologies.
CLT in a Non-Residential, Heritage Context
The construction system chosen for the intervention is CLT (Cross Laminated Timber), a wood-based industrialized building system. Its use in this project is particularly significant for two reasons. First, it challenges the common perception that CLT is primarily a solution for new-build or residential projects — here, it is applied to an office conversion within a historic monastery building. Second, CLT's inherent properties — lightweight, dry-assembled, dimensionally precise, and reversible — make it especially well-suited to working within the constraints of a listed building, where minimizing structural impact on existing fabric is essential.

Multiple value creation: Matching local pop-up factory scenario with local needs
This paragraph provides a discussion on the type(s) of pop-up factory scenario which best suits each Ecosystem, including, when possible, insights obtained through the modifications and optimizations made while developing it and testing it.

Local pop-up factory scenario: Assembly factory

Exploring the Pop-Up Factory Concept in Pamplona

The project's location in Pamplona opens a valuable opportunity to explore the local pop-up factory model in practical terms. ACR, as the construction company leading the Spanish ecosystem pilot, has deep-rooted relationships with small and medium-sized local suppliers and subcontractors in the Navarre region — a network built through years of emblematic projects in the area, including the Parliament of Navarre, the CIMA research centre, and Pamplona's Music Complex. This proximity to a trusted local supply chain creates fertile ground for testing how industrialized renovation components can be prefabricated or assembled close to the construction site, reducing logistics complexity, supporting local economies, and demonstrating the viability of a territorially embedded production model for industrialized renovation.

Assembly Factory, facilities near project sites focused on assembling prefabricated components; Production of singular pieces on-site

External Business Environment of the local pop-up factory

In a first step the external business environment of the pre-selected local pop-up factory will be defined in detail. Different fields of external factors which influence the operation of the pop-up factory are considered, such as the market demand and existing alternatives, the customers and competitors as well as influence of environmental, economic, technological, socio-cultural and political trends.

Market demand analysis

Over the last five years, the Spanish construction sector has shown a **clear post-pandemic recovery**, although with some deceleration after the interest-rate shock of 2023–2024. According to Funcas[16], construction accounted for **around 5.0% of Spain's GDP in 2023**, close to the EU-27 average of 5.2%. After the pandemic, sector gross value added grew strongly, at an annual rate of **7.2% between 2019 and 2022**, before stagnating in 2024 as higher material, energy and financing costs constrained activity. Funcas also stresses that labour shortages are becoming a structural bottleneck for the sector.

The most relevant market segment is residential construction and renovation, rather than civil engineering or large non-residential works. The Spanish housing market is currently characterised by strong demand and insufficient supply. BBVA Research[17] estimates that unmet demand accumulated between 2021 and 2025 reached about 625,000 households, while CaixaBank Research[18] similarly identifies an accumulated deficit of more than 500,000 homes since 2021. CaixaBank notes that, since 2021, only about 118,000 new homes per year have been approved on average, compared with the creation of around 226,000 households annually. This mismatch supports continued demand for faster, more scalable delivery models in housing and building upgrading.

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[16] **Funcas** (2025) "Weakness in overall construction sector profitability: Low productivity exacerbated by labour shortages", in *Spanish and International Economic & Financial Outlook (SEFO)*.
[17] **BBVA Research** (2025) *Spain Real Estate Watch. November 2025*.
[18] **CaixaBank Research** (2025) *Spain's housing market enters a new expansionary phase*.

The renovation and energy-retrofitting market is also structurally important, because a large part of the housing stock is old and in need of upgrading. The Spanish residential building stock comprises approximately 25.2 million dwellings (Census 2021). The segment with the greatest rehabilitation potential is that of multifamily buildings of more than 3 floors built between 1961 and 1980, which account for 22% of the total stock (approximately 5.6 million dwellings). These are the buildings with the greatest need for energy intervention and the highest improvement potential. A second relevant segment consists of buildings built before 1940, found especially in historic city centres. Public policy is reinforcing this trend. The Ministry of Housing states that the NextGenerationEU rehabilitation programmes support residential renovation provided projects achieve at least 30% energy savings, with grant intensity typically between 40% and 80% depending on performance. At EU level, the recast Energy Performance of Buildings Directive (EPBD) entered into force on 28 May 2024 and must be transposed by 29 May 2026, which will further strengthen the pipeline for renovation, decarbonisation and industrialised building solutions.

The current penetration of industrialized solutions in Spain stood at around 1% of total works in 2021, according to the Platform for Housing Industrialization (PIV). The goal of the Spanish ecosystem within the project is to increase this figure to 1.6%.

At the provincial level, Navarre is actively engaged in improving the energy performance of its building stock. As an initial step, the focus has been on identifying the starting point in terms of Energy Performance Certificates (EPC) for public buildings Información Energética De Gobierno De Navarra.

The main alternatives competing with the PUF model are traditional on-site construction (the dominant method, without centralized logistics), off-site prefabrication with direct delivery to the construction site without an intermediate node, and service factory or advisory platform models without their own productive capacity. In the Spanish context, given that awareness of industrialized solutions is still in its early stages, the greatest threat does not come from comparable alternative models but rather from market inertia towards traditional craft construction, which is the real default substitute.

Customer analysis

There is a wide range of potential customers in the Spanish renovation market, from private homeowners and homeowner communities to public housing bodies, public developers and heritage-building owners. For the type of renovation that best fits industrialised delivery, however, demand is concentrated in a smaller number of customer groups with recurring needs, sufficient scale, and a clear policy incentive to improve energy performance. This demand is shaped by Spain’s ageing housing stock, by the national rehabilitation framework linked to the Recovery, Transformation and Resilience Plan (PRTR), and by the tightening regulatory context associated with the recast Energy Performance of Buildings Directive (EPBD). In Spain, access to NextGenerationEU support for residential rehabilitation generally requires at least a 30% reduction in non-renewable primary energy consumption, which strongly favours interventions in façades, building envelopes and other repeatable energy-upgrade packages. The Ministry of Housing also places rehabilitation alongside the expansion of affordable rental housing as one of the central pillars of current housing policy, while

the EPBD will continue to push the market towards renovation and decarbonisation in the near future.
The first and most relevant segment consists of homeowner communities in multifamily buildings from 1960–1980, which represent the primary target. These are private owners organized under a property manager, whose collective decision-making capacity is slow and complex. The presence of a professional external manager to facilitate the process is crucial for activating demand. This segment is particularly relevant in Spain, where a large share of the housing stock is old and requires energy upgrading. They have access to PRTR subsidies and are sensitive to price and to minimizing the disruption of construction works on their daily lives. Their bargaining power is limited by fragmented decision-making, although their price sensitivity is high.

The second segment comprises public housing associations and public developers, who manage homogeneous housing stocks and have medium-term mass renovation plans. These are clients with greater demand aggregation capacity and lower unit price sensitivity, but with slow decision-making processes subject to public procurement. They represent the most favourable segment in terms of scale, as they can generate renovation volumes that are better suited to standardised and industrialised solutions. At the same time, their influence on prices is relatively strong because procurement procedures tend to emphasise compliance, competition and cost control.
The third segment consists of public bodies and owners of listed or heritage buildings (such as the Salesas case), who seek solutions adapted to protected buildings. These clients have high technical demands, long decision cycles, and budgets that depend on specific budget lines. Their influence on pricing is limited, but the complexity of their projects can generate potentially higher margins.
The fourth segment comprises individual private owners of single-family homes, identified as an emerging segment with potential once specific subsidies for middle-income households are developed, but currently showing limited penetration of industrialized solutions. These customers usually purchase on a one-off basis, have smaller project volumes and are highly price-sensitive. Their influence on prices is low, as their demand is fragmented and their bargaining power limited.
Overall, the Spanish market shows a clear hierarchy in customer influence on prices. Public housing bodies and public developers are the most influential segment because they aggregate demand and procure through formal tendering procedures. Homeowner communities are likely to represent the largest practical market for energy renovation, but their bargaining power is weakened by fragmented governance and complex decision-making. Heritage-building owners have lower direct price leverage, although their projects may allow higher margins due to their technical complexity. Individual single-family homeowners exert the least influence on prices, since their projects are small and their demand is highly dispersed.

Competitor analysis

The Spanish market for renovations that fit an industrialised delivery model is still emerging and remains less mature than conventional building construction. Competition does not yet take the form of a large number of fully established operators with integrated off-site production for residential renovation. Instead, it is characterised by a highly fragmented building sector, a limited but growing industrialised-construction ecosystem, and a wider network of contractors, manufacturers, engineering firms and

project managers that can combine to deliver standardised renovation solutions. Sectoral analyses also point to the predominance of small and medium-sized firms in construction, which helps explain why industrialisation is advancing more through partnerships and specialised platforms than through a large number of vertically integrated firms.

For this reason, the most relevant competitors are not only construction firms in the traditional sense, but also those actors capable of organising an industrialised delivery chain for residential building works. In practice, this includes building contractors, prefabrication and component manufacturers, specialised off-site firms, engineering companies and consortium managers. On the demand side, public housing bodies, developers and homeowner communities remain the commissioning clients, but they are not necessarily the actors that will invest directly in production capacity. Rather, they are more likely to influence the market by aggregating projects, shaping procurement criteria and selecting delivery models. The firms most likely to invest in an industrialised platform are therefore those seeking to optimise execution times, standardise processes and improve their service offering in residential refurbishment. This interpretation is consistent with the policy approach of the new PERTE for housing industrialisation, which explicitly aims to create industrial capacity and promote collaboration across the value chain.

The main determinants of competition in this market are price, delivery time, technical reliability, capacity to comply with subsidy and regulatory requirements, and the ability to minimise disruption during works. In conventional renovation, competition is still largely based on price and local contractor relationships. In the industrialised segment, however, firms increasingly compete on their ability to offer integrated and repeatable solutions, including design adaptation, manufacturing, logistics, installation and compliance with energy-performance targets. Recent sector work in Spain links the growth potential of industrialised construction precisely to its capacity to improve productivity, reduce delays, address labour shortages and scale up housing delivery.

The sector is highly fragmented and atomized, composed mainly of SMEs that lack sufficient scale to autonomously operate an industrialized model. This reduces the threat of new entrants with their own PUF model, but increases the likelihood of service platforms or consortium managers emerging to aggregate existing actors. The low market maturity in industrialized solutions acts as an informal entry barrier, but also represents an opportunity for those who first consolidate a model. In this sense, the most plausible new entrants are not entirely new firms, but existing building, manufacturing or development actors that expand into industrialised refurbishment through alliances, dedicated platforms or selective investment.

The threat of new entrants should therefore be considered moderate. Entry barriers remain significant, including the need for upfront investment, process standardisation, coordination across the supply chain, and access to a stable project pipeline. Overall, rivalry is likely to intensify over the next few years, but competition will probably centre on which actors are able to organise the most efficient project-based production and delivery ecosystem for residential renovation.

The Spanish construction sector has shown a steady recovery since the 2008 economic crisis, with renovation activity growing approximately 10% in the number of buildings between 2017 and 2019. However, this growth remains well below neighbouring countries and insufficient to meet national climate objectives. Spain's current building renovation rate stands below 0.3% annually, far from the 2–3% required to achieve climate neutrality by 2050. At the same time, official data point to renewed activity in both residential construction and rehabilitation: in 2024, permits for new dwellings increased by 16.7%, while permits linked to residential renovation rose by 7% compared with 2023.[19][20]

The injection of Next Generation EU funds (PRTR) from 2021 onwards has created an unprecedented stimulus for renovation, triggering growing demand particularly in residential multifamily buildings. National policies such as the PNIEC 2021–2030 and the Long-Term Strategy for Energy Rehabilitation (ERESEE) are aligning public investment and regulatory pressure toward accelerating renovation. In parallel, the new **PERTE for housing industrialisation** points to a structural shift in the sector, as it seeks to scale up industrialised construction capacity in order to reduce delivery times, improve productivity and respond more effectively to housing needs[21][22][23].

The prospects for the next five years are therefore positive, although growth is expected to be moderate rather than exceptional. Sector forecasts indicate that both residential construction and renovation should continue expanding in the near term, supported by housing shortages, decarbonisation targets, and the implementation of EU recovery funds.In Navarre specifically, the regional government has begun systematically mapping the energy performance of public buildings as a strategic baseline for future investment, indicating a strong institutional drive for large-scale intervention[24]. The prospect of a new national R&D centre focused on industrialization further points to a structural shift that could expand the market for solutions such as the Assembly Pop-Up Factory over the next five years.

Business case

The market analysis established both the scale and the urgency of residential renovation in Spain and the specific characteristics of the Spanish ecosystem that call for modular, industrialized approaches. In this section we evaluate their financial fit for the Spanish market and underpin what circumstances would be most beneficial for the financial viability of the popup factory. The pop-up factory type that better fit this ecosystem: the *Assembly Factory*.

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[19] **Observatorio 2030** / **CSCAE** (2022), *Claves de sostenibilidad para acelerar el proceso de rehabilitación de viviendas en España*.
[20] **FIEC** (2025), *Statistical Report 2025: Spain*.
[21] **MIVAU** (2020), *ERESEE 2020: Estrategia a largo plazo para la rehabilitación energética en el sector de la edificación en España*.
[22] **MIVAU** (2025), *PERTE de la industrialización de la vivienda*.
[23] **MIVAU** (2025), *Impacto esperado del PERTE*.
[24] **Gobierno de Navarra** (2019), *Presentada una web que informa sobre el consumo energético en los edificios del Gobierno de Navarra*.

Research Design

In this section, we present the steps followed to dive into the examined business case. Based on literature related to the evaluation of innovations for the redesign of the construction sector as well as the opinion of experts in the field, the main criteria selected are: the required financial investment, the fit to the project scale, and the ecosystem's fits to the region. These also depend on the type of ownership that is involved. Below, the criteria and ownership model will be explained.

PUF Application in Spain

Based on key assumptions and relevant risk considerations from experts, we elaborate on each ownership scenario and evaluate it against the 3 main evaluation criteria. Below, we elaborate on key assumptions and risk considerations from experts for the PUF assembly . Finally, we present the reasoning of this business case in the following paragraphs.

Table 61: The Assembly PUF compared across four ownership scenarios

Ownership scenario	**Assembly PUF**		
	Tool investments	**Project scale fit**	**Ecosystem fit**
Single construction company	High	Weak	Moderate
Consortium of construction companies	Medium	Strong	Strong
Industry Association	Medium	Strong	Strong
Housing corporations	High	Weak	Strong

Overall, the comparison suggests that the Assembly PUF is most viable when there is sufficient programme scale to justify the higher tool investments. This is reflected in consistently strong project scale fit for consortium, and industry association scenarios, while single company and housing corporation ownership shows a weaker scale fit despite ecosystem fit.

PuF type - Key assumptions and risk implications

The first is the **Assembly PuF workflow**, which handles newly supplied industrialised components. Incoming wood materials are received and stored, then undergo an initial cutting stage to prepare them for gluing, where components are bonded and any required adaptations are incorporated. A second, precision cutting stage follows, guided by BIM documentation to ensure accurate sizing and fitting at complex junctions. The finished assemblies are then completed by integrating the remaining building components into the industrialised solution, before being transported to their final installation position.

Internal Business Analysis of the local pop-up factory

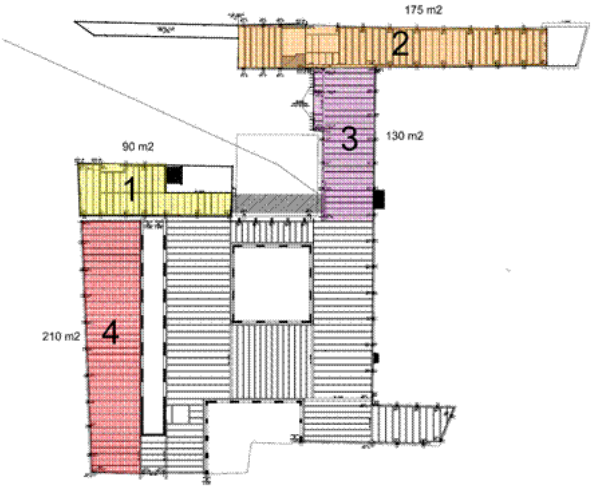
Puf Type - Value proposition

The Spanish PuF operates according to two complementary process flows that together define its full value chain.

The first is the **Assembly PuF workflow**, which handles newly supplied industrialised components. Incoming wood materials are received and stored, then undergo an initial cutting stage to prepare them for gluing, where components are bonded and any required adaptations are incorporated. A second, precision cutting stage follows, guided by BIM documentation to ensure accurate sizing and fitting at complex junctions. The finished assemblies are then completed by integrating the remaining building components into the industrialised solution, before being transported to their final installation position.
The second is the **Material Reuse workflow**, which runs in parallel and is specific to the Spanish pilot. Reusable structural elements are recovered from the demolition area — identified on the site plan in red — which corresponds to the zone that has undergone selective deconstruction. These materials are inventoried, assessed against quality standards, and any sections deemed unsuitable for reuse are discarded at this stage. The usable elements are then cut to specification using BIM-based documentation and subsequently assembled on site for installation.
Together, these two flows illustrate the circular character of the Spanish Assembly Factory: new industrialised components and reclaimed materials converge within the same on-site production logic, each following a tailored process path before being integrated into the final construction.
The material recovered through the reuse workflow consists of **timber beams** extracted from the demolished structural floor of the building. As can be seen in the photographs below, an initial visual and structural assessment revealed a significant reuse potential in a substantial portion of the beams. Following a first inspection, classification, and cleaning process, the beams were confirmed as suitable for reintegration into the new construction, contributing directly to the circular material approach that characterises the Spanish ecosystem.

Value Creation

During the construction phase, the PuF is organised into four distinct work areas, in which assembly activities take place alongside other tasks inherent to the construction process:



During the construction phase, the PuF is organised into four distinct work areas, where assembly activities take place alongside other tasks inherent to the construction process. The spatial distribution of these areas is as follows:

- Area 1: 90 m² Beam storage, precedence of raw material
- Area 2: 175 m² Other works
- Area 3: 130 m² Assempbly of CLT and elements
- Area 4: 210 m² PuF
- Total area: 605 m²

The team has extensive experience working with CLT elements in refurbishment projects, which enables both development and assembly to be carried out with a high degree of operational autonomy

Capabilities: 'upskilling' to operate the local pop-up factory

A local pop-up factory can be considered as an ecosystem on its own as it brings together the capacity of local SME's, addresses unemployment of local construction workers. This requires supporting training and upskilling programs for involved craftsmen, designers, engineers, architects, and operational construction workers, etc, using outcomes and methods of the BUS and Construction Skills projects. All in all it is important to consider the required competences, skills and know-how of (future) employees. Complementary, the processing of information, data and systems; institutional and legal conditions, and financial, technical and material resources to instate and operate the local pop-up factory are key capabilities to take into consideration.

For the Assembly Spanish PuF the following human capital is envisioned:

Job description: Title
Tasks and responsibilities: • Head of construction site, organize CLT storage and providing • Worker, know the task that needs to be done and study the planes
Capabilities:

- Prior experience
- Carpentry or equivalents

Recommended training:

- Wooden Structure Installer
- Specific training in the CLT system to be installed
- Documented training/authorisation for the equipment used (including practical training on existing equipment in accordance with the manufacturer's manual and site procedures)
- Specific training on industrialised renovation and circular construction practices.

Value Delivery

The Spanish Assembly PuF delivers value mainly through proximity to the construction site and integration with the construction workflow. Prefabricated and/or recovered timber elements can be received, temporarily stored, adapted and assembled close to their final installation point, reducing unnecessary handling and improving coordination between logistics, site management, subcontractors and installers.
In this case, the main value delivered to the client is not a direct cost reduction, but improved execution control. The close-to-site assembly process supports dimensional accuracy, better adaptation to heritage constraints, quicker response to unforeseen site conditions and improved quality assurance before installation. The PuF logic is therefore embedded in the construction schedule as an operational support system, helping to align material flows, assembly tasks and installation sequences.
From a social and local ecosystem perspective, the model also reinforces the role of local subcontractors and skilled workers, particularly those with experience in CLT, timber works, selective deconstruction and on-site assembly. Although no dedicated training programme was implemented, the pilot provides practical learning that could support future upskilling around industrialised renovation and circular construction practices.

Touchpoints and market activation

In the case of the assembly PuF in Spain, it was implemented in a non-residential building. The building was refurbished and converted from a monastery into an administrative building for the regional government of Navarre. The new users of the building (civil servants) found the renovation already completed when they moved in.
The prefabricated solution is designed for tertiary buildings; it cannot be directly applied to the nearby residential buildings. Non onboarding and/or sales activity was foreseen.

Value Capture

In the Spanish pilot, the Assembly PuF does not operate as an independent revenue-generating business model. It is not conceived as a separate commercial entity selling assembly services, nor does it currently include a specific revenue stream, service fee

or dedicated cost recovery mechanism. Its costs are embedded within the overall construction process and managed through the existing contracting chain.
Value capture is therefore mainly indirect. The PuF contributes to broader project value by improving operational efficiency, execution precision, quality control and the capacity to adapt industrialised CLT elements to the specific requirements of a complex heritage renovation. Potential benefits may include fewer execution errors, better coordination of subcontracted works, improved use of recovered timber elements and reduced logistical friction on site.
The non-financial value is particularly relevant. The model supports local supply-chain activation, strengthens practical know-how in industrialised renovation, promotes the reuse of timber elements where technically feasible, and demonstrates how a close-to-site assembly logic can be applied in complex public and heritage-building contexts.
For future replication, economic value capture would require a clearer business model, a stable pipeline of projects and a defined mechanism to allocate the benefits among clients, contractors, suppliers and local partners.

Cost structure and revenue model

It is not possible to provide data on the “cost structure and revenue model”, as the Spanish Assembly PuF that has been analysed was not initially conceived as such, and the cost structure of the initiative is included within the overall costs of the entire renovation project; therefore, there is no disaggregated data on the costs associated with the PuF.

Summary of findings

The Spanish case focuses on an Assembly PuF logic, rather than on a fully independent or stand-alone pop-up factory business model. The PuF is embedded within the construction site organisation and supports the adaptation, preparation and assembly of industrialised CLT-based components and selected recovered timber elements close to their final installation point.
The main benefit of this model is operational. It improves coordination between design, logistics, subcontractors and on-site installation, while supporting higher execution precision in a complex heritage renovation context. Its value lies particularly in the capacity to respond to site-specific conditions, reduce handling complexity, improve quality control and make better use of local skills and supply-chain relationships.
From a business model perspective, the Spanish Assembly PuF cannot yet be considered a self-sustaining commercial model, as it has no separate revenue stream or confirmed demand pipeline. However, it is a viable operational model when integrated into a specific renovation project and managed through the existing contracting structure. Future replication would require three main steps: early integration of the PuF logic in the design and planning phase, clear allocation of responsibilities among contractors and suppliers, and a stable portfolio of similar renovation projects to justify repeatable processes and potential cost optimisation.

The table below shows Assembly PUF respectively of the Spanish ecosystem summarized through the Business Model Canvas. The three areas depict the three types of value as seen in the business model canvas; value creation (value proposition, customer relationships, customer segments, channels),

value delivery (key partners, key activities), and value capture (cost structures, revenue streams).

Table 62: Business Model Canvas summarizing the Assembly PUF of the Spanish ecosystem.

<table>
<tr>
<td rowspan="2">Key partners

Key partners include the main contractor (ACR), local SMEs and subcontractors in the Navarre region, suppliers of prefabricated components, and public clients. The model strongly depends on existing local supply chain relationships and collaboration networks</td>
<td>Key Activites

Key activities include on-site and near-site assembly of prefabricated components, selective deconstruction, material sorting and reuse, and the integration of components into the construction process. These activities are organised spatially across multiple work zones and supported by BIM-driven design and cutting processes</td>
<td rowspan="2">Value Proposition

The value proposition is based on the integration of industrialised assembly and circular material reuse within a near-site production environment. The Assembly PUF combines prefabricated components (e.g. CLT elements) with reclaimed materials from selective demolition, creating a hybrid circular construction process. This approach enables adaptation to complex contexts such as heritage buildings with value primarily driven by improved adaptability, precision, and execution control in complex contexts</td>
<td>Customer Relationships

Customer relationships vary per segment but are generally project-based and influenced by procurement structures and collective decision-making processes. In homeowner communities, relationships are complex and mediated by property managers, while public clients operate through formal procurement and long decision cycles.</td>
<td rowspan="2">Key partners

Key partners include the main contractor (ACR), local SMEs and subcontractors in the Navarre region, suppliers of prefabricated components, and public clients. The model strongly depends on existing local supply chain relationships and collaboration networks</td>
</tr>
<tr>
<td>Key Resources

The model relies on a combination of skilled labour experienced in CLT construction, temporary on-site or near-site production space, BIM-based digital tools, and access to reusable materials recovered from demolition. A strong local SME network also functions as an important resource</td>
<td>Channels

The Assembly PUF operates primarily through project-based and programme-based procurement channels, including public tenders and renovation programmes supported by EU funding. Delivery channels consist of near-site production and direct integration into construction sites, supported by local contractor networks.</td>
</tr>
<tr>
<td colspan="3">Cost Structure

Costs are embedded within the overall construction process and managed through the existing contracting chain.</td>
<td colspan="3">Revenue Streams

NO information are available about the revneue streams</td>
</tr>
</table>

SWOT analysis: Strategic orientation for the introduction of the local pop-up factory

The SWOT analysis below reflects the current status of the Spanish Assembly Pop-up Factory (PuF) scenario. It should be interpreted as an operational feasibility assessment rather than as evidence of a fully consolidated business model. In the Spanish pilot, the PuF concept emerged from the execution logic of the Salesas renovation rather than from a pre-defined PuF implementation strategy. Therefore, the main value identified at this stage is operational: improved precision, better adaptation of CLT-based components to a complex heritage building, local coordination of assembly tasks, and the possibility of integrating selective reuse workflows. No direct economic advantage has been demonstrated with the available data.
The analysis also assumes that the Spanish PuF is best understood as an Assembly Factory located close to, or embedded within, the construction site. It supports the preparation, adaptation, assembly and quality control of prefabricated timber-based components and reclaimed elements before final installation. Its feasibility depends less on dedicated industrial investment and more on the capacity to organise skilled subcontractors, logistics, BIM-based documentation, site planning and quality assurance around a repeatable workflow

Strength

• Operational precision in a complex heritage context. The Salesas pilot shows that an Assembly PuF logic can support accurate adaptation of CLT components to non-standard geometries, protected elements and complex interfaces.
• Low need for dedicated PuF-specific equipment. The Spanish scenario relies mainly on existing construction-site resources, subcontracted trades, local logistics and standard tools, which reduces upfront investment compared with a fully equipped production facility.
• Strong fit with CLT and dry-assembly solutions. The use of CLT is compatible with off-site preparation, on-site adjustment and rapid assembly, while reducing wet trades and supporting reversibility in heritage-sensitive renovation.
• Local supply-chain integration. The pilot benefits from ACR's existing network of local suppliers and subcontractors in Navarre, which facilitates coordination, responsiveness and knowledge transfer.
• Circularity potential through material reuse. The selective recovery and assessment of timber beams from demolition areas provides a practical link between the PuF concept and urban mining strategies, even if this remains project-specific.
• Potential to generate reliable process knowledge. Project documentation, planning data, LPS information and interviews can provide evidence on time, quality, coordination and operational risks, even where financial PuF data are incomplete.

Weakness

The PuF was not originally planned as a formal pilot concept. As a result, the site was not designed from the outset to collect PuF-specific data, define a dedicated business model, or test a replicable PuF governance structure.
• Limited evidence of economic advantage. Available information indicates that the Spanish PuF does not currently provide a clear cost advantage; its value is mainly linked to execution quality, precision, coordination and operational control.
• Undefined revenue and ownership model. There is no separate revenue stream for the PuF, and the model is embedded within the construction project rather than operated as an independent service or facility.
• Weak market and demand validation. The feasibility study identifies a lack of confirmed anchor clients, renovation pipeline and recurring demand able to justify a scalable PuF business case.
• Dependence on experienced teams. The operational know-how required for CLT adaptation, heritage constraints, logistics and quality control is largely experience-based and not easily transferred within a short feasibility period.
• Limited standardisation due to building specificity. Heritage renovation requires case-by-case technical adaptation, reducing the degree of repetition normally needed to capture industrialisation benefits.

Opportunities

The PuF was not originally planned as a formal pilot concept. As a result, the site was not designed from the outset to collect PuF-specific data, define a dedicated business model, or test a replicable PuF governance structure.
• Limited evidence of economic advantage. Available information indicates that the Spanish PuF does not currently provide a clear cost advantage; its value is mainly linked to execution quality, precision, coordination and operational control.
• Undefined revenue and ownership model. There is no separate revenue stream for the PuF, and the model is embedded within the construction project rather than operated as an independent service or facility.
• Weak market and demand validation. The feasibility study identifies a lack of confirmed anchor clients, renovation pipeline and recurring demand able to justify a scalable PuF business case.
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• Limited standardisation due to building specificity. Heritage renovation requires case-by-case technical adaptation, reducing the degree of repetition normally needed to capture industrialisation benefits.

Threats

The PuF was not originally planned as a formal pilot concept. As a result, the site was not designed from the outset to collect PuF-specific data, define a dedicated business model, or test a replicable PuF governance structure.
• Limited evidence of economic advantage. Available information indicates that the Spanish PuF does not currently provide a clear cost advantage; its value is mainly linked to execution quality, precision, coordination and operational control.

• Undefined revenue and ownership model. There is no separate revenue stream for the PuF, and the model is embedded within the construction project rather than operated as an independent service or facility.
• Weak market and demand validation. The feasibility study identifies a lack of confirmed anchor clients, renovation pipeline and recurring demand able to justify a scalable PuF business case.
• Dependence on experienced teams. The operational know-how required for CLT adaptation, heritage constraints, logistics and quality control is largely experience-based and not easily transferred within a short feasibility period.
• Limited standardisation due to building specificity. Heritage renovation requires case-by-case technical adaptation, reducing the degree of repetition normally needed to capture industrialisation benefits.

Findings and conclusions

The strategic orientation for the Spanish Assembly PuF should be conservative and evidence-based. The concept should not be presented as a mature, economically proven factory model, but as a promising operational configuration that can improve precision, logistics coordination and quality in complex renovation projects. The following TOWS options are the most relevant:
• SO strategy - Use technical strengths to exploit renovation opportunities. The experience gained in the Salesas pilot should be positioned as a reference case for CLT-based, heritage-sensitive and public-building renovation, highlighting precision, dry assembly, reduced disruption and potential circularity.
• SO strategy - Convert the local supplier network into a repeatable delivery ecosystem. Existing relationships with local subcontractors and suppliers can be formalised into a standard workflow for future renovation projects, including roles, interfaces, documentation and QA procedures.
• WO strategy - Address data gaps through a PuF monitoring protocol. Future pilots should define PuF-specific indicators before works begin, focusing on operational value: installation time, rework, quality defects, waste generated, reused material flows, number of local companies involved and logistics distance.
• WO strategy - Develop a light business case around services, not infrastructure. Because no strong cost advantage has been demonstrated, the short-term value proposition should focus on assembly coordination, quality assurance, BIM-to-site adaptation and circular material handling rather than on a standalone factory investment.
• ST strategy - Use precision and planning to reduce heritage and regulatory risks. Early design freeze, BIM-based documentation, heritage constraints mapping, access planning and crane/logistics planning should be used to reduce uncertainty in similar projects.
• WT strategy - Avoid scaling until demand is validated. Replication should only be proposed where there is an anchor client, a clear project pipeline, and enough repeatability to justify the additional coordination effort.
Overall, the preferred strategy is a conditional development pathway: consolidate the Assembly PuF as an operational method first, then test its economic viability only in future projects with a stable pipeline, predefined KPIs and a clearer contracting model.

Italian Ecosystem Report

Annex presents the analysis of the Italian ecosystem with regard to the market potential and feasibility of Pop-up Factory (PuF) concepts, with the aim of informing the development of implementation plans, scenarios, and supporting activities. The methodological framework adopted for this assessment is described in detail in Deliverable D4.1 of Work Package 4. The findings presented in this Annex are subsequently compared and discussed alongside the results from the other national ecosystems in the main report, contributing to a broader cross-ecosystem evaluation of the opportunities and challenges associated with the deployment of PuF models.

Addressing ecosystem needs: Offering a deep-renovation kit by a local pop-up factory scenario

Various theories and concepts have been developed to boost the efficiency of deep retrofits. One of the key challenges is to turn these theories and concepts into real-world implementations being adopted beyond demonstration. In this chapter the preferred local pop-up factory scenarios are being presented for each Ecosystem.

The Italian Ecosystem deep-renovation needs

Key focus for the Italian ecosystem is the metropolitan city of Milan, since it's the most responsive to new renovation approaches, and it has a radial infrastructure, so all peripheries are suitable for the delivery on industrialized components supplied by Lombardy, and other close regions.
In Italy, Milan manages the largest number of **social housing units**, which represents a relevant portion of the residential stock. Such stock generally suffers from severe under-funding; hence it has a low level of new supply and problems with maintenance, management and refurbishment of the stock (an estimated 10% of the units are vacant since they are not in the condition to be rented). For this reason, models of factories supplying components for both new affordable housing, deep renovation, and demolition plus reconstruction of buildings are needed to be explored to create synergies and economies of scale. Key focus for the Italian ecosystem is the metropolitan city of Milan, since it's the most responsive to new renovation approaches, and it has a radial infrastructure, so all peripheries are suitable for the delivery on industrialized components supplied by Lombardy, and other close regions.
The Milanese renovation market is in line with the broader Italian one and is characterized by a strong and structurally anchored demand that aligns closely with the conditions required for the deployment of a pop-up factory model. Italy counts approximately **12.4 million residential buildings (32 million dwellings)**, **with public social housing covering around 1 million units and cooperative housing managing 100.000 dwellings**. More than 60% were built before the first national energy regulation (1976), making them inherently inefficient and in need of both insulation upgrades and system modernization. The 25% of this amount is made by buildings requiring from 160 kWh/m2 to 220 kWh/m2 per year. This structural obsolescence is reflected in the national energy label distribution: 68% of

dwellings fall within classes G to E, with only 20% in classes A–B. Even in advanced metropolitan areas like Milan, the percentage of dwellings in low energy classes remains high (≈58%), confirming that energy performance constitutes a widespread bottleneck in the housing market and a clear driver for large-scale renovation strategies. The same can be said for social housing since it does not perform better than the average residential stock.

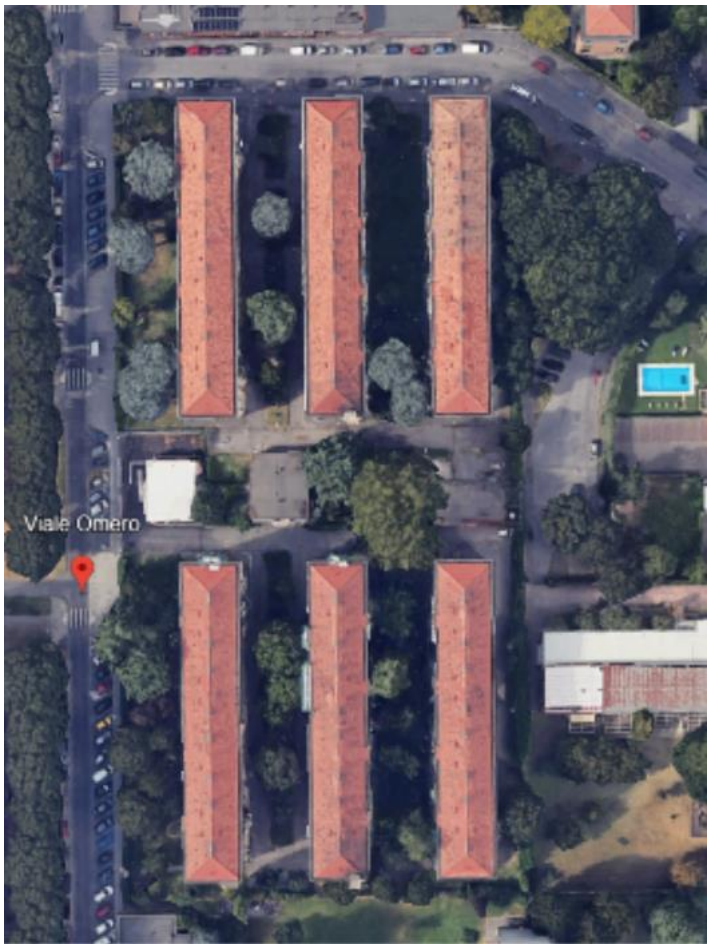
Epoca di costruzione	N. Edifici	Epoca di costruzione	Superficie (m²)
<1919	1.832.503	fino al 1945	678.743.665
1919-1945	1.327.007		
1946-1960	1.700.834	1946-1976	1.293.138.628
1961-1970	2.050.830		
1971-1980	2.117.649		
1981-1990	1.462.766	1977-1990	600.244.196
1991-2000	871.017	1991-2014	439.536.250
2001-2005	465.092		
2006-2011	359.991		
2012-2018	232.714	post 2014	38.143.445
Totale	12.420.403	Totale	3.049.806.184

Figure 105: Residential buildings in Italy by construction period: prevalence of pre 1976 stock.

In Italy, the **52.4% of the population is living in apartments within multi-family properties**. The 22.8% in single families. The remaining 24.4% lives in semi-detached houses. These data highlights that in most of the cases, decisions at building level must be shared and agreed with different families living in the same condominium. Of course, organizing any intervention in this context make the decision process for the renovation more difficult.
This problem is partially overcome when dealing with public social housing. Indeed, they offer a unique opportunity to deliver effective retrofits programs at scale.

The **77.4% of Italian families own the apartments where they are living**. The 8.8% of the building stock is for rent. The share is reversed when dealing with social housing.
The public one is indeed mainly rented while cooperatives can be both owned and rented by its members. The 6% of the owners is younger than 35 years; the 56% is between 35 and 65 years;
the remaining 38% is older than 65 years. **The distribution of the age of building owners** could play an important role in the strategy to adopt to promote the renovation uptake. It is, then, worth noticing that the composition slightly differs for public social housing that has a lower share of young and old households.
Moving to **seismic aspects**, more than half of the buildings date back to before 1974, that is, when construction was also carried out without rules and often without even zoning plans. Between 4 and 5 million buildings and public structures today are not up to seismic standards and are at risk of injury or partial collapse. The South has the highest risk: 45% of the pre-1971 national built environment is in the South, 22% is in the Centre and the rest is in the North.

The lot, located at number 15 Viale Omero, represents an emblematic example **of public social housing** dating back to the post-war period, with 6 Siedlung-type buildings constructed between 1950 and 1960, owned by the Comune di Milano and managed by MM S.p.A., currently in a state of partial decay.
Within the large common courtyard, which functions as the distribution space of the complex, the residential units are arranged symmetrically along the East-West axis, optimizing natural lighting and cross-ventilation inside the dwellings.



The entire complex operates according to the logic of a gated community, meaning a closed and controlled residential environment. This configuration ensures privacy and security, but at the same time reduces interaction with the public realm and with the neighbourhood, limiting the potential for urban and social integration.
The complex includes a significant number of green areas, consisting almost exclusively of planted beds with tall trees that provide shading at ground level, act as visual filters between the different buildings, and contribute to microclimatic improvement and mitigation of the urban heat island effect. However, the greenery is mainly functional, lacking equipped areas or elements that could enhance its collective use. There is, in fact, no design approach aimed at improving spatial quality or creating usable areas for specific activities or social gathering moments, such as playgrounds, relaxation areas, or integrated pedestrian paths. In the surroundings of the site, the presence of schools, a central cycle path running along Viale Omero, and

a park equipped with children's play structures highlights an urban context with existing services and public spaces.





The Italian pilot in Milan therefore focuses on a **sustainable renovation**, starting from a single building and subsequently replicable across all six structures of the complex. The building, having 5 storeys and a total gross floor area of 4000 m^2, is made of reinforced-concrete elements combined with brick infill walls and an exterior finish in traditional plaster. It is in poor condition, with outdated installations, single-glazing wooden windows, no insulation, and an energy performance class G. Furthermore, the stairs leading to the raised habitable ground floor implies that no apartments can be reached by people with motor disabilities.
The intervention aims to extend the service life of the buildings, improve overall accessibility and liveability, beside achieving Energy Class A, through the installation of new insulation, new technical systems, and the adoption of innovative practices enabled by offsite systems.
This pilot was selected because public social housing buildings are highly widespread in Italy, particularly in Milan, and show a significant need for retrofit interventions. Furthermore, the uniformity of these typologies in Milan offers a significant potential for scalable renovation solutions, making them particularly suitable for standardized and industrialized retrofit processes produced in dedicated manufacturing environments, such as pop-up factory ones.

See *Annex VIII* for more information.

Multiple value creation: Matching local pop-up factory scenario with local needs

This paragraph provides a discussion on the type(s) of pop-up factory scenario which best suits each Ecosystem, including, when possible, insights obtained through the modifications and optimizations made while developing it and testing it.

Local pop-up factory scenario: Satellite factory

The satellite factory for the Italian ecosystem is composed by:

- **The main hybrid factory** producing concrete offsite elements both for renovation (façade panels) and new construction (slabs, stairs and façade panels).

- A **close-to-site manufacturing** for producing or integrating certain components near the building site, which is the assembly location of the panels on the fabric. While the offsite factories have big storage space, the close-to-site ones are smaller and more locally oriented, so the logistic need to be adapted to their needs and constraints. For this reason, a Just-in-Time (JIT) delivery process, which coordinates the supply and integration of windows, other finishing rather than plaster (photovoltaics, green roof or facades, cladding), heat pump or mechanical ventilation components, electric, hydro connections and seismic dumpers.
- In addition, onsite **tenant engagement service**s are provided since they are crucial in social housing context. Indeed, residents' cooperation ensures smooth installation, minimizes disruptions, and helps adapt behaviours to maximize the benefits of new technologies.

External Business Environment of the local pop-up factory

In a first step the external business environment of the pre-selected local pop-up factory will be defined in detail. Different fields of external factors which influence the operation of the pop-up factory are considered, such as the market demand and existing alternatives, the customers and competitors as well as influence of environmental, economic, technological, socio-cultural and political trends.

Market demand analysis

The **demand for renovation** is supported at national level by a combination of financial instruments, renovation bonuses, energy-efficiency incentives, seismic bonuses, and by new multi-year funding streams. At EU level it's driven **policy obligations**, which impose progressive performance improvements on the residential stock. Under the EPBD (2024/1275) and the Energy Efficiency Directive (EED 2023/1791), Italy must achieve a reduction of at least 16% in primary energy consumption in the residential stock by 2030, reaching 20–22% by 2035, and ensure the renovation of 3% of the public building stock annually. Even if the regulatory trajectory places strong emphasis on the decarbonization of existing dwellings, a specific national law and detailed pathway have not yet been announced to reach such goals.

For this reason, Italy's deep-renovation rate remains low (around 0.85%), constrained by administrative complexity, credit access difficulties for construction firms, and decision-making fragmentation in multi-owner buildings.

The **2026–2032 Climate Social Fund and cohesion funds** (such as **European Regional Development Fund** - ERDF) mechanisms allocate about €10 billion for renovation and social housing programmers, with a focus on reducing energy poverty and renewing public buildings, including social residential stock and vulnerable homeowners. In Lombardy, the region spent its ERDF share through the **PR FESR Lombardia 2021-2027**, for a total of 2 billion, of which a part is dedicated to energy efficiency of public buildings and social housing. This creates a stable medium-term pipeline of interventions that demand predictable timelines and scalable delivery capacity, conditions in which the pop-up factory model provides a strong strategic match. However, quite often in Italy, availability of funds is announced last-

minute and there is a limited time to candidate initiatives, blocking innovative approaches (such as pop-up factories) to access grants.

The main incentive currently available for renovation is **Conto Termico 3.0**, which has the following characteristics:

- €900 million is the total 2026 budget available, split 50/50 between public administrations and private beneficiaries.
- Main beneficiaries are public administrations, third-sector entities (now equated to PAs), housing cooperatives, Renewable Energy Communities (CER), and private homeowners but just for a limited number of measures.
- Incentivized interventions are heat pumps, biomass boilers, solar thermal, building envelope improvements, hybrid systems, and photovoltaic systems.
- The form of incentive is direct cash transfer from GSE (not a tax deduction), paid in 1-5 yearly instalments depending on the size of the intervention, which makes it especially attractive for entities with limited tax capacity.

For residential renovation, **private owners rely mainly on tax deductions** (detrazioni IRPEF). Ecobonus and refurbishment bonus, implies 50% on primary residence and 36% on second homes. The ceiling is €96,000 per unit, recovered over 10 years and it covers ordinary and extraordinary maintenance, plant upgrades, windows, energy saving, security, accessibility and photovoltaic. Also sisma bonus is still available for anti-seismic interventions in the areas of high risk. This is particularly relevant because it increases the ceiling per unit, allowing prefabricated panels which have also anti-tilt performances to be more competitive than traditional ones.

Beside environmental goals to be reached, market pressure is amplified by **affordability challenges and a strong housing crisis.** In Milan, rent prices have increased by over 70% and house prices by 57% in the last decade, making the improvement of existing stock a social and economic necessity rather than a market optionality.
At national level, the **2026 Housing Plan** addresses Italy's housing crisis through an integrated strategy based on the recovery of public housing, the development of social housing, and the involvement of private capital. Within 12 months, the Government plans to renovate 60,000 currently unused public housing units. In the medium to long term, considering all public and private measures, the Plan aims to exceed 100,000 new units within ten years. The goal of the Housing Plan is to improve housing accessibility and sustainability at the same time, involving around 10 billion of public money. At local level, **Milan published the Extraordinary Plan for Accessible Housing.** The goal is to build or make available 10,000 new affordable rental homes over 10 years: roughly 6,500 in the city of Milan and 3,500 in the hinterland. The plan is structured along three operational directions: i) long-term social residential construction, ii) renovation and valorization of the existing public social housing stock, iii) Acquisition of new residential properties and disused buildings.

Overall, this policy environment supports the type of holistic, standardized retrofit packages typical of industrialized renovation approaches.

Customer analysis

Within the broader national framework, Milan area represents one of the most dynamic and demanding ecosystems in Italy. Considering the municipality only, there are:

- 30.000 residential buildings with 750.000 dwellings
- 60.000 public dwellings (25.000 managed by MM spa and 35.000 managed by ALER)
- 10.000 dwellings managed by housing cooperatives (around 100 entities affiliated to Legacoop Abitanti or Confcooperative Habitat).
- Considering the metropolitan area, figures get to:
- 130.000 residential buildings with 1.5 million dwellings
- 100.000 public dwellings (ALER manages other 30.000 dwellings in the Milan surroundings and there is other 10.000 units managed directly by the Municipalities)
- 20.000 dwellings managed by housing cooperatives (more or less the same that operate in Milan municipality).

It's worth noting that the provided numbers are estimations gather from published news and report of housing organizations, but they do not come from a structured census.

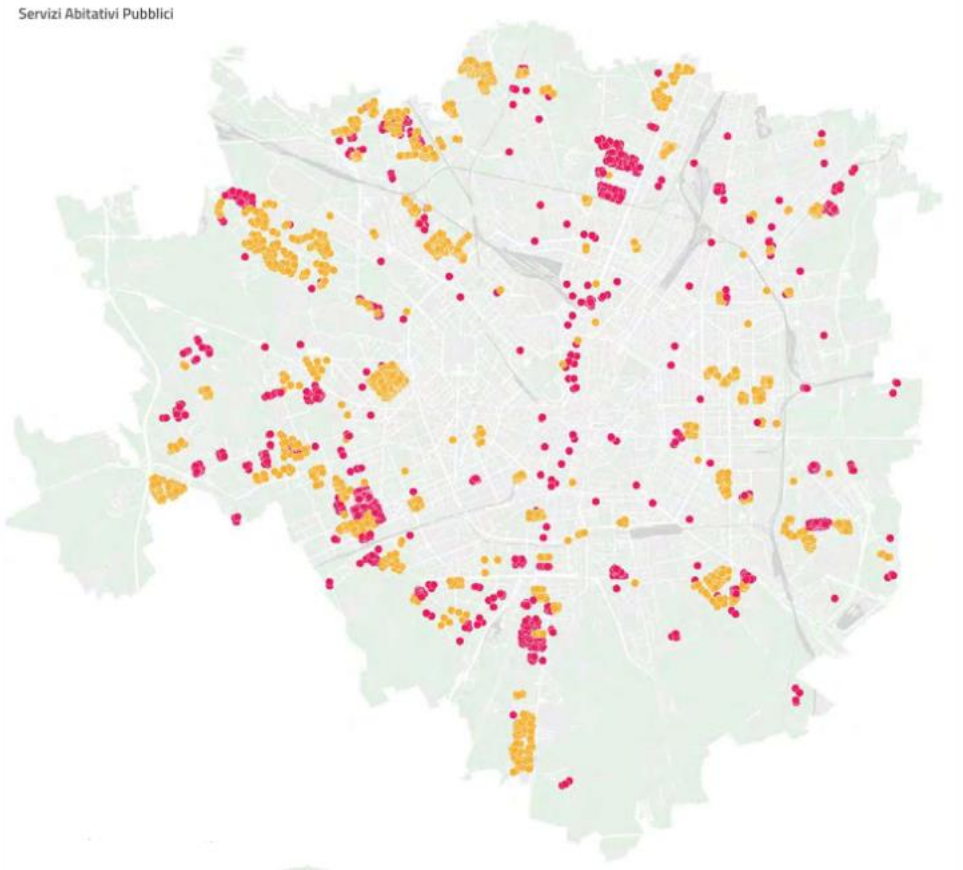


Figure 106: Public social housing buildings managed by ALER (yellow) and MM spa (pink)

Milan metropolitan area is of the largest **social housing** portfolio in the country, with significant maintenance backlogs. Such stock generally suffers from severe under-funding; hence it has a low level of new supply and problems with

maintenance, management and refurbishment of the stock (an estimated 10% of the units are vacant since they are not in the condition to be rented). Even if it's quite large, the city is experiencing a strong accessible housing shortage. For this reason, there is a third model which is born in 2009 to add an additional pillar to Milan's affordable housing offer: the **SGR-driven funds** have delivered several thousand new dwellings in the last 15 years and continue to do so typically targeting the middle band of households too well-off for public housing but priced out of the market, and increasingly integrating non-housing functions (community services, senior care, work spaces). The architecture is centered on the Sistema Integrato dei Fondi (SIF – Integrated System of Funds) which mobilize private and institutional capital. The central fund (FIA – Fondo Investimenti per l'Abitare**)** invests into local real estate funds set up at regional/territorial level, each managed by a different SGR. The system currently includes **29 local funds managed by 9 SGRs**, financing roughly **260 developments and urban regeneration operations** nationwide, with a target of about **20.000 social housing dwellings and 8.500 beds** in temporary/student residences. Milan and Lombardy received the first and most developed pipeline because **Fondazione Cariplo** seeded the model and pushed it heavily on its territory, through The **Fondo Immobiliare di Lombardia (FIL)** managed by **Near SGR**. As a result, Milan hosts the densest cluster of SGR-driven social housing developments in Italy, producing thousands of new affordable units, typically rented at €80-90/sqm/year (cooperative is around €50-70 sqm/year, public housing is at €25-40 sqm/year while the free rental market reaches €220-280 sqm/year).

The three social housing models (public, cooperative and SGR-driven) are definitively the market segments that are triggering innovation, through offsite approaches, and can influence prices. Indeed, they own/ manage aggregated stocks to be renovated or are responsible for big real estate developments which include new affordable housing construction. Clustered volumes are indeed crucial to activating economies of scale and making industrialized solutions convenient.

Beyond social housing, **private residential demand** is also substantial. Although renovation tax incentives have been progressively reduced, the overall need for upgrades remains very high: in 2025, the contraction of extraordinary maintenance by –18% is not attributable to a reduction in need but rather to the policy transition away from the Superbonus framework. The structural drivers—rising energy prices, poor thermal comfort, acoustic issues, and ageing installations—continue to generate significant latent demand for renovation, particularly in mid-century apartment buildings prevalent across Milan's peripheral districts.

In general, the city is characterized by large clusters of mid-20th-century buildings with homogeneous typologies, insufficient energy performance, and significant structural and accessibility issues. The pressure on the housing market, intensified by demographic shifts, student mobility, and high rental demand, further increases the need for efficient renovation solutions capable of delivering predictable timelines and reduced costs. Due to the concentration of intervention needs, the high repeatability of building typologies, and the logistical advantages offered by dense urban districts, Milan represents an **ideal environment for the implementation of industrialized renovation models and pop-up factory concepts**. Industrialized processes, including prefabrication and modular installation, respond to the local need for rapid

execution, reduced disruption in densely populated areas, and scalable solutions suitable for extensive social housing portfolios. Hybrid factories supplying components for both new affordable housing, deep renovation, and demolition plus reconstruction of buildings are needed to be explored to create synergies and economies of scale.

Competitor analysis

The demand for deep renovation in Italy, and particularly in the Milan metropolitan area, continues to be driven by an ageing building stock, increasingly stringent energy-efficiency targets, and the need to deliver interventions that are rapid, standardized, and minimally disruptive. This context, outlined in previous sections, forms the basis on which a new generation of industrialized operators—focused on prefabrication and off-site processes—is emerging. The pop-up factory model fits into this scenario, where market demand is concentrated among stakeholders managing large and repetitive property portfolios, such as public housing agencies and mid-20th-century residential estates, and where regulatory pressure encourages the adoption of scalable, high-performance renovation solutions.

In parallel with the consolidation of this structural demand, the competitive landscape is becoming increasingly dynamic. The most relevant competitors are off-site manufacturers and advanced prefab producers already developing solutions compatible with, or directly inspired by, European standards such as Energiesprong. Companies including Wolf Haus, Rubner Haus/Holzbau, and Focchi Group operate industrial production lines capable of delivering prefabricated envelopes, modular façades, high-performance energy elements, and rapid-installation components. These operators are active contributors to Energiesprong Italy's technical working groups and are beginning to offer integrated retrofit systems for serial residential buildings and social housing estates, effectively entering the competitive space addressed by the pop-up factory.

Alongside these established players, traditional construction firms are undergoing a gradual industrial transformation. Although not pure off-site producers, several large Lombard construction companies are introducing modular systems, digital tools, and prefabricated components to reduce execution times and address labour shortages. However, these initiatives often remain partial and do not achieve the repeatability, production control, and performance consistency required for fully industrialized large-scale renovations. Their competitiveness still depends on coordinating complex supply chains and managing heterogeneous buildings, with performance levels that rarely match those of a fully off-site model.

A further group of indirect competitors consists of manufacturers of specific modular components, such as ventilated façades, plug-and-play mechanical systems, prefabricated roofs with integrated photovoltaics, or high-performance energy panels. Although they do not offer full renovation packages, these actors occupy critical technical niches within deep renovation projects. Many collaborate with designers and contractors across the Energiesprong Italy ecosystem, supporting the diffusion of standardized solutions. Nevertheless, none of these companies currently operate near-site production facilities or temporary fabrication units on a neighbourhood scale—an area where the pop-up factory model offers a clear differentiating advantage.

The main competitive strength of the pop-up factory lies in its ability to localize production close to the buildings being renovated, reducing transport distances, installation times, and logistical costs while preserving industrial-grade standardization. Unlike traditional prefab manufacturers, which operate from centralized facilities often located hundreds of kilometres away, the pop-up factory can adapt rapidly to homogeneous residential clusters, offering greater flexibility and a stronger capacity to meet the needs of public housing authorities and institutional property owners.

Overall, the competitive landscape in Milan's renovation market is characterized by a mix of industrially advanced players, traditional firms in transition, and component manufacturers aligned with emerging Energiesprong-inspired standards, but still lacking the ability to integrate high-performance prefabrication, rapid installation, and territorial proximity into a single model. The Energiesprong ecosystem is accelerating the adoption of industrialized renovation practices and performance-based approaches, yet it has not yet produced operators capable of fully addressing the logistical, spatial, and scalability challenges of large urban portfolios. In this intermediate space—between industrialized prefabrication and neighbourhood-scale implementation—the pop-up factory positions itself as a unique player able to fill a significant competitive gap by offering replicable, scalable, and locally embedded solutions that are particularly suited to the Milan market.

Trend analysis

Over recent years, the **Italian construction sector has shown a dynamic and complex trajectory**, shifting from a phase of exceptional growth to a period of controlled slowdown, while maintaining a central role within the national economic landscape. Overall **construction investments reached their highest levels during the 2021–2023 period**, exceeding two hundred billion euros and accounting for roughly twelve percent of the national GDP. However, the expansionary cycle linked to fiscal incentives began to lose momentum in 2024–2025, as noted in the revisions published by ANCE: in 2025 total construction investments record a negative change of minus 1.1 % at constant prices, with residential investment declining by, 15.6% in 2025, driven mainly by the sharp fall in extraordinary maintenance (–18%) and by the contraction of new housing construction (–5.0%). In parallel, the **private non-residential** segment shows relative stability (+0.5%), supported by extraordinary maintenance in the most reactive sectors, retail, hospitality and logistics, which continue to adapt to evolving market requirements. Against this backdrop, public works represent the strongest engine of demand. In 2025, **public investment** grows by +21% due to the final implementation phase of the National Recovery and Resilience Plan (PNRR) and the advancement of the 2021–2027 European funding programs, which significantly shape the demand for widespread and standardized interventions.
This expansion helps sustain the overall sector, partially offsetting the contraction in private construction, particularly in the residential market. Despite a complex and unstable international geopolitical backdrop, ANCE's 2026 outlook returns to positive territory after the slowdown of the previous two years. Overall **construction investment is expected to grow +5.6% year-on-year**, driven mainly by public works.

Public works are the main engine, benefiting from the acceleration of the final phase of PNRR-funded interventions: ANCE forecasts a further **+12% growth** over the previous year.
Housing renovation is also set to rebound with **+3.5%**, after two years of sharp contraction. Two factors support the recovery: (i) the extension of the tax incentive rates set by the 2026 Budget Law (**50% / 36%**), and (ii) households' now consolidated attention to energy efficiency and sustainability.
The other segments remain weak: **new residential investment –4.5%**, n**ew non-residential investment –3%** and **non-residential extraordinary maintenance –0.8%**. Both are penalized by the decline in building permits. For non-residential, the negative outlook is also weighed down by high uncertainty, which risks further hitting a segment strongly dependent on the general economic cycle.

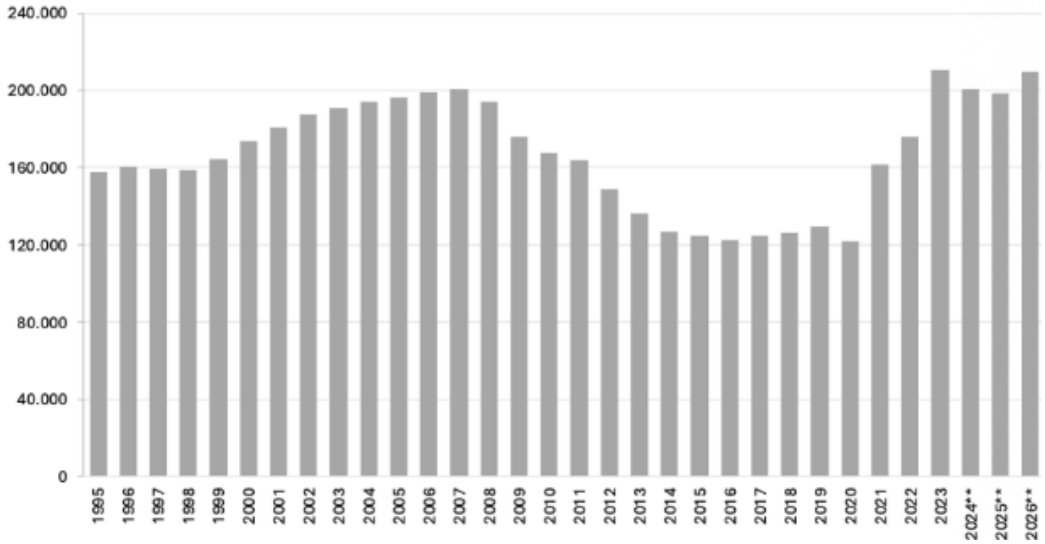


Figure 107: Construction investments in Italy (1995–2026, constant prices) Millions - years

In **real estate dynamics**, **2025 shows encouraging signals**: housing transactions rise by +9.2% in the first nine months of the year, and Nomisma estimates around 760,000 sales for the full year (+6% over already high 2024 levels). The recovery is supported by the European Central Bank's accommodative monetary policy and a markedly improved access to credit. In fact, mortgage lending grows by +32.8% in the first nine months of 2025, driven both by new loans and by refinancing activities. Yet, affordability remains a major structural constraint: the mortgage repayment burden reaches reaches extremely high values in large cities, 58.9% of income in Milan, while rents show similar criticality, with Milan households typically allocating over 47% of their salary to rent payments. These dynamics make access to housing complex for both low-income and middle-income groups. The evolutionary trajectory of the next five years is therefore shaped by a coordinated set of forces pushing demand towards more efficient models: shrinking margins in the construction sector, increasing difficulties in finding qualified labour, the need to reduce disruption in dense urban areas, and the availability of diversified European and national funding lines. These elements collectively contribute to making solutions such as the pop-up factory increasingly favourable, as they meet the requirements of speed, predictability, safety and minimal disturbance in inhabited contexts, while offering the possibility to intervene on entire sets of homogeneous buildings through standardized processes.

Business case

The market analysis in section 1.3 established both the scale and the urgency of residential renovation in Italy and the specific characteristics of the Milanese ecosystem that call for modular, industrialized approaches. In this section we evaluate their financial fit for the Italian market and underpin what circumstances would be most beneficial for the financial viability of the popup factory. The main pop-up factory type that fit this ecosystem is the *Satellite Factory*. Table 1 (below) presents the research design applied to examine the evaluation of the two PUFs.

Term	Definition	Italian Ecosystem
Mobile On-Site Factory	A movable production cell deployed directly on or near the construction site.	No
Satellite Factory	A temporary facility near the site that collaborates with a central production hub.	Yes
District Factory	A semi-permanent facility serving multiple nearby projects, acting as a system integrator.	No
Assembly Factory	A location focused solely on assembling prefabricated components from other sources.	Maybe
Service Factory	A knowledge and facilitation hub that supports sustainable renovation through advice and coordination.	Maybe

Research Design

In this section, we present the steps followed to dive into the examined business case. Based on literature related to the evaluation of innovations for the redesign of the construction sector as well as the opinion of experts in the field, the main criteria selected are: the required financial investment, the fit to the project scale, and the ecosystem's fits to the region. These also depend on the type of ownership that is involved. Below, the criteria and ownership model will be explained.

PUF Application in Italy

Based on key assumptions and relevant risk considerations from experts, we selected the 2 main reasonable ownership scenarios and evaluate it against the 3 main evaluation criteria. The first one, regards the full ownership of the offsite panel manufacturer which invests in the factory, asking for the needed debt, and then returns of the investment through the offsite elements selling to general contractors, ESCOs or building owners directly. The second one implies the creation of a Single Purpose Vehicle, basically a joint venture between the panel manufacturer and the housing

organization who has a big pipeline of projects, so find coherent and strategic to have shares into the production facility that will deliver the solutions. Below, we elaborate on key assumptions and risk considerations from experts for the PUF assembly and service. Finally, we present the reasoning of this business cases in the sub-section.

Table 63: Ownership scenarios for the PuF

Ownership scenario	**Satellite PUF**		
	Tool investments	**Project scale fit**	**Ecosystem fit**
(1) Single offsite construction company	High	Strong	Moderate
(4) Special Purpose Vehicle (SPV)	Medium	Strong	Strong

Overall, the comparison between ownership scenarios shows that, in the Italian context, the **Satellite Pop-up Factory** represents an industrially and strategically viable configuration **only when supported by an ownership and governance structure capable of distributing financial risk and ensuring long-term programme continuity**.
In this regard, the **Special Purpose Vehicle (SPV)** scenario emerges as the most coherent option. It aligns with the substantial investment requirements associated with the construction of a new main hybrid factory and meets the coordination needs typical of social housing renovation programmes. The SPV structure enables the integration of industrial capacity, long-term planning, and multi-actor governance, while mitigating the risks linked to capital concentration and facilitating interaction with public stakeholders. However, it's important mentioning that, if a public housing organization is involved, a public procurement procedure is required to select the panel manufacturer for the joint venture and it's not a very common practice.
By contrast, **single construction company ownership**, while technically feasible, presents limitations in terms of systemic fit within the Italian social-sector ecosystem. These limitations do not stem from inadequate project scale or demand—which remain sufficient—but rather from higher financial exposure and lower predictability on demand.
Taken together, the results indicate that **the choice of the Pop-up Factory configuration in the Italian case is primarily driven by the ability to sustain significant industrial investments through shared-risk ownership models**, rather than by purely technical or technological considerations. The Satellite PUF therefore requires a governance architecture capable of ensuring continuity, scale, and coordinated programme delivery, conditions under which the SPV configuration provides a more robust strategic fit compared to single-company ownership.

PuF type - Key assumptions and risk implications

Single prefab construction company ownership

Under single-company ownership, tool investments are assessed as High. This reflects the need for a single actor to finance and operate a newly built main precast factory, bearing the full weight of capital-intensive fixed assets, long commissioning times, and

limited reversibility of investments. Concentrating such exposure on one balance sheet increases sensitivity to fluctuations in renovation demand and programme delays.
Project scale fit is assessed as Strong. The Italian public and social housing context offers large and relatively homogeneous post-war building portfolios, which provide the scale necessary to support industrialised prefabrication, serial production, and batching effects once the factory becomes operational.
Ecosystem fit is assessed as Moderate. While technically viable, a single-company ownership model does not align optimally with the Italian renovation ecosystem, which is characterised by multi-actor governance and strong fluctuation of demand. If building owners / managers are not involved in the investment, the risk of lack of local project is higher.

SPV (Special Purpose Vehicle) ownership having the construction company and the housing organization as shareholders
In an SPV configuration, tool investments are assessed as Medium. Although the absolute investment level required for the main precast factory remains the same, the distribution of financial risk across multiple stakeholders improves bankability and reduces exposure for individual partners, supporting a more resilient strategy, especially if the demand side (buildings owners) are co-investing.
Project scale fit remains Strong, as the SPV structure facilitates long-term planning, sequencing of multiple buildings, and alignment between industrial capacity and aggregated renovation pipelines of the demand-side shareholder—conditions that are essential for achieving efficiency within the Satellite PuF model.
Ecosystem fit is assessed as Strong. The SPV provides a neutral governance vehicle capable of coordinating municipalities, ERP agencies, contractors, and local SMEs. Its multi-actor structure aligns well with Italian public procurement frameworks and with programme-based delivery approaches, improving compatibility with public governance requirements and enabling effective management of large-scale renovation programmes.

Internal Business Analysis of the local pop-up factory

Satellite Puf - Value proposition

The Italian Pop-up Factory scenario is based on a **Satellite Pop-up Factory configuration**, combining a newly built main precast production facility with a network of close-to-site local SMEs and coordinated on-site operations. The value proposition of this model lies in its ability to address structural inefficiencies of traditional renovation processes while responding to the specific conditions of the Italian ecosystem.

For **public housing authorities and municipalities**, the Satellite PuF offers a value proposition centred on **programme reliability and predictability**. Industrialised off-site production enables shorter and more controllable on-site intervention times, reduced uncertainty in delivery schedules, and higher consistency in quality across multiple buildings. This is particularly relevant for large ERP portfolios, where renovation programmes must balance technical performance objectives with continuity of occupancy and social constraints.

For **construction companies and industrial partners**, the value proposition lies in the **transition from project-based execution to programme-based delivery**. The Satellite PuF supports standardisation, repetition, and learning effects, reducing dependency on ad-hoc site conditions and manual labour availability. The integration of a main factory with local finishing SMEs allows firms to retain flexibility while benefiting from industrial scale and digital production control.

For **local SMEs**, the model creates value through **structured integration into a stable supply chain**. Rather than competing on fragmented, short-term contracts, SMEs participate in a coordinated production and installation process, focusing on specific components (windows, MEP, cladding, PV) within a Just-in-Time logic. This reduces volatility, supports skills specialisation, and strengthens local economic embedding.

For **residents**, particularly in public housing contexts, the value proposition is expressed through **minimised disruption and improved building performance**. Shorter on-site phases, scaffold-free installation approaches, and pre-integrated façade systems reduce disturbance during works, while achieving significant gains in energy efficiency, comfort, and safety.

Overall, the Satellite Pop-up Factory proposes a **hybrid value proposition**: industrial robustness combined with territorial integration. It bridges large-scale industrial investment and local implementation capacity, offering a viable alternative to both centralised prefab supply chains and fragmented site-based renovation processes. This positioning underpins the internal logic of value creation, delivery, and capture discussed in the following sections.

Value Creation

The Satellite Pop-up Factory creates value through the industrialisation and coordination of renovation activities that are traditionally fragmented across multiple actors and construction sites. Its core value creation mechanism lies in combining a centralised off-site production facility with decentralised close-to-site integration and controlled on-site installation processes.

From an operational perspective, value is created by shifting a significant share of construction activities from the building site to a controlled factory environment. The main precast factory enables standardised production of high-performance components, ensuring repeatable quality, dimensional accuracy, and reduced dependency on on-site labour conditions. This industrial setup supports continuous production flows, reduces variability, and enables learning effects across multiple renovation projects.

Additional value is generated through the integration of local SMEs into the production and delivery process. Instead of operating in isolation, local actors specialising in windows, MEP components, cladding systems, or renewable energy installations are incorporated into a coordinated workflow. This integration allows each actor to focus on their core competences while contributing to a unified renovation package delivered under a Just-in-Time logic. As a result, transaction costs, coordination inefficiencies, and idle times are reduced.

From an economic perspective, the Satellite PuF creates value by improving cost predictability and risk distribution. Industrialised production reduces rework, delays, and material waste, while programme-based planning enables better utilisation of equipment and workforce over time. The aggregation of demand across multiple buildings further improves efficiency by enabling batch production and reducing per-unit costs, particularly relevant in the context of large ERP portfolios.

The process of setting up the Pop-up Factory constitutes a key component of value creation. This process includes the design and construction of the main factory, the installation of production equipment, the establishment of digital production and logistics systems, and the formalisation of partnerships with local SMEs and logistics providers. The setup phase is closely linked to securing a stable refurbishment pipeline, ensuring that industrial capacity is aligned with programme demand from the outset.

Despite these advantages, the Satellite PuF also faces structural challenges that directly affect value creation. High upfront investments, long commissioning periods, and dependency on continuous programme demand require robust governance and financing structures. Furthermore, coordinating multiple actors across factory, local integration points, and construction sites increases organisational complexity and necessitates strong operational management and digital support systems.

Value creation within the Satellite Pop-up Factory is driven by the transition from site-based, project-centric renovation to an industrial, programme-oriented model, combining centralised production efficiency with local implementation capacity. This internal logic forms the foundation for the value delivery and value capture mechanisms described in the following sections.

Capabilities: 'upskilling' to operate the local pop-up factory

A local pop-up factory can be considered as an ecosystem on its own as it brings together the capacity of local SMEs and it addresses unemployment of local construction workers. This requires supporting training and upskilling programs for involved craftsmen, designers, engineers, architects, and operational construction workers, etc, using outcomes and methods of the BUS and Construction Skills projects. All in all, it is important to consider the required competences, skills and know-how of (future) employees. Complementary, the processing of information, data and systems; institutional and legal conditions, and financial, technical and material resources to instate and operate the local pop-up factory are key capabilities to take into consideration.

For the satellite factory, the following specialized human capital is envisioned:

Job description: DfMA Designer - Technical designer responsible for translating the architectural project into prefabricated, manufacturable, transportable, and installable components, ensuring full alignment between different components to be integrated

Tasks and responsibilities:

- Develop DfMA models of façade panels and integrated components (windows, MEP, insulation).
- Verify manufacturability according to main factory constraints
- Coordinate anchoring details, interfaces, tolerances, and joint solutions.

- Work closely with the Panel Flow / Installation Supervisor for interface closure and installation feasibility.
- Prepare digital production files

Capabilities:

- Strong knowledge of prefabricated systems and industrial production constraints.
- Advanced BIM modelling skills.
- Ability to resolve interface details and anchoring systems.
- Coordination skills across architecture, structures, MEP, factory teams, and site teams.

Recommended training:

- DfMA and industrialised construction methods.
- Advanced BIM training (Revit / Tekla) with focus on precast.
- Training on factory production processes and assembly constraints.
- Basic site safety and façade installation procedures.

Job description: Quality & Process control officer - Responsible for quality control of prefabricated components and verification of production processes to ensure technical compliance and full traceability.

Tasks and responsibilities:

- Inspect dimensions, tolerances, finishes of precast panels.
- Verify materials (concrete, steel reinforcement, inserts, insulation).
- Monitor production steps (formwork, casting, curing, finishing).
- Record non-conformities and follow corrective actions.
- Perform final pre-dispatch quality checks before shipment.

Capabilities:

- Knowledge of precast quality standards and technical tolerances.
- Ability to read drawings and reinforcement layouts.
- Familiarity with sequential industrial production processes.
- Skilled in using measurement tools.
- Competence with digital traceability systems.

Recommended training:

- Precast quality control training.
- Digital tools (CDE, MES).
- Basic factory safety certification (D.Lgs. 81/2008).

Job description: Panel flow Installation and supervisor - dedicated supervisor responsible for overseeing each panel through all production and installation phases: main factory, secondary finishing factory, transport, and on-site installation. Ensures continuity, quality, and correct interfaces across the full end-to-end process.

Tasks and responsibilities:

- Monitor panel production at the main factory and verify readiness for dispatch.
- Coordinate transfer to the secondary finishing factory and check integration of windows/MEP/cladding components.
- Supervise loading, transport sequencing, and Just-in-Time delivery to site.
- Support the site installation team, ensuring correct anchoring, alignment, sealing, and interface closure.

- Act as the single point of contact for panel-related issues across factories, logistics, and site teams.
- Ensure final acceptance of each panel after installation.

Capabilities:

- Strong knowledge of precast panel production, finishing, transport constraints, and on-site assembly.
- Ability to read technical drawings, installation plans, and interface details.
- Coordination skills across multiple actors (factory, SMEs, logistics, site).
- Problem-solving under time-critical installation conditions.

Recommended training:

- Installation workflows for prefabricated façade systems.
- Transport and lifting safety procedures.
- Interface management and anchoring systems.
- Project management toolbox.
- Basic onsite safety certification (D.Lgs. 81/2008).

Value Delivery

In the Satellite configuration, value delivery hinges on the orchestration of **logistics**, **integrated quality control**, and **structured customer interaction** along a Just-in-Time workflow that connects the main precast factory, the secondary close-to-site finishing facility, and the construction site. Such process involves a coordinated network of actors with clearly defined roles:

- the **main precast factory operator**, responsible for the off-site production of standardised panels and components;
- the **secondary close-to-site finishing facility** (or dedicated finishing area within the main factory), where local SMEs integrate windows, MEP, cladding, insulation, and renewable-energy elements (PV) into the panels;
- **specialized transport and lifting providers**, managing the sequenced delivery of large, prefabricated components from factory to site, including the use of cranes and dedicated heavy-transport routes;
- the **on-site installation team**, in charge of anchoring, sealing, and interface closure;
- the **social housing organisation/client**, coordinating access to dwellings, tenant communication, and site logistics on the building premises;
- the **local public administration**, supporting permits, road-use authorizations, and logistical interfaces with the urban context.

The model is designed to minimize the inefficiencies and externalities of conventional site-based renovation. Key benefits include:

- **proximity to the building site**: the close-to-site finishing facility substantially reduces transport distances, lead times, and CO_2 emissions associated with prefabricated-component delivery, and enables faster issue resolution between factory and site;
- **Just-in-Time delivery**: components arrive on site only when needed, drastically reducing on-site storage requirements, a decisive advantage in dense urban contexts and occupied buildings, where storage space is scarce;
- **fewer, better-sequenced deliveries**: prefabricated panels carry pre-integrated subsystems (windows, MEP, cladding), reducing the total number of trips

compared to traditional supply chains and limiting traffic disruption in the neighborhood;

- **weather independence of production**: off-site fabrication decouples the construction schedule from weather conditions, increasing reliability of delivery timelines and quality of the products;
- **scaffold-free installation**: pre-integrated façade systems enable faster, less invasive installation, reducing both on-site time and dependency on temporary structures;
- **shorter on-site phases**: by shifting a major share of activities to factory environments, the on-site intervention per building is compressed, lowering the overall disturbance for residents and accelerating handover.

Customer interaction is structured along the touchpoints described in the paragraph below and continues throughout execution. A dedicated **resident-communication channel** — co-managed by the social housing organisation and the PuF operator — accompanies the works, providing information sessions, on-site signage, milestone notifications, and a help-desk for tenants. The renovation calendar is synchronised with the factory production schedule through shared BIM and 4D planning tools, which allow the building owner to anticipate apartment-level interventions, coordinate temporary relocations where needed, and plan resident services accordingly. The proximity of the finishing facility to the site enables tight scheduling feedback loops: production rates can be adjusted to actual installation progress, and unforeseen on-site conditions can be reflected back into manufacturing within hours rather than weeks.

Value delivery also encompasses a strong social dimension that goes beyond the purely contractual relationship with the client:

- **training and upskilling**: the operation of the Satellite PuF activates structured training pathways for the specialised profiles identified above (DfMA Designer, Quality & Process Control Officer, Panel Flow Supervisor), as well as for installation workers and SME staff. These pathways can be embedded in collaborations with vocational schools, ITS academies, and CPT (Comitato Paritetico Territoriale) training centres;
- **stable local employment**: by anchoring local SMEs in a program-based supply chain, the model reduces the volatility typical of fragmented construction contracts and supports the retention of skilled workers in the territory; this is particularly relevant in metropolitan Milan, where construction labor shortages have become a structural constraint;
- **inclusion and gender balance**: the industrialized, controlled production environment lowers some of the physical barriers associated with traditional site work, opening opportunities for under-represented profiles (women, young people, workers in retraining) to enter the prefabrication and digital-production segments of the construction sector;
- **community involvement**: the renovation programs can integrate dedicated channels for tenant engagement — co-design sessions on shared spaces, information desks during works, and post-occupancy evaluation — leveraging the proximity of the finishing facility to organize open days, neighborhood visits, and educational activities;
- **social value as a procurement criterion**: public clients can include social clauses in tender bids (e.g., local hiring quotas, training hours, apprenticeships,

inclusion targets), making the social outcomes a measurable and contractually anchored component of value delivery.

Touchpoints and market activation

To further develop the research, and in line with the suggestions of Passlack (2021) and Broers et al. (2022), for the PuF a detailed customer journey needs to be developed specifically addressing the touchpoint with the residents requiring some level of action.

For the Satellite factory, and considering that the pilot project is a public social housing building, the following touchpoints will be considered as part of the sales strategy and the first stage ('onboarding') of the customer journey:

1) Local SMEs for components integration. Indeed, for the owner(s) of the main hybrid factory, the first customers to engage are local suppliers, having the characteristics and willingness to work with prefabricated panels.

Touchpoint with Local SMEs	**Onboarding and sales activity**
1. Mapping of local SMEs (initial contact, call or email)	SMEs understand the opportunity to join an industrialised supply chain.
2. Participation in sector fairs attended by SMEs	The SME becomes aware of the Satellite PuF model, understands the collaboration opportunities within the industrialised renovation supply chain, and evaluates the compatibility of its products and services with the technical requirements of the programme.
3. Introductory qualification meeting	SMEs learn about quality standards, timelines, and required capabilities.
4. Main Hybrid factory open day	The SME visits the main factory, observes production workflows, understands interface requirements with panels, and evaluates how its products or services can integrate into the industrialised process.

2) Public authorities owning or managing social housing. The final customers are public authorities who need to be aware on innovative renovation approaches on the market and be convinced by its benefits.

Touchpoint with Public Authorities	**Onboarding and sales activity**

1. Introductory outreach (email / info package)	Public authority receives a first overview of the Satellite PuF concept, its benefits, and suitability for public social housing programmes.
2. Awareness meetings & institutional presentations	Client understands how the model fits their renovation objectives and regulatory constraints.
3. Site visits to existing industrialised projects	Client sees industrialised renovation in practice and builds trust in feasibility and performance.
4. Participation in institutional working groups established by the public authority	The public authority involves the PuF team in thematic working groups, gaining deeper technical understanding and evaluating the model's compatibility with policy, planning frameworks, and programme governance.
5. Interest in a public tender	The public authority reviews the Satellite PuF proposal, assesses its relevance to the upcoming tender, and evaluates the potential for collaboration.

Value Capture

The value capture logic of the Satellite Pop-up Factory is based on a programme-oriented economic model, rather than on maximising margins at the level of individual projects. Financial sustainability is achieved through the alignment of industrial investment, long-term renovation pipelines, and shared governance structures.

From a cost perspective, the main cost drivers relate to the establishment and operation of the main precast factory, including capital expenditure for production facilities, equipment, and digital systems, as well as operational costs associated with workforce, energy consumption, maintenance, logistics, and coordination activities. These costs are largely fixed or semi-fixed and therefore require a sufficient and continuous level of utilisation to be efficiently absorbed over time. In addition to industrial and infrastructure investments, the business model also requires significant start-up working capital to support the ramp-up phase and the progressive increase in production capacity.

On the revenue side, the Satellite Pop-up Factory captures value primarily through programme-based contracts, public private partnerships and framework agreements associated with large-scale renovation programmes, particularly in the public social housing sector. Revenues are generated through the delivery of integrated renovation packages—combining prefabricated components, local integration, and on-site installation—under predefined contractual conditions. This approach enables more predictable cash flows and reduces exposure to volatility linked to single, stand-alone projects.

Beyond direct financial returns, the Satellite Pop-up Factory also generates non-financial value, which forms an essential component of its overall value capture logic. These include reduced life-cycle costs for building owners due to improved construction quality and performance, increased reliability of delivery timelines for public renovation programmes, and strengthened local economic ecosystems through the stable involvement of SMEs. Additional social value is created through reduced disruption for residents, improved living conditions, and support for skills development and employment continuity within the construction sector.

Cost structure and revenue model

The cost structure and revenue model of the Satellite Pop-up Factory is presented in the tables below.

• **TOTAL INITIAL INVESTMENTI (CAPEX)**	• **€ 35.000.000**

- Which includes **investment for automated production equipment**:
- Concrete batching plant and concrete distribution system
- Production lines for prestressed hollow-core slabs
- Technological machinery for stationary production
- Stationary equipment to produce internal and external prefabricated panels
- Formwork for staircase production with landing slabs
- Equipment for steel processing
- Heating system for accelerated curing
- Equipment for handling raw materials and prefabricated elements
- **Investment for Infrastructure**:
- Land acquisition (50 €/m²)
- Construction of the production building (600 €/m²)
- Construction of storage areas (100–200 €/m²)
- Construction of the office / management building (1,500 €/m²)

TOTAL OPERATING COST (OPEX)	**€ 59.400.000**

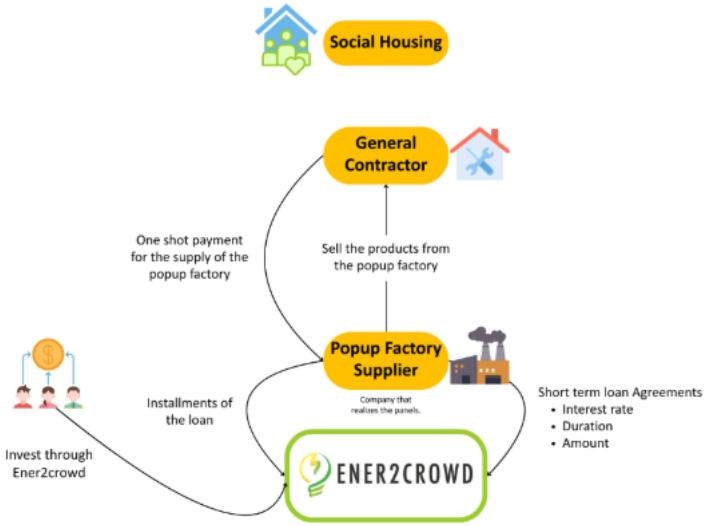
FACTORY PRODUCTION CAPACITY	**217.000 m2**
Retrofit elements (renovation of 25 buildings as the one of the Italian pilot in Viale Omero)	51.000 m2 166.000 m2

New build elements (construction of 13 buildings as the one of the Italian pilot)	

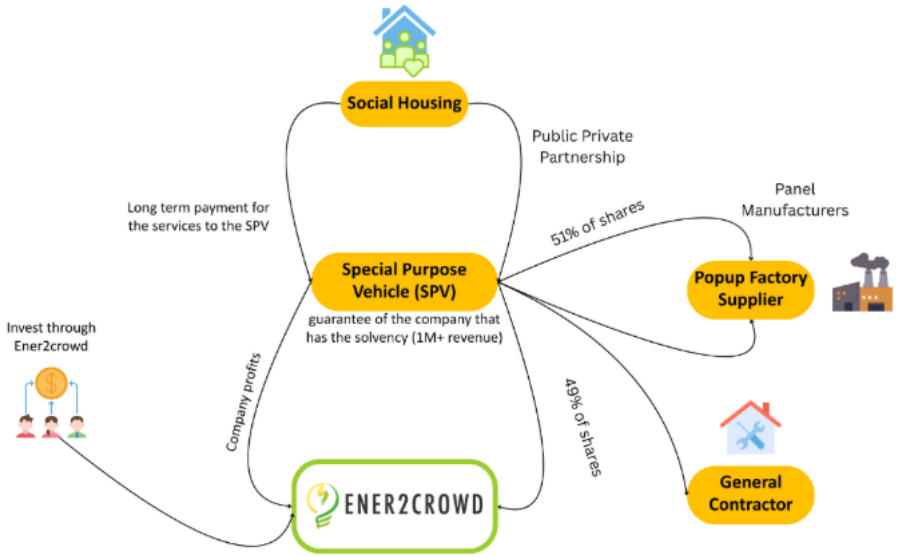
TOTAL SALES	**84.825.000 €**

ANNUAL MARGIN	**25.425.000 €**

For both ownership scenarios, it is foreseen that the offsite manufacturer has an initial capital of 6 M€ of the 35 M€ needed.
For the "(1) Single offsite construction company" scenario, 25 M€ are asked as debt, both to traditional banks and to Ener2Crowd investors (up to 5 M€). Considering a debt repayment of 5 years, and a interest rate of 6%, the simplified payback period is lower than 2 years.



For the "(4) Special Purpose Vehicle (SPV)" scenario, an equity model is implemented, with the offsite manufacturer keeping more than 50% of the shares to have strategic and operational controls on the decisions taken. The other part of shares is divided between the social housing provider willing to co-invest in the factories and a pull of other shareholders gather through the Ener2Crowd platform. In this case, since dividends are distributed only when the business is stable, the simplified payback period is even shorter, slightly above 1 year.



It's worth mentioning that the calculation of the payback period is simplified and not accurate because it doesn't consider taxes, which can cover a relevant portion of the net income. Furthermore, an actualized cashflow analysis should be performed to properly split inflows and outflows over the years and to include different production scenarios, reaching full capacity in different moments.

Summary of findings

The internal business analysis highlights that the **Satellite Pop-up Factory** represents a coherent and robust operational model for large-scale renovation programmes in the Italian context, particularly within the public social housing sector.
The analysis confirms that the **value proposition** is well aligned with ecosystem needs: public clients benefit from predictable delivery, reduced on-site disruption, and consistent performance outcomes, while industrial operators and local SMEs gain from programme-based planning, standardisation, and stable integration within the value chain. This positioning addresses both technical inefficiencies and organisational fragmentation typically associated with conventional renovation processes.
From an internal perspective, the **value creation logic** is grounded in the combination of an industrial off-site production facility with decentralised local integration and controlled on-site installation. This configuration enables efficiency gains through standardisation and repetition, while maintaining the flexibility required to operate in dense, occupied urban environments. The presence of dedicated capabilities and upskilling mechanisms further reinforces the operational feasibility of the model.
The **value delivery logic** confirms the operational soundness of the model in the Italian context. By combining proximity between the close-to-site finishing facility and the building site, Just-in-Time logistics, and structured customer and resident interaction, the Satellite Pop-up Factory delivers renovation outputs with significantly shorter on-site phases, lower disturbance for occupants, and higher schedule reliability for public clients.

In parallel, value delivery captures an important **social dimension**, including the activation of training and upskilling pathways for specialized profiles, the stabilization of local SMEs and construction employment, opportunities for inclusion and gender balance, and channels for community involvement with residents. These elements reinforce the alignment between technical performance, public-policy objectives, and territorial integration that characterizes the Italian Satellite configuration.
The **value capture analysis** shows that the economic sustainability of the Satellite Pop-up Factory relies on programme-based execution rather than individual project margins. High upfront investments in production equipment and infrastructure, complemented by start-up working capital requirements, necessitate long-term pipelines and shared-risk ownership structures. The payback period of the investment is quite short if the main factory runs at full capacity, meaning that it's crucial to secure an medium-term pipeline of projects.
The findings indicate that the Satellite Pop-up Factory is **internally consistent, economically rational, and operationally viable** when embedded within stable renovation programmes and supported by appropriate governance arrangements. These conditions enable the transition from isolated retrofit projects to an industrialised, programme-oriented renovation approach, providing a credible basis for scalability and replication within similar Italian urban contexts.

The Table 1 shows the Satellite PUF of the Italian ecosystem summarized through the Business Model Canvas. The three areas depict the three types of value as seen in the business model canvas; value creation (value proposition, customer relationships,

customer segments, channels), value delivery (key partners, key activities), and value capture (cost structures, revenue streams).

Table 64: Business Model Canvas summarizing the Satellite PUF of the Italian ecosystem.

<table>
<tr>
<td rowspan="2">Key partners

Partners include public authorities, housing organisations, contractors, SMEs, and financial actors. SPVs play a crucial role in enabling investment and coordinating stakeholders.</td>
<td>Key Activites

Key activities include industrial prefabrication, coordination of SMEs, logistics, and on-site installation. Programme planning and demand aggregation are essential to support continuous production.</td>
<td rowspan="2">Value Proposition

The Satellite PuF offers a value proposition centred on programme reliability and predictability. Industrialised off site production enables shorter and more controllable on site intervention times, reduced uncertainty in delivery schedules, and higher consistency in quality across multiple buildings.</td>
<td>Customer Relationships

Relationships are long-term and programme-based, especially with public clients. The model relies on continuous collaboration and integration of SMEs within a stable supply chain.</td>
<td rowspan="2">Customer segments

The model targets mainly public housing authorities and municipalities managing large-scale renovation programmes. Construction firms and industrial partners support execution, while SMEs are integrated as suppliers.</td>
</tr>
<tr>
<td>Key Resources

The model depends on a central production facility, specialised equipment, logistics systems, and a coordinated network of SMEs supported by digital tools and skilled labour.</td>
<td>Channels

Delivery takes place through public tenders and framework agreements. Production is centralised, while logistics and installation are organised locally, supported by institutional coordination activities.</td>
</tr>
<tr>
<td colspan="3">Cost Structure

The model is highly capital-intensive, with high upfront investment and significant fixed costs. Its viability depends on continuous utilisation and a stable renovation pipeline.</td>
<td colspan="2">Revenue Streams

Revenue comes from programme-based contracts and framework agreements delivering integrated renovation packages. The model focuses on stable long-term revenue, not individual project margins.</td>
</tr>
</table>

SWOT analysis: Strategic orientation for the introduction of the local pop-up factory

Strength

The Satellite Pop-up Factory displays several structural strengths linked to its industrial configuration and territorial integration. Offsite production within a controlled factory environment enables a high degree of standardisation, execution quality, and performance predictability, reducing uncertainties typically associated with traditional construction sites. The programme-oriented approach allows economies of scale, learning effects, and improved long-term resource planning. A further strength lies in the reduction of on-site duration and disturbance, which is particularly relevant in dense urban areas and occupied residential buildings. The structured integration of local SMEs into the production and installation chain reinforces local embeddedness, promotes skill specialisation, and supports employment stability.

Weakness

The main weakness of the Satellite Pop-up Factory is the high initial investment required for the establishment of the main precast production facility and associated infrastructures. This cost structure entails significant financial exposure and long start-up and amortisation periods.

The model also shows a structural dependency on the continuity of the renovation pipeline: in the absence of stable, long-term programmes, the risk of under-utilisation of production capacity increases substantially. Interruptions, fragmented demand, or insufficient clustering of interventions may significantly reduce cost efficiency and erode the expected industrial advantage. Additional weaknesses relate to organisational complexity and the need to coordinate multiple actors (factory, SMEs, logistics, construction sites, and public authorities), requiring advanced management systems and competencies. In parallel, the logistical rigidity associated with heavy prefabricated components, fixed production layouts, and distance-sensitive transport flows may limit competitiveness beyond tightly defined territorial areas.

Opportunities

The Italian context offers favourable opportunities for the implementation of the Satellite Pop-up Factory. The widespread presence of public social housing and large building portfolios characterised by repetitive typologies and low energy performance creates a significant potential demand for serial and industrialised renovation programmes.

European and national policies addressing decarbonisation of the building stock, energy poverty reduction, seismic safety and supply of more affordable housing, further reinforce the need for scalable and reliable renovation approaches. In parallel, increasing shortages of skilled on-site labour and growing pressure on time and cost

efficiency in urban contexts make industrialised models that reduce on-site dependency increasingly attractive.

Threats

Key threats include uncertainty related to public funding mechanisms and their continuity over time, as well as potential delays resulting from permitting procedures and rigid procurement frameworks. Regulatory changes or misalignment between institutional levels may further slowdown the activation of renovation programmes, increasing the risk of discontinuities that directly affect the economic viability of a capital-intensive industrial asset.

Another thread could regard skills gap in local SMEs for offsite component integration and Just-in-Time delivery, which risks delaying production ramp-up, compromising panel quality, and disrupting the synchronization between factory output and on-site installation.

Further risks concern social acceptance in occupied buildings if communication and resident engagement are not adequately managed. Proper dissemination is needed to overcome the cultural legacy that associates prefabrication to low quality fabrics, as it occurred in the 1960s. Finally, adverse macro-economic conditions, such as rising energy or material costs, may negatively affect the economic sustainability of the model, particularly during the initial ramp-up phase, when production efficiency and learning effects have not yet fully stabilised.

Conclusions

Building on the SWOT analysis, the strategic orientation for introducing the Satellite Pop-up Factory within the Italian ecosystem can be articulated through a TOWS-based interpretation, linking the internal characteristics of the model with external contextual conditions.

The analysis confirms that the strengths of the Satellite Pop-up Factory, in particular industrialised off-site production, programme-oriented organisation, and structured integration of local actors, are well aligned with the opportunities offered by the Italian context. The widespread presence of large public social housing portfolios, combined with strong regulatory pressure towards deep renovation, decarbonisation and provision of new affordable housing, creates favourable conditions for approaches that rely on standardisation, repetition, and integrated planning for both retrofit and new construction. In this framework, the programme-based nature of the model enables a more effective response than traditional renovation practices centred on isolated projects and site-based execution.

At the same time, the TOWS reading highlights that the structural weaknesses of the model, notably high capital intensity, organisational complexity, and dependency on continuous programme pipelines, are not circumstantial, but intrinsic to a highly industrialised and automated production system. These characteristics require deliberate strategic positioning, based on alignment with stable, long-term public renovation programmes and governance arrangements capable of coordinating demand over time. In this respect, the SPV configuration emerges as a coherent strategic response, as it allows risk sharing, improves bankability, and structurally connects industrial investment with public and private financing.

The interaction between strengths and external threats further indicates that the model can mitigate several contextual risks, such as skilled labour shortages, operational challenges in dense and occupied urban areas, and the need to reduce on-site duration and disturbance. However, this same interaction makes clear that the economic and logistical advantages of the factory are realised only under specific conditions, including sufficient scale, geographical clustering of interventions, and stable renovation pipelines. In contexts characterised by demand discontinuity, fragmentation, or uncertainty, less capital-intensive and more flexible renovation solutions may temporarily appear more competitive, despite offering lower industrial performance in the long term.

The combination of internal weaknesses and external threats therefore reinforces the importance of robust governance and effective institutional coordination. The high degree of automation, the sequential nature of production processes, and the rigidity of the industrial layout make the Satellite Pop-up Factory poorly suited to short-term, episodic, or opportunistic deployment logics. Delays in funding, regulatory uncertainty, lack of local workforce, or rigid procurement frameworks can amplify the risks associated with long commissioning periods and under-utilisation of production

capacity, confirming the strategic relevance of early public-sector engagement, programme-based planning and local ecosystems creation from the outset.

Overall, the strategic sustainability of satellite Pop-up Factories depends on the alignment of its industrial characteristics with institutional, regulatory, economic and local frameworks capable of supporting its complexity and accompanying a long-term, structural transformation of the existing building stock.

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Appendix VIII

Dutch Pilot in Hoensbroek, Heerlen

Between the neighborhoods of Hoensbroek-Centrum and De Dem in the city of Heerlen (NL), four portico-style[25] apartment blocks, constructed in 1957, are situated. The last major renovation of these buildings took place in 1986. Together, the four buildings comprise 36 apartments, of which two are currently vacant. The existing apartments are in poor condition, both in terms of sustainability and livability. Each unit has a limited living area of only 76 m², which includes a living room, two bedrooms, a hallway, a kitchen, and a bathroom. This layout does not provide sufficient space for larger households, such as families with multiple children.

The exterior façades are in urgent need of comprehensive maintenance, including masonry, window frames, and glazing. Most of the window frames are made of wood and are in poor condition, requiring replacement. The windows no longer meet current insulation standards, and in several areas, the masonry is deteriorating to the extent that mortar joints are crumbling, and bricks are becoming loose.

Portico apartment blocks are a characteristic element of the local housing landscape of the Netherlands. These buildings typically consist of multiple floors with apartments accessible via a shared entrance or stairwell. The apartments vary in size and are generally designed to accommodate a range of household types, from single occupants to families. Depending on the building, units may include studios or one- to two-bedroom apartments. Shared amenities may include a central entrance hall, bicycle storage, and communal outdoor spaces such as gardens or balconies.

[25] The authors refer to the Dutch housing typology of *portiek etageflat*, defined as a multi-family dwelling with several floors, where the flats are accessible via a communal, covered and lockable porch, which is centrally located at the main entrance of the building. Unlike a gallery block (*galerijflat*, in Dutch), where the flats are located along an open corridor on the outside of the building, the front doors of a porch block are located around a central stairwell. For more information, see: https://kennis.cultureelerfgoed.nl and https://www.tudelft.nl/beyondthecurrent/benadering/typologie



Figure 108: One of the apartment buildings

Need for Renovation

Like many older residential buildings, portico flats require modernization to improve comfort and energy efficiency. Renovation efforts should focus on enhancing insulation, upgrading facilities, and renewing shared spaces, with an emphasis on circularity and sustainability. The renovation project in Hoensbroek aims to improve these flats in terms of environmental performance, circular construction practices, and social livability. Through innovative solutions and renovation strategies, the project seeks to enhance residents' quality of life and contribute positively to the local community and environment.

Figure 1
Layout appartement



Problem Description

The severely outdated portico flats have several negative impacts on both residents and the surrounding area. The apartments have poor energy labels (ranging from C to G), primarily due to inadequate or absent insulation and single glazing that no longer meets current standards. Accessibility is also limited, as the buildings lack elevators and have uneven paving. Furthermore, the internal layout is illogical, contributing to poor livability.

Problem Statement

The portico apartment blocks are in a deteriorated structural condition, have high energy consumption, and are poorly accessible. In addition, the inefficient internal layout results in low residential comfort and reduced livability.

Analysis current situation

Demographics neigbourhood

Mariarade, a district in Hoensbroek within the municipality of Heerlen, has a population of approximately 3,360 residents and a high population density of 3,728 residents per square kilometre. This figure is significantly above both the provincial average of 529 residents/km² and the national average of 526 residents/km² (CBS, 2023).

Age Distribution

The population profile shows a trend toward aging. Approximately 12% of residents are under the age of 15, while 10% are between 15 and 25 years old. The largest demographic group, 31% of the population, falls within the 45–65 age range, forming the core of the working-age population. Furthermore, 25% of residents are 65 years or older, indicating a significant aging population that will require tailored housing, healthcare, and social services (Gemeente Heerlen, 2023).

Household Composition

Mariarade exhibits a relatively high share of single-person households, which account for 39% of the total households. Families without children comprise 32%, and families with children represent 29%. This pattern suggests a high degree of independence among residents but also signals potential social isolation risks, particularly for elderly individuals living alone (Aedes, 2024).

Education Levels

Educational attainment levels in Mariarade are below the national average. Around 33.8% of residents have a low level of education (vs. 26.8% nationally), 43.7% have medium education (vs. 41.5% nationally), and only 22.4% have higher education (vs. 31.7% nationally) (CBS, 2023). This indicates a need for targeted initiatives to improve education and skill development in the area.

Housing and Density

The housing stock in Mariarade is diverse but leans toward smaller units, consistent with the high share of single-person households:

- Apartments: 24%
- Terraced houses: 28%
- Corner houses: 19%
- Semi-detached houses: 22%
- Detached houses: 7%
  (Woonpunt, 2023).

Economic Indicators

Economic data highlights structural challenges. The average annual income is €26,900, which is lower than both the provincial average (€29,200) and the national average (€35,400) (CBS, 2023). Additionally, 9% of residents receive disability benefits, more than double the national average of 4%, indicating a higher prevalence of health-related employment limitations (UWV, 2023).

Key challenges

This demographic profile underscores key challenges in Mariarade, including an aging population, lower education levels, income disparities, and limited economic resilience. These factors necessitate integrated planning strategies aimed at improving economic opportunities, enhancing social support networks, and creating age-friendly and inclusive public services.

Economic Profile

Mariarade's economy is characterized by limited local activity and a relatively weak economic base. The neighborhood hosts approximately 260 registered businesses, equating to around one business for every 13 residents (Gemeente Heerlen, 2023). These enterprises are primarily concentrated in retail, food services, and healthcare, providing essential goods and services while fostering social interaction within the community.

Despite this, the area faces several economic challenges:

- Limited business diversity and activity, resulting in fewer local job opportunities and slower economic growth (Gemeente Heerlen, 2023).
- Minimal tourism and recreational facilities, restricting economic diversification and neighborhood attractiveness (Woonpunt, 2023).
- High unemployment rates, although labor market participation remains slightly higher than in other Heerlen districts (UWV, 2023).
- Low property values, averaging €199,000, approximately €169,000 below the national average. Despite this, property values have risen sharply in recent years, signaling some recovery (CBS, 2023).
- Inflation levels are consistent with national trends, standing at 2.8% in February 2024 (CBS, 2024).

These factors highlight the need for targeted economic revitalization, such as fostering entrepreneurship, enhancing job creation, and developing tourism or recreational facilities to stimulate local growth and improve economic resilience.

Livability

The livability of the portico apartment blocks and their surrounding area, as assessed by the *Leefbaarometer* in 2020, is presented below. The *Leefbaarometer* is a tool

developed by the Dutch national government to visually represent livability across different regions in the Netherlands. Livability is assessed based on five key factors: housing stock, physical environment, amenities, social cohesion, and nuisance & safety (Ministry of the Interior and Kingdom Relations, 2020).

The the overall livability in Hoensbroek is generally rated as “more than sufficient.” However, it is notable that in three specific areas, livability is rated as “weak” or even “insufficient.” These low scores are clearly linked to high levels of nuisance and safety concerns. It is expected that these issues are partly caused by the architectural layout of the area. In the zones with insufficient livability, the urban structure is closed off, with dead-end streets contributing to a sense of isolation.

Zooming in on the complex level, it shows that livability ranges from “sufficient” to “weak.” The *Leefbaarometer* illustrates that the overall score is primarily negatively impacted by the high levels of nuisance and safety issues. According to the *Leefbaarometer*, the current safety situation is therefore considered poor. This is likely due in part to the enclosed parking area at the rear of the buildings and the limited street lighting.

The social cohesion in the area is predominantly negative. This is likely due to the absence of facilities aimed at fostering community interaction. There are no communal spaces or neighborhood centers available within the area. However, each apartment block does have a shared entrance, and a public park is located directly across the street, which may help facilitate informal encounters among residents.



Figure 109: Surroundings of apartment blocks

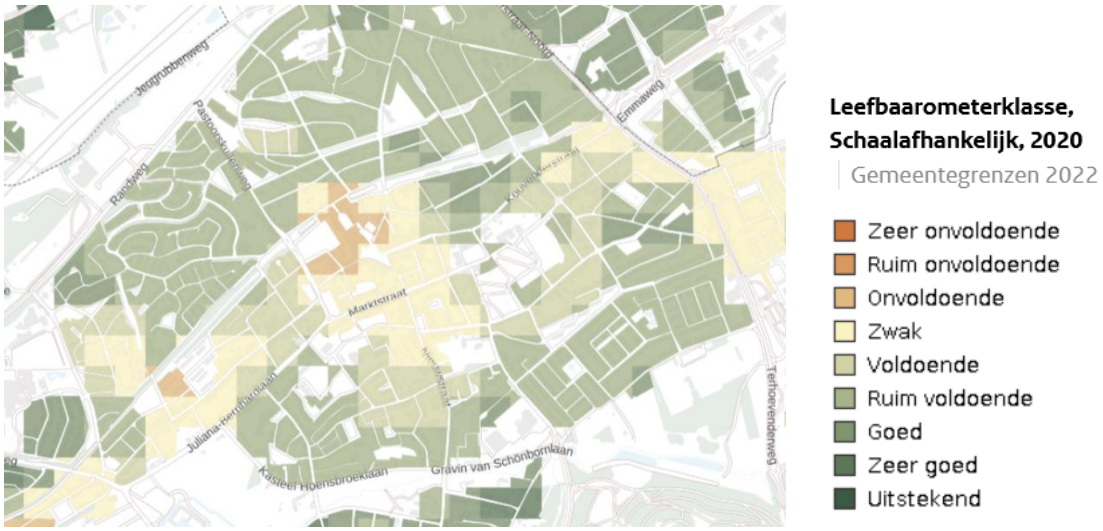


Figure 110: Leefbaarometer Hoensbroek – Heerlen (Ministry of the Interior and Kingdom Relations, 2020).

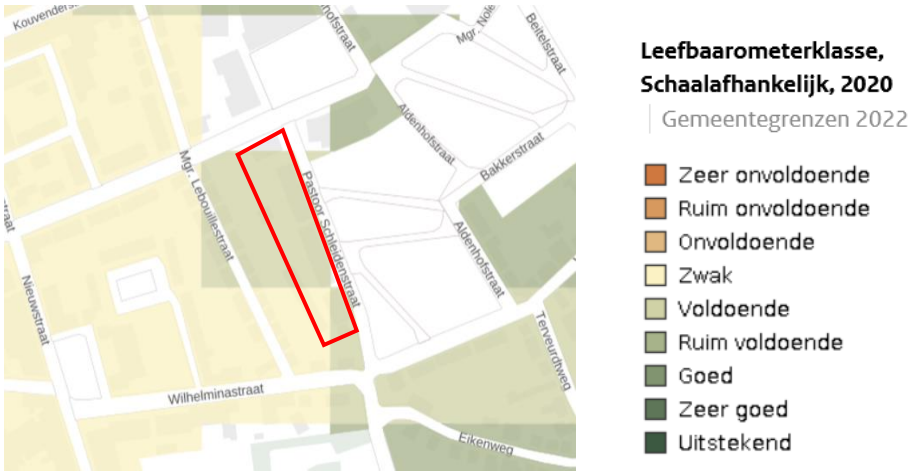


Figure 2: Score livability apartment blocks (Leefbarometer, (Ministry of the Interior and Kingdom Relations, 2020).

The living environment is in a state of noticeable neglect. Behind the apartment blocks lies a large, paved area with several loose stones, and visible waste disposal takes place on the premises. In addition, the buildings themselves are poorly maintained, which negatively impacts the overall aesthetic quality of the area. Furthermore, new apartment complexes are currently being constructed on the green space opposite the flats. Although these new developments contribute positively to the streetscape in terms of architecture and aesthetics, they do result in a reduction of the available park area.

Technological status

Construction year:	1957
Insulation values:	Floor: RC 2,6, Facade: RC 1,4, Roof: RC 2,1
Building state:	Poor windows with mainly single glazing, and damaged brickwork.
Accesibility:	Only stairs (no elevator).
Green space:	Very little around the buildings, poorly maintained; park located across the buildings.
Social housing:	All apartments are owned by social housing association Woonpunt
Accesiblity:	The portico apartment blocks are only equipped with stairwells, including at the main entrance. As a result, the buildings are not accessible for individuals with physical disabilities.
Balconies:	One at the front and one in the back facade of every apartment..
Sun protection:	Not installed; balcony overhangs give some shading in summer but limited.

Source: Woonpunt (2024)

Energy Performance Analysis

The portico apartment buildings in Hoensbroek, constructed in 1957, have an average usable floor area of 76.34 m² per dwelling. The current energy performance of these buildings is below contemporary standards, with average energy labels of E, F, or G. According to Aedes (2024), housing corporations are required to renovate properties with such low labels to at least label D by 2028. In September 2023, Woonpunt, the corporation that owns these buildings, published a concept Program of Requirements (PvE) outlining a renovation strategy. This strategy aims to extend the lifespan of the apartments by 30 years and achieve a minimum energy label A after renovation.

The current energy consumption averages 362.83 kWh/m² per year, indicating significant inefficiency and high operational costs. To address this, the renovation plan targets substantial improvements in insulation, installations, and building systems, aligning with the Paris Climate Agreement goals. The ambition is to potentially meet NOM (Nearly Zero Energy Building) or NOM-ready standards. Implementing circular design principles, the use of renewable materials, and efficient construction processes will also reduce both operational CO_2 emissions and material-related carbon equivalents. These measures will not only enhance the buildings' performance but also create a more sustainable, resilient, and comfortable living environment for residents (Roijakkers et al. 2014).

Energy Loss and Inefficiency Analysis

To effectively improve the energy performance of these apartment buildings, the primary sources of energy loss and inefficiency must be identified. The following issues have been observed:

1. Inadequate insulation

- Walls – Most walls lack insulation, causing significant heat loss. An exception is the building at Pastoor Schleidenstraat 68, where 30 mm cavity wall insulation has been applied.
- Roofs – The existing roofs have only minimal insulation and are covered with bituminous roofing that no longer meets current standards. The concept PvE (September 2023) specifies that the roofing, gutters, downspouts, and penetrations will be replaced and upgraded, and the roof edges will be raised to accommodate additional insulation. At present, these roofs lack sustainability features, such as solar panels or sedum green roofs to improve biodiversity.
- Windows and Doors – Many apartments still feature single-glass windows or outdated double glazing, along with non-insulated doors. This contributes to considerable heat loss and drafts. At Pastoor Schleidenstraat 68, upgrades have been made, including HR++ glazing and insulated doors with a U-value of 2.00.

2. Outdated Installations

All apartments are equipped with gas-fired combination boilers (CV-combi), ranging in age from 1992 to 2011 (brand: Agpo), making them highly inefficient compared to modern systems. Kitchens date mostly from 1986, installed during the last major renovation, with only a few units having been upgraded since. Additionally:

- Asbestos is present around standpipes and in some ceilings near meter cabinets, requiring removal.
- There is minimal individual mechanical ventilation, resulting in poor indoor air quality.
- Meter cabinets are outdated and must be modernized to accommodate new systems such as heat pumps, mechanical ventilation, or solar panel connections.

3. Building Design and Orientation

The original design and orientation of the buildings limit the effective use of natural light and solar heat. This results in higher heating demands in winter and greater cooling needs in summer.



Figure 111: Location of the four apartment buildings (Kadaster, 2024)

Summary

The current condition of the Hoensbroek portico apartments demonstrates a clear need for comprehensive renovation. Addressing insulation deficits, replacing outdated installations, and improving the overall building envelope are critical to achieving energy label A and meeting long-term sustainability targets. These measures will not only reduce energy consumption and CO_2 emissions but also enhance comfort and health for residents, while extending the functional lifespan of the buildings by at least three decades.

Environmental Aspects

The portico apartment buildings are located in the centre of Hoensbroek and are connected to Monseigneur Nolenstraat, providing excellent accessibility. The surrounding area includes several green spaces, such as a large park at the front, integrated greenery along the streetscape in the form of tree beds, and additional green areas at the rear of the buildings (Gemeente Heerlen, 2023).

While these green elements add value, the extensive paved surfaces — primarily functioning as parking areas — limit their environmental effectiveness. These hard surfaces are not climate-adaptive, as they prevent water infiltration, forcing rainwater into the sewer system, and they intensify urban heat stress during warmer periods (Klimaateffectatlas, 2024).

The front park is of limited ecological and social quality. It consists largely of open lawn areas with few trees or shrubs, asphalt walking paths, and a poorly developed vegetation structure composed mainly of a single herbaceous layer with minimal species diversity (Hofman et al., 2024). There are no benches or recreational facilities, restricting its function primarily to that of a pedestrian and cycling route. To improve its ecological and social value, a multi-layered vertical vegetation structure should be implemented, incorporating tree, shrub, herbaceous, and moss layers (Hofman et al., 2024).

Heat stress is another notable environmental concern. According to heat maps (Klimaateffectatlas, 2024), the immediate surroundings of the portico apartments experience temperatures between 38°C and 42°C, compared to 41°C to 43°C in adjacent areas. Integrated greenery in the streetscape contributes to localized cooling, but this effect is diminished by the paved parking area, which retains heat. Similarly, the park provides only a minimal cooling effect, largely due to its limited vegetation diversity and lack of shading (Klimaateffectatlas, 2024).

Water management presents a significant challenge. Flood maps (Klimaateffectatlas, 2024) indicate that during heavy rainfall events — such as 70 mm of rain in two hours — water accumulation of more than 30 cm is likely around the apartment buildings and the park. This vulnerability is primarily due to the low elevation of the area, which naturally collects stormwater, combined with the extensive paving that prevents infiltration and accelerates pooling in the lowest terrain sections.

From a broader ecological perspective, Mariarade faces multiple challenges but also opportunities for improvement. Biodiversity levels are average — above the national benchmark but below regional levels — indicating potential for ecological enhancement (Gemeente Heerlen, 2023). Ecological connectivity is limited due to surrounding major roads (N300, A76) and railway lines, which act as barriers for wildlife movement. Although existing ecoducts, fauna tunnels, and badger tunnels provide some connections, further investment is needed to strengthen these networks (Provincie Limburg, 2023).

Field observations in February 2024 (Gemeente Heerlen, 2024) revealed significant waste issues, including litter, dog waste, and even drug-related debris. Although public waste bins for separate collection are present, their usage and maintenance

are inadequate. Additionally, environmental stress from infrastructure, such as noise, light, and chemical pollution, continues to negatively affect both human well-being and local ecosystems (RIVM, 2023).

Addressing these challenges requires targeted strategies, including reducing hard surfaces, expanding and diversifying green spaces, strengthening ecological corridors, and improving waste management systems. These interventions will help create a climate-resilient, socially valuable, and ecologically robust environment around the portico apartment buildings and the broader Mariarade area.

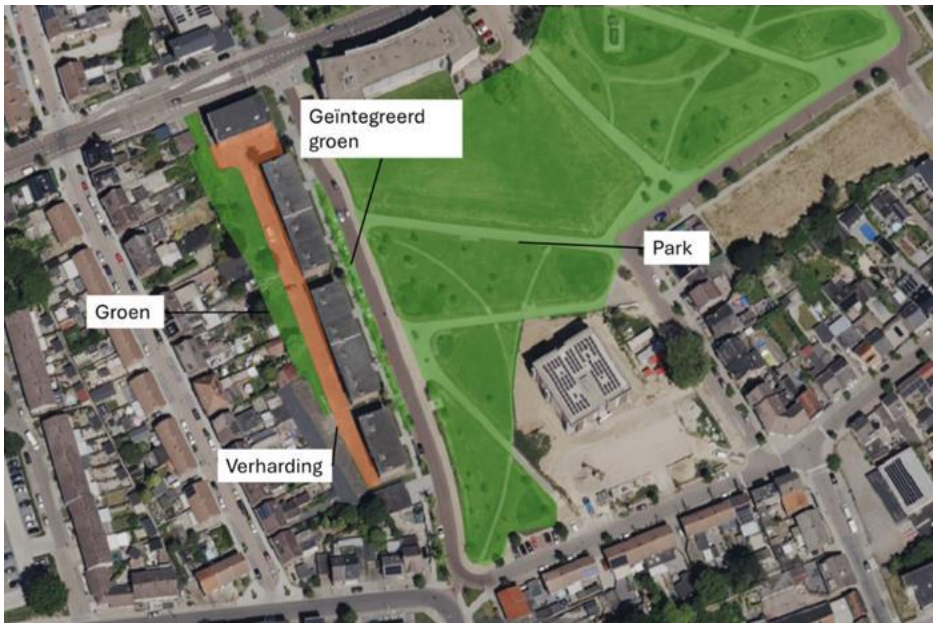


Figure 112: Green spaces



Figure 113: heat in the surrounding area (Klimaateffectatlas, 2025)



Figure 114: Flood map of the area of the apartment buildings in the case of heavy rainfall (Klimaateffectatlas, 2025)

Stakeholder and Actor Analysis

This section provides a stakeholder and actor analysis of the apartment buildings and their surroundings. The objective of this analysis is to identify the key stakeholders within the area, assess their level of influence, and evaluate their relevance in the context of current and future developments. Such insights are crucial for creating an inclusive and well-supported development plan, in which participation and collaboration are central elements.

Key Stakeholders and Actors

Hoensbroek-Centrum comprises a diverse set of stakeholders, each playing a distinct role in shaping the area:

- **Residents** – The residents are the most critical stakeholders. They interact with the neighbourhood daily and possess valuable insights regarding its strengths, weaknesses, and opportunities for improvement.
- **Businesses and Retailers** – Local entrepreneurs, including supermarkets, retail outlets, and service providers, contribute significantly to the economic vitality of the area. Creating and maintaining an attractive business climate is essential to retain existing businesses and attract new investments.
- **Educational Institutions** – Schools, such as the Broekland College and primary schools, are integral to the social fabric of the community and influence the way developments are implemented.
- **Housing Association Woonpunt** – As the principal housing corporation in the area, Woonpunt plays a decisive role in the maintenance, renovation, and sustainability of the housing stock.
- **Municipality of Heerlen** – The municipality holds a facilitating and regulatory role, providing permits, safeguarding policy compliance, and co-developing the area's vision together with local stakeholders.

Together, these parties form the foundation of the area's social, economic, and physical structure, making them indispensable in any development or transformation project.

Participation and Collaboration

Effective participation is essential for successful urban development. Engaging residents from the earliest stages ensures that the neighbourhood evolves in line with their needs and aspirations. Similarly, collaboration with businesses and Woonpunt is critical, as their investments and expertise directly influence the area's attractiveness and liveability. By making participation both accessible and appealing, stakeholders are encouraged to actively contribute ideas and feedback, fostering a sense of shared ownership and commitment to the area's progress.

Stakeholders in the Renovation of Portico Apartment Blocks

The renovation and sustainability process of the portico apartment complexes involves a network of stakeholders with varying levels of interest and influence:

- Current Residents – Engagement with residents is not only mandated under the Environment and Planning Act but is also crucial for generating support and preventing delays.
- Woonpunt – As the owner of the complexes, Woonpunt determines the scope and pace of renovations, while operating within legislative frameworks.
- Municipality of Heerlen – The municipality grants permits, enforces compliance, and aligns the project with broader policy objectives, such as sustainability goals.
- Project Developers and Contractors – These parties are responsible for the technical planning, design, and execution of the renovation works.
- Other Stakeholders – Additional actors such as Waterschap Limburg, schools, and the housing corporation Vincio Wonen play supporting roles, for instance in safety planning, infrastructure management, and urban design coordination.

Interest and Influence Assessment

A structured analysis was conducted to evaluate each stakeholder's level of interest and degree of influence over the project:

Stakeholder	Interest	Influence	Key Considerations
Woonpunt	Very High	Very High	Central role in decision-making and investment allocation.
Waterschap Limburg	High	Very High	Regulatory authority critical for infrastructure and compliance.
Residents/Tenants	Very High	High	Essential for support and smooth project implementation.
Municipality of Heerlen	Moderate	High	Key in permitting and policy alignment, though less involved in daily operations.
Vincio Wonen	High	Moderate	Collaborative opportunities for coordinated neighbourhood development.
Schools	Moderate	Moderate	Concerned with safety and operational continuity during renovations.
Neighbouring Residents	High	Low	Directly affected by changes but limited formal influence.

This matrix provides a foundation for designing tailored engagement strategies that match stakeholders' influence and interest, ensuring efficient communication and collaboration throughout the development process.

In summary, the analysis highlights that residents and primary users of the area are the pivotal stakeholders in the development of Hoensbroek-Centrum. Collaborative efforts involving residents, the municipality, Woonpunt, and other partners are essential to achieve sustainable, widely supported results. Participation is not merely a procedural requirement but a strategic approach to co-create solutions that enhance the liveability and resilience of the area.

By carefully balancing the interests and influence of all stakeholders, the transformation of Hoensbroek-Centrum can proceed efficiently, fostering a neighbourhood that is both vibrant and future-proof.

Renovation plans

Service life extension	**30 years**
New energylabel	A
Current energylabel	EFG (average)





Source drawings: Architectenzaak, 2025, opdrachtgever Woonpunt

Table 65: Overview of Renovation Interventions – Pastoor Schleidenstraat & Mgr. Nolensstraat

Category	Interventions / Activities
General	Renovation of 36 apartments, including technical installations and structural elements.
Demolition Work	Complete and partial demolition of frames, doors, windows, tiling, sanitary fixtures, kitchens, piping.
Asbestos Removal	Removal of asbestos-containing materials in accordance with legal regulations and certification.
Masonry	Removal and repair of joints, crack repairs with spiral anchors, façade cleaning.
Frames, Windows, Doors	Replacement of wooden and plastic frames, windows, and doors; fire-resistant modifications.
Roofing	New bituminous roofing, insulation, vapor barriers, roof detailing, and slope layers.
Interior Finishes	Plastering, tiling, flooring, metal and plastic works, painting, and interior fittings.
Mechanical & Electrical	Renewal of water, drainage, ventilation, electrical, and sanitary installations.
Ventilation	Mechanical extraction, CO_2 sensors, ventilation grilles, and acoustic vents.
Sanitary Installations	Replacement of toilets, sinks, showers, faucets, and accessories.
Kitchen Installations	Removal and installation of new kitchen units.
Painting	Interior and exterior painting on wood, metal, and masonry surfaces.
Ceilings & Walls	System walls, plasterwork, tiling, carpentry.
Flooring	Repair of cement screeds, new floor coverings, leveling.
Stairs & Balustrades	Replacement of balustrades and handrails, repair of prefab concrete stairs.
Fire Safety	Fire-resistant provisions, fire alarm system, extinguishers, compartmentalization.
Flora & Fauna	Integration of swift boxes and bat slides into façades.
Planting	Removal, pruning, and replanting of greenery around buildings.
Nuisance Reduction	Dust barriers, temporary facilities (toilet, heating), protection of furnishings.
Documentation & Planning	Work plans, drawings, revisions, warranty declarations, maintenance contracts.

Table 66: Insulation details

Component	Description	Insulation Value
Roof Insulation	PIR rigid foam boards (Kingspan Therma TR26 FM)	Rc > 6.45 m²·K/W
Window Frames	K-Vision Trend PVC profile	U = 1.4 W/m²·K
Insulating Glazing	Double glazing (IsoPerform ALFA)	U = 1.1 W/m²·K
Ventilation Grilles	Thermally insulated aluminium grilles (DucoLine, DucoMax)	U = 2.58 – 2.81 W/m²·K
Souterrain Ceiling	EPS + wood wool cement boards	Rc ≈ 1.03 m²·K/W

Table 3: Overview of new Installations

Installation Type	Description / Components	Specifications
Ventilation System	Mechanical ventilation with CO_2 control, fans, ducts, dampers, and external grilles	Airflow rates, noise reduction, insulated ducts, in compliance with NEN standards
Heating & Hot Water	Replacement of heating and domestic hot water systems	Energy-efficient systems, balanced regulation, commissioning required
Sanitary Installations	New toilets, showers, sinks, taps, and accessories	Water-saving fixtures, compliant with Dutch building codes
Water Supply	New piping and connections	Metal piping, insulated where needed, pressure-tested
Drainage / Sewer	New internal drainage system	Plastic piping, tested for leaks, compliant with NEN standards
Electrical Installations	New wiring, switchboards, sockets, lighting, and door openers	Low-voltage systems, LED lighting, safety tested, compliant with NEN 1010
Communication Systems	Intercom, video door entry, signal and detection equipment	Integrated with electric door openers, tested for functionality
Fire Safety Systems	Smoke detectors, fire alarm system, fire extinguishers	Compliant with NEN 2654-II, maintenance contract required
Control Systems	Regulation and automation equipment	Includes thermostats, CO_2 sensors, and system controllers
Kitchen Installations	New kitchen units, plumbing, and electrical connections	Modular cabinets, soft-close hinges, LED lighting, water and power connections

The PuF Model and the construction works

More information on D4.1

Figure 8 illustrates the District/Assembly Factory concept for the Dutch ecosystem. The process begins with the Manufacturing phase in which the (raw) material is collected and prepared. For the Dutch pilots we reckon three main workflows, related to the Insulation shell (façade and roof), the Installation of the window frames/façade system, and the Energy works. In addition, these cases show the added value of using the occasion of the deep-renovation for intervening on smaller portion of the building blocks, such as the interior systems and finishing. In both pilots, not all these work flows are executed within the PuF logic, with the exception of the window frames/façade system work flow which will be further discuss below. In this way, The reason for this difference lays on the opportunities for mass production and repetition of elements (higher in repetitive façade, lower in insulation installation), as well as the specific type of work required for the other processes, such as those energy-related.
The Dutch pilots also show how these different work flows are operated simultaneously in the building but proceedings at two different speeds. The first stream is related to the outside works, which is organised vertically on the facades, requiring for the pilot in Heerlen around 28 days per block (9 apartments) for the façade system and the roof insulation; the second one, instead, is a horizontal type and it refers to works that happen inside the building and the apartments.

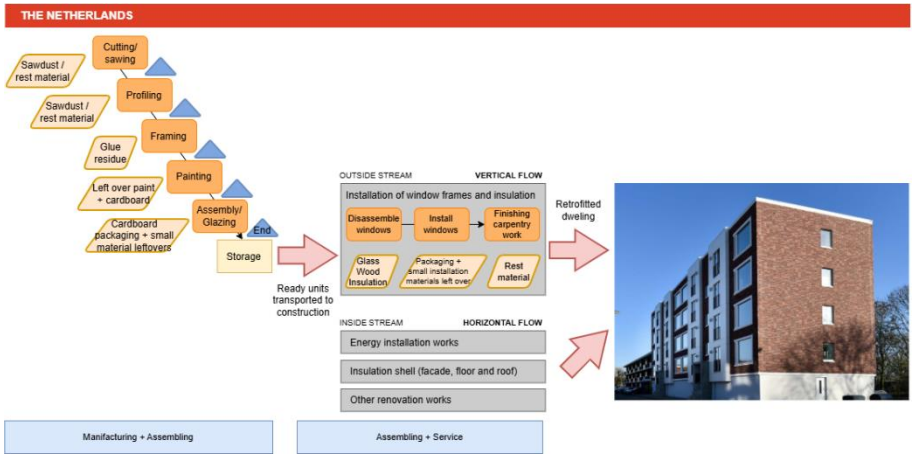


Figure 115: District Factory - Tailored Design

Within this PuF model flow, the works related to the instalment of the window frames can be divided into two blocks of actions: the first related to Manufacturing and the initial Assemblage of the part (which happens off-site), and the second related to Assemblage and Service, which takes place on-site.
The first block includes also activities such as cutting of profiles, framing, painting, glazing and finally assembly: all these steps results in a waste streams (e.g., leftover paint, cardboard packaging) and a final check necessary to proceed to the following step. Completed units are then moved to storage before being transported to the construction site.
Once at the construction site, the second block includes the preliminary activity of disassembling the windows, then installing the new (prefabricated) facade, and finishing the carpentry work. Also these actions will result in related waste stream.

In parallel, other actions are happening within the **horizontal flow** in the inside of the building and the apartments, namely the insulation of the basements, the renovation of gas/boiler, the (partial) removal of asbestos in the wc pipes, the upgrade of fire compartments (in the Hoensbroek pilot), the installation of ventilation system, and the renovation of kitchen and bathrooms with the related finishing. A relatively small portion of the site environment is dedicated to storing the construction material (partially o pre-assembled), in a variable range between 60-100 sm.
The sum of these two streams result in the final (deep) renovation of the building blocks and the related dwellings.

Construction works

The following photographs were taken during a series of site visits conducted together with the owner of the housing complex, the housing association Woonpunt, and the main contractor, BCG.

The renovation works are progressing according to the planned schedule and follow a dual implementation strategy. A vertical workflow focuses on the renovation of the interior spaces, while a horizontal workflow addresses the building envelope, including the façades, roof, and external shell. These parallel work streams enable different manufacturers, contractors, and specialist teams to operate simultaneously, improving efficiency and reducing overall construction time.

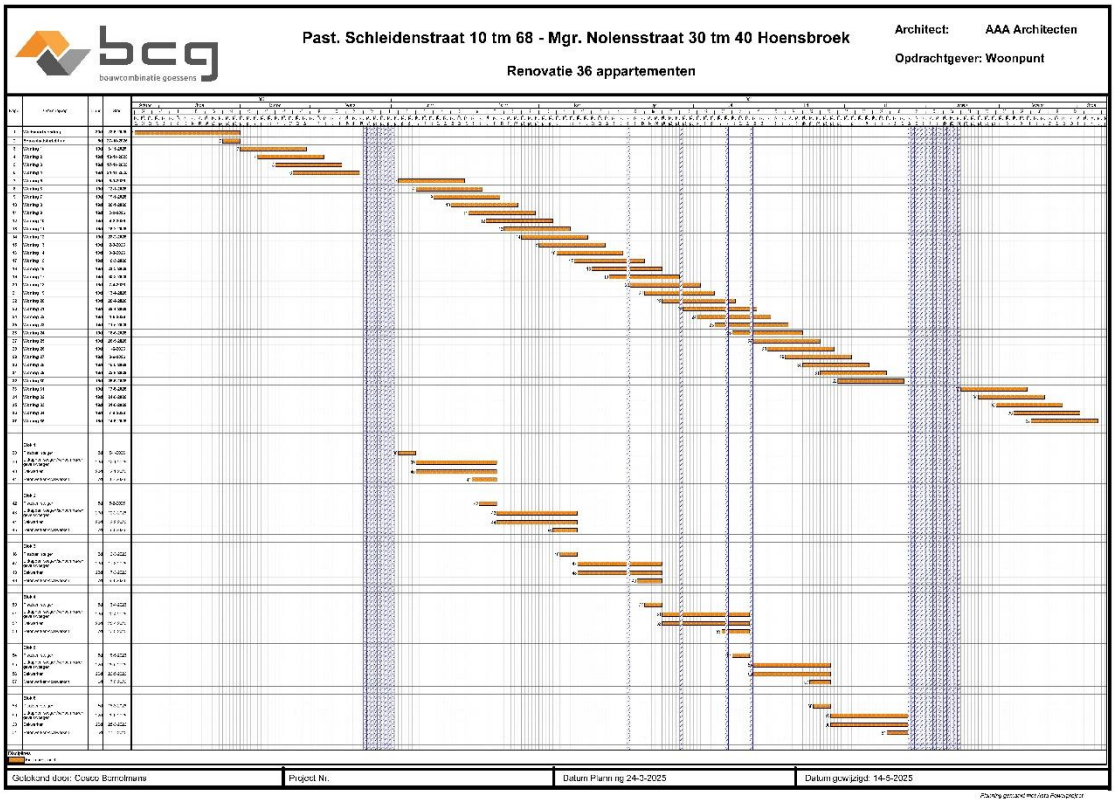


Figure 116: Time plan of BCG for the renovation of the building complex



Figure 117: The main facade side, Pastoorschleidenstraat, during renovation



Figure 118: Details of the installation of bat friendly devices in the external facade



Figure 119: Rear facade, Pastoorschleidenstraat, during renovation



Figure 120: Details of the installation of bat friendly devices in the external rear facade

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Dutch Pilot in Maastricht

The renovation of the Quirinaalhof complex in Maastricht is a landmark project for the housing association Woonpunt, representing a strategic shift from traditional maintenance to a highly coordinated, industrialized renovation model. The building, a high-rise residential structure dating back to 1970–1971, has reached a critical 55-year milestone where significant investment is required to ensure its functionality for at least another 50 years. This project is not being conducted in isolation; rather, it is a deliberate emulation of the Palatijnhof renovation, a neighboring pilot project where the contractor Smeets Bouw successfully implemented industrialized methods for the housing association Servatius. By utilizing the same contractor and building upon the Palatijnhof experience, Woonpunt aims to validate whether this approach is truly more sustainable, faster, and less expensive while producing significantly less waste than traditional building methods. The initiative is further framed by the broader "Market Activation Platform," an ecosystem-wide effort to identify exemplary actors in the renovation sector and demonstrate that large-scale, sustainable change is technically and logistically feasible. In summary, the Quirinaalhof project is a strategic effort to apply industrialized lessons from the Palatijnhof pilot to a 144-unit complex, aiming for structural longevity and environmental compliance through local partnerships.



Figure 121: The Quirinaalhof, view from the parking

Need for Renovation and Problem Statement

The necessity for renovating the Quirinaalhof building stems from a convergence of structural obsolescence, urgent regulatory mandates, and severe social inequities resulting from the building's current systems. Constructed between 1970 and 1971, the 55-year-old complex has reached a critical stage in its lifecycle where a major

investment is required to ensure it remains functional and relevant for an additional 50 years. A primary driver is the legal requirement for Dutch housing associations to eliminate all poor energy labels (E, F, and G) by the end of 2028. Failure to comply with these energy targets would expose the owner, Woonpunt, to significant government fines and prevent them from implementing annual rent increases.

Beyond legal compliance, the renovation addresses deep-seated issues of fairness regarding the building's outdated collective heating system.

The technical condition of the building also presents hazards and discomfort; asbestos is present in the facade connections, and many existing windows are inoperable, which prevents the natural ventilation necessary for a well-insulated building. Furthermore, internal fixtures such as kitchens and toilets are over 30 years old, meaning they have fundamentally reached the end of their technical lifespan and require full replacement.

The problem at Quirinaalhof can be framed as a research question focused on the efficiency and scalability of modern building methodologies: Does an industrialized renovation approach, utilizing local manufacturers and prefabricated elements (PuF Distric/Assembly), deliver a more sustainable, rapid, and cost-effective outcome with less waste than traditional construction methods?

This question explores how standardized and repeatable processes can be used to navigate complex technical constraints, such as the safe management of asbestos and the transition to fossil-free energy systems like individual heat pumps.

The research further investigates the logistical and social feasibility of implementing these industrialized strategies while tenants remain in place, drawing on data and lessons from previous pilots like the Palatijnhof project. It seeks to understand how the convergence of technical feasibility, regulatory pressure, and economic incentives, such as the ISDE subsidy for heat pumps, can create a replicable model for preserving and upgrading aging residential building stock across the European ecosystem

Analysis current situation

Demographics neigbourhood

Daalhof is a residential neighbourhood located in the Buitenwijk West district of the municipality of Maastricht, province of Limburg, the Netherlands. As of 2025, it counts 6,370 inhabitants, spread across a relatively compact urban area. The neighbourhood has experienced a gradual demographic contraction over the past decade, declining from 6,815 residents in 2013 to 6,370 in 2025, representing a reduction of approximately 6.5%. The following sub-sections provide a structured overview of the key demographic, spatial, educational, and socio-economic characteristics of Daalhof, drawing on data compiled from the Dutch Central Bureau of Statistics (CBS), the Land Registry (Kadaster), and allied institutional sources.

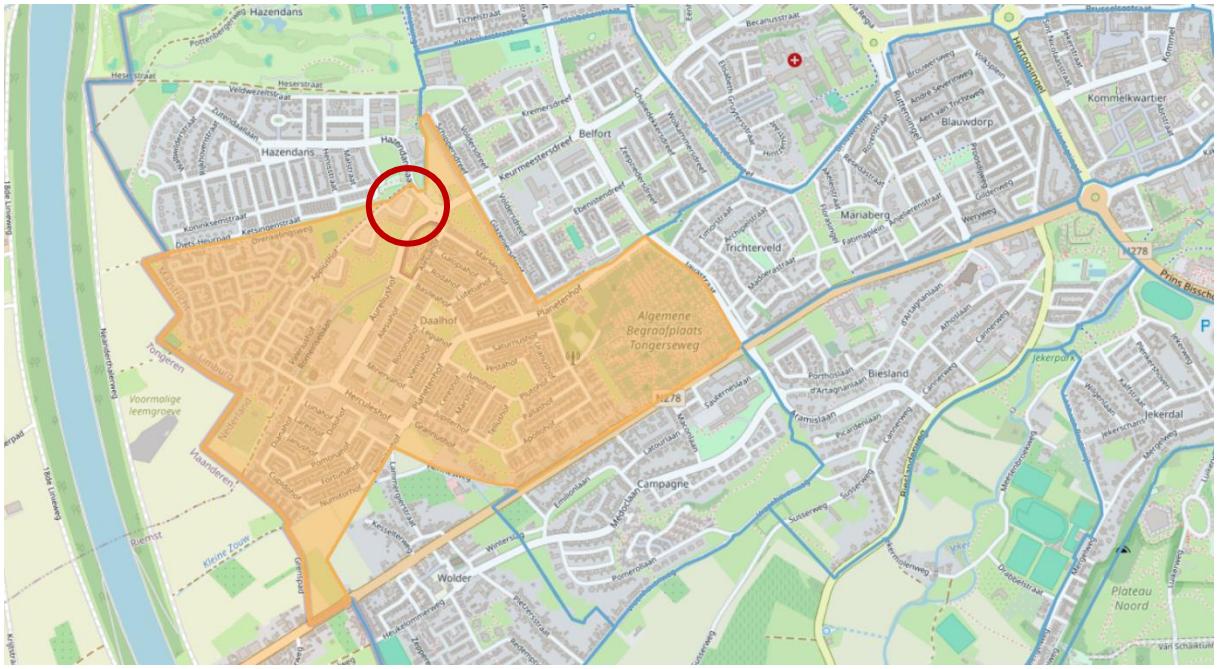


Figure 122: Daalhof neighbourhoof in the western part of the city of Maastricht (source: Allecijfers.nl)

Age Distribution

The age structure of Daalhof is notably skewed towards older cohorts. As of 2025, 30% of residents are aged 65 or over (approximately 1,910 individuals), while the 45–65 age group constitutes 26% of the population (approximately 1,655 individuals). Working-age adults between 25 and 45 years account for 22% (approximately 1,430 individuals), while younger age groups are comparatively underrepresented: those aged 15–25 comprise 10% (655 individuals) and children under 15 account for 11% (715 individuals). This demographic profile indicates a significantly ageing population, with nearly one third of residents past retirement age — a pattern consistent with broader demographic trends observed in post-war residential neighbourhoods across the Netherlands.

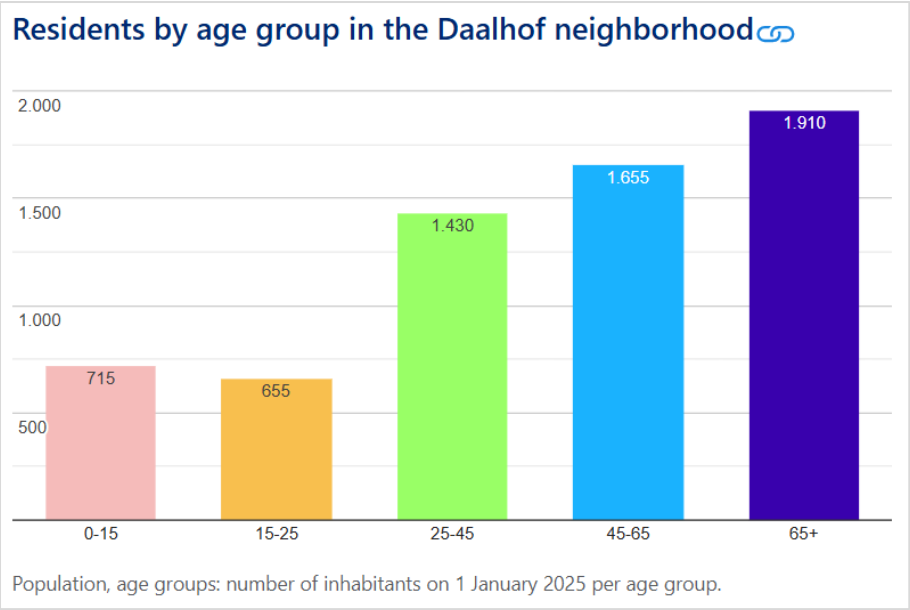


Figure 123: Daalhof, Age distribution (source: Allecijfers.nl)

Household Composition

Daalhof comprises 3,475 households with an average household size of 1.8 persons. Single-person households constitute 47% of all households (approximately 1,640), while multi-person households account for the remaining 53% (approximately 1,835). Of the latter, 29% are multi-person households without children, and 24% include dependent children. The predominance of single-person and childless households, combined with the elevated share of elderly residents, suggests a neighbourhood in which social care needs are likely above average. The marital status data further reflect this: 44% of residents are unmarried, 38% are married, 12% are divorced, and 6.1% are widowed.

Education Levels

Among residents aged 15 to 75, the educational attainment profile of Daalhof is as follows: 31.9% hold a low (practical) level of education, 46.1% have attained an intermediate (secondary vocational) level, and 21.9% hold a higher educational qualification. This distribution indicates that the neighbourhood's adult population is predominantly concentrated at the intermediate level, with a relatively modest share of higher-educated residents compared to more centrally located or university-adjacent urban areas. In 2024, a total of 910 students and pupils resided in Daalhof, including 350 in primary education, 180 in secondary education, 130 in vocational training (MBO), 110 in higher professional education (HBO), and 140 in university-level programmes (WO). The neighbourhood itself contains no school premises; the average road distance from a home address to the nearest primary school is 0.8 kilometres.

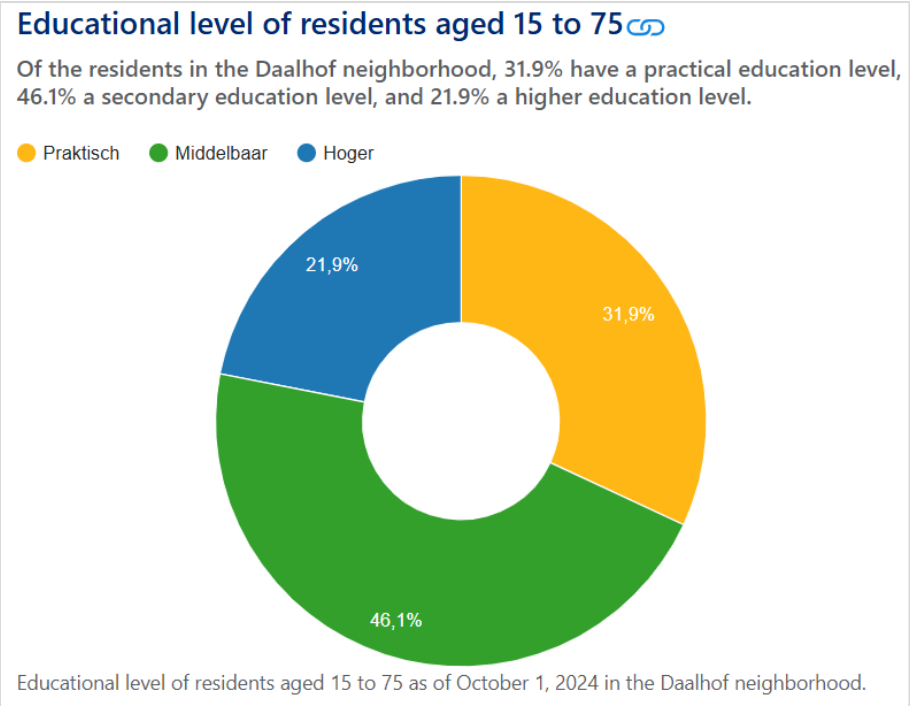


Figure 124: Daalhof, education level of residents (source: Allecijfers.nl)

Housing and Density

Daalhof covers a land area of 110 hectares and contains 4,073 registered addresses and 3,401 dwellings, yielding an address density of 2,046 per km² — broadly comparable to the national average of 2,082 per km². The population density stands at 5,791 inhabitants per km², considerably exceeding the national average of 536 per km², which reflects the neighbourhood's urban character. The housing stock is equally divided between owner-occupied and rental dwellings. The predominant dwelling type is the apartment, with 1,581 registered apartment addresses. The majority of the built environment dates from the 1970–1980 period, with 2,201 buildings constructed during that decade. The average WOZ (official property valuation) stood at €250,000 in 2025, representing a 63% increase from €153,000 in 2013. In terms of energy performance, energy label C is the most prevalent, applying to 1,309 addresses, followed by label B at 633 addresses.

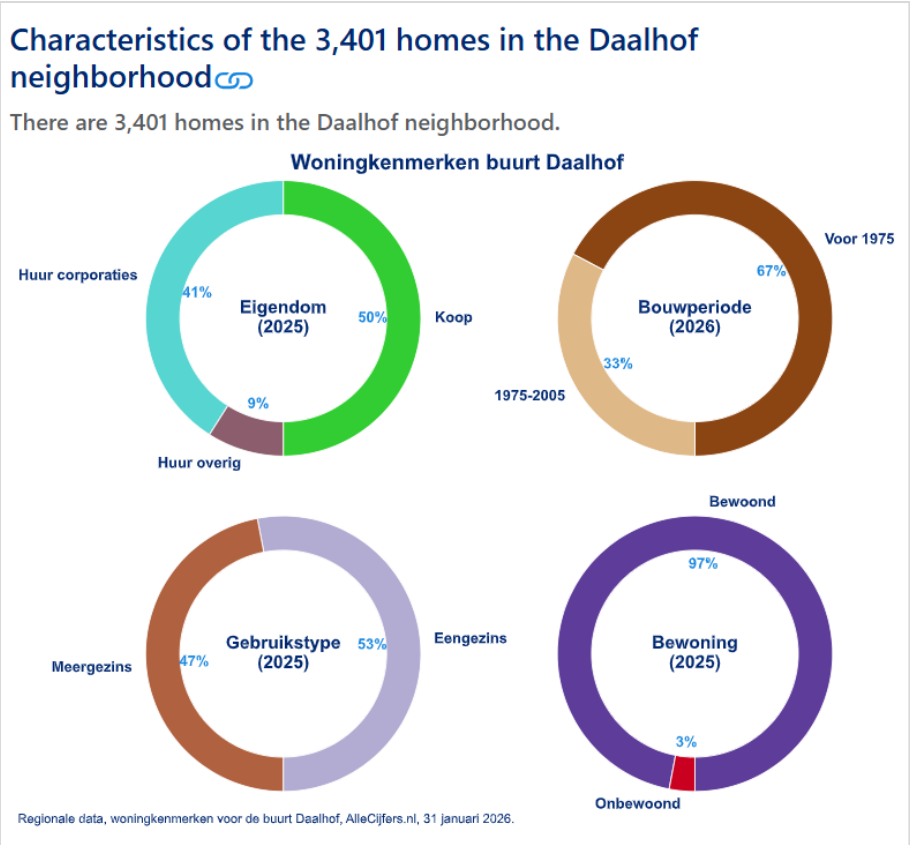


Figure 125: Daalhof, details of home property (source: Allecijfers.nl)

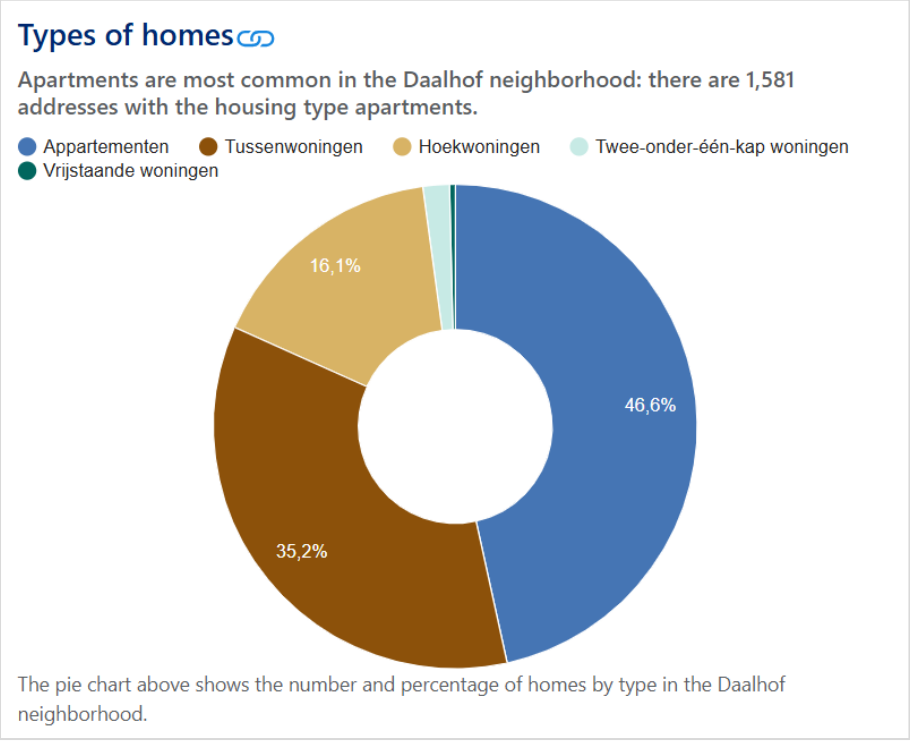


Figure 126: Daalhof, types of homes (source: Allecijfers.nl)

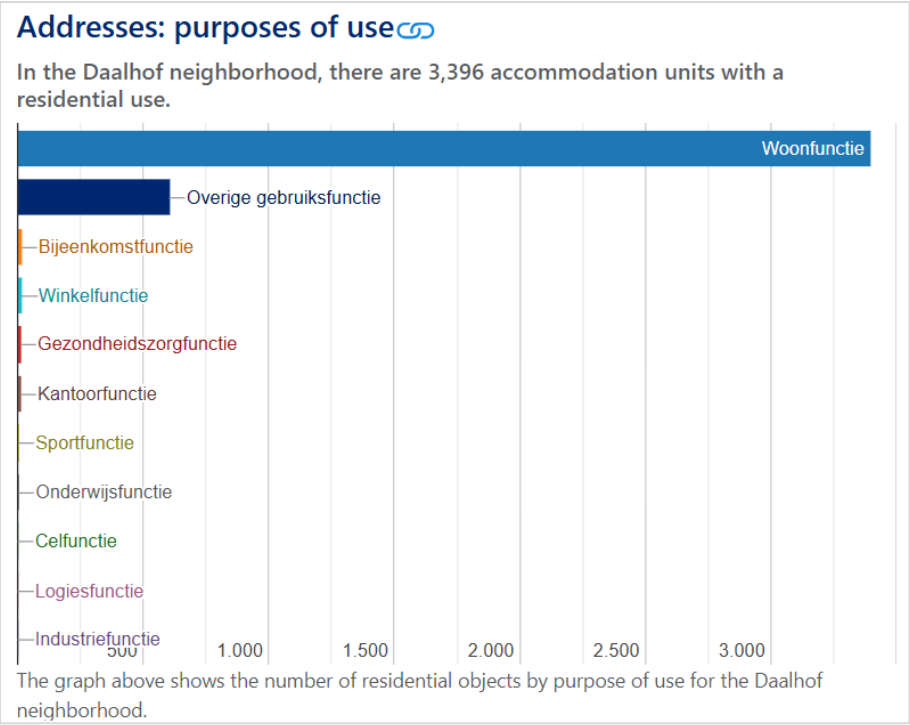


Figure 127: Daalhof, usage of spaces (source: Allecijfers.nl)

Economic Indicators

The average gross annual income per resident in Daalhof is €30,600, while the average income per income recipient is €35,100. The neighbourhood counts 5,500 income recipients out of 6,370 total residents. The net labour force participation rate is 63%, with 91% of working residents in employee positions, of which 64% hold permanent contracts and 27% flexible ones. Self-employed individuals account for 9% of the working population. Approximately 9.2% of households have an income at or near the social minimum, and 2.9% of residents live below the poverty line. The median household wealth stands at €49,100. The neighbourhood hosts 375 registered business establishments, the largest sectors being government, education and healthcare (85 establishments, 23%), business services (80 establishments, 22%), and culture, recreation and other services (65 establishments, 18%).

Key challenges

The demographic and socio-economic data collectively point to several structural challenges confronting Daalhof. First, the pronounced ageing of the population — with 30% of residents aged 65 or older — places considerable demands on local care infrastructure. This is reflected in the high WMO (Social Support Act) caseload of 805 clients, equivalent to 127 per 1,000 residents, and in the elevated proportion of residents with one or more chronic health conditions (43%) or functional limitations (41%). Second, 56% of residents report feelings of loneliness, including 18% who report severe loneliness, pointing to a significant issue of social isolation. Third, 57% of residents are overweight and only 40% meet the national physical activity guidelines, indicating relevant public health concerns. Fourth, the neighbourhood's population has declined steadily over the past decade, suggesting limited attraction for younger families. Fifth, the proportion of residents from non-Dutch backgrounds

has grown: in 2025, 14% of residents originate from other European countries and 13% from outside Europe, compared to 12% and 9.5% respectively in 2013 — a shift that implies growing needs for integration support and culturally sensitive service provision.

Livability

The Leefbaarometer is a national monitoring instrument developed by the Dutch Ministry of the Interior and Kingdom Relations (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties) that produces statistical estimates of residential liveability at a granular spatial level — down to 100×100 metre grid cells. The instrument draws on 45 types of environmental characteristics, derived from 94 underlying variables, and organises these into five dimensions: housing stock (woningvoorraad), physical environment (fysieke omgeving), provisions and amenities (voorzieningen), social cohesion (sociale samenhang), and nuisance and insecurity (overlast en onveiligheid). The dimensions of provisions and nuisance and insecurity carry the greatest weight in the overall score. Liveability scores are expressed either as an absolute valuation — ranging from "very poor" to "excellent" — or as a deviation from the national average in standard deviations. Measurement rounds have been conducted for the years 2002, 2008, 2012, 2014, 2016, 2018, 2020, 2022, and 2024, with the instrument substantially revised into version 3.0 in 2021.

With respect to the broader municipal context, Maastricht as a whole is identified in national reporting as one of the cities where liveability in certain neighbourhoods has come under sustained structural pressure. National analyses note that Maastricht — alongside cities such as Lelystad, Delfzijl, Leeuwarden, Emmen, and Den Helder — contains areas where liveability scores have persistently remained below satisfactory levels. More recent analysis covering the 2020–2022 measurement period further identified Maastricht, together with other Limburg municipalities such as Parkstad Limburg, Sittard-Geleen, and Venlo, among the cities where pockets of already unfavourable liveability continued to deteriorate, driven primarily by worsening scores on the nuisance and insecurity dimension.



Figure 128: 'Livability meter class' classification for the area of Quirinaalhof (Source: leefbaarometer.nl)

For Daalhof, the 2024 measurement places the neighbourhood in the **"Voldoende"** (sufficient) class on the liveability index at the neighbourhood scale, as visible on the map layer, which corresponds to a light green classification. This indicates that while residents' assessments of their living environment are broadly acceptable, the neighbourhood scores below the national average overall. The dimensional deviation chart for 2024 shows that the total score deviation from the national average is slightly negative but close to zero, with all five dimensions falling within a narrow range around the national mean. The *voorzieningen* (provisions) dimension shows the most clearly negative contribution, pulling marginally below average, while *fysieke omgeving* (physical environment) and *woningvoorraad* (housing stock) register slight positive contributions. *Sociale samenhang* (social cohesion) and *overlast en onveiligheid* (nuisance and insecurity) are both approximately at the national average, with the latter sitting marginally below it.

Taken together, the Leefbaarometer profile of Daalhof in 2024 reflects a neighbourhood that is broadly stable and liveable but not notably strong in any single dimension. The relative weakness in amenity provision is consistent with the earlier finding that the neighbourhood contains no primary or secondary school premises of its own, and that access to higher-order services requires travel beyond the immediate residential area. The absence of major negative deviations on the nuisance and insecurity dimension is a relatively positive signal, suggesting that despite the socio-economic pressures documented elsewhere in this profile, the neighbourhood has not deteriorated into patterns of acute disorder.

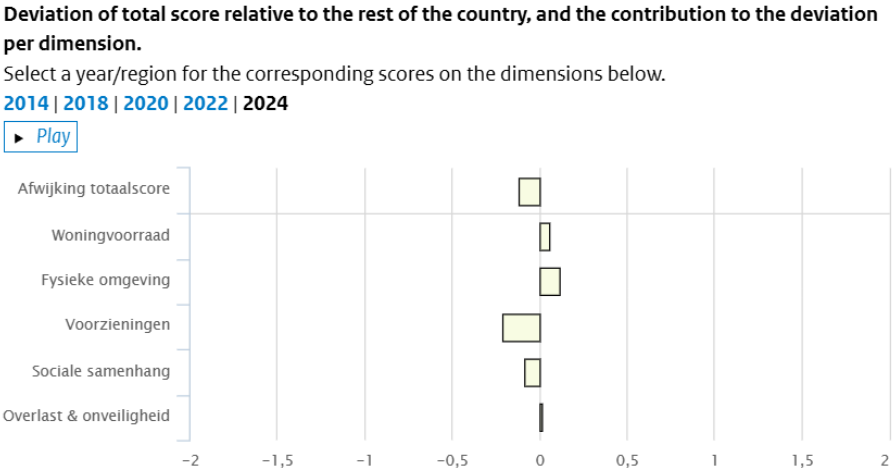


Figure 129: 'Livability meter class' details for the area of Quirinaalhof (Source: leefbaarometer.nl)

The Klimaateffectatlas (Climate Effect Atlas), a national platform commissioned by the Dutch government to visualise climate-related risks and adaptation opportunities at neighbourhood scale, reveals a compound and spatially differentiated climate vulnerability profile for Daalhof. The following analysis focuses in particular on the Quirinaalhof building cluster, situated in the central-eastern section of the neighbourhood, as it consistently emerges as a concentration point across multiple risk indicators.

Urban Heat Island Effect

The urban heat island (UHI) map for the current scenario shows that the built-up areas of Daalhof, including Quirinaalhof and its surrounding residential blocks, experience a temperature surplus of approximately 1.0–1.4°C above the rural baseline, placing them in the orange range of the classification. The more densely built residential corridors and hard-surfaced streets connecting the hofjes register the highest UHI values within the neighbourhood, while the green corridor running along the southern edge of Daalhof (visible in pale green on the map) provides moderate thermal relief. By contrast, the more sparsely built northern portion of Daalhof, with greater spacing between buildings, shows somewhat lower UHI intensities.

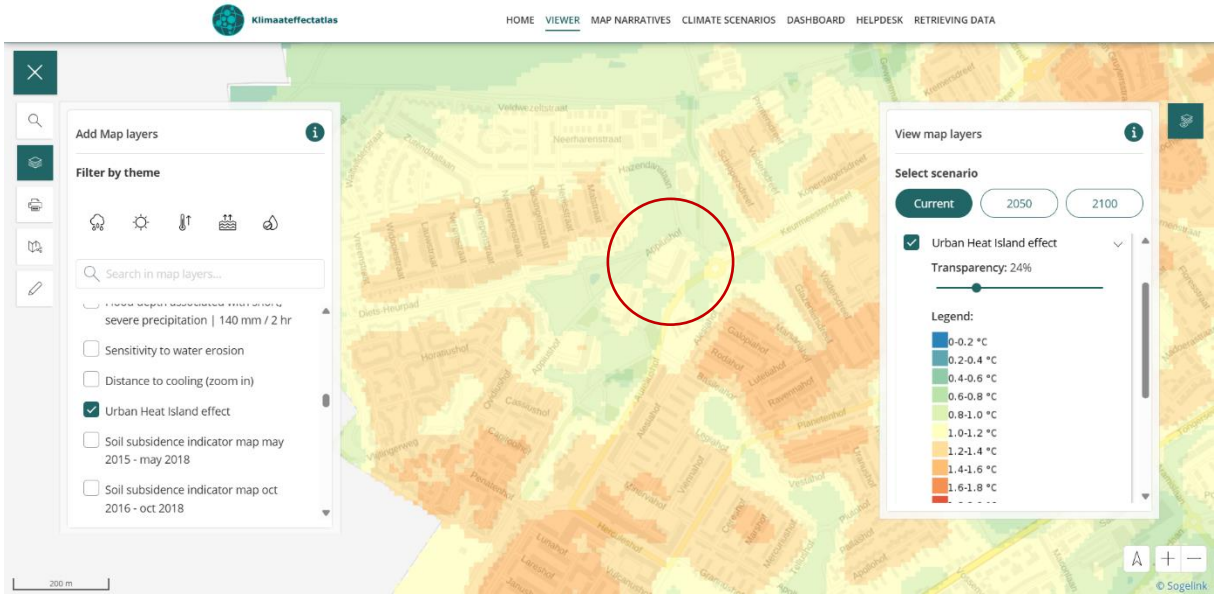


Figure 130: Urban Heat Island (Source: www.klimaateffectatlas.nl)

Social Vulnerability to Heat

The social vulnerability to heat layer classifies most of the Daalhof area — and Quirinaalhof in particular — in the category of moderate to high fragility combined with moderate to high heat minima exposure (rendered in medium pink-red tones). This composite indicator combines physical heat exposure with population fragility, drawing on factors such as age, health status, and social isolation. Given that 30% of Daalhof's residents are aged 65 or over and that 56% report feelings of loneliness — as

established in the demographic analysis above — this classification is structurally coherent. The Quirinaalhof area shows a predominantly moderate fragility profile, though adjacent areas to the north of the neighbourhood register higher fragility levels.

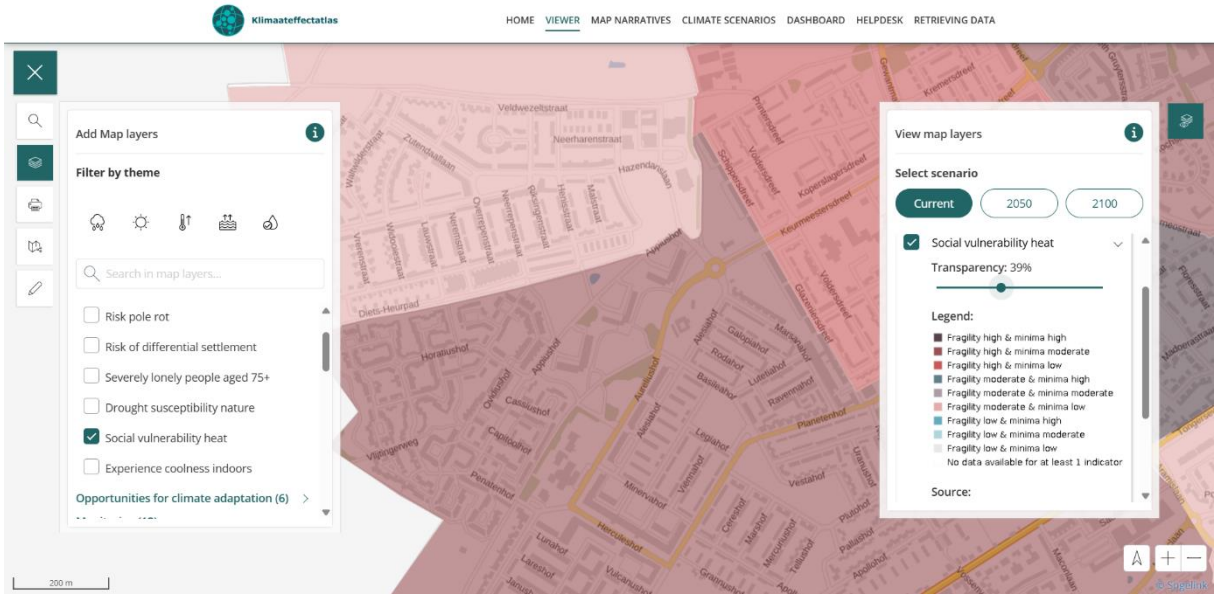


Figure 131: Social Vulnerability to Heat (Source: www.klimaateffectatlas.nl)

Experience of Coolness Indoors

The indoor coolness experience layer (current scenario) shows that the majority of the Daalhof residential area, including Quirinaalhof, falls in the 40–60% category, meaning that between 40 and 60% of residents report being able to experience adequate cooling indoors. Several sub-areas register values below 40%, depicted in deep pink, indicating that a significant share of residents are unable to find sufficient thermal relief within their own homes during heat events. The northern part of the neighbourhood, where larger apartment blocks from the 1970s–1980s are concentrated, appears particularly affected. This is consistent with the energy performance data showing that

energy label C is the most common classification and that a substantial share of the housing stock dates from a period before modern thermal insulation standards.

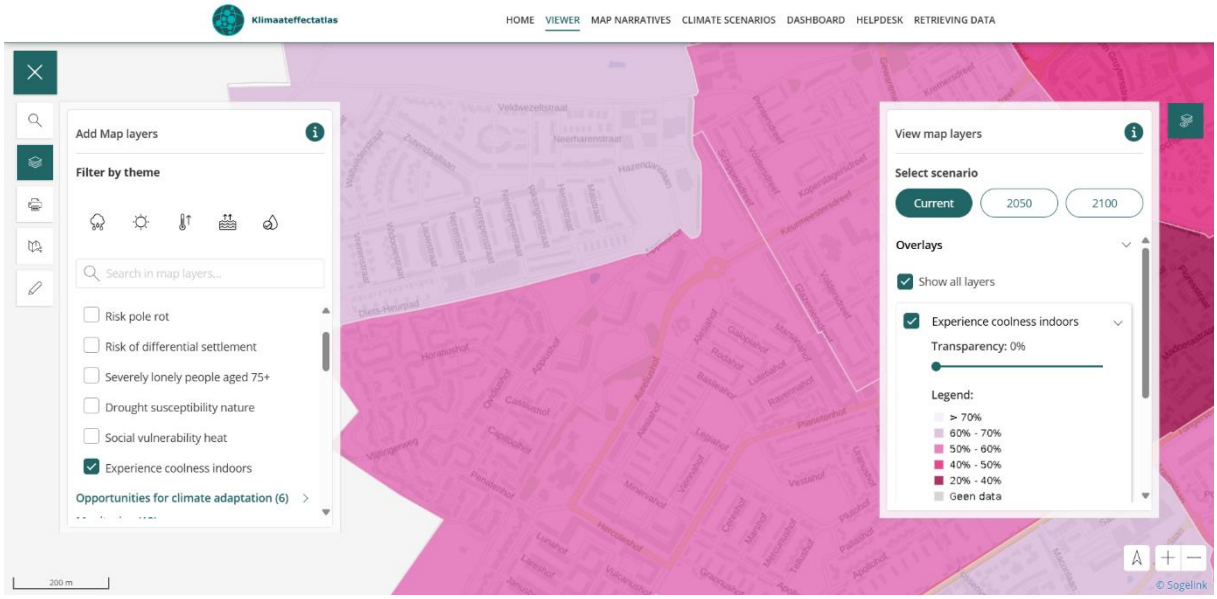


Figure 132: Experience of Coolness Indoors (Source: www.klimaateffectatlas.nl)

Tree-Crown Cover

The tree-crown cover monitoring layer (most recent data) reveals a heterogeneous green canopy distribution across Daalhof. The map shows clusters of tree cover concentrated along the main access route on the eastern edge of the neighbourhood and in scattered garden areas between residential blocks, while the street-level environment of the central hofjes — including Quirinaalhof — appears to have limited canopy coverage. The green buffer zone at the southern perimeter of Daalhof provides a more substantial tree-crown area, but its spatial position at the edge of the neighbourhood limits its cooling effect on the denser central residential fabric.

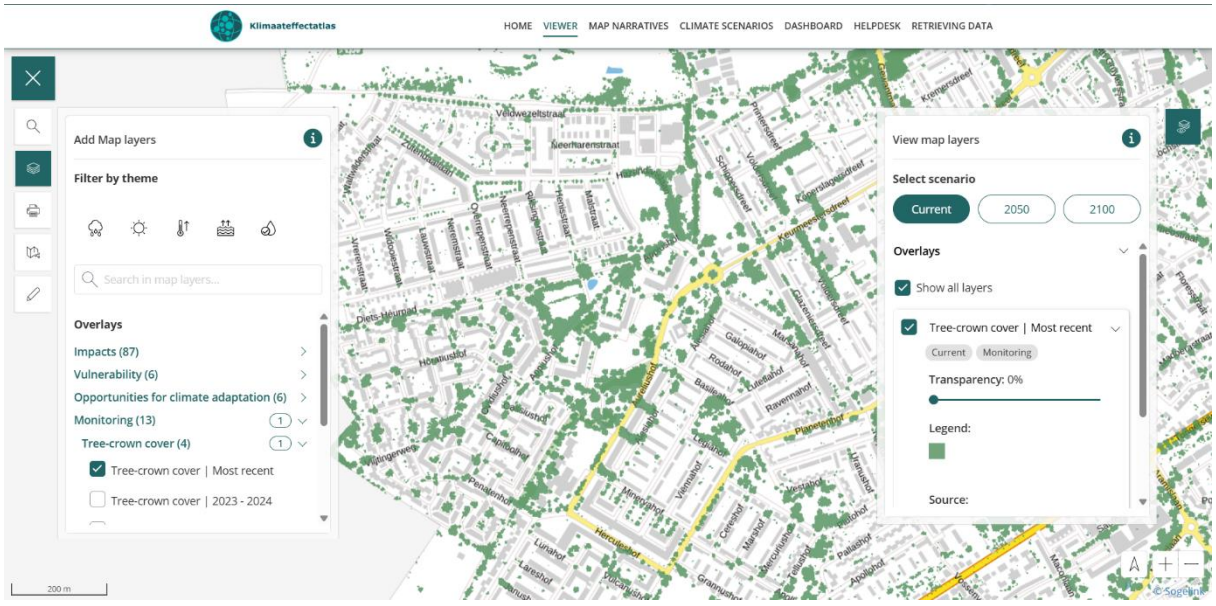


Figure 133: Tree-Crown Cover (Source: www.klimaateffectatlas.nl)

Shaded Footpaths and Cycle Tracks

The shaded footpaths and cycle tracks layer (2023–2024 data) indicates that the pedestrian and cycling network within Daalhof is largely characterised by limited shade provision. The main east–west corridor through the neighbourhood (shown in gold/yellow on the base map) and several internal footpaths show shade coverage in the lower 10–30% bracket (lightest blue), while only isolated path segments achieve shade levels above 40% (dark blue). The relative lack of shading along active travel routes is a notable vulnerability for the elderly population who are dependent on walking and cycling for daily mobility, particularly during heatwave events.

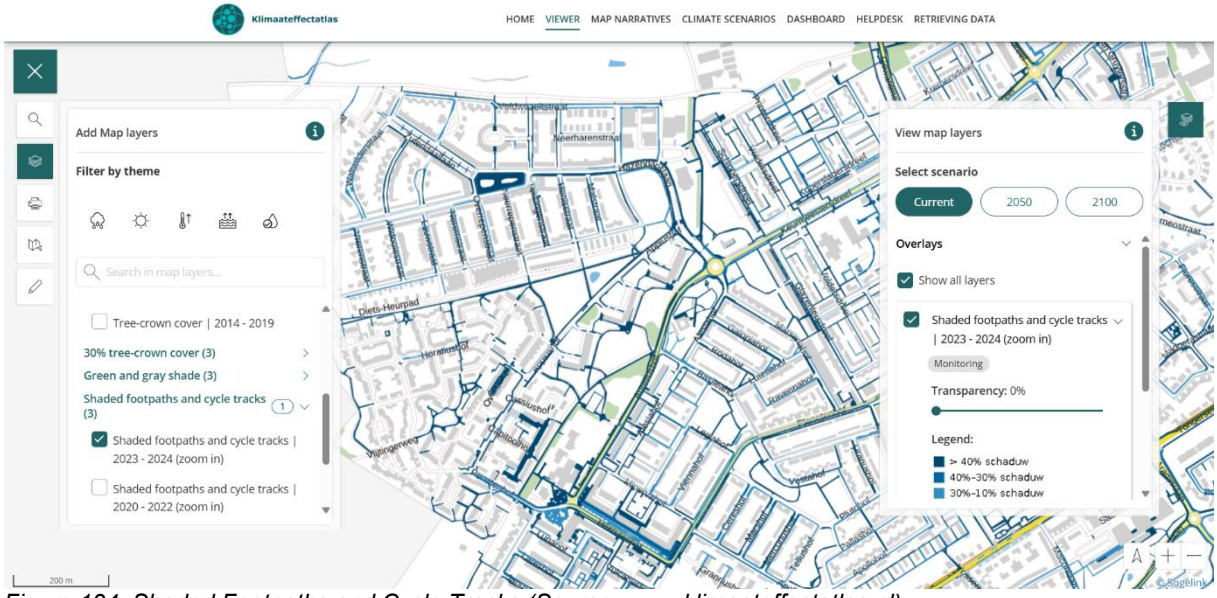


Figure 134: Shaded Footpaths and Cycle Tracks (Source: www.klimaateffectatlas.nl)

Flood Depth — Short, Severe Precipitation (70 mm / 2 hr, 2050 scenario).

The pluvial flood risk map, shown under the 2050 climate scenario for a severe precipitation event of 70 mm in two hours, reveals that Daalhof faces a meaningful but spatially concentrated flood risk from surface water accumulation. The main drainage corridors — the primary roads and their adjacent low-lying areas — are projected to accumulate water depths of 5–15 cm, with the densest accumulations visible along the central spine of the neighbourhood and at low-lying junctions. The Quirinaalhof surroundings appear to lie in a moderate-risk zone, with water accumulation predominantly channelled along the bordering streets rather than in the inner courtyard areas, though this depends on local drainage capacity. The pattern is consistent with

the typical hydraulic behaviour of post-war residential neighbourhoods where road surfaces and paved areas dominate over permeable green space.

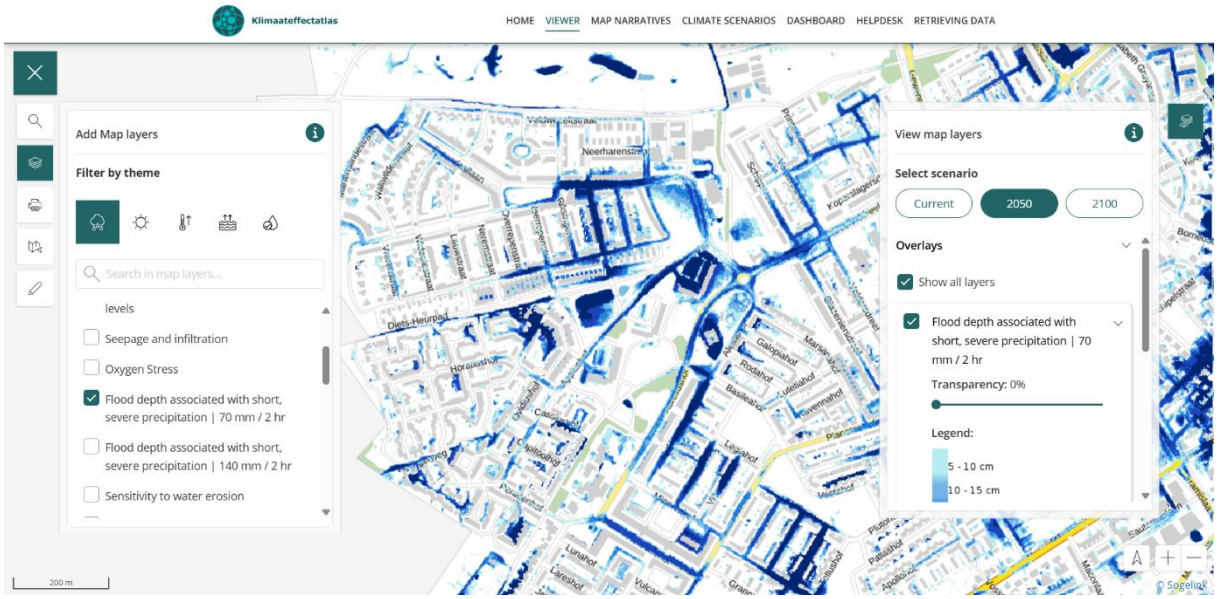


Figure 135: (Source: www.klimaateffectatlas.nl)

Taken together, the Klimaateffectatlas data portray Daalhof — and the Quirinaalhof cluster in particular — as an area exposed to a convergence of heat stress, limited indoor and outdoor cooling capacity, inadequate shade infrastructure, and moderate pluvial flood risk. These physical vulnerabilities are compounded by the social fragility of the population, making climate adaptation a structurally urgent policy priority for this neighbourhood.

Renovation plans

Service life extension	**30 years**
New energylabel	A(+/++)
Current energylabel	A-F

Construction year:	1971
Building state:	Last maintenance works were conducted 40 years ago for the exterior (especially the roof) and 30 years ago for the interior (kitchen/bathrooms).
Accesibility:	Stairs block and lift at the intersection of the two wings
Green space:	Green area around the building of property of the Municipality of Maastricht. A parking lot is also available for the building on the ground floor but it is in poor conditions.
Social housing:	All apartments are owned by social housing association Woonpunt
Balconies:	Gallery distribution on the infer side of the building for allowing entrance to the apartments; on the outer side, each apartment has their own balcony.
Sun protection:	Not installed; balcony overhangs give some shading in summer but limited.

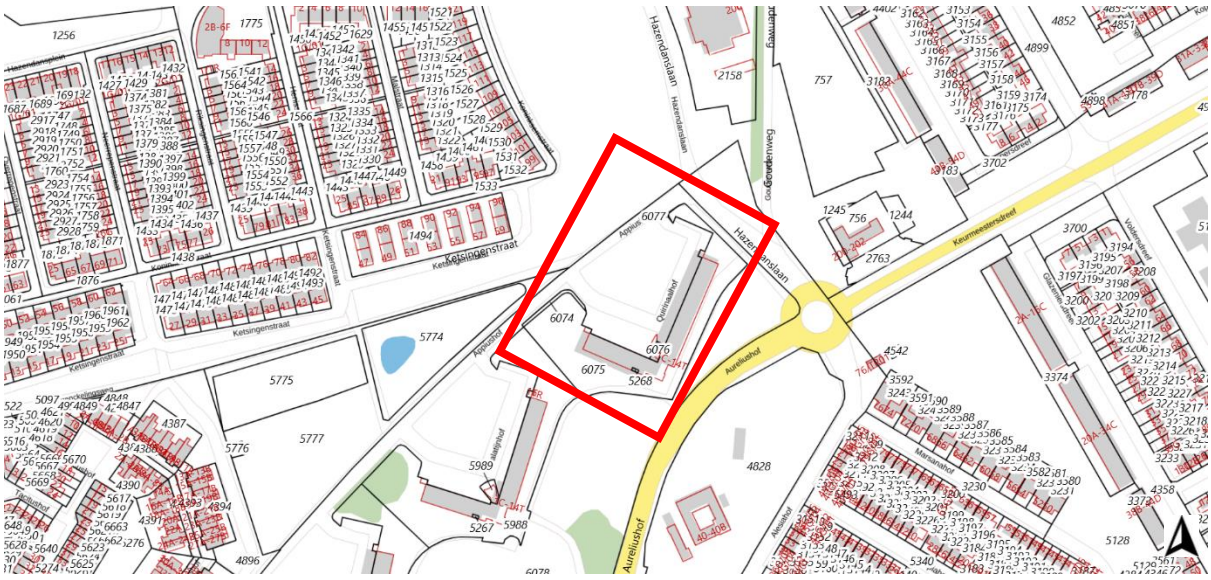


Figure 136: Location of the Quirinaalhof building (Kadaster, 2026)

Goals of the renovation

The primary drivers for the renovation are the stringent Dutch and European climate targets for 2030 and 2050, which mandate a transition to fossil-free dwellings. Specifically, Woonpunt is under regulatory pressure to eliminate all poor energy labels(from E to G) from its housing stock before the end of 2028. Failure to meet this deadline would result in financial penalties and a legal freeze on annual rent increases, making the renovation a financial necessity as much as an environmental one. Beyond regulatory compliance, a central goal is to address deep-seated issues of tenant fairness regarding the collective heating system.
The existing system relies on outdated meters and estimates. By upgrading the building to an Energy Label A (and in some cases A+), the project aims to improve living comfort, reduce energy costs, and ensure that every resident pays only for the heat they actually consume. Within this framework, the core goals include meeting 2028 energy label mandates, transitioning to a fossil-free infrastructure, and correcting long-standing billing inequities for the 144 resident households.

Table 67: Overview of Renovation Interventions

Category	Activities
General	This industrialized renovation project uses local prefabricated elements and a "just-in-time" delivery model to extend the building's functional life by 50 years.
Demolition Work	Demolition involves removing old window glass, wooden sashes, outdated kitchen units, toilets, and the entire vertical water and waste pipeline system.
Asbestos Removal	Specialist certified companies will remove asbestos found throughout the building, though hazardous removal at the window frames is bypassed by mounting new units externally.
Masonry	Masonry-related work includes applying new plasterwork above tiles and installing prefabricated tile panels directly over existing wall finishes to minimize dust and noise.
Frames, Windows, Doors	New wooden window frames are mounted in front of existing ones to avoid asbestos, complemented by the installation of new front doors and wooden meter cupboard doors.
Roofing	The old roofing and its thin insulation are replaced with a modern system featuring 30 cm of insulation to achieve Energy Label A performance.
Interior Finishes	Kitchens, bathrooms, and toilets are completely renovated using local "cradle-to-cradle" tile panels and new cabinetry, followed by full interior painting.
Mechanical & Electrical	The outdated collective boiler is replaced with individual heat pumps and roof-mounted PVT panels that generate electricity and absorb thermal energy to pre-heat water.
Ventilation	Natural ventilation is reintroduced through the installation of operable windows, supported by a mechanical exhaust system for kitchens and bathrooms.
Sanitary Installations	Replacement of toilets, sinks, showers, faucets, and accessories.
Kitchen Installations	Removal and installation of new kitchen units.
Water Supply	New piping and connections
Drainage / Sewer	New internal drainage system

Painting	Interior and exterior painting on wood, metal, and masonry surfaces.
Ceilings & Walls	System walls, plasterwork, tiling, carpentry.
Flooring	Repair of cement screeds, new floor coverings, leveling.
Flora & Fauna	Integration of tailored solutions for preserving protected local species, such as bats and house sparrow.
Nuisance Reduction	Dust barriers, temporary facilities (toilet, heating), protection of furnishings.
Documentation & Planning	Work plans, drawings, revisions, warranty declarations, maintenance contracts.

Detailing the Renovation Plans

The renovation of the Quirinaalhof complex involves a comprehensive technical and structural overhaul designed to upgrade the building envelope, internal facilities, and energy systems. Externally, the work includes stripping the old roof to install 30 cm of insulation and new roofing layers, applying wall and floor insulation, and executing a specialized window strategy where new wooden frames are mounted over existing ones to bypass hazardous asbestos removal. The building's energy infrastructure will transition from an outdated collective system to individual heat pumps for all 144 units, supported by roof-mounted PVT panels that generate electricity and capture thermal energy to pre-heat water. Interior works are equally intensive, featuring the full replacement of kitchens, bathrooms, and toilets using prefabricated tile panels, alongside the renewal of all vertical water and waste pipelines. Final interventions include reintroducing natural ventilation via operable windows, installing bat boxes to comply with ecological regulations, and updating facade elements such as front doors, meter cupboard doors, and exterior lighting.

The Apartments Renovation: An Industrialized Interior and Exterior

Inside the units, the renovation focuses on a "just-in-time" delivery model and prefabricated elements to minimize dust and noise for the residents. A major technical highlight is the "window-in-front-of-window" strategy; since asbestos is present between the concrete structure and the original wooden frames, the project avoids the high cost and hazard of full removal by retaining the old frames. Workers remove only the glass and sashes, mounting new wooden window units externally in front of the old ones. From the interior, finishing elements are added to conceal the original wood, ensuring a clean appearance while reintroducing natural ventilation through new operable windows. For kitchens and bathrooms, the project uses prefabricated tile panels from Royal Mosa, which are glued directly over existing tiles to speed up the process and reduce waste. To further reduce disruption, an external lift and temporary roads for cranes are used so that workers do not interfere with the building's busy internal elevators.
Therefore, the apartment renovation leverages a circular strategy of retaining asbestos-encased frames and using local prefabricated tile panels to accelerate the 15-day internal work cycle per unit.

The PuF renovation of the Quirinaalhof is organized around a dual-track logistics strategy referred to as the "twee sporen" or two pathways, which allows for highly coordinated, simultaneous progress on the building's interior and exterior. This approach utilizes a horizontal flow for the primary teams; for instance, the interior team might begin their work on the left side of the complex while the exterior team, tasked with balconies and window frames, starts on the right, with both eventually meeting in the middle of the building. Running concurrently with this horizontal movement is a vertical line of renovation necessitated by the building's internal infrastructure. Because the project involves replacing vertical shafts for water and waste pipelines, workers must coordinate their efforts vertically through the stacks of apartments to update the kitchens, bathrooms, and toilets. This synchronized sequencing between horizontal and vertical tracks is designed to maintain a continuous, industrialized flow to ensure the 1.5-year construction schedule remains efficient and free of major surprises.



Figure 137: Distribution of function across the floors of the Palijtinhof building, which reflects the same structure and distribution [red/green: residential; orange: other functions; blue: support].

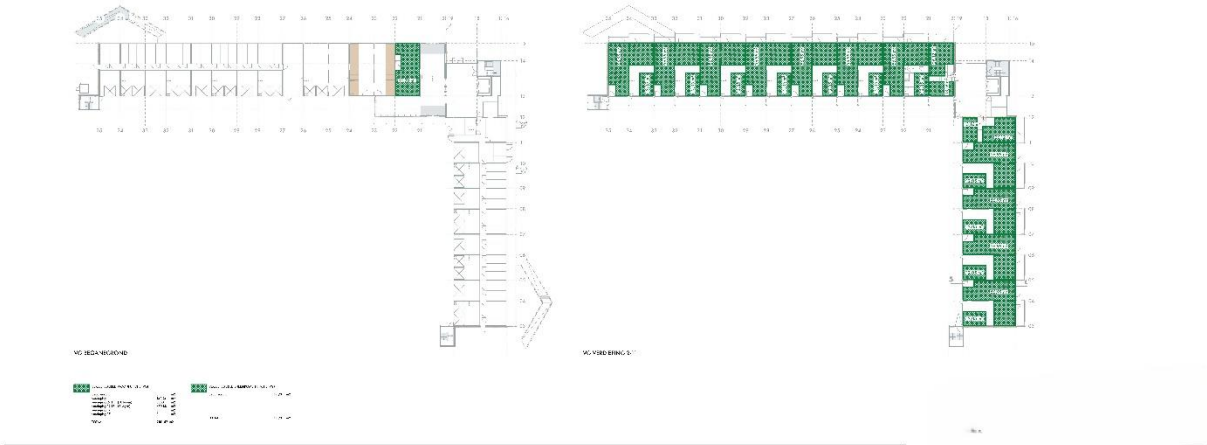


Figure 138: Distribution of function across the floors of the Palijtinhof building, which reflects the same structure and distribution [red/green: residential; orange: other functions; blue: support].



Figure 139: Mosa Panel: prefab renovation with real tiles (Source: Mosa Royal).

The prefabricate window frames

The window frame replacement is planned to follow a specialized industrialized and circular strategy that prioritizes efficiency and safety by **retaining the original wooden frames** rather than removing them entirely. Workers will remove only the old glass and the operable wooden sashes, after which **new wooden window units** are mounted externally directly in front of the original frames.
This additive approach is primarily dictated by the presence of asbestos in the connection between the existing frames and the concrete structure; by leaving the original frames in place, the project avoids the high costs and significant time delays associated with removing hazardous materials under controlled conditions.
To ensure a clean aesthetic, interior finishing elements are installed on all four sides to completely conceal the old frames from the tenants' view. Furthermore, the new windows are designed to be operable, reintroducing natural ventilation that is critical for maintaining comfort in a building that will become much more airtight following its extensive insulation upgrades. This method not only accelerates the construction timeline—allowing a facade to be installed in as little as one day—but also aligns with sustainability goals by utilizing wooden materials instead of plastic.



Figure 140: Picture of prefabricated window frame produced by Helwig kozijnen (Source: Helwig kozijnen).

The Roof Renovation: Thermal and Ecological Constraints

The roof renovation is a high-priority intervention designed to combat the significant heat loss currently experienced by top-floor apartments. The existing insulation, which is roughly 40 years old and only 5 to 10 centimeters thick, will be stripped and replaced with a modern 30-centimeter insulation layer. This upgrade is technically necessary to achieve the target Energy Label A. However, the timing of this work is strictly dictated by flora and fauna regulations; external work on roofs is generally prohibited between March and August because this is the breeding season for protected bird species. To bypass these restrictions, the team must work with ecologists to establish alternative nesting locations well before the birds arrive in the spring. Ultimately, the roof renovation involves a massive increase in insulation thickness to meet energy standards, though its execution must be carefully scheduled around seasonal ecological breeding windows.



Figure 141: Types of poles for hosting the bats during the renovation works.



Figure 142: Vleermuiskast, technical solution which needs to be installed within the renovation to ensure the protected species of bats to find reparir within the building cavity.

PVT, Heat Pumps, and Other Interventions

The technological heart of the renovation is the shift from a collective boiler to individual heat pumps for all 144 apartments. This transition is supported by the installation of PVT (photovoltaic-thermal) panels on the roof, which combine photovoltaic electricity generation with thermal energy collection within a single system. Unlike conventional photovoltaic panels, PVT panels recover heat from the surrounding air through an integrated thermal absorber located beneath the photovoltaic cells. This absorbed heat

is used as a low-temperature energy source for the heat pumps, pre-heating the circulating fluid and reducing the energy required to reach usable temperatures. At the same time, the photovoltaic layer generates electricity that can support the operation of the heat pumps and other building services. By simultaneously producing electrical and thermal energy, the system increases the overall energy yield of the available roof surface and contributes to reducing the building's reliance on fossil-fuel-based heating.



Figure 143: PVT Hybrid solar panel type (Source: Solar Master)

Other critical interventions include the complete replacement of vertical water and waste pipes, which necessitates the temporary relocation of tenants to "hotel apartments". Wall and floor insulation will also be added where feasible to eliminate the cold zones currently found in units above the basement or next to lift shafts.

Permits and Subsidies

The project requires a complex array of approvals, including municipal permits for **façade changes** (which can take up to 14 weeks) and specialized **ecological licenses**. Because **protected bats and house mice** inhabit the building, Woonpunt has already installed **bat boxes** a year in advance so that the animals can acclimate to new homes before their original entry points are sealed for construction. Financially, the project is offset by the **ISDE subsidy**, which provides approximately **€1,400 per heat pump**. Other regional subsidies may also be available for measures that help elderly residents stay in their homes longer.

Table 68: Overview of Renovation Interventions

Permit / Requirement	Purpose	Approval
Omgevingvisie **[Façade Change]**	Required for any modifications to the exterior of the building; the municipality reviews the plans to ensure they fit the surroundings.	14 weeks (consisting of a standard 8-week term plus a potential 6-week extension).
Flora & Fauna **[Ecological License]**	Required to ensure that protected species, specifically bats, house mice, and various bird species, are not disturbed during construction.	Requires alternative habitats (bat boxes) to be installed at least one year in advance so species can acclimate before work begins.
Asbestos Removal License	Required for the removal of asbestos in various parts of the building by a certified company, involving a detailed plan for disposal and safety.	4 to 6 weeks.
Municipal Ground Use Permission	Required if the contractor needs to use land belonging to the municipality (such as public parking areas) for long-term storage or containers.	Not explicitly stated, though early-stage communication with the municipality is required to ensure no conflicting plans exist for the area.
Legal Tenant Consent	A mandatory requirement under Dutch law whereby a set percentage of current residents must approve the renovation plan before it can start.	70% of all tenants must formally agree to the plan; if this threshold is not reached, the plan must be adjusted.

In the following picture it is possible to see which areas are allowed for the working site, according to the permits submitted to the Municipality:

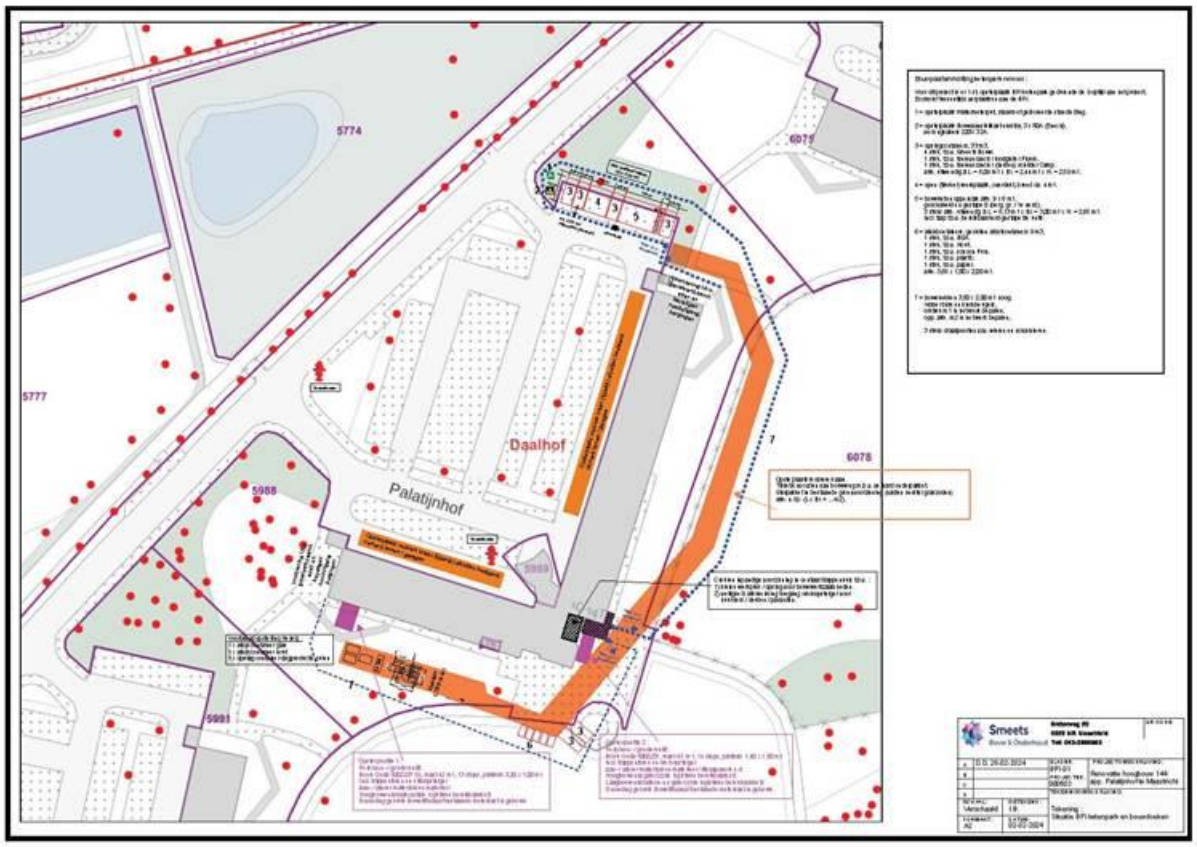


Figure 144: Detailed site plan with areas of work and load according to the permits (source: Smeets).

Project Schedule

The timeline for the Quirinaalhof renovation is characterized by a "train" metaphor—once the project enters the execution phase, it must run continuously to maintain efficiency and manage costs. The project is currently in the initiative and definition phases, with site preparation and detailed engineering expected to take roughly 12 to 14 weeks. At the latest update (June 2026), the team is targeting a construction start in late 2027 or early 2028. The total construction duration is estimated at 1.5 years (approximately 50 to 60 work weeks). Before the full rollout, Woonpunt and Smeets Bouw will deliver one large and one small test apartment to solve any technical "surprises" and show residents exactly what the final result will look like.

Table 69: Overview of Renovation Interventions

Phase	Activities	Actors involved	Duration
Initiation Phase	Exploration of renovation options (cost, time, energy); analysis of Palatijnhof pilot lessons; defining 50-year functional goal	Housing Association, main contractor	About 1.5 year
Definitive phase	Detailed planning and drawings; site visits for technical fit; engineering for heating, water, and electricity; asbestos and ecological research	Housing Association, Constructors, specialized advisors	Approx.. 6-12 months

Developemnt phase	Realisation of the test apartments Goal to reach 70% consensus of the inhabitants	Housing Association (tenant coach), main contractor	Approx 192 days
Bouwvoorbereiding	Finalisation of subcontractor planning; permit applications (omgevingsvergunning for façade changes, asbestos removal licence, ecological clearance); pre-check with municipality; bat box installation; ordering of prefabricated elements and materials	Housing Association, main contractor, municipality, ecological advisor, certified asbestos firm	Approx. 12-14 weeks
Site preparation	Construction of temporary access roads and crane positions; installation of site containers (storage, canteen, office); placement of external construction lift; removal of balcony partition fences; installation of safety fencing; tenant relocation preparation	Main contractor, Housing Association (tenant coach), municipality (public ground permits)	Approx 12-14 weeks
Renovation	Exterior: crane-assisted installation of new prefabricated wooden window frames over existing frames; façade panel replacement; roof insulation removal and renewal (approx. 30 cm); installation of PV-thermal panels. Interior (per apartment, 15 working days each): replacement of kitchen, bathroom, toilet, vertical water/waste pipes, heat pump installation; interior finishing	All (sub) contractors, housing association	Approx 50-60 weeks
Operation & Maintenance	Ongoing maintenance of wooden frames (repainting); monitoring energy performance of heat pumps and PV-thermal panels	Housing Association, main contractor	Targeted 50 years

All these works happen in accordance with the following timetable, in which all actors are also included:

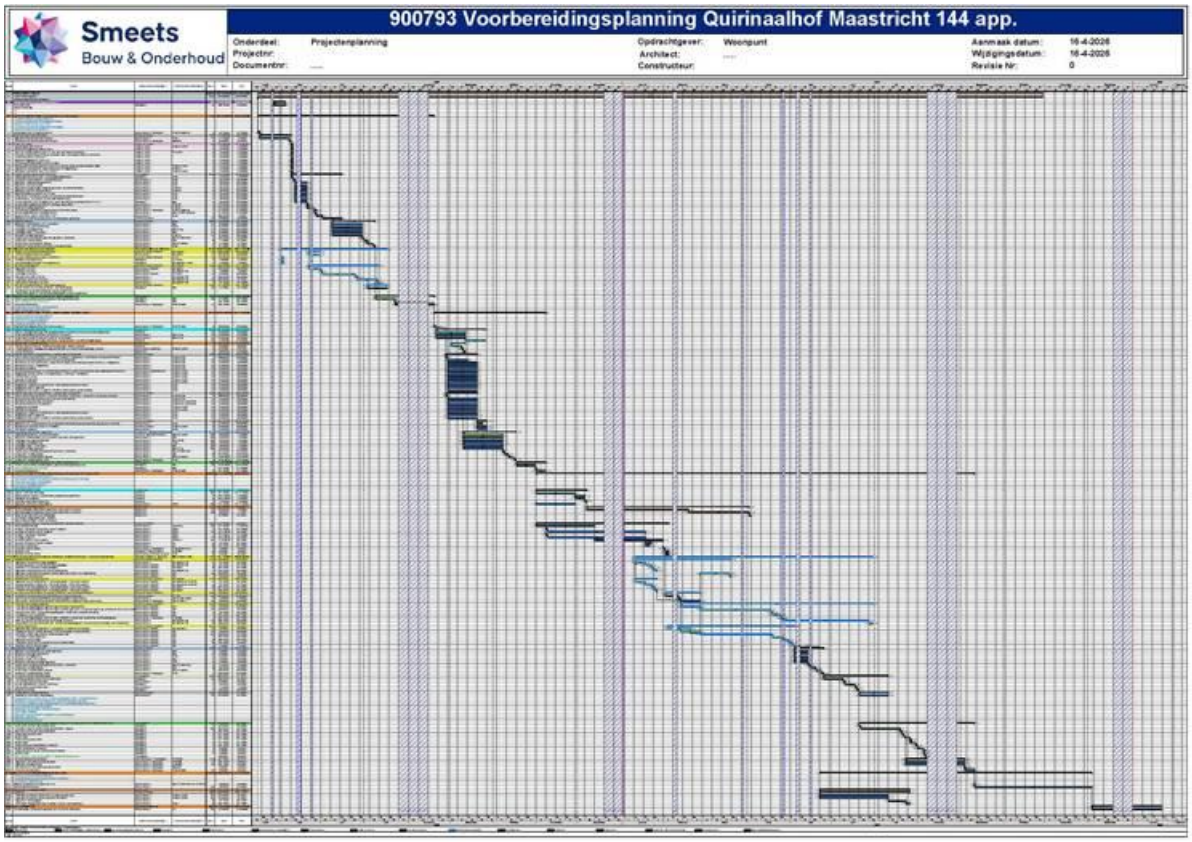


Figure 145: Timetable of works (source: Smeets)

Financial Aspects: Investment and ROI

Financing the Quirinaalhof renovation requires a total investment of approximately €13 million from the main contractor, which exclude some of the building expertise hired directly by the Housing Association, like apintes, insulation and heating suppliers. Woonpunt's business model for the project is based on a breakeven calculation over a very long horizon. The housing association expects a 40% rent increase post-renovation, which is justified to the tenants by the significant increase in living comfort and the substantial reduction in individual energy bills. Despite the massive upfront cost, the projected long-term return is only 2.3% over 50 years, reflecting the social mission of the association to preserve its assets rather than maximize profit. It is also noted that significant "soft" costs exist beyond construction, including the organization of social work, the relocation of tenants to furnished hotel apartments, and the management of hazardous asbestos reports.

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Italian Pilot

The lot, located at number 15 Viale Omero, represents an emblematic example of public housing dating back to the post-war period, with six Siedlung-type buildings constructed between 1950 and 1960, owned by the Comune di Milano and managed by MM S.p.A., currently in a state of partial decay.
Within the large common courtyard, which functions as the distribution space of the complex, the residential units are arranged symmetrically along the East-West axis, optimizing natural lighting and cross-ventilation inside the dwellings. The access system of the residential complex is organized according to a regular grid laid out on perpendicular axes, ensuring clear legibility of the spaces and a functional organization of circulation routes.



The entire complex operates according to the logic of a gated community, meaning a closed and controlled residential environment. All entrances, both primary and secondary, are protected by a system of gates that regulate their use and limit access

exclusively to residents, guaranteeing a high level of security and control within the complex. The main entrance faces Viale Omero, and there is an additional secondary pedestrian entrance along the North-South axis from Via Augusto Osimo. This configuration ensures privacy and security, but at the same time reduces interaction with the public realm and with the neighbourhood, limiting the potential for urban and social integration and creating an enclosure that serves both as protection and as a form of isolation.
The complex includes a significant number of green areas, consisting almost exclusively of planted beds with tall trees that provide shading at ground level, act as visual filters between the different buildings, and contribute to microclimatic improvement and mitigation of the urban heat island effect. However, the greenery is mainly functional, lacking equipped areas or elements that could enhance its collective use. There is, in fact, no design approach aimed at improving spatial quality or creating usable areas for specific activities or social gathering moments, such as playgrounds, relaxation areas, or integrated pedestrian paths. In the surroundings of the site, the presence of schools, a central cycle path running along Viale Omero, and a park equipped with children's play structures highlights an urban context with existing services and public spaces.



Figure 146: Rilievo fotografico

Analysis current situation

Demographics neigbourhood

From the analyses conducted on the NIL (Nucleo di Identità Locale) using data provided by Milano Statistica, it emerges that approximately 2.65% of Milan's total population resides in Corvetto. As of 31/12/2024, the resident population amounts to approximately 37.184, placing the district in sixth position in terms of number of inhabitants.

The population density is 10.215 inhabitants/km², compared to a Milan average of 7.745 inhabitants/km².

The history of Corvetto as a public-housing district has significantly influenced the development of the neighborhood and the profile of its residents. As previously mentioned, the area, originally agricultural, was extensively built up during the twentieth century as a result of the growing demand for public housing, driven by internal migration flows within the country in the mid-twentieth century.

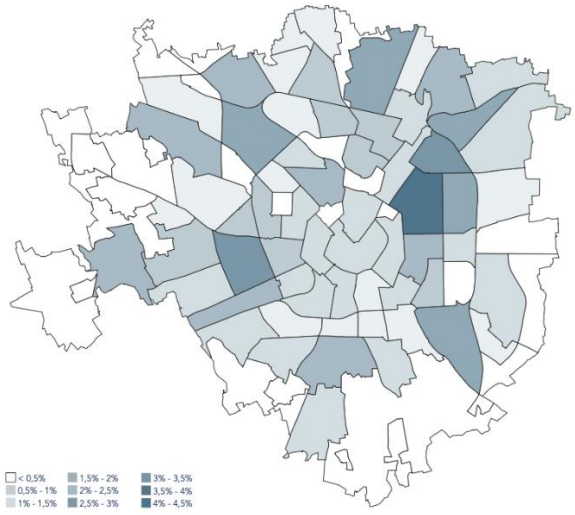


Figure 147: % Distribution of NIL Population

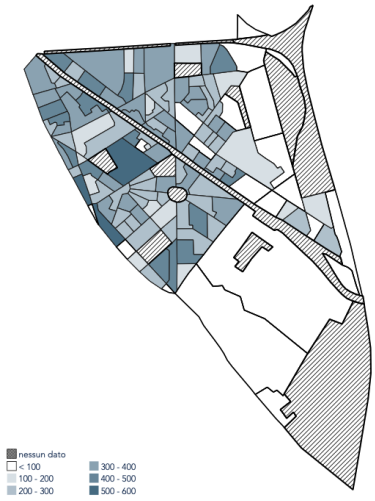


Figure 148: Population Distribution of the Corvetto District

In the last decades, following significant immigration from foreign countries, public-housing units have been allocated to numerous requesting families, who over time have formed a new population group identified as “fragile” (Bovone, 2009).
Although subject to several redevelopment initiatives, the neighborhood has substantially remained unchanged over time; to this day, the area continues to be characterized primarily by public housing. The strong presence of such residential stock is not the sole factor behind the high concentration of foreign residents. Over time, groups that were once small minorities began to form a community and a support network, with the subsequent establishment of numerous associations and organizations aimed at helping and supporting migrant individuals and families, thus making access to the neighborhood increasingly simple and facilitated.
Fluctuations in the population of the Corvetto district have generally remained aligned with those of the city of Milan. From 2001 to the present, the population has grown by 6%, with significant increases in 2011 and 2012, rising from 35.370 inhabitants to 37.187 at the end of 2024.
As of 31/12/2023, the resident population registered with non-Italian citizenship amounted to 10.906 people, approximately 3,62% of the foreign component of the entire Comune di Milano (301.149). The percentage of foreign residents within the district has been steadily increasing since the early 2000s, rising from 9,1% in 2001 to 29,0% at the end of 2023, compared to an overall population increase of only 5,8%.
The analysis of the population’s age groups makes it possible to identify the types of services most needed by residents and, consequently, to plan targeted interventions and projects.
The population was studied not by functional classes but by the following age groups:

- < 5 years
- 5–25 years (school years)
- 25–64 years (working age)
- > 65 years

Research into the percentage distribution of these groups shows that the district does not diverge from the general trend observed across the municipality.
The study was further deepened by identifying the components by nationality, distinguishing between Italian and foreign residents. The latter group has increasingly occupied the younger age brackets, rising from 13% in 2001 to 37% in 2023 in the 5–25 age range, and only in recent years showing an increase in the older cohorts.
Social policies and integration spaces must therefore be designed to address the needs of the entire population, regardless of age. Such an approach will make it possible to build a cohesive society, in which different age groups can interact, learn from one another, and offer mutual support, avoiding the exclusion of vulnerable groups or the failure to adequately address intergenerational dynamics.

Source: SISI data

Associations in the neighborhood

Milan boasts an extensive network of social promotion associations (APS), volunteer organizations (ODV), cooperatives, and active citizenship groups operating in various sectors, including culture, volunteering, civil rights, and integration.
Within the district, there are at least twelve associations, including La Strada, Casa per la Pace, and Dare.ngo, which provide services for the community while promoting inclusion and cooperation. They support young people at risk of dropping out of school and assist young adults in entering the labor market. An example is Dare.ngo with the project “Corvetto Digital School,” a digital education program hosted at the Centro Internazionale di Quartiere, offering aggregation opportunities with culturally and socially diverse classes (Dare.ngo, 2020).
Many associations active in the area have independent premises within the neighborhood, enabling direct contact with the population and fostering interaction between activities and residents. However, the wide variety of topics addressed makes collaboration between cooperatives difficult, limiting resource optimization and the number of citizens involved. While there is a strong associative presence, there is also a lack of adequate gathering spaces where residents can meet, develop a sense of community, and build a shared identity.
Events organized by the associations strengthen neighborhood identity and social cohesion, while resident-led initiatives enhance community spirit and improve the area’s reputation, supporting not only architectural and urban regeneration but also social renewal, contributing to the creation of a more inclusive and vibrant environment capable of attracting new investments.
Associations and residents therefore represent a vital resource, but to ensure that their impact becomes lasting, mutual collaboration—and collaboration with institutions—must be improved. A more integrated and cohesive system could better meet the needs of the population and help transform Corvetto into a more united and efficient district, one that makes diversity its strength.

CORVETTO DIGITAL SCHOOL by DARE.NGO

Urban fabric and Environmental aspect

The Corvetto district has a distinctive composition that blends urban and rural elements. The northern urban area is characterized by a compact fabric of ERP (Edilizia Residenziale Pubblica) buildings, except for the large industrial blocks on the edges of Porto di Mare, along Via Fabio Massimo and near the Rogoredo railway tracks on the eastern border.
Integrated within the urban fabric are few open public green spaces, which limits social activities to streets, large squares such as Piazzale Gabriele Rosa and Piazzale

Ferrara, and a few other multifunctional public areas. This dense urban landscape in the north changes abruptly at the lower end of Quartiere Mazzini, a crucial point of divergence.
South of this point extends a vast network of rural landscape composed of two large municipal parks, Parco della Vettabbia and Parco Gino Cassinis within Porto di Mare, along with several community farms and private agricultural lands. The rural ecosystem also includes numerous unused and abandoned cascine scattered throughout the area. All these elements are part of the Parco Agricolo Sud, as proposed by the Piano Territoriale di Coordinamento Provinciale.
Due to the intense urbanization of the city of Milan, the heat-island effect is particularly evident: temperatures are significantly higher than in the surrounding hinterland areas. Urban warming is mainly caused by the limited amount of greenery within the city, resulting from high building density and pollution.
From reading the map, although Corvetto is located at the edge of the city, it still experiences a significant increase in temperatures due to the lack of vegetation integrated within the built environment.

Buildings

From the analysis of the floor plans and elevations, the following dimensional characteristics emerge for one of the buildings:

- overall length of the main façade: 61,70 m (as indicated in the typical floor plan);
- average depth of the building body: approximately 10,10 m;
- total perimeter: 168.30 m (value already reported in the technical documentation);
- gross floor area: approximately 660 m², with a regular and repetitive plan layout;
- number of floor slabs: 6;
- total gross floor area: 3,960 m²;
- total volume: approximately 14,170 m³.

These proportions reflect a construction typical of mid-twentieth-century public residential housing, characterised by a rectilinear plan configuration and a longitudinal development.
From a construction standpoint, the building is characterized by a structure consisting of reinforced-concrete elements combined with brick infill walls and an exterior finish in traditional plaster. The absence of decorative elements and the adoption of an essential compositional language confirm the economic nature of the original intervention, in which architectural quality relies mainly on the proportions of the façades and on the rhythm of solids and voids rather than on ornamental devices. The roofs are pitched with projecting eaves, and the façades lack representative architectural features.
The general state of conservation of the settlement shows widespread conditions of degradation, particularly evident on the exterior finishing surfaces (plasterwork) and on the paving of the adjoining open spaces. These deteriorations, in addition to compromising the overall appearance of the complex and the durability of its components, indicate the need for integrated interventions addressing both the various types of degradation affecting the built fabric (detachment, cracking, surface erosion,

decay caused by moisture and atmospheric agents) and the performance deficiencies of the complex.
The analysis of the façades highlights an overall geometric regularity of the layout but reveals a marked discontinuity between the East and West fronts. On the East side, the organization of the façade is defined mainly by the alternation of window openings, with a uniform rhythm, except for two projecting balconies arranged in vertical alignment, which introduce a localized interruption in the continuity of the elevation, resulting from the different distribution of the one-bedroom units in the floor plan. On the West side, by contrast, the presence of four protruding stair cores and their connection to two balconies on each side results in a more articulated frontage, with more evident volumetric variation and increased complexity.
Access to the building occurs through four main entrances, positioned opposite the stair cores, which allow entry and ascent to the raised ground floor, the first habitable level of the complex. This distribution solution, common in constructions of the period. however, presents a clear critical issue in terms of accessibility: at present, no accessibility for users with motor disabilities is ensured, either fully or partially, and no floor complies with standards for the removal of architectural barriers. This condition introduces a central design theme in the redevelopment, as the upgrading of accessibility is not merely a functional addition but a requirement of spatial quality and compliance with contemporary user needs.

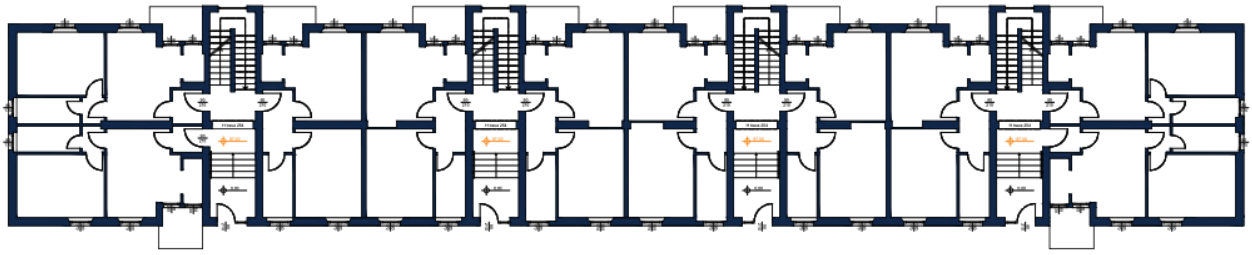


Figure 149: Plan of the elevated ground floor

Regarding the transparent envelope, the window frames are largely original, featuring wooden frames with single glazing. In some units, replacements with aluminium frames equipped with double glazing can be found, although these also lack thermal breaks; in both cases, the overall performance is inadequate when compared to current standards concerning energy efficiency and thermo-hygrometric comfort.
From the four stair cores, access is provided to the residential units, organized according to a standardized distribution scheme: each apartment consists of an entrance area, a living room with a kitchenette, a bathroom with a window, one or two bedrooms, and an adjoining outdoor space.
The analysis of the floor plans made it possible to identify three main typologies: one three-room configuration (B) and two two-room configurations (A and C). A symmetry with respect to the central axis of the layout is also evident, confirming the typical approach of mid-twentieth-century public residential construction, oriented toward repetition and standardization in design. Except for the layout of the elevated ground

floor, the distribution of the apartments remains substantially unchanged on the upper levels.



Figure 150: Typical floor plan

In the basement level are located the cellars, currently in a state of deterioration that affects not only aesthetic aspects but also entails functional and hygienic-sanitary issues associated with rising damp, infiltrations, and material decay. The refurbishment of these spaces therefore constitutes an additional component of the overall intervention.
From a geometric and dimensional standpoint, the floors have an inter floor height of 3,20 m, with a net internal height of 2,90 m. This value reflects a construction characteristic of the period, namely the greater generosity of interior heights compared to much of the more recent building production, and it assumes design relevance for the possibility of integrating building services and managing the stratigraphy of any technical false ceilings or acoustic and thermo-energetic improvement measures, without excessively compromising the usable internal height.
Overall, the building can therefore be identified as a typologically recognizable structure, characterized by a substantial deviation from the performance standards required in contemporary construction. The main critical issues concern:

- the deterioration of the envelope and outdoor spaces;
- the inadequacy of the window frames and, more generally, of thermal performance;
- the need for mechanical and functional upgrades;
- the complete lack of accessibility for persons with disabilities.

These elements constitute the technical basis for defining an effective refurbishment strategy, capable of combining typological conservation, improved performance, and enhanced usability of the entire complex.



Figure 151: East elevation – existing condition



Figure 153: South/north elevation - existing condition



Figure 152: West elevation – existing condition

Technological status

Load-Bearing Structure and Opaque Envelope

The structural system is based on reinforced-concrete frames (columns and beams), combined with clay masonry infill walls. This solution, widely adopted in the post-war period, ensured rapid construction and contained costs. The external perimeter walls have an overall thickness of approximately 35 cm, finished with traditional plaster on both interior and exterior faces. From a thermo-hygrometric perspective, the defining feature is the complete absence of insulation, which results in significant heat losses and accentuated thermal bridging at junctions with structural elements and window openings.

The thermal transmittance of the standard wall section is U ≈ 1.20 W/m²K, while the stairwell walls, which reach thicknesses of around 50 cm, show U ≈ 1.90 W/m²K. Both typologies exhibit poor performance and emphasise the lack of thermal correction of nodes.

The intermediate floors consist of hollow-block reinforced-concrete slabs approximately 28 cm thick, also without insulation, with a corresponding U ≈ 1.40 W/m²K. A similar configuration is found in the floor slab below the attic (≈ 25 cm), likewise uninsulated, with U ≈ 1.70 W/m²K. The floor slab above the basement reaches ≈ 26 cm and records U ≈ 1.40 W/m²K, its performance further weakened by contact with unheated and moisture-affected underground spaces. Taken together, these conditions confirm the highly energy-dissipative nature of the existing opaque envelope.



Figure 154: Detail of window frame

Roof System and Weatherproofing

The buildings feature a pitched roof with a clay-tile finish on a traditional supporting structure. Although originally constructed without insulation, the energy survey identifies a configuration with U ≈ 0.40 W/m²K, assessed as being in "sufficient" condition. This suggests the later addition of some insulation layer, though not as part of a comprehensive, documented retrofit. There are no corrections for thermal bridges at ridge, eaves, or junctions with the façade. The sheet-metal components (gutters, downpipes) show wear and require replacement, while water infiltration issues appear more frequently at façade openings and junctions between opaque and transparent components.



Figure 155: External opaque element

Transparent Envelope: Windows and Related Issues

The stock of windows displays a combination of original fixtures and sporadic more recent replacements. The majority are softwood frames with single glazing, with

measured U-values between 4.5 and 5.3 W/m²K, weakened seals, and significant air and water infiltration. A smaller percentage has been replaced with aluminium frames without thermal break and double glazing, resulting in U ≈ 3.5–3.9 W/m²K. Although these perform slightly better than the original units, they remain far below current energy standards due to the thermal bridging of the metal frame and the lack of insulated shutter boxes.
Overall, both groups of windows exhibit poor airtightness, contributing to thermal discomfort, condensation risks, and compromised durability of the indoor spaces.

External Spaces and Semi-Basement Conditions

The outdoor areas are predominantly paved in bituminous conglomerate and have developed irregularities, cracks, and deformations, partly caused by the roots of existing trees. The circulation space is still functional but suffers from limited accessibility and a lack of user comfort, especially given the level differences between the courtyard and the raised entrances to the stairwells.
Within the semi-basement, the cellars show clear signs of rising damp, deteriorated plaster, and damaged flooring. These conditions raise concerns regarding hygiene, air quality, and long-term material durability, particularly in relation to the technical installations located in these spaces.

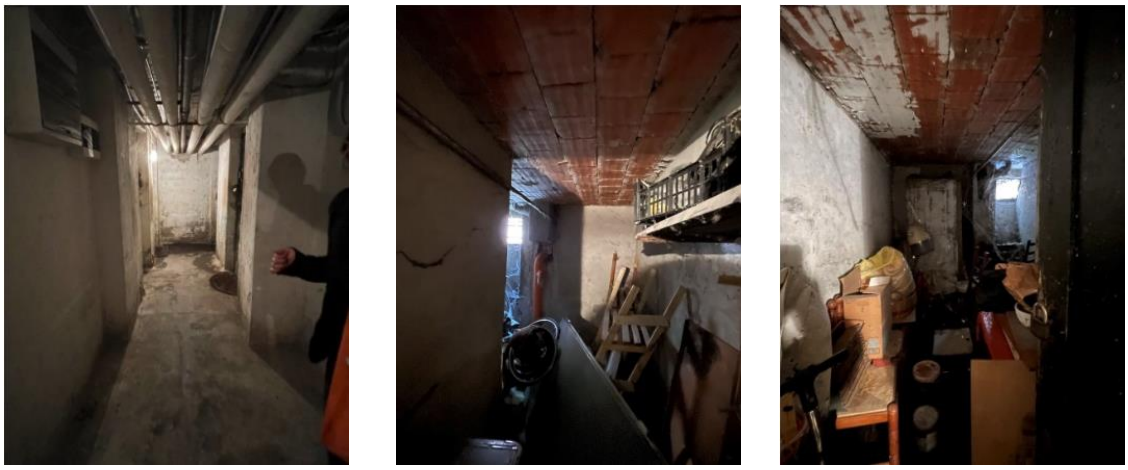


Figure 156: Semi basement rooms – cellar spaces, Source: General Report – Definitive Design

Heating System: Generation, Distribution, Emission, and Control

Heating is centralised, serving groups of three buildings at a time. Heat generation relies on four ELCO TRIGON L PLUS 200 condensing boilers (2017), each providing 180,3 kW of useful output with a nominal efficiency of 97.7%; the survey adopts a generation efficiency of 89,6% based on real operating conditions.
Heat distribution occurs through a single heating circuit with variable-speed DAB KLME 80-600 M circulation pumps. Emission is provided by cast-iron radiators, still original, with an emission efficiency of approximately 93%. The control system is based on climate compensation across a single thermal zone for the entire building

group, using external and internal temperature sensors and restricted to the operating slots mandated for Climate Zone E. This “single-zone” architecture limits the modulation capacity and reduces optimisation across exposures and floor levels.
Although the boiler plant is comparatively recent and well maintained, the absence of zoning and the reliance on traditional radiators limit potential efficiency gains under real-world operating conditions.



Figure 157: Boiler generation system (floor – standing boilers), Source: Energy Diagnosis – Definitive Design

Domestic Hot Water and Gas for Cooking

Domestic hot water is currently produced through individual gas-fired appliances in each dwelling. This configuration generates dispersed consumption, poor efficiency, and significant compliance issues, given the age of the appliances and the presence of wall flue terminals and inadequate ventilation arrangements.
Similarly, the gas networks serving kitchen appliances show signs of age and require careful assessment to ensure safety, correct aeration, and compliance with current standards.

Electrical System and Lighting in common Areas

The electrical installations in common spaces are outdated. Lighting relies mainly on fluorescent fixtures in stairwells, corridors, and technical rooms, all switched manually without presence sensors or zoned controls. The main electrical loads relate to the heating distribution pumps, with relatively low but continuous absorption during heating periods. Electrical panels and the earthing system are not aligned with current safety or energy-efficiency standards and exhibit clear signs of ageing.

Ventilation and Indoor Comfort

The complex is not equipped with a mechanical ventilation system. Air exchange depends solely on the manual opening of windows, whose poor airtightness can lead to uncontrolled airflow in winter without ensuring adequate indoor air quality. The

absence of cooling systems and the limited effectiveness of exterior shading increase the sensitivity of thermal comfort to climatic conditions and user behaviour.

Performance Overview and Existing Issues

The combined effect of an uninsulated envelope, obsolete window frames, and the presence of significant thermal bridges leads to a high winter heating demand and performance levels far below contemporary standards, as confirmed by the energy diagnosis results. Additional concerns emerge in relation to the hygienic and structural conditions of basement areas and the lack of accessibility to raised entrances, both of which affect overall usability.

While the centralised generation system is relatively modern, its benefits are limited by the single-zone control logic and by the highly dissipative building envelope. As a result, the thermal plant operates under suboptimal conditions for much of the heating season, contributing to elevated consumption and reduced comfort.

TIPO DI COMPONENTE	SPESSORE [cm]	ISOLAMENTO	TRASMITTANZA TERMICA [W/m2K]	STATO DI CONSERVAZIONE
Copertura	~ 15	Presente	0,4	sufficiente
Parete verticale esterna	35	Assente	1,2	scarso
Parete vano scala	~ 50	Assente	1,9	scarso
Pavimento su piano interrato	26	Assente	1,4	sufficiente
Solaio sottotetto	25	Assente	1,7	scarso
Solaio interpiano	28	Assente	1,4	sufficiente

Renovation plans

The renewal intervention focuses on the rehabilitation of only one of the six existing buildings, defining a prototype case that can subsequently be replicated on the others. Furthermore, the following chapter provides an in-depth analysis of the refurbishment of the building through the prefabricated “Rekoskeleton” technology (ES – Enhanced System), which is then compared with the same intervention carried out using traditional construction technologies (BAU – Business As Usual).

The analysis continues with a comparison involving the possibility of demolition and reconstruction, using traditional (BAU) construction methods and industrialised “Bearing Walls” technology.

Offsite retrofitting with Rekoskeleton technology

The refurbishment intervention carried out with Rekoskeleton technology aims to achieve a comprehensive improvement of the building in terms of architectural quality, structural performance, energy efficiency, and building services, through the use of an industrialised construction system based on high-performance prefabricated panels. This approach enables the regeneration of the external envelope with significantly

shorter on-site times and a level of execution quality superior to traditional construction methods.

3.1.1 General Characteristics of the System

The Rekoskeleton technology represents an industrialized and advanced construction solution, based on the off-site production of high-performance structural and envelope components. The system reduces on-site activities to foundation works and light finishing operations, while the main building components are manufactured in a controlled, automated factory environment.

The system's philosophy aims to:

- increase construction quality,
- reduce construction time and costs,
- enhance energy and seismic performance,
- minimize the environmental impact of the intervention.



The Rekoskeleton prefabricated panels function as load-bearing structural elements, fully manufactured off-site and designed to integrate:

- provisions for electrical and mechanical systems;
- recessed housings for window and door frames;
- internal and external finishing layers;
- optional decorative claddings.

Production within a controlled factory environment ensures high qualitative consistency, dimensional precision, and a significant reduction in errors typically associated with traditional on-site construction.

On-site assembly is carried out using cranes and lifting systems, allowing for:

- rapid installation (as little as 3–5 days per floor),
- reduced need for scaffolding,
- minimal interference with the surrounding urban context.

Technical Advantages of the Rekoskeleton System

3.1.2.1 Design Benefits

- High-performance building envelope:
- The panels achieve thermal transmittance values below the limits set by Italian Ministerial Decree 26/06/2015, enabling the attainment of A/A2 or higher energy classes.
- Improved thermo-acoustic comfort:
- The multilayer assembly with high-performance insulation materials allows for sound insulation levels of approximately 55 dB.
- Reduction of on-site finishing works: Most operations are carried out off-site, resulting in lower waste generation and reduced on-site execution variability.
- Ease of attaining energy and environmental certifications: The system is fully compatible with LEED, BREEAM, and GRESB certification protocols.
- Reduced environmental impact: Material optimisation, shorter construction phases, and reduced transportation of raw materials contribute to a lower ecological footprint.

3.1.2.2 Production-Related Advantages

- Lower life-cycle costs. The higher construction quality leads to fewer extraordinary maintenance requirements and increases the durability of façade components.
- High degree of industrialisation. Prefabrication allows the industrialisation level to be adapted to specific design needs.
- Automation of the production process.
  The use of moulds, robots, and precision systems minimizes human error and ensures a consistently high-quality output.

3.1.2.3 Logistical Advantages

- Significantly reduced construction time.
  The fast installation of prefabricated panels makes it possible to reduce construction schedules by 40–60% compared to traditional building sites.
- Reduced use of scaffolding and temporary structures.
  Installation is carried out using platforms, hoists, and mobile cranes, which also enhances overall site safety.
- Optimised on-site material flows.
  Prefabricated components arrive ready for installation, minimizing storage needs and reducing interference within the site.

3.1.2.4 Cost Breakdown: Off-site vs On-site

The Rekoskeleton system introduces a hybrid cost model, distributed as follows:
Off-site Production – 48.2% of total cost includes:

- executive design;
- establishment and setup of the production facility;
- machinery and equipment;
- panel production;
- quality control;
- industrial storage and logistics.

On-site Works – 51.8% of total cost includes:

- foundation and preparatory works;
- panel installation;
- interior completions;
- building services connections;
- final finishes.

Technical Composition of the Prefabricated Panels

Rekoskeleton panels consist of three main functional layers:

3.1.3.1 Inner Layer – Load-bearing Structure

- C40/50 concrete
- B450C reinforcing steel
- Provides the load-bearing and seismic resistance of the system.

3.1.3.2 Intermediate Layer – Thermal and Acoustic Insulation

- 14 cm rock wool, density 70 kg/m³
- Panel thermal transmittance: ≈ 0.20 W/m²K
- Acoustic reduction: ≈ 55 dB

3.1.3.3 Outer Layer – Cladding and Finishing

- Finishes include plaster, porcelain stoneware, clinker, or other materials upon request
- Ensures weather resistance and long-term durability

Detail of Structural Connections

The connections between panels form an integrated system designed to ensure box-like behaviour and seismic continuity throughout the structure.

3.1.4.1 Horizontal connection to floor beams

- Mechanical linkage between panels and the floor slab;

- Ensures the transfer of horizontal actions and the structural collaboration between vertical and horizontal elements.
- Stabilization during installation

3.1.4.2 Lateral connection between panels

- Perimetral joints, including those at corner intersections;
- Ensures structural continuity as well as air- and water-tightness.

3.1.4.3 Vertical connection using sleeves

- Allows the alignment and locking of stacked panels;
- Enables the transfer of vertical loads;
- Contributes to the overall seismic performance of the system.

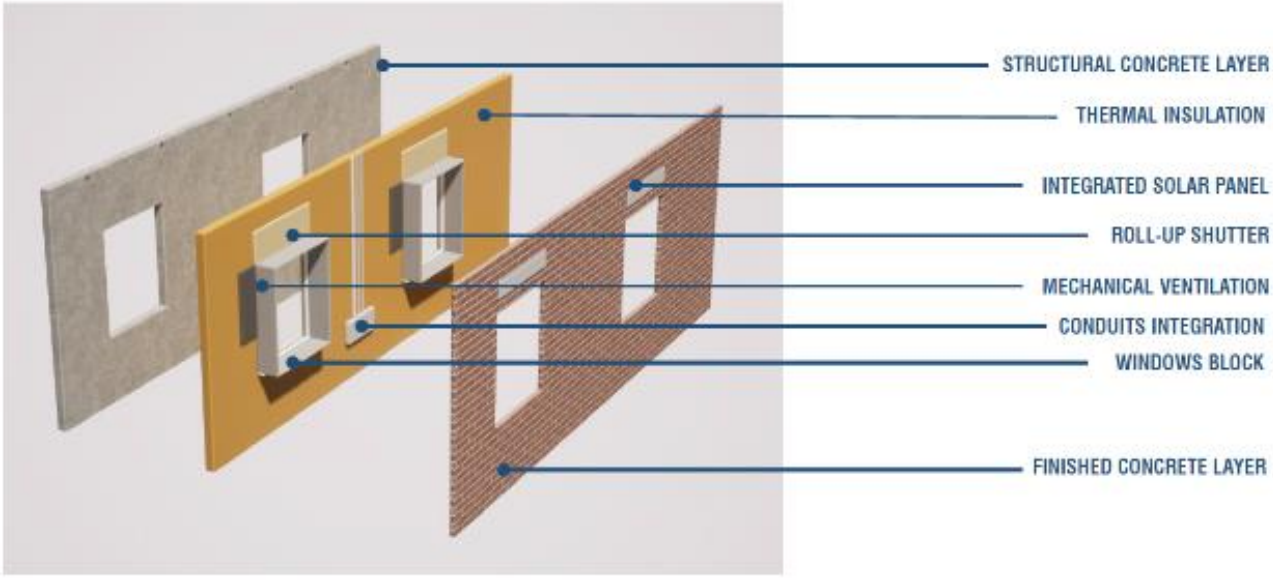
Typological Flexibility and Fields of Application

Thanks to its fully modular configuration, the Rekoskeleton system is suitable for:

- social and affordable housing (ERP, social housing),
- market-rate residential buildings,
- student housing,
- hospitality and office buildings,
- urban regeneration projects and redevelopment/replacement interventions.

The compositional flexibility of the system allows for the construction of buildings:

- from 2 up to more than 7 storeys,
- with various unit sizes and distribution layouts,
- featuring a high degree of architectural customization.





Refurbishment Intervention

3.1.6.1 Site Setup

The first phase includes all safety measures and the preparation of the construction site through the arrival of:

- site huts and temporary facilities,
- fencing and protective barriers,
- cranes and lifting equipment,
- limited scaffolding structures.

This setup phase remains active for the entire duration of the works, as it includes the rental of the necessary equipment.

- Estimated duration: 6 months
- Estimated cost (including final removal): € 45,000.00

3.1.6.2 Preliminary Structural Intervention: Reinforced Perimeter Foundation Ring

The initial project phase includes the construction of a reinforced-concrete perimeter foundation ring, positioned at the base of the building footprint and designed to support the Rekoskeleton prefabricated panels.

This operation pursues the following objectives:

- increasing the local load-bearing capacity,
- improving the stiffness of the perimeter,

- rationalising the transfer of vertical loads induced by the new load-bearing panels,
- enhancing the building's seismic response,
- mitigating degradation mechanisms affecting the existing masonry.

Based on preliminary assessments of the existing structure and the characteristics of the intervention, this operation allows for an improvement in the building's seismic classification from class F to class C, in accordance with the parameters of the Italian Ministerial Decree 17/01/2018 (NTC) for existing buildings.

- Estimated cost: € 75,000.00

3.1.6.3 Demolitions and Surface Preparation

The second phase involves the removal of deteriorated surface layers and the preparation of the substrate for anchoring the new panels.
The works include:

- removal of degraded plaster on all façades,
- cleaning and smoothing of masonry surfaces,
- elimination of loose or incoherent parts,
- preliminary treatments to ensure proper adhesion and superficial flatness.

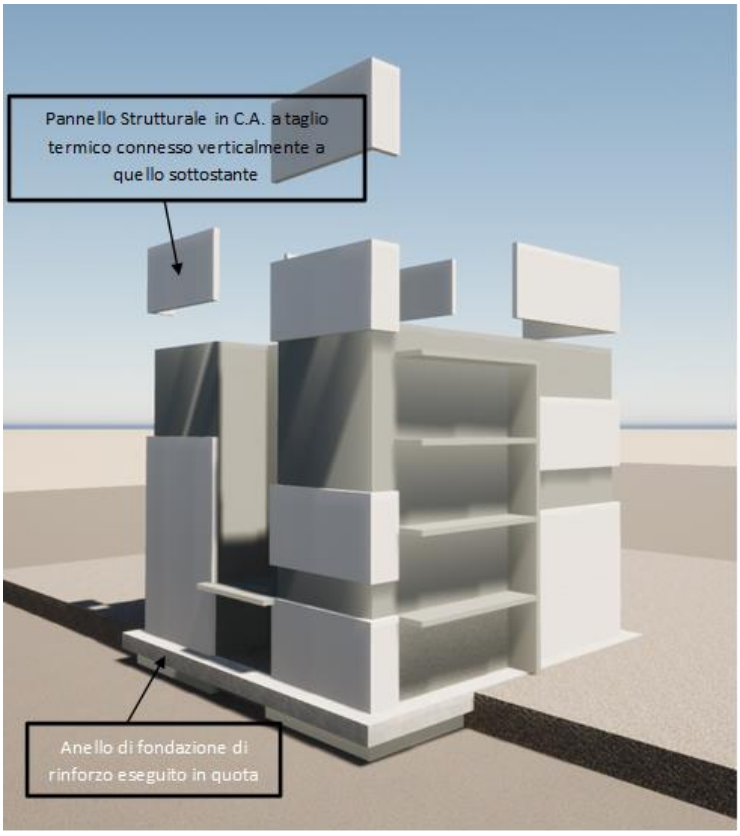
This entire phase is carried out without scaffolding, relying exclusively on two aerial platforms (baskets) and a mobile crane, significantly reducing both time and site interference.

- Estimated cost: € 60,000,00

3.1.6.4 Installation of Rekoskeleton Prefabricated Panels

The main phase of the intervention consists of installing the Rekoskeleton prefabricated panels, which form the new external envelope of the building.
Each panel includes:

- an internal load-bearing structure in C40/50 concrete reinforced with B450C steel bars,
- continuous high-density rock wool insulation,
- pre-shaped recesses for high-performance window and door systems,
- integrated MEP (mechanical, electrical, plumbing) provisions,
- a predefined or customisable external finish.



3.1.6.5 Expected Performance Outcomes

- Significant improvement in seismic behaviour thanks to vertical, horizontal, and corner connections;
- Continuous thermal insulation and a drastic reduction of thermal bridges;
- Energy class upgrade for the building from G → A2;
- Acoustic reduction up to 55 dB.

3.1.6.6 Timeframes and Costs

The installation of the panels takes approximately 3 months for the entire building, including:

- lifting with a mobile crane,
- positioning on the perimeter foundation ring,
- structural connections,
- installation of window and door frames.

Total cost of panels (manufacturing + transport + installation): € 1,200,000.00

3.1.6.7 Treatment of Loggias and Balconies

Loggias and balconies are not clad with prefabricated panels, due to weight and related geometric compatibility reasons.

In these areas, a phenolic foam insulation is applied in order to:

- maintain continuity of insulation,
- reduce linear thermal bridges,
- optimise the available thickness without altering levels and profiles.

The affected surfaces are identified through colour mapping, distinguishing:

- red areas → prefabricated panels;
- blue areas → phenolic insulation.

3.1.6.8 Insulation of the Attic and Basement Levels

To ensure continuity of the thermal refurbishment, the following are planned:

- insulation of the slab below the non-habitable attic,
- insulation of the basement slab.

These measures reduce heat losses towards unheated spaces and complete the overall performance package.

3.1.6.9 Rooftop Photovoltaic System

A photovoltaic system is planned on the roof, sized to meet the common-area energy demand.
The system contributes to:

- reducing energy expenditure,
- increasing the building's autonomy,
- securing additional benefits for energy class ratings and CAM compliance.

3.1.6.10 Internal Works

The internal works are analogous to those in a traditional refurbishment, involving targeted maintenance and local adjustments to building services.

3.1.6.11 Overall Time and Cost

- Total site duration: 6 months
  (50% less than a BAU refurbishment)
- Total cost of the intervention: € 3,500,000.00

Rekoskeleton technology	
Site setup	45,000.00 €
Demolitions and surface preparation	60,000.00 €
Foundations	75,000.00 €
Building works	2,000,000.00 €
MEP systems	1,320,000.00 €
Totale	**3,500,000.00 €**

Demolition and Reconstruction with Bearing Walls (AOH)

The demolition and reconstruction intervention using Bearing Walls technology represents an industrialised construction solution based on the use of prefabricated reinforced-concrete load-bearing walls, designed to function simultaneously as the structural framework and the external envelope of the new building.

This methodology enables the construction of a building with high structural and energy performance standards, while maintaining significantly shorter execution times compared to fully traditional construction methods.

The Technology

The prefabricated load-bearing walls arrive on site:

- already complete with internal reinforcement;
- with integrated MEP (mechanical, electrical and plumbing) provisions;
- with their final geometry;
- ready to be lifted and positioned.

The use of these panels enables:

- very rapid structural progress of the building;
- reduced casting and curing times compared to traditional in-situ concrete;
- high geometric precision;
- dry-construction site operations, with fewer interferences and reduced on-site activities.

Estimated installation duration: 6 months.

Estimated cost: € 2,400,000.00

3.2.1.1 Walls

- External load-bearing walls: thickness 32 cm
- Internal load-bearing walls: thickness 20 cm

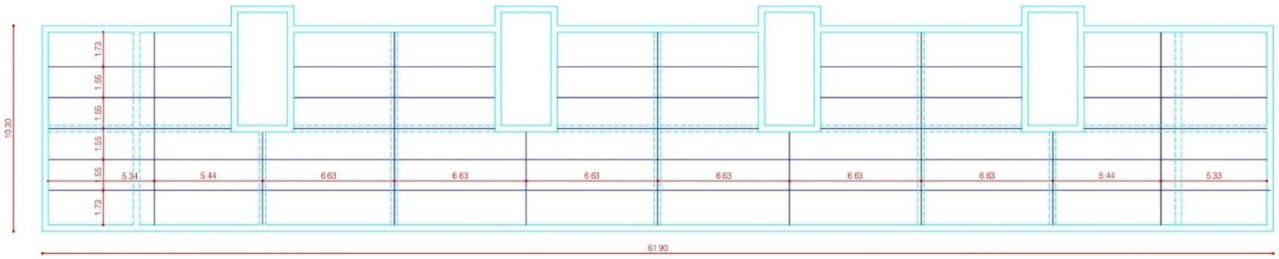
This configuration ensures:

- adequate vertical load-bearing capacity and seismic resistance;
- rapid construction;
- reduced structural weight and optimisation of foundation loads.

3.2.1.2 Floor Slabs

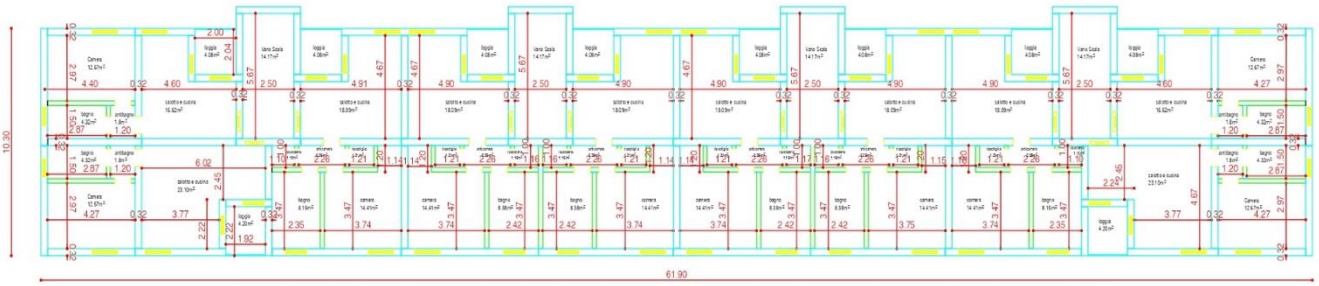
For horizontal structures, 20-cm hollow-core precast slabs are planned, featuring:

- structural lightness;
- high load-bearing capacity;
- quick installation;
- composite behaviour with the load-bearing walls.



3.2.1.3 Prefabricated Staircases

The staircases are also fully manufactured in the factory and installed on site using dedicated lifting equipment, improving both safety and construction speed.



3.2.1.4 Roof and Renewable Energy Systems

The roof will be constructed as a walkable flat roof, serving multiple functions:

- architectural (technical and usable spaces),

- mechanical (placement of technical units),
- energy-related (installation of photovoltaic systems).

The following installations are planned:

- photovoltaic solar panels for self-consumption by the dwellings and common services;
- preassembled MEP units, positioned directly on the roof to simplify maintenance and improve accessibility.

Logistics

The Bearing Walls construction site employs:

- mobile cranes,
- forklifts,
- just-in-time scheduled deliveries,
- limited use of scaffolding.

These measures significantly reduce:

- impacts on the surrounding context,
- dust and noise emissions,
- the duration of public-space occupation,
- risks associated with working at height.

Cost Breakdown – Off-Site/ On-Site

Reconstruction using Bearing Walls technology features the following economic structure:

- 45% off site (panel production, floor slabs, staircases, preassembled MEP units, industrial logistics)
- 55% on site (foundations, installation, structural connections, finishes)

Conclusion

Bearing Walls technology enables the construction of an entirely new building with:

- high energy performance,
- A+-level seismic efficiency,
- shorter construction times compared to traditional methods,
- industrial-grade precision,
- reduced execution risks,
- decreased need for temporary works and scaffolding.

It is the ideal solution when the goal is the full replacement of the existing building, achieving the highest structural and energy performance through a reliable, programmable, and scalable construction process.

Bearing walls technology	
Site setup	185,000.00 €
Demolitions and surface preparation	190,000.00 €
Foundations	275,000.00 €
Building works	4,000,000.00 €
MEP systems	1,350,000.00 €
Totale	**6,000,000.00 €**

Comparison and Considerations

Comparison of Refurbishment Solutions

The comparison between three refurbishment options, traditional refurbishment (BAU), traditional refurbishment with seismic upgrading (BAU + seismic), and refurbishment using the Rekoskeleton system, shows that the Rekoskeleton solution achieves a 50% reduction in schedule, together with an overall cost decrease of 6.65%.

The advantages achieved are attributable to:

- greater industrialisation of the process;
- reduction of on-site operations;
- elimination of scaffolding and other temporary works;
- increased predictability in execution and reduced site risks.

Final energy performance levels are similarly high (class A2 in both cases), but the prefabricated technology ensures more consistent quality, reduced thermal bridges, and better seismic behaviour thanks to structural panels connected through certified connections.

	Rekoskeleton technology	Traditional refurbishment with seismic	Traditional refurbishment (BAU)
Site setup	45,000.00 €	150,000.00 €	130,000.00 €
Demolitions and surface preparation	60,000.00 €	75,000.00€	70,000.00€
Foundations	75,000.00 €	125,000.00 €	
Building works	2,000,000.00 €	3,300,000.00 €	3,000,000.00 €
MEP systems	1,350,000.00 €	1,350,000.00 €	1,350,000.00 €
Totale	**3,530,000.00 €**	**5,000,000.00 €**	**4,550,000.00 €**

Comparison of Demolition and Reconstruction Solutions

In the building replacement scenario, the comparison between traditional methods and Bearing Walls technology highlights an approximate 17.50% cost improvement, with a 25% reduction in schedule.

Reconstruction with prefabricated load-bearing walls enables:

- industrialised management of the construction process;
- reduced curing times for concrete compared to in-situ casting;
- rapid production of above-ground floors;
- high geometric precision and reduced interferences;
- achievement of A+ seismic performance, which is not attainable as quickly with traditional methods.

The resulting building exhibits significantly superior structural, energy, and MEP quality, with a longer life cycle and lower maintenance costs over time.

	Bearing walls technology	Traditional method
Site setup	185,000.00 €	350,000.00 €
Demolitions and surface preparation	190,000.00 €	200,000.00 €
Foundations	275,000.00 €	300,000.00 €
Building works	4,000,000.00 €	5,500,000.00 €
MEP systems	1,350,000.00 €	1,350,000.00 €
Totale	**6,000,000.00 €**	**7,700,000.00 €**

Overall Considerations

A synthesis of the results shows that Rekoskeleton technologies (refurbishment) and AOH (reconstruction) currently represent more effective, competitive, and sustainable solutions than traditional methods.

In particular, they:

- provide reliable schedules, not subject to on-site variability;
- cause fewer interferences with the urban area and less disruption for residents;
- improve site safety, reducing work at height and the use of scaffolding;
- ensure high and repeatable energy performance;
- lower the cost per square metre for the same final outcome;
- facilitate process scalability across multiple buildings or entire districts.

Considerations on the Industrial Model (Prefabrication Plant)

It should be noted that the adoption of Rekoskeleton or Bearing Walls systems requires access to a factory dedicated to the production of prefabricated elements.

The characteristics, size, and costs of such a facility are detailed in the document “stationary factory presentation.”

Although the initial investment is not negligible, it should be considered from the standpoint of:

- multi-year amortisation;
- access to incentives supporting construction industrialisation;
- continuous production of panels and components;
- parallel construction of multiple buildings or refurbishment projects;
- optimisation of the logistics chain and reduction of unit component costs.

An operational plant makes it possible to:

- start producing components for the second project while the first is still on site;
- ensure high standardisation and reduced non-conformities;
- develop an industrial supply-chain logic, moving beyond a purely artisanal site approach;
- deliver new builds and refurbishments simultaneously, boosting overall productivity.

General Conclusion

The comparison among the four alternatives considered—BAU refurbishment, Rekoskeleton refurbishment, BAU demolition/reconstruction, and demolition/reconstruction with Bearing Walls—shows that industrialised systems enable significant time and cost savings, while maintaining (or increasing) energy and structural standards.

In particular:

- Refurbishment: using Rekoskeleton reduces site time by 50% (6 months vs 12 months) and costs by 6.65% (€ 4.062 M vs € 4.351 M) compared to the traditional solution, achieving energy class A2 with better insulation continuity and fewer thermal bridges; the seismic improvement is estimated to reach Class C with minimally invasive external interventions.
- Building replacement: Bearing Walls technology achieves a 25% time reduction (18 months vs 24 months) and a 17.50% cost reduction (€ 6.608 M vs € 8.010 M) compared to BAU reconstruction, ensuring A2 energy performance and a structural configuration targeting seismic Class A+.

	Rekoskeleton technology	Traditional refurbishment with seismic	Traditional refurbishment (BAU)	Bearing walls technology	Traditional method
Site setup	45,000.00 €	150,000.00 €	130,000.00 €	185,000.00 €	350,000.00 €

Demolitions and surface preparation	60,000.00 €	75,000.00€	70,000.00€	190,000.00 €	200,000.00 €
Foundations	75,000.00 €	125,000.00 €		275,000.00 €	300,000.00 €
Building works	2,000,000.00 €	3,300,000.00 €	3,000,000.00 €	4,000,000.00 €	5,500,000.00 €
MEP systems	1,350,000.00 €	1,350,000.00 €	1,350,000.00 €	1,350,000.00 €	1,350,000.00 €
Totale	**3,530,000.00 €**	**5,000,000.00 €**	**4,550,000.00 €**	**6,000,000.00 €**	**7,700,000.00 €**

Appendix IX

Workshop Details

This appendix provides context and guideline for this workshop, outlines the objectives, and details eight key requirements for PuFs (see Section Session 2 – Interactive Breakouts), each with descriptions, guiding questions, and example answers to support the discussion.

Implementation Plans and Scenarios for PuF Workshop

This workshop will focus on evaluating progress in Pop-up Factory (PuF) implementation, identifying current gaps, and collecting key requirements. Through two sessions, we will gather input on stakeholder engagement, regulatory needs, financial feasibility, site logistics, and sustainability to shape the next steps for PuFs.

Table 70: Implementation Matrix

	Dutch ecosystem	French ecosystem	Austrian ecosystem	Italian ecosystem	Spanish ecosystem
Mobile on-site factory		☑	☑		
Satellite factory				☑	
District factory	☑				
Assembly factory	☑	☑	☑		☑
Service factory	☑	☑	☑	☑	☑

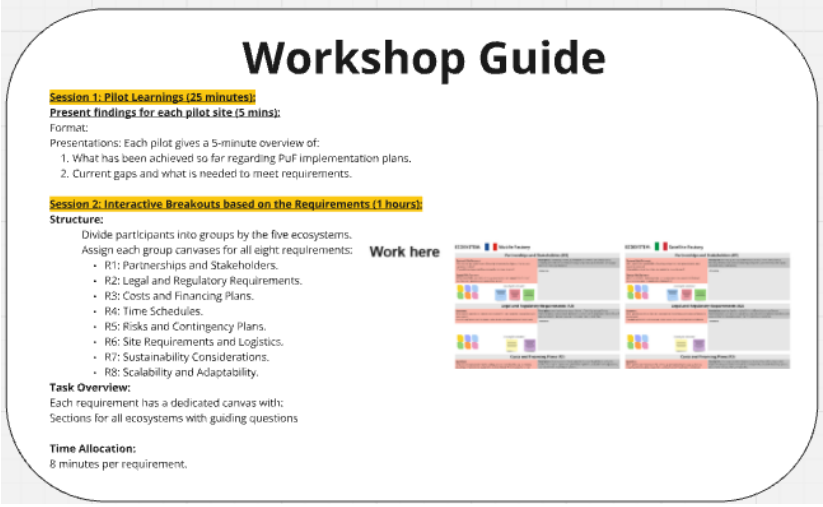


Figure 158: Screenshot from Miro

The workshop will be conducted in Miro Board and includes a guideline (see Figure 158). It is **important** to note that we will kick-off this workshop with your valuable pilot presentations, for which a template and guideline is provided in the e-mail.

Session 1 – Pilot Updates

As can be seen in Table 71, we have created the Use-case and Progress Table based on the updates from the previous GA within the scope of WP5. During Session 1, **each**

ecosystem representative are expected to provide insights into their respective pilot sites, focusing on progress, challenges, and future steps. Each ecosystem should begin with a brief description of the pilot site, outlining its implementation progress and key objectives, such as circular economy strategies, the use of reused materials, or other sustainability-driven approaches.

Following this, a progress overview should be provided, summarizing the activities completed so far and any specific innovations or technologies that have been introduced. Participants are encouraged to share any barriers they have encountered -whether regulatory, financial, or technical- and elaborate on the solutions they have applied to address these challenges.

Looking ahead, ecosystems should outline their planned activities for the next 6 to 12 months, specifying the expected outcomes and how these will contribute to the broader success of the Pop-up Factory concept. Finally, participants should highlight any outstanding issues or areas where additional input, expertise, or support is needed, particularly in terms of collaboration with stakeholders or overcoming persistent challenges.

This structured input will help ensure a productive discussion, facilitating the identification of common challenges, opportunities, and next steps across pilot sites.

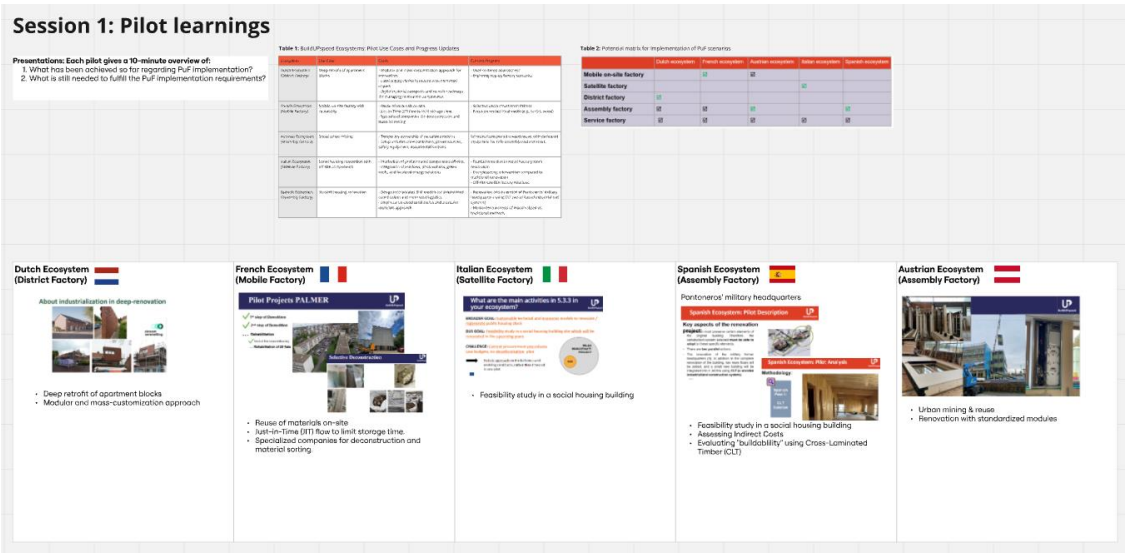


Table 71: BuildUPspeed Ecosystems: Pilot Use Cases and Progress Updates

Ecosystem	Use Case	Goals	Current Progress
Dutch Ecosystem (District Factory)	Deep retrofit of apartment blocks	- Modular and mass-customization approach for renovation. - Local supply chains to reduce environmental impact. - Digital material passports and retrofit	- User-centered approaches? - Exploring pop-up factory scenarios

		roadmaps for managing renovation components.	
French Ecosystem (Mobile Factory)	Mobile on-site factory with reusability	- Reuse of materials on-site. - Just-in-Time (JIT) flow to limit storage time. - Specialized companies for deconstruction and material sorting.	- Selective deconstruction in Palmer - Focus on reused local waste (e.g., bricks, wood)
Austrian Ecosystem (Assembly Factory)	Social urban mining	- Temporary ownership of reusable products - Setup includes crew containers, power sources, safety equipment, documentation tools.	Infrastructure geared toward reuse, with dedicated equipment for safe assembly and transport.
Italian Ecosystem (Satellite Factory)	Social housing renovation with off-site components	- Production of prefabricated components off-site. - Integration of windows, photovoltaics, green roofs, and localized energy solutions.	- Feasibility studies in social housing stock renovation - Energiesprong intervention compared to traditional renovation - Off-site satellite factory solutions
Spanish Ecosystem (Assembly Factory)	Student housing renovation	- Design incorporates BIM models for streamlined coordination and minimized logistics. - Emphasis on wood certification and a circular materials approach.	- Renovation and extension of Pontoneros' military headquarters using CLT (wood-based industrialized systems) - Multicriteria analysis of industrialized vs. traditional methods

Session 2 – Interactive Breakouts

In this session, all ecosystem participants will engage in interactive group discussions in breakout rooms on Teams. Each ecosystem will work within its dedicated workspace on the Miro Board (see Figure 160). **To ensure a productive session, participants are expected to review the requirements in below section in advance and gather relevant data.** During the session, they will use sticky notes to provide answers to the questions under each requirement, allowing for a structured and collaborative exchange of insights. A maximum of **8 minutes** will be allocated per requirement to keep discussions focused and efficient.

Requirements and Questions

Partnerships and Stakeholders (R1): Identifying the key stakeholders involved in the pilot projects, including demand-side partners (housing companies, governments) and supply-side (local SMEs, contractors).

- Demand-side partners:

    - Who are the key stakeholders (e.g., housing companies, local governments) currently involved in the pilot project?
    - What additional partnerships are needed to move forward?
- Supply-side partners:
    - Which local SMEs, manufacturers, or constructors can support the factory?
    - Are there any collaboration gaps on the supply-side?

Example Answers: **a)** We are currently working with XXX housing company; **b)** In order to integrate renewable energy like solar panels, we still need to find providers to collaborate; **c)** We have wood supplier from a local SME to provide prefabricated panels

Legal and Regulatory Requirements (R2): Legal and policy-related factors influencing pop-up factory implementation, such as local regulations, permits, and compliance standards, and opportunities for leveraging government incentives or subsidies.

- What specific permits or licenses are required for setting up the pop up factory in your region, *considering factors such as space, noise levels, and environmental compliance?*
- Are there government incentives or subsidies that can support the implementation of the pop-up factory?

Example Answers: **a)** To set up the factory, we require a land-use permit, to ensure the site complies with zoning regulations for light industrial activities; **b)** We need a detailed plan for handling and recycling construction waste generated during operations.

Costs and Financing Plans (R3): Evaluating the financial feasibility of each pilot project, focusing on capital and operational expenses, available financing options, also consider the possibility of subsidies.

- What are the estimated costs for setting up and operating the pop-up factory, including infrastructure, equipment, and workforce?
- If estimates are unavailable, what are the plans to gather this data?

Example Answers: **a)** The estimate for setting up the factory is approximately €500,000, which includes €300,000 for equipment and €200,000 for workforce training and site preparation; **b)** We have secured an initial grant of €200,000 from the regional development.

Time Schedules (R4): Assessing the timeline for establishing and operating the pop-up factory. Includes: identifying potential delays, dependencies, and life-cycle considerations (such as the duration of operations and decommissioning plans).

- What is the estimated timeline for setting up the pop-up factory? For the factory that requires setup? (e.g. mobile, assembly, district, satellite)
- Are there external constrain that could affect the time schedule (e.g., regulatory approvals, material availability, workforce training)?

Example Answers: **a)** Additionally, delays in the delivery of prefabricated equipment from regional suppliers could extend the timeline; **b)** The main constraint is obtaining

land-use permits, which may take up to 3 months depending on municipal approval processes; **c)** The setup of the mobile factory is expected to take 1 month, with 1 month allocated for infrastructure preparation as it utilizes modular, pre-assembled components and 1 month for equipment installation and workforce training.

Risks and Contingency Plans (R5): Identifying potential risks (e.g., financial, logistical, regulatory) and existing contingency plans to mitigate the risks identified. By addressing challenges in establishing, operating, and scaling the pop-up factory we can improve the stability of its timeline/life-cycle.

- What are the key risks affecting the implementation of the pop-up factory, logistics, workforce capacity, material availability, regulatory delays)?
- What contingency plans are in place to mitigate these risks?

Example Answers: **a)** Insufficient availability of skilled workers for assembling prefabricated components may delay operations

Site Requirements and Logistics (R6): Understanding the specific site-related details necessary for an effective operation of the pop-up factory. Includes assessing available space, infrastructure (e.g., access to roads, utilities and so on), in parallel with logistical challenges (e.g., materials transport and site access.

What follows are the pilot-specific questions:

- **France (Mobile Factory):**
  - What specific infrastructure (e.g., roads, storage areas) is required to support mobile factory operations during transport and setup?
  - Are there logistical challenges related to materials transport or site access?
- **Italy (Satellite Factory):**
  - How can proximity to the Gigafactory or regional suppliers, reduce transport needs?
  - What infrastructure is required for the satellite factory to operate efficiently?
- **Spain (Assembly Factory):**
  - What specific infrastructure (e.g., roads, storage areas) is required to support mobile factory operations during transport and setup?
  - How are utilities (e.g., electricity, water) managed for semi-permanent operations?
- **The Netherlands (District Factory):**
  - What (and how) district-level infrastructure supports localized manufacturing and assembly?
  - How are site requirements scaled to fit urban or district environments?
- **Austria (Assembly Factory):**
  - What specific infrastructure (e.g., roads, storage areas) is required to support assembly factory operations during transport and setup?
  - How are utilities (e.g., electricity, water) managed for semi-permanent operations?

Example Answers: **a)** local government has allocated industrial zones with access to utilities such as electricity, water, and waste management facilities; **b)** Noise reduction

measures, such as soundproofed and scheduled operating hours, need to be implemented.

Sustainability Considerations (R7): Exploring the strategies employed by the pop-up factory to minimize waste, optimize energy use, and integrate renewable or local materials. Also examining how the factory aligns with regional sustainability goals, such as decarbonization and circular economy practices.

- **France (Mobile Factory):**
  - How does the mobile factory minimize energy consumption during transport, setup and operations?
  - How does the mobile factory plan utilize Just-in-Time (JIT) flows to limit storage time?
- **Italy (Satellite Factory):**
  - How does the satellite factory ensure low-carbon transport between the Gigafactory and its site?
- **Spain (Assembly Factory):**
  - How does the factory promote material reuse or sustainable prefabrication processes?
- **The Netherlands (District Factory):**
  - How do you plan to utilize local supply chains in a district level?
- **Austria (Assembly Factory):**
  - How does the factory promote material reuse or sustainable prefabrication processes?

Example Answers: **a)** Footprint has been minimized by adopting vertical storage solutions and compact modular assembly lines

Scalability and Adaptability (R8): Evaluating the factory model's ability to scale and adapt to different regions, project types, or production needs. It identifies barriers to scaling and the necessary adjustments for broader implementation while ensuring flexibility for diverse applications.

- What site-specific logistics are required for assembling prefabricated components on-site?
- How are utilities (e.g., electricity, water) managed for semi-permanent operations?
- What adjustments are needed for broader implementation in other regions?

Example Answers: **a)** We need site-specific access roads for large trucks and cranes.

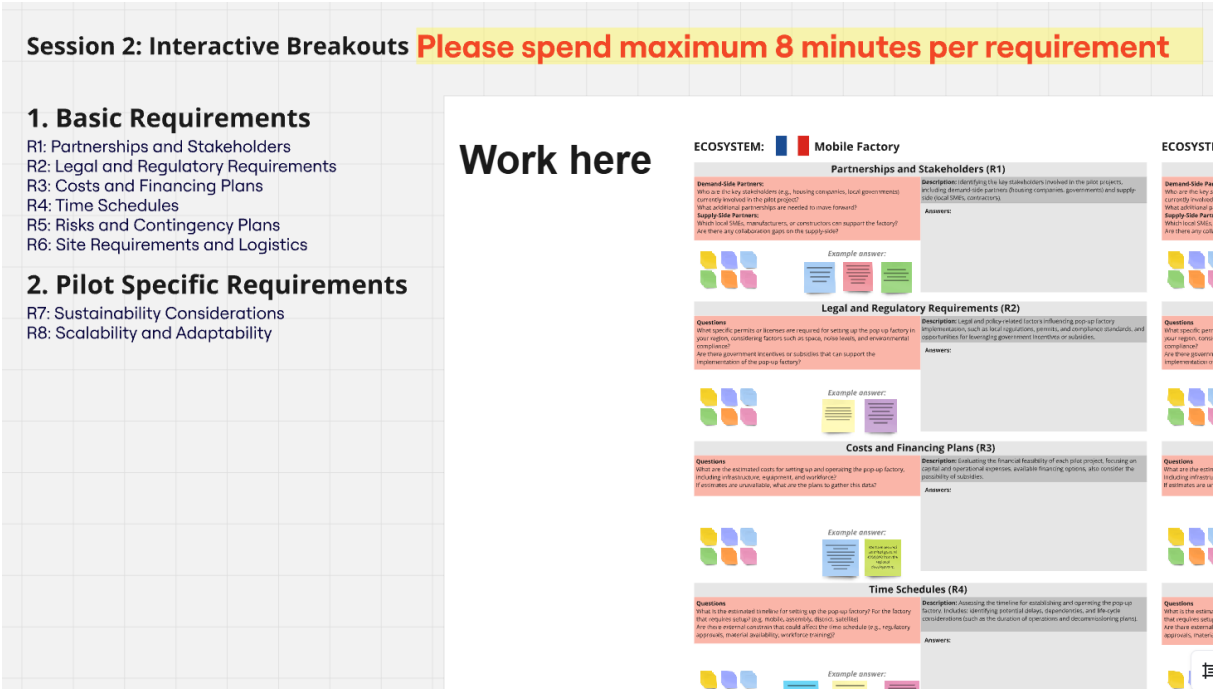


Figure 159: Interactive Breakouts for collecting requirements

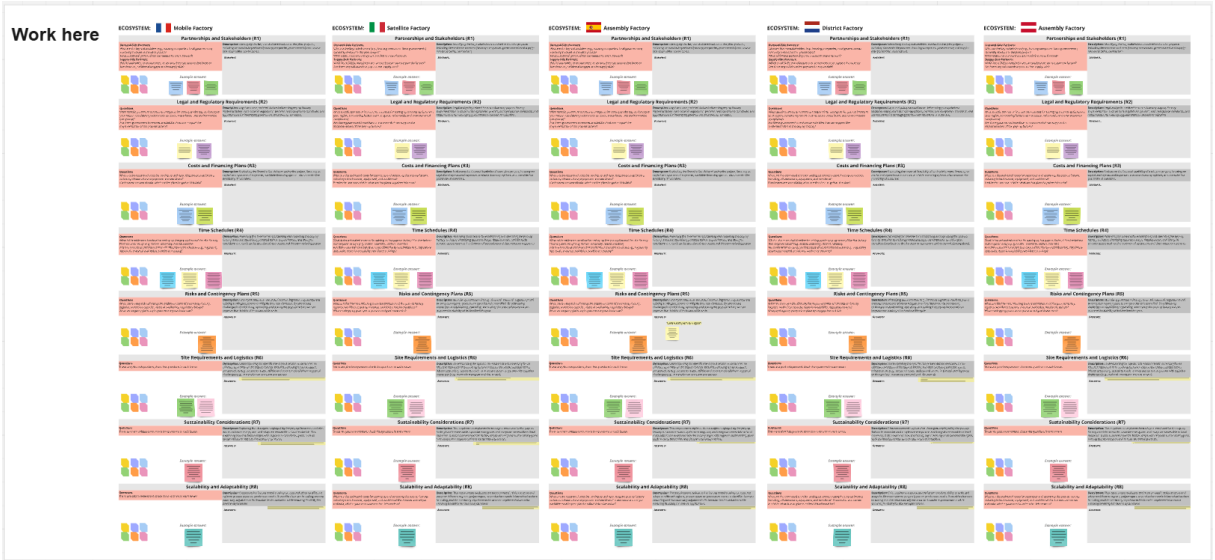


Figure 160: Workspace for each ecosystem

Final Miro Board

Welcome!

Welcome to the Implementation Plans and Scenarios for PuFs Workshop.

The Goal and Scope of the Workshop

We aim to collect missing requirements of Pop-up Factory (PuF) scenarios for each ecosystem which is contributing to Tasks 4.3 and 4.4 in our workpackage.

We will focus on evaluating progress in PuF implementation, identifying current gaps, and collecting key requirements. Through two sessions, we will gather input on stakeholder engagement, regulatory needs, financial feasibility, site logistics, and sustainability to shape the next steps for PuFs.

	Dutch ecosystem	French ecosystem	Austrian ecosystem	Italian ecosystem	Spanish ecosystem
Mobile on-site factory		☑	☑		
Satellite factory				☑	
District factory	☑				
Assembly factory	☑	☑	☑		☑
Service factory	☑	☑	☑	☑	☑

Dutch Ecosystem (District Factory)



- Deep retrofit of apartment blocks
- Modular and reuse-oriented design approach

French Ecosystem (Mobile Factory)



- Reuse of materials on-site
- Just-in-Time (JIT) flow to limit storage time.
- Specialized companies for deconstruction and material sorting.

Italian Ecosystem (Satellite Factory)



- Feasibility study in a social housing building

Spanish Ecosystem (Assembly Factory)

Pontevedra' Military headquarters



- Feasibility study in a social housing building
- Assessing Indirect Costs
- Evaluating 'Buildability' using Cross-Laminated Timber (CLT)

Austrian Ecosystem (Assembly Factory)



- Urban mining & reuse
- Renovation with standardized modules

Table 1: BuildUPspeed Ecosystems: Pilot Use Cases and Progress Updates

Ecosystem	Use Case	Goals	Current Progress
Dutch Ecosystem (District Factory)	Deep retrofit of apartment blocks	- Modular and mass-customization approach for renovation - Local supply chains to reduce environmental impact - Digital material passports and retrofit roadmaps for managing renovation components.	- User-centered approaches? - Exploring pop-up factory scenarios.
French Ecosystem (Mobile Factory)	Mobile on-site factory with reusability	- Reuse of materials on-site. - Just-in-Time (JIT) flow to limit storage time. - Specialized companies for deconstruction and material sorting.	- Selection deconstruction in Palmer. - Focus on reused local waste (e.g., bricks, wood)
Austrian Ecosystem (Assembly Factory)	Social urban mining	- Temporary ownership of reusable products - Setup includes crew containers, power sources, safety equipment, documentation tools.	Infrastructure geared toward reuse, with dedicated equipment for safe assembly and transport.
Italian Ecosystem (Satellite Factory)	Social housing renovation with off-site components	- Production of prefabricated components offsite. - Integration of sensors, photovoltaics, green roofs, and localized energy solutions.	- Feasibility studies in social housing stock renovation - Energy-saving intervention compared to traditional renovation - Off-site satellite factory solutions
Spanish Ecosystem (Assembly Factory)	Student housing renovation	- Design incorporates BIM models for streamlined coordination and minimized logistics. - Emphasis on wood certification and a circular materials approach.	- Renovation and extension of Pontevedra' military headquarters using CLT (wood-based industrialized system). - Multicriteria analysis of industrialized vs. traditional methods

Workshop Process

Pilot Learnings

Presentations: Each ecosystem gives a **5-minute** overview of:
- What has been achieved so far regarding PuF implementation plans.
- Current gaps and what is needed to meet requirements.

PuF Requirements

Divide participants into groups by the five ecosystems.
Assign each group canvases for all eight requirements:

1. **R1:** Partnerships and Stakeholders.
2. **R2:** Legal and Regulatory Requirements.
3. **R3:** Costs and Financing Plans.
4. **R4:** Time Schedules.
5. **R5:** Risks and Contingency Plans.
6. **R6:** Site Requirements and Logistics.
7. **R7:** Sustainability Considerations.
8. **R8:** Scalability and Adaptability.

Findings

Short presentation by the ecosystems: Workshop findings





Ground Rules

Let's all agree to these ground rules to make this workshop enjoyable 😊

1 - **Assign yourself** to the **breakout room** of your **ecosystem**

2 - **Introduce yourself** and the **organization you represent**, then **place your post-it note** in **your ecosystem's box**

3 - If **you need help** during the **breakout session**, post in the GA meeting chat: ***"We need support in room [Your Room Name]"***

4 - Go through **each requirement within 6 minutes** and **actively engage** with all of them

5 - **Select one participant** to **present your findings** and **outputs** in the **final session**

Introduction 2 min

Facilitators

Participants

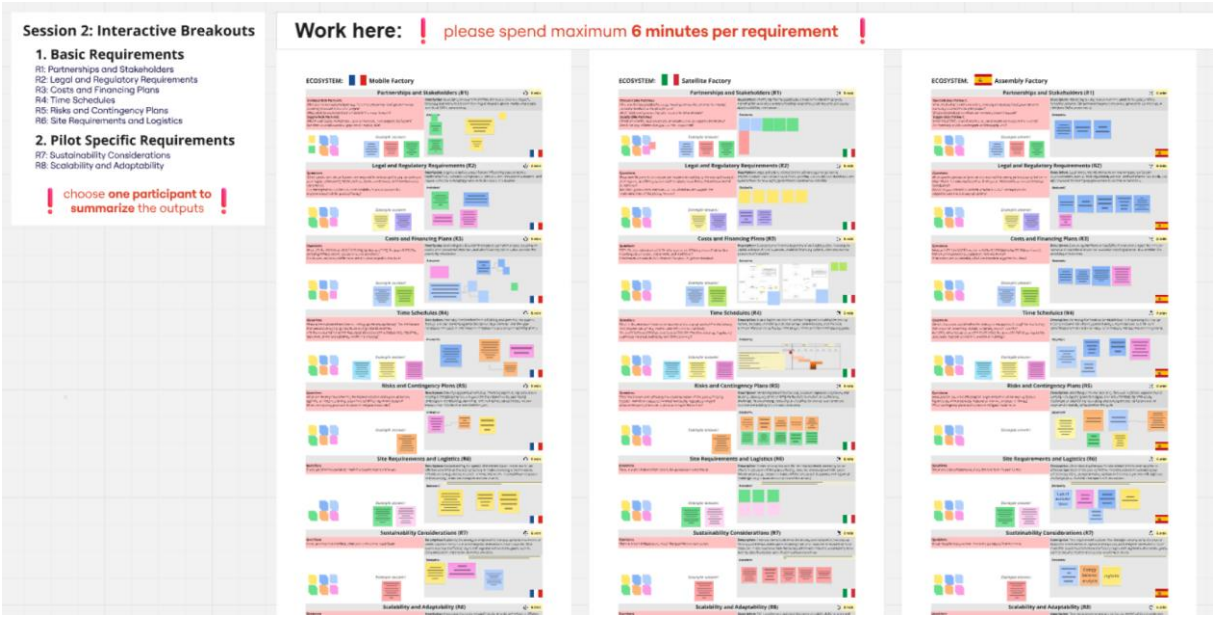
French Ecosystem

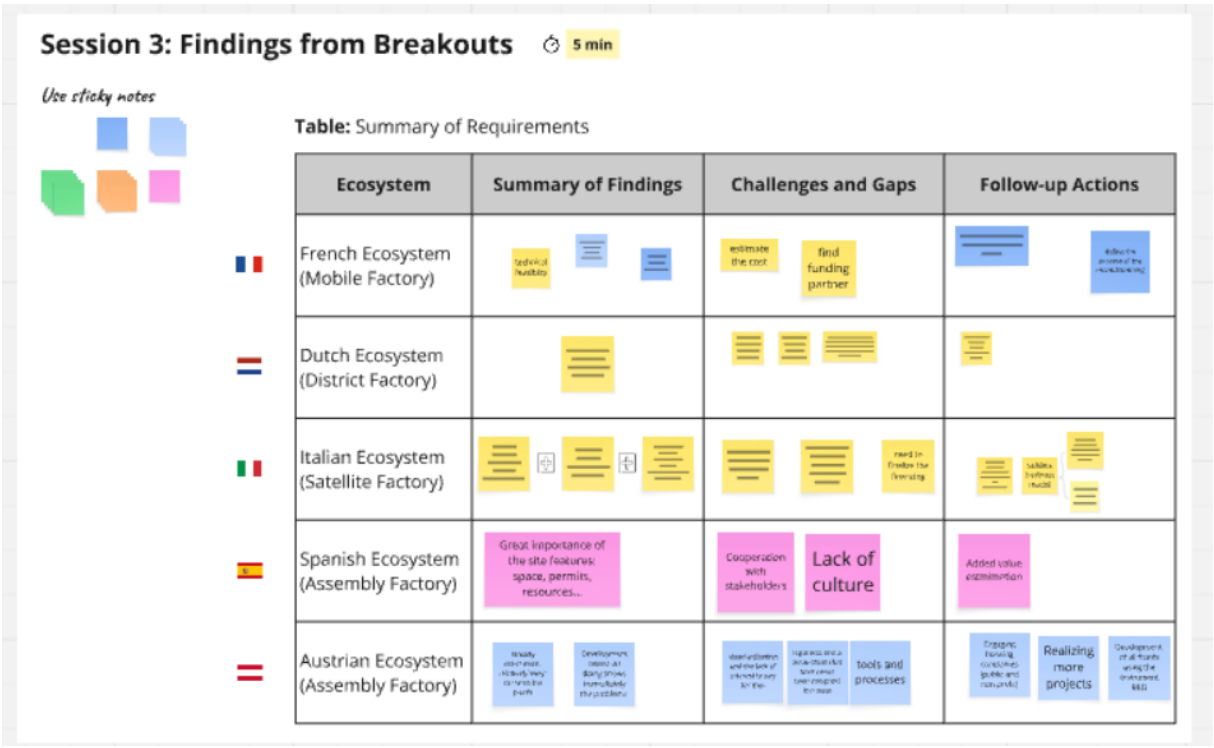
Italian Ecosystem

Spanish Ecosystem

Dutch Ecosystem

Austrian Ecosystem





Further Data Collection from Ecosystem-specific PuF Implementation Plans

The Dutch Ecosystem

Table 72: R0 – Scenario and Strategy

ID / Category	R0 – Scenario and Strategy
Definition	The PuF scenario requires a clear scenario definition and strategy to achieve a shared implementation direction
Question (s)	Please complete the fields in the answer schema below.
Answer	**PuF Type**: Disctrict Factory **PuF Purpose**: Assembles pre-fabricated components locally **Deep Renovation Scope:** • **Renovation areas addressed (tick multiple if necessary):** ☒ façade / envelope (insulation; cladding) ☒ windows/doors replacement ☒ roof insulation / roof refurbishment ☒ floor / basement insulation ☒ ventilation (balanced/mechanical) ☒ HVAC / heating system upgrade ☒ renewable energy (PV / solar thermal) ☐ electrical / controls / smart systems ☒ interior modules (bathroom/kitchen pods) ☐ other: [ ] • **Package level (choose):** ☐ single-measure ☐ multi-measure bundle ☒ whole-building deep retrofit • **Interfaces with site works (1–2 lines):** Within the PuFs it is possible to include the facade renewal, while insulation works often require tailored action which may vary per case on site. **Target Renovation Building Typology**: Multi-facility building block with structure in brick and sand-lime brick with external cavity walls. **Main Materials Processed and Produced**: Processed: wood and Timber (for doors, window frames, internal reinforcements, and roof edge adjustments); insulation and plastics (for the roof insulation package, walls and souterrain); anodized aluminium (for ventilation grilles and architectural trims), pure zinc (for folded rainwater drainage pipes), and stainless steel (for renovation anchors for masonry repair); composite and natural hard stone (for window sills and shower edges), dry-pressed ceramic tiles (for bathrooms, toilets, and kitchens); insulating double glazing. Main component produced: (1) building envelope modules with prefabricated timber-frame (HSB) wall elements and multi-layer

	roof insulation modules; (2) integrated window and door systems, with glazing, airtight seals, and fire-resistant provisions; (3) prefab ventilation roof caps; (4) modular kitchen units. **Production Capacity (e.g., units/week; m2/day; dwellings/month or other):** vertical flows (roof/facade): 28 days per block (9 apartments); horizontal flow: around 18 days per apartment. **Best-fit conditions (context triggers):** this type of PuF is recommended especially in case of repeated building typology and type of renovation works, and also suitable for limited on-site space.
Evidence / supporting material	Among the attached document, consult the document "Heerlen_construction details"[Dutch: 'bestek'] for more detailed information on the type of works. ***Remark: Although these documents are collected and stored in the BuildUPspeed SharePoint for the Dutch ecosystem, they will not be included here given the extensive scope.***

Table 73: R1 – Partnerships and Stakeholders

ID / Category	R1 – Partnerships and Stakeholders
Definition	Identifying the key stakeholders involved in the pilot projects, including demand-side partners (housing companies, governments) and supply-side (local SMEs, contractors).
Question (s)	Demand-side partners: ○ Who are the key stakeholders (e.g., housing companies, local governments) currently involved in the pilot project? ○ What additional partnerships are needed to move forward? Supply-side partners: ○ Which local SMEs, manufacturers, or constructors can support the factory? ○ Are there any collaboration gaps on the supply-side?
Answer	**Client / contracting authority:** Local Housing Associations (Woonpunt) **Who signs contracts:** Housing Association and Main contractor (winner of tender) **Who pays:** Housing Association **Decision-maker / governance lead:** Housing Association **Demand-side partners (name + role):** • **Name**: Housing Association (HA); **Role**: demand-side / owner / end user • **Name**: Tenants; **Role**: end users

	• **Name**: Structural advisor and rapporteur; **Role**: (preliminary) consultant for HA • **Name**: Advisors for fire safety and asbestos inventory; **Role**: (preliminary) consultant for HA • **Name**: Advisors for roofing systems and maintenance; **Role**: (preliminary) consultant for HA • **Name**: Advisors for concrete components; **Role**: (preliminary) consultant for HA **Supply-side partners (name + role):** • **Name**: Main Contractor (BCG); **Role**: service supplier • **Name**: Architecture studio; **Role**: service supplier • **Name**: Sub-contractor for (Circular) façade system; **Role**: production, service supplier • **Name**: Sub-contractor for carpentry; **Role**: assembly service + tailored works on site • **Name**: Sub-contractor for masonry; **Role**: service works on site • **Name**: Sub-contractor for PV; **Role**: assembly service + installation • **Name**: Sub-contractor for insulating glass; **Role**: assembly service + installation • **Name**: Sub-contractor for ventilation system; **Role**: assembly service on site • **Name**: Sub-contractor for tiles; **Role**: assembly service on site • **Name**: Sub-contractor for kitchen components; **Role**: assembly service on site **Missing roles/trades needed (tick):** ☐ electrician ☐ HVAC ☐ façade/insulation ☐ logistics/transport ☐ crane ☐ QA/QC ☐ O&M ☐ other: [X] the main contractor subcontracts the missing services and suppliers.
Evidence / supporting material	Information retrieved from interviews, site visits, documents (attached). Some specific information might be confidential and therefore not shared in detail. ***Remark: Although these documents are collected and stored in the BuildUPspeed SharePoint for the Dutch ecosystem, they will not be included here given the extensive scope.***

Table 74: R2 – Legal and Regulatory Requirements

ID / Category	R2 – Legal and Regulatory Requirements
Definition	Legal and policy-related factors influencing pop-up factory implementation, such as local regulations, permits, and compliance standards, and opportunities for leveraging government incentives or subsidies.
Question (s)	What specific permits or licenses are required for setting up the pop up factory in your region, *considering factors such as space, noise levels, and environmental compliance?*

	Are there government incentives or subsidies that can support the implementation of the pop-up factory?
Answer	**PERMITS** **1) Omgevingsvergunning (Environmental/Building Permit)** • **Permit/requirement:** This is the primary overarching permit required for the renovation • **Issuing authority:** Local municipality • **Lead time:** 8-14 week, if the renovation doesn't deviate from the zoning plan or is protected or part of the heritage register. • **Key constraints/conditions:** This permit is comprehensive and includes the sloopvergunning **(demolition permit)** as an integral component • **Responsible applicant:** Contractor + Housing association (owner) **2) Asbestos notification and work plan** • **Permit/requirement:** Before removing asbestos-containing materials, a formal notification must be submitted to the Inspectiedienst Sociale Zaken en Werkgelegenheid (I-SZW). The associated work plan must be approved by the regional director of the I-SZW before work begins • **Issuing authority:** Inspectiedienst Sociale Zaken en Werkgelegenheid (I-SZW) • **Lead time:** around 1 week, without complications • **Key constraints/conditions:** For materials in Risk Class 2 and 2A, the work must be performed by a company holding a specialized process certificate for asbestos removal. A formal asbestvrijverklaring (asbestos-free declaration) must be drafted after completion and sent to the Inspectiedienst Sociale Zaken en Werkgelegenheid (I-SZW) for approval. Also a certified contractor (SC-530) must be involved. • **Responsible applicant:** Main contractor **3) Terrain and Traffic Management** • **Permit/requirement:** The contractor must submit a site layout plan (including transport, disposal, and emergency exit routes) for approval by the municipality, the fire department, and the traffic police (Bouwplaatsinrichtingsplan, BIP) • **Issuing authority:** local municipality, the fire department, and the traffic police • **Lead time:** around 1-3 weeks (but it might take longer for more complex cases) • **Key constraints/conditions:** The plan must outline transport, waste disposal, and emergency escape routes, requiring explicit approval from the municipality, the local

fire department, and the traffic police. Public streets adjacent to the site must remain functional for traffic unless a specific deviation is approved by the authorities
- **Responsible applicant:** Contractor

4) Local Building Supervision
- **Permit/requirement:** The contractor is obligated to inform the local Building and Housing Supervision (*bouwen woningtoezicht*) prior to starting any structural work or "special activities" during construction. After the law changed in 2024 with the Environment and Planning Act (Omgevingswet) ad Wkb (Construction Quality Assurance Act , Wet kwaliteitsborging voor het bouwen)
- **Issuing authority:** Local municipality
- **Lead time:** Municipality checks completeness, not full approval
- **Key constraints/conditions:** contractor must submit a start notification including quality assurance plan and risk assessment, 2 days prior the beginning.
- **Responsible applicant:** Main contractor

The following information are the result of a desk research, as no relevant information is known from the involved stakeholders

Incentives/subsidies (if any):
- **Instrument name:** SAH (Stimuleringsregeling Aardgasvrije Huurwoningen)
- **Who applies:** Housing associations and landlords
- **Eligibility/key condition:** Existing rental dwellings (pre 2019); Connection to district heating or gas-free system
- **Expected value:** Approx. €1,200–€5,000 per dwelling
- **Timing/deadline:** Open scheme (budget-based)

Incentives/subsidies (if any):
- **Instrument name:** SPOR (Subsidieregeling aardgasvrije huurwoningen) [it is not a standalone antional scheme name anymore];
- **Who applies:** Housing associations
- **Eligibility/key condition:** Deep renovation toward gas-free housing; Often part of larger programmes
- **Expected value:** around €4,000–€7,000 per dwelling
- **Timing/deadline:** Periodic rounds / budget-dependent
-

Evidence / supporting material	**SAH:** https://www.rvo.nl/subsidies-financiering/sah **Overview of subsidies for rental housing sustainability (RVO):** https://www.rvo.nl/subsidies-financiering/svoh **National platform to verify the need for permits in areas:** https://www.omgevingsloket.nl

Table 75: R3 – Costs and Financing Plans

ID / Category	R3 – Costs and Financing Plans
Definition	Evaluating the financial feasibility of each pilot project, focusing on capital and operational expenses, available financing options, also consider the possibility of subsidies.
Question (s)	What are the estimated costs for setting up and operating the pop-up factory, including infrastructure, equipment, and workforce? **CAPEX range (€):** What is the CAPEX range (min–max €) and what is included? (1 line) **OPEX/month (€):** What is the OPEX range per month (min–max €) and what is included? (1 line) **Cost basis:** If you use €/m², what is the basis? (façade / GFA / net / other) **€/m² value:** What is the €/m² value (if used) and what does it include? **Revenue:** Is there a revenue stream? (Y/N). If yes: amount (€/month or €/project), source (reuse sales / service fee / other). **Financing model:** Which financing model applies (tick): grant / loan / equity / ESCO / PPP / other (specify). **Loan parameters** (if loan): Interest rate (%), duration (years), amount (€). (ranges OK) **Equity/SPV parameters** (if equity/SPV): Who invests, share split (%), payback logic (dividend/profit share/service fee), who controls (majority holder).

Answer	**CAPEX (€):** [min–max] (what included: [ ]) //
	OPEX (€ / month): [min–max] (what included: [ ]) //
	Cost basis (if €/m² used): [façade / GFA / net area / other] //
	€/m² value: [ ] (what included: [ ]) //
	
	Revenue assumptions (if any): [€/month or €/project] (source: [reuse sales/service fee/etc.]) For the Housing Associations (owner) “revenue” is usually indirect and regulated, depending on rental income, external subsidies, and asset value increase.

	Financing model (tick): ☐ grant ☒ loan ☒ equity ☐ ESCO ☐ PPP ☐ other: [ ] For Housing Association in NL investments are financed through WSW-guaranteed loans (Waarborgfonds Sociale Woningbouw system) to ensure lower risks and lower interest rates. Equity is partially included in recent business schemes within HA in NL. **If loan:** interest [%] | duration [years] | amount [€] **If equity/SPV:** investor(s) [ ] | share split [%] | payback logic [ ] **Payment/contracting chain (one line):** Housing Association (owner) → Architect Housing Association (owner) → Contractor → Sub-contractors **Owner of revenue & inventory (if reuse sales): //**
Evidence / supporting material	Some of this information have not been shared by the parties involved due to confidentiality. Information on WSW are retrieved at: https://www.wsw.nl/financiers/over-financiering-van-corporaties/voordelen-voor-financiers? https://www.wsw.nl/over-wsw/nieuws-publicaties/laatste-nieuws/nieuwsdetail/geborgde-leningenportefeuille-gestegen-tot-recordbedrag-van-ruim-eur-90-miljard? https://finance-ideas.nl/handboek-marktwaardering-2022-hogere-disconteringsvoet-aannemelijk/ Information on HA model are also discussed online at: https://www.woonpunt.nl/application/files/4116/8967/4280/Woonpunt_jaarverslag_2018_definitief.pdf?

Table 76: R4 –Time Schedules

ID / Category	R4 – Time Schedules
Definition	Assessing the timeline for establishing and operating the pop-up factory. Includes: identifying potential delays, dependencies, and life-cycle considerations (such as the duration of operations and decommissioning plans).
Question (s)	What is the estimated timeline for the PuF lifecycle for this scenario (setup → operate → decommission, if temporary)? Please provide durations (weeks/months) or target dates for: setup/installation, start of operations (go-live), typical operating period per site/project, and wrap-up/decommissioning (pack-down + site restoration). Are there external constrain that could affect the time schedule (e.g., regulatory approvals, material availability, workforce training)?

Answer	**Setup duration:** Around 50 weeks (per 36 apartments), including 2 weeks for work preparation and 3 days to set up the construction site;
	Operations duration on site / per project: around 20 days/apartment but strongly related to specific conditions;
	Wrap-up / decommissioning duration : N/A
	Milestones (estimated lead times in weeks or months):
	• Funding secured: N/A
	• Permits approved: around 8 weeks
	• Design freeze: subjective to specific project, can be related to specific requirements or additional permits/license required by Municipalities
	• Procurement complete: around 3-6 months, of which
	  • 2-4 weeks: preparation and publication
	  • 1-3 months: tendering
	  • 3-5 weeks: evaluation and award
	• Start operations: 2 weeks
	•
	Top 5 dependencies:
	• Sequence of permit application, especially if environmental aspects, heritage, asbestos removal and zoning plan are involved;
	• Availability of sufficient space in the proximity of the building for setting up the site;
	• Management of inhabitants during the works;
	• Workforce availability, especially in a small-medium region;

Evidence / supporting material	See TimePlan in the Annex documents. See the document "Leidraad Aanbesteden" (Procurement Guideline) published by Bouwstenen voor Sociaal: https://www.bouwstenen.nl/fileswijkplaats/1604-leidraad-aanbesteden.pdf for regulation on construction tender, for public or semi-public clients.

Table 77: R5 – Risks and Contingency Plans

ID / Category	R5 – Risks and Contingency Plans
Definition	Identifying potential risks (e.g., financial, logistical, regulatory) and existing contingency plans to mitigate the risks identified. By addressing challenges in establishing, operating, and scaling the pop-up factory we can improve the stability of its timeline/life-cycle.
Question (s)	What are the key risks affecting the implementation of the pop-up factory, logistics, workforce capacity, material availability, regulatory delays)? What contingency plans are in place to mitigate these risks?

Answer	Possible and common situations: • **Risk:** Limited availability for storing materials near the building → **Mitigation:** early coordination with Municipality and planning → **Owner:** contractor • **Risk:** Delays in product supply → **Mitigation:** early set up of site plan → **Owner:** supply-chain coordinator or contractor → **Trigger threshold:** component delivery delaying more than 1-2 weeks from plan • **Risk:** Presence of asbestos → **Mitigation:** early request for asbestos evaluation → **Owner:** main contractor → **Trigger threshold:** the evaluation needs to happen right after the tender (or even before) • **Risk:** Not easy access to high-skilled manufacturers for circular products → **Mitigation:** planning per time the integration of supplier from out the region // incentives for training → **Owner:** main contractor → **Trigger threshold:** inability to secure the right workforce to respond properly to the tender
Evidence / supporting material	Interview with contractors

Table 78: R6 – Site Requirements and Logistics

ID / Category	R6 – Site Requirements and Logistics
Definition	Understanding the specific site-related details necessary for an effective operation of the pop-up factory. Includes assessing available space, infrastructure (e.g., access to roads, utilities and so on), in parallel with logistical challenges (e.g., materials transport and site access.
Question (s)	**Space requirements:** What space is required (m²) for: manufacture / assembly / storage / staging-loading? **Access constraints:** What access constraints apply? • vehicle type/size/weight limits (text or numbers) • delivery time windows (hours/days) • road restrictions / low-emission zone (LEZ) / permits needed (Y/N + name) • public space required (Y/N) **Utilities -** Provide: • power requirement (kW + single/three-phase) • water needed (Y/N + connection type or liters/day) • drain needed (Y/N + where it discharges) • internet needed (Y/N + minimum requirement if any) **Waste handling:** What waste streams occur and who is responsible for collection/disposal? **Provider responsibility:** Who provides/installs utilities and how long does it take? (entity + setup time) **Special items:** Are any of these required? (Y/N + details)

	• containers (#) • crane access (Y/N) • security/lockable room (Y/N) • fencing (Y/N)
Answer	**Space required (m²):** • Assembly: either off-site and on-site assembly needs depend on the product; • Storage: 60-100 sm • Staging/loading: crane **Access constraints:** • vehicle type: trucks, car • time windows: 7:00-16:00 in occupied buildings (sometimes 9:00-15:00 is the 'noise window') • road limits: N/A • public space needed (Y/N) : Usually the proximity of the building is used. In narrow spaces, a permit for public space occupancy might be required **Utilities**: • Power [kW + phase]: 3-phase • Water (Y/N): Y • Drain (Y/N): preferably • Internet (Y/N): not necessary but often used **Waste streams + responsible party**: Main contractor **Who provides utilities/setup**: External companies or Municipalities **Special items (if any)**: • containers [#]: 2 (material + team) • crane needed (Y/N): Yes over 4 floors • security (lockable room) (Y/N): The contractors have access to a private apartment within the block that they are renovation for storing personal items
Evidence / supporting material	Interview with contractors, site visits

Table 79: R7 – Sustainability Considerations

ID / Category	R7 – Sustainability Considerations
Definition	Exploring the strategies employed by the pop-up factory to minimize waste, optimize energy use, and integrate renewable or local materials. Also examining how the factory aligns with regional sustainability goals, such as decarbonization and circular economy practices.
Question (s)	**Top measures:** List max 3 sustainability measures planned (short bullets). **KPI selection:** Which 2–3 KPIs will you track? (tick): CO_2e / waste diverted / reuse rate / energy use (kWh) / water use / other (specify).

	Targets: For each chosen KPI, what is the target value (or "TBD")? **Reuse scope** (if applicable): Which materials/components are reused (top 3) and what acceptance criteria/certification applies? **Energy approach:** What is the renewable energy approach? (on-site / green purchase / mix) and target % renewable. **Logistics decarbonization:** What is the approach (routing, consolidation, low-emission vehicles) and what logistics KPI will be tracked (km/CO_2e/other)?
Answer	**Main sustainability measures (max 3):** 1. Energy label up to B/A 2. Circular glass: re-use of flat glass (GLS); 3. Thermal envelope and insulation; 4. Circular wooden window frames 5. Installation of Solar Panels (PV) 6. Smart ventilation 7. Selective demolition 8. Nature-inclusive design with nesting boxes for bats in the facades 9. (partial) Asbestos removal 10. Integration of Nature-inclusive elements (swift boxes and bat slides) **KPI tracking (choose 2–3):** ☒ CO_2e ☐ waste diverted ☐ reuse rate ☒ energy use ☐ water use ☐ other: As the renovations are not completed at the current state it is not possible to track these KPIs. However, the CO2 emission and the energy use after renovation should be crucial for the type of PuF and renovation works. **KPIs target values (if known): //** **Materials reuse scope (if applicable):** Glass and partially window frames **Energy approach:** Energy label from < D to > A **Logistics decarbonization approach:** efficient work planning and management to reduce material and products' transportation.
Evidence / supporting material	Check this information in the 'Bestek' document and in the Pilot Annex. ***Remark: Although these documents are collected and stored in the BuildUPspeed SharePoint for the Dutch ecosystem, they will not be included here given the extensive scope.***

Table 80: R8 – Scalability and Adaptability

ID / Category	R8 – Scalability and Adaptability
Definition	Evaluating the factory model's ability to scale and adapt to different regions, project types, or production needs. It identifies

	barriers to scaling and the necessary adjustments for broader implementation while ensuring flexibility for diverse applications.
Question (s)	**Scaling approach:** Choose the scaling approach (tick): replicate sites / increase capacity at one site / multi-site coordination / other (specify). **Scalability thresholds:** Provide numerical thresholds (write "N/A" if not applicable): • max distance (km) • max storage duration (days) • max volume (units/week or m²/week) • other limiting metric (e.g., district size: #dwellings or renovation volume) **Adaptability mechanism:** How is adaptability achieved? (choose): standardized process / modular equipment / digital tools / other (specify). **Digital tools:** Which tools/software are used (names) OR list required features (documentation/sales/stock control). **Coordination owner:** Who coordinates replication/multi-site planning (name/role/entity)?
Answer	**Scaling approach:** ☒ replicate sites ☐ increase capacity at one site ☐ multi-site coordination ☐ **other**: **Scalability limit/threshold (numbers):** • distance [km]: within the region • storage duration [days]: N/A • volume [units/week]: N/A • district size metric [ ] **Adaptability mechanism:** [e.g., standardized process / modular equipment / digital tools / other]: Standardized process and modular products; increasing use of digital tools **Digital tools used (names or required features):** BIM software (not always) **Coordination owner:** Main contractor
Evidence / supporting material	

The French Ecosystem

Table 81: R0 – Scenario and Strategy

ID / Category	R0 – Scenario and Strategy
Definition	The PuF scenario requires a clear scenario definition and strategy to achieve a shared implementation direction
Question (s)	Please complete the fields in the answer schema below.

Answer	**PuF Type**: Mobile On-Site Factory **PuF Purpose**: Assembles pre-fabricated components locally **Deep Renovation Scope :** • **Renovation areas addressed (tick multiple if necessary):** ☐ façade / envelope (insulation; cladding) ☐ windows/doors replacement ☐ roof insulation / roof refurbishment ☐ floor / basement insulation ☐ ventilation (balanced/mechanical) ☐ HVAC / heating system upgrade ☐ renewable energy (PV / solar thermal) ☒ electrical / controls / smart systems ☒ interior modules (bathroom/kitchen pods) ☐ other: [ ] • **Package level (choose):** ☐ single-measure ☐ multi-measure bundle ☐ whole-building deep retrofit • **Interfaces with site works (1–2 lines):** **Target Renovation Building Typology**: residential building, public housing, multi-family apartment block, any social housing, community centres **Main Materials Processed and Produced**: sanitary equipment (WC, sink, bath, stainless sink) **Production Capacity (e.g., units/week; m2/day; dwellings/month or other):** depending on the need and the Schedules, but expect to attend 3 apartments per day, so approximately 15 sanitary equipment's (WC, sink, bath) **Best-fit conditions (context triggers):** when a building owner needs to renovate their building within a short timeframe, while it remains occupied, the sanitary equipment should be removed and replace at the end of the day. It is really suitable for buildings where apartments are being renovated one after another. Also, most of the time there is no storage area on the deconstruction or construction site.

Evidence / supporting material	  

Table 82: R1 – Partnerships and Stakeholders

ID / Category	R1 – Partnerships and Stakeholders

Definition	Identifying the key stakeholders involved in the pilot projects, including demand-side partners (housing companies, governments) and supply-side (local SMEs, contractors).
Question (s)	Demand-side partners: ○ Who are the key stakeholders (e.g., housing companies, local governments) currently involved in the pilot project? ○ What additional partnerships are needed to move forward? Supply-side partners: ○ Which local SMEs, manufacturers, or constructors can support the factory? ○ Are there any collaboration gaps on the supply-side?
Answer	**Client / contracting authority:** Domofrance (social landlord) **Who signs contracts:** project owner (DOMOFANCE) and mobile unit leader (FAVRES) **Who pays:** Favre invest financially and develop the concept **Decision-maker / governance lead:** • **Name :** FAVRE ; **Role** : support and develop the concept of the mobile on site factory • **Name**: Ecominéro; **Role**: Proposition of Funding to support reuse initiatives as this project of mobile factory **Demand-side partners (name + role):** • **Name**: Domofrance (social landlord); **Role**: provide residential building and sanitary equipment to be reconditioned • **Name**: housing companies/public authority; **Role**: Other project manager (housing companies, public authority, …) who own real estate, particularly residential buildings in need of renovation, and whose mobile factory would be suitable for their project. **Supply-side partners (name + role):** • **Name**: Plumber companies (Favres); **Role**: sanitary-related works, rehabilitation specialists • **Name**: Compagnons Bâtisseurs; **Role**: worker grouping / implementation capacity **Missing roles/trades needed :** ☐ electrician ☐ HVAC ☐ façade/insulation ☒ logistics/transport ☐ crane ☐ QA/QC ☐ O&M ☐ other: [ ]
Evidence / supporting material	There is no a real contract for now. We (Buildupspeed partner project assist FAVRE (the plumberie company) who support the concept and take the initiative and the development of the mobile factory. DomoFrance then hire the services of FAVRE to support the reconditionnning of their sanitary equipment and, in a sense, makes experimental buildings available for FAVRE. In a second time, FAVRE will propose this service to other project manager,

	clients, etc. We will hire companies to transport the containers-factory, but there is no specific problem with that (simple containers transport).

Table 83: R2 – Legal and Regulatory Requirements

ID / Category	R2 – Legal and Regulatory Requirements
Definition	Legal and policy-related factors influencing pop-up factory implementation, such as local regulations, permits, and compliance standards, and opportunities for leveraging government incentives or subsidies.
Question (s)	What specific permits or licenses are required for setting up the pop up factory in your region, *considering factors such as space, noise levels, and environmental compliance?* Are there government incentives or subsidies that can support the implementation of the pop-up factory?
Answer	**Permit/requirement #1:** Transporting chemical products in a truck • Issuing authority: REACH • Lead time: 1-2 days • Key constraints/conditions: • Responsible applicant: project manager **Permit/requirement #2:** Authorization to deploy truck on-site (specific area) • Issuing authority: public authority, site owner, project owner • Lead time: +/- 1 month • Key constraints/conditions: Access to the power grid and water supply. A dedicated installation area must be designated on the construction site, without disrupting ongoing site operations or other workers. • Responsible applicant: project manager Incentives/subsidies: • Subsidies: NONE • Incentives: new regulations that focus on increasing reused equipment rate in construction *(cf the REP link below)*
Evidence / supporting material	French regulations encourage the incorporation of reuse into projects (RE2020). However, there is still a need to strengthen support for local policies to help develop local supply chains. The CSRD/taxonomy also serves as a framework for integrating the circular economy into projects -Diagnostic Products, Materials, and Waste Assessment, since 2023 & Loi AGEC https://www.ecologie.gouv.fr/politiques-publiques/diagnostic-produits-equipements-materiaux-dechets-pemd for building >1000m^2 -REP : The Extended Producer Responsibility (EPR) for Building Construction Products and Materials (PMCB) sets national targets for reuse

	and recycling : At least 5% of the collected waste must be reused or recycled. https://filieres-rep.ademe.fr/principe-et-reglementation/reglementation https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000034110584/2019-03-01/ -Transports of containers : containers ISO are especially designed to comply with the imposed limits of the French -Installation on site : in accordance with the Urban Planning Code. Temporary structures necessary for the performance of construction work may be exempt from building permits. https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000034722169/2020-02-21#:~:text=Sont%20dispens%C3%A9es%20de%20toute%20formalit%C3%A9,n'exc%C3%A9dant%20pas%20trois%20mois. -Working area : subject of the labor code : Articles R4121-1 à R4823-6) -Power supply : NF C 15-100 -disinfectants products : must be documented in **FDES** sheet : and **REACH regulations** https://www.inies.fr/contenu-de-la-base/fdes-produits-de-construction/ https://eur-lex.europa.eu/legal-content/FR/TXT/?uri=CELEX%3A32006R1907&qid=1691566598405

Table 84: R3 – Costs and Financing Plans

ID / Category	R3 – Costs and Financing Plans
Definition	Evaluating the financial feasibility of each pilot project, focusing on capital and operational expenses, available financing options, also consider the possibility of subsidies.
Question (s)	What are the estimated costs for setting up and operating the pop-up factory, including infrastructure, equipment, and workforce? **CAPEX range (€):** What is the CAPEX range (min–max €) and what is included? (1 line) **OPEX/month (€):** What is the OPEX range per month (min–max €) and what is included? (1 line)

	Cost basis: If you use €/m², what is the basis? (façade / GFA / net / other) **€/m² value:** What is the €/m² value (if used) and what does it include? **Revenue:** Is there a revenue stream? (Y/N). If yes: amount (€/month or €/project), source (reuse sales / service fee / other). **Financing model:** Which financing model applies (tick): grant / loan / equity / ESCO / PPP / other (specify). **Loan parameters** (if loan): Interest rate (%), duration (years), amount (€). (ranges OK) **Equity/SPV parameters** (if equity/SPV): Who invests, share split (%), payback logic (dividend/profit share/service fee), who controls (majority holder).
Answer	**CAPEX (€): ~ 62 k€** **OPEX (€ / month): ~ 1200 € per housing** **Cost basis (if €/m² used):** -- **Revenue assumptions (if any): 1800 € per housing** **Financing model (tick):** ☒ grant ☐ loan ☒ equity ☒ ESCO ☐ PPP ☐ other: [ ] • **If loan:** interest [%] | duration [years] | amount [€] • **If equity/SPV:** investor(s) [FAVRE] | share split [%] | payback logic [ ] **Payment/contracting chain (one line):** **Owner of revenue & inventory (if reuse sales):** FAVRE
Evidence / supporting material	**CAPEX** : Containers factory : 62k€ including • container • a workbench; • an indoor layout with shelving, power supply and wastewater evacuation; • lifting and handling equipment; • various tools (high-pressure cleaner, hand tools, etc.); • consumable supplies (personal protective equipment, cleaning products, etc.). **OPEX** : Reconditioning of sanitary equipment : • Unit price for careful removal • supply and application of disinfectant • replacement of toilet flush mechanism, drain, siphon • supply of the mounting kit

Table 85: R4 –Time Schedules

ID / Category	R4 – Time Schedules

Definition	Assessing the timeline for establishing and operating the pop-up factory. Includes: identifying potential delays, dependencies, and life-cycle considerations (such as the duration of operations and decommissioning plans).
Question (s)	What is the estimated timeline for the PuF lifecycle for this scenario (setup → operate → decommission, if temporary)? Please provide durations (weeks/months) or target dates for: setup/installation, start of operations (go-live), typical operating period per site/project, and wrap-up/decommissioning (pack-down + site restoration). Are there external constrain that could affect the time schedule (e.g., regulatory approvals, material availability, workforce training)?
Answer	**Setup duration:** ~3 months (project leader + funding + truck adaptation) **Operations duration on site / per project**: depending of the number of housing per building, approximately 6months. **Wrap-up / decommissioning duration**: The mobile unit system features simple logistics and lightweight equipment. It can be dismantled quickly (approximately 0.5 days to remove from the construction site and about 1/2 days to clear out the interior of the module or renovate the unit). **Milestones (estimated lead times in weeks or months)**: • Funding secured : done • Permits approved : done • Design freeze: in progress, under testing → May 2026 • Procurement complete: → June 2026 • Start operations: about July 2026 **Top 5 dependencies**: 1. finding project leader/funding 2. worker motivation / workforce availability
Evidence / supporting material	The prototype has already been built and is currently being tested. It doesn't yet have the final shape of a container, but the entire reconditioning process is currently being tested.

Table 86: R5 – Risks and Contingency Plans

ID / Category	R5 – Risks and Contingency Plans
Definition	Identifying potential risks (e.g., financial, logistical, regulatory) and existing contingency plans to mitigate the risks identified. By addressing challenges in establishing, operating, and scaling the pop-up factory we can improve the stability of its timeline/life-cycle.
Question (s)	What are the key risks affecting the implementation of the pop-up factory, logistics, workforce capacity, material availability, regulatory delays)?

	What contingency plans are in place to mitigate these risks?
Answer	Provide up to 5 lines: • **Risk:** transport and handling of chemical products (descaling, disinfection) → **Mitigation:** Designed to eliminate the use of chemical products or limited to easily transportable ones, strict HSE procedures, operator training, → **Owner:** FAVRES is in charge / Logistics Manager → **Trigger threshold:** incident or regulatory non-compliance • **Risk:** workforce availability and skills → **Mitigation:** dedicated training on refurbishment processes, multi-skilled teams, use of local partners, social integration → **Owner:** Operations Manager → **Trigger threshold:** understaffing or drop in productivity • **Risk**: variability and availability of equipment streams for refurbishment → **Mitigation**: contracts with suppliers (housing providers, deconstruction actors), buffer stock, flexible planning → **Owner**: Supply Manager → **Trigger threshold**: insufficient volumes for economic viability
Evidence / supporting material	

Table 87: R6 – Site Requirements and Logistics

ID / Category	R6 – Site Requirements and Logistics
Definition	Understanding the specific site-related details necessary for an effective operation of the pop-up factory. Includes assessing available space, infrastructure (e.g., access to roads, utilities and so on), in parallel with logistical challenges (e.g., materials transport and site access.
Question (s)	**Space requirements:** What space is required (m²) for: manufacture / assembly / storage / staging-loading? **Access constraints:** What access constraints apply? • vehicle type/size/weight limits (text or numbers) • delivery time windows (hours/days) • road restrictions / low-emission zone (LEZ) / permits needed (Y/N + name) • public space required (Y/N) **Utilities -** Provide: • power requirement (kW + single/three-phase) • water needed (Y/N + connection type or liters/day) • drain needed (Y/N + where it discharges) • internet needed (Y/N + minimum requirement if any) **Waste handling:** What waste streams occur and who is responsible for collection/disposal? **Provider responsibility:** Who provides/installs utilities and how long does it take? (entity + setup time) **Special items:** Are any of these required? (Y/N + details)

	• containers (#) • crane access (Y/N) • security/lockable room (Y/N) • fencing (Y/N)
Answer	**Space required (m²):** • Storage: 50 m² (around truck) • Assembly / staging/loading: idem **Access constraints:** Access for Container Truck **Utilities:** • **Water:** Yes • **Drain:** Yes • **Power:** Yes, connexion to power grid • **Internet:** not necessary • **Special items:** containers [# TBD], repacking tools a workbench; an indoor layout with shelving, power supply and wastewater evacuation; lifting and handling equipment; various tools (high-pressure cleaner, hand tools, etc.); consumable supplies (personal protective equipment, cleaning products, etc.). **Waste streams + responsible party:** Waste generated during equipment refurbishment is classified as construction waste and must therefore be fully integrated into the project owner's overall waste management plan consumables, wastewater, …). Equipment deemed too deteriorated for refurbishment must be managed by the refurbishment company, which is responsible for setting up an appropriate recycling scheme. **Who provides utilities/setup**: the project owner of the mobile unit provides all equipment necessary for the reconditioning. The project owner of the construction must provide electric and water access.
Evidence / supporting material	-power supply and water access/connection -all necessary equipment for the reconditioning is a part of the factory, including into the main containers (lifting equipment, high pressure cleaner, hand tools, various tools, disinfectants, etc.)

Table 88: R7 – Sustainability Considerations

ID / Category	R7 – Sustainability Considerations
Definition	Exploring the strategies employed by the pop-up factory to minimize waste, optimize energy use, and integrate renewable or local materials. Also examining how the factory aligns with regional sustainability goals, such as decarbonization and circular economy practices.
Question (s)	**Top measures:** List max 3 sustainability measures planned (short bullets). **KPI selection:** Which 2–3 KPIs will you track? (tick): CO_2e / waste diverted / reuse rate / energy use (kWh) / water use / other (specify).

	Targets: For each chosen KPI, what is the target value (or "TBD")? **Reuse scope** (if applicable): Which materials/components are reused (top 3) and what acceptance criteria/certification applies? **Energy approach:** What is the renewable energy approach? (on-site / green purchase / mix) and target % renewable. **Logistics decarbonization:** What is the approach (routing, consolidation, low-emission vehicles) and what logistics KPI will be tracked (km/CO_2e/other)?
Answer	**Main sustainability measures (max 3):** *11.* sustainable chemical products. No hazardous chemical products required. The cleaning process is designed to avoid the use of chemical substances that are dangerous to transport, difficult to process for recycling, and harmful to the environment. 12. optimized routing between sites to reduce transport emissions 13. overall contribution to sector sustainability *(generic)* **KPI tracking (choose 2–3):** ☐ CO_2e ☐ waste diverted ☐ reuse rate ☐ energy use ☒ water use ☐ other: **KPIs target values (if known):** to be defined after testing the cleaning process. **Materials reuse scope (if applicable):** (which products/components; acceptance criteria/certification) **Logistics decarbonization approach**: routing optimization

Table 89: R8 – Scalability and Adaptability

ID / Category	R8 – Scalability and Adaptability
Definition	Evaluating the factory model's ability to scale and adapt to different regions, project types, or production needs. It identifies barriers to scaling and the necessary adjustments for broader implementation while ensuring flexibility for diverse applications.
Question (s)	**Scaling approach:** Choose the scaling approach (tick): replicate sites / increase capacity at one site / multi-site coordination / other (specify). **Scalability thresholds:** Provide numerical thresholds (write "N/A" if not applicable): • max distance (km) • max storage duration (days) • max volume (units/week or m²/week) • other limiting metric (e.g., district size: #dwellings or renovation volume)

	Adaptability mechanism: How is adaptability achieved? (choose): standardized process / modular equipment / digital tools / other (specify). **Digital tools:** Which tools/software are used (names) OR list required features (documentation/sales/stock control). **Coordination owner:** Who coordinates replication/multi-site planning (name/role/entity)?
Answer	**Scaling approach:** ☒ replicate sites ☐ increase capacity at one site ☒ multi-site coordination (JIT Matching) ☐ **other**: **Scalability limit/threshold (numbers):** • distance [km] [ ] 20km between deconstruction site and receiving site. No distance limit between different PuF, it is independent • storage duration [days] one/two mmonths. Depending of the price of the storage • volume [units/week] [ ] 60/weeks per mobile units • district size metric [ ] : Even with this theoretical scaling limit, it is possible to exceed it by adding supplementary units. As explained above, units can be added or even stacked to expand daily reconditioning throughput and storage capacity. The limiting factor would most likely be the available space on site to accommodate the modules. **Adaptability mechanism:** JIT local matching : The process developed above should be standardized in order to facilitate the deployment of the mobile unit. The capacity of the careful removal, reconditioning and reinstallation should be the same process in each building, regardless the project owner. **Digital tools used:** for traceability and the FDES data sheet. It is important to develop a numerical tools and an well communication/exchange between each mobile units to share th **Coordination owner:** project manager of the mobile unit. To begin it would be FAVRES, the leader of the first unit, support by DOMO or other social landlords interested in the concept.
Evidence / supporting material	

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Table 90: R0 – Scenario and Strategy

ID / Category	R0 – Scenario and Strategy
Definition	The PuF scenario requires a clear scenario definition and strategy to achieve a shared implementation direction
Question (s)	Please complete the fields in the answer schema below.
Answer	**PuF Type**: Assembly Factory **PuF Purpose**: Assembles pre-fabricated components locally **Deep Renovation Scope:** • **Renovation areas addressed (tick multiple if necessary):** ☒ façade / envelope (insulation; cladding) ☒ windows/doors replacement ☐ roof insulation / roof refurbishment ☒ floor / basement insulation ☒ ventilation (balanced/mechanical) ☒ HVAC / heating system upgrade ☒ renewable energy (PV / solar thermal) ☒ electrical / controls / smart systems ☒ interior modules (bathroom/kitchen pods) ☒ other: [A Re-Use Box deals with all components that are potentially reuseable a building scheduled for demolition.] • **Package level (choose):** ☒ single-measure ☐ multi-measure bundle ☐ whole-building deep retrofit • **Interfaces with site works (1–2 lines):** After a Re-Use Box the state of the art process of dismantling takes place. The contract to run a Re-Use Box mentions that the ownership of all components stays with the building owner. Only in case the organiser finds a buyer the owner ships changes. **Target Renovation Building Typology**: In principal all type of building larger than roughly 2.000m². Preferable are office buildings, factory buildings, healthcare facilities and educational institutions. **Main Materials Processed and Produced**: a wide range like: furniture, floorings, wand coverings, electric products, installations, cooling units, windows, façade elements, static elements like beams, concrete elements or roof trusses. **Production Capacity (e.g., units/week; m2/day; dwellings/month or other):** Considering a Re-Use as the “unit” the organisation takes three to six months before it gets operational. Because each object is unique the schedule for the

	development is unique also. A Re-Use Box is operational on site as long as the schedule allows. Practice shows in general between two weeks and two months. **Best-fit conditions (context triggers):** A client who wants to be involved in the design process A demolition building of sufficient size (at least 2.000 m²) Sufficient time for exploration and planning (at least three months) A proper Time slot for operational work (at least two weeks) Truck access, construction power, sanitary facilities Temporary storage facilities
Evidence / supporting material	

Table 91: R1 – Partnerships and Stakeholders

ID / Category	R1 – Partnerships and Stakeholders
Definition	Identifying the key stakeholders involved in the pilot projects, including demand-side partners (housing companies, governments) and supply-side (local SMEs, contractors).
Question (s)	Demand-side partners: ○ Who are the key stakeholders (e.g., housing companies, local governments) currently involved in the pilot project? ○ What additional partnerships are needed to move forward? Supply-side partners: ○ Which local SMEs, manufacturers, or constructors can support the factory? ○ Are there any collaboration gaps on the supply-side?
Answer	**Client / contracting authority:** Building owners, public or private ones. **Who signs contracts:** Building owners and BauKarussell **Who pays:** The Building Owner, but the contract is cofinanced by the urban mine (=the building) due to the revenues of the reuse sales. **Decision-maker / governance lead:** Building owner **Demand-side partners (name + role):** • **Name**: Public and non-profit housing organisations, ; **Role**: building owner / client **Supply-side partners (name + role):** • **Name**: Building owner and their general contractors; **Role**: decision taking • **Name**: BauKarussell **Role**: plan, design, run, manage and evaluate the Re-Use Box

	• **Name**: local social economic enterprises **Role**: act as subcontractors to perform operational deconstruction work for purchasers at local level • **Name**: Original producers and Circular Economy Startups ; **Role**: legally and technically experienced companies for checking component functionality (e.g., PV panels or HVAC systems, electrical equipment) **Regulatory / assurance partners (name + role):** • **Name**: authorised professionals for building or other products; **Role**: certification / conformity in case needed • **Name**: Insurance companies; **Role**: insurance coverage **Missing roles/trades needed (tick):** ☒ electrician ☐ HVAC ☐ façade/insulation ☐ logistics/transport ☐ crane ☐ QA/QC ☐ O&M ☒ other: higher potential possible in cooperation with producers, manufacturing partner, dismantling companies
Evidence / supporting material	

Table 92: R2 – Legal and Regulatory Requirements

ID / Category	R2 – Legal and Regulatory Requirements
Definition	Legal and policy-related factors influencing pop-up factory implementation, such as local regulations, permits, and compliance standards, and opportunities for leveraging government incentives or subsidies.
Question (s)	What specific permits or licenses are required for setting up the pop up factory in your region, *considering factors such as space, noise levels, and environmental compliance?* Are there government incentives or subsidies that can support the implementation of the pop-up factory?
Answer	**Permit/requirement #1:** pre demolition audit according to the national recycling material ordinance • Issuing authority: Federal ministry of environment • Lead time: min od three Months to evaluate the building and the chemical analysis. • Key constraints/conditions: define the framework for save working conditions and acknowledgement of limitations due to waste management act. • legal status of waste and the consequences for options and documentation efforts, end of waste • Responsible applicant: performed by experts on behalf of the Building owner (the client) • Insurance/liability holder (if relevant): - **Permit/requirement #2**: requirements/certificates beads in other administrative legal acts (like chemical regulation REACH, Trade regulation act, electrical engineering law)

	• Issuing authority: the respective national bodies • Lead time: integrated in the organisation to avoid the need for additional time • Key constraints/conditions: in general: our legal framework was never designed to deal with reuse of products. Therefore many details limit and hinder reuse sales • Responsible applicant: the organiser of the Re-Use Box **Compliance / certification**: • Permit/requirement: Certification by licensed/authorized organisations for building products • Issuing authority: at the end EU • Lead time: integrated in the organisation to avoid the need for additional time • Key constraints/conditions: uncertainties on how to deal with the legal framework for reuse components. Still not solved if there is a need for new testing. **Incentives/subsidies**: • Instrument name: Regional public funding schemes to support sustainable business (WIN, ÖKOPLUS, OekoBusiness Wien, KPC Kreislaufwirtschaft) • Who applies: national or regional authorities • Eligibility/key condition: in general an additional impact beyond legal demands • Expected value: various, depending on region • Timing/deadline: ongoing funding programmes with regularly calls and dealines
Evidence / supporting material	*Here please provide (if possible) web links or names of the standards and specific regulations that you must comply to establish or operate your PuF.* *https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20002086* *https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20009212* *https://www.austrian-standards.at/de/shop/onorm-b-3151-2022-05-15~p2622876* *https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10012241* *https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10007517* *https://www.wko.at/umwelt/f-gase-verordnung* *https://www.oib.or.at/kernaufgaben/bauprodukte/bauprodukteverordnung-und-ce-kennzeichnung/* *etc.*

Table 93: R3 – Costs and Financing Plans

ID / Category	R3 – Costs and Financing Plans
Definition	Evaluating the financial feasibility of each pilot project, focusing on capital and operational expenses, available financing options, also consider the possibility of subsidies.
Question (s)	What are the estimated costs for setting up and operating the pop-up factory, including infrastructure, equipment, and workforce? **CAPEX range (€):** What is the CAPEX range (min–max €) and what is included? (1 line) **OPEX/month (€):** What is the OPEX range per month (min–max €) and what is included? (1 line) **Cost basis:** If you use €/m², what is the basis? (façade / GFA / net / other) **€/m² value:** What is the €/m² value (if used) and what does it include? **Revenue:** Is there a revenue stream? (Y/N). If yes: amount (€/month or €/project), source (reuse sales / service fee / other). **Financing model:** Which financing model applies (tick): grant / loan / equity / ESCO / PPP / other (specify). **Loan parameters** (if loan): Interest rate (%), duration (years), amount (€). (ranges OK) **Equity/SPV parameters** (if equity/SPV): Who invests, share split (%), payback logic (dividend/profit share/service fee), who controls (majority holder).
Answer	**CAPEX (€):**app. 1.800EUR/month for the legal entity to run the company. Re-Use Box is one service of the company; for rent, insurance, accounting, phone and internet, -devices, software, hand tools, fees and taxes **OPEX (€ / month):**app. 1.000EUR/Mon of operation; for: travel, certification, subcontracts **Cost range provided:** €7.000–€150,3 to 1,9,000 (depending on the size and state of the building for planning and execution **Cost basis (if €/m² used):** depending on size and state of the building between 1 to 2 EUR/m² for the analysis and 1,5 to 2,5 EUR/m² for the operation **Revenue assumptions (if any):** cofinancing due to the revenue from selling reuse products **Financing model (tick):** ☐ grant ☐ loan ☐ equity ☐ ESCO ☐ PPP ☒ other: contract based **Payment/contracting chain (one line):** the building owner and the buyers of reuse components **Owner of revenue & inventory (if reuse sales**): The Re-Use Box Organiser temporarily takes possession of the property. This is then transferred to the buyer.

	Cost estimate owner + deadline: The completion date for the box is agreed with the client and fits into the construction schedule. **Other known cost item:** To run a detailed exploration is an essential foundation to run a Re-Use Box. The Social Urban Mining concept cost between 5.000 and 10.000EUR depending on the size and location of the building.
Evidence / supporting material	

Table 94: R4 –Time Schedules

ID / Category	R4 – Time Schedules
Definition	Assessing the timeline for establishing and operating the pop-up factory. Includes: identifying potential delays, dependencies, and life-cycle considerations (such as the duration of operations and decommissioning plans).
Question (s)	What is the estimated timeline for the PuF lifecycle for this scenario (setup → operate → decommission, if temporary)? Please provide durations (weeks/months) or target dates for: setup/installation, start of operations (go-live), typical operating period per site/project, and wrap-up/decommissioning (pack-down + site restoration). Are there external constrain that could affect the time schedule (e.g., regulatory approvals, material availability, workforce training)?
Answer	**Setup duration:** to prepare, plan, organise and PR it should be months (atl east three months, better six) **Operations duration on site / per project**: between two weeks and two months (depending on the size of the building) **Wrap-up / decommissioning duration**: maybe two **Milestones (estimated lead times in weeks or months)**: • Social Urban Mining Concept done: six months • Pre-demolition audit: six to three months • Contract signed: six months prior Operation • Permits approved: one month before operation • Procurement complete: the day of the opening • Start operations: Opening day • Storage time: time limit set to use the building for interim storage **Top 5 dependencies**: 3. The mind of the building owner (Is an innovative action thinkable?)

	4. It must fit into deconstruction time schedule set by the client 5. Matchmaking / buyer search duration (weeks to months) 6. Availability of a local social economic partner 7. Local conditions (storage space, water and power supply) 8. Storage time: How long area we allowed to use the building as an interim storage
Evidence / supporting material	

Table 95: R5 – Risks and Contingency Plans

ID / Category	R5 – Risks and Contingency Plans
Definition	Identifying potential risks (e.g., financial, logistical, regulatory) and existing contingency plans to mitigate the risks identified. By addressing challenges in establishing, operating, and scaling the pop-up factory we can improve the stability of its timeline/life-cycle.
Question (s)	What are the key risks affecting the implementation of the pop-up factory, logistics, workforce capacity, material availability, regulatory delays)? What contingency plans are in place to mitigate these risks?
Answer	Provide up to 5 lines: • **Risk:** High investment in negotiation phase; many cases without realization → **Mitigation:** standardize the offer → **Owner:** PuF operator → **Trigger threshold:** no order • **Risk:** Failing the restrictions from several legal acts (as listed above) → **Mitigation:** communication, training and communication strategy to authorities → **Owner:** PuF operator → **Trigger threshold:** accidents and misunderstandings • **Risk:** Long duration from negotiation start to operational business → **Mitigation:** Focus and fast decision if it might be worth the efforts → **Owner:** PuF operator → **Trigger threshold:** passed time • **Risk:** Failure of function of the product → **Mitigation:** Quality checks written and communicated → **Owner:** PuF operator → **Trigger threshold:** customer complaint

	• **Risk:** Continuity of operations needed to secure sufficient business → **Mitigation:** Management of operational activities in the board → **Owner:** PuF operator → **Trigger threshold:** overwork of employees • **Risk:** Not reaching the estimations regarding reuse sales of the concept **Mitigation:** Headlining it is estimations in the concept, agree upon a liability for default → **Owner:** PuF operator → **Trigger threshold:** evaluation within the close-knit local building control authority • Risk:
Evidence / supporting material	

Table 96: R6 – Site Requirements and Logistics

ID / Category	R6 – Site Requirements and Logistics
Definition	Understanding the specific site-related details necessary for an effective operation of the pop-up factory. Includes assessing available space, infrastructure (e.g., access to roads, utilities and so on), in parallel with logistical challenges (e.g., materials transport and site access.
Question (s)	**Space requirements:** What space is required (m²) for: manufacture / assembly / storage / staging-loading? **Access constraints:** What access constraints apply? • vehicle type/size/weight limits (text or numbers) • delivery time windows (hours/days) • road restrictions / low-emission zone (LEZ) / permits needed (Y/N + name) • public space required (Y/N) **Utilities -** Provide: • power requirement (kW + single/three-phase) • water needed (Y/N + connection type or liters/day) • drain needed (Y/N + where it discharges) • internet needed (Y/N + minimum requirement if any) **Waste handling:** What waste streams occur and who is responsible for collection/disposal? **Provider responsibility:** Who provides/installs utilities and how long does it take? (entity + setup time) **Special items:** Are any of these required? (Y/N + details) • containers (#) • crane access (Y/N) • security/lockable room (Y/N) • fencing (Y/N)

Answer	**Space required (m²):** • Assembly this happens in the whole building • Storage*:* depending on the site app. 200m² • Staging/loading depending on the site app. 20m² • Site Office 20m² **Access constraints:** • vehicle type: best case a Truck access is possible • time windows must happen within the time agreed with the building owner • road limits none • public space needed (Y/N): might happen, which results in the need for permits to do that (this takes time) **Utilities:** • Power [5kW + 240V, better 400V phase] *(construction site electricity required)* • Water (Y/N) Yes, for social needs • Drain (Y/N) Yes *(grey water handling required; method not specified)* • Internet (Y/N) Yes, for organising the sales and payments **Waste streams + responsible party:** • Waste streams: waste form transport packaging • Responsible party: PuF operator **Who provides utilities/setup:** • to be negotiated between the building owner and the PuF operator **Special items (if any):** • containers [#] at least one for residual waste and waste bins for separate collection • crane needed (Y/N) NO • security (lockable room) (Y/N) [YES, the PuF operator must have the control the access to the building/building site. **Additional site facilities:** • Sanitation [required; can be mobile] ○ Rule: 1 mobile toilet per 5 workers • Social/contact point room [required; can be temporary/mobile] • Construction office [required] • Construction site fencing [required] • Parking lot and entrance [required] • Access to roads [required] • Packaging materials (e.g., pallets) [required] • “Material for invoices” [ambiguous: likely documentation/traceability] • WIFI access point

Evidence / supporting material	

Table 97: R7 – Sustainability Considerations

ID / Category	R7 – Sustainability Considerations
Definition	Exploring the strategies employed by the pop-up factory to minimize waste, optimize energy use, and integrate renewable or local materials. Also examining how the factory aligns with regional sustainability goals, such as decarbonization and circular economy practices.
Question (s)	**Top measures:** List max 3 sustainability measures planned (short bullets). **KPI selection:** Which 2–3 KPIs will you track? (tick): CO_2e / waste diverted / reuse rate / energy use (kWh) / water use / other (specify). **Targets:** For each chosen KPI, what is the target value (or "TBD")? **Reuse scope** (if applicable): Which materials/components are reused (top 3) and what acceptance criteria/certification applies? **Energy approach:** What is the renewable energy approach? (on-site / green purchase / mix) and target % renewable. **Logistics decarbonization:** What is the approach (routing, consolidation, low-emission vehicles) and what logistics KPI will be tracked (km/CO_2e/other)?
Answer	**Main sustainability measures (max 3):** • Re-Use of building components increases the resource efficiency (ecological impact) • Integration of social enterprises generates social impact due to their main goal the reintegration of long time unemployed people **KPI tracking (choose 2–3):** ☐ CO_2e ☒ waste diverted ☒ reuse rate ☐ energy use ☐ water use ☐ other: TBP **KPIs target values (if known):** the targets are specific and individual for each PuF. We define the potentials in the Social Urban Mining concept. So these numbers are the targets for a contract for realisation. **Materials reuse scope (if applicable):** Re-Us Box is dedicated to this topic. Activities result in reuse of used building components. As another activity we also dismantle specific materials as waste, so a PuF creates also a higher quality in waste separation. **Energy approach**: not relevant **Logistics decarbonization approach:** not relevant

Evidence / supporting material	

Table 98: R8 – Scalability and Adaptability

ID / Category	R8 – Scalability and Adaptability
Definition	Evaluating the factory model's ability to scale and adapt to different regions, project types, or production needs. It identifies barriers to scaling and the necessary adjustments for broader implementation while ensuring flexibility for diverse applications.
Question (s)	**Scaling approach:** Choose the scaling approach (tick): replicate sites / increase capacity at one site / multi-site coordination / other (specify). **Scalability thresholds:** Provide numerical thresholds (write "N/A" if not applicable): • max distance (km) • max storage duration (days) • max volume (units/week or m²/week) • other limiting metric (e.g., district size: #dwellings or renovation volume) **Adaptability mechanism:** How is adaptability achieved? (choose): standardized process / modular equipment / digital tools / other (specify). **Digital tools:** Which tools/software are used (names) OR list required features (documentation/sales/stock control). **Coordination owner:** Who coordinates replication/multi-site planning (name/role/entity)?
Answer	**Scaling approach:** ☐ replicate sites ☐ increase capacity at one site ☒ multi-site coordination (it is possible to sell the same product from different PuF sites.) ☒ **other**: process standardization + digital tools + second hand material market platforms + continuous search for legislation compliance for new products **Scalability limit/threshold (numbers):** • distance [km] [local max. regional level up to 50km. This is a rough estimation aligned with the distances we see in the building sector] • storage duration [days] [no limit. Yet a PuF operator should avoid to much storage (risk management). PuF operators do not store components for sale, only already sold ones in the sense of interim storage until the delivery] • volume [units/week] [only limited due to the options at the building sites.] **Adaptability mechanism:** Standardized processes + enhanced use of digital tools (documentation/placement/selling/stock control)

	Digital tools used (names or required features): Documentation and placement via tablet and a digital tool based on the open source database (ODOO)
Evidence / supporting material	

The Italian Ecosystem

Table 99: R0 – Scenario and Strategy

ID / Category	R0 – Scenario and Strategy
Definition	The PuF scenario requires a clear scenario definition and strategy to achieve a shared implementation direction
Question (s)	Please complete the fields in the answer schema below.
Answer	**PuF Type**: Satellite Factory **PuF Purpose**: Produce main panels in major hybrid factories and integrate more fragile components close to the building site. **Deep Renovation Scope:** The PuF supports deep renovation through an integrated multi-measure approach focused primarily on the building envelope and its interface with building systems. The scope includes prefabricated façade solutions with integrated insulation, windows, ventilation, HVAC upgrades, renewable energy systems, and smart electrical controls. Roof elements are not produced by the main precast factory so there will be a dedicated subcontractor in case the roof needs insulation which can be directly chosen locally when available. • **Renovation areas addressed (tick multiple if necessary):** ☒ façade / envelope (insulation; cladding) ☒ windows/doors replacement ☐ roof insulation / roof refurbishment ☐ floor / basement insulation ☒ ventilation (balanced/mechanical) ☒ HVAC / heating system upgrade

☒ renewable energy (PV / solar thermal)
☒ electrical / controls / smart systems
☐ interior modules (bathroom/kitchen pods)
☐ other: [ ]

- **Package level (choose):** ☐ single-measure ☒ multi-measure bundle ☐ whole-building deep retrofit

Interfaces with site works (1–2 lines): The interfaces with site works involve the coordination between the prefabricated panels and the site preparation, including structural anchoring, new foundations, MEP connections, and scaffold-free installation activities. Also, tenant engagement activities are planned onsite.

Target Renovation Building Typology: Large multi-storey residential buildings from the 1950s–1990s, typically social housing blocks with extensive façade surfaces requiring industrialized envelope renovation, seismic performance improvement and need to maintain residential continuity.

Main Materials Processed and Produced: Prefabricated concrete elements (external wall panels, insulated façade panels, internal walls, hollow-core slabs, stairs, balconies) using low-impact binders and recycled aggregates, along with steel reinforcement cages and carpentry components produced in dedicated workshop areas.

Production Capacity (e.g., units/week; m²/day; dwellings/month or other):

The hybrid offsite factory has an annual production capacity of:

- Retrofit or internal insulated walls (20 cm thick) = 80.000 m²
- External walls (32 cm thick, for new construction) = 85.000 m²
- Hollow core slabs = 40.000 m²
- Staircase with landing = 3.400 m²
- Balconies = 9.000 m²

For renovation, RECOskeletron panels can be installed at an average rate of 200 m²/day, allowing a typical building like Viale Omero to be fully refurbished in approximately 10 days (excluding preparation and finishing works).

Best-fit conditions (context triggers):

The Pop-Up Factory is best suited for renovation projects concentrated on a limited geographical area, where buildings share similar typologies and façade dimensions. In addition, the project is suitable for large-scale regeneration interventions that also include demolition and reconstruction activities, particularly in contexts where the local workforce is highly skilled and able to integrate the needed technical components.

Evidence / supporting material	 Picture of the PuF pilot: public social housing complex in Viale Omero, Milan.

Table 100: R1 – Partnerships and Stakeholders

ID / Category	R1 – Partnerships and Stakeholders
Definition	Identifying the key stakeholders involved in the pilot projects, including demand-side partners (housing companies, governments) and supply-side (local SMEs, contractors).
Question (s)	Demand-side partners: ○ Who are the key stakeholders (e.g., housing companies, local governments) currently involved in the pilot project? ○ What additional partnerships are needed to move forward? Supply-side partners: ○ Which local SMEs, manufacturers, or constructors can support the factory? ○ Are there any collaboration gaps on the supply-side?
Answer	**Client / contracting authority:** Comune di Milano or Regione Lombardia (public authority) **Who signs contracts:** Public social housing agencies (ERP) or other institutional owners sign the renovation contracts, typically MM S.p.A. or ALER Milano for the Milan case, as asset manager and delegated contracting authority for large-scale interventions. Contracts related to Pop-Up Factory setup or offsite production may also be signed by construction companies partnering in the model. **Who pays:** Renovation works are funded by the public housing owner (Comune di Milano) through dedicated investment programmes and framework agreements, often supported by regional or national resources, or by financial actors involved in

	regeneration projects (e.g., funds, social impact investors). It's getting more common the Public Private Partnership (PPP) procedure with EPC contract, in which the ESCO company anticipate the capex of the renovation investment and asks the public authority a payback annual fee. **Decision-maker / governance lead:** For public housing, the governance lead is the public housing organization in coordination with the Municipality. In regeneration projects, decision-making may be led by developers or investment funds. Public authorities (Municipality, Metropolitan City, Lombardy Region) act as strategic aggregators of demand and impose performance standards, influencing the adoption of industrialized models such as the Pop-Up Factory. **Demand-side partners:** • **Name**: Milan Municipality or Lombardy Region; **Role**: public authority / building owner /demand-side lead / funder of large-scale renovation initiatives • **Name**: MM S.p.A or ALER Milano; **Role:** public housing asset manager / contracting authority / procurement and maintenance operator • **Name**: COIMA, Lendlease, Hines, Prelios, Near sgr, DeA capital sgr, Kryalos sgr etc.; **Role:** private urban regeneration developer / project promoter / demand driver for high-performance and innovative interventions. **Supply-side partners:** • **Name**: LOMBARDA SpA, Camuna prefabbricati, Bianchi precast, Progress srl, etc.; **Role**: panel manufacturer • **Name**: local companies (site-dependent); **Role**: Subcontractors of windows, PV panels, MEP systems, etc. • **Name**: STRUCTURAMA; **Role**: system integrator and consultant for satellite precast pop-up factories design. **Operations / maintenance:** • **Name**: A2A, E.ON, Enel X, etc.; **Role**: ESCO contractual part in PPP with EPC procedures/ maintenance for panels and technical systems / energy provider. **Financing-related actor:** • **Name**: Ener2Crowd; **Role**: crowdfunding • **Name**: Intesa Sanpaolo, Unicredit, etc; **Role**: debt finance • **Name**: Fondazione Cariplo; **Role:** social impact investor / co-funder in affordable and sustainable housing programmes. **Missing roles/trades needed:** ☐ electrician ☐ HVAC ☐ façade/insulation ☒ logistics/transport ☒ crane ☐ QA/QC ☐ O&M ☒ other: [General contractor, Works supervisor]

Evidence / supporting material	

Table 101: R2 – Legal and Regulatory Requirements

ID / Category	R2 – Legal and Regulatory Requirements
Definition	Legal and policy-related factors influencing pop-up factory implementation, such as local regulations, permits, and compliance standards, and opportunities for leveraging government incentives or subsidies.
Question (s)	What specific permits or licenses are required for setting up the pop up factory in your region, *considering factors such as space, noise levels, and environmental compliance?* Are there government incentives or subsidies that can support the implementation of the pop-up factory?
Answer	**Permit/requirement #1:** Factory building permit according to regional regulation • **Issuing authority:** Municipality (Sportello Unico per l'Edilizia / SUAP) issuing the Building Permit under DPR 380/2001; additional technical clearances may be required for seismic, fire-safety, and landscape constraints according to regional/competent bodies. • **Lead time:** 3–6 months for full Building Permit (longer if fire, seismic or landscape authorizations are required). • **Key constraints/conditions:** Compliance with urban planning/zoning, structural and seismic codes, accessibility and fire-safety where applicable; full viability at completion. • **Responsible applicant:** Project developer of the new factory, represented by certified designers and coordinated with the general contractor. • **Insurance/liability holder:** Factory owner and project developer. **Permit/requirement #2:** Environmental authorization • **Issuing authority:** AUA (Autorizzazione Unica Ambientale) under DPR 59/2013 for non-AIA plants, with ARPA technical instruction; AIA (Autorizzazione Integrata Ambientale) under D. Lgs. 152/2006 Part II, Title III-bis if thresholds/activities fall under IPPC/EID annexes. • **Lead time:** AU: 3 – 4 months; AIA typically longer (≥ 6 months) due to technical review and conference of services. • **Key constraints/conditions:** Integrated compliance for air emissions, water discharges, waste, noise, and energy/resource efficiency.

- **Responsible applicant:** Future plant operator submitting through SUAP/Competent Authority with support from environmental consultants.
- **Insurance/liability holder:** Future plant operator responsible for compliance with permit conditions and monitoring obligations.

Permit/requirement #3: General building codes

- **Key constraints/conditions:** Full compliance with national and regional building rules (structural/seismic, accessibility, energy efficiency, fire-safety where applicable) under DPR 380/2001; no longer "minimal obligations" since this is a new industrial construction.

Permit/requirement #4: Safety and health regulations

- **Key constraints/conditions:** Construction phase governed by D.Lgs. 81/2008—Temporary or Mobile Construction Sites (Title IV): PSC/POS, CSP/CSE appointments, training and PPE, equipment checks; after commissioning, ongoing workplace safety compliance (Titles I–III).

Permit/requirement #5: Noise level regulations (affects where factory can be located)

- **Thresholds / measurement method / enforcing body:** Municipal noise zoning plan thresholds. Measurements under UNI 11728:2018 and law 447/1998 and D.P.C.M. 14/11/1997. Enforced by Municipality + ARPA.

Possible incentives/subsidies (as listed):

- **Digital Transformation Incentive (Invitalia/MIMIT)** – supports digital and Industry 4.0 technologies of micro, small and medium enterprises; 50% aid (10% grant + 40% soft loan). https://www.invitalia.it/incentivi-e-strumenti/digital-transformation
- **Upcoming "Transition 5.0" tax credit** – new national incentive (fiscal deduction) supporting digital and green industrial investments, which requires a 3% reduction of energy emissions of the production plant. https://www.mimit.gov.it/it/incentivi/piano-transizione-5-0
- **Regional grants (ex. Bando Nuova Impresa 2026 for Lombardy region)** – 10.000 € reimbursement to each PMI starting a new business to pay back some costs in capital account or current account. https://www.unioncamerelombardia.it/bandi-e-incentivi-alle-imprese/dettaglio-bando/bando-nuova-impresa-2026

Evidence / supporting material	

Table 102: R3 – Costs and Financing Plans

ID / Category	R3 – Costs and Financing Plans
Definition	Evaluating the financial feasibility of each pilot project, focusing on capital and operational expenses, available financing options, also consider the possibility of subsidies.
Question (s)	What are the estimated costs for setting up and operating the pop-up factory, including infrastructure, equipment, and workforce? **CAPEX range (€):** What is the CAPEX range (min–max €) and what is included? (1 line) **OPEX/month (€):** What is the OPEX range per month (min–max €) and what is included? (1 line) **Cost basis:** If you use €/m², what is the basis? (façade / GFA / net / other) **€/m² value:** What is the €/m² value (if used) and what does it include? **Revenue:** Is there a revenue stream? (Y/N). If yes: amount (€/month or €/project), source (reuse sales / service fee / other). **Financing model:** Which financing model applies (tick): grant / loan / equity / ESCO / PPP / other (specify). **Loan parameters** (if loan): Interest rate (%), duration (years), amount (€). (ranges OK) **Equity/SPV parameters** (if equity/SPV): Who invests, share split (%), payback logic (dividend/profit share/service fee), who controls (majority holder).

Answer	**CAPEX (€):** ≈35 million (land acquisition and civil works for the new main factory, production and office buildings, batching plant, prefabrication production lines (panels, slabs, stairs), automation and machinery, digital production and control systems, installation, testing, and commissioning). **OPEX (€ / month):** ≈59.4 million (direct and indirect costs included: factory workforce of around 50 employees, energy consumption, mechanical and electrical maintenance, consumables, factory-side logistics, transport, operational coordination and management. **Cost basis (if €/m² used):** 510 €/m^2 for retrofit panels, 335 €/m^2 for new construction elements. **€/m² value:** 790 €/m^2 for retrofit panels, 450 €/m^2 for new construction elements (NB: it's the price for square meter of precast piece exiting the main factory not of floor area and it includes the transport to local facilities). The cost of the whole energy and seismic retrofit intervention (site preparation, foundations, MEP technical systems, additional buildings work on roof and balconies, installations of offsite panels with integrated components such as windows) is around 1.400 €/m^2 of floor area. **Revenue assumptions:** Revenues are generated through programme-based renovation contracts, usually in Public Private Partnerships. Cash flow is linked to the selling of integrated panels to the General Contractor (GC) which coordinates the works and the relationship with the Public Authority. In case of the creation of Single Purpose Vehicle (SPV), there is no GC intermediation, so cash flows are linked to delivery milestones rather than to single product sales. **Financing model (tick):** ☐ grant ☒ loan ☒ equity (SPV) ☐ PPP ☐ ESCO ☐ other: [ ] **If loan**: interest [6%] | duration [5 years] | amount [25 M€, both from credit institutions and crowdfunding but up to 5 M€] **If equity/SPV:** investor(s) [precast panel manufacturer, housing organizations and external investors] | share split: More than half of the share is of the precast manufacturer (to have control over production); the rest is split among housing organization and external shareholders willing to co-invest. | payback logic: Residual dividend policy (dividends are paid only after the factory investment and all profitable industrial projects have been financed). **Payment/contracting chain (one line):** Public authority → General Contractor (construction company or ESCO in PPP) or SPV→ precast panels manufacturer → suppliers and local integrated SMEs **Owner of revenue & inventory (if reuse sales):** None **Cost estimate owner + deadline:** //

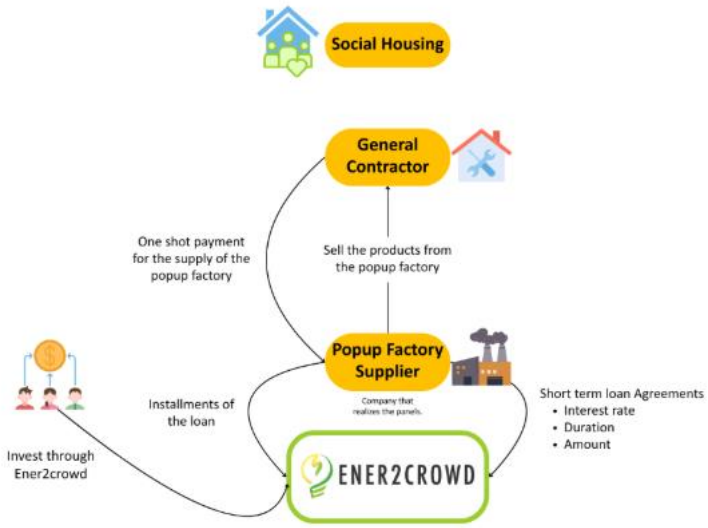
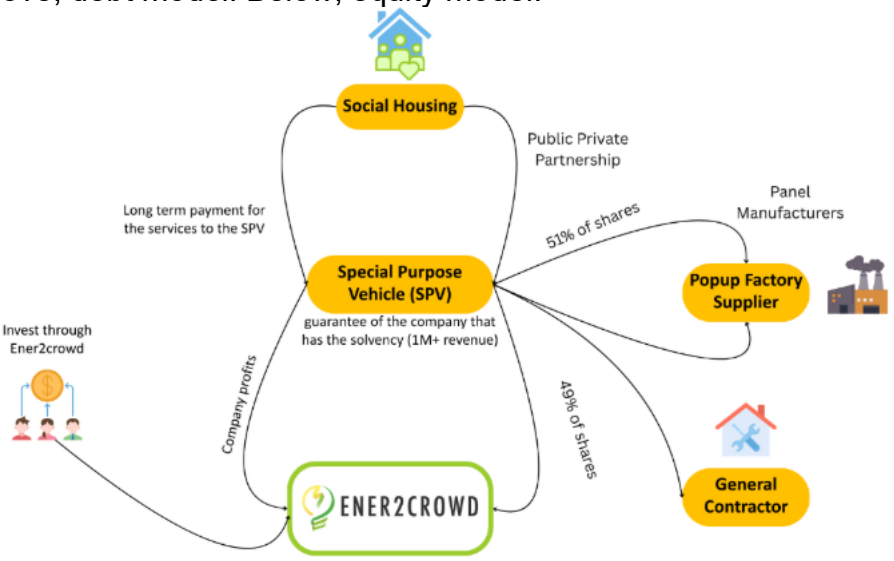
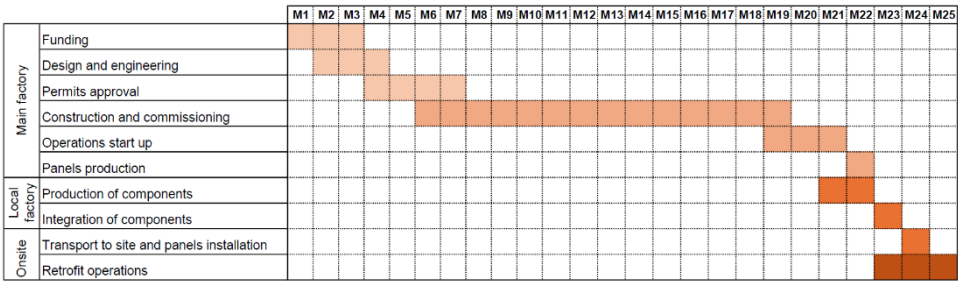
Evidence / supporting material	 Above, debt model. Below, equity model. 

Table 103: R4 –Time Schedules

ID / Category	R4 – Time Schedules
Definition	Assessing the timeline for establishing and operating the pop-up factory. Includes: identifying potential delays, dependencies, and life-cycle considerations (such as the duration of operations and decommissioning plans).
Question (s)	What is the estimated timeline for the PuF lifecycle for this scenario (setup → operate → decommission, if temporary)? Please provide durations (weeks/months) or target dates for: setup/installation, start of operations (go-live), typical operating period per site/project, and wrap-up/decommissioning (pack-down + site restoration).

	Are there external constrain that could affect the time schedule (e.g., regulatory approvals, material availability, workforce training)? **Total PuF setup duration: ~21 months** It includes project funding, building and environmental permitting for the new precast factory, detailed design and engineering, procurement, full construction of the precast plant, installation of production lines, commissioning, and production start-up. **Main milestones**: • **Funding secured: ~3 months**, depending on credit institution verifications and crowdfunding collection times. • **Permits approved: ~4 months**, including Building Permit (DPR 380/2001) and environmental AUA/AIA procedures, plus minor municipal authorizations for temporary onsite logistics. • **Design freeze: ~3 months**, including digital modelling, structural/process engineering, and final layout. • **Factory commissioned: ~14 months** for construction of the new precast concrete factory, installation of machinery (tilting tables, battery molds, overhead cranes, batching plant), utilities setup, testing, and commissioning of production lines. • **Operations start**: immediately after commissioning, typically **within 2–3 months** from the completion of factory. It includes also the research and partnership with local components' factories across Italy.
Answer	**From panel production to components integration: ~3 months** It includes dispatch from main precast factory, JIT component integration from local finishing factories, routing and arrivals within 100 km, temporary micro-stock, and pre-installation checks. **Main milestones**: • **Panel release from main precast factory:** 10 days • **Loading, dispatching and arrival at staging area:** 2 days • **Integration of components from local factories (windows/MEP/cladding/PV):** 20 days • **Transport to site (≤100 km) and pre-installation checks:** max 2 -3 hours per delivery slot **Onsite full retrofit duration: ~3months** It includes site setup, demolitions and surface preparation, foundations works, RECOskeletron panels installation, other building works (roof insulation, balconies, basement, etc.), MEP systems connection. **Main milestones:** • **RECOskeletron panels installation:** rate ≈ 200 m²/day, which means ~10 days of installation for a 2,000 m² façade.

	• **Connection of integrated MEP to onsite technical systems:** 2 weeks • **Onsite façade testing and commissioning:** 1 week **Wrap-up / decommissioning duration**: N/A for the satellite factory since it relies on permanent structures. **Top 10 dependencies**: • Securing a project leader and funding partners before starting factory design • Construction of the main precast factor, following permitting dependencies • Testing and commissioning of machinery at the main factory and start of production • Workforce availability and specialized training before production running • Supply chain coordination between the main factory and local finishing SMEs • Lead time and availability of windows / MEP / cladding components before integration in the panels • Renovation or demolition/reconstruction permitting before starting the intervention onsite • Onsite works preparation before transport of integrated panels to the building. • Availability of installers and proper weather conditions for panels' installation. • Testing and commissioning of completed works before final payment
Evidence / supporting material	

ID / Category	R5 – Risks and Contingency Plans
Definition	Identifying potential risks (e.g., financial, logistical, regulatory) and existing contingency plans to mitigate the risks identified. By addressing challenges in establishing, operating, and scaling the pop-up factory we can improve the stability of its timeline/life-cycle.
Question (s)	What are the key risks affecting the implementation of the pop-up factory, logistics, workforce capacity, material availability, regulatory delays)?

	What contingency plans are in place to mitigate these risks?
Answer	Provide up to 5 lines: • **Risk:** Delay in securing a project leader and financing partners → **Mitigation:** activate multiple funding channels + early engagement with institutional and crowdfunding investors. → **Owner:** Business developer → **Trigger:** no project lead identified within 6 months • **Risk:** Difficulty finding proper workers for hybrid factory → **Mitigation:** targeted recruitment + short intensive training + incentives for workers → **Owner:** External HR consultant → **Trigger threshold:** inability to secure workforce within 2 – 3 months • **Risk:** Structural under-utilisation of factory production capacity due to insufficient or discontinuous renovation pipeline and geographical clustering. → **Mitigation:** advance aggregation of demand through multi-year framework agreements; alignment with public renovation programmes; conversion of production lines to new build or renovation. → **Owner:** Sales manager → **Trigger threshold**: confirmed renovation pipeline below minimum capacity utilisation threshold for 2 consecutive quarters. • **Risk**: Reduced operational flexibility due to rigid production layout and sequencing constraints → **Mitigation:** standardisation of interfaces; early locking of design and production batches; use of local finishing factories to absorb variability → **Owner:** DfMA Designer → **Trigger threshold:** repeated production interruptions or re-sequencing affecting more than one production line per week • **Risk**: Exposure to fluctuations in energy and raw material costs affecting operating margins and cost competitiveness → **Mitigation**: long-term energy contracts; on-site renewable generation where feasible; framework agreements for key materials; periodic cost pass-through clauses in programme contracts → **Owner:** Procurement department → **Trigger threshold**: sustained increase in energy or material costs exceeding financial contingency allowances.

	• **Risk:** Delays in windows/MEP/cladding supply and Just In Time logistics disruption → **Mitigation:** framework agreements with multiple SMEs + backup transport routes + daily coordination meetings → **Owner:** Panel flow Installation and supervisor → **Trigger:** component delivery slipping more than 2 weeks from plan • **Risk:** Disruptions during installation phase → **Mitigation:** phased quality checks, accurate intolerance management, daily coordination between main factory, local SMEs, and site teams, proper installers training → **Owner:** Quality & Process control officer → **Trigger threshold:** delays or failures in the installation of 2 panels.
Evidence / supporting material	

Table 104: R6 – Site Requirements and Logistics

ID / Category	R6 – Site Requirements and Logistics
Definition	Understanding the specific site-related details necessary for an effective operation of the pop-up factory. Includes assessing available space, infrastructure (e.g., access to roads, utilities and so on), in parallel with logistical challenges (e.g., materials transport and site access.
Question (s)	**Space requirements:** What space is required (m²) for: manufacture / assembly / storage / staging-loading? **Access constraints:** What access constraints apply? • vehicle type/size/weight limits (text or numbers) • delivery time windows (hours/days) • road restrictions / low-emission zone (LEZ) / permits needed (Y/N + name) • public space required (Y/N) **Utilities -** Provide: • power requirement (kW + single/three-phase) • water needed (Y/N + connection type or liters/day) • drain needed (Y/N + where it discharges) • internet needed (Y/N + minimum requirement if any) **Waste handling:** What waste streams occur and who is responsible for collection/disposal? **Provider responsibility:** Who provides/installs utilities and how long does it take? (entity + setup time) **Special items:** Are any of these required? (Y/N + details) • containers (#) • crane access (Y/N) • security/lockable room (Y/N)

	• fencing (Y/N)
Answer	1) **Main hybrid precast factory** **Space required (m²):** • **Assembly:** N/A (integrated into existing production lines) • **Storage:** Large storage yards (~20,000 m² for panels) • **Staging/loading:** Truck loading bays **Access constraints:** • **Vehicle type:** Heavy trucks (16–18 m, 32–40 tons) • **Type of road:** Industrial roads suitable for long vehicles • **Time windows:** Standard industrial delivery hours • **Road limits:** None beyond normal heavy-vehicle constraints • **Public space needed (Y/N):** No **Utilities:** • **Power:** Yes, high-capacity three-phase • **Water (Y/N):** Yes • **Drain (Y/N):** Yes • **Internet (Y/N):** Yes, fixed industrial connection **Waste streams + responsible party:** Very low waste due to optimized precast processes: steel scraps, formwork residues, washing water, all handled by the hybrid factory operator. **Who provides utilities/setup:** Long-term contracts with different suppliers. **Special items:** • **Containers:** No additional needed • **Crane (Y/N):** Yes, internal overhead cranes • **Security/lockable room (Y/N):** Yes • **Fencing (Y/N):** Yes 2) **Local Finishing Factories (existing SMEs)** **Space required (m²)** They must be integrated with respect to ordinary use, for the storage and assembly of components on panels coming from the main factories:

	• **Assembly:** up to 1000 m² (to integrate components simultaneously in 6 panels) • **Storage:** 80–100 m² (small buffer, JIT model) • **Staging/loading:** N/A The route from main factory to local SMEs till the building site reduces transport needs because the travel of each component integrator to the main factory is avoided. Indeed, the deviations to reach component integrators are much shorter, if they are properly selected. The satellite approach has only one additional risk: panels have to be handled on and off trucks multiple times and such phase is the most delicate one in terms of possible breaks, scratches, dents, or other damage. The most fragile components must be the last ones to be installed so to minimize such risk.
Evidence / supporting material	

Table 105: R7 – Sustainability Considerations

ID / Category	R7 – Sustainability Considerations
Definition	Exploring the strategies employed by the pop-up factory to minimize waste, optimize energy use, and integrate renewable or local materials. Also examining how the factory aligns with regional sustainability goals, such as decarbonization and circular economy practices.
Question (s)	**Top measures:** List max 3 sustainability measures planned (short bullets). **KPI selection:** Which 2–3 KPIs will you track? (tick): CO_2e / waste diverted / reuse rate / energy use (kWh) / water use / other (specify). **Targets:** For each chosen KPI, what is the target value (or "TBD")? **Reuse scope** (if applicable): Which materials/components are reused (top 3) and what acceptance criteria/certification applies? **Energy approach:** What is the renewable energy approach? (on-site / green purchase / mix) and target % renewable. **Logistics decarbonization:** What is the approach (routing, consolidation, low-emission vehicles) and what logistics KPI will be tracked (km/CO_2e/other)?

Answer	**Main sustainability measures (max 3):** 1. **Process optimisation & waste minimisation** through automated batching plant, reusable formworks, and recycling of washing water in concrete production. 2. **High renewable energy use** combined with energy-efficient machinery and digitalised production processes. 3. **Material-specific sustainability compliance**, including low-impact binders, recycled aggregates, and standardised prefabrication processes that reduce offcuts and rework. **KPI tracking (choose 2–3):** ☒ CO_2e ☒ waste diverted ☐ reuse rate ☒ energy use ☐ water use ☐ other **CO_2e:** −20% logistics-related CO_2e per building (vs traditional factories' models) **Waste diverted:** ≥15% of packaging/pallets/concrete scraps **Energy use:** −10% kWh per m² of panel produced **Materials reuse scope (if applicable):** Not applicable **Energy approach:** **Mix:** on-site photovoltaic at hybrid plants **+** green power purchase to cover remaining demand + selection of local SMEs according to their renewable energy share; **target ≥60% renewable share** of total electricity used by involved factories. **Logistics decarbonization approach:** Routing optimisation and consolidation of deliveries within the ≤100 km logistics envelope; use of low-emission vehicles for urban segments; sequencing and bundling of JIT flows to minimise empty runs. **Logistics KPI tracked:** CO_2e per tonne-km delivered and number of consolidated deliveries per building.
Evidence / supporting material	

Table 106: R8 – Scalability and Adaptability

ID / Category	R8 – Scalability and Adaptability

Definition	Evaluating the factory model's ability to scale and adapt to different regions, project types, or production needs. It identifies barriers to scaling and the necessary adjustments for broader implementation while ensuring flexibility for diverse applications.
Question (s)	**Scaling approach:** Choose the scaling approach (tick): replicate sites / increase capacity at one site / multi-site coordination / other (specify). **Scalability thresholds:** Provide numerical thresholds (write "N/A" if not applicable): • max distance (km) • max storage duration (days) • max volume (units/week or m²/week) • other limiting metric (e.g., district size: #dwellings or renovation volume) **Adaptability mechanism:** How is adaptability achieved? (choose): standardized process / modular equipment / digital tools / other (specify). **Digital tools:** Which tools/software are used (names) OR list required features (documentation/sales/stock control). **Coordination owner:** Who coordinates replication/multi-site planning (name/role/entity)?
Answer	**Scaling approach:** ☒ replicate sites (if more capacity of the main factory is needed) ☐ increase capacity at one site ☒ multi-site coordination (more partnerships with local SMEs for components integration) ☐ **other**: - **Scalability limits/thresholds (numbers):** • distance: **100 km** (max distance for panel transport, from main factory to building site, including deviations for components integration) • storage duration: **1–3 days** (Just In Time limit given by local SMEs which keep minimal buffers) - volume: maximum capacity of **80.000 m² /year for retrofit panels**, 85.000 m²/year for new built external walls and 40.000 m²/year for new built slabs. Over these quantities a new factory, an extra line or and additional shift is needed. **Adaptability mechanism:** Main hybrid factory can be converted into other needs easily. Indeed, concrete production (with standardized processes in the first workstations and modular equipment in the following ones) is quite flexibility and with few adaptations the plant can produce any precast elements (for infrastructures or tertiary and industrial buildings). **Digital tools used:** • **BIM / Common Data Environment (CDE)** for design freeze and interface control • **WMS** (Manufacturing & Warehouse Management) for panel sequencing and micro-stock

	• **TMS (Transportation Management System) / delivery scheduler** for Just In Time routing and time-window slots (≤100 km) • **CNC machines** perform precise automated cutting, drilling, and shaping of panel elements to ensure high-accuracy, repeatable production in offsite manufacturing. **Coordination owner:** Opening new factories or enlarging the existing scope is decided by the Business developer of the main hybrid factories. Then, multiple other roles are needed to put the operation in place. If SPV model, a consultation among all shareholders is required.
Evidence / supporting material	

The Spanish Ecosystem

Table 107: R0 – Scenario and Strategy

ID / Category	R0 – Scenario and Strategy
Definition	The PuF scenario requires a clear scenario definition and strategy to achieve a shared implementation direction
Question (s)	Please complete the fields in the answer schema below.
Answer	**PuF Type**: Assembly Factory **PuF Purpose**: Assembles pre-fabricated components locally **Deep Renovation Scope:** • **Renovation areas addressed (tick multiple if necessary):** ☒ façade / envelope (insulation; cladding) ☒ windows/doors replacement ☒ roof insulation / roof refurbishment ☒ floor / basement insulation ☐ ventilation (balanced/mechanical) ☐ HVAC / heating system upgrade ☐ renewable energy (PV / solar thermal) ☒ electrical / controls / smart systems ☐ interior modules (bathroom/kitchen pods) ☐ other: [ ] • **Package level (choose):** ☐ single-measure ☐ multi-measure bundle ☒ whole-building deep retrofit • **Interfaces with site works (1–2 lines):** **Target Renovation Building Typology**: Public building, heritage buildings **Main Materials Processed and Produced**: timber beams recovered from the construction site to produce and complete the particular joints of the CLT that has been received 1) Reused timber beams 2) New timber beams **Production Capacity (e.g., units/week; m2/day; dwellings/month or other):** 52,5 m²/day and 159,65 €/m **Best-fit conditions (context triggers):** Deep renovation with limited on-site space, urban constrains and reuse target. Heritage buildings.
Evidence / supporting material	

Table 108: R1 – Partnerships and Stakeholders

ID / Category	R1 – Partnerships and Stakeholders
Definition	Identifying the key stakeholders involved in the pilot projects, including demand-side partners (housing companies, governments) and supply-side (local SMEs, contractors).
Question (s)	Demand-side partners: ○ Who are the key stakeholders (e.g., housing companies, local governments) currently involved in the pilot project? ○ What additional partnerships are needed to move forward? Supply-side partners: ○ Which local SMEs, manufacturers, or constructors can support the factory? ○ Are there any collaboration gaps on the supply-side?
Answer	**Client / contracting authority:** Privat companies and public bodies **Who signs contracts:** Constructor **Who pays:** Client **Decision-maker / governance lead:** Construction manager **Demand-side partners (name + role):** • **Name**: Private company; **Role**: Architect • **Name**: Public body; **Role**: Client **Supply-side partners (name + role):** • **Name**: Technology provider; **Role**: Demolish • **Name**: Technology provider; **Role**: Logistic, transport • **Name**: Technology provider; **Role**: Carpenter • **Name**: Construction worker; **Role**: measure, cut • **Name**: Local installers; **Role**: Assembly elements **Missing roles/trades needed (tick):** ☒ electrician ☒ HVAC ☐ façade/insulation ☐ logistics/transport ☒ crane ☒ QA/QC ☒ O&M ☐ other: [ ]
Evidence / supporting material	

Table 109: R2 – Legal and Regulatory Requirements

ID / Category	R2 – Legal and Regulatory Requirements
Definition	Legal and policy-related factors influencing pop-up factory implementation, such as local regulations, permits, and compliance standards, and opportunities for leveraging government incentives or subsidies.
Question (s)	What specific permits or licenses are required for setting up the pop up factory in your region, *considering factors such as space, noise levels, and environmental compliance?*

	Are there government incentives or subsidies that can support the implementation of the pop-up factory?
Answer	**Permits and compliance items:** **For each permit/compliance item:** • Permit/requirement: Sustainaiblity requirement • Issuing authority: Nacional technical building code • Lead time: [weeks/months] 1-2 • Key constraints/conditions: Heritage and energetical requirement balance **For each permit/compliance item:** • Permit/requirement: Local standards • Issuing authority: Regional government • Lead time: [weeks/months] 1-2 • Key constraints/conditions: Heritage and lightning **For each permit/compliance item:** • Permit/requirement: Available space on site • Issuing authority: Local government • Key constraints/conditions: Leak of space and surrounding houses • Responsible applicant: construction manager **For each permit/compliance item:** • Permit/requirement: Possibility of using public space • Issuing authority: Local government • Key constraints/conditions: residents, dust and noise **For each permit/compliance item:** • Permit/requirement: Health and safety • Issuing authority: Local government • Key constraints/conditions: Noise, safety and available space • Responsible applicant: [Name/role] construction manager **Incentives/subsidies (if any):** • Instrument name: Next generation • Who applies: Local government • Eligibility/key condition: Integral refurbishment • Expected value: [€ or %] Not available information • Timing/deadline: Not available information
Evidence / supporting material	

Table 110: R3 – Costs and Financing Plans

ID / Category	R3 – Costs and Financing Plans
Definition	Evaluating the financial feasibility of each pilot project, focusing on capital and operational expenses, available financing options, also consider the possibility of subsidies.
Question (s)	What are the estimated costs for setting up and operating the pop-up factory, including infrastructure, equipment, and workforce? **CAPEX range (€):** What is the CAPEX range (min–max €) and what is included? (1 line) **OPEX/month (€):** What is the OPEX range per month (min–max €) and what is included? (1 line) **Cost basis:** If you use €/m², what is the basis? (façade / GFA / net / other) **€/m² value:** What is the €/m² value (if used) and what does it include? **Revenue:** Is there a revenue stream? (Y/N). If yes: amount (€/month or €/project), source (reuse sales / service fee / other). **Financing model:** Which financing model applies (tick): grant / loan / equity / ESCO / PPP / other (specify). **Loan parameters** (if loan): Interest rate (%), duration (years), amount (€). (ranges OK) **Equity/SPV parameters** (if equity/SPV): Who invests, share split (%), payback logic (dividend/profit share/service fee), who controls (majority holder).
Answer	**CAPEX (€):** not proceding **OPEX (€ / month):** not proceding, we work through subconstrators **Cost basis (if €/m² used**): 27 €/m^2 (CLT panels) **€/m² value:** [ ] (what included: [ ]) **Revenue assumptions (if any):** none **Financing model (tick**): ☐ grant ☐ loan ☒ equity ☐ ESCO ☐ PPP ☐ other: [ ] **If loan:** interest [%] | duration [years] | amount [€] **If equity/SPV:** investor(s)100%| share split [%] | payback logic [ ] **Payment/contracting chain (one line):** (Client → Architects→ Client → Grant → Permission→ Constructor → Construction → New building)
Evidence / supporting material	

Table 111: R4 –Time Schedules

ID / Category	R4 – Time Schedules
Definition	Assessing the timeline for establishing and operating the pop-up factory. Includes: identifying potential delays, dependencies, and life-cycle considerations (such as the duration of operations and decommissioning plans).
Question (s)	What is the estimated timeline for the PuF lifecycle for this scenario (setup → operate → decommission, if temporary)? Please provide durations (weeks/months) or target dates for: setup/installation, start of operations (go-live), typical operating period per site/project, and wrap-up/decommissioning (pack-down + site restoration). Are there external constrain that could affect the time schedule (e.g., regulatory approvals, material availability, workforce training)?
Answer	**Setup duration:** ~1–2 months **Operations duration on site / per project**: 24 month **Wrap-up / decommissioning duration**: 4 months **Milestones (estimated lead times in weeks or months)**: • Funding secured: Not available information • Permits approved: 6 months • Design freeze: Once the construction begins • Procurement complete: 28 months • Start operations: 0 month **Top 5 dependencies**: • Public permits are a great source of time uncertainty. Access permission, connection to energetical resources, demolish permission & building permission • Heritage building definitions, identification and classifications of historical elements that need to be afterwards re-built as original • Lack of design definitions (there is not definition of the construction site) availability and possibility of using public space
Evidence / supporting material	

Table 112: R5 – Risks and Contingency Plans

ID / Category	R5 – Risks and Contingency Plans
Definition	Identifying potential risks (e.g., financial, logistical, regulatory) and existing contingency plans to mitigate the risks identified. By addressing challenges in establishing, operating, and scaling the pop-up factory we can improve the stability of its timeline/life-cycle.

Question (s)	What are the key risks affecting the implementation of the pop-up factory, logistics, workforce capacity, material availability, regulatory delays)? What contingency plans are in place to mitigate these risks?
Answer	Provide up to 5 lines: • **Risk:** Unclear requirements → **Mitigation:** Working with a familiar worker • **Risk:** Providers' capabilities → **Mitigation:** Planification • **Risk:** Raw material shortage → **Mitigation:** Storage → **Owner:** Available space → **Trigger threshold:** Planification • **Risk:** Temporary regulations due to political priorities → **Mitigation:** Alternative workflows • **Risk:** Insufficient availability of skilled workers for assembling prefabricated components may delay operations → **Mitigation:** Planification
Evidence / supporting material	

Table 113: R6 – Site Requirements and Logistics

ID / Category	R6 – Site Requirements and Logistics
Definition	Understanding the specific site-related details necessary for an effective operation of the pop-up factory. Includes assessing available space, infrastructure (e.g., access to roads, utilities and so on), in parallel with logistical challenges (e.g., materials transport and site access.
Question (s)	**Space requirements:** What space is required (m²) for: manufacture / assembly / storage / staging-loading? **Access constraints:** What access constraints apply? • vehicle type/size/weight limits (text or numbers) • delivery time windows (hours/days) • road restrictions / low-emission zone (LEZ) / permits needed (Y/N + name) • public space required (Y/N) **Utilities -** Provide: • power requirement (kW + single/three-phase) • water needed (Y/N + connection type or liters/day) • drain needed (Y/N + where it discharges) • internet needed (Y/N + minimum requirement if any) **Waste handling:** What waste streams occur and who is responsible for collection/disposal? **Provider responsibility:** Who provides/installs utilities and how long does it take? (entity + setup time) **Special items:** Are any of these required? (Y/N + details) • containers (#) • crane access (Y/N)

	• security/lockable room (Y/N) • fencing (Y/N)
Answer	**Space required (m²):** • Assembly 130 • Storage 223m2 • Staging/loading crane **Access constraints:** • vehicle type: trucks, cars… • time windows: 9:00-16:00 • road limits: access restriction, high and width • public space needed Y **Utilities**: • Power [kW + phase] >35 • Water (Y/N) Y • Drain (Y/N) Y • Internet (Y/N) Y **Waste streams + responsible party**: construction manager **Who provides utilities/setup**: Construction manager **Special items (if any)**: • containers [#] 4 • crane needed (Y/N) Y • security (lockable room) (Y/N) Y
Evidence / supporting material	

Table 114: R7 – Sustainability Considerations

ID / Category	R7 – Sustainability Considerations
Definition	Exploring the strategies employed by the pop-up factory to minimize waste, optimize energy use, and integrate renewable or local materials. Also examining how the factory aligns with regional sustainability goals, such as decarbonization and circular economy practices.
Question (s)	**Top measures:** List max 3 sustainability measures planned (short bullets). **KPI selection:** Which 2–3 KPIs will you track? (tick): CO_2e / waste diverted / reuse rate / energy use (kWh) / water use / other (specify). **Targets:** For each chosen KPI, what is the target value (or "TBD")? **Reuse scope** (if applicable): Which materials/components are reused (top 3) and what acceptance criteria/certification applies? **Energy approach:** What is the renewable energy approach? (on-site / green purchase / mix) and target % renewable.

	Logistics decarbonization: What is the approach (routing, consolidation, low-emission vehicles) and what logistics KPI will be tracked (km/CO_2e/other)?
Answer	**Main sustainability measures (max 3):** 14. Possibility of materials re-use, WOOD 15. Logistics **KPI tracking (choose 2–3):** ☐ CO_2e ☐ waste diverted ☒ reuse rate ☐ energy use ☐ water use ☐ other: **KPIs target values (if known): -** **Materials reuse scope (if applicable):** (which products/components; acceptance criteria/certification) Technical evaluation, there is not a certification **Energy approach:** **Logistics decarbonization approach:**
Evidence / supporting material	

Table 115: R8 – Scalability and Adaptability

ID / Category	R8 – Scalability and Adaptability
Definition	Evaluating the factory model's ability to scale and adapt to different regions, project types, or production needs. It identifies barriers to scaling and the necessary adjustments for broader implementation while ensuring flexibility for diverse applications.
Question (s)	**Scaling approach:** Choose the scaling approach (tick): replicate sites / increase capacity at one site / multi-site coordination / other (specify). **Scalability thresholds:** Provide numerical thresholds (write "N/A" if not applicable): • max distance (km) • max storage duration (days) • max volume (units/week or m²/week) • other limiting metric (e.g., district size: #dwellings or renovation volume) **Adaptability mechanism:** How is adaptability achieved? (choose): standardized process / modular equipment / digital tools / other (specify). **Digital tools:** Which tools/software are used (names) OR list required features (documentation/sales/stock control). **Coordination owner:** Who coordinates replication/multi-site planning (name/role/entity)?

Answer	**Scaling approach:** ☒ replicate sites ☐ increase capacity at one site ☐ multi-site coordination ☒ **other**: Technical evaluation, there is not a certification **Scalability limit/threshold (numbers):** • allocated space: 130 m2 • storage duration [days] 1 • volume [units/week] 200 m2/day **Adaptability mechanism:** standardized process / modular equipment / digital tools / **Digital tools used (names or required features):** Autodesk Revit
Evidence / supporting material	

Appendix X

The Dutch Ecosystem Feasibility Report

Use this template to assess whether the selected PuF concept can be implemented in the chosen remote location. Keep inputs concise and evidence-based; put details in the Annex and reference them in the tables.

Document Information

Version:	Final	
Date:	27.05.2026	
Organization Name:	ZUYD	
Prepared by:	B. Andaloro (ZUYD)	

10.1.1. Context and Scope

General

Field	Partner input
Location name (city/region/country)	Van Heemskerckflat, Groningen (the Netherlands)
Coordinates / map reference	53.212683383824256 N, 6.546702001529453 E
Pop-up Factory (PuF) type (e.g., Mobile / Satellite / District / Assembly)	District Factory
Building typology / pilot context	Renovation and partial expansion of the student residential building 'van Heemskerckflat'. This project serves also as a pilot case within a funded research project called "InCube".
Target renovation product/package	Main interventions: 1. **Deep Stripping:** The building is stripped down to its bare concrete structure. 2. **Structural Expansion:** New foundations are laid to expand the building outward by approximately 2 meters using a light steel substructure. 3. **Additional top floor**: While the original building had a partial structure on top of the roof (referred to as a 9th floor), the renovation utilizes the entire roof area to add a full additional floor to the building 4. **Prefabricated facade:** The envelope is closed using prefabricated wooden framing and facade elements.

	5. **Bathroom Units:** Fully prefabricated "pods" containing a toilet, shower, and sink are installed and connected to utilities on-site. 6. **In-situ Finishing:** Traditional metal stud walls, plastering, painting, and floor leveling are performed inside the expanded structure Specifically, the works on the windows include: • Integrated solar panels (PV) for energy generation. • Bio-based (wood fiber) insulation material. • A "plug and play" installation system designed to follow the existing building structure
Target volume (units/week, m²/month, # renovations/month, etc.)	• Inner apartments: 10 units/day • Window/Façade delivery: 12 elements/day for "just in time" delivery to minimize on-site storage. • Installation Speed: A crew of four people installed the entire façade structure in two to three weeks. • Unit Scale: Each façade element generally covers two apartments
Feasibility Assessment Period (start-end)	The renovation of the project Heemskerckflat (InCUBE pilot) was originally estimated to take approximately 15 to 18 months. While the works were supposed to end in June 2026, the project has been granted a 12-month extension because several partners have not yet completed their contributions. As a result, the actual completion is now projected for mid-2027 Length of façade/windows works: May-october 2025.
Key local partners involved in the feasibility study (owner, municipality, utilities, unions, building owner, etc.)	**Partners involved in the feasibility study:** • Main Contractor: van Wijnen; • Window/Facade constructors and suppliers: WEBO/VRONT • Research unit: ZUYD University of Applied Science **Other partners/stakeholders of the project:**

	• Client and building owner: Housing Association Lefier • Lead Contractor: Van Wijnen (specifically the North East region and Groningen office) • Municipality: Municipality of Groningen, which provided permits and mandated specific aesthetic requirements, such as the placement of the main entrance. • Innovation/Research: New Energy Coalition, which helped establish the building as a "demo site" for European innovation research. • Advisors: A team including the architect, structural engineers (handling structural integrity), and biophysical advisors (focused on sound, moisture, and temperature). • Sub-contractors: Local companies from the provinces of Groningen, Drenthe, and Friesland are prioritized to ensure a shared understanding of the workflow. • Specialized Suppliers: Portisa (prefabricated bathrooms from near Rotterdam) and WEBO/ VRONT®, Responsible for engineering, producing, and installing the façade elements (production and construction). • AAS: The external architectural firm hired for the design. • Warringtonfire: Conducted necessary fire duration and resistance tests for the new façade system. Saint-Gobain Construction Products Nederland, for production of the energy-generating façade system mockup

Remote definition

Define what "remote" means for this location using tick boxes and -if possible- quantified constraints (e.g., km, hours, reliability, limits).

Field	Partner input

Remote classification (tick one)	☐ Island ☐ Mountain/valley ☐ Rural/low-connectivity ☒ Hard-to-access urban ☐ Other: low connectivity
Distance/time to nearest logistics hub (port/rail/highway)	Groningen is a relatively peripheral regional market compared with the central Dutch renovation ecosystem, although it is practically accessible. _(not relevant)___ km
Access constraints (tick all that apply)	☐ ferry schedule limits ☐ seasonal closures ☒ narrow roads ☐ weight limits ☐ urban time windows ☒ crane restrictions ☐ other: _____
Utilities reliability (tick)	☐ power unstable ☐ water limited ☐ drainage limited ☐ internet weak ☒ none
Local supply chain constraint (tick one)	☒ long lead times ☐ limited suppliers ☐ high transport cost ☒ limited skilled labour ☐ other: _____
Local regulatory sensitivity (tick all)	☐ protected area ☐ heritage ☒ noise/working hours strict ☐ public space constraints ☒ other: seismic area

Additional text and materials

Use this section only for essential context (e.g., a short narrative, key map/photo) needed to understand the pilot.

The Heemskerckflat renovation in Groningen is here considered as an interesting and critical case for understanding and assessing the feasibility of the Pop-up Factory model within the Dutch construction ecosystem, specifically examining the district-level/assembly scenarios. This study explores the viability of establishing such industrialized production hubs in various regions, including the peripheral areas like Groningen, to demonstrate that high-tech renovation methods can be effectively decentralized. It is relevant to note that this project is originally developed as a pilot case within the broader InCUBE research project, an EU-funded initiative (Grant no. 101069610) focused on demonstrating sustainable and scalable industrialized renovation strategies across Europe.

The Dutch city of Groningen is categorized as a remote area within this feasibility study because its significant geographic distance from the Randstad (Amsterdam-Rotterdam-Utrecht area, and the Netherlands' primary economic and industrial hub) results in a lack of local, highly specialized manufacturers and limited availability of complex components.

While the city is well-connected by highways and the country's small scale makes transport costs manageable, the site's relative isolation from high-tech industrial centers allows to explore how to successfully deploy innovative construction "trains" using a mix of traditional local labour and specialized external components.



Figure 163: Localisation of Groningen on the map of the Netherlands

The physical works on the building involved stripping the 1966 structure down to its bare concrete core and installing a new foundation to support a lightweight steel substructure. This expansion allowed the building to gain approximately two meters of floor space per unit and the addition of an entirely new top floor. The renovation utilized high-performance prefabricated components, including facade modules with integrated insulation and solar energy (BIPV), as well as fully finished bathroom pods containing a toilet, shower, and sink. Internal finishing was completed using metal stud walls and specialized materials to level out significant deviations in the original concrete floors.


Figure 164: Aerial view of the city of Groningen and localisation (in red) of the site of the project

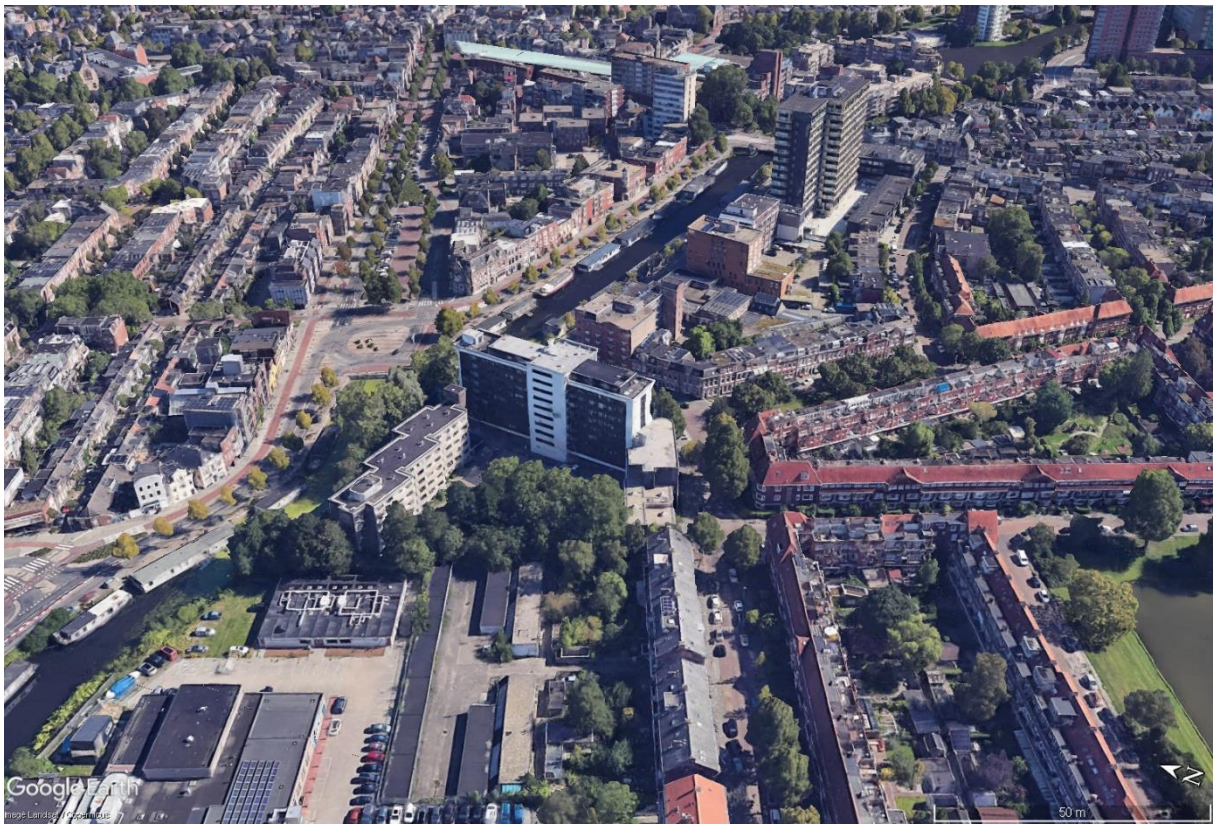


Figure 165: Aerial view of the building

10.1.2. Part A: Requirement Collection

*Answer each requirement for the **new remote location** (not your original pilot site). Each requirement includes the following fields: **ID**, **Definition**, **Guiding Questions**, **Answer**, and **Evidence /Supporting Material**. For the **Answer** field, we have already created a **structured schema**. We expect your answers in the structured schema we provided.).*

*For the **Evidence / Supporting Material** field, please include any relevant **diagrams, tables, figures, photos, or other materials** that support or clarify your answers. Additionally -and most importantly- if you are unable to provide the required data, please use this field to explain the reason and limitation and the assumptions you made to complete this feasibility study.* This will enable us to clearly communicate the limitations in the **WP4 conclusions** for each PuF.

Table 116: R0 – Scenario and Strategy (Dutch Feasibility Study)

ID / Category	R0 – Scenario and Strategy
Definition	The PuF scenario requires a clear scenario definition and strategy to achieve a shared implementation direction
Question (s)	Please complete the fields in the answer schema below.

Answer	**PuF Type**: District Factory **PuF Purpose**: Assembles pre-fabricated components locally **Deep Renovation Scope:** • **Renovation areas addressed (tick multiple if necessary):** ☒ façade / envelope (insulation; cladding) ☒ windows/doors replacement ☐ roof insulation / roof refurbishment ☐ floor / basement insulation ☐ ventilation (balanced/mechanical) ☐ HVAC / heating system upgrade ☒ renewable energy (PV / solar thermal) ☐ electrical / controls / smart systems ☒ interior modules (bathroom/kitchen pods) ☐ other: [structure enlargement and floor addition] • **Package level (choose):** ☐ single-measure ☐ multi-measure bundle ☒ whole-building deep retrofit • **Interfaces with site works (1–2 lines):** finishing activities must be done on-site; initial works needs to be done on-site, as they include stripping the whole facade and structure, as well as new (parts of) foundation. **Target Renovation Building Typology**: High-rise apartment buildings from the year 1966. Heemskerckflat is a residential building originally designed for families and currently utilized as student housing. **Main Materials Processed and Produced**: The renovation process centers on stripping the building down to its bare concrete structural core, which is then preserved and reused as the primary framework for the project. To facilitate a two-meter exterior expansion and the addition of a new top floor, a lightweight steel substructure is mounted onto the original 1960s building. The project extensively utilizes high-performance prefabricated components, specifically facade modules integrated with contemporary insulation and building-integrated photovoltaics (BIPV), as well as fully finished bathroom pods containing a toilet, shower, and sink. Internal spaces are finalized with in-situ materials, including metal stud walls, prefabricated wooden framing used as floor filler, and leveling compounds to correct significant deviations in the original concrete floors. Finally, circularity is supported through the reuse of internal doors, which are salvaged during the initial demolition phase and reinstalled one-to-one within the renovated units. **Production Capacity (e.g., units/week; m2/day; dwellings/month or other):** Original plan included 10 apartment/day, with a general plan of renovating the whole

	building in 15 to 18 months. Eventually, a 12 months extension has been granted.
Evidence / supporting material	Interview with Video from van Wijnen: https://www.youtube.com/watch?v=HklVq4qWJ_A&t=18s

Table 117: R1 – Partnerships and Stakeholders (Dutch Feasibility Study)

ID / Category	R1 – Partnerships and Stakeholders
Definition	Identifying the key stakeholders involved in the pilot projects, including demand-side partners (housing companies, governments) and supply-side (local SMEs, contractors).
Question (s)	Demand-side partners: ○ Who are the key stakeholders (e.g., housing companies, local governments) currently involved in the pilot project? ○ What additional partnerships are needed to move forward? Supply-side partners: ○ Which local SMEs, manufacturers, or constructors can support the factory? ○ Are there any collaboration gaps on the supply-side?
Answer	**Client / contracting authority:** Lefier (Housing Association) who is the building owner and renovation commissioner **Who signs contracts:** Lefier and van Wijnen (main contractor) **Who pays:** Lefier + Europen grant from Horizon 2020 project **Decision-maker / governance lead:** Primarily Lefier as the owner, supported by Van Wijnen for execution management; the Municipality of Groningen also acts as a key decision-maker regarding regulatory compliance and aesthetic urban planning **Demand-side partners (name + role):** • Name: Lefier; Role: Housing Association, building owner, and primary client. • Name: Municipality of Groningen; Role: Regulator and urban planner responsible for permits and neighborhood integration. • Name: European Union (CINEA); Role: High-level stakeholder providing grant funding for research and innovation. • Name: New Energy Coalition; Role: Innovation partner that facilitated the selection of the demo site within the project InCube. **Supply-side partners (name + role):**

	• Name: Van Wijnen (North East region/Groningen); Role: Lead Contractor responsible for site management, preparation, and the industrialized "train" sequence. • Name: Local Sub-contractors; Role: Specialized partners from Groningen, Drenthe, and Friesland handling steel structures, foundations, facades, and interior finishing. • Name: WEBO/VRONT; Role: Specialized production company involved in component manufacturing. • Name: Portisa; Role: Specialized supplier near Rotterdam providing prefabricated bathroom "pods". • Name: Advisory Team; Role: Professionals including architects, structural engineers, and biophysical advisors (sound, moisture, temperature). **Missing roles/trades needed (tick):** ☐ electrician ☐ HVAC ☐ façade/insulation ☐ logistics/transport ☐ crane ☐ QA/QC ☐ O&M ☐ other: [ ]
Evidence / supporting material	Interview to van Wijnen Interview to WEBO/VRONT Project documentation Specific websites of involved parties: InCube: https://incubeproject.eu/about-groningen/ Van Wijnen: https://www.vanwijnen.nl/projecten/horizon-project-incube WEBO: https://www.webo.nl/projecten/van-heemskerckflat-groningen/

Table 118: R2 – Legal and Regulatory Requirements (Dutch Feasibility Study)

ID / Category	R2 – Legal and Regulatory Requirements
Definition	Legal and policy-related factors influencing pop-up factory implementation, such as local regulations, permits, and compliance standards, and opportunities for leveraging government incentives or subsidies.
Question (s)	What specific permits or licenses are required for setting up the pop up factory in your region, *considering factors such as space, noise levels, and environmental compliance?* Are there government incentives or subsidies that can support the implementation of the pop-up factory?
Answer	**Permit/requirement:** Standard Construction Permit (omgevingsvergunning) • **Issuing authority:** Municipality of Groningen • **Lead time:** around 10 weeks but it varies based on the complexity of the project • **Key constraints/conditions:** Must authorize the technical aspects of the work, specifically structural integrity and aesthetics • **Responsible applicant:** The Architect/design firm (after finishing the final design) on behalf of the owner, Lefier

- **Insurance/liability holder (if relevant):** Lefier (Building Owner/Client)

Permit/requirement: Zoning/Systemic Plan Compliance (bestemmingsplan)

- **Issuing authority:** Municipality of Groningen
- **Lead time:** not specified but no relevant changes were requested to avoid long time wait
- **Key constraints/conditions:** The renovation, including the additional top floor and building footprint expansion, must remain within the limitations of the existing height and density rules
- **Responsible applicant:** Architect and Van Wijnen team during the collaborative design phase

Permit/requirement: Municipal Aesthetic Demands / Approval

- **Issuing authority:** Municipality of Groningen
- **Lead time:** Integrated into the standard design and permit application period
- **Key constraints/conditions:** Mandate to move the main entrance from the back to the front of the building to align with future neighborhood redevelopment
- **Responsible applicant:** Architect and Van Wijnen team

Permit/requirement: National Building Regulations (Bouwbesluit)

- **Issuing authority:** National/Municipal regulatory bodies
- **Lead time:** Continuous compliance throughout the project lifecycle
- **Key constraints/conditions:** Compliance with modern safety and health standards; utilizes "rechtens verkregen niveau" (legal room to deviate) for 1960s buildings, specifically allowing ceiling heights of 2.40m instead of the current 2.60m standard
- **Responsible applicant:** Van Wijnen (Work Preparation and Technical Design departments)
- **Insurance/liability holder (if relevant):** Van Wijnen (Lead Contractor)

Permit/requirement: Environmental/Safety Clearances (Asbestos)

- **Issuing authority:** Relevant environmental/safety inspectorate
- **Lead time:** Must be completed during the demolition phase before the "building up" phase can begin
- **Key constraints/conditions:** Requirement for complete asbestos removal from old installations, specifically gas boilers and ventilation (shunt) channels
- **Responsible applicant:** Van Wijnen as the specialized demolition party

	• **Insurance/liability holder (if relevant):** Van Wijnen (Lead Contractor) **Incentives/subsidies (if any):** • **Instrument name:** European Union Funding (Specifically Horizon Europe, Grant Agreement no. 101069610, under the call HORIZON-CL5-2021-D4-01 • **Who applies:** A consortium of partners, including housing associations like Lefier, lead contractors such as Van Wijnen, and innovation facilitators like the New Energy Coalition • **Eligibility/key condition:** The project must serve as a demo site for an innovation and research project focused on the industrialized renovation of aging (1960s and 70s) apartment buildings. Key conditions include demonstrating cost-effective and sustainable modernization that contributes to the EU Building Renovation Wave • **Expected value:** N/A **Timing/deadline:** up until mid 2026, but partners received a 12 months extension until mid 2027 for project completion.
Evidence / supporting material	• Omgevingsvergunning / Environmental & Construction Permit — https://omgevingsloket.overheid.nl (omgevingsloket.overheid.nl) (National portal for checking, applying, and viewing rules; used by Municipality of Groningen) • Bestemmingsplan / Zoning & Land-Use Plan — https://omgevingsloket.overheid.nl/regels-op-de-kaart (omgevingsloket.overheid.nl) (Official zoning rules viewer under the Omgevingswet) • Welstand / Municipal Aesthetic Requirements — https://www.groningen.nl/bouwen-en-verbouwen (groningen.nl) (Municipality of Groningen – aesthetic policy, welstandsnota, and design requirements) • Bouwbesluit / Besluit Bouwwerken Leefomgeving (Bbl) — https://wetten.overheid.nl/BWBR0040692 (wetten.overheid.nl) (Official legal text of the national building regulations) • Asbestos Regulations / Asbestregelgeving — https://www.nlarbeidsinspectie.nl/onderwerpen/asbest (nlarbeidsinspectie.nl) (Nederlandse Arbeidsinspectie – asbestos inventory, removal rules, certification requirements)

Table 119: R3 – Costs and Financing Plans (Dutch Feasibility Study)

ID / Category	R3 – Costs and Financing Plans

Definition	Evaluating the financial feasibility of each pilot project, focusing on capital and operational expenses, available financing options, also consider the possibility of subsidies.
Question (s)	What are the estimated costs for setting up and operating the pop-up factory, including infrastructure, equipment, and workforce? **CAPEX range (€):** What is the CAPEX range (min–max €) and what is included? (1 line) **OPEX/month (€):** What is the OPEX range per month (min–max €) and what is included? (1 line) **Cost basis:** If you use €/m², what is the basis? (façade / GFA / net / other) **€/m² value:** What is the €/m² value (if used) and what does it include? **Revenue:** Is there a revenue stream? (Y/N). If yes: amount (€/month or €/project), source (reuse sales / service fee / other). **Financing model:** Which financing model applies (tick): grant / loan / equity / ESCO / PPP / other (specify). **Loan parameters** (if loan): Interest rate (%), duration (years), amount (€). (ranges OK) **Equity/SPV parameters** (if equity/SPV): Who invests, share split (%), payback logic (dividend/profit share/service fee), who controls (majority holder).
Answer	**CAPEX (Capital Expenditure) range (€)** — What is the CAPEX range (min–max €) and what is included? (1 line) Lefier has reserved €12.5 million to renovate one of these buildings, with the majority (€9.7 million) going towards energy-saving changes. **OPEX/month (€)** — What is the OPEX range per month (min–max €) and what is included? (1 line) No partners have wanted to shared this information **Cost basis** — If you use €/m², what is the basis? (façade / GFA / net / other) No other information is available. Other info: • Façade element: complete wall element, including solar panels, is approximately €550/m², with a range of €300-600. **€/m² value** — What is the €/m² value (if used) and what does it include? Based on the project parameters, the estimated costs for the demo site are as follows: • Total Investment Value: With a budget of €12.5 million for a total floor area of 9,800 square meters, the total renovation cost is approximately €1,275.51 per m².

	• Energy-Specific Value: The energy-saving portion of the budget (€9.7 million) accounts for approximately €989.80 per m² **Revenue** — Is there a revenue stream? (Y/N). If yes: amount (€/month or €/project), source (reuse sales / service fee / other). For the housing association (Lefier), the revenue source is the rent from the 265+ students who occupy the building. Furthermore, the project is described as having a difficult return on investment (ROI) and is considered a "prestige project" to prove technical feasibility rather than a high-profit commercial venture. For the sub-contractor there is a revenue stream from selling their services/products. **Financing model** — Which financing model applies (tick): grant / loan / equity / ESCO / PPP / other (specify). General financial model is Equity, as main owner Housing Association defined a budget of €12.5 million for the whole project. The pilot was made financially viable primarily through grants from the "InCube" Horizon project. **Loan parameters** (if loan) — Interest rate (%), duration (years), amount (€). (ranges OK) // **Equity/SPV parameters** (if equity/SPV) — Who invests, share split (%), payback logic (dividend/profit share/service fee), who controls (majority holder). General financial model is Equity, as main owner Housing Association defined a budget of €12.5 million for the whole project. **Payment/contracting chain (one line):** HA Lefier → architect HA Lefier / EU grant → van Wijnen (main contractor) → sub-contractors (=> certificators) → Lefier for revenue
Evidence / supporting material	

Table 120: R4 –Time Schedules (Dutch Feasibility Study)

ID / Category	R4 – Time Schedules
Definition	Assessing the timeline for establishing and operating the pop-up factory. Includes: identifying potential delays, dependencies, and

	life-cycle considerations (such as the duration of operations and decommissioning plans).
Question (s)	What is the estimated timeline for the PuF lifecycle for this scenario (setup → operate → decommission, if temporary)? Please provide durations (weeks/months) or target dates for: setup/installation, start of operations (go-live), typical operating period per site/project, and wrap-up/decommissioning (pack-down + site restoration). Are there external constrain that could affect the time schedule (e.g., regulatory approvals, material availability, workforce training)?
Answer	**Setup duration:** N/A **Operations duration on site / per project**: 15-18 months with 12 months extension granted **Wrap-up / decommissioning duration**: N/A **Milestones (estimated lead times in weeks or months)**: • Funding secured: N/A • Permits approved: around 10 weeks • Design freeze: 8 weeks • Production: 12 weeks around • Procurement complete: N/A • Start operations: 2 weeks **Top 5 dependencies**: • Building Vacancy: The project cannot begin until all residents have moved out, as demolition and stripping to the concrete core require an empty building. • Sub-contractor Market Capacity: The ability to execute and scale the project depends on securing enough trusted local subcontractors who understand the industrialized rhythm. • Zoning/Systemic Plan Compliance: To avoid lengthy delays (years), the project depends on staying within the height and density limitations of the existing municipal *bestemmingsplan*. • Asbestos Mitigation: Successful progression from demolition to "building up" is dependent on the complete removal of asbestos found in old ventilation channels and gas boiler installations. • Sequential Rhythm (The "Train"): The project's efficiency depends on every subcontractor hitting a fixed daily output (specifically 10 apartments per day) to ensure the production "train" is not disrupted
Evidence / supporting material	

Table 121: R5 – Risks and Contingency Plans (Dutch Feasibility Study)

ID / Category	R5 – Risks and Contingency Plans
Definition	Identifying potential risks (e.g., financial, logistical, regulatory) and existing contingency plans to mitigate the risks identified. By addressing challenges in establishing, operating, and scaling the pop-up factory we can improve the stability of its timeline/life-cycle.
Question (s)	What are the key risks affecting the implementation of the pop-up factory, logistics, workforce capacity, material availability, regulatory delays)? What contingency plans are in place to mitigate these risks?
Answer	**1. Financial Viability and Low ROI** • Risk: Deep renovations are highly expensive, and the cost increases as the target energy label improves. It is currently very difficult to achieve a high return on investment (ROI) for such projects. > Contingency: The project utilizes a collaborative "Building Team" (Bouwteam) model, allowing the owner, contractor, and advisors to share experiences from previous buildings to optimize costs from the design phase. **2. Logistical Chaos in Dense Urban Areas** • Risk: The building is in a densely populated area with very limited space (at most 20 meters along the building) and high student bike traffic, which could lead to "complete chaos" during construction. > Contingency: Van Wijnen employs "Just-In-Time" (JIT) delivery for all large prefabricated elements like bathroom pods and facade modules. These are hoisted directly from the truck to the specific floor using mobile tower cranes, eliminating the need for on-site storage or scaffolding. **3. Structural Integrity of 1960s Concrete** • Risk: The 1960s concrete floors are only 10cm thick, making them too weak to support heavy high-tech equipment like standard demolition or drilling robots, which often weigh over 1,000 kg. > Contingency: The execution team uses lightweight equipment, such as simple manual pump pallet lifters, to move materials within the building. For the building expansion, a lightweight steel substructure is used to minimize the load on the existing structure. **4. Asbestos** • Risk: Old buildings often contain asbestos in unexpected places like ventilation (shunt) channels or gas boilers, leading to significant additional costs and delays not directly related to energy improvements. > Contingency: A rigorous stripping phase is conducted where the building is demolished down to its bare concrete

core. This ensures all hazardous materials are identified and professionally removed before the "building up" phase begins.

5. Subcontractor Coordination and Delays

- Risk: If one trade falls behind, it can halt the entire industrialized "train" sequence, delaying the overall project timeline.
  > Contingency: Van Wijnen implements a strict "train" schedule with fixed daily targets. For example, subcontractors are required to finish 10 units per day.

6. Prefabrication Fitting and Deviations

- Risk: Old buildings often deviate significantly from their original historical drawings in terms of floor levels and slopes, which can make standardized prefabrication difficult to fit.
  > Contingency: Detailed 3D modeling is performed based on actual site measurements. Furthermore, prefabricated elements are designed with built-in tolerances (e.g., 6cm) to allow for standardization while still being adjustable to the specific deviations of the building on-site.

7. Regulatory and Zoning Constraints

- Risk: New additions (like an extra floor) could trigger lengthy procedures to change the zoning or "systemic plan" (*bestemmingsplan*).
  > Contingency: The project was specifically designed to stay within the limitations of the existing systemic plan regarding building height and footprint, which allowed for a much faster and simpler permit procedure.

8. Workforce and Market Capacity

- Risk: There is a shortage of subcontractors in the market who understand and have the capacity for this specific industrialized renovation workflow.
  > Contingency: Van Wijnen prioritizes working with a consistent list of local "Co-makers" (subcontractors) from the same region. Repeatedly using the same partners across multiple projects ensures they understand the expectations and can anticipate potential issues based on past experience. However, for specialised product, an exception has been made (toilet/facade) to ensure performance and quality.

Specifically, for the windows flow:

1. **Technical and Regulatory Risks**
   - **Fire Testing Failure:** During the development phase, one of the primary risks was meeting strict fire duration and resistance regulations for the new energy-generating façade.
     > Contingency: The project team proactively tested solar panels from two different producers simultaneously; when

	one supplier failed the test, they were able to immediately proceed with the second supplier who passed. • **Grid Congestion:** A significant external risk that materialized was the overloaded electrical grid in the Netherlands, which prevented the building from delivering excess solar energy back to the grid. > Contingency: The main contractor secured additional funding to install large external batteries to store the generated energy on-site. **2. Environmental and Safety Risks** • **Earthquake Vulnerability:** The project is located in Groningen, an area known for minor earthquakes, which required a façade that would not add excessive weight to the existing structure. > Contingency: The team utilized a lightweight timber façade system that is specifically designed to be earthquake-proof. • **Installation Safety:** The process of lifting large prefabricated elements onto a 10-storey building presented physical safety risks. **> Contingency:** A comprehensive safety and assembly plan is prepared before every project, featuring strict mitigation strategies. **3. Operational and Workforce Risks** • **Structural Discrepancies:** In renovation projects, there is a risk that the new prefab elements will not align with the existing building structure. **> Contingency:** The project used 3D BIM modeling connected to an ERP system to ensure exact measurements, allowing elements to be manufactured with near-zero waste and a "plug and play" fit. • **Workforce Skill Gaps:** There is a lack of formal schooling for this specific type of prefab engineering and installation. **> Contingency:** WEBO/VRONT® provides specialized in-house training for their modellers and uses certified crews specifically authorized for the electrical work required for solar panels. **Labor Shortage:** Traditional on-site construction is increasingly difficult to staff due to labor shortages and poor weather conditions. **> Contingency:** By moving 70–80% of the work into a factory-controlled environment, the project reduced its reliance on on-site labor and minimized delays caused by weather.
Evidence / supporting material	

Table 122: R6 – Site Requirements and Logistics (Dutch Feasibility Study)

ID / Category	R6 – Site Requirements and Logistics
Definition	Understanding the specific site-related details necessary for an effective operation of the pop-up factory. Includes assessing available space, infrastructure (e.g., access to roads, utilities and so on), in parallel with logistical challenges (e.g., materials transport and site access.
Question (s)	**Space requirements:** What space is required (m²) for: manufacture / assembly / storage / staging-loading? **Access constraints:** What access constraints apply? • vehicle type/size/weight limits (text or numbers) • delivery time windows (hours/days) • road restrictions / low-emission zone (LEZ) / permits needed (Y/N + name) • public space required (Y/N) **Utilities -** Provide: • power requirement (kW + single/three-phase) • water needed (Y/N + connection type or liters/day) • drain needed (Y/N + where it discharges) • internet needed (Y/N + minimum requirement if any) **Waste handling:** What waste streams occur and who is responsible for collection/disposal? **Provider responsibility:** Who provides/installs utilities and how long does it take? (entity + setup time) **Special items:** Are any of these required? (Y/N + details) • containers (#) • crane access (Y/N) • security/lockable room (Y/N) • fencing (Y/N)
Answer	**Space required (m²):** • Assembly: van Wijnen has a factory in Heerenveen with a total floor area of 14.000 sm • Storage: around 100 sm on site, but JIT model was preferred and used • Staging/loading: area surrounding the building, around 20 m wide to accommodate mobile tower cranes and reach trucks used to move pallets and small parts **Access constraints:** • vehicle type: mobile tower cranes, telescopic cranes for scaffold-free facade installation, reach trucks to move materials and pallets around the site, and pump pallet lifters for moving components (like bathroom pods) within the building floors • time windows: 7am-4pm • road limits N/A • public space needed (Y/N): Y, around 20 m wide around the building **Utilities**:

	• Power [kW + phase]: 55kW • Water (Y/N): Y • Drain (Y/N): Y • Internet (Y/N): N **Waste streams + responsible party**: van Wijnen with certified waste processors **Who provides utilities/setup**: Municipality at the request of van Wijnen **Special items (if any)**: • containers [#]: N/A; material brought into the site within small/mid-size packaging • crane needed (Y/N): Y, mobile tower crane, telescopic crane, reach trucks • security (lockable room) (Y/N): Y
Evidence / supporting material	 *Figure 166: the building in its context (source: van Wijnen)*

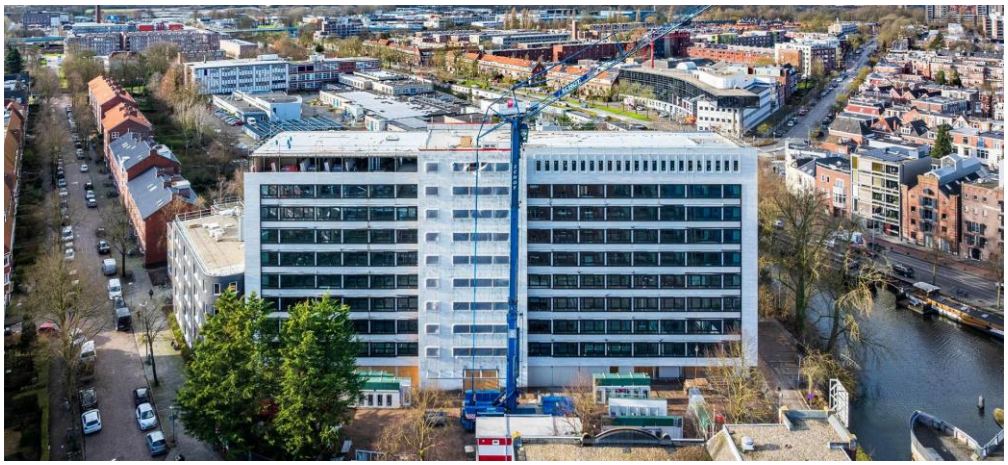


Figure 167: Building in its context with crane

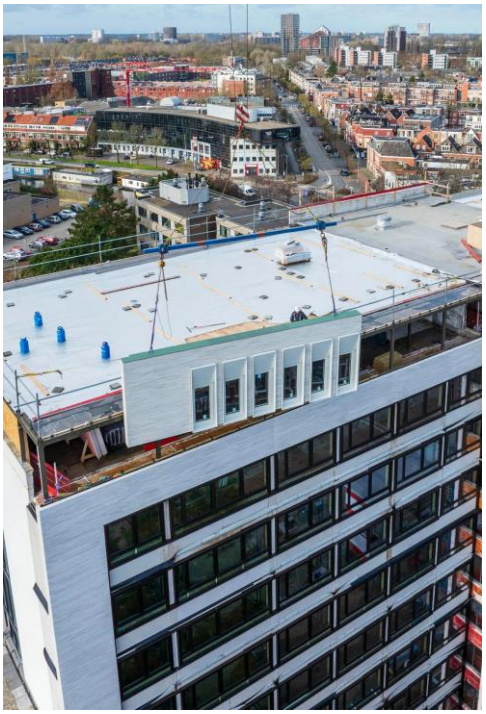


Figure 168: Installation of facade unit (source: WEBO)

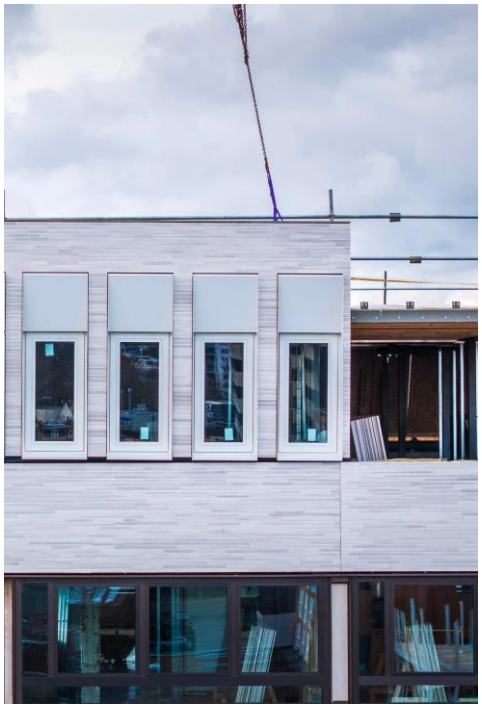


Figure 169: Installation of the facade unit (source: WEBO)

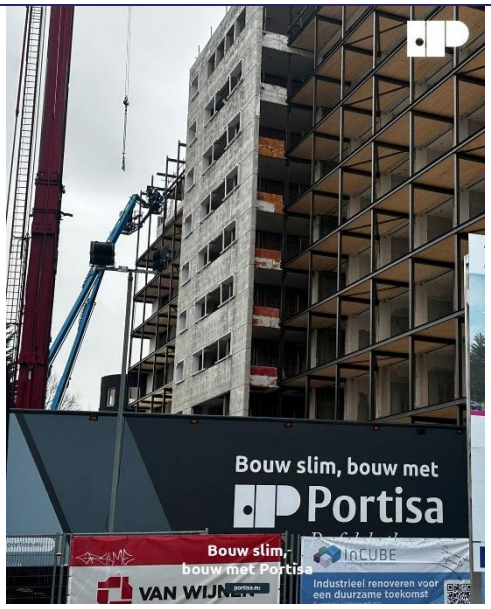
	 *Figure 170: Installation of the bathroom pod (source: Portisa)*

Table 123: R7 – Sustainability Considerations (Dutch Feasibility Study)

ID / Category	R7 – Sustainability Considerations
Definition	Exploring the strategies employed by the pop-up factory to minimize waste, optimize energy use, and integrate renewable or local materials. Also examining how the factory aligns with regional sustainability goals, such as decarbonization and circular economy practices.
Question (s)	**Top measures:** List max 3 sustainability measures planned (short bullets). **KPI selection:** Which 2–3 KPIs will you track? (tick): CO_2e / waste diverted / reuse rate / energy use (kWh) / water use / other (specify). **Targets:** For each chosen KPI, what is the target value (or "TBD")? **Reuse scope** (if applicable): Which materials/components are reused (top 3) and what acceptance criteria/certification applies? **Energy approach:** What is the renewable energy approach? (on-site / green purchase / mix) and target % renewable. **Logistics decarbonization:** What is the approach (routing, consolidation, low-emission vehicles) and what logistics KPI will be tracked (km/CO_2e/other)?

Answer	**Top measures:** General, for PuF model: • Industrialized Prefabrication; • Integrated Renewable Energy: Increasing local production by installing building-integrated photovoltaics (BIPV) on prefabricated facades and deploying water-water heat pumps connected to the municipal district heat network; • Deep Thermal Retrofit: Applying contemporary insulation and prefabricated facade modules to significantly decrease consumption, aiming for net-zero or high-efficiency energy labels. For window flow: ○ Use of biobased material: Utilizing a lightweight timber structure combined with wood-fiber (bio-based; Gutex) insulation to enhance sustainability and reduce the structural load; ○ Integrated Solar Cladding: Replacing traditional façade materials with energy-generating solar panels (PV cladding) to transform the building into an energy producer; ○ Energy production (PV) and energy consumption reduction: Aiming at NZEB or ZNE standard. **KPI selection** — Which 2–3 KPIs will you track?: CO_2e / **waste diverted** / reuse rate / **energy use (kWh)** / water use / **other**: **Delivery and Installation Volume**. **Targets** — For each chosen KPI, what is the target value (or "TBD")? • Waste diverted: Near-zero production waste; • Energy use: Nearly Zero Energy Building (NZEB) or Zero Net Energy (ZNE) Standards; • Delivery and Installation volume: "just-in-time" (JIT) flow, not a specific target value expressed. **Reuse scope** (if applicable) — Which materials/components are reused (top 3) and what acceptance criteria/certification applies? • **Concrete Structure/Core:** The entire building is stripped down to the bare **concrete structure**, which serves as the foundation for the expansion and new prefabricated elements. • **Internal Doors:** In the demolition phase, doors are removed and **reused "one-to-one"** within the building. • **Original Foundations:** While new foundations are added to support the 2-meter building expansion, the **existing foundations** remain in use to support the original concrete core;

- Glass: Use of recycled glass for windows, due to the lower temperatures needed

Energy approach — What is the renewable energy approach? (on-site / green purchase / mix) and target % renewable.
The project prioritizes generating energy directly on the building's envelope through industrialized components:

- Building-Integrated Photovoltaics (BIPV): Solar energy is generated using PV panels that are pre-installed onto the prefabricated facade elements before they arrive at the site.
- Water-Water Heat Pumps: These systems are deployed on-site to boost the building's energy production efficiency.

The window/facade systems use specialized prefabricated solar façade elements provided by Megasol, with the following technical specifications:

- Product Type: Megasol HiR G1 Half-cut cells with SOLARCOLOR (Design 01 & 02) finishing for a high-quality visual appearance.
- Cell Efficiency: The solar cells have a high efficiency of 22.3%.

Logistics decarbonization — What is the approach (routing, consolidation, low-emission vehicles) and what logistics KPI will be tracked (km/CO_2e/other)?

- **Just-In-Time (JIT) Routing:** Due to the extremely limited space at the Heemskerckflat site, the project relies on Just-In-Time delivery. Materials and prefabricated modules are delivered precisely when they are needed for installation. This systems works in combination with ‘the train’ model of PuF, which targets the completion of 10 apartments per day. This ensures a predictable, consolidated flow of both workforce and materials;
- **Scaffold-Free Installation:** To minimize the logistical footprint and the duration of site equipment presence, the project uses mobile tower cranes and telescopic cranes to hoist prefabricated elements directly from the transport truck onto the building floors.
- **Local Sourcing:** Van Wijnen prioritizes local "Co-makers" and subcontractors from the provinces of Groningen, Drenthe, and Friesland, to ensures shorter transport distances and allow partners to anticipate site-specific logistical challenges;
- **Low-Emission On-Site Movement:** To move materials within the building, the team uses lightweight, manual equipment—specifically simple pump pallet lifters. This is a necessity because the 10cm-thick concrete floors

	cannot support heavy, motorized machinery, but it also serves as a low-emission alternative to traditional forklifts • **Minimize Movements:** Transport management aims to minimize the movements of heavy vehicles to prevent chaos in the densely populated area. For The window/facade: • WEBO has the availability of eclectic trucks, but it would have been three times more expensive, due to the distance; • "just-in-time" (JIT) logistics model delivers a full truckload of approximately 12 prefabricated timber elements daily to minimize on-site storage to a mere 100 square meters; • Waste is drastically reduced through precision 3D BIM modeling connected to an ERP system, ensuring near-zero waste during factory production; consequently, on-site waste is limited to basic transport materials like wood and plastic.
Evidence / supporting material	

Table 124: R8 – Scalability and Adaptability (Dutch Feasibility Study)

ID / Category	R8 – Scalability and Adaptability
Definition	Evaluating the factory model's ability to scale and adapt to different regions, project types, or production needs. It identifies barriers to scaling and the necessary adjustments for broader implementation while ensuring flexibility for diverse applications.
Question (s)	**Scaling approach:** Choose the scaling approach (tick): replicate sites / increase capacity at one site / multi-site coordination / other (specify). **Scalability thresholds:** Provide numerical thresholds (write "N/A" if not applicable): • max distance (km) • max storage duration (days) • max volume (units/week or m²/week) • other limiting metric (e.g., district size: #dwellings or renovation volume) **Adaptability mechanism:** How is adaptability achieved? (choose): standardized process / modular equipment / digital tools / other (specify). **Digital tools:** Which tools/software are used (names) OR list required features (documentation/sales/stock control). **Coordination owner:** Who coordinates replication/multi-site planning (name/role/entity)?

Answer	**Scaling approach** — Choose the scaling approach (tick): 1. replicate sites > for window flow 2. multi-site coordination > for PuFs model and main contractor **Scalability thresholds** — Provide numerical thresholds (write "N/A" if not applicable): • max distance (km): N/A (PuF) within the same region (provinces of Groningen, Drenthe, and Friesland) but allowing further sub-contractors; (facade) within the Dutch borders, including the islands; • max storage duration (days): (facade) 18 months outside according to KOMO standard (certification standard for the construction and infrastructure sector); • max volume (units/week or m²/week): info not available, as tailored solutions can be made with prefabrication systems; (PuF) 10 apartments / day; • other limiting metric (e.g., district size: #dwellings or renovation volume): (PuF) For each project, Van Wijnen maintains a specialized staff, typically including a site supervisor and 4–5 core employees, who coordinate up to **20 people** from various subcontractors during peak periods. Managing multiple sites would require duplicating this specialized oversight team for each location. (facade) the typology of the dwelling can constitute a constraint, as for example, in historical or protected building it is not possible to replace the facade with these solutions, while there are no problems with terrace house or apartment flat. **Adaptability mechanism** — How is adaptability achieved? (choose): **standardized process** / **modular equipment** / **digital tools** / other (specify). (facade) For the window flow, all approaches could be viable and are performed by the company. However, for single piece production can be done within a certain range (not further specified); despite the modularity of the pieces and their standard production process, it is possible to have different variations in thickness, colours, shape of window frames. **Digital tools** — Which tools/software are used (names) OR list required features (documentation/sales/stock control). (general – digital tools) 1. InCube suite: A specific digital tool being developed as an outcome of the InCUBE project is the "InCUBE suite". This tool

	allows users to input specific parameters to generate tailored renovation scenarios; 2. Kopersportaal (Buyer Portal): For new-build industrialized homes, a digital portal is used to manage communication and choices for buyers (general – robotic tools) 1. Demolition and Drilling Robots: Specifically, a commercially available Hilti drilling robot was mentioned. They also face physical constraints, such as being too heavy for the 10cm-thick concrete floors of 1960s buildings (facade) For the window flow, BIM softwares are used in all phases, from ideation/design (by architect), to production. BIM is also used for tracking changes, (fore)seeing clashes, checking costs, rating possible mistakes and preparing the site installation **Coordination owner** — Who coordinates replication/multi-site planning (name/role/entity)? PuF: there is always a site supervisor and 4–5 core employees, who coordinate up to **20 people.** For the window flow, there is always a project coordinator.
Evidence / supporting material	 *Figure 171: Use of robots for controlling demolitions and status of the work (source: van Wijnen)*

10.1.3. Part B: Feasibility Assessment

For each row, select one outcome (F/C/N), add 1–2 sentences (or bullets) explaining why, and reference supporting evidence using Annex (or write N/A). If "Conditional," state the condition(s) required and who is responsible.

Status: Feasible **(F)**, Conditionally Feasible **(C)**, Not feasible **(N)**.

Scoring and thresholds (manual):

- F (Feasible) = 2 points
- C (Conditionally feasible) = 1 point
- N (Not feasible) = 0 points

How to calculate each dimension score:

- Count the number of F, C, and N selections in the table.
- Dimension score = (2 × #F) + (1 × #C).
- Maximum score = 2 × (number of rows in the dimension).
- Dimension percentage = Dimension score / Maximum score × 100%.

Gate (must-pass) rows:

Rows marked with 🔒 are non-negotiable prerequisites. If any 🔒 row is scored N, the dimension is NOT FEASIBLE (and the overall decision in Part C should normally be NO-GO unless that row can realistically be changed to C/F with clear conditions).

Suggested thresholds (per dimension):

- FEASIBLE: ≥ 75% and no 🔒 row scored N
- CONDITIONAL: 50–74% and no 🔒 row scored N
- NOT FEASIBLE: < 50% or any 🔒 row scored N

B1 – Technical Feasibility

Table 125: Technical Feasibility Assessment (Dutch Feasibility Study)

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
Process configuration	Are the PuF processes (factory-side, close-to-site, on-site assembly/services) clearly defined and workable in this location?	☒F ☒C ☐N	The PuF model is clear and in use by the main contractor, especially for its replicability. What is not available yet is the high specialised manufacturers/services providers within the area. For this reason the PuF model is in between district and Assembly model.	Interview with main contractor
Technology readiness	Are the required technologies/equipment mature (proven) and available/procurable within acceptable lead times for the remote context?	☐F ☒C ☐N	Required technologies/equipment are mostly available in the region, with the exception of some hightech who are not. However, being the Netherlands a fairly small country, and being Groningen a mid-size city, transport are still affordable.	Interview with main contractor
🔒 Space & infrastructure	Is sufficient space available for work zones, storage and loading/unloading, with required utilities (power/water/drainage/internet) at the proposed site(s)?	☒F ☐C ☐N	With JIT model, not too much space is required	Interview with main contractor and window supplier
🔒 Quality & certification	Can outputs and processes comply with applicable standards/certification requirements (e.g., QA	☒F ☐C ☐N	All products are approved beforehand and certification must be available	Interview with main contractor and window supplier

	procedure, documentation, traceability)?			
🔒 Skills & labour	Are required skills locally available or trainable within the feasibility period (including supervision/QA as needed)?	☐F ☒C ☐N	Not all skills are locally available. However, it would be possible to train people in the Groningen region; Specific skills: assembly of the façade technical façade = training period of 1 week in factory + 6 month training on site with expert colleagues	Interview with WEBO

B2 – Operational Feasibility

Table 126: Operational Feasibility Assessment (Dutch Feasibility Study)

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
Supply chain readiness	Are key suppliers/service providers identified and able to deliver reliably under remote constraints (lead times, minimum order quantities, transport limits)?	☐F ☒C ☐N	Transports are not too problematic. Problems can arise in the case of multiple site renovations happening at the same time	Interview with main contractor and window supplier
Coordination capacity	Is there a clear governance/coordination setup (roles, decision rights, communication cadence) across factory–sites–suppliers–public actors?	☒F ☐C ☐N	Mangaed by the main contractor, in contact with the owner/client	Interview with main contractor
🔒 Logistics feasibility	Can inbound/outbound logistics be executed reliably (routes, ports/rail/highway	☐F ☒C ☐N	Yes, however streets in the urban environment are not too big, so some logistic choice may vary.	Interview with main contractor

	access, time windows, vehicle/weight limits, weather/seasonality)?			
Operations continuity	Can operations be sustained (staffing, utilities reliability, maintenance, storage strategy) during the assessment period and pilot rollout?	☒F ☐C ☐N	For this project an extension of six months has been granted because of delays due to material availability, delays on phases completion.	Interview with main contractor
🔒 Health and Safety (HS) & site operations	Can HS, traffic management and operational procedures be implemented and enforced at the factory and building sites?	☒F ☐C ☐N	They are mainly regulated by law, no further information is provided	Interviews
Anchor stakeholders	Is there an anchor client/launching partner and confirmed access to sites/projects to start operations as planned?		The main contractor ahs been chosen by the Housing Association because of its prvious expertise and portfolio with similar projects	Interviews

B3 – Legal & Regulatory Feasibility

Table 127: Legal & Regulatory Feasibility Assessment (Dutch Feasibility Study)

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
🔒 Legal classification	Is the PuF legally classifiable and compatible with local rules (e.g., temporary/permanent facility, industrial activity, construction site annex)?	☐F ☒C ☐N	Th Puf model is feasible and compatible with regulation, but may require implementation mainly for the acquisition of needed expertise's	Interviews

🔒 Zoning / land-use compliance	Is the proposed location permitted for the intended activities under zoning/land-use rules (including temporary use where relevant)?	☒F ☐C ☐N	Yes	Interviews
🔒 Permitting pathway & timeline	Are required permits/authorisations identifiable and realistically obtainable within the needed timeline (authorities, steps, expected durations)?	☒F ☐C ☐N	Yes, no special permit was required and all the operation were made within the typical permit stream for renovation	Interviews
Environmental compliance	Can noise, dust, waste handling and traffic impacts comply with local regulations and any protected/heritage-area constraints?	☒F ☐C ☐N	All within the permit No specific permit is required (reduction of waste, noise,…)	Interviews
Contracting & liability	Are contracting, insurance, and liability responsibilities manageable across factory, transport and on-site works (clear allocation and coverage)?	☐F ☒C ☐N	Yes, all is put in place by builders company (main contractor) and discussed/agreed upon with its sub-contractors	Interviews

B4 – Financial Feasibility

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
🔒 Investment costs (CAPEX)	Are the required upfront investments realistic and fundable in this context (site setup, equipment, vehicles, ICT), given the remote constraints?	☒F ☐C ☐N	Yes, with the support of the Horizon grant and the contribution of the owner (12 million)	

🔒 Operational costs (OPEX)	Are ongoing operating costs sustainable (staffing, transport, rent/utility, maintenance, consumables), given local cost levels and remote penalties?	☐F ☒C ☐N	High-level skills needed to be found out of the district area/region. Same for some of the products Material provision also had some delays due to remote area	
Revenue model *(if applicable)*	Is there a viable revenue model (who pays, for what, how priced) that matches local procurement practices and PuF delivery scope?	☐F ☒C ☐N	Revenue model comes from housing association, who is going to rent the building out, taking advantage of the increased value due to renovation	
Break-even *(if applicable)*	Can break-even be realistically reached within the intended time horizon (pilot vs long-term), given expected demand and cost structure?	☐F ☐C ☐N	Information not available	

B5 – Market / Demand Feasibility

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
🔒 Fit to project scale *(Demand volume)*	Is there sufficient renovation demand in the target area to justify operating the PuF at the intended capacity (target volume/time period)?	☒F ☐C ☐N	Yes, as this for the main contactor is one of eight pilots to carry on with the same client/owner (Housing association) following the same or a simialr renovation model (with Puf). For additional subcontractor from out of the region, this depends on the diemnsion of the order, to make it sustainable.	

🔒 Fit to project scale *(Demand continuity)*	Is demand continuous (multi-year pipeline/portfolio) rather than one-off/project-based, so the PuF can operate reliably over time?	☐F ☒C ☐N	Depends also on the clients/market	
Client willingness	Are key clients (owners/housing providers/municipalities) willing to adopt PuF delivery (contracting, access, scheduling, site interfaces)?	☐F ☒C ☐N	This specific client is a housing association (has funds partially from government) and the project benefitted also from a Horizon funds. This has allowed to be able to spend more than usual.	
Ecosystem fit	Is the PUF aligned with the broader network of actors in the renovation market (housing corporations, municipalities, contractors, suppliers and residents) and with governance or procurement arrangements/ trust and neutrality considerations?	☐F ☒C ☐N	Yes, although the model must be in between a District and the Assembly scenario.	

10.1.4. Part C: Feasibility Summary

C1 – Blocking Issues, Risks, and Mitigation

*List only the **top 5–10 blocking issues** that can prevent implementation. For each, assign, a category, an owner, one concrete mitigation/contingency action and rate its impact.*

Issue/Risk	Category (Market/Tech/ Ops/Legal/Financial)	Impact (High/Medium/Low)	Owner/ Responsible	Mitigation / Contingency
Low Return on Investment (ROI)	Financial	High	Lefier (Client) Van Wijnen (main contractor)	
Hidden Asbestos Contamination	Operational / Legal	Medium	Van Wijnen / Specialized Subcontractor	Mandatory stripping and professional remediation of shunt channels and old installations before the construction works begin. Hire a specialised technician to assess, test, and map out the presence of asbestos in the building.
Logistical Chaos on Site (Limited space)	Operational	Medium	Site Supervisor (Van Wijnen)	Implementing "just-in-time" deliveries with no on-site storage; coordinating precise vehicle windows to prevent blockages in the densely populated student area.
Works delay	Operational/Logistic	Medium-High	Van Wijnen Sub-contractors	Strict time plan and roadmap to complete each phase on time, with possible scenarios to accommodate delays. Agreements with sub-contractors for managing last minute delays and possibility of coordination with similar other project happening in the same area at the same time (with the same actors).
Sub-contractor Market Capacity	Market / Operational	Medium-High	Van Wijnen: head of Work Preparation	Utilizing a trusted list of local partners who are trained in the industrialized "train" sequence of finishing 10 apartments per day.
			Association of constructors	Support/Offer the training of specialised figures who can supply this market gap in the area

Inconsistent Building Quality	Tech	Low-Medium	Van Wijnen / Sub-contractors	Detailed 3D modeling and site measurements to account for deviations in floor levels and weak adhesion in original walls
Structural Floor Limits	Tech	Medium	Van Wijnen (Lead Contractor)	Adapting the site works to the specific needs of the building from a technical point of view. For example, considering 10cm thick concrete, using lightweight steel structures for expansion; avoiding heavy high-tech robotics (approx. 1,000kg) in favor of lighter manual equipment like pump pallet lifters.
Unviability of Circular Reuse	Market / Financial	Medium	Van Wijnen / Lefier	Focusing circular efforts on on-site reuse (e.g., internal doors) to avoid the high transport and storage costs that make external reuse commercially uninteresting.

C2 – Decision Summary and Next Steps

Step 1: Summarise Part B results
Scoring: F=2, C=1, N=0 → Score = 2×#F + 1×#C. Max = 2×Rows → % = (Score/Max) × 100.

Table 128: Summary Table - Suggested thresholds (per dimension): FEASIBLE: ≥ 75% and no 🔒 row scored N; CONDITIONAL: 50–74% and no 🔒 row scored N; NOT FEASIBLE: < 50% or any 🔒 row scored N

Dimension	Rows	#F	#C	#N	Score	Max	%	Result
B1 Technical feasibility	5	3	2	0	8	10		☒F ☐C ☐N
B2 Operational feasibility	6	4	2	0	10	12		☐F ☒C ☐N
B3 Legal & regulatory feasibility	5	3	2	0	8	10		☐F ☒C ☐N
B4 Financial feasibility	4	1	2	0	4	8		☐F ☒C ☐N
B5 Market & demand feasibility	4	1	3	0	5	8		☐F ☒C ☐N

OVERALL SCORE	-	-	-	-	35	48	[73%]	☐F ☒C ☐N

Step 2: Final Decision
Choose exactly one decision (GO / CONDITIONAL GO / NO-GO) based on your final overall score in above table. If CONDITIONAL GO, list measurable conditions and a deadline; if NO-GO, list the non-negotiable constraints causing the decision.

☐ GO - Implementable with no major unresolved blockers.
☒ CONDITIONAL GO - Implementable if the conditions below are met by the deadline.
☐ NO-GO - Not implementable due to hard constraints or unacceptable risk.

Conditions (if Conditional GO):
District/Assembly PuF in remote areas in the Netherlands receives a conditional GO, at the following conditions:

1. **Client–contractor coordination ensured:** Clear governance structure and shared planning routines established before tender lock-in.
2. **Sub-contractor capacity secured:** Core subcontractors confirmed and aligned with the required production rhythm before final design freeze.
3. **Financial support secured:** Full funding package (equity + grants, if applicable) confirmed before site setup mobilisation.
4. **Supply-chain buffers defined**: Buffer strategy for critical components approved before first façade batch enters production.
5. **Workforce availability confirmed**: Sufficient skilled labour allocated to maintain the industrialised workflow before façade installation starts.

Hard constraints (if NO-GO): _____//_____

Decision owner (name/org): _____//_____

C3 – Feasibility Study Summary (maximum one page)

The feasibility assessment of the renovation of van Heemskerckflat building indicates that the District/Assembly-type Pop-up Factory can be implemented in the Dutch city of Groningen, provided that several operational and market-related constraints are actively managed. The renovation scenario is clearly defined, with a mature industrialised workflow based on prefabricated façade elements, bathroom pods, and a lightweight steel substructure. The governance and stakeholder ecosystem is strong: Lefier, the Municipality of Groningen, and Van Wijnen form a stable and experienced partnership, supported by specialised suppliers such as WEBO/VRONT and Portisa. Regulatory requirements are well understood and manageable within standard Dutch permitting procedures, and the project benefits from EU-level innovation funding that reduces financial exposure.

Technical feasibility is high, as demonstrated by the successful deployment of complex prefabricated systems in a peripheral region. Operational feasibility is more sensitive, given the strict sequencing required by the industrialised "train", the need for a fully vacant building, and the dependency on subcontractor availability. Legal and regulatory feasibility is favourable, though asbestos removal and seismic-area requirements could lead to additional procedural steps. Financial feasibility remains challenging, as the project relies heavily on equity from the housing association and EU grants, with limited prospects for short-term ROI. Market feasibility is mixed: while demand for deep renovation is high, Groningen's peripheral position results in longer lead times, limited specialised labour, and dependence on external suppliers. At the same time, the long-standing collaboration between Van Wijnen and Lefier in the region demonstrates that stable demand can, over time, stimulate the development of a more capable local ecosystem. Their shared experience suggests that repeated renovation cycles in the northern provinces could create new opportunities for regional capacity building, including the reuse of construction materials across multiple sites, which becomes far more viable when several renovation projects are coordinated at district scale.

The "remote" character of Groningen remains a structural challenge: specialised skills are not readily available in the immediate area, and nearby regions offer only limited additional capacity. However, the small geographic scale of the Netherlands mitigates this risk to some extent, as specialised teams and components can still reach Groningen within manageable time and cost constraints.

Across the assessment, the main blockers relate to (i) subcontractor capacity and the need for a stable, well-trained local workforce; (ii) the risk of delays caused by asbestos removal and sequential workflow disruptions; (iii) long lead times for specialised components; and (iv) the difficulty of achieving cost efficiency in a peripheral market. Mitigation measures include early subcontractor engagement and training, strict pre-construction planning to secure building vacancy and asbestos clearance, buffering of critical components to reduce supply-chain risk, and leveraging the project's demonstration status to offset financial constraints.

Overall, the study supports a **CONDITIONAL GO** decision. The PuF concept is technically and organisationally feasible in the city of Groningen, but successful implementation requires targeted mitigation of operational and supply-chain risks, as well as continued financial support to compensate for the region's structural market limitations.

Next steps could include formalising subcontractor commitments, validating component lead times with WEBO/VRONT and Portisa, confirming regulatory

compliance milestones with the municipality, exploring district-level coordination of renovation sites to enable material reuse, and refining the production rhythm to ensure the required renovation throughput. These actions will strengthen the reliability of the PuF deployment model and provide a robust foundation for scaling industrialised renovation in other remote Dutch regions.

The Italian Ecosystem Feasibility Report

Use this template to assess whether the selected PuF concept can be implemented in the chosen remote location. Keep inputs concise and evidence-based; put details in the Annex and reference them in the tables.

Document Information

Version:	1.0
Date:	17/06/2026
Organization Name:	EDERA srl Impresa Sociale
Prepared by:	Chiara Stanghini

10.1.5. Context and Scope

General

Field	Partner input
Location name (city/region/country)	Catania, Sicily, Italy
Coordinates / map reference	Via Acquicella Porto, Catania
Pop-up Factory (PuF) type (e.g., Mobile / Satellite / District / Assembly)	**Hybrid model: Main factory + Sicilian satellite SMEs** (centralized production facility in Campania with local assembly and integration activities in Sicily)
Building typology / pilot context	Residential retrofit pilot – multi-storey social housing building owned by IACP Catania
Target renovation product/package	Offsite integrated retrofit system
Target volume (units/week, m²/month, # renovations/month, etc.)	Pilot project: 1 residential building (10 dwellings, 5 floors, 1,230 m² façade area). Target production configured for scalability beyond the pilot and service extension to neighbouring Southern Italian regions. For this reason, the volume has been considered equal to the ones manufactured in Milan area (51.000 m^2 retrofit walls and 166.000 m^2 for new-built elements).
Feasibility Assessment Period (start-end)	May – June 2026
Key local partners involved in the feasibility study (owner, municipality, utilities, unions, building owner, etc.)	IACP Catania (building owner), Regional government of Sicily, Sicilian SMEs network, local contractors, utilities providers and logistics operators.

Remote definition

Define what "remote" means for this location using tick boxes and -if possible- quantified constraints (e.g., km, hours, reliability, limits).

Field	Partner input
Remote classification (tick one)	☒ Island ☐ Mountain/valley ☐ Rural/low-connectivity ☐ Hard-to-access urban ☐ Other:
Distance/time to nearest logistics hub (port/rail/highway)	• Factory → nearest port (Campania): 40–60 km (~1 h) • Sea transport (Campania → Sicily): 350–450 km (~12–18 h) • Port → satellite local factories (Catania): 10–20 km (~30 min) • Satellite factories → pilot site (Ex. Via Acquicella Porto, Catania): 5 km (~15 min) Total logistics chain: approximately 420–530 km Estimated total transport time: ~14–20 hours
Access constraints (tick all that apply)	☒ ferry schedule limits ☐ seasonal closures ☐ narrow roads ☐ weight limits ☐ urban time windows ☐ crane restrictions ☐ other: ____
Utilities reliability (tick)	☐ power unstable ☒ water limited ☐ drainage limited ☐ internet weak ☐ none
Local supply chain constraint (tick one)	☒ long lead times ☐ limited suppliers ☐ high transport cost ☒ limited skilled labor ☐ other:____
Local regulatory sensitivity (tick all)	☐ protected area ☐ heritage ☒ noise/working hours strict ☒ public space constraints ☒ other: high seismic zone

Additional text and materials

Use this section only for essential context (e.g., a short narrative, key map/photo) needed to understand the pilot.

Pilot project: The case study consists of a multi-storey residential building located in the city of Catania, in Via Acquicella Porto, owned by the Autonomous Institute for Public Housing (IACP) of Catania. In terms of typology and construction system, this building is representative of the reinforced-concrete framed buildings widely constructed in Italy in the period prior to the introduction of the more recent and stringent seismic and energy-efficiency regulations. There is an identical twin that has already been renovated as pilot of Horizon e-Safe project, using prefabricated wood-based panels (see render in the picture below). In addition, there are are 9 attached fabrics in the same block having similar characteristics, which could be served by the same satellite factory.



Figure 1: As-is pilot building



Figure 2: e-SAFE render



Figure 3: pilot context

Utilities reliability: Sicily is structurally exposed to recurring drought and water-supply constraints (severe 2024–2025 emergency, rationing across many municipalities. Reference: Regione Sicilia, Deliberazione di Giunta n. 100 of 11 March 2024). However, this constraint is not operationally binding for the proposed model, since water-intensive concrete production is located in Campania, while Sicilian activities are limited to low-water component integration and assembly.

Local supply chain constraint: in this island context the structural supply-chain constraints are long lead times and limited skilled labor. The maritime leg adds roughly one day of lead time and exposes JIT scheduling to ferry frequency and sea-state variability; the offsite-integration skills gap — i.e. the limited local availability of workers trained to assemble and integrate prefabricated components off site — will be addressed through training and recruitment ahead of commissioning. Transport cost is treated as a secondary, quantifiable factor rather than a primary constraint: RoRo (Roll-on/Roll-off) freight is billed per lane-meter of vehicle and is broadly cost-competitive with road per ton-km, so the sea route is not intrinsically more expensive than the all-land alternative. That makes the transport more costly is the longer route to be travelled (> 100 km). Since lane-meter pricing is independent of the value carried, pre-installing light components in Campania would not increase the billed length and would raise the value moved per paid meter — so transport's economics alone do not favor local integration.

Local regulatory sensitivity: the dominant regulatory sensitivity for this island context is seismic. Catania lies in a high-seismicity area at the foot of Mt Etna and is classified in seismic zone 2, so panel integration and connections must fully comply with the Italian NTC seismic-design code. Noise and working-hour limits apply because works are carried out on an occupied residential building, and public-space constraints apply in the dense urban setting, since one façade of the building overlooks the public road. The building is peripheral 1960s–70s social housing, outside Catania's UNESCO Baroque historic center, so no built-heritage constraint applies. Proximity to the port/coast and to the Simeto reserve to the south means a coastal landscape constraint should be verified against the site's cadastral map.

10.1.6. Part A: Requirement Collection

*Answer each requirement for the **new remote location** (not your original pilot site). Each requirement includes the following fields: **ID**, **Definition**, **Guiding Questions**, **Answer**, and **Evidence /Supporting Material**. For the **Answer** field, we have already created a **structured schema**. We expect your answers in the structured schema we provided.).*

*For the **Evidence / Supporting Material** field, please include any relevant **diagrams, tables, figures, photos, or other materials** that support or clarify your answers. Additionally -and most importantly- if you are unable to provide the required data, please use this field to explain the reason and limitation and the assumptions you made to complete this feasibility study.* This will enable us to clearly communicate the limitations in the **WP4 conclusions** for each PuF.

The PuF configuration assessed for the Sicilian remote location is the same Satellite Factory model defined for the mainland Milanese ecosystem. The main hybrid precast factory is in Campania and is not dedicated to Sicily alone: it serves the wider southern catchment area. Its defining characteristics — production technology and lines, annual capacity, CAPEX/OPEX, financing structure, governance of production, quality/certification framework and sustainability profile — are therefore unchanged with respect to the mainland case. For this reason, the Part A requirement tables R0–R8 are not repeated in full here: only the location-specific differences are reported, and these concentrate almost entirely on the **transport and logistics dimension** introduced by the mainland-to-island delivery. The differences are:

- **R0 – Scenario & Strategy.** The factory model (centralized precast production in Campania → secondary component integration by local Sicilian SMEs → Just-In-Time on-site installation) is unchanged. The only location-specific element is the renovation scope, which reflects the specific pilot building (the IACP Acquicella block in Catania), a multi-family residential social housing built in 1964, typically mid-rise with repetitive façade modules and mandatory anti-seismic adaptation.
- **R1 – Partnerships & Stakeholders.** This is the genuinely location-specific requirement. On the demand side, the contracting authority is the Regione Sicilia as public promoter of the pilot programme, with IACP Catania/Sicily as building owner and asset manager identifying housing demand and pilot sites; ACER Campania supports the mainland production side through knowledge transfer on social-housing delivery, and Federcasa provides national network support for replicability. Works are publicly funded through regional housing and regeneration programmes and private industrial investment for the factory setup, with PPP/EPC and SPV arrangements as in the mainland model. On the supply side, the precast manufacturing base differs markedly across regions: Lombardy hosts Italy's densest, most established cluster while Campania has a smaller but solid base (e.g. Travi Sud, Seieffe, Ipiemme) — enough to anchor the main factory. Sicily is not without capacity (e.g. Sicep, Siciliana Prefabbricati, F.lli Scalzo), but it is geared to conventional industrial precast rather than the specialised renovation-panel system, so a dedicated local factory would require technology transfer and a multi-year demand pipeline. Sicilian SMEs are aggregated for local component integration (coordinated through Sicindustria, the regional association of industrial solution providers),

and local construction contractors handle site installation and commissioning (engaged through ANCE Sicilia); operations/maintenance and financing actors (energy/ESCO providers, debt finance, crowdfunding, social-impact investors) follow the same categories as the mainland case, to be confirmed with local counterparts.

- **R2 – Legal & Regulatory.** The national permitting/authorisation framework is identical, since the factory is in Campania (DPR 380/2001, AUA/AIA, D.Lgs 81/2008). As a special-statute region, Sicily applies national building law through its own regional legislation: the Italian Building Code (DPR 380/2001) is in force as transposed by Regional Law 16/2016 (and subsequent amendments) under L.R. 19/2020 on territorial governance; industrial-area siting is governed by the regional authority IRSAP (L.R. 8/2012, reformed by L.R. 33/2021); seismic authorisation is handled by the regional Genio Civile; landscape and heritage clearances by the regional Soprintendenze. Substantive technical standards (seismic NTC 2018, health & safety, CE marking, environmental rules) are national/EU and apply uniformly; the special statute affects the institutional pathway and procedural timelines rather than the substantive feasibility. Location-specific additions regard the **ZES Unica** incentive (dedicated to the Southern Italy Special Economic Zone, it's an investment tax credit, extended by the 2026 Budget Law to 2026–2028, with a nominal rate up to 60% for small enterprises in Campania and Sicily). In addition, for the pilot building, the **Sismabonus** (seismic-retrofit tax deduction incentive) can be applied, making the retrofit model more appealing due to CAPEX reduction. It is confirmed for 2026 at 50% for the owner's main residence and 36% for other and non-residential buildings, for a maximum of €96,000 per unit over ten years.
- **R3 – Costs & Financing.** Factory CAPEX/OPEX and the financing structure are unchanged. The only cost difference is the interregional transport to Sicily, which raises the delivered €/m² of the panels (the figure already includes transport to mainland local facilities). An order-of-magnitude estimate — based on an incremental Campania-to-Sicily delivery cost of roughly €500–1,000 per truck over the mainland baseline — points to an additional ~€5–15/m² of panel.
- **R4 – Time Schedules.** Factory setup (~21 months) and on-site retrofit (~3 months) are unchanged. The production-to-delivery cycle lengthens from ~3 to ~4months, entirely due to the interregional leg (~1–2 weeks transport plus ~1 week of Sicilian staging/buffering) absent in the ≤100 km mainland case.
- **R5 – Risks.** Risks are re-prioritized for the island context (interregional coordination over distance, mainland-to-island logistics disruption, uneven local manufacturing/installation capability, permitting and site readiness). These are consolidated in Part C1.
- **R6 – Site & Logistics.** Factory and SME site requirements are unchanged. The differences are the maritime leg, an additional Sicilian staging/buffer platform, and the multiple-handling (truck + ship) damage risk. Water supply is a structural regional sensitivity but is not operationally binding, since water-intensive production remains in Campania.
- **R7 – Sustainability.** The factory sustainability profile is unchanged. The logistics dimension changes: regional road transport is replaced by interregional truck-and-maritime transport, with shipment consolidation and an added transport-efficiency KPI. Maritime carriage can reduce CO_2 per ton-km relative to long-distance road haulage. However, since the total transport is longer, the

overall sustainability of the model is lower, and it should be better assessed against building the main factory in Sicily: if most of raw materials and equipment still come to the mainland the longer transportation is just hidden upfront in the supply chain.

- **R8 – Scalability & Adaptability.** Production-capacity thresholds are unchanged. The fixed 100 km factory-to-SME radius defined for the mainland is relaxed (the factory is deliberately distant); optimization shifts to the SME-to-site distance, and digital tools add interregional/maritime shipment tracking. Overall, scalability is limited. Indeed, since the main factory is in Campania and is planned to serve also local territories, if the Sicilian demand rises considerably, it’s necessary to build the precast production facility on the island.

10.1.7. Part B: Feasibility Assessment

For each row, select one outcome (F/C/N), add 1–2 sentences (or bullets) explaining why, and reference supporting evidence using Annex (or write N/A). If "Conditional," state the condition(s) required and who is responsible.

Status: Feasible **(F)**, Conditionally Feasible **(C)**, Not feasible **(N)**.

Scoring and thresholds (manual):

- F (Feasible) = 2 points
- C (Conditionally feasible) = 1 point
- N (Not feasible) = 0 points

How to calculate each dimension score:

- Count the number of F, C, and N selections in the table.
- Dimension score = (2 × #F) + (1 × #C).
- Maximum score = 2 × (number of rows in the dimension).
- Dimension percentage = Dimension score / Maximum score × 100%.

Gate (must-pass) rows:

Rows marked with 🔒 are non-negotiable prerequisites. If any 🔒 row is scored N, the dimension is NOT FEASIBLE (and the overall decision in Part C should normally be NO-GO unless that row can realistically be changed to C/F with clear conditions).

Suggested thresholds (per dimension):

- FEASIBLE: ≥ 75% and no 🔒 row scored N
- CONDITIONAL: 50–74% and no 🔒 row scored N
- NOT FEASIBLE: < 50% or any 🔒 row scored N

B1 – Technical Feasibility

Table 129: Technical Feasibility Assessment (Italian Feasibility Study)

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)

Process configuration	Are the PuF processes (factory-side, close-to-site, on-site assembly/services) clearly defined and workable in this location?	☒F ☐C ☐N	The proposed PuF configuration is clearly defined through a three-stage model: centralized panel production in Campania, secondary component integration by local SMEs in Sicily, and final Just-In-Time delivery and installation onsite. Roles, logistics flow and responsibilities have been identified.	R0 – Scenario & Strategy; R1 – Partnerships & Stakeholders
Technology readiness	Are the required technologies/equipment mature (proven) and available/procurable within acceptable lead times for the remote context?	☒F ☐C ☐N	The required manufacturing technologies (precast production lines, lifting systems, logistics operations and component integration processes) are mature and commercially available. No experimental production technology is required.	R1 – Partnerships & Stakeholders
🔒 Space & infrastructure	Is sufficient space available for work zones, storage and loading/unloading, with required utilities (power/water/drainage/internet) at the proposed site(s)?	☐F ☒C ☐N	Industrial areas and infrastructure are available in Campania and Sicily; however, feasibility remains conditional upon final site selection, utility availability and confirmation of logistics and temporary staging areas. For the selected pilot building, space is sufficient since 3 facades al facing an internal driveway courtyard.	R6 – Site & Logistics; Figure 3
🔒 Quality & certification	Can outputs and processes comply with applicable standards/certification	☒F ☐C ☐N	Compliance can be achieved through existing Italian and EU certification frameworks including	R2 – Legal & Regulatory

	requirements (e.g., QA procedure, documentation, traceability)?		QA/QC procedures, CE marking, environmental approvals and traceability processes integrated into production and assembly phases, including compliance with the Italian NTC seismic-design code for structural elements and connections, given the high-seismicity location.	
🔒 Skills & labour	Are required skills locally available or trainable within the feasibility period (including supervision/QA as needed)?	☐F ☒C ☐N	Required competencies are generally available but additional training and coordination are expected for off-site manufacturing, assembly operations and integrated quality procedures across Campania and Sicily. This is needed to retain workforce and avoid the structural outflow of qualified human capital. Indeed, Sicily and Campania together account for almost half of the South-to-Centre-North outflow of young people, and the loss is increasingly selective and early.	Over the 2002-2024 period South of Italy recorded a net loss of more than 500,000 people aged 25-34, around 270,000 of them graduates, which weakens the local skills base and the ability to retain talent Reference: SVIMEZ–Save the Children, "Un Paese, due emigrazioni", 2026).

B2 – Operational Feasibility

Table 130: Operational Feasibility Assessment (Italian Feasibility Study)

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
Supply chain readiness	Are key suppliers/service providers identified and able to deliver reliably under	☐F ☒C ☐N	Key suppliers, industrial actors and local assembly partners have been identified and integrated into a	R1 – Partnerships & Stakeholders

	remote constraints (lead times, minimum order quantities, transport limits)?		structured delivery model linking production in Campania with assembly and installation in Sicily. However, reliable delivery depends on aggregating the local SME network and on longer interregional lead times.	
Coordination capacity	Is there a clear governance/coordination setup (roles, decision rights, communication cadence) across factory–sites–suppliers–public actors?	☒F ☐C ☐N	A governance structure has been defined with clear responsibilities across factory operations, local SMEs, logistics coordination and onsite delivery, supported by phased planning and Just-In-Time principles.	R1 – Partnerships & Stakeholders
🔒 Logistics feasibility	Can inbound/outbound logistics be executed reliably (routes, ports/rail/highway access, time windows, vehicle/weight limits, weather/seasonality)?	☐F ☒C ☐N	Feasibility depends on the mainland-to-island maritime leg (RoRo Campania–Sicily), which adds roughly one day of lead time and exposes JIT scheduling to ferry frequency and sea-state variability. RoRo keeps panels on the trailer (no extra handling at the crossing); As in the mainland, the multiple-handling damage risk arises from the satellite-integration logic and is mitigated by buffer stock of critical components, multiple carriers/alternative routes, and installing the most fragile components last.	R6 – Site & Logistics Paragraph: Local supply chain constraint above
Operations continuity	Can operations be sustained (staffing, utilities reliability, maintenance, storage strategy) during the	☒F ☐C ☐N	Operations can be maintained through centralized production, planned delivery batches and temporary buffering strategies,	R6 – Site & Logistics Paragraph: Utilities reliability above

	assessment period and pilot rollout?		absorbing short maritime disruptions and reducing the impact of local interruptions on construction activities. Utility availability is adequate. Even if Sicily is structurally exposed to recurring water-supply constraints, this is not operationally binding here, as water-intensive concrete production remains in Campania while Sicilian activities are limited to low-water component integration.	
🔒 Health and Safety (HS) & site operations	Can HS, traffic management and operational procedures be implemented and enforced at the factory and building sites?	☒F ☐C ☐N	Health and safety procedures can be implemented through established Italian regulatory frameworks and dedicated regional operational protocols covering manufacturing, transport and onsite installation activities.	R2 – Legal and Regulatory
Anchor stakeholders	Is there an anchor client/launching partner and confirmed access to sites/projects to start operations as planned?	☐F ☒C ☐N	Public and industrial stakeholders have been identified; however, implementation remains dependent on formal project commitment, budget availability and allocation of initial pilot projects and sites. In public residential housing, even where a triennial works program exists, it is a planning instrument rather than a funding guarantee, so financing must be secured project by project and is chronically insufficient	R1 – Partnerships & Stakeholders Supporting evidence: Osservatorio nazionale ERP 2024/25 Federcasa–Nomisma (2026); Forum Disuguaglianze e Diversità, "Rilanciare l'edilizia residenziale pubblica" (2020).

			relative to the estimated maintenance/renovation backlog.	

B3 – Legal & Regulatory Feasibility

Table 131: Legal & Regulatory Feasibility Assessment (Italian Feasibility Study)

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
🔒 Legal classification	Is the PuF legally classifiable and compatible with local rules (e.g., temporary/permanent facility, industrial activity, construction site annex)?	☒F ☐C ☐N	The proposed PuF can be legally classified as an industrial manufacturing facility combined with construction support activities and is compatible with both existing Italian regulatory frameworks for productive activities and local adaptation for Sicily, being a special-statute region due to its island configuration.	R2 – Legal and Regulatory
🔒 Zoning / land-use compliance	Is the proposed location permitted for the intended activities under zoning/land-use rules (including temporary use where relevant)?	☐F ☒C ☐N	Suitable industrial locations are available; however, final feasibility depends on confirmation that the selected site complies with local zoning regulations, industrial land designation and temporary logistics use requirements.	R2 – Legal and Regulatory
🔒 Permitting pathway & timeline	Are required permits/authorisations identifiable and realistically obtainable within the needed timeline (authorities, steps, expected durations)?	☒F ☐C ☐N	Required permits and authorisation procedures have been identified, including building permits, SUAP procedures, environmental authorisations and operational approvals, with timelines compatible	R2 – Legal and Regulatory

			with the proposed implementation schedule. For the Sicilian pilot, additional seismic and landscape technical clearances may apply and can extend timelines, though permits remain identifiable and obtainable.	
Environmental compliance	Can noise, dust, waste handling and traffic impacts comply with local regulations and any protected/heritage-area constraints?	☐F ☒C ☐N	Environmental impacts related to noise, dust, transport and waste can be managed through existing mitigation measures and environmental procedures; final compliance remains dependent on site-specific assessment. Constraints include municipal noise/working-hour limits (works on an occupied residential building), and public-space occupation for crane/staging.	R2 – Legal and Regulatory
Contracting & liability	Are contracting, insurance, and liability responsibilities manageable across factory, transport and on-site works (clear allocation and coverage)?	☒F ☐C ☐N	Contractual responsibilities, insurance coverage and liability allocation can be structured through existing procurement and delivery models covering manufacturing, transport, assembly and onsite installation phases. No difference with respect to the mainland model occurs, beside that an additional insurance needs to be considered for the maritime transportation.	R1 – Partnerships & Stakeholders R2 – Legal and Regulatory

B4 – Financial Feasibility

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
🔒 Investment costs (CAPEX)	Are the required upfront investments realistic and fundable in this context (site setup, equipment, vehicles, ICT), given the remote constraints?	☒F ☐C ☐N	The required upfront investment is significant but realistic for an industrial-scale precast facility. The proposed financing structure (loan and/or equity through SPV) and phased implementation approach make investment mobilization feasible despite the remote delivery context. Capex is further supported by the ZES Unica investment tax credit applicable to the Campania factory (up to 60% nominal for small enterprises).	R3 – Costs & Financing
🔒 Operational costs (OPEX)	Are ongoing operating costs sustainable (staffing, transport, rent/utility, maintenance, consumables), given local cost levels and remote penalties?	☐F ☒C ☐N	Operating costs are manageable through centralized production in Campania and local integration in Sicily; however, financial sustainability remains dependent on maintaining production volumes and controlling logistics costs across regions. Sustainability depends on production saturation and on controlling interregional logistics costs (order-of-magnitude transport uplift ~€5–15/m² of panel).	R3 – Costs & Financing
Revenue model *(if applicable)*	Is there a viable revenue model (who pays, for what, how priced)	☒F ☐C ☐N	A viable revenue model has been identified based on programme-	R3 – Costs & Financing

	that matches local procurement practices and PuF delivery scope?		driven renovation contracts, milestone-based payments and delivery of integrated prefabricated systems through PPP/SPV mechanisms. Revenue streams and contractual allocation are defined.	
Break-even *(if applicable)*	Can break-even be realistically reached within the intended time horizon (pilot vs long-term), given expected demand and cost structure?	☐F ☒C ☐N	As for the mainland model, break-even appears achievable in the medium term provided that production capacity is progressively saturated and project demand extends beyond the pilot phase into a stable portfolio of interventions. Sicily represent an additional market for Campania main factory, lowering the risk of variable pipelines if properly planned.	R3 – Costs & Financing

B5 – Market / Demand Feasibility

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
🔒 Fit to project scale *(Demand volume)*	Is there sufficient renovation demand in the target area to justify operating the PuF at the intended capacity (target volume/time period)?	☒F ☐C ☐N	The target regions show sufficient potential demand related to renovation, residential delivery and renewal of the existing building stock to justify operation of the PuF at the intended capacity. The model also enables simultaneous servicing of multiple projects. Indeed, the addressable public-housing stock is substantial: around 60,000 ERP	Evidence: Regione Campania / ACER (Agenzia Campana per l'Edilizia Residenziale) + aggregated data from individual IACP sources

			dwellings managed by ACER in Campania, plus at least ~50,000 across the nine IACP in Sicily. Together this approaches the scale of the Lombardy reference indicating that the long-term demand base is potentially sufficient.	
🔒 Fit to project scale *(Demand continuity)*	Is demand continuous (multi-year pipeline/portfolio) rather than one-off/project-based, so the PuF can operate reliably over time?	☐F ☒C ☐N	Multi-year demand potential exists; however, long-term operation of the PuF depends on establishing a stable pipeline of projects beyond the initial pilot. Public residential funding is structurally limited and fragmented — committed project by project rather than guaranteed by multi-year programming — so securing a continuous, adequately financed pipeline is the key condition for sustained operation. Indeed, Sicily is among the most critical regions with high shares of dwellings unavailable because they are uninhabitable or in need of works, against a historically high level of social demand.	The highest numbers of vacant public dwellings awaiting intervention are recorded in Sicily and Calabria (each just above 2,000 units), with the lack of maintenance funding being the main obstacle to recovery. Evidence: Osservatorio nazionale ERP 2024/25 Federcasa–Nomisma
Client willingness	Are key clients (owners/housing providers/municipalities) willing to adopt PuF delivery (contracting, access, scheduling, site interfaces)?	☐F ☒C ☐N	Relevant public and industrial stakeholders have been identified, and the proposed delivery model is compatible with local implementation practices; There is concrete local interest in offsite renovation solutions in Sicily, driven by the strong added value they offer in seismic contexts	Evidence: Horizon 2020 e-SAFE project "Energy and Seismic AFfordable rEnovation solutions" (GA No. 893135)

			(faster, less invasive, externally-applied combined energy-and-seismic upgrading). This is demonstrated by the involvement of IACP Catania as a partner in the Horizon 2020 e-SAFE project	
Ecosystem fit	Is the PUF aligned with the broader network of actors in the renovation market (housing corporations, municipalities, contractors, suppliers and residents) and with governance or procurement arrangements/ trust and neutrality considerations?	☒F ☐C ☐N	The PuF aligns with the broader regional ecosystem by integrating industrial manufacturing, local SMEs, construction contractors and public actors into a coordinated delivery chain. Governance and procurement fit the established public framework (PPP/EPC and SPV arrangements, multi-year framework agreements), with a public authority acting as neutral aggregator of demand.	R1 – Partnerships & Stakeholders

10.1.8. Part C: Feasibility Summary

C1 – Blocking Issues, Risks, and Mitigation

*List only the **top 5–10 blocking issues** that can prevent implementation. For each, assign, a category, an owner, one concrete mitigation/contingency action and rate its impact.*

Issue/Risk	Category (Market/ Tech/ Ops/ Legal/ Financial)	Impact (High/ Medium /Low)	Owner/ Responsible	Mitigation / Contingency
Reliability of mainland-to-island (maritime) logistics: lead time, ferry frequency, sea-state variability and panel damage from multiple handling	Ops	High	Logistics Operator + Project Delivery Entity	Confirmed logistics operator and Sicilian staging/buffer strategy; buffer stock of critical components; multiple carriers and alternative routes (RoRo Campania-Sicily); RoRo keeps panels on the trailer (no handling during the crossing); most fragile components installed last.
Confirmation of the industrial site, logistics layout and temporary staging areas (Campania + Sicily), and zoning / land-use compliance	Ops / Legal	Medium	Project Developer + Industrial Area Operator + Local Authority	Early site selection and securing of the Sicilian staging/buffer platform; confirmation of industrial land designation and temporary-use compliance before operations start.
Local workforce skills gap and uneven manufacturing/installation capability; Sicilian SME network still to be aggregated	Tech / Ops	Medium -High	Factory Operator + Sicilian SME Network (HR & Ops)	Training programme and recruitment plan before commissioning; shared QA/QC protocols; aggregation of the local SME network (e.g. via Sicindustria); temporary workforce reallocation between hubs.
OPEX sustainability dependent on	Financial	High	Factory Operator +	Secure target factory utilisation; logistics consolidation and route

production saturation and control of interregional logistics costs			Financial Lead	optimisation (interregional transport uplift in the order of ~EUR 5-15/m^2 of panel, plus staging and double-handling); long-term energy and key-material framework contracts.
Demand continuity beyond the pilot (multi-year pipeline) and achievement of break-even	Market / Financial	High	Regione Sicilia + Project Delivery Entity + SPV	Define a minimum project portfolio and multi-year framework agreements; align with regional housing/regeneration programmes; financial case supported by the ZES Unica investment tax credit (and, on the seismic component, the Sismabonus, subject to the owner's fiscal capacity and delivery model).
Formal commitment of an anchor client and allocation of pilot sites	Market / Ops	High	Regione Sicilia + Project Promoter + IACP / Housing stakeholders	Formal appointment of the project promoter; confirmation of initial clients, pilot sites and procurement strategy.
Permitting and site-readiness delays, including seismic and coastal/landscape clearances for the Sicilian pilot, plus site constraints (noise/working hours, public-space occupation)	Legal	Medium	Local Implementation Manager + Project Developer + Local Authority	Early stakeholder engagement; parallel approval processes; phased activation; early verification of seismic and landscape constraints against the cadastral map and of noise/working-hour and public-space requirements.
Coordination between the Campania main factory and the Sicilian SMEs over distance and	Ops	Medium	Programme Manager	Integrated production planning; shared digital coordination platform (BIM/CDE, TMS, shipment tracking); fixed handover

production dependency				milestones; weekly alignment meetings.

C2 – Decision Summary and Next Steps

Step 1: Summarise Part B results
Scoring: F=2, C=1, N=0 → Score = 2×#F + 1×#C. Max = 2×Rows → % = (Score/Max) × 100.

Table 132: Summary Table - Suggested thresholds (per dimension): FEASIBLE: ≥ 75% and no 🔒 row scored N; CONDITIONAL: 50–74% and no 🔒 row scored N; NOT FEASIBLE: < 50% or any 🔒 row scored N

Dimension	Rows	#F	#C	#N	Score	Max	%	Result
B1 Technical feasibility	5	3	2	0	8	10	80	☒F ☐C ☐N
B2 Operational feasibility	6	3	3	0	9	12	75	☒F ☐C ☐N
B3 Legal & regulatory feasibility	5	3	2	0	8	10	80	☒F ☐C ☐N
B4 Financial feasibility	4	2	2	0	6	8	75	☒F ☐C ☐N
B5 Market & demand feasibility	4	2	2	0	6	8	75	☒F ☐C ☐N
OVERALL SCORE	24	13	11	0	37	48	[77%]	☒F ☐C ☐N

Step 2: Final Decision
Choose exactly one decision (GO / CONDITIONAL GO / NO-GO) based on your final overall score in above table. If CONDITIONAL GO, list measurable conditions and a deadline; if NO-GO, list the non-negotiable constraints causing the decision.

☒ GO - Implementable with no major unresolved blockers.
☐ CONDITIONAL GO - Implementable if the conditions below are met by the deadline.
☐ NO-GO - Not implementable due to hard constraints or unacceptable risk.

Conditions: (1) formal appointment of the project promoter and commitment of an anchor client + pilot site(s); (2) multi-year pipeline / framework agreements securing target factory utilization; (3) confirmed logistics maritime operator and Sicilian staging/buffer setup; (4) workforce training/recruitment and SME-network aggregation before commissioning

Decision owner (name/org): EDERA srl Impresa sociale

C3 – Feasibility Study Summary (maximum one page)

*Provide a concise half-page (**max 200 words**) storyline for inclusion in **D4.1**: location + remote context → key Part A findings → Part B outcomes → main blockers/mitigations → final decision and next steps*.

The assessment examined a Pop-up Factory (PuF) model for offsite retrofit in Catania (Sicily), using the IACP-owned Acquicella building — representative of Italy's pre-seismic-code reinforced-concrete stock — as pilot. Given the island (remote) context, the configuration keeps the centralized precast main factory in Campania, serving the wider southern catchment, with local Sicilian SMEs integrating components before on-site installation.

The analysis confirms that this configuration is essentially identical to the validated mainland model (T4.5); the difference is concentrated in the transport and logistics dimensions introduced by the mainland-to-island leg. Governance is interregional, the permitting pathway feasible (mediated by Sicily's special-statute institutions), and quality requirements include NTC seismic compliance.

The feasibility assessment scored 77%, with strong outcomes in process definition, technology readiness, governance, regulatory compliance and demand potential. The main conditional issues are maritime-logistics reliability, workforce preparation (against a structural Sicilian brain drain), production saturation and demand continuity — the latter constrained by chronic ERP underfunding and the fragmentation of nine provincial IACP, though the combined Campania–Sicily public-housing stock approaches Lombardy scale. ZES Unica (Southern Italy supply-side investment tax credit) and the Sismabonus (demand-oriented seismic-retrofit tax deduction) support the financial case; IACP Catania's role in the H2020 e-SAFE project evidence local readiness and engagement in offsite renovation projects.

Final decision: **FEASIBLE (77%) – GO**, conditional on securing an anchor client, a multi-year pipeline and a confirmed logistics setup.

The Spanish Ecosystem Feasibility Report

Use this template to assess whether the selected PuF concept can be implemented in the chosen remote location. Keep inputs concise and evidence-based; put details in the Annex and reference them in the tables.

Document Information

Version:	Final
Date:	02.06.2026
Organization Name:	ACR
Prepared by:	Sara Dorregaray Oyaregui

10.1.9. Context and Scope

General

Field	Partner input
Location name (city/region/country)	Pamplona, Navarra, Spain
Coordinates / map reference	42.816550, -1.648088
Pop-up Factory (PuF) type (e.g., Mobile / Satellite / District / Assembly)	Assembly
Building typology / pilot context	Public building
Target renovation product/package	Complete renovation
Target volume (units/week, m²/month, # renovations/month, etc.)	**52.5 m²/day**
Feasibility Assessment Period (start-end)	24
Key local partners involved in the feasibility study (owner, municipality, utilities, unions, building owner, etc.)	none

Remote definition

Define what "remote" means for this location using tick boxes and -if possible- quantified constraints (e.g., km, hours, reliability, limits).

Field	Partner input
Remote classification (tick one)	☐ Island ☐ Mountain/valley ☐ Rural/low-connectivity ☐ Hard-to-access urban ☐ Other:
Distance/time to nearest logistics hub (port/rail/highway)	5 km
Access constraints (tick all that apply)	☐ ferry schedule limits ☐ seasonal closures ☐ narrow roads ☐ weight limits ☐ urban time windows ☒ crane restrictions ☐ other: ____
Utilities reliability (tick)	☐ power unstable ☐ water limited ☐ drainage limited ☐ internet weak ☒ none
Local supply chain constraint (tick one)	☐ long lead times ☐ limited suppliers ☐ high transport cost ☐ limited skilled labour ☐ other: ____
Local regulatory sensitivity (tick all)	☐ protected area ☒ heritage ☒ noise/working hours strict ☐ public space constraints ☐ other: ____

Additional text and materials

Use this section only for essential context (e.g., a short narrative, key map/photo) needed to understand the pilot.

10.1.10. Part A: Requirement Collection

*Answer each requirement for the **new remote location** (not your original pilot site). Each requirement includes the following fields: **ID**, **Definition**, **Guiding Questions**, **Answer**, and **Evidence /Supporting Material**. For the **Answer** field, we have already created a **structured schema**. We expect your answers in the structured schema we provided.).*

*For the **Evidence / Supporting Material** field, please include any relevant **diagrams, tables, figures, photos, or other materials** that support or clarify your answers. Additionally -and most importantly- if you are unable to provide the required data, please use this field to explain the reason and limitation and the assumptions you made to complete this feasibility study.* This will enable us to clearly communicate the limitations in the **WP4 conclusions** for each PuF.

Table 133: R0 – Scenario and Strategy (Spanish Feasibility Study)

ID / Category	R0 – Scenario and Strategy
Definition	The PuF scenario requires a clear scenario definition and strategy to achieve a shared implementation direction
Question (s)	Please complete the fields in the answer schema below.
Answer	**PuF Type**: Assembly Factory **PuF Purpose**: Assembles pre-fabricated components locally **Deep Renovation Scope:** • **Renovation areas addressed (tick multiple if necessary):** ☒ façade / envelope (insulation; cladding) ☒ windows/doors replacement ☒ roof insulation / roof refurbishment ☒ floor / basement insulation ☐ ventilation (balanced/mechanical) ☐ HVAC / heating system upgrade ☐ renewable energy (PV / solar thermal) ☒ electrical / controls / smart systems ☐ interior modules (bathroom/kitchen pods) ☐ other: [ ] • **Package level (choose):** ☐ single-measure ☐ multi-measure bundle ☐ whole-building deep retrofit • **Interfaces with site works (1–2 lines):** **Target Renovation Building Typology**: Public building, heritage buildings **Main Materials Processed and Produced**: Creation of holes at the CLT, integration of windows, joins for balconies and wastevery utility that is needed.

	Production Capacity (e.g., units/week; m2/day; dwellings/month or other): 52,5 m²/day and 159,65 €/m
Evidence / supporting material	

Table 134: R1 – Partnerships and Stakeholders (Spanish Feasibility Study)

ID / Category	R1 – Partnerships and Stakeholders
Definition	Identifying the key stakeholders involved in the pilot projects, including demand-side partners (housing companies, governments) and supply-side (local SMEs, contractors).
Question (s)	Demand-side partners: ○ Who are the key stakeholders (e.g., housing companies, local governments) currently involved in the pilot project? ○ What additional partnerships are needed to move forward? Supply-side partners: ○ Which local SMEs, manufacturers, or constructors can support the factory? ○ Are there any collaboration gaps on the supply-side?
Answer	**Client / contracting authority:** Privat companies and public bodies **Who signs contracts:** Constructor **Who pays:** Client **Decision-maker / governance lead:** Construction manager **Demand-side partners (name + role):** • **Name**: Private company; **Role**: Architect • **Name**: Public body; **Role**: Client **Supply-side partners (name + role):** • **Name**: Technology provider; **Role**: Demolish • **Name**: Technology provider; **Role**: Logistic, transport • **Name**: Technology provider; **Role**: Carpenter • **Name**: Construction worker; **Role**: measure, cut • **Name**: Local installers; **Role**: Assembly elements **Missing roles/trades needed (tick):** ☐ electrician ☐ HVAC ☐ façade/insulation ☐ logistics/transport ☐ crane ☐ QA/QC ☐ O&M ☐ other: [ ]
Evidence / supporting material	

Table 135: R2 – Legal and Regulatory Requirements (Spanish Feasibility Study)

ID / Category	R2 – Legal and Regulatory Requirements
Definition	Legal and policy-related factors influencing pop-up factory implementation, such as local regulations, permits, and compliance standards, and opportunities for leveraging government incentives or subsidies.
Question (s)	What specific permits or licenses are required for setting up the pop up factory in your region, *considering factors such as space, noise levels, and environmental compliance?* Are there government incentives or subsidies that can support the implementation of the pop-up factory?
Answer	**For each permit/compliance item:** • **Permit/requirement:** Sustainaiblity requirement • **Issuing authority:**Nacional technical building code • **Lead time:** 1-2 • **Key constraints/conditions:** Heritage and energetical requirement balance • **Responsible applicant:** Construction manager • **Insurance/liability holder (if relevant):** [Name/role] **Incentives/subsidies (if any): No** • **Instrument name:** [ ] • **Who applies:** [ ] • **Eligibility/key condition:** [ ] • **Expected value:** [€ or %] **Timing/deadline:** [ ]
Evidence / supporting material	

Table 136: R3 – Costs and Financing Plans (Spanish Feasibility Study)

ID / Category	R3 – Costs and Financing Plans
Definition	Evaluating the financial feasibility of each pilot project, focusing on capital and operational expenses, available financing options, also consider the possibility of subsidies.
Question (s)	What are the estimated costs for setting up and operating the pop-up factory, including infrastructure, equipment, and workforce? **CAPEX range (€):** What is the CAPEX range (min–max €) and what is included? (1 line) **OPEX/month (€):** What is the OPEX range per month (min–max €) and what is included? (1 line) **Cost basis:** If you use €/m², what is the basis? (façade / GFA / net / other) **€/m² value:** What is the €/m² value (if used) and what does it include?

	Revenue: Is there a revenue stream? (Y/N). If yes: amount (€/month or €/project), source (reuse sales / service fee / other). **Financing model:** Which financing model applies (tick): grant / loan / equity / ESCO / PPP / other (specify). **Loan parameters** (if loan): Interest rate (%), duration (years), amount (€). (ranges OK) **Equity/SPV parameters** (if equity/SPV): Who invests, share split (%), payback logic (dividend/profit share/service fee), who controls (majority holder).
Answer	**CAPEX (€):** [min–max] not proceding **OPEX (€ / month):** [min–max] not proceding, we work through subconstrators **Cost basis (if €/m² used**): 27 €/m^2 (CLT panels) **€/m² value:** [ ] (what included: [ ]) **Revenue assumptions (if any):** none **Financing model (tick**): ☐ grant ☐ loan ☒ equity ☐ ESCO ☐ PPP ☐ other: [ ] **If loan:** interest [%] | duration [years] | amount [€] **If equity/SPV:** investor(s) 100% | share split [%] | payback logic [ ] **Payment/contracting chain (one line):** (Client → Architects→ Client → Grant → Permission→ Constructor → Construction → New building) → … **Owner of revenue & inventory (if reuse sales):** [Name]
Evidence / supporting material	

Table 137: R4 –Time Schedules (Spanish Feasibility Study)

ID / Category	R4 – Time Schedules
Definition	Assessing the timeline for establishing and operating the pop-up factory. Includes: identifying potential delays, dependencies, and life-cycle considerations (such as the duration of operations and decommissioning plans).
Question (s)	What is the estimated timeline for the PuF lifecycle for this scenario (setup → operate → decommission, if temporary)? Please provide durations (weeks/months) or target dates for: setup/installation, start of operations (go-live), typical operating period per site/project, and wrap-up/decommissioning (pack-down + site restoration). Are there external constrain that could affect the time schedule (e.g., regulatory approvals, material availability, workforce training)?

Answer	**Setup duration:** 1-2 months **Operations duration on site / per project**:24 months **Wrap-up / decommissioning duration**: 4 months] **Milestones (estimated lead times in weeks or months)**: • Funding secured: Not available information • Permits approved: 6 months • Design freeze: Once the construction begins • Procurement complete: 28 months • Start operations: 0 month • **Top 5 dependencies**: • Public permits are a great source of time uncertainty. Access permission, connection to energetical resources, demolish permission & building permission • Heritage building definitions, identification and classifications of historical elements that need to be afterwards re-built as original • Lack of design definitions (there is not definition of the construction site) availability and possibility of using public space
Evidence / supporting material	

Table 138: R5 – Risks and Contingency Plans (Spanish Feasibility Study)

ID / Category	R5 – Risks and Contingency Plans
Definition	Identifying potential risks (e.g., financial, logistical, regulatory) and existing contingency plans to mitigate the risks identified. By addressing challenges in establishing, operating, and scaling the pop-up factory we can improve the stability of its timeline/life-cycle.
Question (s)	What are the key risks affecting the implementation of the pop-up factory, logistics, workforce capacity, material availability, regulatory delays)? What contingency plans are in place to mitigate these risks?
Answer	• **Risk:** Unclear requirements → **Mitigation:** Working with a familiar worker • **Risk:** Providers' capabilities → **Mitigation:** Planification • **Risk:** Raw material shortage → **Mitigation:** Storage → **Owner:** Available space → **Trigger threshold:** Planification • **Risk:** Temporary regulations due to political priorities → **Mitigation:** Alternative workflows • **Risk:** Insufficient availability of skilled workers for assembling prefabricated components may delay operations → **Mitigation:** Planification

Evidence / supporting material	

Table 139: R6 – Site Requirements and Logistics (Spanish Feasibility Study)

ID / Category	R6 – Site Requirements and Logistics
Definition	Understanding the specific site-related details necessary for an effective operation of the pop-up factory. Includes assessing available space, infrastructure (e.g., access to roads, utilities and so on), in parallel with logistical challenges (e.g., materials transport and site access.
Question (s)	**Space requirements:** What space is required (m²) for: manufacture / assembly / storage / staging-loading? **Access constraints:** What access constraints apply? • vehicle type/size/weight limits (text or numbers) • delivery time windows (hours/days) • road restrictions / low-emission zone (LEZ) / permits needed (Y/N + name) • public space required (Y/N) **Utilities -** Provide: • power requirement (kW + single/three-phase) • water needed (Y/N + connection type or liters/day) • drain needed (Y/N + where it discharges) • internet needed (Y/N + minimum requirement if any) **Waste handling:** What waste streams occur and who is responsible for collection/disposal? **Provider responsibility:** Who provides/installs utilities and how long does it take? (entity + setup time) **Special items:** Are any of these required? (Y/N + details) • containers (#) • crane access (Y/N) • security/lockable room (Y/N) • fencing (Y/N)
Answer	**Space required (m²):** • Assembly 130 • Storage 223m2 • Staging/loading crane **Access constraints:** • vehicle type: trucks, cars… • time windows: 9:00-16:00 • road limits: access restriction, high and width • public space needed Y **Utilities**: • Power [kW + phase] >35 • Water (Y/N) Y • Drain (Y/N) Y • Internet (Y/N) Y

	Waste streams + responsible party: construction manager **Who provides utilities/setup**: Construction manager **Special items (if any)**: • containers [#] 4 • crane needed (Y/N) Y • security (lockable room) (Y/N) Y
Evidence / supporting material	

Table 140: R7 – Sustainability Considerations (Spanish Feasibility Study)

ID / Category	R7 – Sustainability Considerations
Definition	Exploring the strategies employed by the pop-up factory to minimize waste, optimize energy use, and integrate renewable or local materials. Also examining how the factory aligns with regional sustainability goals, such as decarbonization and circular economy practices.
Question (s)	**Top measures:** List max 3 sustainability measures planned (short bullets). **KPI selection:** Which 2–3 KPIs will you track? (tick): CO_2e / waste diverted / reuse rate / energy use (kWh) / water use / other (specify). **Targets:** For each chosen KPI, what is the target value (or "TBD")? **Reuse scope** (if applicable): Which materials/components are reused (top 3) and what acceptance criteria/certification applies? **Energy approach:** What is the renewable energy approach? (on-site / green purchase / mix) and target % renewable. **Logistics decarbonization:** What is the approach (routing, consolidation, low-emission vehicles) and what logistics KPI will be tracked (km/CO_2e/other)?

Answer	**Main sustainability measures (max 3):** 16. Possibility of materials re-use, WOOD 17. Logistics, adapt industrialised product on-site to specific requirements 18. **KPI tracking (choose 2–3):** ☐ CO_2e ☐ waste diverted ☐ reuse rate ☐ energy use ☐ water use ☐ other: **KPIs target values (if known): none** **Materials reuse scope (if applicable):none** (which products/components; acceptance criteria/certification) **Energy approach:** Technical evaluation, there is not a certification **Logistics decarbonization approach:**
Evidence / supporting material	

Table 141: R8 – Scalability and Adaptability (Spanish Feasibility Study)

ID / Category	R8 – Scalability and Adaptability
Definition	Evaluating the factory model's ability to scale and adapt to different regions, project types, or production needs. It identifies barriers to scaling and the necessary adjustments for broader implementation while ensuring flexibility for diverse applications.
Question (s)	**Scaling approach:** Choose the scaling approach (tick): replicate sites / increase capacity at one site / multi-site coordination / other (specify). **Scalability thresholds:** Provide numerical thresholds (write "N/A" if not applicable): • max distance (km) • max storage duration (days) • max volume (units/week or m²/week) • other limiting metric (e.g., district size: #dwellings or renovation volume) **Adaptability mechanism:** How is adaptability achieved? (choose): standardized process / modular equipment / digital tools / other (specify). **Digital tools:** Which tools/software are used (names) OR list required features (documentation/sales/stock control). **Coordination owner:** Who coordinates replication/multi-site planning (name/role/entity)?

Answer	**Scaling approach:** ☒ replicate sites ☐ increase capacity at one site ☐ multi-site coordination ☒ **other**: Technical evaluation, there is not a certification **Scalability limit/threshold (numbers):** • distance [km] [ ] not available data • storage duration [days] [ ] not available data **Adaptability mechanism:** standardized process / modular equipment / digital tools / **Digital tools used (names or required features):** Autodesk Revit **Coordination owner:** None.
Evidence / supporting material	

10.1.11. Part B: Feasibility Assessment

For each row, select one outcome (F/C/N), add 1–2 sentences (or bullets) explaining why, and reference supporting evidence using Annex (or write N/A). If "Conditional," state the condition(s) required and who is responsible.

Status: Feasible **(F)**, Conditionally Feasible **(C)**, Not feasible **(N)**.

Scoring and thresholds (manual):

- F (Feasible) = 2 points
- C (Conditionally feasible) = 1 point
- N (Not feasible) = 0 points

How to calculate each dimension score:

- Count the number of F, C, and N selections in the table.
- Dimension score = (2 × #F) + (1 × #C).
- Maximum score = 2 × (number of rows in the dimension).
- Dimension percentage = Dimension score / Maximum score × 100%.

Gate (must-pass) rows:

Rows marked with 🔒 are non-negotiable prerequisites. If any 🔒 row is scored N, the dimension is NOT FEASIBLE (and the overall decision in Part C should normally be NO-GO unless that row can realistically be changed to C/F with clear conditions).

Suggested thresholds (per dimension):

- FEASIBLE: ≥ 75% and no 🔒 row scored N
- CONDITIONAL: 50–74% and no 🔒 row scored N
- NOT FEASIBLE: < 50% or any 🔒 row scored N

B1 – Technical Feasibility

Table 142: Technical Feasibility Assessment (Spanish Feasibility Study)

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
Process configuration	Are the PuF processes (factory-side, close-to-site, on-site assembly/services) clearly defined and workable in this location?	☒F ☐C ☐N	Assembly factories are not theoretically defined but they are precisely defined by the workflow definition.	
Technology readiness	Are the required technologies/equipment mature (proven) and available/procurable within acceptable lead times for the remote context?	☒F ☐C ☐N	It is affordable due to there is not specific technologies/equipment needed.	
🔒 Space & infrastructure	Is sufficient space available for work zones, storage and loading/unloading, with required utilities (power/water/drainage/internet) at the proposed site(s)?	☒F ☐C ☐N		
🔒 Quality & certification	Can outputs and processes comply with applicable standards/certification requirements (e.g., QA procedure, documentation, traceability)?	☒F ☐C ☐N	Yes, a quality traking if it previously defined.	
🔒 Skills & labour	Are required skills locally available or trainable within the	☐F ☒C ☐N	The experience based knowledge is not transferable during the feasibility period	

	feasibility period (including supervision/QA as needed)?			

B2 – Operational Feasibility

Table 143: Operational Feasibility Assessment (Spanish Feasibility Study)

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
Supply chain readiness	Are key suppliers/service providers identified and able to deliver reliably under remote constraints (lead times, minimum order quantities, transport limits)?	☐F ☒C ☐N	Suppliers are used to work under task planification even that timing related to weather can create some constrains	
Coordination capacity	Is there a clear governance/coordination setup (roles, decision rights, communication cadence) across factory–sites–suppliers–public actors?	☒F ☐C ☐N	Construction site manager is the coordinator for every and each task	
🔒 Logistics feasibility	Can inbound/outbound logistics be executed reliably (routes, ports/rail/highway access, time windows, vehicle/weight limits, weather/seasonality)?	☒F ☐C ☐N		
Operations continuity	Can operations be sustained (staffing, utilities reliability, maintenance, storage strategy) during the	☒F ☐C ☐N		

	assessment period and pilot rollout?			
🔒 Health and Safety (HS) & site operations	Can HS, traffic management and operational procedures be implemented and enforced at the factory and building sites?	☒F ☐C ☐N		
Anchor stakeholders	Is there an anchor client/launching partner and confirmed access to sites/projects to start operations as planned?	☐F ☐C ☒N	The assembly process don't respond to any stakeholder	

B3 – Legal & Regulatory Feasibility

Table 144: Legal & Regulatory Feasibility Assessment (Spanish Feasibility Study)

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
🔒 Legal classification	Is the PuF legally classifiable and compatible with local rules (e.g., temporary/permanent facility, industrial activity, construction site annex)?	☒F ☐C ☐N		
🔒 Zoning / land-use compliance	Is the proposed location permitted for the intended activities under zoning/land-use rules (including temporary use where relevant)?	☐F ☒C ☐N		
🔒 Permitting pathway & timeline	Are required permits/authorisations identifiable and realistically	☒F ☐C ☐N		

	obtainable within the needed timeline (authorities, steps, expected durations)?			
Environmental compliance	Can noise, dust, waste handling and traffic impacts comply with local regulations and any protected/heritage-area constraints?	☐F ☒C ☐N	There are several noise and traffic constrains in urban areas	
Contracting & liability	Are contracting, insurance, and liability responsibilities manageable across factory, transport and on-site works (clear allocation and coverage)?	☒F ☐C ☐N		

B4 – Financial Feasibility

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
🔒 Investment costs (CAPEX)	Are the required upfront investments realistic and fundable in this context (site setup, equipment, vehicles, ICT), given the remote constraints?	☒F ☐C ☐N		
🔒 Operational costs (OPEX)	Are ongoing operating costs sustainable (staffing, transport, rent/utility, maintenance, consumables), given local cost levels and remote penalties?	☒F ☐C ☐N		
Revenue model *(if applicable)*	Is there a viable revenue model (who pays, for what, how priced) that matches local procurement	☐F ☐C ☒N	PuF responds to required qualiti/time scheduling, not to revenue model	

	practices and PuF delivery scope?			
Break-even *(if applicable)*	Can break-even be realistically reached within the intended time horizon (pilot vs long-term), given expected demand and cost structure?	☐F ☒C ☐N	From the begginign of a builidgn design process until its constructions can take 3-4 years, so adapting the process requires longer time periods.	

B5 – Market / Demand Feasibility

Assessment Topic	Feasibility Question	Outcome (choose one)	Reasoning (1-2 sentences)	Evidence (Annex cross-ref only or N/A)
🔒 Fit to project scale *(Demand volume)*	Is there sufficient renovation demand in the target area to justify operating the PuF at the intended capacity (target volume/time period)?	☐F ☐C ☒N		
🔒 Fit to project scale *(Demand continuity)*	Is demand continuous (multi-year pipeline/portfolio) rather than one-off/project-based, so the PuF can operate reliably over time?	☐F ☐C ☒N		
Client willingness	Are key clients (owners/housing providers/municipalities) willing to adopt PuF delivery (contracting, access, scheduling, site interfaces)?	☐F ☐C ☒N		
Ecosystem fit	Is the PUF aligned with the broader network of actors in the renovation market (housing corporations, municipalities, contractors, suppliers and	☐F ☐C ☒N		

	residents) and with governance or procurement arrangements/ trust and neutrality considerations?			

10.1.12. Part C: Feasibility Summary

1.1.1.5 C1 – Blocking Issues, Risks, and Mitigation

*List only the **top 5–10 blocking issues** that can prevent implementation. For each, assign, a category, an owner, one concrete mitigation/contingency action and rate its impact.*

Issue/Risk	Category (Market/Tech/Ops/Legal/Financial)	Impact (High/Medium/Low)	Owner/ Responsible	Mitigation / Contingency
TBD	TBD	TBD	TBD	TBD

1.1.1.6 C2 – Decision Summary and Next Steps

Step 1: Summarise Part B results
Scoring: F=2, C=1, N=0 → Score = 2×#F + 1×#C. Max = 2×Rows → % = (Score/Max) × 100.

Table 145: Summary Table - Suggested thresholds (per dimension): FEASIBLE: ≥ 75% and no 🔒 row scored N; CONDITIONAL: 50–74% and no 🔒 row scored N; NOT FEASIBLE: < 50% or any 🔒 row scored N

Dimension	Rows	#F	#C	#N	Score	Max	%	Result
B1 Technical feasibility	5	4	1	0	9	10	90	☒F ☐C ☐N
B2 Operational feasibility	6	4	1	1	9	12	75	☒F ☐C ☐N
B3 Legal & regulatory feasibility	5	3	2	0	8	10	80	☒F ☐C ☐N
B4 Financial feasibility	4	2	1	1	5	8	62,5	☐F ☒C ☐N
B5 Market & demand feasibility	4	0	0	4	0	8	0	☐F ☐C ☒N

OVERALL SCORE	-	-	-	-	31	61,5	☐F ☒C ☐N

Step 2: Final Decision
Choose exactly one decision (GO / CONDITIONAL GO / NO-GO) based on your final overall score in above table. If CONDITIONAL GO, list measurable conditions and a deadline; if NO-GO, list the non-negotiable constraints causing the decision.

☐ GO - Implementable with no major unresolved blockers.
☒ CONDITIONAL GO - Implementable if the conditions below are met by the deadline.
☐ NO-GO - Not implementable due to hard constraints or unacceptable risk.

Conditions (if Conditional GO): _____

Hard constraints (if NO-GO): _____

Decision owner (name/org): _____

C3 – Feasibility Study Summary (maximum one page)

The Assembly Pop-up Factory (PuF) assessed in this study is located in **Pamplona, Navarra (Spain)**, targeting the complete deep renovation of public and heritage buildings through on-site assembly of prefabricated CLT-based components, at a target throughput of 52.5 m²/day. The remote context doesn't reply in this case rather than the viability study is developed for this PuF where a heritage sensitivity, strict noise/working-hours regulations, and urban crane restrictions, though proximity to logistics infrastructure (5 km to nearest hub) is adequate.
Part A findings indicate a technically workable process relying on subcontracted skilled trades with low equipment CAPEX, but a notable absence of confirmed clients, financing structures, or defined stakeholder partnerships. Market demand data is unavailable, and no pipeline of renovation projects has been identified.
Part B assessments yield strong results for Technical (90%), Operational (75%), and Legal/Regulatory (80%) dimensions, but Financial feasibility is only Conditional (62.5%) due to an undefined revenue model, and Market/Demand feasibility scores 0% — all four rows rated Not Feasible — representing the critical blocker.
The **final decision is CONDITIONAL GO**. Progression requires: (1) identifying and confirming anchor clients or a renovation demand pipeline; (2) defining a viable revenue and contracting model; and (3) securing at least one committed public or private project to validate operational assumptions. These cosnditions must be resolved before pilot implementation begins.