

Deliverable

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D.3.4 - Technical Standard Documents

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Table of contents

1.	Glossary / Glossary	5
2.	Introduction – From Methodological Framework to Proven Technical Standards ...	10
A.	From Methodology to Proven Practice	10
B.	Role of D3.4 within LIFE GRF	11
C.	Structure of the Deliverable.....	11
3.	Why the MASH Grand Oust Reference Case?	12
A.	From Fragmented Procurement to Shared Industrialisation	12
B.	A Proven Technical and Organisational Ecosystem	13
C.	Measurable Outcomes	14
D.	A European Demonstrator of LIFE GRF Principles.....	14
E.	Relevance for the LIFE GRF Consortium	15
4.	Technical Framework for Industrialised Retrofit.....	15
A.	Building Envelope Standards.....	16
	Prefabricated Façade Typologies	16
	Design-for-Manufacture and Assembly (DfMA)	16
	Installation and Logistics	16
B.	Energy Module Standards	17
	The SynerPod EnerPOD.....	17
	Connection with Local Energy Networks	17
C.	Lean Construction and Industrial Process Management.....	17
	Planning and Flow Management.....	18
	Digital Tools and Workflow	18
D.	Performance Guarantee and Monitoring Protocols.....	18
	Scope of the Guarantee	18
	Monitoring and Verification	18
E.	Industrialisation and Ecosystem Development	19
	Local Industrial Capacity	19
	Skills and Workforce Development	19
F.	Alignment with LIFE GRF Technical Objectives	19
G.	Summary.....	19



5.	Procurement and Governance Standards.....	20
A.	Grouped Procurement and Centralised Purchasing	20
	Formation of a Central Purchasing Body	20
	Tendering and Competitive Dialogue	20
B.	Framework Agreements and Performance-Based Contracting.....	21
	Contractual Logic.....	21
	Flexibility and Replicability	21
C.	Governance and Decision-Making Structure.....	21
D.	Financial and Institutional Backing	22
	Multi-Donor Financing	22
	Public Policy Integration	22
E.	Collaborative Ecosystem Governance	22
F.	Lessons for LIFE GRF Replication	23
G.	Summary.....	23
6.	Performance Measurement and Quality Control.....	24
A.	Principles of Performance-Based Retrofit.....	24
B.	Monitoring and Verification System.....	24
	Scope of Monitoring.....	25
	Data Management and Tools.....	25
C.	Quality Assurance and Control Protocols.....	25
D.	Continuous Improvement and Feedback.....	25
7.	Replicability and Transferability Recommendations	26
A.	Key Conditions for Successful Replication	26
B.	Adaptation Pathways for LIFE GRF Regions	26
	France.....	26
	Italy.....	27
	Germany	27
	Common European Framework.....	27
C.	Transfer Tools and Resources	27



8.	Conclusions	28
9.	Annex 1 – Technical Reference Document.....	28



1. Glossary / Glossary

A

AMO or PMO (Project Management Assistance)

Support role assisting the project owner in defining, implementing, and monitoring complex renovation or construction projects.

ATEX (Technical Assessment of Experimentation)

Temporary evaluation issued by CSTB (France) to assess innovative systems or products that lack existing technical standards.

B

BIM (Building Information Modelling)

Digital process integrating 3D design, data management, and lifecycle monitoring of buildings, used to optimise prefabrication and coordination.

Business Model Tool

Analytical tool used in LIFE GRF to structure the financial viability of industrial retrofit offers, modelling investment, cost, and profitability parameters.

C

CAPEX (Capital Expenditure)

Investments required to acquire or improve durable assets such as prefabrication lines, industrial units, or digital equipment.

CINEA (European Climate, Infrastructure and Environment Executive Agency)

European Commission agency responsible for managing the LIFE Programme and other sustainability-related funding instruments.

Co-design

Collaborative design process involving key stakeholders (landlords, architects, engineers, manufacturers) from the earliest stages to align technical and social objectives.

Commissioning

Systematic process of testing and verifying that building systems operate according to design intent and performance targets.

CSTB (Scientific and Technical Centre for Building)

French public authority that evaluates, certifies, and standardises construction methods and products to ensure safety and performance.



D

DfMA (Design for Manufacture and Assembly)

Design principle aiming to simplify the manufacturing and on-site assembly of building components, improving productivity and quality.

DHW (Domestic Hot Water)

Hot water used for domestic purposes, typically produced within energy modules or collective systems in retrofit projects.

DTU (Unified Technical Document)

French set of construction standards defining best practices for design and implementation, serving as technical references in contracts.

E

E=0 (Energy Zero)

Energy performance condition achieved when a building's annual consumption is fully offset by its renewable energy production, monitored over 12 months.

Energiesprong

European approach to energy retrofit combining prefabrication, digitalisation, and guaranteed performance (E=0) through industrial and contractual innovation.

ERDF (European Regional Development Fund)

European Union fund supporting regional development, including energy efficiency and retrofit initiatives.

EPC (Energy Performance Contracting)

Contractual arrangement where the service provider guarantees energy savings and is remunerated based on verified results.

EPD (Environmental Product Declaration)

Standardised document quantifying the environmental impacts of a product using Life Cycle Assessment (LCA) principles.

F

Facade Prefabrication

Manufacturing of insulated wall panels, cladding, and joinery in factories before rapid on-site assembly, reducing time and defects.

FOB or TFF (Timber Frame Façade)



Wood-based wall system integrating insulation, finishes, and sometimes openings, ideal for industrial retrofit due to its lightness and modularity.

G

GRF (Giga Regio Factory)

Name of the LIFE project aiming to accelerate industrialised, off-site, and performance-based retrofit across European regions.

I

Industrialisation

Transformation of construction activities into standardised, repeatable, and scalable production processes.

Integrator

Key actor in LIFE GRF able to coordinate the entire retrofit value chain (design, digital modelling, prefabrication, logistics, and performance monitoring).

Interoperability

Ability of digital, technical, or organisational systems to work together seamlessly without major adaptation.

K

KPI (Key Performance Indicator)

Quantifiable metric used to measure performance in areas such as energy efficiency, quality, comfort, and process reliability.

L

LCA (Life Cycle Assessment)

Method for evaluating environmental impacts of a product or building throughout its entire life cycle (production, use, end-of-life).

Lean (Lean Construction / Manufacturing)

Industrial management method that optimises workflows by reducing waste, improving coordination, and increasing quality in both factories and on-site operations.



M

Massification

Strategy that groups similar retrofit projects to reach sufficient volume for industrial investment and cost reduction.

MEP (Mechanical, Electrical, Plumbing)

Technical systems (heating, ventilation, electricity, plumbing) often integrated into off-site modules in industrial retrofit projects.

MOB (Timber Frame House)

Construction typology using a structural timber frame, commonly applied in retrofit and off-site manufacturing for its efficiency and thermal performance.

N

NZEB (Nearly Zero-Energy Building)

Building with very high energy performance where low residual consumption is largely covered by renewable energy.

P

PAC (Heat Pump)

Heating and/or cooling system that transfers heat from air, water, or ground sources with high efficiency.

Prefabrication (PREFAB)

Manufacturing process where components are produced in controlled factory environments and then assembled on site.

PV (Photovoltaic Panels)

Solar panels that convert sunlight into electricity, often integrated into building envelopes or technical modules.

R

R&D (Research and Development)

Systematic activity focused on designing, testing, and improving new technical or organisational solutions.

REX (Retour d'Expérience / Feedback)

Structured review of completed projects to identify lessons learned, successes, and best practices for future replication.



Replication

Capacity to reproduce a validated solution across different contexts, regions, or markets efficiently and at scale.

S

SNBC (National Low-Carbon Strategy)

French roadmap setting targets for reducing greenhouse gas emissions to reach carbon neutrality by 2050.

SME (Small and Medium-sized Enterprise)

Company with fewer than 250 employees and annual turnover under €50 million, often part of the local retrofit ecosystem.

Supply Chain

Set of actors, processes, and resources involved in designing, manufacturing, transporting, and installing prefabricated retrofit components.

T

Technical Standard

Reference specification defining the characteristics, interfaces, or performance of retrofit components, processes, or contracts.

V

VSE (Very Small Enterprise)

Structure with fewer than 10 employees and annual turnover below €2 million; plays a vital role in local retrofit delivery.

W

WP (Work Package)

Operational unit structuring a European project into defined tasks, deliverables, deadlines, and responsible partners.



2. Introduction – From Methodological Framework to Proven Technical Standards

The **LIFE Giga Regio Factory (LIFE GRF)** project addresses a core structural barrier in Europe’s building retrofit market: the lack of **coordinated, replicable, and industrialised retrofit processes** capable of achieving deep energy performance at scale.

While innovative technologies exist, from prefabricated façades to plug-and-play energy modules, their integration remains fragmented across countries, regions, and market actors.

LIFE GRF tackles this fragmentation by promoting a **systemic shift toward industrialised, performance-based retrofit**, anchored around new roles and standards.

Among these, the emergence of the “**integrator**” - an actor capable of orchestrating the entire retrofit value chain, from digital design to energy monitoring - plays a pivotal role.

This approach is not about incremental improvements: it is about **industrial transformation**, aligning digitalisation, prefabrication, procurement, and long-term energy guarantee under a common technical and governance framework.

Work Package 3 (WP3) of LIFE GRF “Framework for Technical and Market Replication” has therefore been devoted to building this foundation.

It has progressively structured the methodological, operational, and technical pillars that will allow large-scale replication of industrial retrofit solutions across Europe.

Under WP3, several complementary deliverables have shaped this framework:

- **D3.1 – Requirements and Benchmarking of Integrators**, defining the organisational capacity needed to deliver industrial retrofit;
- **D3.2 – Common Framework**, establishing the shared logic and process reference for cross-country collaboration;
- **D3.3 – Technical Guidelines**, providing methodological tools and specifications for replication;
- and now **D3.4 – Technical Standard Documents**, which consolidates the *validated technical standards and real-world references* supporting this transformation.

A. From Methodology to Proven Practice

Unlike the previous deliverables that focused on framework development, D3.4 translates the LIFE GRF methodology into practice, grounding it in a real European example:



the MASH Grand Ouest retrofit programme (Pays de la Loire, France) - the first industrialised and performance-guaranteed large-scale retrofit market in Europe.

The MASH initiative (Mutualisation d'Achat au Service de l'Habitat) was developed by USH Pays de la Loire, in partnership with Ressorts / Energiesprong France and several industrial consortia (Sogea Atlantique, Spie Batignolles, Altyn, Synerpod).

It represents a functional demonstration of the LIFE GRF vision:

- A grouped procurement model capable of pooling demand from 14 housing associations,
- An industrial supply chain integrating prefabricated façades, energy modules, and digital workflows,
- A performance contract guaranteeing 30 years of zero-energy operation (E=0),
- and a regional ecosystem of SMEs, architects, manufacturers, and social landlords collaborating through Lean and off-site approaches.

Through its 1,458 renovated homes, 42 operations, and €130M in investment, MASH Grand Ouest shows that industrial retrofit can move from pilot to mass market - provided technical, contractual, and governance standards are aligned.

B. Role of D3.4 within LIFE GRF

The Technical Standard Documents (D3.4) serve as the bridge between framework design (WP3) and pilot implementation (WP4).

By adopting the MASH Grand Ouest case as a reference standard, this deliverable provides a tested, transferable baseline for:

- defining retrofit system components (façades, pods, MEP systems, controls),
- structuring industrial and procurement processes,
- ensuring quality, monitoring, and long-term energy performance,
- and enabling replication in other LIFE GRF pilot regions (Italy, Germany, France).

This deliverable therefore formalises what “industrial retrofit” means in practice technically, contractually, and organisationally. It documents *how* performance-based retrofit can be standardised and scaled, and *how* public and private actors can co-invest with confidence in such processes.

C. Structure of the Deliverable

To reflect both the theoretical and applied dimensions of the LIFE GRF approach, Deliverable D3.4 is composed of two complementary parts:

- **Part I – Technical Standard Synthesis (this document)**



Summarises the methodological rationale, scope, and contribution of the MASH Grand Ouest experience to the European standardisation of retrofit processes.

- **Part II – Annex 1: “Rex MASH Grand Ouest – Successes and Project Sheets”**

A detailed *Return of Experience (REX)* document produced by Ressorts and Energiesprong France.

It serves as the technical backbone of D3.4, providing real-world documentation of façade systems, energy pods, Lean production methods, grouped procurement, and long-term energy guarantees.

Together, these components ensure that the LIFE GRF *Technical Standard Documents* are not abstract recommendations, but a living, demonstrable reference for the industrialisation of retrofit in Europe.

3. Why the MASH Grand Ouest Reference Case?

The **MASH Grand Ouest** (Mutualisation d’Achat au Service de l’Habitat) initiative was launched in 2019 in the **Pays de la Loire region (France)** by **USH Pays de la Loire**, in partnership with **Ressorts / Energiesprong France**.

It represents one of the most advanced examples in Europe of **industrialised, performance-guaranteed retrofit at scale**, fully aligned with the objectives of LIFE Giga Regio Factory.

With four framework agreements, forty-two retrofit operations, and 1,458 social homes upgraded to net-zero energy (E=0) standards, the MASH programme demonstrates the feasibility of large-scale, standardised, and replicable retrofit.

It integrates grouped procurement, off-site prefabrication, digitalised design, and long-term performance guarantees within a single multi-actor governance model.

A. From Fragmented Procurement to Shared Industrialisation

Before MASH, energy retrofit projects in France and across Europe were often fragmented and small-scale.

Each social landlord worked independently, launching separate tenders and adopting different technical specifications.

This fragmented approach limited economies of scale, made industrial investment risky, and often resulted in higher costs and inconsistent quality.



MASH introduced a completely different logic based on cooperation, scale, and industrialisation.

Three elements were key to its success:

- **Collective Procurement**

Fourteen housing associations joined forces to form a central purchasing body pooling more than 2,000 dwellings under a single competitive dialogue procedure.

This collective procurement created sufficient volume to attract industrial actors and encourage investment in prefabrication and logistics.

- **Standardised Framework Agreements**

Four multi-lot framework contracts were signed, covering both collective and individual housing across three departments.

These contracts were designed around performance outcomes (E=0) rather than prescriptive technical rules, allowing solution providers to innovate and optimise.

- **Collaborative Governance**

The MASH Grand Ouest structure coordinated technical alignment, procurement procedures, and performance verification.

It provided a shared decision-making framework that enabled continuous feedback, adaptation, and mutual learning between all parties involved.

This governance model has since inspired other regions in France and abroad and forms a direct reference for the regional cooperation models promoted within LIFE GRF.

B. A Proven Technical and Organisational Ecosystem

The MASH Grand Ouest initiative structured a complete industrial and territorial ecosystem linking public demand, private supply, and innovation clusters.

It established the foundations of a local retrofit industry.

Layer	Actors and Functions	Contribution to the Model
Strategic Coordination	USH Pays de la Loire, Ressorts	Aggregation of demand, facilitation, alignment of technical and contractual standards
Project Owners	Seven social housing organisations	Long-term commitment through 30-year performance contracts
Industrial Consortia	Altyn Group, Spie Batignolles, Sogea Atlantique, Synerpod	Prefabrication, façade and module manufacturing, installation, energy monitoring



Layer	Actors and Functions	Contribution to the Model
Architects and Design Offices	Atelier Floret-Scheide, Lionel Vie, Redcat, Symoe	Integration of architectural quality, modular design, and industrial feasibility
Facilitators and Networks	Novabuild, Fibois, Atlansun	Regional upskilling, clustering, and knowledge-sharing platforms
Financial and Public Partners	Banque des Territoires, European Regional Development Fund (FEDER), Region Pays de la Loire	Strategic co-financing, technical support, and long-term risk sharing

This ecosystem demonstrates that industrial retrofit can only succeed through **multi-actor cooperation**.

MASH Grand Ouest created the institutional, financial, and technical alignment that LIFE GRF aims to replicate across European regions.

C. Measurable Outcomes

The first retrofit wave under MASH Grand Ouest produced tangible and quantifiable results:

- 1,458 homes renovated, including 762 collective and 696 individual dwellings;
- Energy performance guaranteed at E=0 for 30 years (including heating, hot water, ventilation, and auxiliary uses);
- Capital expenditure (CAPEX) reduction of 25% to 48% compared to early Energiesprong pilots;
- Average public support between €24,000 and €36,000 per dwelling (regional, national, and EU combined);
- Façade installation times reduced by two to three times through off-site prefabrication;
- Significant social benefits: 50% to 70% lower tenant energy bills, improved comfort and air quality, and minimal disruption during works.

Beyond these figures, MASH Grand Ouest has proven that **industrial retrofit can simultaneously address energy poverty, climate objectives, and economic revitalisation**.

D. A European Demonstrator of LIFE GRF Principles

The MASH Grand Ouest project embodies the main operational principles of LIFE Giga Regio Factory:

LIFE GRF Principle	MASH Grand Ouest Example
Integrated Retrofit Supply Chains	Multi-actor industrial consortia delivering end-to-end E=0 systems
Digitalisation and Design-for-Manufacture	3D scanning, parametric modelling, and BIM workflows



LIFE GRF Principle	MASH Grand Ouest Example
Lean and Off-Site Construction	Process optimisation, sequenced logistics, and reduced on-site work
Performance-Based Contracting	30-year energy performance guarantees and outcome-based payment logic
Ecosystemic Cooperation	Collaboration between landlords, SMEs, architects, manufacturers, and facilitators
Replication and Scaling	Launch of a second retrofit wave and transfer of lessons to other LIFE GRF regions

Through MASH, the region demonstrated that deep retrofit could become a **structured industrial process**, not a one-off prototype.

It is the practical embodiment of what LIFE GRF defines as a “Giga Regio Factory”: a regional ecosystem capable of producing high-quality, zero-energy retrofits at scale.

E. Relevance for the LIFE GRF Consortium

For LIFE GRF, the MASH Grand Ouest experience provides both evidence and direction:

- **As a technical reference**, it delivers validated standards for prefabricated façades, modular energy systems, and digital monitoring tools.
- **As a governance model**, it shows how aggregated demand and performance-based procurement can unlock large-scale industrialisation.
- **As a replication lever**, it provides the operational DNA for new Giga Regio Factories across Europe, bridging the gap between innovation and market deployment.

For these reasons, the complete **Rex MASH report** is annexed to this deliverable as the core of Technical Standard Document under D3.4.

It offers a comprehensive and proven foundation for future standardisation, replication, and policy dialogue within the LIFE GRF framework.

4. Technical Framework for Industrialised Retrofit

The LIFE Giga Regio Factory project promotes a unified framework for the technical standardisation of industrial retrofit processes.

The **MASH Grand Ouest** initiative provides the empirical foundation for this framework.



Its results confirm that deep retrofit can be achieved at scale through the combination of **off-site manufacturing, digital integration, and performance-based contracting**.

This section summarises the **key technical standards and processes** derived from the MASH experience, which can be replicated, adapted, or harmonised at European level under LIFE GRF.

A. Building Envelope Standards

The envelope is the cornerstone of energy performance and industrial feasibility. MASH demonstrated that **prefabricated façade systems** can meet performance, aesthetic, and cost requirements while drastically reducing on-site time.

Prefabricated Façade Typologies

Three main façade solutions were deployed, reflecting varying building typologies and industrial capabilities:

Type	Description	Example Consortium
Wood-frame façades (FOB panels)	250 mm multilayer wall with structural timber, insulation (bio-based), and integrated finishes. Designed for high-rise applications (up to R+10).	Altyn Group / Atelier Floret-Scheide
Light metal-frame façades	OSB board, rock wool, vapour barrier, and mineral finishing. Adapted for mid-rise housing and floodplain areas.	Sogea Atlantique / Vinci Construction
Modular crate façades	Small wooden prefabricated units easily handled on constrained sites. Parametrically designed and assembled off-site.	Spie Batignolles / IDEA Logistics

All solutions complied with **DTU 31.4**, the **CSTB RAGE** guidelines, and French fire safety classifications.

Design-for-Manufacture and Assembly (DfMA)

Façade modules were designed and manufactured using **3D scanning, parametric modelling, and digital twins**, ensuring millimetre precision for existing building geometries.

This reduced on-site adjustments and accelerated installation.

Installation and Logistics

Thanks to Lean sequencing and kitting logistics:



- Installation time for collective façades was reduced from 120 days (traditional insulation) to **50 days** per site.
- For multi-storey buildings, **4 months** of installation replaced up to 14 months using conventional techniques.
- Modular packaging ensured safety, reduced waste, and simplified site management.

B. Energy Module Standards

The MASH Grand Ouest programme validated the integration of **prefabricated technical modules** that combine heating, ventilation, and domestic hot water systems.

These “energy pods” enable consistent performance, faster installation, and simplified maintenance.

The SynerPod EnerPOD

Developed in Vendée by **Synerpod**, the *EnerPOD* is a compact off-site module integrating:

- Silent heat pump
- Dual-flow ventilation (CMV double flux)
- Hot water and buffer tank
- Monitoring and predictive maintenance systems
- Optional renewable generation and user interfaces

Each module is designed for exterior installation with minimal intrusion into occupied dwellings.

Its design allows maintenance without tenant displacement, aligning with the **Energiesprong “occupied retrofit” principle**.

Connection with Local Energy Networks

Depending on site context, the pods were combined with renewable or hybrid systems:

- **District heating** (biomass network in Nantes Métropole)
- **Wood-fired boiler rooms** (Bois Rochefort, Georges Gauthier)
- **Hybrid loops** combining electric production and collective storage

All systems integrate a **30-year energy performance guarantee**, verified through digital monitoring platforms.

C. Lean Construction and Industrial Process Management

One of the strongest technical lessons from MASH Grand Ouest is the success of **Lean Management** in construction.



Applied to both prefabrication and on-site operations, Lean reduced costs and improved reliability.

Planning and Flow Management

Lean planning tools were used to:

- Synchronise supplier logistics and site readiness
- Sequence façade and pod installation
- Minimise downtime between trades
- Ensure “right-first time” delivery through daily coordination

Digital Tools and Workflow

Digital platforms such as *RéhApp* and 3D parametric configurators enabled:

- Rapid modelling of each dwelling
- Standardisation of repetitive operations
- Transparent coordination between landlords, designers, and contractors

As a result, retrofit times were reduced to **three weeks per dwelling** in some single-family cases, with higher consistency and lower rework rates.

D. Performance Guarantee and Monitoring Protocols

Performance-based contracting was a defining feature of MASH Grand Ouest and is a core LIFE GRF standard.

Scope of the Guarantee

All renovated homes are guaranteed to achieve **E=0 energy balance** for 30 years. The guarantee covers:

- Heating and hot water
- Ventilation
- Auxiliary systems and user electricity
- Renewable energy generation balance

Monitoring and Verification

Monitoring systems collect real-time data on consumption and production through:

- Smart meters and sensors integrated into the energy pods
- Centralised dashboards for landlords
- Predictive maintenance and anomaly detection algorithms

These systems ensure compliance with contractual performance and provide feedback for continuous improvement.



E. Industrialisation and Ecosystem Development

The MASH approach demonstrated that industrial retrofit is not only a technical process but also an **ecosystem-building effort**.

Local Industrial Capacity

More than 75% of subcontractors involved in MASH were based in the Pays de la Loire region. New production lines were created, including a dedicated façade factory (Sogea Atlantique) and expanded wood module facilities (OSSABOIS, LCA, SYBOIS).

Skills and Workforce Development

Regional networks such as Novabuild, Fibis and Atlansun coordinated training and innovation clubs to prepare SMEs for off-site retrofit markets.

This local capacity-building mirrors the “Giga Regio Factory” concept: regional platforms uniting training, production, and delivery under one industrial logic.

F. Alignment with LIFE GRF Technical Objectives

The MASH Grand Ouest experience provides validated inputs for the LIFE GRF technical standardisation process.

Its components directly support the project’s cross-country objectives:

LIFE GRF Objective	Validated through MASH Grand Ouest
Industrialised prefabrication standards	Façade systems and pods complying with DfMA principles
Digital integration and interoperability	Parametric design tools, BIM workflows, real-time monitoring
Performance-based retrofit model	E=0 guarantee, data-driven verification
Multi-actor governance and procurement	Collective tendering, shared framework agreements
Replicable and scalable regional model	Proven market logic adaptable to Italy, Germany, and beyond

G. Summary

The MASH Grand Ouest reference case demonstrates that large-scale industrial retrofit requires the convergence of technical, digital, and organisational standards.

These standards can now serve as **the operational reference** for LIFE GRF partners and future European replication.

The integration of prefabrication, digitalisation, Lean management, and long-term performance guarantees defines the next stage of Europe’s retrofit transformation - one that the LIFE GRF project aims to scale across regions and industries.



5. Procurement and Governance Standards

A key innovation of the MASH Grand Ouest initiative, and one of its most transferable outcomes for LIFE GRF, lies in its **procurement and governance model**.

The approach replaces fragmented contracting with a structured, collaborative system capable of aggregating demand, mobilising industrial suppliers, and securing long-term performance guarantees.

The MASH model represents a **functional prototype of the “Giga Regio Factory” concept**: a territorial alliance in which public and private actors co-develop shared specifications, launch coordinated tenders, and manage collective decision-making across projects.

This section outlines the procurement logic, governance structure, and coordination mechanisms that define the MASH approach and form the backbone of LIFE GRF’s replication strategy.

A. Grouped Procurement and Centralised Purchasing

The MASH Grand Ouest programme was based on a **grouped procurement system**, designed to overcome the limited purchasing power of individual landlords and to create an attractive market for industrial suppliers.

Formation of a Central Purchasing Body

In 2020, **USH Pays de la Loire** established a **central purchasing group (MASH)** representing 14 social landlords across three regions (Pays de la Loire, Brittany, Normandy).

This entity was legally empowered to:

- Pool retrofit needs under a single competitive dialogue procedure
- Manage framework agreements and collective governance mechanisms
- Represent landlords in negotiations with industrial consortia

This cooperative purchasing structure enabled a **unified demand signal** to the market, unlocking volume-based efficiencies and innovation investment from suppliers.

Tendering and Competitive Dialogue

The MASH procurement process was structured in **five lots**, each representing a distinct technical and geographical segment of the housing stock.

A **competitive dialogue procedure** was chosen to allow iterative co-design between landlords and potential suppliers.

This process:

- Encouraged innovation and flexibility in technical solutions
- Ensured alignment between performance requirements and industrial feasibility
- Allowed integration of SMEs and specialised subcontractors into the supply chain



At the end of the dialogue, **four framework agreements** were signed covering 1,456 dwellings, with one or more consortia selected per lot.

B. Framework Agreements and Performance-Based Contracting

Contractual Logic

The framework agreements combined the **Energiesprong performance model with industrial supply logic**.

Instead of prescribing methods, the contracts defined outcomes:

- **Zero energy (E=0)** target over a 30-year period
- Guaranteed performance covering heating, ventilation, hot water, and auxiliary uses
- Defined monitoring, maintenance, and reporting obligations
- Incentive and penalty mechanisms linked to measured performance

This performance-based model created accountability throughout the value chain, from manufacturer to operator.

Flexibility and Replicability

Each framework agreement allowed individual landlords to activate “subsequent contracts” as their projects advanced.

This ensured:

- Replication at scale without reopening full tenders
- Stable industrial activity across multiple years
- Continuous improvement through feedback loops

Such a model is directly replicable within LIFE GRF’s regional pilots, enabling collective procurement while respecting national legal frameworks.

C. Governance and Decision-Making Structure

The MASH Grand Ouest governance framework ensured coordination across technical, contractual, and strategic levels.

It was built on **collective decision-making** and **transparent monitoring**, ensuring that all stakeholders remained engaged and accountable.

Governance Level	Lead Entities	Main Functions
Strategic Steering Committee	USH Pays de la Loire, Ressorts	Overall strategy, framework supervision, communication with financiers



Governance Level	Lead Entities	Main Functions
Technical Coordination Committee	Landlords, industrial partners, designers	Validation of technical adaptations, product qualification, and feedback management
Monitoring Committee	Facilitators, Ressorts, Energy agencies	Follow-up on performance data, KPIs, and guarantee verification
Operational Lot Committees	Landlords and contractors per lot	Site management, scheduling, issue resolution, tenant liaison

This structure mirrors the governance foreseen under LIFE GRF, where local clusters (France, Italy, Germany) will act as **regional steering nodes**, coordinating between demand and supply.

D. Financial and Institutional Backing

The success of the MASH model relied on strong **institutional support and financial engineering**, combining regional, national, and European funding streams.

Multi-Donor Financing

A unique multi-donor structure provided financial stability to the framework:

- **Banque des Territoires** developed a dedicated loan offer including long-term, boosted eco-loans, and improved PAM loans
- **MASSIRENO national programme** provided recovery plan support for massification and innovation
- **ERDF (European Regional Development Fund)** co-financed the project as part of the regional energy efficiency strategy
- **Regional and departmental subsidies** complemented investment costs for social landlords

This comprehensive mix of loans, grants, and incentives created a viable financial model that balanced ambition with affordability.

Public Policy Integration

The programme's alignment with France's **National Low Carbon Strategy (SNBC)** and **Climate and Resilience Law** reinforced its institutional legitimacy. It became a **strategic regional policy instrument**, bridging public housing retrofit goals with industrial and employment strategies.

This policy coherence is an essential condition for replication under LIFE GRF.

E. Collaborative Ecosystem Governance

Beyond contracts and tenders, the MASH process fostered a **learning community** of landlords, contractors, and suppliers.



Facilitated by Ressorts and Energiesprong France, and supported by regional innovation networks, this ecosystem governance created shared ownership of technical standards and collective improvement mechanisms.

Key practices included:

- **Monthly retrofit clubs** and technical workshops coordinated by Novabuild, Fibois, and Atlansun
- **Open innovation competitions** to identify modular and scalable retrofit solutions
- **Cross-learning visits** to Dutch Energiesprong sites and factories
- **Regional knowledge-sharing platforms**, now connected to Ressorts Commons and LIFE GRF databases

This continuous dialogue between market actors transformed procurement from a transactional process into an **industrial collaboration framework**.

F. Lessons for LIFE GRF Replication

The governance and procurement architecture developed in MASH Grand Ouest provides a ready-to-adapt blueprint for other European regions.

Its key transferable lessons include:

Lesson	Transferable Mechanism for LIFE GRF
Aggregation of fragmented demand	Establishment of regional procurement clusters
Competitive dialogue and flexibility	Adapted public procurement frameworks in Italy and Germany
Framework agreements enabling replication	Standard LIFE GRF contract templates
Long-term performance contracts	Energy Performance Guarantees with 30-year validity
Public-private coordination platforms	Regional steering committees under Giga Regio Factory model

These elements form the **institutional and contractual DNA** of industrial retrofit, enabling the LIFE GRF consortium to replicate the MASH logic while adapting to national contexts.

G. Summary

The MASH Grand Ouest procurement and governance model proves that industrial retrofit requires not only technical excellence but also **shared governance and collective risk management**.



By merging procurement scale, contractual flexibility, and transparent monitoring, the initiative transformed how public clients and industrial actors collaborate.

This model directly supports LIFE GRF's mission to turn regional retrofit markets into **structured, self-sustaining “Giga Regio Factories”**, capable of delivering high-performance retrofits at European scale.

6. Performance Measurement and Quality Control

Ensuring long-term performance is one of the most critical aspects of industrial retrofit. The MASH Grand Ouest programme provides a robust reference for **measurement, verification, and continuous improvement**, translating technical ambition into verifiable outcomes.

This section summarises the monitoring protocols, quality assurance methods, and control indicators validated under MASH and aligned with LIFE GRF objectives.

A. Principles of Performance-Based Retrofit

MASH adopted the **Energiesprong “Guaranteed Performance” model**, which links contractual payments, technical design, and operational monitoring to real-life energy outcomes.

All participating landlords benefit from a **30-year performance guarantee**, covering energy balance (E=0), comfort, and operational reliability.

The guiding principles are:

- **Measure what matters:** focus on end-use energy consumption and generation balance, not theoretical calculations.
- **Monitor continuously:** integrate real-time data collection and feedback loops into daily asset management.
- **Improve systematically:** use monitoring data to enhance system performance, detect anomalies, and update future designs.

These principles have been adopted as baseline requirements for LIFE GRF's replication strategy.

B. Monitoring and Verification System

The monitoring system established under MASH Grand Ouest combines **hardware-based metering, digital platforms, and predictive analytics**.



Scope of Monitoring

Performance is monitored across four main domains:

- Heating, domestic hot water (DHW), and ventilation energy use
- Local renewable generation (photovoltaic, biomass, or hybrid systems)
- User-related electricity and comfort indicators
- Indoor air quality and thermal comfort
- Data are collected continuously via smart meters and sensors embedded in energy pods and façade modules.

Data Management and Tools

Each dwelling is connected to a digital monitoring platform enabling:

- Real-time energy balance visualisation
- Remote supervision by maintenance teams
- Predictive maintenance based on anomaly detection
- Automated reporting to landlords and financiers

In the MASH case, tools developed by **Synerpod** enabled multi-site data aggregation and anonymised performance dashboards shared with all project stakeholders.

C. Quality Assurance and Control Protocols

MASH established a **multi-level quality management process**, combining industrial QA/QC methods with construction-site supervision.

Control Phase	Key Activities	Responsible Actors
Design Phase	Model validation, DfMA compatibility check, thermal simulation	Design offices, architects, Energiesprong France
Factory Phase	In-factory testing, material traceability, product certification	Industrial partners (Altyn, Sogea, Spie)
Installation Phase	On-site assembly verification, air-tightness testing, commissioning	Site managers, QA supervisors
Operational Phase	Monitoring verification, periodic audits, user satisfaction surveys	Landlords, maintenance providers, Ressorts

This integrated approach aligns with **ISO 9001 principles** and can serve as a quality assurance reference for other LIFE GRF pilots.

D. Continuous Improvement and Feedback

Each wave of projects under MASH generated structured feedback:

- Technical optimisations (simplified joints, lightweight façades, faster assembly)



- Procurement adjustments (batch size, supplier coordination)
- Monitoring refinements (data frequency, comfort parameters)

This feedback loop forms the **foundation for LIFE GRF’s future “Factory Learning System”**, where technical and process data from all European pilots will feed into an open improvement platform hosted by the consortium.

7. Replicability and Transferability Recommendations

The LIFE GRF project aims to replicate the industrial retrofit standards proven in MASH Grand Ouest across Europe.

However, replication is not a simple copy; it requires **adaptation to national contexts**, while maintaining the common technical and governance DNA developed under WP3.

A. Key Conditions for Successful Replication

Based on the lessons of MASH, three conditions are critical for replication:

- **A Shared Demand Platform**

Aggregating sufficient housing stock under a unified framework is essential to attract industrial suppliers.

LIFE GRF regional clusters (in France, Italy, and Germany) will replicate the MASH collective procurement model to reach this threshold.

- **Industrial Readiness and Local Ecosystems**

Each region must identify or develop capable industrial actors (façade producers, MEP integrators, logistics specialists).

The mapping work from **D3.1** and **D3.3** provides the basis for this identification.

- **Policy and Financing Alignment**

Multi-level financing, including regional funds, EU programmes (ERDF, LIFE, Horizon Europe), and national subsidies, must be aligned with industrial retrofit objectives.

Public authorities should ensure stable and long-term policy support.

B. Adaptation Pathways for LIFE GRF Regions

France

The next wave of the MASH programme (Wave 2) is already planned and will apply refinements identified during the first cycle: simplified specifications, extended factory capacity, and streamlined governance.



The French cluster under LIFE GRF will use this as a testing ground for standardised contracts and new monitoring protocols.

Italy

In Italy, the Lombardy and Emilia-Romagna regions will adapt the MASH procurement model to local cooperative structures, integrating housing agencies and ESCOs.

Partners such as **EDERA** will test similar competitive dialogue formats and develop new performance-based frameworks compliant with Italian public procurement law.

Germany

German replication will focus on **Berlin and Brandenburg**, leveraging the country's strong prefabrication industry and growing interest in modular retrofits.

The focus will be on digital integration (BIM-to-production) and financing mechanisms compatible with KfW energy efficiency standards.

Common European Framework

To ensure coherence across regions, LIFE GRF will establish a **Common Standardisation Framework** based on three reference documents:

- **Technical Reference Standards** (derived from MASH specifications)
- **Procurement and Governance Guidelines** (model contracts, framework templates)
- **Performance Monitoring Protocol** (harmonised KPIs and data templates)

These documents will serve as the foundation for a **European Industrial Retrofit Standard** to be shared with public authorities and industry associations under WP5.

C. Transfer Tools and Resources

To facilitate replication, LIFE GRF partners will develop:

- **Standard templates** for grouped procurement and framework agreements
- **Training modules** for landlords and integrators on industrial retrofit processes
- **Digital repositories** for open-source resources (through Ressorts Commons and LIFE GRF online platforms)
- **Cross-country learning exchanges** between pilot regions

This approach ensures that the LIFE GRF framework is **not prescriptive but empowering**, enabling each territory to adapt and adopt proven solutions within its own context.



8. Conclusions

The **D3.4 – Technical Standard Documents** deliverable marks a turning point in the LIFE GRF project.

It demonstrates that the ambition of large-scale, zero-energy retrofit can move beyond concept to **structured industrial implementation**.

Through the MASH Grand Ouest experience, the consortium now has:

- A **proven technical and organisational reference**, validated at full scale
- A set of **standardised tools and frameworks** ready for European adaptation
- And a concrete proof that **industrial retrofit is not an exception, but a replicable model**

By annexing the **REX MASH report**, this deliverable anchors the LIFE GRF framework in tangible practice.

It turns abstract technical guidelines into a verified operational standard for integrated retrofit.

The lessons of MASH – collective procurement, industrial production, digital integration, and performance guarantees – now form the foundation of a European transformation pathway.

As LIFE GRF advances into WP4 and WP5, these standards will guide pilot replication, policy recommendations, and the scaling of **Giga Regio Factories** across Europe.

9. Annex 1 – Technical Reference Document

■ *Rex MASH Grand Ouest – Successes and Project Sheets*

Produced by **Ressorts / Energiesprong France (2025)**

Used within LIFE GRF as the **core reference for Technical Standards and industrial retrofit models**.

