Life Giga Regio Factory

Guide to scaling industrialised retrofit

Co-funded by the European Union

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Project Acronym: LIFE Giga Regio Factory

Project full name: Life Giga Regio Factory: going next stage in market uptake and factory development for more affordable Net Zero energy Retrofit industrialised solutions

Guide to scaling industrialised retrofit

Industrialised and off-site retrofit ecosystems

This guide has been developed within the LIFE Giga Regio Factory project to support the scaling of industrialised and off-site energy renovation in Europe. It focuses on integrators and industrial actors involved in the design, production and deployment of off-site retrofit solutions, and provides a methodological and operational reading of the conditions required to move from pilot projects to scalable industrial approaches.

The document is intended for manufacturers, integrators and construction companies, as well as public authorities, housing providers, clusters and market facilitators involved in the development of industrialised retrofit.

Scope and positioning of the report

This public guide builds on analytical work and industrial support activities carried out throughout the project, including feedback from supported companies, pilot projects and cross-country observations.

It consolidates these elements into a standalone, public-facing document, with a strong focus on product and system logics, industrial organisation and ramp-up strategies, business models, and partnership dynamics for scaling industrialised retrofit.

No confidential or company-identifiable data are disclosed.

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1. Preamble

Europe faces a double challenge: **to drastically reduce its greenhouse gas emissions** and **to improve the quality of life of millions of citizens**. The building sector, which is responsible for around 40% of energy consumption and a third of CO_2 emissions, is at the heart of this transformation. Efficient renovation of housing is therefore not an option: it is an environmental, social and economic imperative. But the scale of the needs (millions of homes to be treated by 2050) requires us to rethink our methods.

In this context, the **industrialization of renovation** appears to be a strategic solution. By relying on prefabricated components (facades, roofs, technical modules, sanitary pods, etc.) and proven processes (digitalization, Lean, continuous improvement), it reduces **the duration of construction sites**, **limits nuisance for occupants**, **improves the quality of implementation** and **guarantees performance over time**. It also paves the way for a **low-carbon** approach, integrating bio-based materials, logistics optimization and waste reduction.

This guide is primarily aimed at **manufacturers** and **renovation and construction companies** who wish to structure or strengthen their offer. It also provides valuable benchmarks for **architects**, **project owners**, **design offices** and **public stakeholders**. Everyone will find the keys to:

- Better understand the conditions for the success of massification,
- Anticipate the obstacles encountered in the field,
- Explore possible business models,
- And to project ourselves into the prospects for 2030 and 2050.

Based on **feedback from France, Germany, Belgium and Italy**, and enriched with **practical resources, operational recommendations and inspiring examples**, this document is intended to be both educational and pragmatic. It is not limited to an inventory, but proposes concrete levers to **collectively organise the sector, standardise solutions and build a robust and sustainable European value chain**.

The ambition is clear: to make the industrialisation of high-performance renovation not an innovative niche, but a **reference model**, capable of responding to the climate emergency, social constraints and the economic imperatives of the energy transition.

2. Synthesis – Why and how to scale industrialised retrofit?

This guide is part of the Life Giga Regio Factory project. It aims to provide a strategic and operational vision to industrialists and companies wishing to get involved in mass energy renovation via off-site solutions. It is aimed at both actors already engaged in this dynamic and those who wish to understand the opportunities, challenges, economic models and conditions for success.

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1. Why off-site renovation?

The massification of energy renovation is an environmental, social and economic imperative. To meet this challenge, off-site construction (prefabricated facades, roof boxes, MEP modules, sanitary pods, etc.) offers major advantages:

- Reduction of construction time,
- Limitation of nuisance for occupants,
- Improved installation quality and performance,
- Industrialization compatible with the environmental move upmarket (bio-based materials, waste reduction).

As previous guides for landlords and companies have shown, off-site renovation is not only a technical innovation: it offers a systemic response to the challenges of deadlines, costs and performance. It combines **both industrialized components** and **structured processes** like digitalization (BIM, scan-to-BIM), Lean methods, continuous improvement which constitute the essential combination to make production more reliable and guarantee reproducibility.

For this approach to truly change scale, it remains to remove several industrial, cultural and regulatory barriers, and to structure a sector capable of cooperating and innovating collectively.

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2. The obstacles to be removed

a. Non-interoperability of solutions

Today, each company designs its own specific solutions, which are often difficult to use elsewhere. There are no shared standards for technical components (fastening systems, interfaces, installation protocols), nor for other key dimensions such as **digital tools** (e.g. 3D scanning, BIM) or **performance and service** monitoring systems.

This absence does not call into question the ability of each player to develop an efficient and industrialized solution on its own, but it strongly limits **"doing together"**: reproducibility, interoperability and cooperation between companies. On the contrary, common technical standards would make it possible to create a shared language, accelerate projects and strengthen confidence in the sector.

b. Unstable and difficult to read market

The renovation market is still marked by:

- Low medium-term visibility
- Strong constraints on occupied sites
- Demanding standards (fire, acoustic, thermal, etc.)
- Long deadlines and complex administrative processes (e.g. MOP law, filing of building permits, verification of control offices, etc.).

c. Difficult profitability without a complementary activity

The production of facades for renovation alone is not enough to make an industrial tool profitable. Diversification (new, elevated, tertiary) is often essential for the industrial asset to run continuously AND thus smooth out operating costs.

d. Defining a "product"

Manufacturers must move away from the logic of tailor-made solutions to think of "products" adapted to the most common typologies. A high-performance off-site product requires:

- Repeatability
- Standards (performance, services provided, thickness, weight, components, etc.)
- A logic of continuous improvement, and not of reinvention with each operation.

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3. Emerging models

European examples (the Netherlands, Germany, France, Italy) show that massification is possible when:

- Public actors aggregate their orders (e.g. groups of social landlords)
- Manufacturers are developing a range of reproducible solutions
- Clear project governance is established from the design phase.

Recent feedback (conducted with project owners such as Vilogia and Est Métropole Habitat, but also with solution providers such as Vinci Rehaskeen in France and Woodbeton in Italy) shows that off-site renovation allows:

- Projects whose duration is divided by two or three
- Smoother management of technical interfaces
- A noticeable improvement in summer and winter comfort and overall performance.

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4. Medium-term opportunities

According to climate and political projections (SNBC, ADEME scenarios, MASE and ISPRA), the volumes of renovation required by 2030 and 2050 largely justify structuring industrial investments. Schemes such as the SGPE, France Nation Verte, the Italian PTE Eco Transition Plan, or European aid can partly secure these markets.

The sector must therefore:

- Consolidate its modelling tools
- Better integrate feedback
- Continuously train its teams in off-site logic.

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5. Towards a cooperative model

The success of this transformation is also based on:

- The development of territorial industrial partnerships: business groups, pooling of logistics and manufacturing, shared R&D
- Enhanced dialogue with project owners, to clarify expectations (particularly in terms of target cost), deadlines and possibilities for adaptation

- Collective skills development through tools such as the Business Plan Tool (BPT), group training and visits to completed projects and factories.

Conclusion

This guide aims to provide a clear overview of the issues, constraints and levers of action to accelerate off-site renovation. It invites manufacturers to integrate this change as a pillar of their long-term strategy, in a structured, cooperative and low-carbon sector. It is also intended to provide practical support, with tool sheets, operational benchmarks and concrete testimonies from the field.

Content

3. Glossary / Glossary

A

ATEx (Technical Assessment of Experimentation)

Procedure issued by the CSTB in France to temporarily evaluate innovative products or systems in the absence of established standards.

B

BIM (Building Information Modelling)

A set of digital processes for creating, managing and operating an intelligent 3D model of the building, integrating technical, structural and energy data.

Building typology

Classification of buildings according to architectural, constructive, use or period criteria, allowing renovation solutions to be adapted.

Business Model Tool

A tool to help with the economic structuring of an offer or a project, used in GRF to help manufacturers model their investments, costs, margins and profitability points.

C

CAPEX (Capital Expenditure)

All expenses related to the acquisition or improvement of durable assets (plants, equipment, infrastructure). In the context of off-site, this refers for example to the investments needed to set up prefabrication lines or new industrial units.

Carbon Neutrality

A state in which CO_2 emissions are fully offset by equivalent removals (via carbon sinks, forests, etc.).

CINEA (European Climate, Infrastructure and Environment Executive Agency)

The European Commission agency responsible for the implementation of climate and energy programmes, including LIFE.

Civil liability

Insurance protecting a company against damage caused to third parties in the course of its activity.

CMV (Controlled Mechanical Ventilation)

Device ensuring the renewal of indoor air. In the single-flow version, it extracts stale air; in double flow, it recovers heat from the outgoing air to preheat the incoming air.

Co-design

Collaborative design method integrating key players (architects, manufacturers, companies, project managers) from the outset to optimize the project according to cross-constraints.

Commissioning

A systematic verification and testing procedure to ensure that a building or system achieves the expected performance in terms of comfort, safety and energy efficiency.

Consortium

Group of partners united in a European project, with distribution of tasks and deliverables among the structures involved.

CSTB (Scientific and Technical Centre for Building)

French public research and expertise establishment. It evaluates, tests and certifies construction products and processes, develops standards (ATEx, Technical Approvals) and supports innovation to guarantee safety, performance and sustainability in the building industry.

D

DfMA (Design for Manufacturing and Assembly)

Design principle aimed at making a product easier to manufacture and assemble, minimizing costs, errors and production time.

Digitizing

Process of integrating digital tools and methods into the value chain (BIM, collaborative platforms, automation).

DO (Structural Damage)

Compulsory insurance covering the cost of repairs related to serious disorders affecting the solidity or use of a building, without waiting for liability to be sought.

DTU (Unified Technical Document)

French normative reference framework that defines the rules of the art for the design and implementation of construction works. The DTU serve as a contractual and technical basis between project owners, project managers and companies, and constitute a reference in the event of a dispute or expertise.

E

Energiesprong

Energy renovation approach developed in the Netherlands, combining guaranteed performance, industrialization, zero energy, prefabrication, and co-design.

EPD (Environmental Product Declaration)

A standardized environmental declaration of a product, used to quantify its environmental impacts according to LCA principles.

EPC (Energy Performance Certificate)

A mandatory document in France that evaluates the energy consumption of a home or building, as well as its greenhouse gas emissions. The DPE classifies the property from A (very efficient) to G (very energy-intensive) and serves as a reference for public policies, real estate transactions and energy renovation projects.

EPC (Energy Performance Contracting)

An energy performance contract committing a service provider to achieve measurable energy results over a given period of time.

F

FCBA (Technological Institute for Forestry, Cellulose, Wood-Construction, Furniture)

French research and development, certification and training organization dedicated to the wood and furniture sectors. It supports innovation, standardization and industrial structuring of wood solutions in construction and renovation.

Financing engineering

A financial package aimed at securing the investments necessary for a project, by combining grants, equity, loans or performance contracts.

FOB (Timber Frame Façade)

Construction principle using wooden frame modules or panels specifically designed to clad or insulate existing facades. The FOB is particularly suitable for off-site energy renovation, thanks to its prefabrication and its ability to integrate insulation, joinery and finishes.

G

GRF (Giga Regio Factory)

Name of the LIFE project aimed at accelerating off-site and industrialised energy renovation on a European scale.

H

HP (Heat Pump)

A heating and/or cooling system that captures the calories present in the air, water or floor and releases them back into a building, with high energy efficiency.

I

Industrialization

Process of transforming artisanal or one-off activities into reproducible, standardized, and automated processes.

Integrator

A pivotal player capable of managing an off-site renovation in its entirety: design, coordination, industrialization, logistics and performance monitoring. He structures the chain of actors around him.

Interoperability

The ability of different systems, components or tools (technical, digital, organisational) to work together without the need for major adaptations.

L

LCA (Life Cycle Assessment)

An environmental assessment method that measures the impacts of a product, service or building throughout its life cycle (from production to end of life).

Lean (Lean management or Lean manufacturing)

Industrial organization method aimed at improving performance by reducing waste (time, materials, travel, defects) and optimizing flows. In the off-site construction and renovation sector, Lean is applied both in the factory (fluid production, continuous improvement) and on site (better coordination, reduced downtime).

Learning curve

A concept describing the gradual improvement in productivity and quality through accumulated experience (the more a process is repeated, the more efficient and reliable it becomes).

M

Massification

Strategy consisting of grouping together several similar operations to create sufficient volumes for industrial investment and reduce costs.

MEP (Mechanical, Electrical, and Plumbing)

Refers to the technical systems of a building (heating, ventilation, electricity, plumbing), often integrated into off-site modules. By extension, MEP modules refer to prefabricated technical modules integrating heating, ventilation, electricity and plumbing networks and equipment, delivered ready to be connected on site.

MOB (Timber Frame House)

Construction system based on a load-bearing wooden structure, widely used in construction and renovation. The MOB is distinguished by its lightness, speed of implementation and good thermal performance.

MOP (law) – public project management

Law governing public construction contracts in France, imposing the separation of roles between project owners, project managers and companies.

MOP law (public project management)

French regulatory framework governing public construction contracts, with strict separation of roles between project owner, project manager, and contractors.

N

NZEB (Nearly Zero-Energy Building)

A building with a very high energy performance, whose low residual consumption is largely covered by renewable energies.

O

Off-site construction

A construction method where building components (e.g. facades, roofs, technical modules) are manufactured in controlled environments (factories) and then assembled on site.

Offsite

See "Off-site construction".

P

PMA (Project Management Assistance)

Role of the project owner in the definition, implementation and monitoring of a complex project.

Prefabricated façade

Wall panel manufactured off-site, often incorporating insulation, cladding, carpentry, or even technical equipment. Installed in a single operation on site.

PREFAB

A manufacturing method in which components are built outside the construction site (factory or workshop) and then assembled quickly.

Project manager (PM)

Professional or team responsible for the technical and architectural design, as well as the monitoring of the execution of a project.

Project owner (PO)

Natural or legal person commissioning the project, defining the objectives, budget, deadlines and performance criteria.

PV (Photovoltaic Panels)

Devices that produce electricity from solar energy, which can be integrated into roofs, facades or technical modules.

R

R&D (Research and Development)

Systematic activity aimed at innovating, improving or designing new technical solutions, upstream of commercialization.

REX (Feedback)

Structured analysis of a completed project to identify successes, bottlenecks, lessons learned, and transferable best practices.

Replicability

The ability of a solution to be replicated on other projects in a reliable, fast and cost-effective manner, capitalizing on previous experiences.

S

Sanitary Pods

Prefabricated modules with a complete bathroom or sanitary facilities, assembled in the factory and installed in one piece on site.

SMEs (Small and Medium-sized Enterprises)

Companies generally with fewer than 250 employees and an annual turnover of less than €50 million. They make up a large part of the French industrial and artisanal fabric.

SNBC (National Low-Carbon Strategy)

French roadmap defining the trajectory for reducing greenhouse gas emissions to achieve carbon neutrality by 2050.

SSE (Social and Solidarity Economy)

A set of organisations (associations, cooperatives, mutuals, social enterprises, foundations) that place social utility, cooperation and democratic governance at the heart of their model, rather than just the search for profit.

Standardization

The process of defining common rules, formats, or components to promote interoperability, quality, and reproducibility.

Supply Chain

All the actors, processes and resources mobilized to design, manufacture, transport and install a product, from the raw material suppliers to the construction site. In the context of industrialized renovation, the supply chain includes the management of prefabricated components, logistics (transport, storage, buffer zones), coordination with construction sites and the securing of strategic supplies.

Supply shock

Market effect created when an industrialized product is sufficiently visible, standardized and well positioned to generate its own demand (e.g. Panobloc, Element'R, BYWalli).

T

TAEx (Technical Assessment of Experimentation)

Procedure issued by the CSTB in France to temporarily evaluate innovative products or systems in the absence of established standards.

V

Very Small Business (VSE)

Structures with fewer than 10 employees and an annual turnover of less than €2 million. There are many of them in the construction sector and they play an essential role in proximity.

W

WP (Work Package)

Unit for structuring the work carried out in a European project. Each WP corresponds to a large business area with its tasks, deliverables, deadlines and leading partners.

4. Introduction

4.1. Background to the project and objectives of the guide

The Life Giga Regio Factory (GRF) project, supported by the European Union's LIFE programme, aims to structure industrial value chains dedicated to the massive and off-site energy renovation of housing on a territorial scale.

It is based on a systemic vision inspired by the Energiesprong approach: industrialization of processes, guaranteed performance, multi-stakeholder coordination, and skills development of the entire sector.

In this context, several factory visits and immersions in industrial environments were carried out in different partner countries (France, Germany, Italy, Belgium), in order to observe the existing processes, the levels of maturity, and the constraints specific to the prefabrication sector applied to renovation.

Faced with the growing challenges of climate change, energy poverty, the ageing of the housing stock and European requirements in terms of energy performance, the renovation of buildings has become a priority.

However, the current model – artisanal, slow, fragmented, low in quality – does not allow for either massification or the required economies of scale. It is therefore imperative to initiate a transition to "off-site" solutions, based on the prefabrication of standardised elements (insulating facades, insulating roofs, technical modules integrating heating, hot water and ventilation), the digitalisation of processes (scan to BIM, digital twins), and inter-stakeholder cooperation.

The purpose of this guide is to:

- Help manufacturers understand the challenges of this structural transformation,
- Identify emerging market opportunities and business models,
- Understand the complexity of group tenders, the associated technical requirements and the logistical ramp-up,
- Appropriate the tools developed by Life GRF to build a sustainable strategic positioning in the renovation markets.

It is mainly aimed at construction companies, designers and manufacturers of off-site solutions, suppliers of technical modules, as well as players in a position to become "industrial integrators" of renovation.

4.2. Off-site mass renovation

4.2.1. Challenges and framework for transformation

The energy renovation of buildings is one of the major pillars of the European Green Deal.

With around 75% of the European building stock considered energy inefficient, and a target of carbon neutrality by 2050, the need to accelerate the pace and quality of renovations is clear.

However, traditional approaches alone – dispersed, artisanal, not very reproducible and of low quality – come up against structural limits: labour shortages, lack of inter-business coordination, low productivity.

Faced with these blockages, off-site renovation appears to be a systemic and promising solution. Inspired by the industrial logic of prefabrication, it is based on the assembly in the factory or workshop of complete elements (insulated facades, technical roofs, energy modules) which are then installed on site in a short time.

This method simultaneously improves the quality, time, cost and energy and environmental performance of renovations. The idea is to create a dedicated market segment, with a different way of doing things that can allow us to achieve our decarbonisation objectives: it is not a question of replacing traditional renovations, but of adding a possible solution to renovate more buildings.

Figure: Example of off-site projects

4.2.2. <u>Inspiring European references and models</u>

Several initiatives have demonstrated the feasibility and effectiveness of large-scale off-site renovation in Europe:

- Netherlands – Energiesprong

  As a pioneering model and conceptual matrix of the Life GRF project, Energiesprong has initiated an integrated "net zero energy" approach for social housing (single-family houses and collective housing). Its model combines prefabricated solutions, a 30-year performance guarantee, a balanced economic model to make it replicable, a strong involvement of industrial players and care for the living comfort of the inhabitants. Several thousand homes have already been renovated.

- France – Energiesprong France & regional demonstrators

  Adapted to the French context by GreenFlex and Ressorts, the approach has made it possible to develop high-performance demonstrators in the North, Pays de la Loire and Auvergne-Rhône-Alpes. It has expanded to other types (educational buildings) and mobilizes a fast-growing ecosystem of manufacturers and integrators.

- Germany – First multi-family housing projects

  Although the regulatory framework differs, Germany is actively exploring prefabricated and serial renovation through industry clusters and the modelling of wood or hybrid solutions. Life GRF is part of a structured spin-off logic.

- Belgium – Industrial appetite and the logic of regional ecosystems

  Belgium has an agile industrial fabric, particularly in Wallonia. Clusters such as GreenWin or projects led by Buildwise (formerly CSTC) contribute to structuring the logic of demonstration projects and skills development, in markets such as public housing.

- Italy – First demonstrators and ramp-up

  Italy, faced with a stock of old and energy-intensive housing, is gradually embarking on off-site renovation pilot projects, particularly on social housing complexes and cooperatives. Local initiatives are emerging around prefabrication techniques and prefab modules and panels for the building retrofitting, supported by European programmes (Life, Horizon Europe) and national funds or incentives. There is a well-structured network of more than 30 building companies/solution providers with a deep technical solutions portfolio, with a particular focus on the architectural quality, energy and seismic performances (due to national context and regulations). These experiments aim to structure a national offer that is expected to growth in the upcoming years, given the climate objectives and new financial schemes coming out.

Building typologies and massification potential: the massification potential is based on a detailed knowledge of the segments to be renovated:

- Collective social housing

  Generalized in the 1950s and 1980s, these buildings are often identical by region or by landlord, facilitating the standardization of solutions. They are a priority target in France, Germany, Belgium, Italy and the Netherlands.

- Single-family homes

  Often more complex to deal with on an industrial scale, but very numerous and critical for the achievement of national objectives (particularly in France). 2D solutions (cladding, roofing) and MEP kits can play a key role, as well as prefabricated "kit" solutions such as Element'R or BYWalli or Yellow Dino.

- Tertiary buildings

  Offices, schools, healthcare buildings: although more heterogeneous, their massification is strategic in the context of the tertiary decree in France, the regulations on public buildings and schools in Germany and Italy.

According to data from the GRF analysis (France) and local analyses carried out in the partner countries, several hundred thousand housing units could be affected by 2030, provided that an adapted and interoperable industrial offer is structured.

5. The main types of solutions for off-site renovation

Off-site renovation is not limited to a single product or process: it covers a set of industrialised solutions designed to meet the challenges of massification, quality, energy performance and reduction of nuisances on site.

Among these solutions, **2D prefabricated facades** occupy a central place. They are now one of the most developed and mature products in the sector, especially in projects with external thermal insulation (ETI), which can integrate: frame, insulation, anchors, cladding, joinery, etc.

But they are **only part of the range of possible solutions**: off-site renovation can also include insulating roof boxes, prefabricated energy modules (interior or exterior), industrialized bathrooms, or even living comfort elements (loggias, balconies, stairs, etc.).

The approach by families of solutions is detailed in the *Off-site Renovation Framework*, which offers a **complete** and **illustrated** classification of these typologies, along with their technical characteristics, implementation conditions and levels of industrialization. This document constitutes a reference basis for the off-site renovation offer.

5.1. A product logic to think about in a constrained framework

Each solution must be chosen and sized according to:

- The **objectives of the project** set by the project owner (thermal, energy, comfort, accessibility, etc.),
- The **morphology of the existing building** (structure, accessibility, general condition, etc.),
- Logistical **feasibility** (site occupied, available land, rights-of-way, lifting, handling, etc.),
- And the **technical** and regulatory constraints (RE2020, fire safety, seismic, etc.).

This requires **rigorous engineering work** from the outset, with a detailed diagnosis of the existing system and a design in DfMA (*Design for Manufacturing and Assembly*), to maximize industrial gains and limit on-site interfaces.

The DfMA approach consists of designing from the outset a product designed to be manufactured in the factory and easily assembled on site. It invites us to move away from a "tailor-made project" logic to a product logic:

- standardised and reproducible components (dimensions, interfaces, attachment systems),
- a range of modular solutions, capable of covering the majority of cases encountered,
- optimised and documented manufacturing and installation processes,
- early integration of site constraints (lifting, access, phasing, nuisances on occupied sites).

This approach makes it possible to industrialize the renovation without sacrificing adaptability: the product becomes a stable base, adaptable according to the type of building, while guaranteeing quality, deadlines and performance.

It is in this context that the designer-manufacturer relationship must be considered. For each project, it is recommended to practice at least a **sourcing of market solutions**, to go as far as setting up design-build teams for the most complex projects.

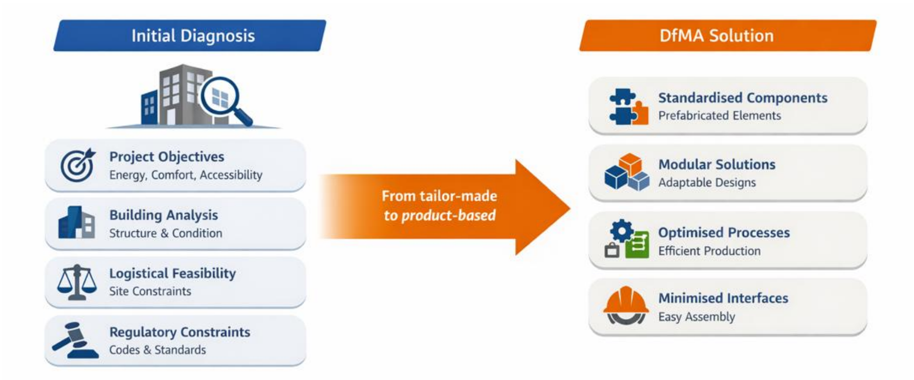


Figure: The DfMA approach

5.2. Thinking of the offer as a system

An industrial strategy cannot be limited to a single product: it must be part of an offer designed **as a system articulating several compatible solutions**, in a logic of massification. This involves:

- A **standardised** design, but adaptable/customisable, i.e. covering around 80% of the needs in a reproducible way, but leaving 20% adaptability to meet the specificities of each building (customisation of finishes, technical adjustments, contextual integration),
- A **controlled logistics chain** (packaging, transport, protection),
- Defined **interfaces** (grip, fluids, finishes, interfaces with other lots),
- And an **ability to produce in large series** without sacrificing quality.

To go further on the structuring of an industrial offer and the types of solutions, consult the *Practical Guide for companies and solution providers* and the *Off-site renovation Framework*.

In addition, off-site renovation players offering prefabricated façade solutions can be identified via an online sourcing tool.


Des solutions industrialisées et réplicables développées pour s'adapter aux projets

La démarche EnergieSprong vise à massifier le nombre de rénovations énergétiques très performantes. Pour accompagner cette montée en puissance et répondre aux ambitions de la démarche, il est utile de maximiser l'utilisation de solutions « tout-en-un » plus intégrées, permettant de répondre en une fois aux différents enjeux de la démarche.

Exemple d'intégration tout-en-un dans un module énergie aux Pays-Bas

Le recours aux solutions de rénovation industrialisées et réplicables sur différents projets permet en effet de limiter les coûts de développement et de fabrication des solutions, de réduire drastiquement les temps de mise à œuvre et d'installation et d'assurer la performance des solutions d'une rénovation à une autre sans pour autant uniformiser l'aspect architectural.
Trois types de modules de rénovation ont ainsi été développés par différents industriels dans le but de répondre aux ambitions de la démarche :

Module énergie intégré
Solution intégrée de module énergie (onduleur PV + chauffage + ECS + ventilation + stockage + monitoring + interface utilisateur) préfabriquée associée à des équipements de transport et de pose dédiés

Toiture isolante avec production d'énergie
Solution intégrée de toiture (couverture + isolation + étanchéité + photovoltaïque) préfabriquée associée à des équipements de transport et de pose dédiés

Façade isolante préfabriquée
Solution intégrée de façade (structure + isolation + ouvrants + conduits) préfabriquée associée à des équipements de transport et de pose dédiés

Façade préfabriquée
Hem - VILOGIA

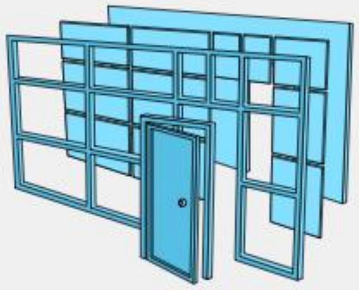
Pose de façade préfabriquée
Longueau - ICF HABITAT

Figure: Example of page from Practical Guide for companies and solution providers

Sommaire

Enveloppe thermique

Eléments de façade en kit/manuportables



Description de la solution

- Systèmes de façade isolante en kit, calepinés et préfabriqués séparément puis assemblés sur site, permettant de s'adapter à de nombreuses configurations et styles architecturaux et pouvant toucher une large gamme de bâtiments existants
- Composition des kits pouvant notamment intégrer :
  - → Ossature
  - → Système d'isolation
  - → Pare-pluie et pare-vapeur
  - → Revêtement extérieur
- Comme les façades 2D simples ou complexes, kits conçus pour être facilement installés grâce à leurs accessoires de fixation et aux guides qui détaillent les étapes de mise en œuvre
- Intègre généralement un complément d'étanchéité à l'air nécessaire à l'amélioration de l'enveloppe thermique du bâtiment

Caractéristiques techniques majeures

Indicateurs-clés de la solution

- Dimensions inférieures aux gabarits routiers
- Poids de la solution pouvant varier de 20 à 70 kg/m^{2}* permettant une mise en œuvre manuportable (les accessoires étant à ajouter sur site)

Compatibilité de morphologie du bâti

- Solution favorable pour tout type de bâti notamment les bâtiments peu compacts, architecturalement plus complexes et/ou avec des décrochés ou de petits pans de façades
- Solution de façade adaptée à des bâtis peu accessibles pour des engins de levage englobant plusieurs étages en cas de trames régulières comme sur les bâtiments tertiaires

Prérequis à l'intégration de la solution dans un projet : MOA

- Conception & allotissement : sourcer les produits existants et prévoir un lot façade isolante intégrée et industrialisée
- Vigilance et formation spécifique à prévoir pour la pose des éléments afin de garantir la solidité de la fixation et l'étanchéité
- Point de vigilance sur l'interfaçage avec les autres solutions (toiture, équipements techniques), les autres corps d'état (gros-œuvre, couverture/étanchéité, etc.)

d'après les retours d'expérience des fournisseurs et projets en rénovation hors-site

Les avantages de la solution

Les avantages

- Réduction des découpes sur site et rapidité d'exécution et de pose (système de fixation rapide)
- Moins de contraintes sur les dimensions pour le transport
- Configuration en kit permettant un fort niveau d'adaptation (choix des éléments et matériaux)
- Peut être préfabriqué dans d'autres usines de découpe bois, permettant ainsi à des produits sous licence d'être fabriqués et vendus partout en France

Les points de vigilance

- Anticipation de la conception selon les méthodes de DfMA (Conception pour l'Industrialisation et l'Assemblage)
- Calepinage précis nécessaire au moment de la conception – configurateurs disponibles ou à venir pour certaines solutions
- Bien que l'installation soit simplifiée, elle nécessite une main d'œuvre plus qualifiée et formée afin de conserver la qualité de l'isolation thermique
- Forte interface entre les différents corps d'états
- N'intègre pas les menuiseries qui sont à prévoir à part
- Pose moins rapide que pour les systèmes de façades 2D simples et complexes : attention au planning de mise en œuvre
- Impose la protection des isolants contre l'humidité, notamment en cas d'intempéries

20 01 02 03 hors site

Figure: Example of page from referential of solutions

6. What are the opportunities and risks?

6.1. The non-interoperability of solutions

One of the most frequently encountered structural obstacles in the development of the off-site renovation industrial offer is the lack of interoperability between the solutions proposed.

This fragmentation of systems, technical interfaces and implementation processes is an obstacle to massification, the reproducibility of projects and the fluidity of public procurement.

6.2. A strong constraint for project owners

In the absence of common standards – whether in product dimensions, fastening systems, logistics interfaces or installation protocols – building owners are often forced to design their projects according to a specific industrial solution. This technical and commercial dependence reduces their freedom of choice, limits competition in public procurement, and creates a risk of lock-in around a single supplier or process.

6.3. An obstacle to pooling and replicability

Each project currently needs to be dimensioned, adapted or readjusted. This situation prevents capitalization from one site to another, complicates the ramp-up of manufacturers (continuity of production chains, etc.) and limits the ability of integrators to aggregate several compatible solutions in the same project. This runs counter to the objectives of massification and standardisation that a structured industrial sector presupposes.

6.4. A standardization challenge to be built collectively

To date, there is no common reference framework for key components (hooks, module formats, assembly logic, quality documentation, etc.). However, several feedback show that there would be a major strategic interest in structuring a base of compatible interfaces between manufacturers.

This is exactly the approach that **car manufacturers** have followed with their subcontractors: to define shared industrial standards that have enabled the massification, the increase in quality and the security of the sector.

This logic had already been put forward in the **LowCarb** project, a regional initiative in Hauts-de-France aimed at structuring a low-carbon offer through cooperation between industrial players, the definition of common standards and the pooling of resources. Experience has shown that standardisation cannot be limited to a local approach: it must be thought out on a **national or even European scale** to have a structuring impact on the sector.

This would make it possible to:

- Facilitate groupings of actors around common projects,
- Improve the flexibility of the offer for clients,
- Securing logistics and supplies,
- Increase the resilience of the value chain (in the event of uncertainties at a supplier),
- For project owners, to limit their specifications to performance requirements and no longer resources, making it possible to standardize the order and thus give significant visibility to the sector for its development.

This standardization project, mentioned in part D of the deliverable, could constitute a major lever for transformation for the entire ecosystem.

It would be less a question of imposing a single product than of building a common language and shared reference points, on which everyone could rely to design, assemble and deliver compatible solutions.

6.4.1. Don't reinvent with each project

In the current operation, each renovation operation is based on an almost complete redeployment of the technical design, logistics processes and site interfaces.

This inefficient way of doing things generates additional costs, wasted time and weakens the dynamics of series.

Conversely, better **interoperability between solutions** would make it possible to secure projects, smooth learning curves and make industrial developments more reliable.

In summary, non-interoperability is now a major blockage, but also an **opportunity for collective progress**. The key question therefore becomes: **who should organize this project?**

Several options can be considered, no doubt complementary:

- **Project owners**, by pooling their requirements and building performance-based specifications,

- **Associations and federations of off-site sectors**, capable of coordinating manufacturers and defending a common vision,

Technical and standard-setting bodies (France: CSTB, FCBA, etc.; Italy: CNR, ENEA, FederLegno, CSI, etc.), which have the expertise to formalise and disseminate standards,

- **Clusters and professional sectors** (e.g. Wood, metal sector, concrete), which can initiate reproducible local approaches,

- And in the long term, **a European support**, via collaborative projects (LIFE, Horizon Europe), to give transnational coherence.

The Life GRF project thus encourages the establishment of a structured and multi-stakeholder dialogue, bringing together manufacturers, integrators, project owners, clusters and standardization bodies, in order to lay the foundations for a true common off-site culture.

6.4.2. A variable market in structuring

The structuring of the large-scale high-performance energy renovation market remains an ongoing process, strongly conditioned by technical, logistical, regulatory and organizational specificities.

For manufacturers and integrators engaged in an "off-site" trajectory, this instability generates as many challenges to overcome as opportunities to seize.

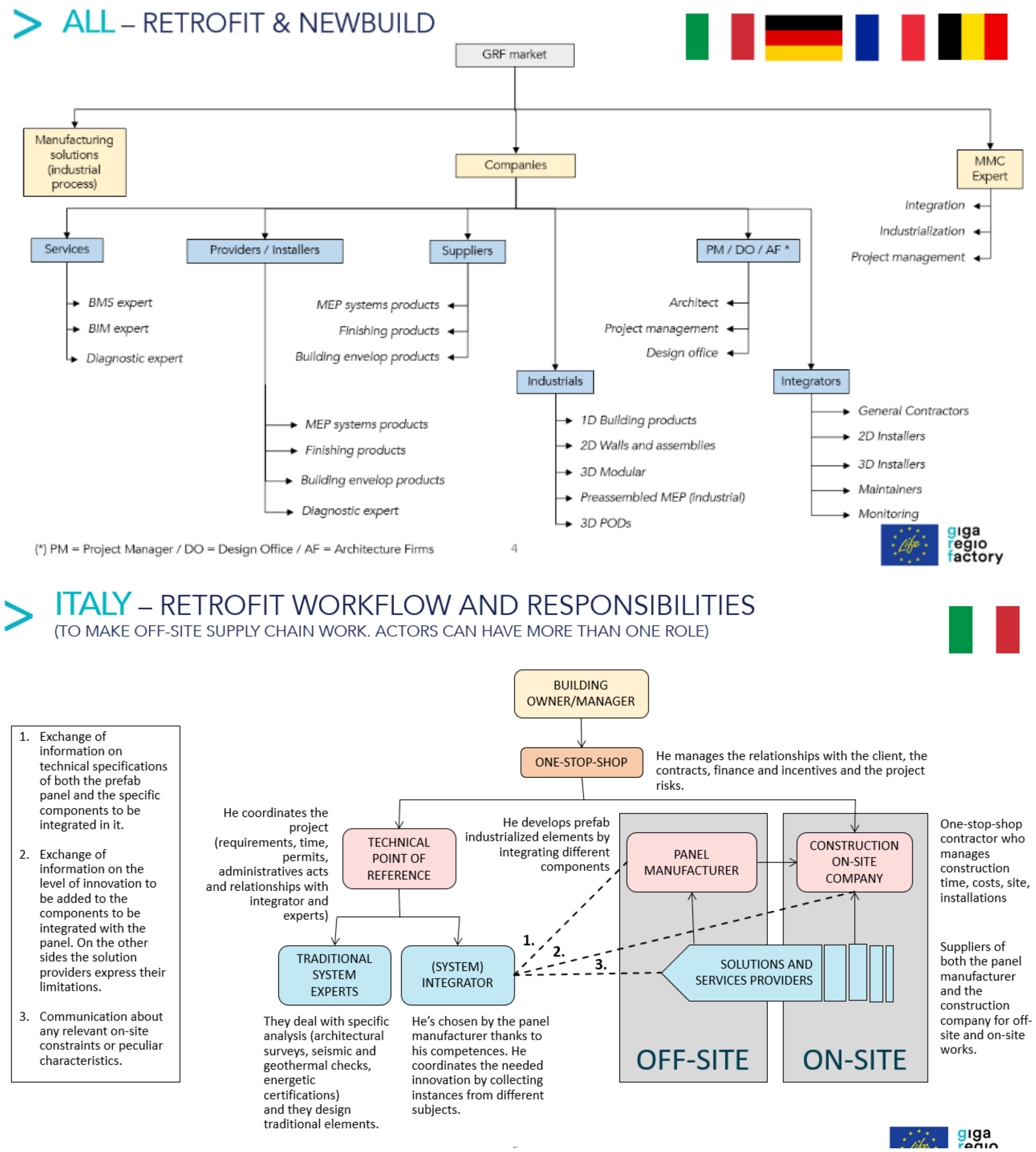


Figure: a common mind map of stakeholders for all countries, considering the specific characteristics of each, particularly for Italy

6.4.3. <u>Projects with high technical requirements</u>

Targeted renovation projects, often led by social landlords or public project owners, are distinguished by their technical complexity.

Industrialized solutions must adapt to constrained environments, in particular occupied sites, while meeting a high level of requirements:

- Fire and seismic standards, particularly on elevated or extended structures,
- Thermal and acoustic performance compatible with the requirements of global renovation,

- Harmonious integration of energy systems (PV, HEAT PUMP, double-flow CMV, etc.) - definition to be found in the glossary) in prefabricated modules,
- Compatibility with existing surfaces, singular points, and site hazards,
- Environmental performance requirements often differ from one region to another, from one territory to another, from one project owner to another; requirements that are often correlated with aid and subsidy schemes that are not homogeneous either (high variability between the actors and territories granting them: between a municipality, a region, the State, etc.)

This technicality requires significant adjustments in the design, prefabrication and implementation processes, and is a barrier to entry for many players.

6.4.4. An uncertain logistics environment (supply chain)

The use of industrialized components implies securing precise supply chains upstream, sometimes on a just-in-time basis, with little room for improvisation.

This need for reliability comes into tension with the variability of the operational schedules of project owners and installation companies, often subject to:

- Unpredictable administrative delays (permits, subsidies, internal arbitration),
- Delays in the examination of contracts,
- Delays in the supply of products and materials, or in the availability of operational teams or subcontractors,
- Or interruptions to construction sites due to occupants, additional diagnostics required or unforeseen events on site (bad weather, etc.).

Faced with this, several strategies are being studied or deployed, including:

- The establishment of long-term industrial partnerships to smooth out volumes,
- The diversification of the order (individual housing, condominiums, public buildings),
- The organisation of local supply chains to guarantee deadlines and reduce dependence on imports.

6.4.5. A complex and evolving regulatory and legal dynamic

The market is also marked by strong regulatory constraints that are sometimes a deterrent for industrial players. For example, we can list:

- The general regulatory laws (the MOP Law in France, the Public Procurement Code in Italy) and their impacts on the structuring of lots and responsibilities,
- The difficulty of obtaining certain certifications necessary for non-traditional components (ATEX, Technical Approvals),
- Insurance constraints (OD, RC) in the event of an innovative process or unconventional integration,
- The lack of a specific reference for off-site renovation projects.

This uncertainty weighs on development schedules and on the ability of manufacturers to invest serenely in new tools or production lines.

6.4.6. The problem of payment

A major obstacle identified by manufacturers concerns the current methods of payment for work. In the majority of cases, companies are paid for the progress of the installation, depending on the "work situations".

This method of payment, adapted to traditional construction sites, is becoming unsuitable for off-site, where a significant part of the value is created upstream, in the factory. In concrete terms, providers of prefabricated solutions must make large cash advances to finance design, material procurement, manufacturing, and logistics, even before the first panel or module is installed on site.

Although contractual advance mechanisms exist, they are often insufficient or conditional on heavy financial guarantees (bank guarantees, first-demand guarantees, etc.). However, not all structures, especially SMEs, have the capacity to mobilise these guarantees, especially when volumes become large.

This discrepancy creates a structural risk for the sector:

- Brake on investment in industrial tools,
- Difficulty in massifying production,
- Increased fragility of the most modest actors.

The implementation of payment schemes adapted to off-site (e.g. progressive payments from the prefabrication phase, financing mechanisms backed by public procurement, or third-party financing schemes) therefore appears to be an essential lever for securing flows and promoting industrialisation.

6.4.7. The time factor: a long cycle to absorb

Finally, it is important to underline the structural gap between the industrial production cycle (rapid, sequential, iterative) and the long-time frame for the development of renovation projects in social housing.

Between the political intent, the feasibility study and diagnostic phases, the financial package, the procurement and the implementation, several years can pass.

This particular temporality weakens the promise of continuity of production chain activity, which is necessary for the economic equilibrium of industrial models.

For manufacturers, this means integrating a degree of anticipation, flexibility and pooling into their strategy, which the project supports in particular through decision-making tools and the dynamics of grouping operations, **but also as proposed by other European initiatives, such as the Life Cosme Reno project, which explores collaborative models to smooth cycles and secure industrial activity.**

6.5. An essential complementary industrial activity

One of the major findings from the support provided to manufacturers in the context of the Life Giga Regio Factory project is that it remains extremely difficult – even economically unrealistic – to operate an industrial tool exclusively from the production of components intended for renovation (in particular elements of facades and insulating roofs, energy modules, etc.).

The structuring of a dedicated production line, its ramp-up, and then its long-term and continuous operation imply regular and predictable volumes, and the very nature of the renovation market makes this very uncertain.

Indeed, even in the case of dynamic markets and grouped orders (by social landlords, public consortia, or private operators), manufacturers are confronted with several limitations:

- The irregularity of project flows, marked by punctual calls for tenders, often spaced out in time, and difficult to predict;
- The length of the decision-making cycle for clients (from 18 to 36 months for some projects);
- The technical adaptations required for each project, which limit the effects of series and increase the time it takes to reconfigure production lines.

In this context, it is becoming essential for manufacturers to develop a complementary activity that makes it possible to:

- Make investments in equipment and skills profitable (3D scanning, BIM, Lean, prefabrication, multi-material assembly, robotization, etc.),
- Smooth out the use of production tools between two waves of renovation orders,
- Stabilize the workforce and internal know-how, avoiding prolonged phases of underload.

Several avenues are identified according to the profiles of the actors:

- Diversification towards new construction (social housing, accommodation, schools, modular buildings), by promoting the same assembly or prefabrication logics as those used for renovation;
- Deployment of activities related to light rehabilitation or extensions (balconies, elevations, sanitary modules, etc.);
- Industrial subcontracting for related markets (street furniture, technical joinery, cladding panels, etc.);
- Pooling of workshops between several companies or territorial groups to smooth out production cycles (example of the prefablabs developed as part of the Life Cosme Reno project).

Finally, this parallel activity is not simply a measure of economic survival. It can also become a strategic lever to:

- Testing new processes or materials in less constrained contexts,
- Gain in industrial agility and adaptability,
- Create bridges between different markets (housing, tertiary, health, education) in order to spread the solutions developed for renovation.

Thus, the economic model of the off-site industrial must be thought of from the outset in a logic of dual anchoring: carrying out a mission of general interest through energy renovation, and entrepreneurial sustainability through the controlled diversification of activities.

6.6. The importance of the definition of a product

One of the central lessons of the Life Giga Regio Factory project, drawn from both the analysis of European ecosystems and industrial support, is the need for companies to enter the off-site renovation market with a clear, coherent and industrializable "product" approach.

Contrary to a single project logic, in which each order gives rise to an ad hoc solution, the development of a viable industrial activity in the field of energy renovation requires thinking in terms of reproducible ranges, standardised elements, and stabilised offers.

This presupposes in particular that the manufacturer:

- Identifies a well-defined market target (e.g., renovation of collective social housing from the 1960s to 1980s, thermal rehabilitation of school buildings, modular elevations for dense urban areas);
- Offers a repeatable product or product line that can be adapted to 70-80% of the target market cases, with modular options for the rest.
- Is based on standardised components and technical interfaces, facilitating assembly, maintenance and compatibility with other solutions (joinery, insulation, technical modules, etc.);
- Establishes a clear performance benchmark: target U-value, waterproofing, durability, ease of installation, carbon impact, recommendations for servicing and maintenance, recyclability, etc;
- Documents and communicates this offer in the form of data sheets, BIM templates, installation instructions and compatibility guides.

Adopting a product logic allows several simultaneous gains:

- Facilitate the integration of project owners, project managers and technicians, who have clear support for the prescription;
- Reduce design and engineering costs for each new project, limiting the need for a restart to zero;
- Accelerate the ramp-up of production and installation teams (notions of learning curve and continuous improvement);
- Create bridges with other solutions on the market, promoting interoperability;
- Guarantee performance, thanks to standardized, tested and documented products, whose results are reproducible;
- Generate a supply shock: a well-marketed product can create its own demand, as shown by emblematic solutions (Panobloc, Element'R, BYWalli in France, Rhinoceros-Wall in Italy), by making project owners want to buy;
- Align the design with the product: in a logic of sourcing and DfMA, it is the designers who build the project around the available product, and not the other way around.

This approach often involves not starting from scratch. Rather, it consists of:

- Capitalize on existing proven solutions (in France or Europe), possibly from Energiesprong demonstrators or other local experiments;
- Adapt them to the production context of the manufacturer (materials, technical constraints, work organization);
- Enrich them by adding progressive innovations: better environmental impact, improved design, integration of renewable energies, etc.

Finally, this product logic is part of a perspective of structuring the sector. By proposing a stabilised and standardised offer, the manufacturer contributes to:

- Build a common language with other market players (integrators, architects, design offices, maintainers and operators, etc.);
- Participate in the creation of sectoral or territorial standards (e.g. component repositories for grouped calls for tenders);
- Strengthen the legibility and credibility of the off-site offer with investors and public authorities.

In short, defining a product is not about restricting oneself: it is about giving oneself the means to industrialize, to cooperate, and to grow.

Figure: The importance of the definition of a product

6.7. Volumes envisaged for 2030 and 2050

One of the foundations of the support offered as part of the Life Giga Regio Factory project is based on a strategic and quantified reading of the market potential of mass and off-site energy renovation.

This vision is based in particular on the trajectories defined in the National Low-Carbon Strategy (SNBC), the scenarios of the French Energy and Climate Strategy (SGPE 2030), as well as on the prospective studies of ADEME and the European Commission for 2050; in Italy, the strategies in place have been defined by the PNIEC, ISPRA and ENEA, together with the MASE - Ministry of the Environment and Energy Security

The figures are clear:

- France needs to renovate around 700,000 homes per year to meet the 2030 climate targets, with a gradual peak expected from 2026-2027; in Italy there is a portfolio of around 3 million houses to be renovated by 2035.
- ADEME and the High Council for the Climate insist on the need to industrialise these renovations to achieve a level of performance (in particular BBC or equivalent) compatible with carbon neutrality by 2050.
- On a European scale, more than 220 million buildings need to be renovated, with a strong priority given to public, social and residential buildings built before the 1990s.

This volume of work calls for a gradual but rapid increase in the power of the industrial sectors. Several structuring trends must be taken into account:

- Growing support for public financing mechanisms (MaPrimeRénov', CEE, Green Funds, InvestEU, Conto Termico 3.0 in Italy, + 15% of incentives in Germany specific for industrial renovations, etc..);

- The development of grouped calls for tenders by social landlords and local authorities, facilitating massification;
- The arrival of new financing mechanisms such as third-party investment, performance guarantees or energy leasing.

For manufacturers, this represents a major opportunity provided that they integrate this dynamic into their business strategy.

This integration involves:

- The identification of promising market segments (dense/diffuse social housing, condominiums in tense areas, public tertiary buildings, etc.);
- The planning of investments in industrial capacity (prefabrication machines and equipment, mobile workshops, digitalization of flows);
- The development of the teams' skills (BIM, industrialization, site logistics on occupied sites, etc.);
- The development of structuring partnerships with integrators, project owners and engineering platforms.

In the short term (2025–2030), manufacturers must be able to respond to targeted calls for projects, while structuring a coherent, visible and replicable product offer.

In the medium term (2030–2050), the ambitions of the SNBC, the European Green Deal and the EPBD’s strategies imply a shift towards a renovation economy: sustainable, regenerative, and based on robust value chains.

This implies a growing role for actors capable of combining environmental performance, economic competitiveness and quality of execution.

In summary:

- The expected volumes are massive and sustainable.
- The challenge is not only technological, but also organizational and strategic.
- Those who have been able to structure their offer, anticipate standards and forge the right partnerships will be best positioned to capture future value.

6.8. Partnerships

In a logic of industrial transformation applied to energy renovation, partnerships appear to be an essential lever. Neither massification nor innovation (development of integrated industrial solutions) can be done in isolation.

It is the interactions (industrial, territorial and strategic that condition the rise of a qualitative and sustainable off-site offer.

6.8.1. The importance of cooperation

While partnerships structure targeted alliances, cooperation refers to a broader logic of collective construction. It implies that the players (industrialists, project owners, integrators, clusters, technical organizations) learn to work together beyond their immediate interests.

Cooperation makes it possible to:

- Pooling resources (logistics, production platforms, digital tools);
- Organise the complementarity of skills between companies of different sizes (large groups, SMEs, VSEs, SSEs);
- Share feedback and accelerate learning;
- Move towards common standards, guaranteeing interoperability and ramp-up.

Successful cooperation already exists in other industrial sectors (automotive, aeronautics) and is beginning to emerge in off-site renovation, through consortia of European projects (LIFE, Horizon Europe) or regional approaches led by clusters (Fibois, FCBA, Buildwise, Clust-Er Build, etc.).

Building a culture of cooperation is therefore a key lever for securing the industrialization of energy renovation and giving the sector the critical mass necessary to deploy on a large scale.

6.8.2. Development of strategic partnerships

Manufacturers must identify and structure high-impact alliances:

- With strategic suppliers: to secure supplies (particularly in joinery, insulation, ventilation systems or structural elements), to guarantee quality and to streamline deadlines.
- With other local companies (SMEs, VSEs, SSE players): to promote proximity, pool certain logistical or installation resources, and strengthen territorial anchoring.
- With research laboratories, competitiveness clusters and technical centres: to accelerate the development of innovative, standardized, modular and interoperable solutions.

The challenge is not only technological or economic. It is also human and systemic: learning to work together in the logic of a sector, a consortium or an industrial ecosystem.

6.8.3. The role of project owners and agents

The success of an industrial strategy in the field of energy renovation also depends on a detailed understanding of the expectations of clients.

Project owners, social landlords, local authorities, public institutions are at the same time customers, regulators and stakeholders. Their involvement from the design of the product or industrial strategy can make it possible to:

- Clarify the technical, economic, functional and regulatory requirements (target cost, acoustics, safety, maintenance, etc.);
- Anticipate site constraints, particularly on occupied sites;
- To build shared and contractualized performance logics.

Agents, project managers, design assistants or procurement assistants also play a key role in making the link between political ambitions, legal realities and technical innovations.

It is therefore strategic for manufacturers to:

- Participate in local exchange and steering networks (clusters, regional platforms, technical dialogues);
- Engage in upstream discussions with project managers to co-construct long-term partnerships, solutions, simulate operations and anticipate contractual locks;
- Work with federations and public agencies to make their industrial offer legible, beyond simple responses to calls for tenders.

In short, a robust partnership strategy is a decisive differentiating factor: it strengthens the capacity for action, reduces risks, and paves the way for exemplary and replicable projects.

7. Feedback and lessons learned from the industrial support of the Life GRF project

The industrial support carried out as part of the Life GRF project has made it possible to meet a wide variety of companies involved in the development of prefabricated façade solutions for energy renovation.

This diversity is a major lesson of the approach: **there is not a single model of entry into this market**, but several possible paths, each reflecting a unique history, ambition and territorial anchoring.

The industrialists supported have **a variety of professional backgrounds**, ranging from players from traditional carpentry to integrated wood builders, prefabrication specialists or cooperative structures with a general contractor vocation.

Some are part of a diversification dynamic from an activity in the new market, others have made renovation their core business, while a few are starting a strategic reorientation towards this fast-growing market.

The levels of industrial maturity observed during the visits were just as heterogeneous, ranging from **structured craft workshops** to **semi-industrial sites**, to organizations already engaged in a **just-in-time logic**.

This plurality of configurations illustrates that **it is possible to structure an efficient industrial response to renovation regardless of its starting point**, provided that a coherent trajectory is built, adapted to its capacities and its territory.

7.1. Common issues identified in scaling up

The objective of this part is to summarize the obstacles and brakes encountered by manufacturers in their ramp-up, whatever the profiles.

7.1.1. The uncertainty of the order

The uncertainty of demand is a major obstacle to industrialization. Many players are experiencing difficulties in **securing a sufficient volume of activity** to amortize their investments and structure their organizations in the long term.

Order books, which are often recent or irregular, have little visibility in the medium term, which complicates the ramp-up of industrial tools. This situation slows down the commitment to standardization, automation or recruitment processes.

Necessary: Structuring the request

The development of **multi-year partnerships** with social housing organisations, real estate companies or local authorities, via **framework agreements or multi-award contracts**, is a powerful lever for stabilising flows. This makes it possible to optimize industrial and logistics flows, and to implement continuous improvement.

To anticipate: the cascading effects on the supply chain

An unstable order has a direct impact on supply and stock management. Several manufacturers are facing flow disruptions related to critical components (joinery, specific insulation, technical cladding). The implementation **of agile stock management** (targeted buffer supplies, standard products, advance bills of materials, digitalization) is necessary to absorb the hazards. The creation and sustainability of partnerships can also help secure orders.

To be managed: site logistics, particularly on occupied sites

Without logistical anticipation, interruptions or disorders on site can destabilize the entire chain. Manufacturers must integrate strategies for **scheduled delivery, protection of the elements against bad weather**, and fine planning of layout and installation to reduce nuisance for residents.

To be optimized: transport and storage

Most structures have not yet deployed **adapted transport racks** or site buffer zones. However, securing **the prefabricated elements**, transporting them vertically and ordering them to be installed are prerequisites to avoid wasting time, disputes or unsuitable installation requirements. It is an investment recommended by those who have done it, if the transport is handled in-house, in particular.

7.1.2. Recruitment and human resources challenges

The development of a prefabricated industrial renovation activity relies on a qualified workforce, capable of operating in mixed environments (workshop / site) and adapting to complex products. However, depending on the local context, manufacturers sometimes face a **critical shortage of skills** to support their ramp-up.

Tensions on key positions

The most difficult positions to fill are production operators, wood designers, quality-safety-environment (QSE) technicians and planning functions. The needs are all the more pressing as most structures are aiming to increase the pace of work, with a switch to 2x8 or a doubling of the number of staff in the design office, for example.

Versatility sought after but difficult to maintain in the event of a ramp-up

Several structures operate with multi-purpose teams between the site and the workshop. This model offers flexibility at low volumes but quickly reaches its limits as soon as flows become denser. It also makes it more complex to manage schedules and increase skills on repetitive industrial gestures.

Progressive recruitment models

Some players have set up integrated pathways (temporary → fixed term → permanent contracts) to secure recruitment. However, this model requires human resources management time, mentoring resources and an ability to smooth the load to stabilize teams. For other players, the majority use of temporary work is in force.

The design office, a link under pressure

In several cases, a single design technician is responsible for layout, pruning plans, execution details and exchanges with the project managers. This creates a **strong dependence on a single profile**, with a major operational risk in the event of overload or departure. The ramp-up therefore involves the **strengthening of the engineering teams**, and their specialization in off-site products.

A territorial issue

Recruitment difficulties are accentuated in dynamic industrial areas, where full employment limits the availability of labour. The location of the workshops (poorly served areas, far from the training basins) reinforces this challenge.

7.1.3. The industrial ramp-up

Accelerating production while maintaining the quality and fluidity of flows remains a difficult step to take for the majority of the manufacturers we met. **Putting production of element into production at a sustained rate quickly reveals the limits of the organizations in place**, whether human, material or logistical. But it can also lead to opportunities for changes in the way things work, depending on the limits identified.

Flows that are still fragile and not very rhythmic

Few structures today have functional **buffer zones** between the workshop and the construction site. Storage is often constrained, without a clear separation between production, preparation and shipping. The installation order is not always respected in deliveries, which generates re-manipulations and risks of disorder on site. The exposure of prefabricated elements to hazards (rain, shocks) is not systematically anticipated.

Unbalanced production lines

The coexistence of standardised elements and other prefabricated "on demand" or "tailor-made" elements frequently disrupts flows. Excessive personalization, not anticipated in advance, **destabilizes scheduling** and causes overall productivity to drop. The implementation of recurring templates and standard grids remains marginal.

Production model choices still in question

The "online" model is often coveted but rarely operational. Organizations operate more in a "U" or semi-iterative fixed workstations.

In a "U" shaped workshop, the stations are organized in a loop, allowing a logical sequence of steps, while facilitating feedback and adjustments. This allows a good flow of information and a flexible mobilization of operators on several stations.

Semi-iterative fixed workstations, on the other hand, consist of holding the panel on a workstation while successive tasks are carried out around it.

This model offers greater flexibility in the processing of different panels, at the cost of a finer frame.

In the structures under development, a reflection is emerging around **hybrid models**: modular workstations, flexible cells, or distribution by product family.

A culture of continuous improvement still under construction

Lean approaches in the construction industry are poorly equipped and often carried out in an empirical manner. Waste **identification**, just-in-time work or visual WIP management (i.e., the use of simple visual cues (labels, colors, bins, tables) to track progress, identify blockages or identify delays in production) remain poorly deployed. Feedback practices are rarely capitalized on, and the standardization of gestures remains low.

Not to skip steps

Scaling cannot rely solely on hardware. It presupposes a **gradual change in industrial culture**, combining skills development, structuring of flows, and implementation of shared benchmarks (cycle time, tolerances, quality standards). Otherwise, the risk is rapid disorganization from the first multi-site projects.

7.1.4. The lack of product formalization

A major difficulty for manufacturers engaged in off-site renovation is **the definition of a product that is standard enough to allow industrial organization, but flexible enough to adapt to projects and allow customization**. This vagueness slows down exchanges with project owners, complicates calls for tenders, and slows down the reproducibility of projects.

Offers that are difficult to read and difficult to mobilise

Few players today have **complete product catalogues**. Technical data sheets are rare or incomplete, and options (thicknesses, insulation, cladding, joinery integration, etc.) are often transmitted informally. This **slows down decision-making on the project management and** causes avoidable back-and-forth in the design phase.

Insufficient standardization of components

Dimensions, interfaces, lifting points or fastening systems vary from project to project. This lack of **technical lock-in** prevents industrial processes from being made more reliable. The diversity of solutions delivered in the field shows that, despite prefabrication logics, **the product often has a high rate of customization**.

Flexibility required, but within a controlled framework

Project owners expect solutions that are adaptable to architectural specificities, but also **compatible with their performance objectives**, which differ from one building to another. The challenge is therefore to offer a **standardised range with controlled variants**, allowing both adjustment to projects and stability of processes in the workshop.

It is not necessarily the product that must be set in stone, but the process

The most advanced manufacturers are not looking to impose a single module, but to **stabilize production steps**, manufacturing tools, tolerances and quality control points. The logic is to design a flexible system, but whose manufacture remains optimized.

Towards a modular and targeted logic

The recommended approach is to **formalize an offer by market segment**, with typical product families (e.g. insulated MOB wall, FOB panel with or without joinery) and configurable options. This makes it possible to respond to various types of buildings, while **securing the site interfaces** (dimensions, weight, anchors).

Integrate finishes from the product design stage

The challenge is also to anticipate customisation requirements: architectural cladding, specific insulation, RE2020 thresholds or local heritage. Clear documentation of **factory-integrable finishes** and **on-site performance limits** becomes a key support for massification.

7.1.5. The lack of quality documentation

Quality processes are a link that is still too often neglected in industrialization processes. However, **it is an essential prerequisite for accessing public contracts, structuring partnerships and reassuring prescribers**.

Embryonic quality approaches

The majority of the structures supported do not yet have a formalized **factory Quality Assurance Plan (QAP)**. Interim control procedures, non-conformance records or checklists by item are often absent or informal. This limits traceability and hinders the reproducibility of operations.

Site execution supports to be consolidated

Installation **plans, lifting instructions or fastening protocols** are rarely standardised. These documents are essential to guarantee the proper implementation of prefabricated elements, especially in multi-stakeholder projects, or in co-contracting with general contractors.

A brake on credibility with clients

In the absence of clear documentation, institutional project owners – especially public ones – may consider the proposed solutions to be **insufficiently mature or at risk**. This constitutes a direct obstacle to access to public procurement and to the validation of control offices.

Formalize to give credibility and structure

Having a minimum **quality kit** is essential to position yourself on large-scale projects. It must contain:

- A structured factory QAP with key control points,
- Annotated and reproducible installation plans,
- Transport, storage and lifting instructions,
- Instruction materials for installers (in-house or partner)
- On-site installation control and verification procedures
- Or even procedures for testing/controlling performance and the services provided (valid in particular for technical equipment but may also exist for envelope elements such as facades or insulating roofs – for example: sun protection).

This foundation makes it possible to make construction sites more reliable, reduce risks and professionalize customer relations. **This is called performance commissioning.**

7.1.6. Essential diagnostic procedures

Industrialization in renovation cannot be effective without **a rigorous and well-equipped upstream diagnosis** of the existing system. This preparatory work determines the technical feasibility, the quality of the elements produced and the smooth running of the site.

Accurate readings to make prefabrication more reliable

The use of **3D scanning** or detailed geometry surveys becomes essential when it comes to off-site production. This data feeds into the design of the panels, makes it possible to identify acceptable tolerances, singular points (slab noses, mismatches, irregularities, networks on the façade), and limits surprises during the installation phase.

A shared digital model as a basis for work

The creation of a **digital twin (BIM)** of the existing building makes it possible to centralise information useful to all stakeholders: manufacturers, design offices, architects, general contractors. This makes exchanges more fluid, avoids back and forth and allows **for controlled co-design** from the very first phases.

Project coordination, the keystone of successful construction site

Projects with occupied sites or specific products require **detailed planning of sequences**, deliveries and responsibilities. A lack of anticipation at this level very quickly generates delays or interface conflicts.

Tools to be formalised to secure deadlines

The implementation of **production and installation scenarios**, integrating workshop capacities, site logistics, weather hazards and buffer margins is a good practice observed in the most fluid projects. This allows the site teams to work with confidence and the manufacturer to **calibrate its production according to real needs**.

7.2. Promising practices and levers observed

7.2.1. Control of a targeted and replicable offer

The most robust approaches observed share a common characteristic: **a clear, identifiable, stabilized product**, without trying to do everything. Rather than aiming for a comprehensive range, manufacturers who are making rapid progress choose to **focus on a controlled product or family of solutions**, with a well-defined technical scope and market segment.

Structure a standard range, with limited options

The objective is not to freeze the product, but to **standardise the key components**: standard and maximum dimensions, type of framework, basic insulation, fixing interfaces, services provided, etc.

This approach makes it possible to optimize production, to gain in quality (continuous improvement) and to make deadlines more reliable. Once this base has been stabilized, variants can be offered on finishes, coatings or the integration of additional optional equipment.

Responding to a specific market segment

Some offers are aimed at grouped individual houses, others at diffuse individual houses, collective buildings on occupied sites or schools. In all cases, it is strategic to **target a type of building, a size, a level of performance or a use**, and to adapt the product to these constraints. This targeting makes it possible to develop demonstrator references, facilitate technical communication and build credibility in the target market.

Know the limits of your product

A targeted offer does not mean rigid. If, despite targeting a well-defined type of project, a site was to deviate from the planned market positioning, it is important **to qualify the technical or logistical risks** associated with this new configuration (irregular structure, complex access, tailor-made requests, etc.) in advance.

Although it is necessary to limit this case, identifying deviations from the standard product makes it possible to **anticipate possible adaptations**, to mobilize partners if necessary, and to **secure quality, costs and deadlines** while capitalizing on each operation.

However, some requests for project management may not be compatible with the proposed offer (particular thermal performance, lower objective cost, types of coating desired according to the urban context, bio-based or reused insulation, etc.). In this case, it is essential to be **transparent**: explain the technical or industrial constraints, propose **realistic variants**, document the **impacts (deadlines, additional costs, site risks)** and make decision-makers aware of the issues at stake (transport, supply, quality of installation, etc.). Speaking the truth is often more constructive than an untenable commitment and allows you to build a lasting relationship of trust, without taking any risks for the project.

Formalize your product in a simple medium

Technical sheets, product sheets, short sales presentations: these are essential tools for effective dialogue with project owners, project managers or architects, and to clarify the possibilities. These supports must specify the key characteristics (dimensions, weight, thermal R, possible finishes), the integrated services (cladding, joinery, rainscreens, etc.), the compatible options and the limits of use.

To go further, **marketing your product is a powerful commercial lever**: it is a question, beyond the technical catalogue, of highlighting:

- Prices provided
- Manufacturing and implementation times
- Its desirability for the inhabitants: thermal comfort in summer and winter, services provided...
- Carbon impact
- Simplicity and reassuring aspects (customer journey)
- All the co-benefits brought by the product... Etc.

The idea is to **make** project owners want to buy the product: it is then **supply that creates demand**, which is the opposite dynamic of that in force in the construction sector – but which allows you to generate your own market and thus secure your order book.

Replicability as a condition for massification

Another essential lever is the **replicability** of solutions, in order to avoid starting from scratch with each operation and to secure the industrial ramp-up. This issue has been worked on in particular within the framework of the **RESTORE** programme led by the CSTB, with the **Element'R solution**.

Replicability is available in several dimensions:

- **Technical**: ability of a solution to adapt to different types of buildings (collective, individual, schools, etc.) while maintaining its performance and ease of implementation;
- **Economic**: development of realistic business plans to amortize industrial tools over a critical volume, with visibility on costs and margins;
- **Commercial**: development of a clear and attractive offer, supported by demonstration projects serving as showcases and by marketing adapted to generate demand;
- **Organizational**: reproducibility of industrial processes, logistics and site interfaces, in order to limit hazards and ensure consistent quality;
- **Contractual and regulatory**: anticipation of legal and insurance frameworks, to secure the reproducibility of operations.

Working on replicability in all its forms makes it possible to create a series dynamic, which is essential to mass efficient off-site renovation and to give credibility to the offer with clients.

7.2.2. Standardisation, ATEx, Technical Opinions: security levers

The ability to mass-produce an industrial solution depends heavily on its technical and regulatory recognition.

Several approaches have been observed to show that obtaining an ATEx (Technical Experimental Assessment) or a Technical Approval (from the CNR in Italy, together with DoP comply to Harmonized Standards) can play a structuring role, both in reassuring project owners and in anchoring a solution in a reproducible standardisation logic.

Identify when recognition is needed

Not all solutions need an ATEx or a Technical Opinion. This depends on the level of innovation, the material used (e.g. in the case of the use of bio-based materials), the complexity of integration on the site, the type of implementation environment targeted (e.g. coastline, seismic zone, etc.), or the requirements of specifiers and control offices.

Some products, although not covered by a technical opinion, are successfully implemented if they are based on solid technical documentation (DTUs) and convincing feedback. The challenge is therefore to assess on a case-by-case basis, upstream of the project, whether or not an official product standardization process is required.

Capitalize on the ATEx or Technical Approval procedures

The ATEx, in particular, makes it possible to secure the use of an innovative solution in a given context. For manufacturers, this approach represents a certain investment (time, testing, support) but it can also become a differentiating argument in responses to calls for tenders.

It also facilitates dialogue with the control offices and makes it possible to promote a rigorous approach to industrialization.

In some cases, it can even be pooled in a group of industrialists or via a recurring project management for several operations (social landlords, local authorities), thus reducing costs and obtaining times.

Consolidate documentation

Where formal recognition is not required, structured technical documentation is still essential.

This includes: a clear product sheet, plans and sections of the scales, the results of internal or laboratory tests, an installation manual (implementation guide), as well as site references accompanied by feedback.

This "credibility kit" often makes it possible to remove reluctance on the part of the project owner or technical inspection while promoting the maturity of the solution.

Moving Collectively Towards Standards

Finally, one of the obstacles to the development of off-site is the lack of shared technical standards (standard dimensions, recurring components, interfaces, attachment systems, test methodologies, etc.) – see the paragraph "*A standardization challenge to be built collectively" - Part A. Promising practices and levers observed*.

Several manufacturers express the need to co-construct these standards to avoid having to reinvent everything with each operation.

Collective approaches (groups of SMEs, territorial clusters, European programmes, professional federations) can accelerate this dynamic, by capitalising on existing practices. Ultimately, this will promote interoperability, reliable approaches and trust among industry players.

7.2.3. Controlled industrialization logic

The success of an off-site renovation industrial project depends less on the size of the workshop or the level of automation than on the **gradual control of its tool and its flows** (supply, manufacturing, delivery, etc.). Several approaches observed show that a ramp-up can be done effectively **with reasoned means**, provided that there is a clear strategy and rigorous management.

Take it step by step, without overinvesting

The most robust approaches often start with a **limited CAPEX**, concentrated on essential equipment (assembly tables, cutting machines, digital saw, etc.). The objective is to **run in processes**, train teams and identify sticking points before generalizing. The workshop thus becomes a **space for learning**, where experimentation is allowed without blocking production.

Separate experimental and stable production flows

Several structures have chosen a **double site or a variable geometry workshop**, to be able to test new integrations (cladding, joinery, etc.) or product configurations without disturbing the main line. This capacity for controlled experimentation is a key lever for moving forward without taking major operational risks.

Choosing an organization adapted to your volumes

Workshops often operate according to **U-flow, fixed stations or semi-flexible cells**, rather than a continuous automated line. This organization allows you to maintain flexibility to manage products of various sizes or with a low level of repeatability, while **progressing towards more stability in sequences**.

Managing flows to make production more reliable

The structuring of workstations, the smoothing of production rates, the limitation of work in progress (i.e. the fact of **reducing the number of items waiting or being manufactured** in the workshop) or the formalization of sequences, i.e. **the clear and reproducible breakdown of production steps**, are the first steps towards a Lean approach adapted to off-site. **Controlling flows before increasing production rates** is a basic rule in this type of workshop: it makes it possible to secure quality, reduce errors, and better manage human and material resources.

Adapt the tool to the product offer (and not the other way around)

The industrial tool must not dictate the product but must **be aligned with the target offer**: format of panels/modules, integrated level of finish, target rate. The most advanced structures gradually adjust their layout (module paths, buffer zones, logistics racks) according to site feedback and changes in their range.

Anticipating tipping points

Going from 2 to 10 sites per year is a gamechanger. It is essential to **model these shifts upstream** in order to size the necessary resources in advance (labour, storage, work-in-progress, logistics). Without anticipation, growth can generate more disorganization than performance.

7.2.4. Risk control in the off-site/on-site interface

The success of an off-site renovation project is not only based on the quality of the products, but on the ability to control the interface between the factory and the site. Several manufacturers supported were able to anticipate, test and make this critical phase more reliable.

Thinking about the site from the product design stage

Prefabricated elements must be designed to be **easily transportable, handleable and installable**. This means locking in certain parameters: weights, lifting points, support tolerances, types of fastening, especially in renovation on non-flat existing buildings. Upstream design errors pay for themselves in time, safety and non-quality on site.

Prepare technical interfaces

The anchoring and integration of **prefabricated elements** (façade panels, roof boxes, technical or energy modules) on existing structures are sensitive points. Junctions in corners, with balconies, roof overhangs, façade or roof networks must be carefully anticipated.

It is essential to test the fastening systems (slab noses, rails, brackets, etc.), to simulate the fasteners and, when necessary, to prototype the complex details.

This upstream preparation avoids improvised adaptations during the construction site and secures the implementation on a variety of building typologies and off-site solutions.

Although the definition of a "universal" type of fastener allowing the interoperability of solutions is desirable in the long term, this is not the case to date. The creation of partnerships with manufacturers already in place could allow a sharing of standards, or failing that, a method of attachment specifically designed for the product.

Beyond the question of hooks, the **interfaces must be thought out in a global way**, because they condition the success of the site and the fluidity of the off-site deployment:

- **Between technical lots**: the prefabricated elements (facades, roofs, energy modules) must be articulated with the other trades. This includes façade-roof junctions, but also connections with CFO (high current), CFA (low voltage), HVAC (heating, ventilation, air conditioning) and PLB (plumbing) lots. Every poorly anticipated interface leads to costly rework, delays, or conflicts of responsibility.
- **Between processes**: continuity must be ensured from design to acceptance. This means coordinating studies, factory execution, site monitoring, testing and quality control. A failure to transmit information at any of these stages may compromise the final performance.

- **Between digital tools**: digitalization is key, but it requires compatibility between systems. Measurement, BIM modelling and data sharing between stakeholders must be fluid, otherwise there is a risk of multiple re-entries, errors and loss of efficiency.
- **With use**: In an occupied building, the interfaces are not only about technology, but also about the daily life of the residents. Interior work must limit nuisances as much as possible (dust, noise, heating or electricity cuts) and anticipate the tenants' living constraints (presence of children, the elderly, working hours, etc.).

By adopting this **transversal and forward-looking** approach, off-site solutions gain in reliability, safety and acceptability, whether they are façade panels, roof boxes, technical modules or energy systems.

Secure logistics and protection of the elements

Several returns show the consequences of a sign (element and panel) delivered the wrong way, exposed to rain, or improperly stored. The **layout of deliveries, protection against bad weather, the right storage medium and the clear identification of elements** are essential. On an occupied site, these points become critical: little space, little room for manoeuvre, little room for error (to minimise the nuisance caused to the inhabitants).

Work on the installation order and site sequences

A panel that is incorrectly positioned in stock or delivered in the wrong order generates re-handling, waiting times and team tensions. The objective is to **deliver in the order of assembly**, with site planning integrated from the study phase. This requires fine coordination between production, logistics and installation – even if this is outsourced.

Integrate feedback from the field into the improvement loop

Each project is a learning opportunity. The most mature manufacturers have set up short loops of REX: what has worked, what has stalled, what needs to evolve. This capitalization makes it possible to **adjust the product, the packaging, the installation tools** – and ultimately, to increase customer satisfaction while reducing hidden costs.

7.2.5. Territorial collaborative approach

The industrial development of solutions for renovation cannot be done in a vacuum. The most promising approaches are those that are based on a **structured local ecosystem** and that build solid cooperation, both technical and commercial.

Anchoring oneself in a territory to secure supply and installation

The regional presence is a strong lever for competitiveness: access to a local wood resource, proximity to construction sites, simplified logistics. But to take full advantage of it, it is necessary **to structure sustainable partnerships** with local stakeholders: sawmills, insulation suppliers, transporters, installers, general contractors. This reduces lead times and costs and increases the robustness of the offer.

Create a network of reliable installers or co-contractors

Most manufacturers are aiming for a supply-only model, but this requires **a competent implementation network**. Whether it is through an agreement, a temporary group of companies or the training of local craftsmen, it is essential to organize this downstream chain. Without this, the offer remains incomplete and **difficult to mobilise by a client**.

Working as a collective to respond to the markets

Responding to calls for tenders for efficient renovation on your own is often complex. Several manufacturers are exploring **grouping strategies with general contractors or carpenters** to build global offers, better distribute risks and facilitate access to critical size projects.

The partnership between 2 manufacturers offering interoperable products is all the more powerful as it promotes the guarantee of the production of the panels until the end of the project, even in the event of a hazard at one of the two (overload, supply difficulties, delays, etc.).

European initiatives, such as the **Life Cosme Reno** project, go even further by experimenting with collaborative systems such as **"prefablabs"**: shared platforms where different players pool their prefabrication resources, test solutions together and structure a collective offer.

This type of approach is a concrete illustration of how cooperation can secure the rise of off-site.

Contributing to a dynamic sector

Beyond the own project, participating in collective initiatives (regional clusters, European projects, experimentation approaches) allows you **to increase visibility, skills and credibility**. These approaches also promote the exchange of good practices and the pooling of tools (standard plans, feedback, quality standards, etc.).

It is also possible to create **territorial (pre)fablabs** centralising skills and production capacities, while forging strategic partnerships with schools or training centres located nearby and welcoming innovation start-ups. These competitiveness clusters provide a secure framework for the development of companies engaged in off-site renovation and contribute to the visibility of the sector and its solutions among clients.

A typical example is the project of the company **SynerPod**, developed in Pays de la Loire, which pools an industrial and logistics platform for efficient renovation. By bringing together companies, technical centres and public actors, it demonstrates how a collective approach can both secure investments, accelerate innovation and strengthen the territorial anchoring of the off-site sector.

Leveraging local public procurement

Several players have been able to initiate their development by relying on local authorities or regional social housing organisations. Building a **relationship of trust with a few local contractors** makes it possible to secure the first references and to test its solutions, on small projects and in real conditions, as well as to structure feedback that can be used commercially.

7.3. In brief

Structure your product offer

- Formalize a clear product range, with its options and limitations (market segments, building typologies, normative requirements such as fire safety, structure, acoustics, etc.).
- Work on both the **standardization of the product** (formats, interfaces, guaranteed performance) and the **standardization of the process** (organization of manufacturing, installation methods).
- Design according to a **DfMA (Design for Manufacturing and Assembly)** and **sourcing logic** : the project is designed from the available product, and not the other way around.
- Document systematically: product sheets for project owners and project managers, installation plans, implementation instructions.
- Ensuring performance with tested, controlled, and repeatable products.

Quality and reliability

- Implement a complete quality approach: quality assurance plan in the factory, intermediate controls, quality control after installation, Commissioning.
- Anticipate standardization and certification procedures (Technical Approvals, ATEx, compliance with Unified Technical Documents).
- Develop demonstrator references (pilots, small exemplary operations) that serve as showcases of the solution.

Industrial and logistics organization

- Smooth production with buffer zones, site-aligned scheduling, and specific treatment of non-standard products.
- Anticipate the factory-site interface: packaging, delivery phasing, lifting and fixing systems, weather protection.
- On occupied sites, organise interior work to minimise inconvenience to residents (dust, noise, power cuts).
- Prototype complex details to avoid improvisations on site.

Economy and financing

- Clarify your business model (supply only, supply and installation, general contractor, grouping).
- Secure cash flow by taking into account the current payment method (payment in advance), by looking for suitable advance or financing solutions.
- Positioning oneself in a targeted and realistic market in order to amortize the industrial tool.

Partnerships and cooperation

- Develop strategic partnerships with key suppliers (joinery, insulation, ventilation systems, structures).
- Build local alliances with local companies (SMEs, VSEs, social and solidarity economy structures) to pool and strengthen the territorial anchoring.
- Work with project owners, from the outset, to clarify expectations and co-construct solutions.
- Rely on research laboratories, technical centres and competitiveness clusters to innovate and standardise.
- Explore the logic of cooperation on a larger scale: groups with general contractors or carpenters, shared platforms and territorial (pre)fablabs, examples such as **SynerPod** in Pays de la Loire or **Life Cosme Reno** in Europe.

Standardization and interoperability

- Participate in the definition of a base of shared interfaces (dimensions, hook points, assembly systems, quality documentation).
- Promote the interoperability of solutions to avoid reinventing everything for each project and secure industrial investments.
- Contribute to a collective standardisation dynamic, in conjunction with technical bodies (CSTB, FCBA, CNR, MIMIT), sectoral clusters and, ideally, European initiatives.

Human Resources and Security

- Invest in internal training, mentoring and skills development for design, production and installation teams.
- Develop a shared culture of health, safety and prevention, both in the factory and on the construction sites.
- Implement a logic of continuous improvement and collective learning.

Environment and responsibility

- Systematically integrate life cycle analysis, carbon performance and environmental product declaration sheets.
- Explore the use of bio-based materials, reuse and recycling, in order to strengthen alignment with carbon neutrality objectives.
- Promote these commitments to project owners and contractors, positioning them as differentiating assets.

giga regio factory by energiesprong

8. The 20 questions to ask yourself to structure your industrial offer in renovation and to ramp up

8.1. Framing your product and market

1. What is the main product I want to offer (type of panel/module, trim level, integration of elements)?
2. What types of buildings and projects is this product best suited for? What need does the product meet? What services does it provide?
3. What are the acceptable deviations from this standard product, and how can they be managed?

8.2. Technical Advice and ATEx

4. Have I identified the normative requirements or recognition procedures necessary to secure the use of my solution (ATEx, Technical Approval, CE marking, etc.)?
5. Have I identified the standards or standards applicable to my products to anticipate their integration into public contracts?
6. Do I need an ATEx or a Technical Evaluation for my solution or certain components?
7. If not, is my technical documentation clear and structured enough to convince the control offices and project owners?
8. Can I pool an ATEx approach (via a group or a recurring project management) to facilitate its acquisition?

8.3. Sizing your industrial tool

9. What is the daily or weekly target flow to be achieved, in line with my capacities and the target market?
10. How much workshop and storage space do I need to produce in good conditions?
11. What equipment is critical in the short term, and what investments should be planned in a second phase?
12. What is the best workshop organization with regard to my volumes (U-shaped flow, flexible cell, fixed station, etc.)?

8.4. Supervise production and resources

13. What are the key skills to be strengthened (production, design office, logistics, quality, construction site)?
14. What training or mentoring materials do I need to increase the skills of the teams?
15. Have I structured a quality plan / a commissioning process (PAQ, checkpoints, site documentation)?

8.5. Securing logistics and the site interface

16. Have I defined a transport strategy adapted to my elements (templates, protections, racks, installation order)?
17. How are incoming and outgoing logistics flows (supply, storage, delivery) managed?
18. Have I integrated a site planning into my organization (production order based on the installation order)?

8.6. Building your market trajectory

(Please see Practical Guide for Companies and Solution Providers)

19. On what type of customers or territories can I build my first references, and what are the replicability levers of my solution?
20. Is my business model clear (supply only, supply + installation, grouping, co-contracting) and have I identified my key partners?

9. Lessons learned from feedback in France and Italy

This synthesis is based on the cross-analysis of five video testimonies of pioneers of off-site renovation in France. This feedback makes it possible to better identify the technical, economic, organisational and partnership levers for a successful scale-up.

Source videos analysed:

1. Est Métropole Habitat – Paul Sachot
2. Vinci Construction / Rehaskeen – Armelle Langlois
3. Rabot Dutilleul – Rodolphe Deborre
4. Vilogia – Fabien Lasserre

In Italy, feedback has been enriched by some discussions and lesson learnt from panel manufacturers of different sizes (Woodbeton, Manni Group, Revosteel and Fanti Legnami) and one general contractor (Teicos Group).

9.1. Massification: a shared imperative

All the speakers agree on the imperative need to massively scale up efficient renovations to face the climate emergency and achieve the objectives of carbon neutrality by 2050, as well as to meet the regulatory requirements set by the Climate and Resilience Law, particularly the treatment of E-rated housing by 2034. This involves:

- A change of scale in public procurement
- An inter-donor organization to aggregate needs and secure stable order books for companies, manufacturers and solution providers
- Strong support from the general management in the structures carrying out projects (Est Métropole Habitat, Vilogia).

In Italy, industrialised renovation products and systems are now technically ready and scalable, as shown by the 12 solutions presented at the Energiesprong Milan call for solutions to renovate recurrent social housing buildings, tested with cost projections at x1, x10 and x50 scales. Public authorities and housing agencies are increasingly acting through large-scale calls for proposals aligned with the PNRR (National Recovery and Resilience Plan), RepowerEU and Conto Termico 3.0 programmes, driven by the need to deploy funds rapidly. This momentum helps to reach industrial scale, but it also introduces distortions: it favours short-term execution rather than long-term industrial investment and stability. Indeed, as seen during the “Superbonus 110%” incentive period, the lack of long-term visibility risks creating a market dominated by low-quality, minimally industrialised products that simply meet maximum eligible costs, often relying on low-skilled labour to achieve volume rather than value.

9.2. Off-site: speed, quality and industrialization

The use of off-site, in particular through the prefabrication of insulating facades, insulating roof elements as well as energy modules (heating/hot water and ventilation equipment), makes it possible to:

- A drastic reduction in lead times (e.g. projects completed in 19 months instead of 4-5 years at Est Métropole Habitat)

- A reduction in nuisances for the occupants (noise, dust, disturbance, etc.)
- Improved quality through workshop work and process control
- Rationalization of openings and assemblies (fewer openings, better precision, increased safety).

9.3. Technical feedback and innovation

Est Métropole Habitat experimented with 3D modelling to the millimetre to design custom-made facades, installed in record time. The Bel Air project in Saint-Priest (930 homes) aims to achieve a carbon-neutral operation thanks to the massive use of bio-sourced materials.

Rehaskeen (Vinci Construction) designs fully prefabricated metal-frame insulating facades, with a product rather than a project approach. The objective is to make the innovation reproducible, via a DfMA (Design for Manufacturing and Assembly) approach, as well as prefabrication carried out by competent operators and then installation carried out by trained workers.

Rabot Dutilleul Construction relies on industrial partnerships to design standardised insulating façade elements capable of covering 80% of existing building typologies, in individual and collective housing. Precision and logistics optimization are key.

Vilogia reiterates the importance of integrating architects, companies and industrialists into a co-design approach from the outset. Adapting to the realities of the site on an occupied site remains a major challenge.

Italian companies illustrate different strategies and challenges in scaling up industrialized renovation:

- **Manni Group** – Following its merge with Marcegaglia, Manni is expanding its architectural product lines to strengthen its position in the renovation market. Its two-tier strategy combines high-end *Greentech* solutions for office buildings with more accessible *Isopan* systems that bridge ventilated façades and traditional ETICS insulation, offering competitive costs and enabling broad market penetration. Each project contributes to incremental technical refinement and process optimization.
- **Wood Beton** – Initially replicating the Rhinoceros-Wall solution installed on Torri di Via *Russoli* demonstrator in partnership with A2A energy utility, the company faced limited scalability due to rising timber costs. It is now pivoting toward hybrid or concrete-based façade systems (developed with Camuna Prefabbricati), enabling higher volumes at lower costs. These systems are suitable for both retrofit and new construction, creating synergies that support off-site diffusion across markets.
- **Revosteel** and **Fanti Construzioni** are small and medium enterprises producing steel and wood-based panels. The former specializes in catalogue-based small modular homes but despite design excellence, it still has limited turnover which constrains diversification and scalability. The latter pursues development mainly through regional or national funds (notably in Trentino), leveraging a local network to expand gradually in offsite renovation of residential buildings.
- **Teicos Group** – A strong advocate for industrialisation, Teicos actively participates in working groups (e.g. *Assimpredil ANCE*) and it is represented in innovation committees. It promotes hybrid façade systems as a compromise between ventilated and traditional solutions, with significant development potential. Teicos also stresses the importance of establishing official *price lists* (regional and national) for prefabricated systems to facilitate their inclusion in public tenders and procurement frameworks. The most explored procedure is PPP with Energy Performance Contracts that in Italy are broadly diffusing due to the limited CAPEX of Public Administrations.

9.4. The conditions for success: governance, organisation and dialogue

Several key factors stand out:

- Whether on the project management or business side, a convinced and mobilized general management (the support of the Executive Committee is decisive)
- Clear governance in the consortiums, with a representative adapted to the phases (e.g. architect in the design phase, company in the works phase)
- A clear and fixed definition of the program by the project owner: avoiding changes during the project
- Industrialization as an opportunity and not as a constraint: to raise the constraints of prefabrication in the factory from the design phase.
- A sharing of culture between project owners, architects, companies and industrialists through anticipated dialogue (open-book work), long-term partnerships and strengthened cooperation at all stages of projects.
- Procurement models, both in terms of company eligibility (size, certified competences OG/OS, workforce, turnover) and in the structure of public tenders.

  Especially in Italy, technical specifications and cost ceilings should differentiate between on-site and off-site works, to ensure compliance with labour law constraints while allowing higher value prefabricated or hybrid approaches to compete fairly.
- Evolved financial mechanisms and contracting models to reflect the industrial nature of off-site production (for example, introducing staged payments during prefabrication phases or specific CAPEX supports) thus reducing the risk of cash-flow imbalances for manufacturers, which is a recurrent issue in Italy and in Europe.

9.5. Obstacles and avenues for improvement

- The initial cost of off-site solutions is still seen as an obstacle, but it is offset by gains in overall cost (solutions amortized over a longer period) and in lead time
- The habit of ordering in separate batches slows down the approach by industrialized and integrated products. At the very least, think in macro-batches (a closed-covered macro-lot, a macro-lot for technical lots for example)
- The lack of visibility on future annual volumes is slowing down industrial investments. We need to "massively scale demand" to enable continuous improvement
- Winter and summer comforts as well as resilience to climate change are becoming essential criteria, to be integrated into diagnostic and DPE tools.

9.6. Towards a paradigm shift

- Moving away from the "single site" logic to enter into a logic of range, product, standardization
- Thinking about renovations in an ecosystem of solutions, including diagnostics, logistics, installation and use
- Consolidate interprofessional value chains (e.g. architects, project managers, industrialists, general contractors) – or even organise cooperation between peers, for example: several general contractors responding together to a massive market, in order to be able to respond realistically to the volume involved (each with its own resources) and to increase skills together (notion of learning curve).
- Develop collective tools: order groups, networks and inter-MOA work (e.g. joint feedback, common specifications, etc.), central purchasing bodies.

Overall, both in France and Italy, compared with five years ago, there has been a significant cultural shift. Architects, developers and public clients increasingly recognize the necessity and advantages of industrialized approaches in terms of quality, cost control, and environmental performance.

Nevertheless, a structured national platform bringing together stakeholders across the value chain (public authorities, manufacturers, designers, ESCOs, clusters, research centres) is essential to ensure a unified dialogue with government bodies and a valorisation of offsite retrofit solutions needed for scale-up, as it occurred in Germany.

These testimonies underline that off-site renovation is no longer an experimental bet but a structuring orientation for the successful transformation of the building sector.

However, the idea is not to seek to replace traditional renovations, only to create a market segment of its own and develop it to renovate what is not currently renovated.

Provided that we pool forces, change methods and engage in the right partnerships, it can combine massification, quality, carbon sobriety and cost control.

10. Reference case studies and operational tools for scaling industrialised renovation

The transition toward large-scale industrialised renovation is no longer theoretical. Across Europe, concrete projects have demonstrated that deep, high-performance renovation can be delivered faster, with greater precision and improved resident experience, when structured through industrial logic.

This section presents selected reference cases developed and documented within the Life Giga Regio Factory project. These examples illustrate how industrialised renovation can be implemented in real conditions in different regulatory environments, housing typologies and governance contexts.

Beyond individual projects, this section also introduces *Batimatch*, a practical tool designed to support housing providers in identifying aggregation potential and initiating collective industrialised renovation strategies.

Together, these cases and tools show how to move from pilot experimentation to structured market activation.

10.1. France - Est Métropole Habitat: From pilot to serial deep renovation

One of the most emblematic examples of industrialised renovation in France is the work carried out with Est Métropole Habitat (EMH), a major social housing provider.

Context

The projects concern large social housing estates built in the post-war decades, characterised by repetitive façades, structural regularity and high energy consumption. These typologies are representative of a significant portion of European housing stock.

The Bel Air project in Saint-Priest, for example, involves approximately 930 dwellings.

Industrial strategy

The renovation approach was structured around:

- Prefabricated façade panels produced in factory conditions
- High-performance roof elements
- Plug-and-play energy modules integrating heating, hot water and ventilation
- Millimetre-precision 3D modelling to anticipate tolerances
- Strong integrator coordination to manage interfaces

The works were conducted in occupied conditions, requiring careful planning and communication with residents.

Results

The industrial logic enabled:

- A significant reduction in project duration (example: 19 months instead of the 4–5 years typically observed in traditional renovation programmes)
- Reduced nuisance for residents (shorter installation time, less dust and noise)
- Improved construction quality thanks to workshop-controlled processes
- Enhanced energy and comfort performance

Lessons for public stakeholders

This case demonstrates that:

- Serial renovation is possible at scale in social housing
- Industrial logic must be embedded from the design phase
- Resident engagement is a central success factor
- Digitalisation and prefabrication reduce technical uncertainty

Most importantly, it shows that industrialised renovation is not a loss of architectural quality, it is a change in production logic.

10.2. Italy - Via Russoli, Milan: Structured supply chain and EPC+ model

In Italy, the Via Russoli project in Milan represents a decisive step in adapting industrialised renovation principles to the national context.

Context

The project concerns four social housing towers (approximately 200 apartments) owned by ALER Milan.

Italy faces additional constraints compared to other countries:

- Seismic regulations
- Architectural integration requirements
- Strong dependence on incentive schemes

Governance and contract model

The project was implemented under an Energy Performance Contract Plus (EPC+), which includes long-term maintenance of the prefabricated envelope.

The supply chain was structured as a coordinated consortium:

- An energy utility (A2A)
- A prefabricated panel manufacturer (WoodBeton)
- A bio-based insulation specialist (Ricehouse)

This integrated model enabled risk-sharing and performance commitment over time.

Strategic value

Via Russoli demonstrates that:

- Industrialised renovation can adapt to national regulatory frameworks
- Consortium-based responses to public procurement are feasible
- EPC models reinforce performance accountability

It also illustrates the importance of ecosystem building: industrialisation does not rely on a single company, but on a coordinated network of actors.

10.3. Germany - From portfolio screening to serial project pipeline

In Germany, the key innovation has not only been technical and it has been strategic.

Green Invest Berlin conducted 11 portfolio analyses covering approximately 130,000 residential units from major housing companies.

The "funnel" methodology

A structured filtering process was developed to identify buildings suitable for serial renovation. Criteria included:

- Building morphology
- Energy consumption thresholds
- Accessibility for industrial installation
- Repetition of typologies within neighbourhoods
- Scale sufficient for industrial deployment

The analysis showed that around 30% of the building stock studied was highly suitable for serial renovation.

Operational outcome

This method led to the identification and launch of projects such as BWB Düsseldorf (approximately 290 dwellings across 40 buildings).

Lessons for scaling

This case underlines a critical point:

Massification does not start on the construction site.

It starts with strategic stock analysis.

By identifying suitable clusters early, housing companies:

- Reduce investment risk
- Provide visibility to industrial partners
- Structure multi-year renovation pipelines

Industrialised renovation becomes viable when demand is predictable.

10.4. France - AURA HLM: Structuring the first collective market

Within the Auvergne Rhône-Alpes region, Life Giga Regio Factory supported the analysis of 13,000 dwellings across several social housing providers.

Key findings

- 30% scaling potential identified
- First coherent asset cluster validated
- Preparation of a renovation wave covering approximately 1,000 dwellings

This work laid the foundations for the first large-scale grouped renovation market in the region.

Why this matters

Unlike single-building demonstrations, this case shows how:

- Several housing providers can coordinate
- Demand can be aggregated
- Industrial visibility can be secured
- Investment conditions can improve

It represents a structural shift from isolated projects to territorial market activation.

10.5. Batimatch – Making industrial aggregation accessible

Industrialised renovation can appear complex, particularly for housing providers unfamiliar with clustering logic or off-site construction principles.

To facilitate understanding and engagement, Ressorts developed *Batimatch*.

What is Batimatch?

Batimatch is a practical and interactive tool designed to:

- Help housing providers analyse their stock
- Identify typologies compatible with industrialised renovation
- Explore grouping potential with other owners
- Initiate structured dialogue on performance ambition and feasibility

Rather than presenting complex spreadsheets or technical matrices, Batimatch translates analytical logic into a participatory experience.

Why it matters

Batimatch acts as:

- An entry point to the Life Giga Regio Factory methodology
- A catalyst for collective buy-in schemes
- A bridge between strategic ambition and operational feasibility

It allows stakeholders to understand that industrialisation is not about standardisation imposed from outside, but about identifying common opportunities within existing assets.

10.6. From demonstration to market transformation

The reference cases presented in this section show that industrialised renovation is:

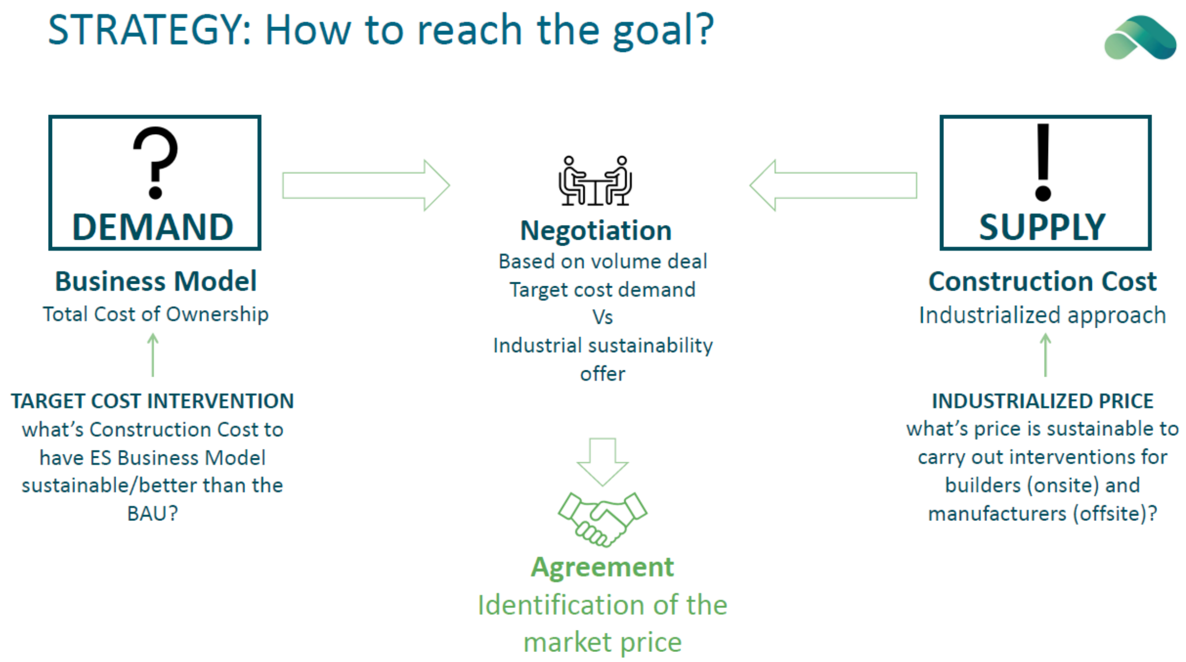
- Technically feasible
- Economically viable under structured conditions
- Compatible with resident well-being
- Adaptable to national contexts

However, the key transition lies in moving from demonstration projects to repeatable market logic.

This requires:

1. Early identification of suitable building clusters
2. Clear product-based industrial offers
3. Stable governance and long-term partnerships
4. Aggregated demand to secure volumes
5. Tools that support decision-making

Life Giga Regio Factory has demonstrated that when these conditions are aligned, industrialised renovation can move beyond innovation and become a reference model for delivering Europe's decarbonisation objectives.



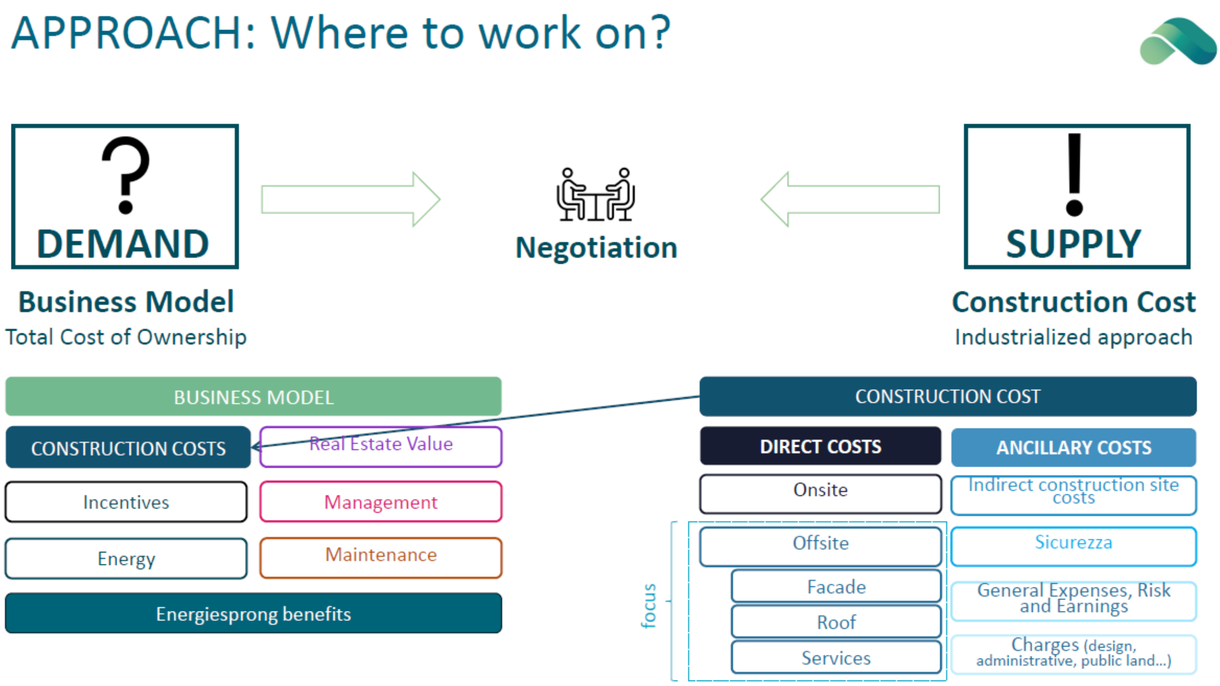


Figure: Illustration of future case studies

11. Sustainability, exploitation and replication

The Life Giga Regio Factory project was not designed as a temporary experiment. Its ambition has always been structural: to transform the way deep energy renovation is delivered, financed and organised in Europe.

The objective is to accelerate large-scale deep renovation by industrialising solutions and processes — reducing costs, shortening delivery times and increasing desirability — so that renovation can become a mature and self-sustaining market rather than a subsidy-dependent niche.

11.1. Building a mature market

The long-term sustainability of industrialised renovation relies on a virtuous circle.

When renovation costs decrease, more building owners are able to invest in deep renovation. This increased demand enlarges the market. Larger volumes enable manufacturers and construction companies to optimise production, invest in better tools and stabilise industrial workflows. These improvements further reduce costs, which again stimulates demand.

Reaching this mature stage progressively reduces dependence on public subsidies. While incentive schemes remain necessary during the transition phase, the long-term goal is clear: deep renovation must increasingly become economically viable through industrial efficiency.

Encouraging results are already visible. The first collective initiatives implemented at regional scale within Life Giga Regio Factory show cost reductions of around 25% compared to the earliest off-site deep renovation projects. This confirms that industrialisation is not only conceptual — it produces measurable economic impact.

11.2. Strengthening skills and industrial capacity

Sustainability is not only about cost reduction. It also depends on the strength of the supply side.

A major achievement of the project has been the structuring of trained networks of manufacturers, integrators and construction companies across France, Italy, Germany and Belgium. Through diagnostics, coaching and workshops, these actors have strengthened their expertise in off-site construction, DfMA approaches and product-based logic.

Companies have improved their industrial workflows, clarified their offers and built stronger partnerships within the value chain. This work has created the foundations for industrial actors capable of delivering serial renovation projects beyond the lifetime of the programme.

The knowledge generated during the project is now embedded in regional ecosystems. It will continue to shape market development.

11.3. Making renovation desirable and attractive

A sustainable renovation market must also be socially attractive.

Industrialised renovation reduces nuisance for residents through shorter installation times and improved planning. It enhances comfort and performance while improving quality control thanks to factory-based production.

For workers, off-site production offers safer and less physically demanding working conditions. In a context of labour shortages across Europe, this shift is strategic. Industrialisation is not only about energy performance — it is also about making the renovation sector more attractive and future-proof.

11.4. From sustainability to replication

As the project progressed, it became clear that the methodology developed within Life Giga Regio Factory could extend far beyond its initial scope.

The housing smart aggregation tool developed under WP2 allows stakeholders to analyse portfolios, identify achievable performance levels, assess compatibility with off-site solutions and cluster buildings with similar characteristics. This supports the programming of grouped renovation contracts based on homogeneous typologies.

Originally designed for social housing providers, the approach is equally relevant for municipalities, metropolitan authorities and public bodies managing schools, offices or public facilities. It can also serve private asset managers renovating office portfolios, hotel chains or other large building stocks.

The principles of aggregation and industrial matching are transferable to multiple building uses.

11.5. AURA HLM and Batimatch: replication in action

In France, the methodology was tested with AURA HLM and six associated housing providers. The analysis covered 13,000 dwellings and identified a scaling potential of around 30%. A first asset cluster was validated to prepare large-scale renovation waves by 2027.

This demonstrates that the methodology is already structuring real markets.

To make the aggregation logic more accessible, Ressorts developed Batimatch — a participatory and educational tool that introduces housing providers to clustering principles in a practical way. Rather than presenting complex analytical models, Batimatch allows stakeholders to explore grouping opportunities and understand off-site compatibility through interactive workshops.

The first sessions, organised during Energiesprong France Days and with AURA HLM, confirmed its value as an entry point for replication.

Example of Life Giga Regio Factory study outcomes for AURA HLM

Example of “Batimatch” game from Giga Regio Factory Life programme

11.6. Continuity beyond the project

All tools and resources developed within Life Giga Regio Factory have been designed to remain accessible after the end of the programme. The open-source nature of the work ensures that new regions and actors can reuse and adapt the methodology.

The Energiesprong Global Alliance will continue to host and disseminate the tools, while national market development teams will keep activating grouped renovation schemes and supporting supply-side actors.

The methodology is already being extended through complementary initiatives such as the French ADEME-funded “On Renov Factory” and the Italian Energiesprong Milano project, which aim to integrate visual recognition technologies and artificial intelligence to automate portfolio analysis and further accelerate scaling.

There has therefore been no change in the sustainability or exploitation strategy. On the contrary, experience gained during the project has reinforced confidence in the approach and revealed additional opportunities for replication.

Life Giga Regio Factory has demonstrated that industrialised renovation can reduce costs, structure demand, strengthen supply chains and create the conditions for a long-term transformation of the European renovation market.

12. Conclusion

The deployment of an **industrialised and mass-produced energy renovation** market is no longer a distant objective, but a strategic necessity. Faced with the scale of climate challenges, the obsolescence of the European built stock and the urgency of measurable results, the model promoted by the Life Giga Regio Factory project – articulated around industrial development, territorial cooperation and organisational innovation – offers a realistic and replicable path.

The work carried out as part of this deliverable has highlighted three key dynamics to encourage and strengthen:

- **Massification**: it is only by industrializing methods, standardizing certain components and aggregating demand via project management collectives that economies of scale can emerge. The objective is clear: to enable SMEs and mid-caps to plan their activity, invest in appropriate tools and produce in a replicable way.
- **Continuous innovation**: whether technological (modularity, BIM, automation), organizational (new consortium models, new governance schemes) or economic (cost pooling, value sharing), innovation must be permanent. It must also be done in dialogue with the realities on the ground and the expectations of project owners.
- **Collective skills development**: the development of shared tools, adapted training and reference kits is essential to advance the entire value chain. The use of participatory workshops, collective coaching and feedback allows each player to assess their position, to consider a concrete transformation trajectory and then to implement continuous improvement.

Resources mobilized and prospects

Many tools developed as part of the Life GRF project remain available and can be activated:

- **Business Plan Tool**: to model production costs, test profitability and structure an investment strategy over several years.
- **National Training Kits**: to introduce the fundamentals of off-site renovation to new players.
- **Guides and summary documents**: for manufacturers, companies, project owners and project facilitators.

The momentum initiated must extend beyond the project, through:

- The animation of groups of actors in each country,
- Capitalization of the workshops and lessons learned from the pilot projects,
- Support for concrete projects in response to grouped or non-grouped calls for tenders for renovation.

The path to industrial renewal is still under construction, but the foundations are now solid. The actors involved now have the first tools, the first feedback and the first networks of partners. It is now up to them to bring these achievements to life, to amplify their impact and to inspire other territories in Europe.