



**BuildUPspeed**

***Italian Ecosystem: Satellite Factory Factsheet***

03.06.2026

# Terminology

Term	Definition
<b>Pop-up factory (PuF)</b>	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. A factory in the district itself for the time of the district retrofitting program. The factory will develop and assemble industrialized prefab building components that will be installed in the retrofitting projects.
<b>On-site</b>	Refers to the closeness of the pop-up factory to the construction project. Usually, it means that the factory itself is located in close proximity to the construction site (usually up to district or regional level).
<b>Off-site</b>	The opposite of on-site concept, where a factory is located in a different geographical area from the construction site.
<b>Service</b>	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.
<b>Manufacturing</b>	(Pre-)Fabrication of materials/products used for construction projects.
<b>Assembling</b>	Assembly of (pre-)fabricated materials/products used for construction projects.
<b>Temporary structure</b>	When a pop-up factory is set-up in a temporary way, e.g. housed in a container, industrial tent or modular building.
<b>Permanent structure</b>	When a pop-up factory is set-up in a permanent building, e.g. in an abandoned building, old industrial building.
<b>Just-in-Time (JIT) delivery</b>	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.

# Overall PuF Concept Background

Table 1: Pop-up Factories Key Features Comparison

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

## 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 2) 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 2: Checklist criterion 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)
<b>Purpose</b>						
P1	Provides localised manufacturing and assembly of construction components and systems in a specific region or district			<input checked="" type="checkbox"/>		
P2	Supports more extensive manufacturing facilities by producing components or products in a more decentralised manner on a local scale		<input checked="" type="checkbox"/>			
P3	Assembles (pre)fabricated components locally				<input checked="" type="checkbox"/>	
P4	Provides specific services related to construction and renovation projects					<input checked="" type="checkbox"/>
P5	Produces customised components on-site	<input checked="" type="checkbox"/>				
P6	It aims to create jobs and boost economic growth locally.			<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
P7	Provides JIT delivery for specific projects	<input checked="" type="checkbox"/>				
<b>Design</b>						
D1	Mobile, easily transportable structure	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			
D2	Semi-permanent structure			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
D3	Temporary structure	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
D4	Permanent structure			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
D5	Uses innovative and flexible manufacturing processes	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			
D6	High level of automation and precision		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
D7	Uses sustainable and eco-friendly solutions			<input checked="" type="checkbox"/>		
<b>Scale</b>						
S1	Large-scale manufacturing		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
S2	Small-, medium-scale manufacturing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			
S3	Large-scale assembling		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
S4	Small-, medium-scale assembling	<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>	
<b>Location</b>						
L1	Near the construction site (on-site)	<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
L2	District level		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
L3	Within proximity (regional level)		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
L4	Off-site (away from the construction site)		<input checked="" type="checkbox"/>			

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:

- 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. 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.

# 1 Italian Ecosystem PuF Development Storyline

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 m<sup>2</sup> 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.

## 2 Satellite Factory Factsheet

### 2.1 Scenario & Strategy

<b>PuF type</b>	Satellite Factory based on a main hybrid offsite precast factory and smaller close-to-site finishing / integration satellites.
<b>PuF purpose</b>	Produce the main concrete panels in major hybrid factories and integrate more fragile components close to the building site before onsite assembly.
<b>Deep renovation / reuse scope</b>	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.



<b>Priority components</b>	RECOskeleton 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.
<b>Target building typology</b>	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.
<b>Design intent</b>	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.
<b>Best-fit conditions</b>	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.

## 2.2 Factory Layout & Production Logic

<b>Factory typology</b>	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.
<b>Production workflow</b>	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.
<b>Production lines / component handling</b>	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.
<b>Dimensions / space allocation</b>	Indicative main factory: about 12,000 m <sup>2</sup> production area, plus about 20,000 m <sup>2</sup> storage for panels. Working areas include batching plant (1,500 m <sup>2</sup> ), steel working (1,500 m <sup>2</sup> ), tilting tables (2,000 m <sup>2</sup> ), battery moulds (2,000 m <sup>2</sup> ), hollow-core slabs (3,000 m <sup>2</sup> ), stairs (500 m <sup>2</sup> ), panel finishing (2,000 m <sup>2</sup> ) and storage with overhead cranes (19,300 m <sup>2</sup> ).
<b>Operational scale</b>	Annual capacity: about 80,000 m <sup>2</sup> retrofit/internal insulated walls, 85,000 m <sup>2</sup> new-construction external walls, 40,000 m <sup>2</sup> hollow-core slabs, 3,400 m <sup>2</sup> staircases with landing and 9,000 m <sup>2</sup> balconies.
<b>Installation productivity</b>	RECOskeleton panels are expected to be installed at about 200 m <sup>2</sup> /day. A 2,000 m <sup>2</sup> facade, such as the Viale Omero reference building, can therefore be renovated in roughly 10 installation days, excluding preparation and finishing works.

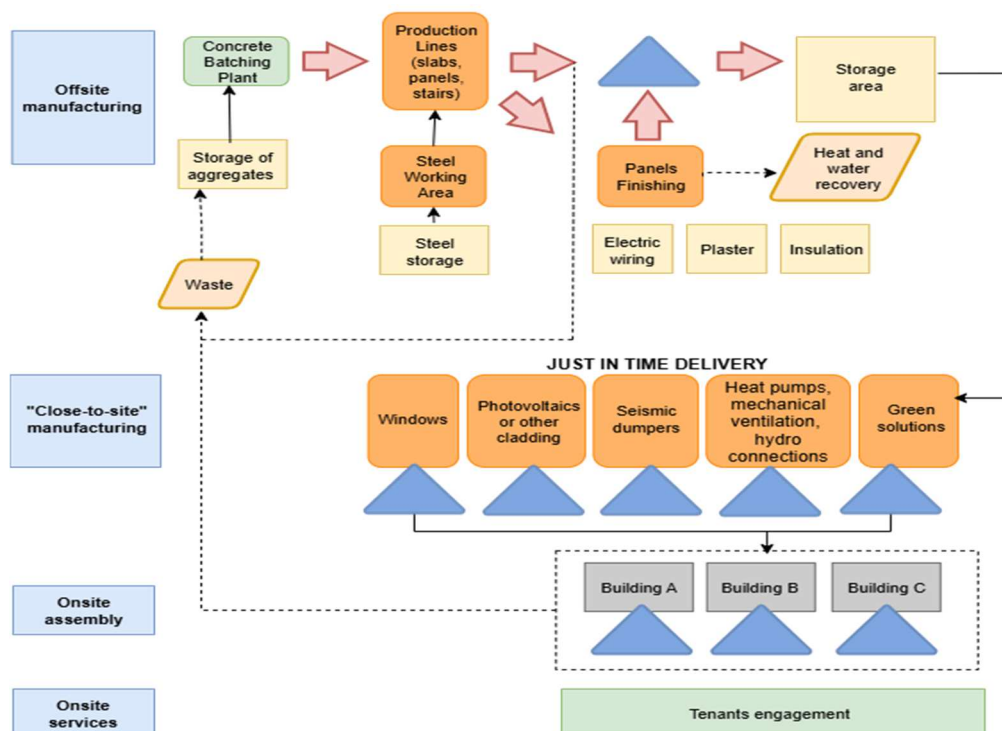


Figure 1: Satellite Factory - Tailored Design

## 2.3 Resources & Utilities

<b>Power &amp; electricity</b>	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.
<b>Water &amp; sanitation</b>	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.
<b>Heating, cooling &amp; ventilation</b>	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.
<b>Digital infrastructure</b>	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.
<b>Equipment and materials</b>	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.

## 2.4 Site & Logistics

<b>Site preconditions</b>	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.
<b>Access constraints</b>	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.
<b>Supply chain integration</b>	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.
<b>Storage &amp; buffer strategy</b>	Large panel storage is located at the main factory. Local finishing satellites work with small JIT buffers, typically around 80-100 m <sup>2</sup> and 1-3 days of storage, to avoid large intermediate stock.
<b>Waste handling</b>	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.
<b>Last-mile logistics</b>	One truck can usually carry 4-6 panels of about 28 m <sup>2</sup> 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.

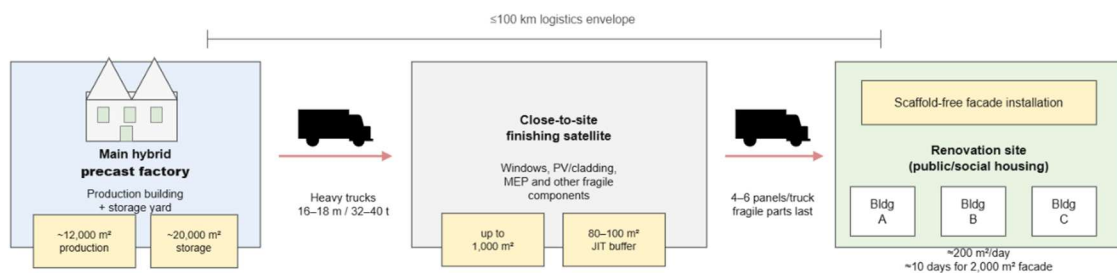


Figure 2: Indicative satellite-factory logistics setup linking the main hybrid precast factory, close-to-site integration facilities and the renovation site.

## 2.5 Actors, Roles & Governance

<b>Factory owner / operator</b>	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.
<b>Client / contracting authority</b>	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.
<b>Contracting and payment</b>	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.
<b>Demand-side partners</b>	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.
<b>Supply-side partners</b>	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.
<b>Financing / O&amp;M partners</b>	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.

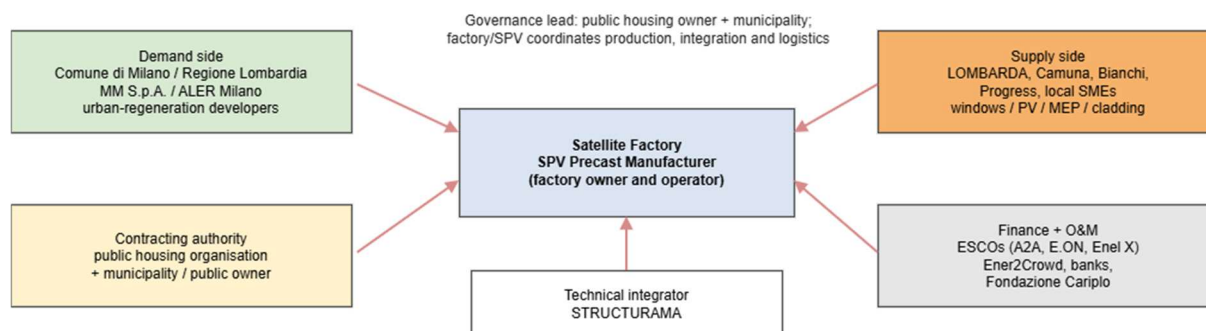


Figure 3: Stakeholder and governance structure of the Italian Satellite Factory.

## 2.6 Labour Force & Required Skills

<b>Typical team</b>	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.
<b>Core roles / indicative FTE</b>	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.
<b>Skills and certifications</b>	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.
<b>Training needs</b>	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.
<b>Labour sourcing</b>	Combination of factory employees, external HR recruitment, local SMEs, subcontractors for windows/PV/MEP/cladding and specialised installation teams.
<b>Shift model</b>	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.

## 2.7 Legal & Regulatory Requirements

<b>Factory building permit</b>	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.
<b>Environmental authorisation</b>	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.
<b>Building, safety and noise rules</b>	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.
<b>Compliance responsibility</b>	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.
<b>Incentives / subsidies</b>	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.

## 2.8 Cost Structure

<b>CAPEX</b>	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.
<b>OPEX</b>	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.
<b>Cost basis</b>	Reported production cost basis: about 510 EUR/m <sup>2</sup> for retrofit panels and 335 EUR/m <sup>2</sup> for new-construction elements.

<b>Price / value basis</b>	Reported price basis: about 790 EUR/m <sup>2</sup> for retrofit panels and 450 EUR/m <sup>2</sup> for new-construction elements, understood as the price per m <sup>2</sup> 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/m <sup>2</sup> of floor area.
<b>Revenue / value logic</b>	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.
<b>Financing model</b>	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.

## 2.9 Lifecycle & Time Schedule

<b>Setup &amp; commissioning</b>	Approx. 21 months overall for project funding, permitting, detailed design and engineering, procurement, factory construction, production-line installation, commissioning and start-up.
<b>Main setup milestones</b>	Funding secured: about 3 months. Permits approved: about 4 months. Design freeze: about 3 months. Factory construction, machinery installation and commissioning: about 14 months.
<b>Panel production and integration</b>	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.
<b>Operational phase</b>	A full onsite retrofit phase is estimated at about 3 months, including site setup, demolitions/surface preparation, foundation works, RECOskeleton panel installation, roof/balcony/basement works and MEP connection. Panel installation itself is around 200 m <sup>2</sup> /day.
<b>Decommissioning / relocation</b>	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.
<b>Main dependencies</b>	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.

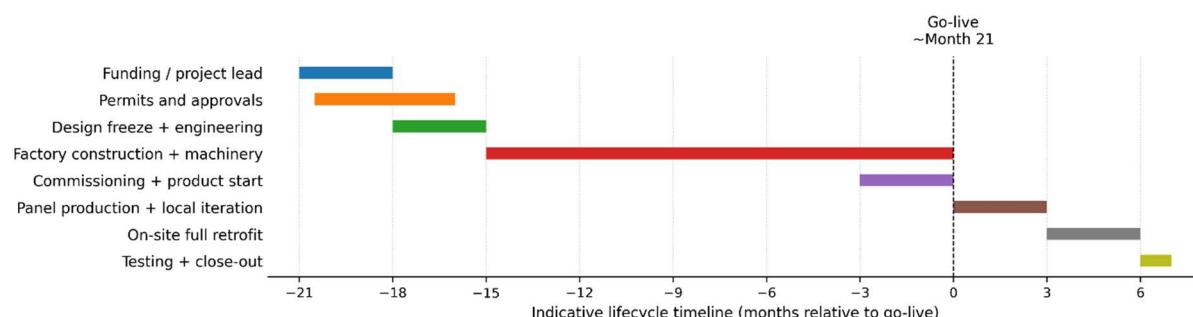


Figure 4: Indicative lifecycle timeline for the Italian Satellite Factory, from funding and permitting to production, onsite retrofit and close-out.

## 2.10 Risks & Contingencies

<b>Financing / project leadership delay</b>	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.
<b>Workforce availability</b>	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.
<b>Capacity under-utilisation</b>	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.
<b>Production rigidity</b>	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.
<b>Energy and material price volatility</b>	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.
<b>JIT logistics and installation disruption</b>	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.

## 2.11 Scalability & Impact

<b>Scalability approach</b>	Scale by replicating sites, increasing capacity at one site, adding shifts or production lines, and coordinating multiple close-to-site finishing partners.
<b>Distance threshold</b>	Approx. 100 km maximum panel-transport distance from the main factory to the building site, including deviations for component integration.
<b>Storage threshold</b>	Close-to-site storage is intended to remain minimal: around 1-3 days of JIT buffer and about 80-100 m <sup>2</sup> local storage where possible.
<b>Volume threshold</b>	Indicative maximum annual capacity: 80,000 m <sup>2</sup> retrofit panels, 85,000 m <sup>2</sup> new-build external walls and 40,000 m <sup>2</sup> new-build slabs. Above this, a new factory, extra line or additional shift is needed.
<b>Adaptability mechanism</b>	Concrete production can be reconfigured with standardized processes and modular equipment to produce different precast elements for renovation, housing, infrastructure, tertiary or industrial buildings.
<b>Digital / coordination tools</b>	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.
<b>Environmental and social impact</b>	Targets include -20% logistics-related CO <sub>2</sub> e per building, at least 15% waste diversion for packaging/pallets/concrete scraps, -10% kWh per m <sup>2</sup> 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.

## 2.12 Contextual requirements for PUF application

Table 3: Contextual requirements as identified through the comparative analysis, retrieved from ecosystem's report Task 4.5.

Characteristic	Description
Multi-purpose Assembly PUF	The assembly PUF is applicable in various environments, such as stimulating re-use, stimulating efficiency and standardisation, and industrialising production whilst maintaining flexibility.
Energy performance	Improvements of energy performance of buildings is a consistent objective across PUF applications in various ecosystems.
Material re-use	Re-using materials during deep-renovation is difficult in traditional approaches due to logistical problems. The PUFs lend itself to stimulate re-use of materials and thereby avoiding additional embodied carbon emissions by the low proximity and extra logistical services it provides.
Institutional organisation of renovation	Important in the application of PUFs is the role of the government in facilitating large-scale renovations and projects, stimulating the need for adoption and application of the PUF.

## 2.13 General implementation of PUFs

Table 4: The general deduction of all ecosystem's business model canvasses, retrieved from the ecosystem's Task 4.5 report.

Pop-up Factory		
Value creation	<b>Value proposition</b>	<i>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.</i>
	<b>Customer relationships</b>	<i>The way the PuF interacts with clients (e.g. housing associations, contractors), often involving long-term</i>

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

## 3 Evaluation Questions for Assembly Factory Factsheet

Please review the attached PuF factsheet and answer the questions below. The aim is to assess whether the PuF concept is understandable, feasible, useful, and replicable in different local contexts.

For Questions 1–8, please use the scale:

**1 = Very low / strongly disagree**

**2 = Low / disagree**

**3 = Moderate / neutral**

**4 = High / agree**

**5 = Very high / strongly agree**

### 3.1 Concept clarity and relevance

1. **Clarity:** How clear and understandable is the PuF concept described in the factsheet?

Score: [1–5]

Optional comment:



2. **Relevance:** How relevant is this PuF concept for renovation, deep renovation, or circular construction activities in your context?  
Score: [1–5]  
Optional comment:
3. **User need:** Does the PuF concept respond to a real need or bottleneck in the renovation market?  
Score: [1–5]  
Optional comment:

### 3.2 Implementation feasibility

4. **Technical feasibility:** How feasible does the proposed PuF setup seem from a technical and operational perspective?  
Score: [1–5]  
Optional comment:
5. **Partner and governance feasibility:** Are the required actors, roles, and responsibilities realistic and complete enough for implementation?  
Score: [1–5]  
Optional comment:
6. **Legal and regulatory feasibility:** Are the legal, permitting, compliance, and policy aspects sufficiently clear for implementation?  
Score: [1–5]  
Optional comment:
7. **Economic feasibility:** Are the cost structure, financing logic, and value proposition convincing enough to support implementation?  
Score: [1–5]  
Optional comment:

### 3.3 Replication and scalability

8. **Replicability:** How easy would it be to replicate or adapt this PuF concept in another region, project, or market context?  
Score: [1–5]  
Optional comment:
9. **Main conditions for replication:** Which conditions are most important for this PuF concept to work?  
Please select up to three:
  - Sufficient renovation demand / project pipeline
  - Similar building typologies
  - Available local partners / SMEs
  - Skilled labour availability
  - Suitable site space and logistics
  - Permits and supportive regulations
  - Access to financing or subsidies
  - Digital tools / data availability
  - Market demand for circular or industrialized solutions
  - Other: [please specify]

10. **Main barriers:** What are the most important barriers or risks for implementing this PuF concept?

Please select up to three:

- High upfront costs
- Unclear business model
- Lack of skilled workers
- Lack of suitable partners
- Legal or permitting uncertainty
- Limited site space
- Logistics complexity
- Low market demand
- Lack of standardization
- Difficulties with resident/user acceptance
- Other: [please specify]

### *3.4 Impact and added value*

11. **Expected added value:** What do you see as the main added value of this PuF concept?

Please select up to three:

- Faster renovation process
- Lower renovation costs
- Better quality control
- Reduced disruption for residents/users
- Lower transport or logistics impact
- Higher circularity / reuse
- Lower CO<sub>2</sub> emissions
- Local employment or skills development
- Better coordination between stakeholders
- Other: [please specify]

12. **Most useful factsheet information:** Which parts of the factsheet were most useful for evaluating the PuF concept?

Please select up to three:

- Scenario & strategy
- Factory layout and production logic
- Resources and utilities
- Site and logistics
- Actors, roles and governance
- Labour force and skills
- Legal and regulatory requirements
- Cost structure
- Lifecycle and time schedule
- Risks and contingencies
- Scalability and impact

### 3.5 Improvements and platform relevance

13. **Missing information:** What information is still missing or unclear in the factsheet to properly assess the PuF concept?
14. **Suggested improvements:** What should be improved in the PuF concept, factsheet, or blueprint to make it more useful for future users?
15. **Digital platform support:** Which functionalities should a digitized market activation platform provide to support this PuF concept?  
Please select up to five:
- Match renovation demand with PuF solutions
  - Identify suitable local partners / SMEs
  - Compare PuF scenarios and suitability
  - Estimate costs and financing options
  - Support permit and regulatory checks
  - Support logistics and site planning
  - Provide standard templates / blueprints
  - Track sustainability KPIs
  - Support circular material or product matching
  - Support stakeholder communication
  - Other: [please specify]
16. **Final recommendation:** Would you recommend further development or testing of this PuF concept?
- Yes
  - Yes, but only with major adaptations
  - Not sure
  - No

Please briefly explain your answer: