Life Giga Regio Factory

Off-site retrofit companies mapping

Co-funded by the European Union

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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

Off-site retrofit companies mapping

Integrators and industrial actors

Industrialised and off-site retrofit ecosystems

This report presents a public synthesis of the actor mapping and ecosystem analysis carried out within the LIFE Giga Regio Factory project. It focuses on integrators and industrial solution providers involved in industrialised and off-site retrofit and provides a methodological and strategic reading of ecosystem maturity across participating countries.

The document is intended for public authorities, housing providers, market facilitators, clusters and other stakeholders seeking to understand and structure industrialised retrofit ecosystems.

Scope and positioning of the report

This public report builds upon analytical work conducted throughout the project, including confidential profiling of retrofit integrators, public mapping of selected integrator profiles, and analysis of industrial suppliers of off-site retrofit solutions.

*The present document consolidates these insights into a **standalone, public-facing report**, with a strong focus on methodology and analytical framework, functional roles and ecosystem dynamics, cross-country maturity insights, strategic implications for scaling industrialised retrofit.*

No confidential or company-identifiable data are disclosed.

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Executive Summary - **Scaling industrialised and off-site retrofit through ecosystem integration**

Context and challenge

Across Europe, the transition toward climate neutrality and housing affordability increasingly depends on the capacity to **upgrade existing building stock at scale**. While technical solutions for energy-efficient retrofit are widely available, their deployment remains fragmented, slow and costly. This gap is particularly visible in collective housing and public portfolios, where the need for speed, predictability and performance is the greatest.

Industrialised and off-site retrofit has emerged as a promising pathway to address these challenges. By shifting a significant share of work from construction sites to controlled factory environments, off-site approaches can reduce delays, improve quality, stabilise costs and limit disruption for occupants. However, experience across multiple countries shows that **technology alone does not deliver scale**. The decisive factor is the organisation of actors, roles and interfaces within retrofit ecosystems.

This report addresses a fundamental question for decision-makers:

How ready are national ecosystems to deliver industrialised retrofit at scale, and what is required to accelerate this transition?

Methodological approach

The analysis presented in this document is based on a **functional, ecosystem-level methodology**. Rather than evaluating individual companies or technologies, the approach focuses on how retrofit systems function in practice, by examining:

- the distribution of roles along the retrofit value chain;
- the presence and strength of integration and coordination functions;
- the alignment between industrial supply and project delivery;
- the quality of interfaces between design, manufacturing, site execution and operation;
- and the collective maturity of ecosystems rather than isolated performance.

This qualitative and function-based framework allows comparison across countries with very different industrial traditions and market structures, while remaining suitable for public dissemination. It avoids ranking or scoring individual actors and instead provides **strategic intelligence** to support policy design, ecosystem structuring and market facilitation.

Key findings

Integration capacity is the primary bottleneck

Across all contexts analysed, the main limitation to scaling industrialised retrofit is not the absence of technical solutions, but the **lack of clearly identified and empowered integrator roles**.

Integrators are actors capable of orchestrating the full retrofit process: aligning design with industrial constraints, coordinating off-site production and logistics, managing on-site assembly, and ensuring continuity toward commissioning and long-term performance. Where such roles are weak or fragmented, industrial solutions remain underused and retrofit delivery remains project-based and inefficient.

Strengthening integration capacity is therefore the most impactful lever for ecosystem transformation.

Industrial strength does not automatically translate into retrofit readiness

The comparative analysis of France, Germany, Belgium and Italy highlights that **industrial capacity and retrofit integration do not evolve in parallel**.

- Countries with strong industrial and prefabrication traditions may still struggle to deploy these capabilities in retrofit contexts if coordination models remain adapted to new build.
- Conversely, countries with strong demand pressure and high motivation for retrofit may lack mature, interoperable industrial supply chains.

This disconnect explains why industrialised retrofit remains unevenly deployed despite widespread availability of prefabricated components.

Ecosystem maturity profiles differ, but are complementary

The analysis identifies four distinct maturity profiles:

- **France** is in a phase of ecosystem structuring, with emerging integrator roles and increasing policy alignment, but still faces fragmented supply chains and fragile interface management.
- **Germany** combines very strong industrial capacity with limited retrofit-specific integration, creating high potential that remains underexploited.
- **Belgium** shows a supplier-strong, cluster-driven ecosystem, with significant cross-border orientation but weaker end-to-end retrofit coordination.
- **Italy** represents a demand-driven ecosystem in formation, characterised by strong motivation and need, but limited industrial depth and formalised integration structures.

These differences are not obstacles per se. They reveal **complementarities** that can be leveraged through cooperation, learning and ecosystem-level coordination.

Capacity-building accelerates ecosystem readiness

Beyond mapping and analysis, the project has demonstrated the impact of **targeted capacity-building and learning processes**.

Across all four countries, stakeholders involved in retrofit delivery have developed:

- a shared vocabulary around integration, interfaces and industrial logic;
- greater awareness of the organisational requirements of off-site retrofit;
- improved ability to position themselves within value chains;
- and a clearer understanding of how industrial solutions and project delivery must align.

As a result, baseline ecosystem maturity has increased, particularly in relation to integration capacity and coordination awareness. This confirms that **skills, processes and shared understanding** are as critical as technology for scaling retrofit.

Strategic implications for decision-makers

Move from project-based to portfolio-based strategies

Industrialised retrofit requires volume, predictability and repetition. Public authorities and large building owners should prioritise **portfolio-level programming** rather than isolated projects, enabling learning effects and investment in standardisation.

Recognise and support integrator roles explicitly

Integration should be treated as a distinct and strategic function. Support mechanisms (policy, procurement, funding) should encourage actors to assume coordination responsibilities across the full retrofit lifecycle.

Focus public intervention on interfaces, not only products

The greatest systemic gains come from improving interfaces: between design and factory, factory and site, installation and operation. Public support should prioritise interoperability, standardisation and interface management.

Align industrial development with retrofit-specific constraints

Industrial solutions must be adapted to the variability of existing buildings. Early collaboration between integrators and industrial providers is essential to ensure feasibility, repeatability and performance.

Institutionalise capacity-building and ecosystem learning

Training and upskilling should be embedded as permanent ecosystem functions, focusing on integration, coordination and industrial logic rather than on tools alone.

Leverage cross-border complementarities

Differences in maturity across countries create opportunities for transnational value chains. Facilitating cross-border cooperation can accelerate scaling, particularly where domestic capacity is limited.

From analysis to market transformation

The work synthesised in this executive summary goes beyond diagnostic. It provides a **practical framework for transforming how industrialised and off-site retrofit markets are structured and governed**.

Its core legacy is not a database or a static mapping of actors, but a **shared way of reading retrofit ecosystems**—one that makes integration capacity, interface management and collective readiness visible. This shift in perspective is essential for moving from isolated pilot projects to repeatable, large-scale delivery.

Looking ahead, the framework can be mobilised as:

- a strategic support tool for public authorities structuring large-scale retrofit programmes;
- a reference for ecosystem builders, clusters and market facilitators;
- a basis for monitoring market evolution and adjusting support mechanisms over time.

In a context where retrofit must rapidly move from ambition to execution, the value of such ecosystem-level intelligence lies in its ability to **reduce uncertainty, align actors and accelerate collective action**.

Content

Glossary

A

Aggregation / Portfolio approach

Strategy consisting in grouping multiple buildings or projects into a coherent programme. Aggregation enables standardisation, learning effects, industrial investment and more predictable delivery conditions for off-site and industrialised retrofit.

C

Capacity-building

Processes aimed at strengthening skills, knowledge, organisational practices and coordination capabilities of actors involved in retrofit delivery. Capacity-building is a key accelerator of ecosystem maturity, particularly for integration roles, interface management and industrial logic.

Cross-border value chain

Retrofit delivery model in which industrial production, integration functions and demand are distributed across different countries or regions. Cross-border value chains allow ecosystems to leverage complementary strengths (industrial capacity, integration know-how, demand) beyond national boundaries.

D

Digital enablement / Digital maturity

Degree to which digital tools and workflows support the retrofit lifecycle, including data capture, modelling, interoperability, logistics planning, commissioning and performance monitoring. Digital enablement acts as a multiplier of integration capacity when aligned with organisational processes.

E

Ecosystem maturity

Collective level of readiness of a retrofit ecosystem to deliver industrialised retrofit at scale. Ecosystem maturity reflects the alignment between integration capacity, industrial supply, interface management, digital enablement and market structuring.

F

Functional approach / Functional mapping

Method of analysing retrofit ecosystems based on the roles and functions required along the value chain, rather than on legal status, sector or contractual form. The functional approach focuses on what actors do in practice and how they interact.

I

Industrialised retrofit

Approach to upgrading existing buildings based on standardisation, repeatability and industrial production principles. Industrialised retrofit combines off-site manufacturing, coordinated logistics, digital workflows and rapid on-site assembly to improve speed, quality, cost control and performance.

Industrial provider / Industrial actor

Company or organisation that designs and manufactures prefabricated or modular retrofit components, systems or assemblies (e.g. façade systems, MEP kits, pods). Industrial providers operate at different levels of system integration and depend on integrators for deployment at scale.

Integration capacity

Ability of an actor or ecosystem to coordinate multiple functions, actors and interfaces into a coherent and repeatable retrofit process. Integration capacity is a primary determinant of scalability in industrialised retrofit.

Integrator

Actor capable of orchestrating the full retrofit value chain. An integrator coordinates design, industrial production, logistics, on-site installation and, where relevant, long-term performance and maintenance. The integrator role is functional, not legal, and may evolve over time.

Interface

Point of interaction between functions, actors, systems or phases of the retrofit process (e.g. design–factory, factory–site, installation–operation). Interfaces are critical risk points in industrialised retrofit.

Interface management

Processes, standards and coordination mechanisms used to secure compatibility and continuity across interfaces. Effective interface management is essential to achieve repeatability, quality and performance in off-site retrofit.

M

MEP (Mechanical, Electrical and Plumbing)

Technical building systems including heating, ventilation, cooling, electrical installations, water supply and sanitation. In industrialised retrofit, MEP systems are increasingly modularised and prefabricated to reduce site complexity and improve reliability.

O

Off-site retrofit

Retrofit approach in which a significant share of construction and installation activities is carried out in factory-controlled environments rather than on site. Off-site retrofit includes prefabricated components, systems or modules designed for installation on existing buildings.

P

Performance-based retrofit

Retrofit approach focused on achieving measurable outcomes—such as energy performance, comfort or reliability—rather than only delivering physical works. Performance-based models often include monitoring and long-term commitments.

Prefabrication

Manufacturing of building elements in a factory prior to transport and installation on site. Prefabrication can involve components, sub-assemblies or complete systems. Prefabrication alone does not guarantee an industrialised or integrated process.

R

Repeatability

Capacity to deliver similar retrofit projects multiple times using standardised processes, products and workflows, while maintaining quality and performance. Repeatability is a core objective of industrialised retrofit and a condition for scaling.

S

Standardisation

Process of defining common rules, interfaces, components or workflows to enable compatibility and repeatability. In retrofit, standardisation must balance industrial efficiency with the variability of existing buildings.

V

Value chain (retrofit)

Set of interconnected functions required to deliver retrofit projects, typically including design, prefabrication, integration, installation, commissioning, maintenance and, in some cases, financing and aggregation.

2D / 3D

2D systems

Prefabricated surface-based elements such as façade panels or roof assemblies, typically integrating multiple functions (structure, insulation, finishes) and designed for rapid on-site installation.

3D systems / Volumetric modules

Prefabricated three-dimensional units integrating several functions (e.g. bathroom pods, technical cores), manufactured and largely completed in factory conditions before delivery to site.

1. Introduction – Integrated profiling of integrators and industrial actors in LIFE GRF

Across Europe, the retrofit market faces a structural bottleneck that goes beyond the availability of technical solutions. While ambitions for deep energy retrofit and large-scale transformation of existing building stocks continue to grow, the sector still lacks **coordinated, replicable and industrialised approaches** capable of simultaneously meeting performance, cost and scalability objectives.

Industrialised and off-site retrofit solutions such as prefabricated façade systems, modular technical elements, volumetric pods or integrated HVAC kits are increasingly available and technically mature. However, their large-scale deployment remains limited. The main challenge lies not only in product readiness, but in the **ability of retrofit ecosystems to organise the interaction between industrial supply and project delivery** in a coherent and repeatable way.

This document addresses that challenge by focusing on the **joint profiling of integrators and industrial actors** involved in industrialised retrofit value chains. It considers both sides of the system:

- the actors who **develop and manufacture retrofit solutions**, and
- the actors who **integrate, coordinate and deliver these solutions** on real buildings.

1.1. From fragmented value chains to integrated retrofit systems

The retrofit market is traditionally organised around fragmented value chains. Industrial actors, designers, contractors, installers and maintenance providers often operate in silos, with limited coordination across project phases. This fragmentation is particularly problematic in retrofit contexts, where existing buildings introduce technical, logistical and social constraints that require a high level of anticipation and interface management.

At the same time, two parallel dynamics are accelerating across Europe:

- a growing **industrial supply of retrofit products and systems**, designed to improve quality, speed, predictability and on-site efficiency;
- an increasing **demand for performance-based retrofit**, driven by energy and climate objectives, rising energy costs, and public policies targeting large building stocks.

Yet, despite this convergence of supply and demand, the actors capable of **bridging industrial solutions and on-site delivery** remain scarce. This gap highlights the importance of a specific coordination role: the integrator.

1.2. The role of integrators in industrialised retrofit delivery

In the context of industrialised retrofit, an integrator is not defined by legal status, company size or traditional market category. Rather, it refers to an actor capable of **orchestrating the full retrofit value chain**, ensuring continuity between industrial production and building-specific delivery.

This role typically includes:

- coordination of building diagnosis, technical studies and design interfaces;
- alignment of design choices with industrial constraints and product standards;
- organisation of procurement and logistics linked to off-site manufacturing;
- management of on-site installation and interfaces between trades;
- and, in some cases, long-term monitoring of energy performance and operational outcomes.

Integrators provide a single point of accountability for housing providers, public authorities and building owners. They play a critical role in transforming industrial products into **coherent retrofit systems**, adapted to the constraints of existing buildings. However, this integrator role is still emerging and unevenly distributed across Europe. In some contexts, it is partially assumed by general contractors or design-and-build companies. In others, it is shared between multiple actors or embedded within industrial companies expanding downstream.

Understanding these configurations requires a structured and comparative approach.

1.3. Industrial actors and the supply side of retrofit systems

On the supply side, industrial actors play an equally critical role in enabling industrialised retrofit. These actors include manufacturers of prefabricated façade panels, volumetric modules, technical pods, integrated MEP systems and other modular retrofit components.

Their capacity to support large-scale retrofit depends not only on product performance, but also on:

- the degree of standardisation and modularity of their solutions;
- their ability to interface with digital design tools and retrofit workflows;
- their readiness to adapt products to building-specific constraints without losing industrial efficiency;
- and their openness to long-term collaboration with integrators and delivery partners.

In many cases, industrial actors are developing solutions originally designed for new construction and adapting them to retrofit contexts. This transition raises specific challenges related to interoperability, logistics, installation constraints and performance guarantees. Mapping these actors and their positioning within retrofit value chains is therefore essential to understanding the real deployment potential of off-site solutions.

1.4. Why joint profiling matters

Profiling integrators and industrial actors separately provides only a partial view of the retrofit ecosystem. Industrialised retrofit relies on the **alignment between supply and integration capacities**. A mature industrial offer without capable integrators cannot be deployed at scale, just as strong integrators cannot deliver industrialised retrofit without reliable and interoperable industrial solutions.

For this reason, the approach presented in this document is based on **joint profiling**, examining:

- how integrators and industrial actors position themselves within the same value chains;
- how responsibilities and interfaces are distributed between them;
- and how different configurations influence the scalability of retrofit delivery.

Rather than evaluating individual companies, the profiling focuses on **functional roles, recurring configurations and aggregated patterns**. This allows for a public, non-competitive reading of market maturity, suitable for strategic analysis and policy-oriented discussions.

1.5. Methodological scope and purpose of the document

The methodology presented in this document is designed to be **robust, transparent and transferable**. It is based on qualitative analysis, cross-country comparison and consolidation of market observations, without relying on public scoring or disclosure of company-level data.

The scope is intentionally limited to **retrofit of existing buildings**, with particular attention to deep and energy-focused retrofit approaches that require high levels of coordination between industrial supply and project delivery. New construction is not addressed, except where relevant industrial or organisational lessons are directly transferable.

This document is intended as a **standalone public reference**. It can be used by public authorities, innovation agencies, clusters, housing organisations and market facilitators seeking to:

- understand the structure of retrofit ecosystems;
- identify bottlenecks and development levers;
- design support programmes or policy instruments;
- and replicate or adapt mapping approaches to other territorial contexts.

By clarifying the roles of integrators and industrial actors and by making explicit the logic behind their joint profiling, this introduction lays the foundation for the methodological sections and aggregated findings that follow.

2. From fragmented value chains to integrated retrofit ecosystems

Across Europe, the deployment of industrialised and off-site retrofit solutions is constrained less by the availability of technologies than by the way retrofit value chains are organised. While prefabricated systems, modular components and digitally enabled processes are increasingly present on the market, they are rarely deployed as part of fully integrated and repeatable retrofit ecosystems.

Retrofit activities continue to rely on fragmented responsibilities, sequential project delivery and weak coordination between industrial supply and on-site execution. This fragmentation limits scalability, increases costs and risks, and undermines the ability to deliver performance guarantees at scale. Moving from isolated solutions to integrated retrofit ecosystems therefore requires a fundamental shift in how actors interact, coordinate and assume responsibility across the value chain.

This section introduces the rationale for focusing on **integrators** as a central function within retrofit ecosystems, and explains why joint consideration of integrators and industrial actors is essential to understand and structure industrialised retrofit markets.

2.1. Why focus on integrators in industrialised retrofit?

Across European markets, the supply of prefabricated retrofit products including 2D façade panels, modular technical systems, and 3D pods is expanding steadily. At the same time, demand for performance-oriented retrofit, including energy, comfort and operational guarantees, is also increasing. Yet one critical function remains underdeveloped: the capacity to **coordinate these resources into coherent, repeatable and scalable retrofit processes**.

This function is referred to in this document as the role of the **integrator**.

In the context of industrialised retrofit, an integrator is not simply a general contractor or a traditional builder. It is an actor capable of acting as a **systemic orchestrator of the full retrofit lifecycle**, ensuring continuity and coherence between industrial supply and project delivery. This role typically covers:

- upstream engagement with building owners and occupants, including diagnosis and solution definition;
- coordination of digital modelling, technical design and procurement;
- alignment with off-site manufacturing constraints and logistics;
- organisation of on-site installation, sequencing and quality control;
- and, where applicable, long-term monitoring of performance related to energy, comfort and maintenance.

This integrator function is both rare and essential. Without it, industrial products remain isolated components, deployed on a project-by-project basis without the organisational structure required for mass deployment. For industrialised retrofit to scale, the integrator role must therefore be identified, understood and actively supported within retrofit ecosystems.

2.2. Analytical objectives and profiling approach

To understand how integrator functions emerge and operate across different contexts, a structured profiling approach is required. Rather than relying on traditional market categories, the approach presented in this document is based on **functional analysis**, focusing on what actors do rather than how they label themselves.

The profiling logic is built around three core objectives:

- identifying actors capable of assuming integrator functions within retrofit value chains;
- analysing how these actors interact with industrial solution providers;
- and assessing ecosystem readiness for industrialised retrofit without exposing sensitive company-level information.

The analytical process follows a progressive and replicable logic:

- building on existing market knowledge and previous mapping efforts in more advanced contexts;
- analysing current and future retrofit needs through exchanges with building owners, industrial actors and delivery partners;
- identifying priority actor profiles and professions required to enable integrated retrofit delivery;
- and consolidating findings into country-level and cross-country readings.

This approach allows for the identification of **recurring integrator profiles**, without public scoring or ranking of individual companies. Instead, it provides qualitative insights into coordination capacity, digital readiness, scalability potential and strategic positioning within retrofit ecosystems.

2.3. Joint consideration of integrators and industrial actors

Integrated retrofit ecosystems cannot be understood by analysing integrators and industrial actors separately. Industrialised retrofit depends on the **alignment between the supply of industrial solutions and the capacity to integrate them into real projects**.

Industrial actors   including manufacturers of prefabricated façades, modular systems, technical pods and integrated MEP solutions   play a decisive role in enabling standardisation, predictability and off-site efficiency. However, the maturity of industrial products alone is not sufficient. Their deployment depends on:

- compatibility with retrofit constraints;
- interoperability with digital workflows;
- logistical integration with on-site activities;
- and the ability to work within coordinated delivery models.

For this reason, the profiling approach adopted here applies a **common analytical framework** to both integrators and industrial actors. This makes it possible to analyse two complementary dimensions of the same ecosystem:

- the **capacity to coordinate and deliver retrofit projects**, and
- the **capacity to supply industrialised solutions suitable for integration**.

By using shared concepts, typologies and functional categories, the approach highlights how different configurations of actors either enable or constrain the scalability of industrialised retrofit.

2.4. From internal profiling to public mapping and ecosystem insights

The profiling of integrators and industrial actors is not an end in itself. It serves as a foundation for producing **aggregated, public-facing insights** that support ecosystem structuring and decision-making.

Rather than publishing detailed company-level assessments, the public output of the mapping focuses on:

- geographical distribution of actor types;
- functional roles within retrofit value chains;
- recurring ecosystem configurations;
- and maturity trends at national or territorial level.

This layered approach allows sensitive analytical work to inform public understanding without exposing confidential data. It also makes it possible to:

- support housing providers and public authorities in identifying potential partners;
- inform policy design and support schemes;
- guide future matchmaking and ecosystem-building initiatives;
- and enable replication of the mapping methodology in other contexts.

Taken together, the joint profiling of integrators and industrial actors provides a coherent reading of how retrofit ecosystems function, where they are fragile, and how they can evolve towards more integrated, industrialised and scalable delivery models.

3. A shared functional reading of retrofit ecosystems

Before detailing the methodological framework used for profiling integrators and industrial actors, it is essential to clarify the **conceptual and functional reading of retrofit ecosystems** that underpins the entire analysis.

Industrialised and off-site retrofit cannot be understood through traditional sectoral boundaries alone. In practice, retrofit delivery mobilises a wide range of actors whose roles often overlap, evolve over time, or vary depending on the project configuration. A single organisation may act as a product supplier in one context, an integrator in another, or combine industrial, coordination and installation functions within the same value chain.

To address this complexity, the approach adopted in this document relies on a **functional representation of retrofit ecosystems**. Rather than categorising actors by legal status or market segment, it distinguishes:

- product families involved in off-site retrofit,
- functional roles required along the retrofit value chain,
- and the interfaces between industrial supply and project delivery.

This functional reading provides the conceptual foundation for the profiling methodology presented in the following section.

3.1. Common vocabulary used in this document

Industrialised and off-site retrofit ecosystems are often difficult to read because stakeholders use different words for the same realities (products, roles, responsibilities). To ensure that the mapping methodology is transparent and reproducible, this document relies on a **shared vocabulary** covering both:

- the **main families of retrofit products and systems** typically involved in off-site approaches, and
- the **actor categories** that shape industrial supply chains and project delivery.

This vocabulary is not intended as a rigid classification. Instead, it provides a **functional reference** that supports the profiling of integrators and industrial actors and clarifies how they interact within retrofit value chains. In practice, a single organisation may cover several roles depending on the project configuration (for instance, an industrial actor may also act as an installer, or an integrator may internalise parts of design or manufacturing interfaces).

VOCABULARY

<u>Products</u>

- **MEP systems products (Mechanical Electrical Plumbing):** Technical products related to the Plumbing / Electricity / HVAC lots
- **Building envelop products:** Products related to the air and water tightness of the building
- **1D Building Products:** Manufacturers of beams, framing elements (wood/concrete/metal, etc.)
- **2D Walls and assemblies:** Surface elements such as facades or roofs, products that include several trades
- **3D Modular:** Volume elements such as pre-assembled elements with walls, roof and floor, in 3 dimensions including almost all the trades in plants
- **Preassembled MEP (industrial):** Technical boxes, manufacturers of prefabricated technical ducts
- **3D PODs:** Prefabricated bathroom kits and finished kitchens

<u>Actors</u>

- **Suppliers:** Company providing technical components for industrials
- **Providers/Installers:** Company installing technical components
- **Industrials:** Company manufacturing technical solution with materials from suppliers, manufacturing complex building products integrating several trades
- **Integrators:** Company that integrate industrial solutions on the building site, it can be General contractors, fitters or industrials themselves
- **MMC experts:** Company of experts specialized in the Modern Methods of Construction like lean construction, off-site building ; most of time it is building owners consultants
- **General contractors:** responsible for the day-to-day realization of a <u>construction</u> site with all the trades involved, management of vendors and trades, and the communication of information to all involved parties. Il can be internal skills or subcontracting trades.
- **Manufacturing solutions (industrial process):** Company that sell manufacturing tools needed to produce the industrial solution.
- **Architecture firm / Project Manager (PM) / Design Office (DO):** Company that helps actors of the process with his expertise
- **Diagnostic expert**: geotechnical, 3D scan

The vocabulary distinguishes two complementary dimensions that are essential to analyse industrialised retrofit ecosystems.

1) Product families (what is being industrialised and integrated)

Off-site retrofit relies on varying degrees of product integration, from single components to multi-trade assemblies. The categories used here help structure the supply-side landscape, notably:

- **MEP systems products** (mechanical, electrical, plumbing) and preassembled technical elements, which are critical for "plug-and-play" technical upgrades;
- **building envelope products**, covering airtightness and watertightness functions, often central in deep energy retrofit;
- **1D / 2D / 3D distinctions**, reflecting increasing levels of integration:
  - **1D**: linear or component-based elements (e.g., framing, beams, rails);
  - **2D**: surface assemblies such as façade or roof systems that may integrate several trades;
  - **3D**: volumetric elements (modules, pods) that consolidate multiple functions within a single factory-produced unit.

This product-based reading supports the mapping of **industrial actors** by clarifying what kind of retrofit systems they can manufacture, standardise and supply at scale.

2) Actor categories (who provides, integrates, installs and supports delivery)

Industrialised retrofit requires more than manufacturers: it requires coordination roles and interface management. The actor categories highlight the main functions typically found in industrialised retrofit value chains:

- **suppliers**, providing components and sub-products that feed industrial manufacturing;
- **industrials**, manufacturing integrated retrofit solutions (often multi-trade products) using upstream components;
- **providers/installers**, enabling on-site execution and system connection to existing buildings;
- **integrators**, whose role is to bring together industrial solutions on site and ensure coherent delivery across interfaces, trades, logistics and performance commitments;
- supporting roles such as **MMC experts**, design and engineering actors, and diagnostic experts who contribute to system definition, feasibility and execution readiness.

Crucially, these categories should be read as **functions rather than labels**. Industrialised retrofit ecosystems frequently rely on hybrid organisations and partnerships, and the mapping methodology therefore focuses on what actors actually do within the value chain.

This shared vocabulary provides the foundation for the next methodological sections, where actor profiling is conducted through a functional lens that captures both the **supply side (industrial capability)** and the **delivery side (integration capability)**.

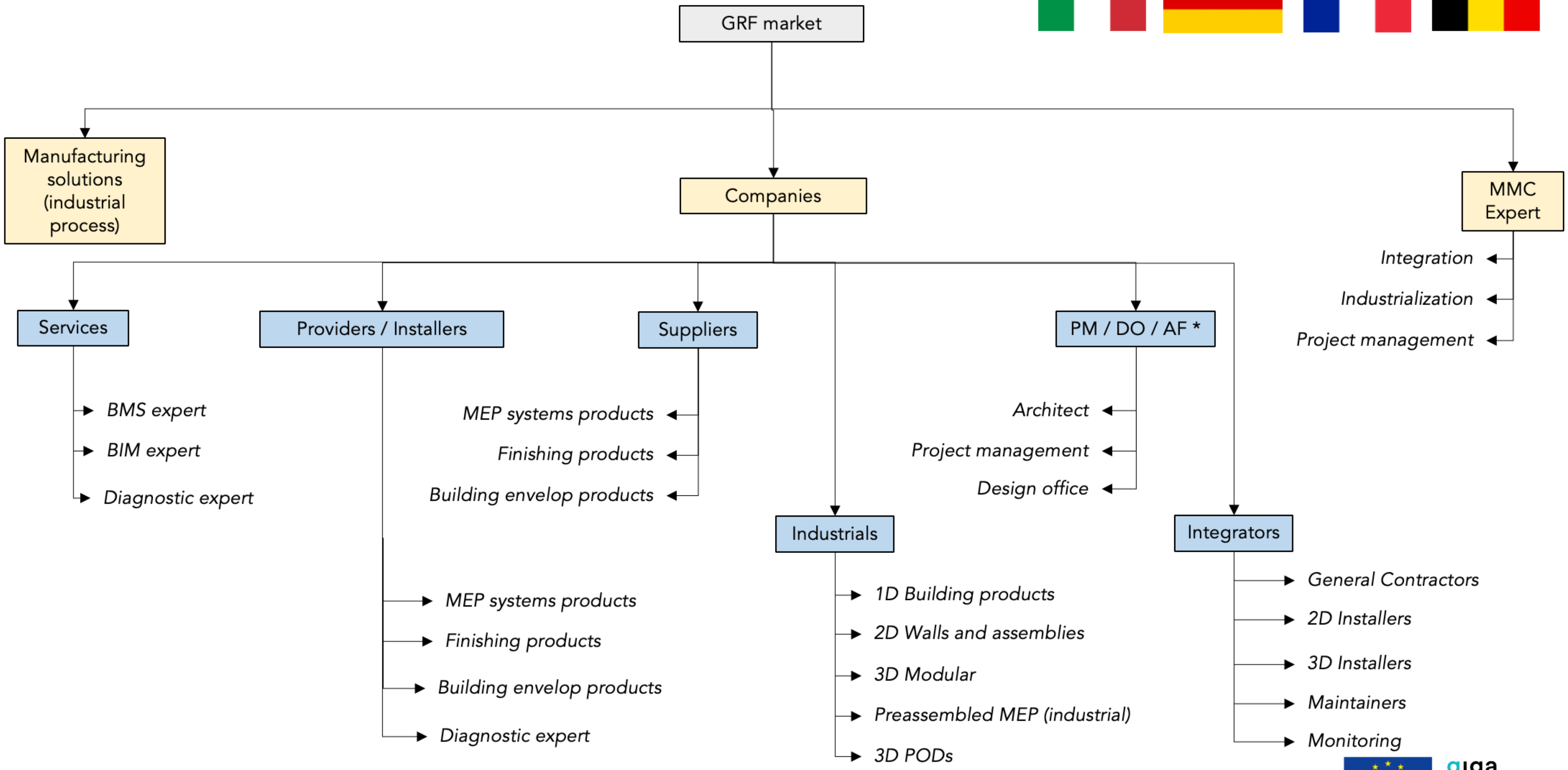
3.2. Functional organisation of retrofit ecosystems: actors, roles and interfaces

Building on the shared vocabulary introduced above, this section clarifies how the different actor categories are organised within **industrialised retrofit ecosystems**, and how their roles interact along the value chain.

Industrialised and off-site retrofit does not rely on a linear or sequential supply chain. Instead, it mobilises a **system of interdependent actors** whose responsibilities span industrial production, project coordination, on-site execution and long-term operation. Understanding how these roles are structured and how they relate to one another is a prerequisite for any meaningful analysis of ecosystem maturity.

The following figure presents a **functional organisation of retrofit ecosystems**, applicable to both retrofit and, where relevant, transferable practices from new build. It provides a synthetic view of how companies, industrial actors and integrators interact around products, services and project delivery functions

> ALL – RETROFIT & NEWBUILD



(*) PM = Project Manager / DO = Design Office / AF = Architecture Firms

The figure illustrates a functional reading of retrofit ecosystems centred on **companies and the roles they assume**, rather than on rigid sectoral boundaries. At its core, the ecosystem is structured around the interaction between industrial supply, project delivery and coordination functions.

On the **industrial side**, the diagram distinguishes:

- **manufacturing solutions**, referring to actors and processes that enable industrial production (tools, factories, industrial processes);
- **industrials**, who manufacture integrated retrofit products and systems, ranging from 1D components to 2D assemblies, 3D modular elements, preassembled MEP systems and pods.

This distinction highlights that industrial capacity in retrofit is not limited to product manufacturers alone but also depends on upstream industrial processes and production know-how.

On the **delivery side**, the figure shows a range of actors involved in bringing industrial solutions to buildings:

- **suppliers**, providing technical components and sub-products;
- **providers and installers**, responsible for on-site installation and system connection;
- **project management, design and architectural actors**, who support feasibility, design coordination and regulatory compliance;
- **service providers**, such as BIM, BMS and diagnostic experts, who enable digitalisation, commissioning and performance monitoring.

The **integrator function** appears as a central coordination role within this organisation. Integrators are positioned at the interface between industrial products and on-site delivery, combining responsibilities related to integration, industrialisation and project management. They may take different organisational forms including general contractors, specialised installers or industrial actors expanding downstream but are defined here by their functional role rather than by their legal status.

Importantly, the figure also makes explicit that **actors can assume multiple roles simultaneously**. For example, an industrial actor may also act as an integrator, or an installer may take on coordination or monitoring responsibilities. This functional overlap is a defining feature of industrialised retrofit ecosystems and reinforces the need for a profiling approach that focuses on capabilities and interfaces rather than on traditional categories.

By visualising these relationships, the figure helps identify the **critical interfaces** that condition the success of industrialised retrofit: between manufacturing and design, between factory and site, and between delivery and long-term operation. These interfaces are precisely where coordination failures, delays or performance gaps most often occur.

This functional organisation therefore provides a concrete reference for the methodological framework presented in the next section, which builds on these roles and interfaces to analyse integrators and industrial actors in a structured and comparable way.

3.3. Illustrative example: a national retrofit workflow and role distribution

While the previous figures presented a generic and transferable functional reading of retrofit ecosystems, it is useful to illustrate how these roles and interfaces materialise in practice. Retrofit value chains are highly context-dependent, shaped by national regulations, market structures, industrial maturity and procurement practices.

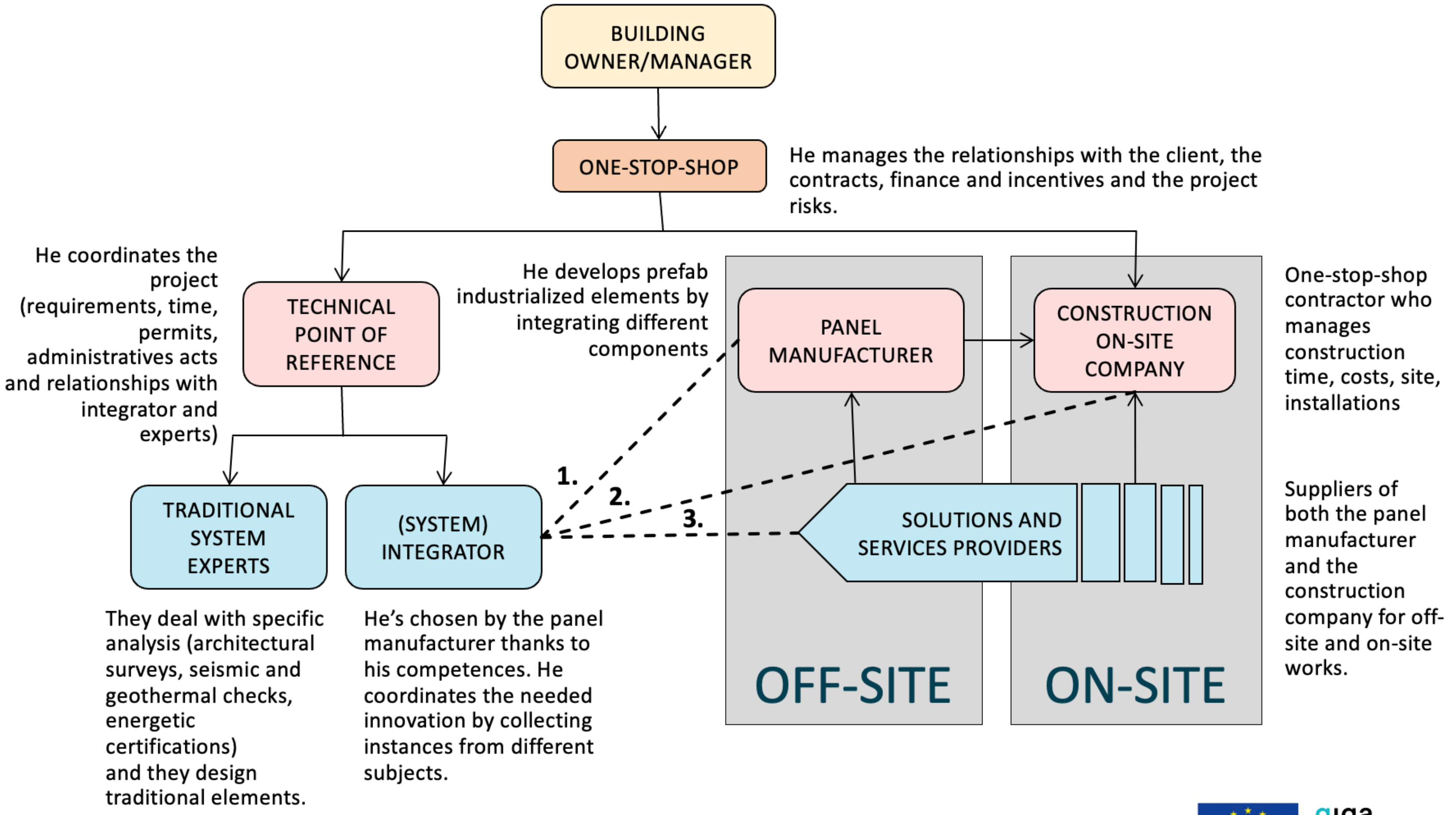
The following figure provides an **illustrative example of a retrofit workflow**, drawn from a national context, to show how off-site supply chains can be organised and coordinated in real projects. It highlights how responsibilities are distributed between actors, how information flows between off-site and on-site activities, and how integration functions emerge to make industrialised retrofit operational.

This example does not represent a universal or recommended model. Its purpose is to **make visible the complexity of coordination** required in industrialised retrofit, and to support understanding of the methodological choices presented later in this document

ITALY – RETROFIT WORKFLOW AND RESPONSIBILITIES

(TO MAKE OFF-SITE SUPPLY CHAIN WORK. ACTORS CAN HAVE MORE THAN ONE ROLE)

1. Exchange of information on technical specifications of both the prefab panel and the specific components to be integrated in it.
2. Exchange of information on the level of innovation to be added to the components to be integrated with the panel. On the other sides the solution providers express their limitations.
3. Communication about any relevant on-site constraints or peculiar characteristics.



The figure illustrates a retrofit workflow in which off-site and on-site activities are closely interdependent, and where multiple actors may assume more than one role along the value chain. It shows how industrialised retrofit relies on **continuous information exchange** rather than on linear handovers.

Several key insights emerge from this example.

First, the workflow highlights the central role of **coordination and integration functions**. The presence of a system integrator and a technical point of reference reflect the need to align design decisions, industrial constraints and on-site realities. These roles are essential to manage interfaces between prefabricated elements and existing buildings, and to arbitrate trade-offs between innovation, feasibility and cost.

Second, the figure makes explicit the **bidirectional flow of information** between off-site manufacturing and on-site execution. Technical specifications, levels of innovation and site-specific constraints must be continuously exchanged between industrial actors, system experts and construction teams. This feedback loop is a defining feature of retrofit projects and differentiates them from more standardised new build processes.

Third, the example illustrates how **industrial actors and construction actors are interlinked**. Panel manufacturers, solution and service providers, and on-site construction companies operate within a shared delivery system, often coordinated through a one-stop-shop or similar contractual arrangement. This reinforces the idea that industrialised retrofit depends not only on products, but on the capacity to structure collaboration across organisational boundaries.

Finally, the figure shows that **actors may accumulate roles**. Industrial manufacturers may influence integration choices, construction companies may manage both site execution and coordination, and integrators may act as intermediaries between multiple expert domains. This reinforces the relevance of a functional, rather than sector-based, approach to actor profiling.

This illustrative workflow underlines why the methodological framework presented in the next section focuses on functional roles, interfaces and coordination capacities, rather than on linear supply chains or static actor categories.

4. Methodology: analytical framework and identification process

This section presents the methodological framework used to analyse **industrialised and off-site retrofit ecosystems**. The objective of this methodology is not to evaluate individual companies, but to provide a **structured, transparent and reproducible way to understand how retrofit ecosystems function**, where their strengths and weaknesses lie, and how they can evolve towards more integrated and scalable delivery models.

Industrialised retrofit is fundamentally a **systemic challenge**. While technical solutions such as prefabricated façades, modular systems or integrated MEP kits are increasingly available, their deployment at scale depends on the ability of ecosystems to coordinate multiple actors, manage interfaces and align industrial supply with project delivery. In many contexts, barriers to scaling up off-site retrofit are organisational rather than technological.

The methodological framework presented here was therefore designed to:

- make complex retrofit ecosystems readable and comparable;
- focus on **functions and interfaces** rather than legal status or company size;
- avoid public ranking or scoring of actors;
- and support strategic reflection for public authorities, clusters, facilitators and market stakeholders.

The approach relies on qualitative analysis, cross-context comparison and aggregation of observations, ensuring that it can be applied in different territorial and national settings without requiring access to confidential tools or datasets.

4.1. Objectives of the methodological framework

The methodological framework was developed to meet four main objectives.

First, it aims to **provide a replicable analytical logic**. The framework can be applied across countries and regions with varying levels of industrialisation, regulatory environments and market readiness. It is not dependent on specific institutional arrangements or market structures and can therefore support comparative analysis and long-term monitoring of ecosystem evolution.

Second, the framework establishes a **function-based reading of retrofit ecosystems**. Actors are analysed according to the roles they effectively play within the retrofit value chain such as coordination, manufacturing, installation, monitoring or financing rather than according to traditional sectoral or contractual categories. This functional perspective reflects the hybrid and evolving nature of industrialised retrofit markets.

Third, the framework enables a **joint reading of integration capacity and industrial capacity**. Scalable retrofit requires both the availability of industrialised solutions and the presence of actors capable of integrating these solutions into coherent delivery models. The methodology therefore considers both dimensions simultaneously, rather than analysing them in isolation.

Finally, the framework is designed to **support strategic use of mapping results**. Its outputs are intended to inform ecosystem structuring, policy design, matchmaking initiatives and capacity-building actions. They are not intended to serve as a public performance benchmark for individual actors.

4.2. Common functional definition: what is an "integrator"?

Within this framework, an **integrator** is defined by its function rather than by its legal form or contractual position. An integrator is an actor capable of **orchestrating the full industrialised retrofit process**, ensuring coherence across the value chain and managing interfaces between actors, products and project phases.

This orchestration role typically includes:

- interfacing with building owners, housing providers and public authorities;
- coordinating building diagnosis, technical design and energy modelling;
- aligning design and procurement choices with industrial product constraints;
- managing interfaces between off-site manufacturing, logistics and on-site assembly;
- and, where relevant, contributing to or coordinating long-term commitments related to energy performance, comfort and maintenance.

Actors assuming integrator functions may include general contractors, prefab-enabled SMEs, design-and-build organisations, energy service companies or emerging territorial groupings. The methodology deliberately focuses on **what actors do in practice**, recognising that integrator roles are often distributed, hybrid or evolving over time.

This functional definition is essential to avoid misclassification and to reflect the realities of industrialised retrofit delivery.

4.3. Step-by-step identification and analysis process

The methodological framework is implemented through a structured process that combines market knowledge, qualitative analysis and aggregation of observations. The process follows three main steps.

The first step consists in **consolidating existing market knowledge and typologies** related to industrialised and off-site retrofit. This involves identifying recurring actor roles, delivery models and product families, and translating them into a shared functional language that can be applied across different contexts.

The second step focuses on **market intelligence and ecosystem observation**. This includes qualitative exchanges with building owners, retrofit coordinators, industrial solution providers and other stakeholders involved in project delivery. The objective is to understand how retrofit ecosystems operate in practice, where coordination challenges arise, and which functions are critical but insufficiently covered.

The third step consists in **functional assessment and ecosystem consolidation**. Observations are synthesised to identify recurring configurations, bottlenecks and maturity patterns at ecosystem level. Rather than producing company-level evaluations, the analysis focuses on aggregated insights that reveal how integration capacity, industrial supply and coordination mechanisms interact.

This process allows for comparison across contexts while remaining adaptable to local specificities.

4.4. Analytical dimensions used for ecosystem reading

To support a consistent and structured analysis, the framework relies on a set of **shared analytical dimensions**. These dimensions are not used as public scoring criteria, but as lenses to understand ecosystem readiness and constraints.

The core dimensions include:

- **Industrialisation capacity**, referring to the ability to rely on standardised processes and industrial production principles, both on the supply side and in project delivery.
- **Project integration capacity**, referring to the ability to coordinate multiple actors, trades and systems into coherent retrofit projects.
- **Digital maturity**, including the use of digital tools, interoperability between systems and continuity of data from design to operation.
- **Market and operational capacity**, referring to scale of activity, geographic reach and ability to manage multiple projects.
- **Maintenance and performance orientation**, referring to the capacity to support long-term outcomes related to energy performance, comfort and reliability.
- **Strategic alignment and willingness to evolve**, referring to openness to industrialised retrofit approaches and readiness to adapt business models.

These dimensions support qualitative comparison and aggregation without exposing sensitive or company-specific information.

4.5. Methodological limits and robustness

Like any analytical framework, this methodology has limits. It does not aim to capture all project-specific variables, nor does it provide a definitive measure of company performance. Its strength lies in its ability to **structure understanding at ecosystem level**, rather than in precise quantification.

The methodology is intentionally qualitative and function-based, making it particularly suitable for public dissemination and strategic dialogue. Its robustness comes from:

- the use of a shared functional language;
- cross-context comparison;
- and aggregation of observations rather than reliance on individual data points.

These characteristics ensure that the framework can be reused, adapted and refined over time, as retrofit ecosystems evolve and industrialised delivery models mature.

5. Typologies of actors: integrators and industrial providers

Building on the methodological framework presented in the previous section, this section introduces a set of **functional typologies** that describe how actors position themselves within industrialised and off-site retrofit ecosystems. These typologies do not represent fixed categories or performance levels. Rather, they reflect **recurring operational profiles** observed across different contexts, and help clarify roles, strengths, limitations and potential evolution pathways.

The typologies are based on a functional reading of retrofit value chains. They are intended to support ecosystem understanding, strategic dialogue and capacity-building, not to classify or rank individual organisations. Importantly, actors may evolve from one typology to another over time or combine characteristics from several profiles depending on project configuration.

5.1. Integrator typologies: functional profiles, strengths and gaps

The analysis of retrofit ecosystems reveals several recurring profiles of actors capable of assuming integrator functions. These profiles differ in their organisational structure, industrial exposure, digital maturity and coordination capacity.

Profile 1 – Project-led integrators with delegated engineering

These actors typically originate from traditional project delivery roles. They have strong experience in managing construction processes and coordinating multiple trades but often rely on external partners for engineering and industrial interfaces.

Typical strengths

- Robust project management and site coordination capacity
- Familiarity with regulatory frameworks and public procurement
- Ability to manage complex stakeholder environments

Typical gaps

- Limited integration of off-site and industrialised solutions
- Weak control over digital models and industrial interfaces
- Dependence on external engineering and design capacity

Potential evolution paths

Strengthening digital capabilities, developing closer partnerships with industrial solution providers, and progressively internalising integration functions related to prefabrication and logistics.

Profile 2 – Integrated and technology-enabled SMEs

These actors combine several functions within the same organisation, often integrating design, production coordination and installation. They are typically early adopters of digital tools and modular approaches.

Typical strengths

- Strong alignment between design, manufacturing constraints and on-site execution
- High digital maturity and process innovation
- Ability to prototype and test new retrofit delivery models

Typical gaps

- Limited geographic reach or project volume
- Challenges in scaling operations and accessing large tenders

- Risk of over-customisation reducing industrial efficiency

Potential evolution paths

Scaling up through partnerships, replication of standardised solutions, and access to financial and institutional support for growth.

Profile 3 – Design- and digital-driven coordinators

These actors play a central role in early project phases, focusing on diagnosis, digital modelling, performance optimisation and coordination. They often act as system architects rather than delivery entities.

Typical strengths

- Advanced technical and digital expertise
- Strong focus on performance, user needs and optimisation
- Ability to structure projects and align stakeholders upstream

Typical gaps

- Limited control over execution and site delivery
- Dependence on partner ecosystems that may vary in maturity
- Difficulty in guaranteeing timelines, costs or long-term performance

Potential evolution paths

Formalising long-term partnerships with industrial and delivery actors and expanding their role towards stronger integration and coordination across the full retrofit lifecycle.

Profile 4 – Local and territorial actors in transition

These actors are often rooted in specific regions and building stocks. They have strong local knowledge and trusted relationships but are at an early stage of transition towards industrialised retrofit.

Typical strengths

- Deep understanding of local building typologies and constraints
- Strong relationships with local authorities and housing providers
- Flexibility and adaptability at project level

Typical gaps

- Low digital maturity and limited exposure to off-site methods
- Fragmented supply chains and limited industrial interfaces
- Project-by-project logic limiting scalability

Potential evolution paths

Progressive adoption of modular components, participation in pilot projects, and step-by-step integration of digital and coordination capabilities.

Profile 5 – Emerging integrators from adjacent sectors

These actors originate from specialised domains such as façade systems, MEP, energy services or digital platforms. They are expanding their scope towards broader integration roles.

Typical strengths

- Strong technical expertise in specific systems
- Potential for vertical integration between product and installation
- High motivation to innovate and explore new business models

Typical gaps

- Limited experience in full project coordination
- Insufficient exposure to retrofit-specific constraints
- Need to develop service-oriented and long-term performance approaches

Potential evolution paths

Building project coordination capacity, forming alliances with complementary actors, and developing integrated offers that combine products, services and guarantees.

5.2. Industrial provider typologies: retrofit system and solution suppliers

In parallel to integrator profiles, the analysis identifies recurring types of **industrial actors** supplying off-site retrofit solutions. These typologies are organised according to product integration level and system role.

Component and sub-system manufacturers

These actors supply individual components or sub-systems used in retrofit projects, such as technical elements, structural parts or envelope components.

Key characteristics

- High specialisation and technical expertise
- Limited responsibility for system-level integration
- Strong dependence on integrator coordination

2D system and assembly providers

These actors manufacture surface-based systems such as prefabricated façades or roof assemblies, often integrating several trades.

Key characteristics

- Medium to high level of product integration
- Significant impact on energy performance and installation speed
- Need for strong coordination with site logistics and design interfaces

3D modular and volumetric solution providers

These actors deliver volumetric elements such as pods or modules that integrate multiple functions.

Key characteristics

- High level of industrialisation and standardisation
- Strong interface requirements with building geometry and logistics
- High dependency on early design coordination

Technical kit and MEP system providers

These actors supply preassembled technical kits for mechanical, electrical and plumbing systems.

Key characteristics

- Potential to decouple technical retrofit from civil works
- Strong need for digital coordination and precise installation
- Limited deployment without capable integrator involvement

Digital and data solution providers

While not manufacturing physical products, these actors play a key enabling role in industrialised retrofit.

Key characteristics

- Support diagnosis, design, coordination and monitoring
- Enable interoperability between actors and systems
- Increasingly critical for performance-based retrofit models

5.3. Strategic value of typologies for ecosystem understanding

These typologies provide a **structured yet flexible framework** for understanding how retrofit ecosystems are composed and how they evolve. Their value lies in their ability to:

- clarify roles and expectations across value chains;
- identify gaps and misalignments between integration capacity and industrial supply;
- support strategic dialogue between public authorities, clusters and market facilitators;
- inform ecosystem-building, matchmaking and policy design initiatives.

Rather than prescribing an ideal model, the typologies highlight **multiple pathways** through which actors and ecosystems can transition towards more integrated and industrialised retrofit delivery.

6. Functional mapping and value chain roles

Understanding industrialised and off-site retrofit requires moving beyond actor lists and typologies, and towards a **functional mapping of the retrofit value chain**. This section presents how retrofit activities can be decomposed into a set of core functions, how these functions interact, and why their coordination is central to scalable delivery.

Rather than assuming a linear sequence of tasks, the mapping approach adopted here views retrofit as a **system of interdependent roles**, where multiple actors may contribute to the same function, and where responsibilities may shift depending on project configuration, market maturity and local context.

This functional mapping provides a common reference to:

- position actors based on what they actually do;
- identify critical interfaces and coordination points;
- and understand where bottlenecks typically occur in retrofit ecosystems.

6.1. Decomposition of the retrofit value chain into core functions

The industrialised retrofit process can be described through six core functional roles. These roles are not tied to specific organisations and may be assumed by one or several actors within a given project.

Design and engineering

This function covers all activities related to understanding the existing building and defining retrofit solutions.

It includes:

- architectural and technical surveys;
- structural and energy analysis;
- performance simulation and optimisation;
- preparation of digital models and technical documentation.

This function is critical in retrofit contexts due to the heterogeneity of existing buildings and the need to align design choices with industrial constraints.

Product development and prefabrication

This function relates to the design and manufacture of industrialised retrofit components and systems.

It includes:

- development of modular and standardised products;
- factory-based manufacturing of components, assemblies or volumetric elements;
- quality control and preparation for transport and installation.

The maturity of this function directly influences the level of standardisation, predictability and scalability achievable in retrofit delivery.

Integration and coordination

This function is central to industrialised retrofit and corresponds to the **integrator role** described earlier.

It includes:

- orchestration of the overall retrofit process;
- coordination of actors across design, manufacturing and site execution;
- planning, procurement and logistics management;
- alignment of interfaces between products, systems and trades;
- consolidation of responsibilities and risk management.

Without strong integration and coordination, industrialised products cannot be deployed effectively at scale.

Installation and commissioning

This function covers on-site activities required to assemble and connect retrofit systems to existing buildings.

It includes:

- site preparation and logistics;
- installation of prefabricated components and systems;
- connection to existing structures and networks;
- commissioning and functional testing.

In retrofit projects, this function is particularly sensitive to sequencing, tolerances and interface quality between off-site and on-site work.

Maintenance and performance monitoring

This function relates to post-retrofit activities and long-term outcomes.

It includes:

- monitoring of energy performance and comfort;
- maintenance and fault management;

- data collection and reporting;
- support to occupants and building managers.

This function is increasingly important in performance-based retrofit models, where long-term outcomes are central to value creation.

Financing and project aggregation

This function supports the economic viability and scalability of retrofit initiatives.

It includes:

- aggregation of projects or building portfolios;
- structuring of financing and investment mechanisms;
- risk-sharing and performance-based contracting;
- coordination with public funding and incentive schemes.

While not always visible at project level, this function strongly influences the capacity to move from isolated projects to mass deployment.

6.2. Interfaces and interdependencies between functions

Mapping functions also makes it possible to identify **critical interfaces** where coordination failures frequently occur.

Common interface challenges include:

- between design and prefabrication, when digital models or specifications are not compatible with industrial requirements;
- between factory and site, when logistics, sequencing or tolerances are not sufficiently anticipated;
- between installation and maintenance, when data handover is incomplete or inconsistent;
- between integration and financing, when delivery models are misaligned with contractual or funding structures.

These interfaces represent key leverage points for improving ecosystem performance. Strengthening coordination at these junctions often yields greater impact than optimising individual functions in isolation.

6.3. Value of functional mapping for ecosystem structuring

The functional mapping approach provides several benefits for stakeholders seeking to develop industrialised retrofit ecosystems.

First, it enables a **shared understanding of roles and responsibilities**, reducing ambiguity and misalignment between actors.

Second, it supports **better positioning of actors**, allowing organisations to identify which functions they currently assume and which they may develop over time.

Third, it helps public authorities, clusters and facilitators to **target interventions more effectively**, whether through training, policy support, procurement design or ecosystem animation.

Finally, functional mapping creates a bridge between **strategic analysis and operational action**, making it possible to translate high-level ecosystem insights into concrete measures for improving retrofit delivery.

7. Cross-country maturity and market context for industrialised retrofit

The capacity to deploy industrialised and off-site retrofit at scale cannot be analysed in isolation from broader construction market dynamics. Housing shortages, production targets, labour constraints and regulatory shifts shape the operating environment in which retrofit ecosystems emerge. While these pressures are often expressed through new housing objectives, they directly affect the feasibility, urgency and organisation of **large-scale retrofit**, particularly for collective housing and public portfolios.

This section builds on a **"state-of-the-art" market reading**, inspired by approaches such as those developed, to contextualise the maturity of retrofit ecosystems in France, Germany, Belgium and Italy. The analysis focuses on **structural drivers**, **off-site readiness as a proxy for retrofit scalability**, and **the role of integrators and industrial actors** within each national context.

7.1. Structural pressure on production capacity: why retrofit must industrialise

Across the four countries, a common pattern emerges: **housing needs exceed effective production capacity**, while constraints on land, labour and costs continue to intensify. This creates a systemic tension that increasingly pushes markets toward more industrialised, repeatable and predictable delivery models.

- **France** faces a long-standing structural housing shortage, with estimated annual needs around 500,000 dwellings. Despite ambitious public targets particularly for social and intermediate housing actual production has fallen sharply in recent years, exposing a widening gap between policy objectives and sector capacity. Land scarcity, administrative complexity and cost inflation reinforce the need to prioritise densification, transformation and retrofit over greenfield development.
- **Germany** has set one of the most ambitious housing targets in Europe, aiming for 400,000 new dwellings per year. In practice, production has consistently undershot this target, and forward-looking indicators suggest further decline. This mismatch between ambition and delivery capacity has placed productivity, serialisation and modularisation at the centre of policy debates creating indirect but powerful drivers for industrialised retrofit.
- **Belgium** does not operate under a single national housing target, but demographic growth and household diversification generate an estimated annual need of 45,000–50,000 dwellings, significantly above current production levels. The deficit is particularly acute in urban and peri-urban areas connected to employment basins, where retrofit and densification of existing stock are increasingly seen as strategic levers.
- **Italy** combines high retrofit potential with chronic fragmentation of the construction sector. While housing pressure varies territorially, ageing building stock, seismic and energy performance requirements, and constrained public finances all point toward the need for scalable, cost-controlled retrofit solutions.

Across all four contexts, these pressures create a shared conclusion: **meeting housing and climate objectives will require a transformation of how existing buildings are upgraded**, not only how new ones are built.

7.2. Off-site maturity as an indicator of retrofit readiness

The penetration of off-site construction in new housing provides a useful though imperfect proxy for assessing **industrial readiness relevant to retrofit**. It is essential, however, to distinguish between:

- the widespread use of prefabricated elements (now almost universal), and
- fully industrialised off-site approaches integrating design, factory production and site assembly.

From a retrofit perspective, the latter is what enables repeatability, cost control and interface management.

- **Germany** displays the highest level of off-site maturity, with industrialised construction representing a significant share of new housing, particularly in single-family and serial programmes. This reflects a long-standing industrial culture and high social acceptance of prefabrication. However, this maturity has not yet translated fully into retrofit-specific integration models.

- **Belgium** shows a solid and growing off-site market, driven by specialised manufacturers and a strong export orientation. The ecosystem is particularly advanced in components and hybrid systems, which are highly relevant for retrofit, even if full system integration remains uneven.
- **France** is in a transition phase. While prefabricated elements are ubiquitous, fully integrated off-site approaches still represent a small share of housing delivery. Adoption is progressing fastest in repetitive segments (social housing, student residences, constrained urban sites), which are also priority targets for industrialised retrofit.
- **Italy** remains at an earlier stage of off-site adoption, with growing interest but limited industrial depth. Retrofit innovation is often driven by incentives and pilot programmes rather than by mature supply chains.

From a GRF perspective, this confirms that **off-site maturity alone does not guarantee retrofit scalability**. What matters is the ability to adapt industrial logic to the variability of existing buildings something that requires strong integrator roles and early coordination.

7.3. Public strategies and policy signals supporting industrialisation

Public policy plays a critical role in shaping the conditions for industrialised retrofit, even when not explicitly labelled as such.

- In **France**, decarbonisation strategies, public procurement guidance and the mobilisation of large housing actors increasingly recognise off-site and industrialised approaches as levers for productivity and environmental performance. While barriers remain, the policy discourse has clearly shifted toward structured, repeatable solutions.
- **Germany** has explicitly promoted serial and modular construction as a response to housing shortages, notably through framework agreements and simplified procurement for social housing. Although primarily focused on new build, these instruments create institutional familiarity with industrialised delivery models that can be leveraged for retrofit.
- In **Belgium**, innovation and industrial transition policies support modular and off-site construction, particularly through regional clusters and applied research. While dedicated retrofit programmes remain limited, the institutional ecosystem is conducive to cross-sector experimentation.
- **Italy** relies more heavily on incentive-driven mechanisms and pilot initiatives. While these have generated significant retrofit activity, they have not yet produced fully stabilised industrial delivery chains highlighting the need for integrator-led ecosystem structuring.

Overall, policy signals across the four countries increasingly align with the requirements of industrialised retrofit, even if implementation remains uneven.

7.4. National maturity profiles for industrialised retrofit ecosystems

Synthesising these elements leads to four distinct maturity profiles:

- **France** can be characterised as an ecosystem in **structuring transition**: integrator roles are emerging, industrial solutions are diversifying, and public demand is becoming more conducive to standardisation, yet interfaces and long-term performance integration remain fragile.
- **Germany** represents a case of **high industrial capacity with under-integrated retrofit delivery**: the challenge lies less in production than in adapting industrial systems to retrofit-specific coordination and accountability.
- **Belgium** appears as a **supplier-strong, integration-light ecosystem**, with significant potential to build retrofit value chains through clustering and cross-border cooperation.
- **Italy** illustrates a **demand-driven, ecosystem-in-formation** profile, where motivation and need are high, but industrial depth and formal integration structures are still emerging.

7.5. Strategic reading at GRF scale

At GRF scale, these differences are not a weakness but a **structural opportunity**. They point toward a complementary landscape in which:

- industrial capacity,
- integrator know-how,
- and demand for scalable retrofit

are distributed unevenly across countries.

This reinforces the relevance of **ecosystem-level coordination**, cross-border learning and structured matchmaking between integrators and industrial providers. Industrialised retrofit, in this perspective, is less a national trajectory than a **networked European value chain**, in which maturity emerges through alignment rather than uniformity.

7.6. Evolution of ecosystem maturity through capacity building and learning

The maturity profiles described above reflect neither a static situation nor a fixed endpoint. Throughout the project, targeted **capacity-building and knowledge-sharing activities** have played a decisive role in accelerating ecosystem readiness for industrialised and off-site retrofit.

Beyond mapping actors and analysing value chains, a central objective has been to **strengthen integration capacity** by building a shared understanding of roles, interfaces and industrial logic among stakeholders. This effort has focused less on technical products alone and more on the **ability of actors to work together within repeatable retrofit systems**.

Across the four countries, several transversal effects can be observed.

First, **a common vocabulary and conceptual framework have emerged** among integrators, industrial providers and facilitators. Concepts such as functional roles, interface management, system integration and repeatability are now more widely understood and mobilised, reducing misalignment between design, manufacturing and on-site execution.

Second, **integration roles have become more explicit and intentional**. Actors who previously operated within narrow scopes (design, construction, supply) have gained a clearer understanding of what it means to orchestrate an industrialised retrofit process, including upstream coordination, logistics planning and performance-oriented delivery.

Third, **awareness of industrial constraints and opportunities has increased**, particularly among actors traditionally rooted in project-based delivery. Exposure to off-site logic, standardisation principles and digital workflows has helped bridge the gap between retrofit ambition and industrial feasibility.

Fourth, **ecosystem-level thinking has progressed**. Rather than focusing solely on individual projects, stakeholders increasingly frame retrofit as a portfolio-based and repeatable activity, requiring long-term partnerships, predictable demand and aligned capabilities.

These learning dynamics have not eliminated structural differences between national contexts. However, they have **raised the baseline level of maturity** across all four ecosystems and reduced the gap between early adopters and more traditional actors. In particular:

- emerging integrators are better equipped to assume coordination roles;
- industrial providers show greater awareness of retrofit-specific integration needs;
- and public and semi-public stakeholders demonstrate improved capacity to structure demand in ways compatible with industrialised delivery.

In this sense, the project's contribution is not limited to identifying where ecosystems stand, but also to **supporting their transition toward higher levels of readiness**. The maturity profiles presented in this section should therefore be read as **dynamic trajectories**, shaped by ongoing learning, collaboration and institutional alignment, rather than as fixed classifications.

8. Applications and use cases of the mapping methodology

The analytical framework and ecosystem mapping presented in this document are not intended as static outputs. Their primary value lies in how they can be **used, reused and adapted** by public authorities, housing providers, facilitators and market actors to support the large-scale deployment of industrialised and off-site retrofit.

Following the capacity-building and learning processes developed throughout the project, the methodology now serves as a **practical reference framework** for action. This section outlines the main use cases that emerge at the end of the project and that can be mobilised beyond its duration.

8.1. Structuring demand for industrialised retrofit

One of the main barriers to scaling industrialised retrofit is the fragmentation of demand. The mapping methodology provides a way to **translate dispersed retrofit needs into structured, repeatable demand**.

By reading retrofit ecosystems through functional roles rather than individual actors, public and semi-public building owners can:

- identify which integration functions are available locally and which are missing;
- design retrofit programmes that align with existing industrial capacity;
- move from one-off projects to portfolio-based approaches compatible with off-site production.

This enables demand to be expressed in a form that reduces risk for industrial providers and integrators, making investment in standardisation and capacity more viable.

8.2. Supporting ecosystem-building and consortium formation

Industrialised retrofit rarely relies on single organisations. It requires **combinations of complementary actors** capable of covering design, manufacturing, coordination, installation and long-term performance.

The functional typologies and value chain mapping support:

- the identification of compatible actor profiles;
- the formation of local or regional retrofit consortia;
- and the clarification of roles and responsibilities within collaborative delivery models.

By making interfaces and dependencies explicit, the methodology reduces coordination friction and supports the emergence of more stable, long-term partnerships.

8.3. Guiding capacity-building and skills development

The maturity analysis highlights that many barriers to industrialised retrofit are related to **skills, processes and organisational culture**, rather than to technology alone.

The methodology can therefore be used to:

- identify gaps in integration capacity, digital maturity or industrial understanding;
- design targeted training and upskilling programmes;
- support learning-by-doing approaches through pilot projects.

By aligning skills development with ecosystem needs, stakeholders can accelerate readiness for industrialised retrofit and avoid isolated or misaligned training efforts.

8.4. Informing public policy and procurement design

Public authorities play a central role in shaping retrofit markets. The mapping framework provides a structured basis to:

- design procurement strategies that reward integration and repeatability;
- adapt tender requirements to off-site and industrialised delivery models;
- identify where regulatory or contractual barriers hinder coordination.

Rather than prescribing specific technologies, the methodology helps policymakers focus on **enabling conditions** such as interface clarity, performance orientation and demand aggregation that are critical for scaling retrofit.

8.5. Enabling cross-border and inter-regional cooperation

Differences in maturity between countries and regions create opportunities for **complementarity rather than competition**. The comparative reading of ecosystems highlights where industrial capacity, integration know-how and demand are unevenly distributed.

The methodology can be mobilised to:

- identify cross-border supply and integration opportunities;
- support knowledge transfer between more and less mature contexts;
- build transnational value chains for industrialised retrofit.

This is particularly relevant in contexts where domestic industrial capacity is limited but demand is strong, and where proximity allows for efficient logistics and collaboration.

8.6. Supporting long-term monitoring and ecosystem evolution

Finally, the methodology provides a foundation for **long-term monitoring of ecosystem evolution**. By periodically updating the functional mapping and maturity reading, stakeholders can:

- track progress in integration capacity and industrial readiness;
- identify emerging bottlenecks or new opportunities;
- adjust support strategies over time.

This dynamic use of the methodology ensures that ecosystem intelligence remains relevant as markets evolve and industrialised retrofit models mature.

9. Strategic recommendations for scaling industrialised retrofit

The comparative analysis and ecosystem mapping presented in this document highlight a clear conclusion: the main challenge for industrialised and off-site retrofit is no longer the absence of technical solutions, but the **ability of ecosystems to organise, integrate and scale**. Based on these findings, this section outlines a set of strategic recommendations to support the next phase of market transformation.

These recommendations are formulated at **ecosystem level**. They are intended to guide public authorities, facilitators, clusters and market stakeholders in designing enabling conditions for large-scale, repeatable retrofit delivery.

9.1. Shift from project-based logic to portfolio-based retrofit strategies

Industrialised retrofit requires **predictability and volume**. Fragmented, one-off projects limit the ability of integrators and industrial providers to invest in standardisation and capacity.

Stakeholders should:

- structure retrofit demand at portfolio level (building groups, neighbourhoods, asset classes);
- promote multi-year programming rather than isolated tenders;
- design procurement approaches that allow learning effects and repetition.

This shift is a prerequisite for making off-site approaches economically and operationally viable at scale.

9.2. Strengthen integrator roles as the backbone of retrofit ecosystems

Across all contexts analysed, the lack of clearly identified and empowered integrator roles remains the primary bottleneck.

To address this, ecosystems should:

- explicitly recognise integration as a distinct and critical function;
- support actors willing to assume orchestration responsibilities across the value chain;
- encourage delivery models that consolidate accountability for interfaces, logistics and performance.

Without strong integrators, industrial solutions remain underutilised and retrofit delivery remains fragmented.

9.3. Focus public support on interface management and interoperability

Public support for innovation often targets products or technologies. However, the findings show that **interfaces**—between design, factory, site and operation—are where most value is lost or gained.

Priority areas for support include:

- standardised interface definitions between systems and trades;
- digital interoperability across tools and phases;
- documentation and processes that support repeatability and quality assurance.

Investing in interface management yields higher systemic impact than isolated product optimisation.

9.4. Align industrial supply development with retrofit-specific constraints

Industrial solutions designed for new build are not always directly transferable to retrofit contexts. Scaling retrofit requires products and systems that accommodate variability while remaining industrially efficient.

Strategic actions include:

- encouraging early collaboration between integrators and industrial providers;
- supporting modularity and adaptability within standardised product families;
- testing solutions under real retrofit conditions to validate interfaces and tolerances.

This alignment is essential to avoid mismatches between supply potential and delivery reality.

9.5. Embed capacity-building as a long-term ecosystem function

The project has demonstrated that **learning and upskilling are critical accelerators** for industrialised retrofit. However, capacity-building should not be limited to project-based initiatives.

Recommendations include:

- institutionalising training and peer-learning formats within clusters or professional networks;
- focusing on integration, coordination and industrial logic rather than on tools alone;
- linking skills development to concrete delivery models and ecosystem needs.

Sustained capacity-building helps ecosystems absorb innovation and evolve collectively.

9.6. Leverage cross-border complementarities and cooperation

Differences in ecosystem maturity across countries create opportunities for **complementarity**. Industrial capacity, integration know-how and demand do not need to be co-located to create value.

Stakeholders should:

- facilitate cross-border partnerships between integrators and industrial providers;
- support knowledge transfer between mature and emerging contexts;
- align regulatory and procurement practices where possible to reduce friction.

Cross-border cooperation can accelerate scaling, particularly in regions where domestic capacity is limited.

9.7. Use ecosystem mapping as a living strategic tool

Finally, ecosystem mapping should be viewed as a **dynamic process**, not a one-off exercise.

To maintain relevance:

- update mappings periodically to reflect market evolution;
- track changes in integration capacity and industrial readiness;
- use insights to adjust policy, support and investment strategies over time.

A living mapping approach enables continuous learning and more responsive ecosystem governance.

10. Conclusion and legacy

This document has presented a comprehensive and publicly accessible framework to understand, analyse and support the development of **industrialised and off-site retrofit ecosystems**. Rather than focusing on individual technologies or actors, the approach has deliberately centred on **functions, interfaces and collective maturity**, reflecting the systemic nature of large-scale retrofit.

The analysis confirms several core findings.

First, the main barriers to scaling industrialised retrofit are **organisational rather than technical**. While industrial solutions are increasingly available, their deployment depends on the ability of ecosystems to coordinate actors, manage interfaces and align industrial supply with retrofit delivery constraints.

Second, **integrator roles are pivotal**. Across all contexts analysed, the presence—or absence—of actors capable of orchestrating the full retrofit value chain largely determines ecosystem readiness. Strengthening these roles is therefore a key lever for market transformation.

Third, ecosystem maturity varies significantly across countries, but these differences are **complementary rather than contradictory**. Industrial capacity, integration know-how and demand pressures are unevenly distributed, creating opportunities for learning, cooperation and cross-border value chains.

Beyond diagnosis, the project has contributed to **raising ecosystem readiness** through structured learning and capacity-building. By developing a shared vocabulary, clarifying roles and exposing actors to industrial and off-site logic, the baseline level of understanding and coordination has increased across all four countries. The maturity profiles presented in this report should therefore be read as **dynamic trajectories**, shaped by ongoing learning rather than fixed states.

The primary legacy of this work lies in the **methodological framework itself**. It provides:

- a transferable way to read and compare retrofit ecosystems;
- a basis for structuring demand, building consortia and guiding policy;
- and a foundation for continued monitoring and ecosystem evolution.

As industrialised retrofit becomes an increasingly central pathway to meeting housing and climate objectives, such ecosystem-level intelligence will be essential. The framework presented here is intended to remain relevant beyond the project, supporting future initiatives, regions and stakeholders seeking to move from ambition to large-scale delivery.