

D4.1 – Demo-case contextualisation report

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Executive Summary

This report aims to provide a comprehensive contextualization of demonstration cases involving the application of biobased thermal insulating materials in energy efficient renovation projects. The adoption of biobased materials for insulation in the construction industry holds significant potential for reducing energy consumption and minimizing the environmental impact of buildings. This report addresses various aspects, including the conceptual framework, prerequisites, legal barriers, heritage protection issues, support in national standards and regulations, technical approvals, selling/renting strategy, stakeholder involvement, feedback collection, decision-making facilitation, and financial instruments. These elements collectively form a roadmap for the successful implementation of energy-efficient biobased technologies highlighting their relevance in the broader context of sustainability and energy conservation.

Section 1 provides general explanations of the objectives and target audience, also the background is mentioned.

Section 2 is focused on the customer value proposition. It identifies the customer segments, highlights the benefits of biobased insulating materials, and presents the unique selling points of biobased insulations.

Section 3 analyses the costs and revenues for selected examples of biobased products. Profitability projection based on the results of analysis is done and business idea is explained.

Section 4 addresses the challenges associated with material sourcing and supply chain for selected example of biobased material. Manufacturing and installation processes are described for the example of prefabricated building envelope.

Section 5 describes the pre-requisites for successful implementation of biobased solutions.

Section 6 identifies the possible implementation risks and barriers and offers possible mitigation strategies.

Section 7 describes the market situation in selected EU countries and the pricing strategy in the segment of renovated buildings.

Section 8 identifies the relevant stakeholders.

Sections 9 and 10 provide an overview of local financial instruments and identify the most attractive financial investment mechanisms.

Section 11 recapitulates the key findings of the deliverable and provides positive outlook for the development of new biobased insulating materials and their acceptance in the market.

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This publication reflects only the author's view. The Agency and the European Commission are not responsible for any use that may be made of the information it contains.

Abbreviations and Acronyms

[illegible]

*The text of this deliverable contains a lot of abbreviations and acronyms. For practical reasons most of them are explained and described directly below in the text.

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1 Introduction

1.1 Background

This report is part of Work Package 4 (WP4) within the BIO4EEB project (101091967), funded by the European Commission under the new Horizon Europe programme. BIO4EEB aims to close the increasing gap of insulation material shortage caused by the regular growing demand and the mismatch caused by lacking production potential and the outcome of the current energy crisis by boosting the use of available biobased qualified materials as alternative solutions. This deliverable links up with the outcomes of the tasks T2.1-T2.4 that will be individually implemented in the demonstration cases. Each demo-case has its own specific context defined by the geographic location, climate, type, age, technical condition of the building, type of user, business case, legal framework and other parameters that shall be described and analysed.

1.2 Aims and objectives

Subtask 4.1.2 and the corresponding deliverable D4.1 set out to deliver the following:

- Provide conceptual framework for the business cases referred to the real demo-cases.
- Describe the pre-requisites and identify the barriers, especially the legal barriers.
- Find an approach for complying with possible heritage protection issues.
- Identify the support in national standards and regulations.
- Define the needs in selling/renting strategy and involve the relevant stakeholders.
- Collect the feedback for the technology manufacturing and product validation.
- Facilitate the decision-making process, finding optimized solutions and best renovation strategies for the demonstration cases.
- Develop an easy understandable overview of local financial instruments and identify most attractive financial investment mechanisms to lower the economical barrier for upgrading the technologies studied in the project.

1.3 Target audience

- Professionals in building materials industry.
- Investors and developers going green and environmentally sustainable with their projects.
- Marketing and sales specialists.
- Energy specialists, architects and building contractors.
- Sustainable housing policy makers
- Financial institutions

2 Customer Value Proposition

2.1 Benefits of Biobased Thermal Insulating materials

The use of biomaterials in buildings can offer various benefits, combining sustainable and eco-friendly approaches with innovative construction methods.





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Some of the potential benefits of BIO4EEB materials are described below:

Renewable Resource Utilization

Biomaterials are derived from renewable resources (either plant-based or animal-based). This reduces dependency on finite resources and promotes sustainability in construction.

Reduced Environmental Impact

Biobased materials typically have a lower carbon footprint compared to traditional construction materials like concrete and steel. The production of these materials is usually less energy demanding than production of mineral wool and involves fewer greenhouse gas emissions.

Energy Efficiency

The materials possess natural insulating properties, contributing to increased energy efficiency in buildings. This can result in reduced heating and cooling costs and overall energy consumption.

Waste Reduction

Biobased materials are often biodegradable or recyclable, leading to decreased waste generation during and after the construction process. This aligns with the principles of a circular economy, where materials are reused or recycled rather than disposed of as waste.

Health and Indoor Air Quality

Biobased materials have generally low levels of toxicity and can contribute to better indoor air quality. This is especially important for occupant health as poor indoor air quality can lead to respiratory issues and other health problems.

Innovative Design Possibilities

Biobased materials often allow for more flexible design, enabling the architects and builders to create unique and aesthetically valuable textures. The versatility of these materials can lead to innovative and sustainable architectural solutions.

While bio-materials offer numerous benefits, it is important to consider factors such as local availability, cost-effectiveness, and the specific requirements of the construction project when choosing these materials. Additionally, building codes and standards may need to be adapted to accommodate the use of bio-materials in construction.

2.2 Target Customer Segments

In the dynamic landscape of thermal insulation products, the emergence of biobased solutions has opened new paths for sales and marketing strategies. Understanding the target customer segments is crucial for successful penetration into the market. This chapter describes the diverse customer groups, identifies types of adopters, and suggests effective approaches for engaging them in the realm of biobased thermal insulation products.

2.2.1 Commercial Builders and Contractors

Large-scale construction projects often seek innovative and efficient insulation solutions.

Adopter Type: Early Majority and Late Majority.





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Approach: Provide case studies and data demonstrating long-term cost savings, energy efficiency, and ease of installation. Establish partnerships with influential construction companies to build credibility.

2.2.2 Residential Homeowners

Individuals looking for sustainable and energy-efficient solutions for their homes.

Adopter Type: All types of adopters but mostly Early Adopters or even Innovators, see Tab. 1.

Approach: Emphasize the environmental benefits, energy savings, and potential government incentives. Utilize digital marketing to reach tech-savvy early adopters through social media and online platforms.

Table 1 Groups of residential homeowners

	Group 1	Group 2	Group 3	Group 4
Description	Faster to transition aged 30-60	Slower to transition aged 30-60	Faster to transition aged 60-75	Reluctant to transition mostly aged 60+
Summary	Highly environmentally engaged. Making climate conscious house upgrades to reduce the energy bills whilst not spending more than they can afford.	Somewhat environmentally engaged. Climate conscious measures are not their highest priority in the near term, however they want to reduce their energy bills. Can be reached through low-cost digital marketing tools.	Somewhat environmentally engaged. Simple measures to upgrade and improve their home comfort and reduce the energy bills.	Less environmentally conscious. Financially constraint.
Adopter category	Early adopters or Innovators	Late majority	Early majority	Laggards
Communication channel	Social media and customer referral scheme	Social media and customer referral scheme	Partnerships with local contractors via local community groups, and adverts in local / national newspapers	Community groups, family, friends, neighbours.

2.2.3 Architects and Designers

Professionals focused on creating energy-efficient and aesthetically pleasing structures.

Adopter Type: Innovators and Early Adopters.

Approach: Collaborate on product development and showcase how non-traditional insulation aligns with modern architectural trends. Provide seminars and workshops to educate them about the product's advantages.





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2.2.4 Government and Regulatory Bodies

Entities interested in promoting energy efficiency and sustainable building practices.

Adopter Type: Innovators and Early Adopters.

Approach: Engage in dialogue regarding compliance with energy efficiency standards. Provide documentation supporting the product's adherence to regulations. Advocate for the inclusion of non-traditional insulation in building codes.

2.2.5 Investors and Developers

Firms looking to invest in innovative and sustainable technologies. Individuals seeking promising opportunities in the construction and energy efficiency sectors with a focus on projects that generate positive social and environmental impact. Professionals working on urban development projects and smart city initiatives.

Adopter Type: Innovators and Early Adopters.

Approach: Provide exclusive early access, trial offers, and emphasize the product's cutting-edge features. Share success stories, testimonials, and demonstrate how adopting the product aligns with industry trends. Establish strategic partnerships.

2.2.6 Best Approaches for Engagement

Education and Awareness Campaigns:

- Develop informative materials explaining the benefits and applications of non-traditional insulation.
- Conduct workshops, webinars, and seminars to educate potential customers.

Strategic Partnerships:

- Collaborate with key players in the construction and design industries to enhance credibility and reach a broader audience.

Digital Marketing:

- Leverage online platforms to target specific customer segments with tailored content.
- Utilize social media, SEO, and content marketing to increase visibility.

Incentives and Rebates:

- Offer financial incentives and rebates to encourage early adoption and ease the financial burden on customers.





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Certifications and Standards:

- Obtain relevant certifications to establish the product's reliability and compliance with industry standards.
- Communicate these certifications effectively in marketing materials.

In conclusion, understanding the diverse customer segments and adopting tailored approaches for each type of adopter is essential in the sales of non-traditional thermal insulation products. By aligning marketing strategies with the needs and characteristics of the target audience, businesses can enhance their market penetration and drive the adoption of innovative insulation solutions.

2.3 Unique Selling Points of Thermal Insulating Biobased Materials Customer Segments

The growing demand for sustainable and eco-friendly energy efficient solutions has led to the emergence of thermal insulating biobased materials as a compelling alternative to traditional insulation products. These materials offer several unique selling points that set them apart and make them increasingly attractive to consumers and businesses alike. The general benefits of biobased thermal insulating materials are described in the section 2.1. The benefits of two crucial thermal insulating materials studied in the BIO4EEB project (i.e. boards from *Posidonia Oceanica* leaves and biobased polyurethane foams), which can be used as a selling points are below described in more detail.

2.3.1 Environmental Sustainability

The main advantage of the thermal insulation boards from *Posidonia Oceanica* is the utilization of wastes abundant around Mediterranean Sea. These wastes (mainly dead leaves) are usually difficult to dispose. The thermal insulating boards can be rather easily prepared from the *Posidonia Oceanica* wastes dead leaves and plant-based epoxy resin as a binder.

The complete LCA (Life Cycle Assessment) of thermal insulation boards from *Posidonia Oceanica* leaves was not performed yet, because the technology-readiness level (TRL) is still rather low, and it must be optimized to reach higher level of TRL. Nevertheless, the environmental impact of these material can be estimated from the data of similar materials. Environmental Product Declarations of VestaEco Straw Insulation Board 140 (made from straw and PMDI resin), board Gramitherm 100 (made from grass, recycled juta fibres and PET binder) and pressed straw bales were used for comparison. Data of *Posidonia Oceanica* fibres were adopted from Gräbe and Woidasky (2011).

The environmental impacts of these materials are given in Tab 2 and resource use in Tab. 3. Data in tables were obtained from Environmental Products Declarations (EPDs), provided by the producers, and referred to a functional unit defined as the mass of material needed to obtain a thermal resistance of 1 m² K/W for a 1m² area. Conversions were made if data were related to other functional unit of material.

There can be seen, that the environmental parameters of these materials are very low and their Global Warming Potential is even negative.



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Table 2 - Environmental impact of materials, close to thermal insulation boards made from Posidonia

Product		VestaEco Straw Insulation Boards 140	Gramitherm 100	Straw bales	Posidonia Oceanica
Parameter	Material	straw, PMDI resin	grass, recycled jute fibre, PET binder	wheat and barley straw, PP cords	fibres
	Units/FU				
GWP total	kg CO ₂ eq	-3.85E+00	-2.03E+00	-1.63E+01	4,45E-01
GWP fossil		5.65E+00	1.01E+00	1.82E+00	
GWP biogenic		-9.53E+00	-3.04E+00	-1.74E-03	
GWP luluc		3.21E-03	6.60E-04	2.41E-03	
ODP	kg CFC 11 eq	7.44E-07	2.05E-06	1.47E-07	
AP	mol H ⁺ eq	3.68E-02	2.91E-03	2.01E-02	5,18E-03
EP - freshwater	kg P eq	4.52E-04	1.89E-05	6.61E-04	6,17E-04
EP - marine	kg N eq	1.67E-02	6.10E-04	1.48E+01	
EP - terrestrial	kgN eq	7.23E-02	6.53E-03	7.75E-02	
POCP	kg Ethene eq	1.95E-02	2.35E-03	6.31E-03	4,12E-04
ADPE	kg Sb eq	1.20E-05	6.66E-06	5.09E-05	
ADPF	MJ	7.97E+01	2.36E+01	1.23E+01	
WDP	m ³ water eq deprived	7.95E+00	3.16E-01	1.09E+01	

GWP total = total Global Warming Potential; GWP-luluc = Global Warming Potential land use and land use change; ODP = Ozone Depletion Potential; AP = Acidification Potential for Soil and Water; EP = Eutrophication Potential; POCP = Photochemical Ozone Creation; ADPE = Abiotic Depletion Potential – Elements; ADPF = Abiotic Depletion Potential – Fossil Fuels; WDP = water use (Water (user) deprivation potential, deprivation-weighted water consumption)

Table 3 - Resource use of materials, close to thermal insulation boards made from Posidonia Oceanica

Product		VestaEco Straw Insulation Boards 140	Gramitherm 100	Straw bales	Posidonia Oceanica
Parameter	Material	straw, PMDI resin	grass, recycled jute fibre, PET binder	wheat and barley straw, PP cords	fibres
	Units/FU				
PERE	MJ	3.36E+01	2.46E+03	-1.70E+02	
PERM		1.20E+02	2.20E+01	2.07E+02	
PERT		1.50E+02	6.34E+01	3.57E+01	
PENRE		9.62E+01	2.36E+01	1.32E+01	
PENRM		7.94E+00	3.94E+00	0.00E+00	
PENRT		1.04E+02	2.75E+01	1.32E+01	8,75E+00
FW	m ³ water eq	1.19E-01	4.15E-03	3.20E-01	2,98E-03

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; FW = Use of net fresh water

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Biobased polyurethane foams (PUF) are not yet commercially produced and therefore any EPD was not made for them. Nevertheless, the environmental sustainability of biobased polyurethane foams was assessed in several scientific studies and biobased PUFs were compared with the fossil-based PUFs. It was found that the properties of biobased PUFs are comparable with the fossil-based types. Nevertheless, the results in particular studies could not be summarized or compared to commercial EPD, because each study used different functional unit, system boundaries and models. The results of some studies are given in Tables 4 and 5.

Obviously, the environmental criteria of biobased PUF are only slightly lower than the criteria of the fossil-based PUFs and sometimes they are even higher. This is caused by the fact that the technology used to produce fossil-based PUF has been extensively developed and optimized over the last decades and is already at a high technology-readiness level (TRL), while the production technology of biobased PUF, despite the growing demand, is still at the beginning and further research is necessary to reach higher TRL.

Table 4 - Results obtained by Quinteiro et al. (2022)

Raw material		Fossil	Soybean oil	Rapeseed oil	Palm oil	Waste cooking oil
Parameter	Units/FU					
GWP total	kg CO ₂ eq	6.17 - 6.55	6.66 - 6.95	5.34 - 5.88	5.53 - 6.04	4.68 - 5.35
AP	mol H ⁺ eq. 10 ⁻²	2.25 - 2.44	1.99 - 2.23	2.85 - 2.92	2.01 - 2.25	1.81 - 2.09
EP - freshwater	kg P eq. 10 ⁻³	1.47 - 1.65	1.4 - 1.6	1.42 - 1.61	1.29 - 1.51	1.26 - 1.48
EP - marine	kg N eq. 10 ⁻³	7.48 - 7.72	8.65 - 8.66	9.83 - 9.61	8.71 - 8.72	7.32 - 7.58

Table 5 - Results obtained by Manzardo et al. (2019)

Raw material		Fossil	Azealic acid and lignin
Parameter	Units/FU		
GWP total	kg CO ₂ eq	4.89	3.33 - 4.59
ODP	kg CFC 11 eq. 10 ⁻⁸	6.40	5.5 - 14.1
AP	mol H ⁺ eq. 10 ⁻²	2.42	1.73 - 2.41
EP - freshwater	kg P eq. 10 ⁻³	0.61	0.34 - 0.57
EP - marine	kg N eq. 10 ⁻³	15.10	11.4 - 21.4
POCP	kg Ethene eq. 10 ⁻²	1.71	1.18 - 1.56
ADPE	kg Sb eq. 10 ⁻⁶	6.38	5.33 - 9.16
ADPF	MJ	95.4	65.5 - 82.4

2.3.2 Health and Indoor Air Quality

In practice, moisture problems in older homes are mostly caused by inadequate waterproofing and internal vapour condensation currently associated with poor indoor climate management. The alternative natural insulation materials could improve the indoor climate and thereby create a healthier and more comfortable and pleasant living or working environment.

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Thermal insulation from *Posidonia Oceanica* has not any potential impacts dangerous to human health. The boards were tested for ecotoxicity to algae, and it was found out, that the material is not ecotoxic to them (Fig. 1). As can be seen, the algae growth was not inhibited in the presence of board particles. *Posidonia Oceanica* Boards are considered to have low emissions of volatile organic compounds (VOCs), contributing positively to indoor air quality. They do not contain the formaldehyde binder; therefore, no formaldehyde pollutions are emitted into air. Boards have very good hygroscopic qualities, which have a positive effect on the control of moisture conditions in the interiors. On the opposite side, they are prone to the growth of mould and mildew when wet, therefore they must be properly installed and protected against water. The boards need to undergo some treatment to enhance fire and pest resistance, but it is important to consider the types of treatments used and their potential impact on indoor air quality.



Figure 1 - Result of ecotoxicity test of *Posidonia Oceanica* boards to algae (samples K1 and K2 are reference samples, Va, Vb and Vc are samples with ground board particles)

Polyurethane foams are often described as a potentially dangerous to the human health, probably because they are results of chemical reaction between polyols and diisocyanates (either fossil- or biobased) and some isocyanates are toxic or possibly carcinogenic (e.g. toluene diisocyanate). Nevertheless, for the insulating foams the methylene diphenyl diisocyanate (MDI) is used, which appears to be relatively safer and is unlikely a human carcinogen. Moreover, once the chemical reaction of components has taken place, the result (polyurethane foam) is completely inert and harmless to humans. No toxic emissions, which could pollute or reduce the quality of the air in the rooms, are produced. The emission of volatile organic compounds (VOCs) of PUF is very low. Unlike conventional foams, bio-based PU foams often have low VOC emissions, contributing to improved indoor air quality. Studies indicate that these foams release significantly fewer harmful chemicals, with VOC levels below 0.5 parts per million (ppm), as written by Kiss, G and Naldzhiev, D. This characteristic not only supports a healthier indoor environment by reducing the risk of respiratory issues but also aligns with stringent indoor air quality standards. For health-conscious consumers, bio-based PU foams represent a smart choice, combining comfort with a commitment to fostering clean and safe living spaces. Besides, the contribution of the building materials to the indoor air quality (IAQ) burden of disease (BoD) is minimal (Fig.2). The ecotoxicity of biobased polyurethane to algae is very low.

Workers who are involved in the installation phase of already manufactured polyurethane insulation products, such as sheets or panels, do not need to take any special measures. The workers in production factories need special training, see further subchapter 4.2.

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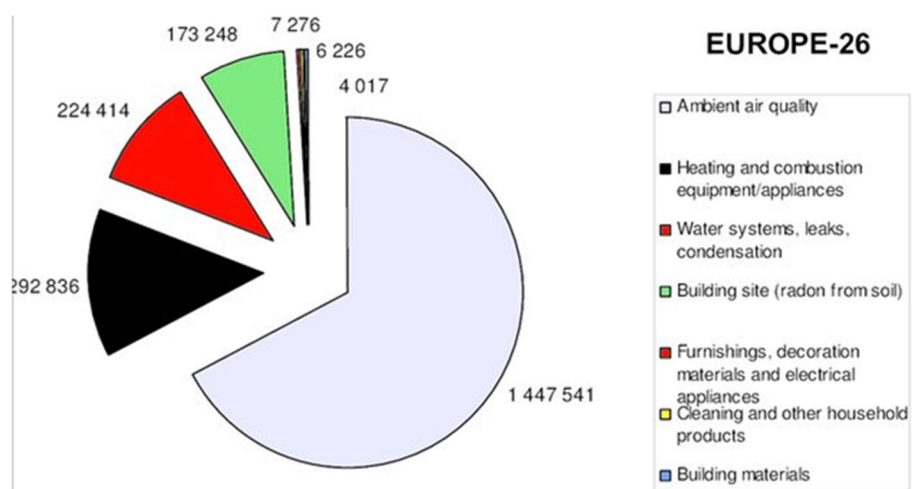


Figure 2 - The indoor air quality associated burden of disease attributed to the key sources of exposure (Jantunen et al., 2011)

2.3.3 Thermal Performance

Thermal insulating properties of biobased materials are usually slightly worse than the those of currently used commercially available products. However the differences are not significant.

Thermal properties of the Posidonia Oceanica insulation board are comparable with the similar biobased thermal insulating materials, as can be seen in Table 6. The boards from this study are compared with the Posidonia Oceanica boards from other study (Kuqo et al., 2022) and commercially available boards from similar materials are compared in the table. There can be seen, that thermal conductivity of Posidonia boards is slightly higher than the thermal conductivity of other materials. This is caused by the higher bulk density of Posidonia boards, because thermal conductivity increases with decreasing volume of pores (i.e. with increasing bulk density).

Table 6 - Basic properties of thermal insulations from Posidonia Oceanica and similar materials

Material	Bulk density	Thermal conductivity	Specific heat capacity	Water vapor resistance factor
	r	l	c	m-value
	kg/m ³	W/m.K	kJ/kg.K	-
Posidonia boards (this study)	159	0.054	1.18	22.7
	177	0.057	1.25	29.9
	189	0.062	1.31	89.1
	198	0.057	1.01	29.9
	200	0.057	1.11	83.8
	220	0.059	1.09	76.2
	236	0.062	1.00	26.8
	238	0.064	1.07	54.0
	287	0.076	1.17	151.8

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	289	0.068	1.05	195.8
	316	0.065	0.91	147.7
Posidonia panels *	90-233	0.042 - 0.050	N.A.	N.A.
VestaEco INTERNAL**	180	0.048	2.10	5.0
Gramitherm 100**	40	0.041	1.50	1.0
*Methylene diphenyl diisocyanate resin used as a binder (Kuqo et al. 2022)				
** Composition described in Tab. AA				

Thermal insulating properties of biobased polyurethane foams are slightly lower than the properties of commercially available product, see Table 7, which is caused by the higher technology-readiness level of commercial PUF after several decades of intense research. There can be expected, that same values will be achieved, when the TRL of biobased PUF achieves the same degree.

Table 7 - Basic properties of bio- and fossil-based PUF

Material	Bulk density r	Thermal conductivity l	Specific heat capacity c
	kg/m ³	W/m.K	kJ/kg.K
Thermal insulating boards	67	0.042	2.34
	62	0.041	2.21
	68	0.042	2.28
	67	0.042	2.15
	67	0.042	2.13
	68	0.042	2.11
Average	67	0.042	2.20
Commercial fossil-based PUR/PIR	30	0.025	1.50

2.3.4 Moisture Regulation

Porous thermal insulating materials are usually hygroscopic, and they can play important role in the moisture regulation of the interiors. Hygroscopic materials can uptake moisture from the air when its relative humidity increases and release moisture to the air when its relative humidity falls (Zhang et al., 2017). The moisture buffering ability of materials starts to be more and more important in the modern houses because of their increasing air tightness. Some of the commonly used building materials have very good moisture buffering capacity (e.g. autoclaved aerated concrete or gypsum) and especially fibrous biobased materials exceed in it. On the contrary, the μ -value of the Posidonia boards is rather high, because their surface is finished by the used binder (bi-component epoxy resin from extracts of plant origin), which is nonporous and water resistant. The treatment is necessary because untreated material is susceptible to mould and fungi degradation. Nevertheless, it means that the thermal insulating boards from Posidonia Oceanica are not able to contribute to the moisture regulation of indoor air.

Bio-based polyurethane foams offer a unique selling point through their exceptional moisture regulation capabilities. These foams exhibit a high moisture vapour permeability, allowing them to effectively manage humidity levels in various applications. According to Turan, D. the biobased PU foams can have moisture vapour transmission rates (MVTR) ranging from 1500 to 3000 grams per square meter per 24 hours. This natural moisture regulation helps prevent mould and mildew growth, enhancing the overall indoor air quality.

2.3.5 Versatility and Adaptability

Biobased thermal insulating materials can be used in many forms and shapes, including batts, loose-fill, boards, and spray insulation. This versatility allows them to satisfy a wide range of construction needs and design preferences. Additionally, they can be seamlessly integrated into new constructions or used for retrofitting, making them a flexible option for both residential and commercial sector.

Because the biobased materials are usually fibrous, they are mostly available in the form of soft matts, solid boards, or free fibres (Fig. 3).



Figure 3 - Various types of fibre based thermal insulations.

A. Grooved fibreboard for underfloor heating. B. Impact sound insulation. C. Wood-fibre insulation, loose fill. D–G. Wood-fibre insulation, semi-rigid sheet. H. Fibreboard (wind stopper or supplementary insulation). I. Fibreboard, tongue, and groove (supplementary insulation) (from <https://www.swedishwood.com/publications/wood-magazine/2016-2/inhibit-moisture/>)

Biobased polyurethane foams demonstrate exceptional versatility and adaptability, making them a versatile choice for a wide range of applications. These foams can be tailored to exhibit diverse physical properties, with varying degrees of flexibility, resilience, and density. For instance, biobased PU foams can be formulated to have densities ranging from 20 to 400 kg/m³, offering a broad spectrum of options for manufacturers. Whether used in furniture, automotive components, or insulation materials, the adaptability of biobased PU foams allows for precise customization to meet specific performance requirements. This versatility, coupled with the sustainable and renewable nature of the raw materials, positions biobased PU foams as a dynamic and eco-friendly solution in various industries.

Thermal insulations from *Posidonia Oceanica* can be used in the form of free fibres or fibre boards (Fig.4) and free leave and boards from leaves (Fig. 5).

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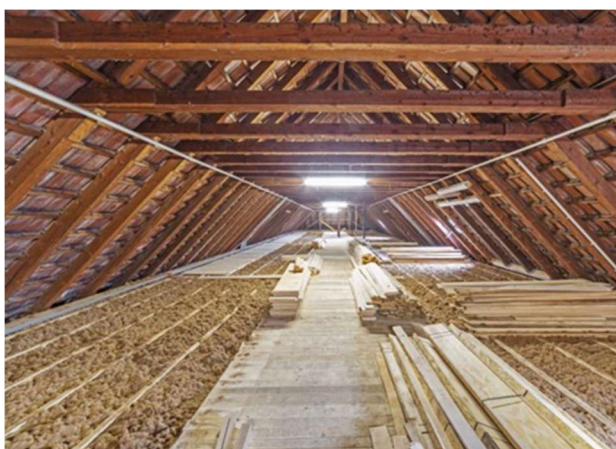


Figure 4 - Insulations from Posidonia Oceanica fibres (Photo Fraunhofer ICT, (left) NeptuTherm (right))



a)



b)

Figure 5 - Insulation from Posidonia Oceanica leaves: a) free leaves (Carmona et al., 2018), b) boards

2.3.6 Local Sourcing and Job Creation

Local sourcing and job creation stand out as compelling unique selling points for biobased manufacturers. By prioritising regional supply chains, these manufacturers contribute to local economies and reduce carbon footprints associated with transportation. Additionally, data shows that local sourcing can lead to a significant reduction in greenhouse gas emissions, promoting environmental sustainability. Moreover, the production of biobased materials on a local scale generates employment opportunities within communities. Studies indicate that for every job created in manufacturing, additional jobs are generated in related industries, further stimulating economic growth. This commitment to local sourcing not only supports regional development but also resonates with consumers who prioritise sustainability and community engagement, making biobased materials an attractive and socially responsible choice in the market.

2.3.7 Aesthetic Appeal

Some biobased insulating materials often possess a natural and visually appealing appearance. This aesthetic quality can be a selling point for environmentally - conscious consumers who appreciate the beauty of sustainable materials in their homes and commercial spaces.

The versatility of biobased PU foams allows for the creation of visually appealing designs while maintaining a commitment to sustainability. The material's adaptability in moulding and shaping enhances its potential for innovative and attractive applications. For consumers who prioritize both eco-conscious choices and aesthetics, biobased PU foams provide a harmonious blend of style and environmental responsibility, making them an appealing choice in industries where design and sustainability converge.

3 Profit Formula

3.1 Cost and Revenue Analysis

Regarding the analysis of cost and revenue for the utilization of Bio4EEB products in demo cases, the analysis of **SOPHIA/Starcell product**, the example of Posidonia core panel, and **INDRESMAT bioPUR** products were selected for the presentation in this chapter.

It is important to clarify that at the time of drafting this document the production is still at laboratory scale and therefore some data are based on estimates and general considerations. The analysis report covers raw material cost, transport cost, production, and storage cost. Machinery purchase cost, manpower cost and industrial plant cost has been estimated since at the time of drafting this document, only a preliminary design of the industrial process exists.

3.1.1 Total cost calculation of Posidonia core panel

The detailed calculation of production costs of the panels is available in the Annex A1. The figures refer to the prototype process, that is not designed for the mass market. The total costs are summarized in the tables Tab 8 and 9.

Table 8 – Posidonia total costs per m²

Cost per m ²	Units	100 kg/m ³ panel density	150 kg/m ³ panel density
Raw material cost	[€/m ²]	18	27,21
Transportation cost	[€/m ²]	4,69	7,05
Screening cost	[€/m ²]	6,42	9,65
Cleaning /Drying cost	[€/m ²]	16,97	25,4
Production cost	[€/m ²]	14,5	14,5
Storage cost	[€/m ²]	0,75	0,75
Logistics cost	[€/m ²]	1,96	1,96
Final unitary cost per m ²	[€/m ²]	63,29	86,52

Table 9 – Posidonia total costs per piece

Cost per panel	Units	100 kg/m ³ panel density	150 kg/m ³ panel density
Raw material cost	[€/pcs]	12,96	19,59
Transportation cost	[€/pcs]	3,38	5,08
Screening cost	[€/pcs]	4,62	6,95
Cleaning /Drying cost	[€/pcs]	12,22	18,33
Production cost	[€/pcs]	10,44	10,44
Storage cost	[€/pcs]	0,54	0,54
Logistics cost	[€/pcs]	1,41	1,41
Final unitary cost per panel	[€/pcs]	45,57	62,34

3.1.2 Total cost calculation of bioPur products

A comparative analysis of the costs, see Table 10, has been carried out by INDRESMAT for the different products that will be developed in BIO4EEB project at current prices (the situation 4 years ago was completely different):

Table 10 – Cost Analysis of different bioPUR based products

Product	Raw material cost €/kg	Production cost €/kg	Storage cost €/m ²	Transport cost €/kg	Total cost €/m ²
bioPUR frames for windows	3,6-5,2	2,50-3,50	0,50	0,40	100-150
bioPUR spray for wall/roof	3,3-4,7	0,25-0,30	0,01	0,05	15-20
bioPUR panel for ETICS	3,5-4,9	0,70-0,90	0,15	1,30	25-35

3.1.3 Conclusion of Cost Analysis

The production costs of Posidonia panels to be used for the demo-cases refer to the prototype process, that is not designed for mass market. Therefore, the unit cost and the cost per m² are not commercial, but typical of a prototype. To reach a cost of 45 €/m² with a density of 100, an industrial process should be implemented with “meaty investments” on the entire production flow.

As can be seen in the Table 10, the bioPUR frames for windows and doors have higher cost than foams for wall/roof insulation mainly due to the high impact of the production process cost. Despite the raw material acquisition and transport costs are essentially the same, the production capacity of the frame manufacturing is much lower than spray foaming or panels manufacturing (continuous process). This is related to the automation level of each process, where the window frames are currently produced at pilot scale so the cost is completely different if compared to insulation foams.

It is expected that INDRESMAT can reach more than 20M€ accumulated revenue in 2030 (Fig.6) through direct exploitation, thus producing around 1280 Tonnes of bioPUR with BIO4EEB products.

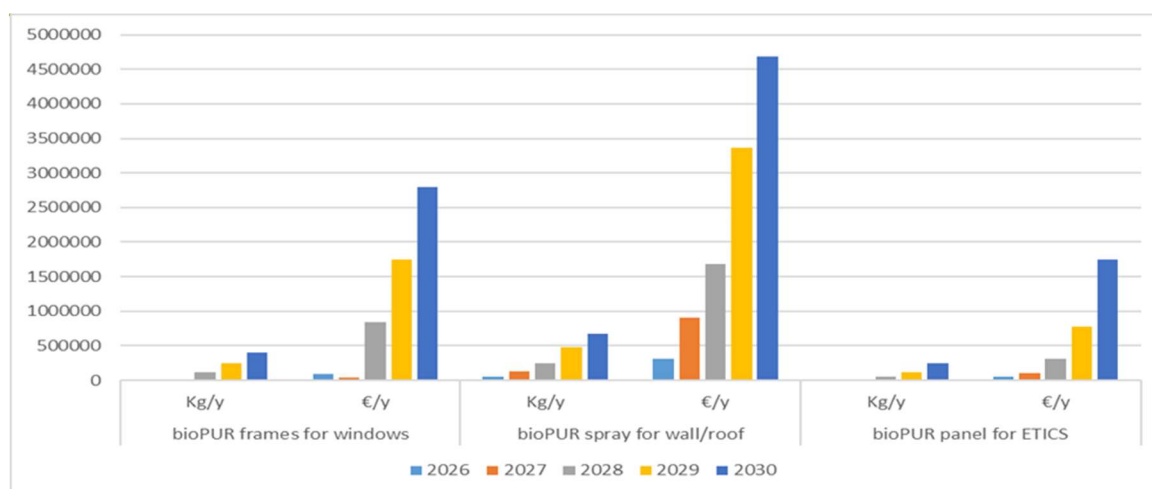


Figure 6 - Revenue analysis of different bioPUR products (direct exploitation)

3.2 Profitability Projection

It is too early to project the profitability of materials developed in the BIO4EEB project. For each product it is essential to conduct thorough market research, including an analysis of the crucial factors, to make accurate projections for the profitability of newly developed biobased insulation materials. Some general guidance is mentioned below:

- Study the product life cycle.
- Identify the input data for industrialization: volumes, seasonality of volumes, delivery times, market prices etc...
- Carry out the strategic analysis of the technological environment.
- Analyse the market demands and trends.
- Use the new product performance benchmarks to compare with existing products on the market.
- Analyse the market environment and assess how the regulatory landscape can impact the product adoption and profitability.
- Identify the specific features associated with the biobased insulation industry.
- Analyse the global economic factors.

Finally, the long-term viability should be considered, ensuring that the business model can adapt to changes and continue to be profitable over time. However, it's important to remember that projections are based on assumptions and uncertainties, so they should be regularly reviewed and revised as needed to reflect the changing business landscape.

An example of profitability projection related to bioPUR production is demonstrated below:

Because profitability is directly related to productivity capacity, which is also linked to the automation of manufacturing processes, in the Polyurethane industry this is a hot topic to address. Polyurethane manufacturing technology remains as 30 years ago, with no disruptive changes in terms of automation of the processes. Only highly automated sectors such as automotive have adapted their processes to high end

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applications but this is not the case in sectors such as construction industry. Another consideration negatively affecting profitability is linked to the availability of biobased raw materials, which are more expensive than petrol based raw materials due to their lower supply capacity. This is a general trend in the biobased economy.

Although INDRESMAT has a main role as materials developer, this company is also involved in the technology automation of processes, as well as in recycling technologies to increase the productivity and competitiveness of the future portfolio of products, as well as their profitability. An estimation of the profitability evolution considering production costs increase 1.5% every year and productivity capacity increases 4% every year is shown below in Table 11.

Table 11 –Gross profit forecast of bioPUR production

		2026	2027	2028	2029	2030
bioPUR frames for windows	Total costs (M€)	0,06	0,24	0,57	1,17	1,85
	Net income (M€)	0,08	0,35	0,84	1,75	2,80
	Gross profit (%)	28%	31%	33%	33%	34%
bioPUR spray for wall/roof	Total costs (M€)	0,07	0,22	0,59	1,36	2,14
	Net income (M€)	0,14	0,45	1,26	2,94	4,69
	Gross profit (%)	50%	52%	53%	54%	54%
bioPUR panel for ETICS	Total costs (M€)	0,04	0,07	0,22	0,53	1,18
	Net income (M€)	0,06	0,10	0,31	0,77	1,75
	Gross profit (%)	26%	30%	31%	32%	33%

3.3 Business Models

Crafting a robust business model around biobased insulation materials necessitates a comprehensive understanding of their production, distribution, and market penetration strategies. Choosing the right business model may depend on factors such as market demand, production capabilities, target customer base, and competitive advantages.

Further, in this subchapter, specific problem analysis and business ideas for Posidonia products and bio polyurethane products are described.

3.3.1 Posidonia case

Posidonia is a type of aquatic plant, the only genus in the Posidoniaceae family. Every year huge quantities of plant residues accumulate on the beaches in the Mediterranean. According to regulations, there are three disposal methods: on-site retention, landfill disposal at a cost of 70-80 €/ton, with additional expenses for effluent treatment, and relocation. However, none of these options involve recycling or the creation of new materials with the high thermo-acoustic performance levels envisioned in the project through recycling techniques.



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The idea is to recover stranded Posidonia residues, process them to enhance their characteristics, and reuse them for making panels used in structures and infrastructure. The concept is to develop environmentally friendly objects or parts of structures that are recyclable and biodegradable. Components made from these materials can have excellent properties if the processing parameters are appropriately adjusted and optimized. By modifying technical parameters, products with high characteristics in terms of thermal insulation, sound insulation, fire resistance, and recyclability can be obtained.

The innovative aspect of the proposal lies in producing bio-material products that are fully customizable according to customer needs, recovering waste, and turning it into a resource. This allows linking the business advantage to the socio-economic impact of the solution.

Innovation also extends to the technology of collection, treatment, and reduction of the bacteriostatic charge between accumulations of marine plants. There is a specific phase of drying and dehydration to block degradative enzymatic processes. A new business is emerging in harmony with the surrounding environment. Significant interest is expected in construction sectors, from building to civil engineering, as well as in related sectors such as environmental and tourism, benefiting from more extensive and cleaner areas. Administrations will also be relieved of the burden of disposing of Posidonia plants.

A crucial aspect is the European dimension of the intervention. The issue of energy efficiency and the environment addressed through these projects is a common need for many European coasts. The goal is to transform waste from marine biomass into resources and marketable products with added value that can generate business.

The project aims to identify competitive solutions, fully respecting environmental policies, and capitalizing on the exchange of know-how among companies.

The Posidonia, historically used as insulation, especially for roofs and walls in fishermen's houses, is cited as an example of traditional construction methods. Inspired by this, there are various construction examples, such as the Modern Seaweed House on Læsø Island, emphasizing sustainability and the use of local materials. The building uses wood for its structure and Posidonia cushions for external roof insulation and internal flooring.

Germany has initiated a research project on Posidonia, viewing it not as waste but as a material to be valued. The Fraunhofer Institute of Chemical Technology conducted systematic research, calculating the optimal density for thermal insulation, and confirming Posidonia's safety and hypoallergenic properties. The Fraunhofer Institute for Building Physics studied psychrometric aspects, highlighting its superior ability to thermally insulate buildings in both winter and summer. The Posidonia is found to be completely recyclable, with a lifespan of 150 years, offering excellent thermal insulation (20% better than wood-based insulation), fire resistance, non-toxicity, mould resistance, and the ability to absorb and release water vapor without compromising thermal insulation properties.

The project aims to create panels using Posidonia leaves and bio-polymeric material for the field of bioconstruction. Initial tests on the panel's general characteristics have been conducted, confirming its high thermal, mechanical, and acoustic performance. There are plans for the design and construction of a pilot plant for processing marine plants and producing the panel, with a preliminary scheme outlining the production stages.

In terms of potential support from Public Administrations, the introduction of specific incentives or eco-bonuses for the commercialization of bio-products could be interesting and useful. Some Municipalities already offer opportunities such as discounts on urban development charges, the possibility of achieving greater volume than stipulated by building regulations, a reduction in property taxation, etc. Panels with good thermal-acoustic insulation characteristics already available on the market are characterized by a high specific production energy and contribute more to atmospheric emissions. The marketing strategy involves



placing the panels in the fire-resistant chipboard and plywood market. Posidonia bio panels are positioned in the insulation panel market, ensuring the advantage of possessing excellent comparable or superior characteristics to comparative solutions while reducing the specific energy required for production and offering an organic product. Moreover, in the specific case, underlying the initial market penetration strategy, an additional advantage over plywood or chipboard panels is that Posidonia bio panels have mechanically, and thermally superior insulation performance compared to plywood or similar solutions. In the future, there will be a growing need to reuse waste to create value-added products for markets that are both high-performing and eco-sustainable, and therefore it becomes necessary to invest in this direction.

3.3.2 BioPUR case

With the aim to increase the revenues as well as upscale the adoption of the new products developed in BIO4EEB project, INDRESMAT aims to transfer the manufacturing of the final products to third parties, thus generating larger incomes for each product, and having a crucial position in the value chain (Fig. 7) as formulation developer and intermediate materials provider.

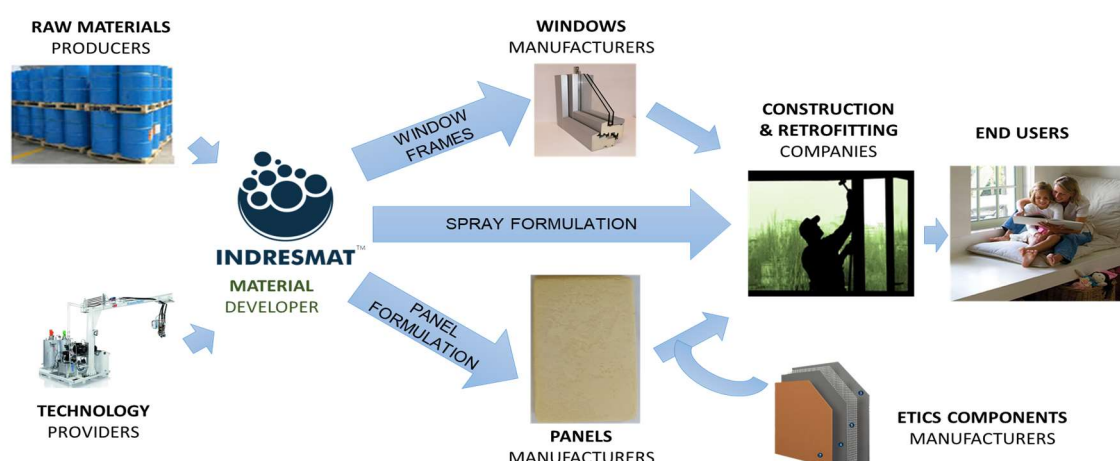


Figure 7 - Value chain of bioPUR products and business model of INDRESMAT

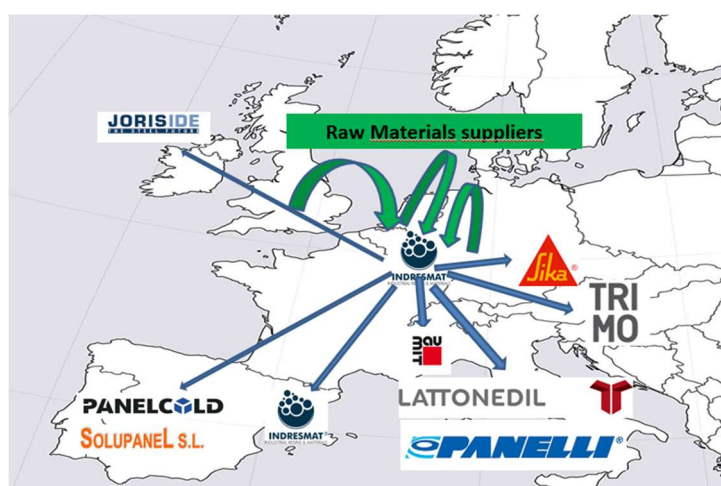


Figure 8 - Key location for bioPUR supply and production



The location in NL (Fig. 8) is particularly interesting due to its proximity to the raw materials providers and the current distribution channels already in place for biobased materials in the Dutch market. This key strategic role is related to a non-competition policy from INDRESMAT, having unique know-how to be exploited through industrial and commercial partnerships.

4 Key Resources and Processes

4.1 Materials Sourcing and Supply Chain

Material sourcing and supply chain management are important aspects for the manufacturers committed to environmental protection and sustainability. In this eco-conscious industry, the choice of raw materials is crucial to ensure a reduced environmental impact.

Regarding production of Posidonia insulating panels, material sourcing and supply chain concern about two raw materials: Posidonia and resin. BioPUR producers need diisocyanates and polyols derived from natural sources. The aspects of raw materials are analysed specifically in the following paragraphs.

4.1.1 Posidonia raw material

Posidonia plant has distinct parts, including roots, a stem (rhizome), and leaves, each with different growth processes. The rhizomes grow quite slowly, while the leaves grow much faster and show clear seasonality.

Today, Posidonia oceanica is protected and considered a distinctive element of the environmental state (EU Directive 92/43). It thrives on sandy to rocky sea beds, ranging from the surface to depths of up to 40 meters, in particularly clear waters. It can withstand temperature fluctuations but does not tolerate temperatures below 10°C or above 28°C. This plant is stenohaline (able to tolerate limited salinity variations in the waters it inhabits), disappears near river outlets, and is absent in brackish areas.

Table 12 – Posidonia raw material availability

Italian Location	Number of meadows
LIGURIA	25
TOSCANA	7
LAZIO	15
PUGLIA	15
BASILICATA	1 da 646 ettari
SICILIA E ISOLE MINORI	60
SARDEGNA	14
CAMPANIA	36
CALABRIA	30

Since the production of the panels will be carried out in Campania (Italy) it was decided to collect it mainly from Campania beaches located in the province of Salerno. This choice with a view to reducing transport costs, environmental impact and improving the bathing potential of Campania beaches with positive impact on the local population.



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Posidonia can be virtually collected for free since the only cost is screening and transport. However, the critical aspect is the bureaucratic one. To collect Posidonia a special authorization from the government authorities is needed but the current legislation in Italy is very complex and currently being updated. This means that it is not clear who has the authority to authorize the collection of Posidonia within the terms of the law.

The BIO4EEB partners Sophia and Starcell investigated various political figures, industry experts, government environmental bodies and what emerged was that currently the legislation does not clarify which body must/can authorize a company to collect Posidonia.

For this reason, the only way to proceed with the supply of Posidonia is to contact an environmental consultant or wait for the new legislation. Once the legal aspect has been resolved, the supply of Posidonia will consist of collecting it directly from the beaches with a screening operation directly on site to separate it from waste and sand. Posidonia will be transported by trucks to production site to be dried and transformed into panels.

4.1.2 Resin raw material

Epoxy resins represent a class of versatile polymers renowned for their exceptional adhesive properties and mechanical strength. Among the various formulations, bi-component epoxy resins stand out as a popular choice in industrial and commercial applications due to their specific characteristics and ease of use. Bi-component epoxy resins, as the name suggests, consist of two components – a resin and a hardener. The resin, often composed of bisphenol A and epichlorohydrin, reacts with a hardener, typically a polyamine. This chemical reaction, known as curing or polymerization, results in a cross-linked, rigid structure. The mixing ratio and precise combination of resin and hardener are crucial, as they determine the properties of the cured epoxy, including its strength, flexibility, and curing time.

Bi-component epoxy resins find wide-ranging applications across various industries:

- **Adhesives and Bonding:** Their strong adhesive properties make them ideal for bonding various materials, including metals, ceramics, and composites.
- **Coatings and Sealants:** Bi-component epoxy resins create durable coatings that protect surfaces from corrosion, chemicals, and wear. They are commonly used in floor coatings, protective coatings for metals, and sealants for concrete structures.
- **Composite Materials:** In the realm of composite manufacturing, these resins are essential for creating lightweight and high-strength structures. They are commonly employed in the production of fiberglass and carbon fiber composites.
- **Electronics:** Epoxy resins are widely used in electronic applications for encapsulating and protecting delicate components due to their excellent electrical insulating properties.
- **Art and Craftsmanship:** Bi-component epoxy resins have gained popularity in artistic pursuits, such as creating glossy coatings on artwork, encapsulating objects in clear resin, and crafting jewelry.

Cured bi-component epoxy resins exhibit exceptional mechanical strength and durability, providing long-lasting performance in various applications. They are resistant to a wide range of chemicals, making them suitable for use in harsh environments. The adaptability of bi-component epoxy resins to different formulations allows for customization of properties to suit specific application requirements. Furthermore, during the curing process, these resins typically experience minimal shrinkage, ensuring accurate and dimensionally stable final products.





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In conclusion, bi-component epoxy resins play a pivotal role in modern manufacturing and construction, offering a reliable combination of strength, versatility, and adhesive properties. Their widespread use in diverse industries underscores their importance in creating robust and resilient materials for an array of applications. The resin chosen to manufacture the panels is G27-Bamboo from the Soyaresin company. It's a resin with medium-low viscosity, with an excellent relationship between processing time and final curing time and with high resistance to UV rays. It has a light green colour, while remaining transparent. It has high mechanical resistance, excellent flexibility, and notable impact resistance. Some substances used for the formulation derive from natural extracts: the percentage of renewable carbon is equal to 56%. The term "renewable carbon" refers to the origin of carbon used in the production of a specific product, indicating that the carbon utilized comes from renewable or sustainable sources. This concept is often associated with efforts to reduce environmental impact and promote the transition to a more sustainable economy. The attribute "renewable" indicates that the source of carbon used is sustainable in the long term and can be regenerated over time. This contrasts with non-renewable sources, such as fossil fuels, which cannot be replenished on a human-relevant timescale once depleted. Therefore, when a product is labelled as containing "renewable carbon," it implies that the carbon used in its production comes from sources that can be replenished, such as plants or other organisms that absorb carbon during their lifecycle. This labelling is often used to signify a commitment by the manufacturing company to reduce the use of non-renewable resources and contribute to mitigating environmental impact. However, it's important to assess the specific context and any environmental certifications, if present, to gain a more comprehensive understanding of the product's sustainability.

G27-Bamboo was chosen both for its renewable carbon content and for the fact that it comes from extracts of plant origin. The expression "epoxy resin from extracts of plant origin" indicates that the epoxy resin is produced using extracts or components obtained from plant sources. Traditional epoxy resins are typically derived from petroleum derivatives, but with the growing interest in more sustainable materials, the industry has explored plant-based alternatives.

However, it's important to note that the sustainability of a product depends on various factors, including production processes, resource management, and the overall life cycle of the material. Developments in the field of epoxy resins from plant origin represent a step towards eco-friendlier practices, but the comprehensive assessment of sustainability should consider multiple aspects.

From the first contact with the resin supplier, it emerged that he could ensure the quantities of resin necessary for the purposes of the project. The purchase price is currently being negotiated.

4.1.3 Raw materials for BioPUR products

The primary feedstocks, including polyols derived from vegetable oils (soya bean, rapeseed, castor, cashew shell, canola, etc) are preferred by INDRESMAT due to the availability in the market and the easiness to convert waste oils into biopolyols (Fig. 9).

Other related sources (sugars, polysaccharids, proteins, CO₂ fixation, etc) along with biobased diisocyanates synthesised from renewable sources, necessitate a reliable network of suppliers with a focus on sustainable agriculture and responsible extraction practices.



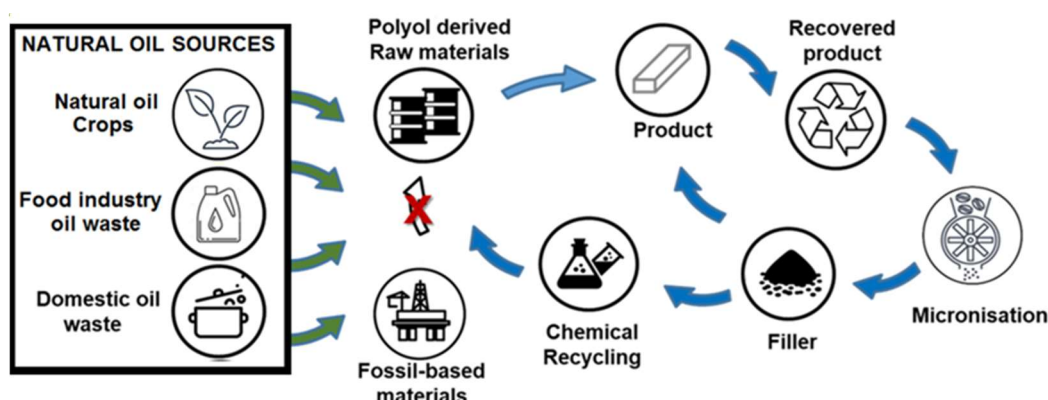


Figure 9 - Sourcing for natural oil derived polyols

Chain extenders, catalysts, and additives sourced from biobased materials further contribute to the environmentally friendly profile of the manufacturing process. To maintain ethical standards, it is essential for manufacturers to establish partnerships with suppliers who adhere to certification standards as per the product portfolio, ensuring the authenticity and sustainability of the sourced materials. A transparent and sustainable supply chain not only aligns with the environmental goals of biobased polyurethane production but also promotes accountability and resilience towards the market demands.

4.2 Manufacturing and Installation Processes

Efficient manufacturing and proper installation methods are essential to ensure the effectiveness, durability, and safety of biobased thermal insulation materials in buildings. The successful installation of biobased products requires a good knowledge of the material properties and the knowledge of compatible system components. The guidelines for storage, handling and safety instructions must be elaborated and respected. As an example, the production processes of Posidonia panels and bioPUR foams were described in the chapter 3.

The manufacturing of biobased polyurethane materials requires a skilled and knowledgeable workforce equipped with specialised training. Employees engaged in the production of biobased PU foams need expertise in chemical processes, polymer science, and the intricacies of handling renewable raw materials. Training programs should encompass the unique characteristics of biobased polyols and diisocyanates, emphasising the importance of sustainable practices and adherence to environmental standards. Additionally, workers must be well-versed in the operation and maintenance of specialised equipment used in the manufacturing process. Safety protocols, including proper handling of biobased chemicals and waste disposal procedures, are paramount. Continuous education and training initiatives are essential to keep the workforce updated on emerging technologies and industry best practices, ensuring the production of high-quality and environmentally friendly biobased PU foam products. This investment in a skilled workforce not only enhances the efficiency and productivity of the manufacturing process but also supports the industry's commitment to sustainable and eco-friendly practices.

Prefabricated building envelope (Fig. 10b) - A curtain wall is a particular type of building envelope ensuring high performances, with the advantage of a dry and prefabricated construction system. Its aluminium grid confers lightness and allows the transfer of loads operating on the building to the primary structure

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elements. The origin of the name “curtain wall” results from the geometric continuity effect that this technology confers to the outer surface of the building. In the unitized system, the façade is entirely characterized by preassembled panels having a grid in extruded aluminium profiles on which the cladding panels or glass units are placed. The units are entirely assembled in the factory and then delivered to site for distribution to the floor slabs and subsequent installation. This ensures exceptional high quality and can be used to achieve complex products.

In this framework, the biobased insulation will be assembled in the prefabricated curtain wall façade off-site, used as a thermal insulation, and filled in an aluminium frame to guarantee high performance. The façade will be designed to be fully manufactured off-site and installed with the only installation on-site of brackets and base profiles for installing kick-off. Indeed, the façade components are designed to be highly replicable maintaining a certain degree of dimensional customization.

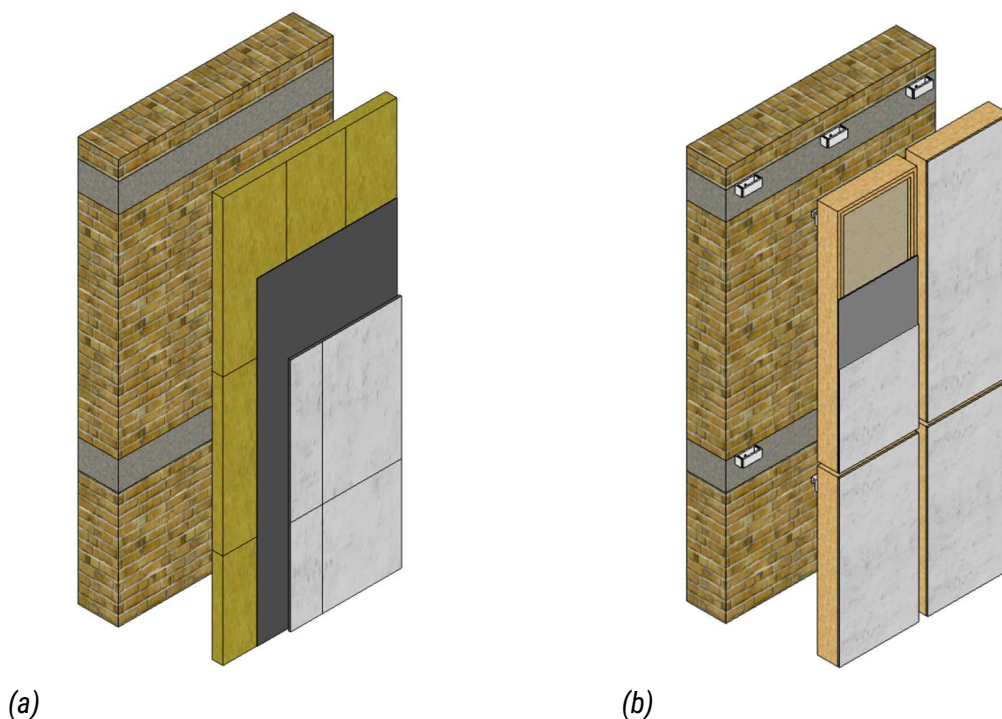


Figure 10 – Examples of traditional retrofitting (a) and curtain wall with biobased components (b)

During the production line, the biobased materials is filled in the aluminium frame,



Figure 11 – Example of manufacturing process – biobased insulation assembly

State-of-the-art facades effectively integrate existing materials, requiring a re-evaluation of facade systems to optimize the performance of new components. While advancements like enhanced thermal insulation and reduced LCA impact are anticipated, drawbacks such as compromised acoustic insulation need consideration. The overall thermal performance will be assessed against market benchmarks, specifically mineral wool facades. Subsequently, a prefabricated facade featuring new materials will be designed, prototyped, and manufactured in adherence to established specifications. Important characteristics for the biobased insulated materials are self-bearing panel, flexible dimension adaptable to modular façade, dry technologies. The prefabricated solution reduces the site activity (reduction of hours on-site and the cost on-site).

5 Pre-Requisites

5.1 Product Knowledge and Training

As already mentioned in the subchapter 4.2 the successful installation of biobased products requires a good knowledge of the material properties and its behaviour. The skilled person must be also able to ensure that all components of the installed product or system are compatible and work together.

Developing a skilled workforce capable of handling biobased thermal insulation materials involves targeted training programs and initiatives. These programs can cover topics such as materials science, installation techniques, safety protocols, and environmental considerations related to biobased materials. Thus, offering certifications or workshops focused on biobased insulation materials can help professionals gain specialized knowledge and skills. These can be conducted by industry associations, manufacturers, or regulatory bodies. Thus, on-site training programs led by experienced professionals will enable individuals to acquire practical skills in using these materials effectively. Government initiatives and grants can encourage the development of training programs focused on sustainable building materials, including biobased insulation. Financial support can make these programs more accessible and attractive to learners. Investing in training and skills development for a workforce qualified to work with biobased insulation materials not only supports the adoption of sustainable construction practices, but also creates employment opportunities in a growing sector focused on environmental responsibility.

5.2 Building Codes and Regulations

All building products in European Union, intended for incorporation into permanent works, including buildings and civil engineering works, are subjects of The Construction Products Regulation (CPR). CPR sets out the rules and requirements for their marketing and use within the European Union (EU).

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For commonly used thermal insulating products the European Commission, with the assistance of European Standards Organizations (CEN, CENELEC), develops harmonized technical specifications (EN, ISO standards). Manufacturers are required to affix the CE marking to their construction products if they fall within the scope of a harmonized standards and must draw up a Declaration of Performance (DoP) for each construction product. The DoP provides information on the product's performance characteristics in relation to the essential requirements. It includes details such as the intended use, performance indicators, and reference to the harmonized standard or technical specification.

Only minimum harmonized EN standards exist for the biobased thermal products because they are mostly innovative and harmonized EN standards does not exist for them yet or they are still under development. Of course, for these materials the EN standards, concerning thermal insulations generally, are valid. EN and ISO standards covers the vocabularies (e.g. EN ISO 9251:1995 Thermal insulation - Heat transfer conditions and properties of materials – Vocabulary), test methods for determination of properties (e.g. ISO 21901:2021 Thermal insulation – Test method for thermal diffusivity – Periodic heat method) and conformity control systems (e.g. ISO 12576-2:2008 Thermal insulation products – Conformity control systems – Part 2: In-situ products).

Large group of standards is dedicated to the specification of products, but mostly the common thermal insulating products (mineral wool, expanded polystyrene and similar) are described. There exist only 9 standards concerning the biobased thermal insulating material. Their list is provided in Table 13.

Table 13 – List of EN and ISO standards concerning biobased thermal insulations.

Standard	Title
prEN 17139 rev*	Thermal insulation products for building - Factory made vegetal fibres-based products (VFBP)
prEN 15498 rev*	Precast concrete products - Wood-chip concrete shuttering blocks - Product properties and performance
EN 15498:2008	Precast concrete products - Wood-chip concrete shuttering blocks - Product properties and performance
EN 15101-1: 2013 +A1:2019	Thermal insulation products for buildings - In-situ formed loose fill cellulose (LFCI) products - Part 1: Specification for the products before installation
EN 13171:2012+A1:2015	Thermal insulation products for buildings - Factory made wood fibre (WF) products - Specification
EN 13170:2012+A1:2015	Thermal insulation products for buildings - Factory made products of expanded cork (ICB) - Specification
EN 13168:2012+A1:2015	Thermal insulation products for buildings - Factory made wood wool (WW) products - Specification
ISO 17749:2018	Thermal insulation products – Sheep wool mat and board – Specification
ISO 2219:2010	Thermal insulation products for buildings – Factory-made products of expanded cork (ICB) – Specification
ISO 24260:2022	Thermal insulation products – Hemp fiber mat and board – Specification
* Preliminary	

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When the product does not have harmonized standard available, European Technical Assessment (ETA) must be provided by the producer. ETAs are not developed by standardization organizations but are issued by Technical Assessment Bodies (TABs) designated by EU member states. TABs assess the performance of products based on European Assessment Documents (EADs), which are developed by the European Organization for Technical Approvals (EOTA). The list of TAB organisation in EU countries is provided in Table 14.

Table 14 – List of the Technical Assessment Bodies (TABs) designated by EU member states

Country	TAB organization
Austria	OIB - Austrian Institute of Construction Engineering
Belgium	UBAtc - Union belge pour l'Agrément technique de la construction / BELGISCHE UNIE VOOR DE TECHNISCHE GOEDKEURING IN DE BOUW vzw
Cyprus	PWD - Central Laboratory - Public Works Department
Czechia	ITC Divize CSI – Centrum stavebního inženýrství
	TZUS - Technical and Test Institute for Construction
	Výzkumný a vývojový ústav dřevařský, Praha, s.p.
	Silnicni vyvoj - ZDZ spol. s r. o.
Denmark	ETA-DANMARK A/S
Finland	Eurofins Expert Services Oy
France	CEREMA-DTeciTM - Technical Department Infrastructures Transportation and Materials
	CSTB - Scientific and Technical Center for Building
Germany	DIBt – Deutsches Institut für Bautechnik – Centre of competence in construction engineering
Greece	Materials Industrial Research & Technology Center S.A. (MIRTEC S.A.)
Hungary	CEMKUT - Research & Development for the Cement Industry
	ÉMI - Quality Control Innovation
	KTI - Institute for Transport Sciences non-profit Ltd.
	TÜV- Certification and Verification of Construction Materials and Products. TÜV Rheinland InterCert Kft.



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Ireland	BRE Global Ireland
	FM APPROVALS
	NSAI - National Standards Authority of Ireland
Italy	ITAB/ITC-CNR – Italian Technical Assessment Body/Construction Technologies Institute
	STC - Public Central Technical Service for Construction
Latvia	BM Certification, SIA
Lithuania	SPSC - Certification Centre of Building Products
Luxembourg	LUXIB - Luxembourg Institute for Building and Technology, SA
Netherlands	ERO - Element Materials Technology Rotterdam B.V.
	KIWA - Certification and Inspection
	UL International (Netherlands) BV
	SGS INTRON - Certification
	SKG-IKOB - Certification, inspection and testing of building products
	RUUV
Poland	ITB - Building Research Institute - Instytut Techniki Budowlanej
	CNBOP-PIB – Scientific and Research Centre for Fire Protection – National Research Institute
	IBDIM - Road and Bridge Research Institute - Instytut Badawczy Drog i Mostow
	ICiMB – Institute of Ceramics and Building Materials – Sieć Badawcza Łukasiewicz - Instytut Ceramiki i Materiałów Budowlanych
	IMBiGS - Institute of Mechanised Construction and Rock Mining - Instytut Mechanizacji Budownictwa i Górnictwa Skalnego
Portugal	ITECONS - Institute for Research and Technological Development for Construction, Energy, Environment and Sustainability - Instituto de Investigação e Desenvolvimento Tecnológico para a Construção, Energia, Ambiente e Sustentabilidade
	LNEC - National Laboratory of Civil Engineering - Laboratorio Nacional de Engenharia Civil, I.P.



Romania	ICECON - Research Institute for Construction Equipment and Technology - Institutul de Cercetari pentru Echipamente si Tehnologii in Constructii "ICECON" SA
Slovakia	FIRES - Certification, Testing and Inspection on Fire Safety
	TSUS - Building Testing & Research Institute - Technický a skúšobný ústav stavebný, n.o.
Slovenia	ZAG - Slovenian National Building and Civil Engineering Institute - ZAVOD ZA GRADBENIŠTVO SLOVENIJE
Spain	IETcc - Eduardo Torroja Institute for construction science - Instituto de Ciencias de la Construcción Eduardo Torroja
	ITeC - The Catalonia Institute of Construction Technology - Institut de Tecnologia de la Construcció de Catalunya
	FUNDACIÓN TECNALIA RESEARCH & INNOVATION
Sweden	RISE - Research Institutes of Sweden

5.3 Building Condition Assessment

Assessing the existing building condition is a crucial step before implementing energy efficiency measures such as replacing windows, adding facade insulation, or improving roof insulation.

A comprehensive assessment will help identify the current state of the building envelope, and potential areas for improvement.

A building envelope inspection should cover the exterior walls, windows, doors, roof, and the floor structure. BIO4EEB energy efficiency measures mostly apply to the façades and windows.

Visual inspection helps to reveal a lot of possible visual distress symptoms that require an evaluation by experienced person. It remains the responsibility of the professional performing the inspection to provide proper diagnosis and decide what measures shall be taken prior to the energy efficiency retrofit.

In-situ testing methods are used to define material properties and behaviour. Mechanical properties, humidity and water absorption are often tested in situ. They are faster than laboratory testing but usually less accurate and reliable. In-situ testing methods are mostly non-destructive

Laboratory testing methods are used to obtain more reliable and accurate data as well as complementary data that could not be obtained on site. The laboratory testing is performed on the specimens taken from the structure. This type of testing is destructive (strength testing of bricks, mortars, concrete). Laboratory testing enables to define many other parameters such as the content of salts, porosity, size distribution of pores, density, bulk density, thermal conductivity etc.

Overview of assessment methods for BIO4EEB demo-projects is presented below in Table 15.

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Table 15 - Overview of building condition assessment methods

Assessment purpose	Method	Main app. field
Detection of cracking, staining, soiling, erosion, pitting, abrasion, organic growth, efflorescence, spalling, delaminating, chipping, peeling of paint or stucco, brick coving, humidity, eroded mortar joints in brickwork, crumbling, loose detached bricks, lime run, defects in the (dilatation) joints.	Visual inspection	in-situ
Detection of detached surface layers of renders and plasters or delamination of surface stone layers	Acoustic tracing	in-situ
Detection of moisture content in the walls	Capacitance moisture measuring	in-situ
Tensile-bond strength	Pull-off testing	in-situ
Detection of thermal bridges	Thermography	in-situ
Evaluation of substrate integrity	Scratching	in-situ
Stucco/paint adhesion test	Tape test "ribbon-off"	in-situ
Plaster adhesion test	Bond test	in-situ
Separation of paints and coatings from the substrate	Cross-cut	in-situ
Determination of the load-bearing capacity of the anchor in the project-specific fastening substrate	Pull out testing	in-situ
Evaluation of compressive strength of mortars and bricks	Pin penetration test (PPT)	in-situ
Evaluation of compressive strength of masonry or concrete	Compressive testing of core drills samples	lab
Determination of bulk density	EN 1015-10, EN 772-4, EN 772-13	lab
Determination of the content of salts	chemical methods	lab
Determination of water absorption	EN 1925, EN 13755, EN 772-7, EN 772-11, EN 772-21	lab
Determination of moisture content by drying at elevated temperature	ISO 12570:2000 Amd.2:2018	lab



6 Barriers

6.1 Legal Barriers

6.1.1 Regulatory Challenges

European Union already has a Construction Products Regulation in force since 2011. It regulates the marketing of hundreds of products such as thermal insulation foams, wood-based panels, and waterproofing sheets. However, its implementation has been difficult and challenging.

Construction product manufacturers and contractors strongly rely on standards and need them to remain aligned with changing market and regulatory demands. Without up-to-date standards, the market for construction products could neither be achieved, nor maintained.

Numerous geographical areas possess building codes and standards that may lack explicit inclusion or sufficient consideration of biobased materials. Adhering to existing codes may present difficulties in the widespread adoption of such materials.

Enabling the utilization of biobased materials in construction necessitates the establishment of a comprehensive policy and legal framework. Such a framework holds the potential to instil confidence among investors and insurance entities. The development of this legal framework must be customized to align with the unique legal landscapes of individual countries.

Moreover, the certification and testing procedures for construction materials typically entail stringent testing protocols and conformity to specific standards. Biobased materials may encounter obstacles in demonstrating or meeting the required compliance with these established standards.

6.1.2 Environmental Compliance

Most of the biobased materials are a good way of transiting towards low-carbon economy. LCA of biobased products helps to understand their decarbonization potential, and all environmental impacts associated with their life cycle. The most challenging part of the life cycle of biobased materials is the application of circular economy principles, especially when speaking of the biobased polyurethane foams.

The difficult waste disposal and recycling of the end-of-life biobased polyurethane foams can be the main obstacle for their utilization. Biobased polyurethane foams have the same chemical composition as a fossil-based foams and therefore they can be disposed or recycled in the same way. The landfilling of PUFs is still the most common way to process polyurethane waste, but there are large volumes of the material because of its high porosity. Furthermore, a great amount of air contained inside foam cells can provide oxygen for deep-seated fires and impede efforts to extinguish flames. Another hazard related to landfill fires are toxic fumes, produced during uncontrolled polyurethane combustion (Kemoni and Piotrowska, 2020).

Recycling seems to be better alternative to landfilling. PUFs can be recycled mechanically or chemically, thermochemically and for energy recovery. Mechanical recycling is done by regrinding polyurethane foams into powders allowing them to be reused in the production of new foam as filler. The methods of reuse are flexible foam bonding, adhesive pressing, and compression molding. Nevertheless, the acquired products are of limited quality and post-consumer waste products cannot be the stock for mechanical recycling due to their contamination or the addition of other materials.

Several chemical and thermochemical processes (e.g. glycolysis, hydrolysis, alcoholysis, pyrolysis, hydrogenation) can be used for converting the waste polyurethane foam back to a reactive raw material. Commercially only glycolysis is used, other methods are still in the stage of research. Glycolysis of



polyurethanes can be economically acceptable, but it is unfavourable from the environmental point of view. According to Quinteiro et al. (2022) the environmental impacts from the recovery process can exceed the environmental benefits from the PUF waste recycling, mainly due to the use of the adipic acid (reagent) during the recovery process.

6.1.3 Heritage Preservation

Historic buildings can be considered as the symbol of European cultural heritage. Currently, about 35 % of the EU's buildings are over 50 years old and almost 75 % of the building stock is energy inefficient. The renovation of existing buildings has the potential to lead to significant energy savings, possibly reducing the EU's total energy consumption by 5-6 % and lowering CO₂ emissions by about 5 %.

Historic buildings have the potential to achieve higher levels of energy efficiency. However, installing internal insulation can be a difficult task subject to the risk of failure and high costs. Building owners and practitioners in the construction industry need greater knowledge and guidelines on how to handle internal thermal insulation in historic buildings effectively and securely.

Concerning the feasibility of adopting biobased thermal insulation to retrofit the historic buildings below some indications emerging from the literature:

- Intervention is excluded for surfaces holding cultural or tangible values or subjected to integral protection.
- Interventions that cause dimensional changes at window and door openings or where original surface details are valuable should be avoided.
- Even though adopting interior insulation is generally more feasible, it can lead to damp build-up in the walls during the heating season.

6.2 Mitigation Strategies

Regulations

On 30 March 2022 the European Commission initiated the review of the current rules to address shortcomings, simplify legal framework and support green and digital transition in the sector.

The new provisionally agreed rules will give a boost to the standardisation system that has been blocked for years. Whereas construction products can be placed on the market without EU level standards (via the so-called EOTA route), the existence of standards makes marketing these products much faster and cheaper. Therefore, to the considerable benefit of manufacturers, the new rules make sure standards will be published faster in the future. This in turn will help innovative products find their way to the EU market quicker and at a lower cost to the manufacturers. The updated law also addresses several sustainability issues in the sector to help Europe achieve its green goals. Importantly, the new rules foresee an opportunity for public authorities to use sustainability as one of the criteria for construction works in public procurement. Further development of harmonised standards implies a combination of technical and legal approaches to satisfy both market and regulatory needs. Legal requirements to be included in standards are agreed by Member States and the European Commission in mandates (Construction Products Directive approach) and standardisation requests (since the entry into force of the standardisation regulation).

Environment

To improve the circularity of biobased materials, effective infrastructure for collection, transportation and sorting facilities and technologies is needed. Enabling policy framework is required to facilitate the transition towards a sustainable biobased circular economy.

The improvement of recycling methods and technologies will be possible thanks to the research and innovations. Getting back to the environmental issues with PUR it was found that by suitable combination of virgin and recycled PUR raw materials the optimal environmental values can be obtained, as can be seen in Fig. 12 (Marson et al., 2021). Even if the chemical recycling method, due to its higher technical difficulty, is difficult to achieve large-scale industrialized production in the short term, but in the long run, it will be the most effective recycling method.

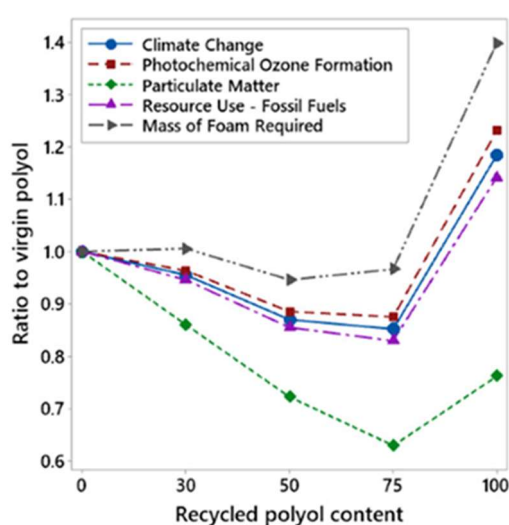


Figure 12 – Environmental impact of polyurethane foams according to the content of recycled polyols

An environmentally feasible possibility of waste polyurethane reuse is the production of the lightweight mortars and concretes with the ground polyurethane as a filler (Václavík et al., 2012, Tantisattayakul et al., 2018).

Interesting method of PUF waste disposal is the biodegradation. Some bacteria and fungal strains or polyurethanase enzymes were tested with remarkable results, nevertheless this method is still at the stage of research (Banik et al., 2023).

Waste polyurethane can be also used for the energy recovery. Energy recovery is often considered the only suitable disposal method for recovered material for which no markets exist or can be created. This strongly applies to scrap with PU laminates to other materials. By this method polyurethane can be burned efficiently resulting in a total consumption of the material. Incineration of a PU foam results in a volume reduction of around 99% which has large implication to reduce the landfilling of this material, at the same time destroying CFCs and other harmful foam blowing agents (Zia et al., 2007).

Heritage

The European Committee for Standardisation has a dedicated CEN Technical Committee (CEN/TC 346 - Conservation of Cultural Heritage) whose scope includes the characterisation of materials, the processes, practice, methodologies, and documentation of conservation of tangible cultural heritage to support its preservation, protection, and maintenance and to enhance its significance. This includes the characterisation of deterioration processes and environmental conditions for cultural heritage and the

products and technologies used for the planning and implementation of their conservation, restoration, repair, and maintenance. One of their working packages was the production of EN 16883:2017 Conservation of cultural heritage - Guidelines for improving the energy performance of historic buildings. The guidelines are meant to be used by building owners, practitioners, and public sector to select appropriate measures in the planning stage. The guidelines are applicable to a wide range of buildings where special considerations are needed to find a sustainable balance between the use of the building, its energy performance and its conservation and are not limited to listed buildings with formal protection. Rather than specifying general solutions beforehand, this standard provides a procedure to facilitate the best decision for each individual building.

7 Needs and Selling/Renting Strategy

7.1 Market Analysis and Demand Assessment

According to the data of the Real Property Register as of 31 December 2019, 2.6 million buildings with a total area of 235.3 million m² were registered in Lithuania (Fig.13).

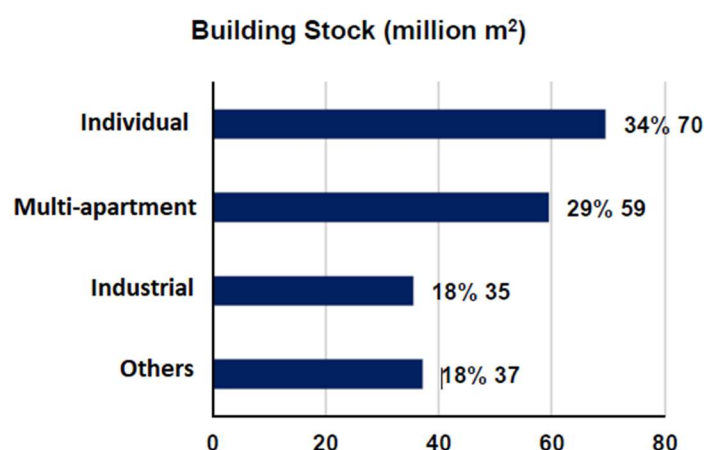


Figure 13 – Building Stock in Lithuania by building group.

75% of the surface of the building stock was built before 1992. About 34 000 of multifamily houses (MFH) constructed before 1990, and almost all of them required renovation. Their energy efficiency is very low: usually they have only D or F level sometimes even lower. Therefore, the Government of the Republic of Lithuania announced Programme of renovation (modernisation) of multi-apartment buildings. The implementation of the Programme started in 2005. Based on the *Lithuanian renovation map* [1] 12.3 % or 3706 multi-apartment buildings are renovated until 2023. Government also approved long term strategy of renovation buildings in Lithuania. According that strategy about 1000 MFH have to be renovated annually from year 2025 and process to be finished up to 2050. Accordingly, at the end of the Long-term renovation strategy implementation (2050), most of the existing building stock will be over 60 years old, and its renovation will be mandatory to continue its operation.

State institution which is responsible for the management of the State renovation program is The Environmental Projects Management Agency (EPMA). This institution arranges legal rules and recommendations for renovation as well as provides support for that deal. According plans of EPMA more



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500 MFH has to be renovated annually during next 3 years and 610 mil. EUR financial support program is foreseen for years 2023 and 2024. State usually covers 30% of investments necessary for renovation works. Community of MFH can also use support of INVEGA which is a State-established financial institution for granting loans for important state projects. MFH can receive 20-year loans there with interest rate not exceeding 3% and it covers last 70% of construction costs. It means that financial incentives are very attractive for the market of renovation works. Totally 2 bil. EUR will be used for renovation in the country during years 2023 and 2024.

State renovation program require huge demand of insulation materials, windows, and other construction materials. Almost all they are based on fossil materials and do not follow current green requirements. Lithuanian Ministry of Environment issued Resolution Due to the use of wood and other materials from renewable sources in construction works. According to Resolution contractors will be required to use biobased materials which are also foreseen to develop in BIO4EEB project. Taking to account that typical multifamily house require near 3000 sq. m of insulation materials and near 150 windows one can see that market for new biobased construction materials will be in great demand in the close future.

In France, the national low-carbon strategy currently in force, defined by Decree No. 2020-457 of 21 April 2020, imposes greenhouse gas emission reductions for the building sector. A housing renovation trajectory has been defined to achieve these objectives, providing for 370,000 complete renovations per year from 2022 (i.e. 1% of the residential stock per year), then 700,000 complete renovations per year from 2023 (i.e. 1.9% of the residential stock per year) (Source: INFORMATION REPORT of the National Assembly). It should be noted that the existing housing stock is estimated at 37 million homes, of which 7.2 million were qualified as energy sieves on 1 January 2022 (Source: ADEME).

Concerning the tertiary sector, the "tertiary decree" sets targets for the energy renovation of existing buildings based on a reduction in final energy consumption compared to 2010 consumption (40% in 2030, 50% in 2040, 60% in 2050). The ambition is to accelerate the renovation of the tertiary sector.

Since February 2023, the NBDB (National Buildings Database) offers a map of the existing building stock in France and will refine the market study according to the targeted targets. To date, this database contains an identity card for each of the 20 million buildings, residential or tertiary. It is available at the following link: <https://www.data.gouv.fr/fr/datasets/base-de-donnees-nationale-des-batiments/#/resources>.

7.2 Pricing Strategy

The pricing strategy for renovated buildings typically considers factors such as the cost of renovations, market demand, location, and the perceived value of the improvements. It's essential to conduct a thorough analysis of comparable renovated properties in the area to determine competitive pricing. Additionally, highlighting unique features and energy-efficient upgrades can justify a premium. Ultimately, the goal is to strike a balance between recouping renovation costs and setting a price that aligns with market expectations. In Lithuania, EPMA regularly updates recommended rates for contract works relevant when modernizing multi-apartment buildings. Rates for general and special contracting works (external wall insulation) without design services are between 100 and 150 Eur/sq.m w/o VAT (based on 2022-04 prices)

In France, the price of traditional exterior insulation (Thin Coating on Insulating boards) is around €100/m², or even €70/m² for the most competitive prices. But this cost can go up to three times for solutions such as wood or metal frame insulating prefabricated facades, despite their industrialized production process... and depending of course on the exterior finishes. It should be noted that owners of real properties forced by regulations to renovate their buildings generally seek a minimal investment, rarely agreeing to pay an added value for better environmental performance.



8 Stakeholder Engagement

Stakeholder engagement is a systematic set of actions designed to involve and influence stakeholders in the project. Each stakeholder has a certain degree of interest and due to his position can be less or more influential (Fig.14). Prior to starting the process, suitable engagement strategy must be developed with the target to identify the key groups of stakeholders their roles and needs. The key groups of stakeholders are always on the top of the process and play a vital role in ensuring the business goals are met. The Lithuanian context as an example is further described below.

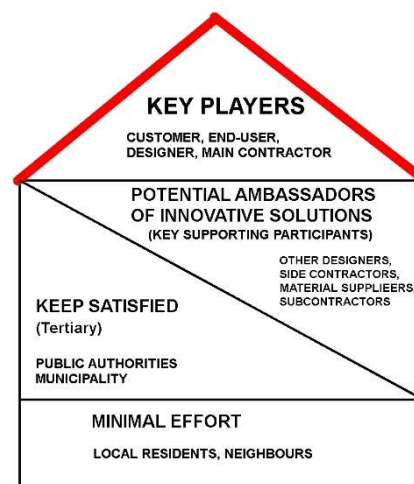


Figure 14 – Groups of stakeholders

8.1 Identifying Relevant Stakeholders

Relevant Stakeholders for implementing results of BIO4EEB could be main public institutions which are related with renovation process and non-profit organizations that connect residents of multifamily houses as well as organizations of construction companies which work in renovation area.

Example from Lithuania

The main public institution which is obligated to support renovation in the country is The Environmental Projects Management Agency under the Ministry of Environment of Lithuania (EPMA). The Agency provides services to all participants of renovation: prepare requirements for design and construction works, recommendations for usage of materials and construction rates, organize seminars and trainings for executors of construction works and communities of multifamily houses.

Institutions which are active in organizing renovation process and working with local housing communities are Municipalities. The best way to reach them is via Association of Local Authorities in Lithuania (ALAL) representing the common interests of its members – local authorities. ALAL together with EPMA discuss rules of support for renovation; arrange seminars and discussions about features of renovation for local communities of MFH. Municipalities provide additional financial support especially when renovation is complicated or require additional equipment for disabled people or other special cases.

Lithuania has system that apartment owners of MFH are usually connected by communities of MFH. In turn, communities are united in a Lithuanian Chamber of Housing Management and Maintenance, or Lithuanian Chamber of Housing (LCH). Chamber assists the Government and Municipalities in implementing the energy saving and home renovation programme. The Association is coordinating the activities of members, represents member interests at national and international level, represents and defends consumer rights and legitimate interests.

Construction and design companies also are active in renovation process. The main organisation which connects contractors of renovation works is Lithuanian Construction Association (LCA). It unites companies involved in construction, design work, manufacturing of building materials and structures, maintenance and other companies as well as education institutions. They are active in searching for

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sustainable construction solution, saving on expensive energy costs and reducing the carbon footprint. They seek to meet the interests of the Residents' in ecology and appreciation of sustainable architecture and construction and healthy living environment.

Active participant of renovation movement is National Passive House Association. They promote highly efficient building materials and construction technologies which allow to reach energy efficiency of renovation up to A+ or even A++ level. They arrange demo sites and help residents to understand features of such sustainability level.

Example from France

[the Ministry of Ecological Transition](#) brings together many services for individuals, elected officials and administrative persons, or professionals. Energy renovation is one of its flagship actions, and we can mention in this respect the "[France Rénov](#)" program which offers educational tools, technical support, and financial aid to individuals and real estate owners. The Ministry's portal also keeps up to date the list of numerous and constantly renewed [local aid](#), regional, municipal, .. for example, the guide proposed make it possible to know that besides the governmental help, Nantes Métropole can provide some funds under certain conditions..).

A list of [licensed professionals](#) is also available. It should be noted that these are architects or general or specialized contractors, not suppliers of materials. It will therefore be important to be known to these players who are an important gateway for owners wishing to renovate their property, as they are mandatory to obtain the public financial aid.

Under the ministry supervision, the organization that promotes energy savings and environmental protection is [ADEME](#), the agency for ecological transition. The agency, located throughout France, offers its expertise (advice, promotion), methodological support, and financial aid.

Several clusters and associations are also relevant stakeholders to inform: [Fédération Française du Bâtiment](#) (FFB), bringing together all companies in the sector, of all sizes. Close to, but independent, the union of [General Contractors of France BTP](#) (EGFBTP) is also a major player. [The Order of Architects](#), which brings together more than 34,000 architects, is a key information channel to reach architects.

On the customer side, the main driver of innovation is among social landlords. [The Union Sociale pour l'Habitat](#) (USH) organizes an unmissable annual congress in France to share the progress of the profession.

Transversally, regional or thematic clusters can be contacted: regional example: [NOVABUILD](#), in Nantes, dedicated to eco-design in construction. Thematic example: [Build and Connect](#), official competitiveness cluster for sustainable buildings and materials for France (based near Strasbourg).

8.2 Collaborative Approach

Collaborative methods can be supported by the following measures: regularly update identified stakeholders on project progress, challenges, and successes; Utilize various communication tools (workshops, events, visits, roundtable discussions. For example, participation in seminars organized by Lithuanian Housing Chamber; visits to local Municipalities and explanation of features of Green renovation for administration of the cities; roundtable discussions with Governmental authorities (EPMA, etc.), Lithuanian Construction Society and National Passive House association about possibilities to use biomaterials in renovation), and mediums (website, linkedIn) to reach different stakeholders effectively.

In the Table 16 identification of roles and responsibilities of stakeholders in Lithuanian.

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Table 16 - Roles and responsibilities of identified stakeholders in Lithuanian market

Stakeholder	Roles and responsibilities in Lithuanian market	Interest to BIO4EEB
The Environmental Projects Management Agency under the Ministry of Environment of the Republic of Lithuania (EPMA) (https://www.apva.lt/en/what-is-epma/)	EPMA is a modern professional body managing projects that are funded by European Union (European Regional Development, Cohesion Funds, LIFE + programs) and National funds (LEIF, Climate Change, Waste Management, Environmental Protection) projects in the environmental and climate change sector. EPMA provides services to environmental protection project promoters to ensure successful implementation of the projects. Agency also is responsible for the implementation of programmes related to the buildings renovation in Lithuania.	Dissemination, funding of further projects
Lithuanian Chamber of Housing (LCH) https://bustorumai.lt/en/lietuvos-busto-rumai/	LCH is a non-profit organisation established in 2004 and operates in all Lithuanian territory. Members are multi-family homeowners' communities and their associations, companies administering residential buildings, consumer rights organisations and other organisations. LCH assists the Government in implementing the energy saving and home renovation programme. It actively cooperates with the Government Chancellery, with the Parliament's Committee on Environment, the Ministry of Environment, the Ministry of Energy, the Ministry of Economy, the Ministry of Justice, the State Consumer Protection Service.	Dissemination
Association of Local Authorities in Lithuania (ALAL) (https://www.lsa.lt/en/)	The ALAL seeks to implement the provisions of the European Charter of Local Self-Government in Lithuania, to organize and coordinate activities of its members in the areas of investment attraction, development of municipal economies, improvement of legislature, business support, public security, culture, education, science, health care, social care and protection, improvement of local services, as well as relations with international organizations and municipalities abroad.	Dissemination, exploitation of project results.
National Passive House Association (https://pasyvuspastatai.lt/lt)	Goals and objectives of the association are related to the development of passive house certified buildings and passive house good practice in	Dissemination, exploitation of

D4.1

	Lithuania and the EU, educating, educating and raising the qualifications of direct customers (society) and opinion makers (architects, engineers, contractors). To become a leader in spreading sustainable and high-quality building development and operation in Lithuania and the EU. By representing the Association's community in the public (government) sector, raising the level of quality and sustainability of Lithuanian construction in Lithuania and the EU.	project results.
Lithuanian Construction Association (LCA) https://www.statybininkai.lt/en/	Currently, the Association brings together nearly 150 companies and organisations involved in construction, design work, manufacturing of building materials and structures, maintenance, training, etc. The LCA also includes the Republican Association of Manufacturers of Windows and Doors, the Lithuanian Association of Plumbers, the Lithuanian Expanded Polystyrene Association, the Baltic Scaffolders Association and the National Electrical Engineering Business Association NETA. The LCA members account for about 70% of the construction work in Lithuania and contribute about 8% of the national GDP to the economy.	Dissemination, exploitation of project results.

Table 17 - Roles and responsibilities of identified stakeholders in French market

Stakeholder	Roles and responsibilities in French market	Interest to BIO4EEB
the Ministry of Ecological Transition	To carry out its missions, the Ministry is organized into directorates. Some exercise their powers at the central level; others are spread over the territory, in regions or departments.	Dissemination
ADEME	The French Environment and Energy Management Agency (ADEME) is a French public industrial and commercial institution created in 1991 ^{1,2} . It also displays the name "Agency for Ecological Transition". It is placed under the supervision of the Ministries of Higher Education, Research and Innovation and Ecological and Inclusive Transition. Ademe initiates, leads, coordinates, facilitates or carries out environmental protection and energy management operations, with a budget of €690 million (€605 million planned for 2019) for a salaried workforce of 963 full-time equivalents.	Dissemination, financing

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<u>Fédération Française du Bâtiment</u>	The French Building Federation is a professional organization created in 1904, and a lobby whose objective is to represent and support construction companies. The FFB brings together 50,000 companies, including 35,000 craftsmen	Dissemination, exploitation of project results.
<u>Entreprises Générales de France BTP</u>	EGFBTP brings together companies of all sizes, the largest companies and many SMEs, recognized for their capacity as general contractors.	Dissemination, exploitation of project results.
<u>L'ordre des architectes</u>	The Order of Architects, established by the law of 3 January 1977 on architecture, and chaired by Christine Leconte since June 2021, is a private law body responsible for public service missions and placed under the supervision of the Ministry of Culture and Communication, whose status is a decree issued by the Council of State pursuant to this law. It is composed of 17 Regional Councils and the National Council. The National Council coordinates the activities of the Regional Councils and contributes to their information. It is consulted by the public authorities on all matters of interest to the profession, in particular the organisation of architectural education	Dissemination, information, future prescription
<u>The Union Sociale pour l'Habitat</u>	The Social Union for Housing fulfils three main missions: - a role of national representation vis-à-vis public authorities, the media, associations, professional circles and public opinion; - a mission of reflection, analysis and study on all issues relating to housing and the development of proposals for a social housing policy and contribution to the public debate; - an information, advice and assistance function for organisations, their associations and federations in order to facilitate, rationalise and develop their activities. The Union runs a network to support the modernisation and professionalisation of social housing organisations.	Dissemination, future prescription
French Institute for Building Performance (<u>IFPEB</u>)	Identifying new practices, testing them, equipping them and leading collective actions to promote their massification: the Institute is committed to accelerating the achievement of carbon neutrality in real estate and construction.	Dissemination, communication

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<u>NOVABUILD</u>	NOVABUILD is the association that brings together more than 400 players in the construction (building and public works), real estate and development sectors in Pays de la Loire committed to the objectives of mitigation and adaptation to climate change and the preservation of biodiversity and resources.	Dissemination, challenging co-design
<u>Build and Connect</u>	The Build & Connect competitiveness cluster (formerly Fibres-Energivie) is the only competitiveness cluster dedicated to the construction sector. It brings together all the players in the construction value chain (material suppliers; building envelope manufacturers, equipment manufacturers, project management, construction companies, integrators, real estate development and project management). The network of members is also one of the pillars of the cluster. With 230 members, the cluster implements many tools and actions to facilitate the sharing of experience, contact, detection of opportunities and visibility of its members both in France and internationally	Dissemination, exploitation, assessment

8.3 Community Involvement

Renovation of buildings in Lithuania is arranged via Communities of residents, which are called Communities of Multifamily houses (MFH). The state encourages their establishment in every MFH and they act according Law of the Republic of Lithuania on Associations of Owners of Multi-apartment Residential Buildings and Other Purpose Buildings. The Law foresee that all contracts for all works related with renovation including agreements with project managers, designers, construction companies and banks arrange community of MFH. Usually, they hire a person experienced in renovation deals – administrator of renovation and authorise him to act on the name of Community. Decisions of the Community must be adopted by 50% of votes majority plus one vote. If MFH has not established Community in that case Municipality appoints administrator of renovation. But consequence of the process is much more complicated and longer.

All these rules mean that Community is directly involved in renovation process and all decisions are taken with Community approval. Communities are usually interested in usage of new materials especially “green” ones. But they are particularly interested in construction and economic details that will be clarified only during execution of the project. Biobased materials seems attractive but some risky therefore it is not easy to find communities interested in experiments.

In France, social housing is the main driver of innovations in construction and renovation. Social landlords regularly join European research consortia to contribute to the environmental and social transition of construction and renovation. Faced with the obstacle represented by the law on public procurement to innovate with targeted actors, (restricted) measures have been put in place to help innovative approaches in simplified contracting mode. Social landlords are obliged by 2025, then 2028 and 2034 to bring all energy-intensive housing up to standard. At the same time, tertiary buildings are also subject to an energy improvement obligation. All public buildings for tertiary use are thus subject to two objectives: 1/ The energy consumption target in absolute value which is based on the category of activity and the different uses



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(ventilation, heating, air conditioning, etc.) 2/ The relative consumption target which is defined from the reference year (from 2010): – 40% for 2030, – 50% for 2040 and -60% for 2050.

The private, residential, or tertiary housing stock faces the same obligations, and in the case of housing co-ownership, which is traditionally difficult to mobilise, is the subject of new state aid.

To involve this panel of stakeholders, local public actors often drive collective actions or support associations, like, following the upper-cited example, Nantes Métropole and NOVABUILD.

9 Financial Instruments

9.1 Local Funding Options

9.1.1 Belgium

In the case of Belgium, several local funding schemes for energy renovations apply depending on the region; for instance, there are the green loans for energy efficiency investments by households in the Brussels-Capital Region, the Property Tax Reduction in Flanders, or the financial incentives for energy efficiency investments in buildings in the Wallonia region.

Brussels-Capital Region

Bruxelles Environnement/Leefmilieu Brussel offers energy loans with interest rates ranging from 0% to 2% to households in Brussels. These loans, capped at a maximum of €25,000, are designed to support insulation, ventilation projects, and the adoption of more efficient heating systems. The scope of the green loan has expanded beyond energy-saving measures to include investments in sustainable energy, such as solar panels, solar boilers, and heat pumps.

Homeowners have a choice between the following two options:

1. A **short-term consumer loan with an interest rate of 0% or 1%** which they have to reimburse in up to 10 years. This loan is offered by Crédal, a financial cooperative.
2. A **long-term mortgage with a personalised interest rate between 0% and 2%** which needs to be reimbursed within 30 years. The long maturity of the loan results in lower monthly installments. The loan is offered by the Housing Fund (Le Fonds du Logement/Woningfonds) of the Brussels-Capital Region, which is a cooperative company.

To qualify for these loans, individuals must have a professional income below specified limits and meet the conditions outlined for Energy grants. It is relevant to note that the added value of these loans is that even low and very low income households are eligible.

Flanders

In Flanders, homeowners and residents can receive a reduction in property tax for an energy-efficient home or other building, taking the E-level to determine whether a building is energy efficient or not. The E-level of a building is recorded in an energy performance certificate, the 'EPC Construction'. The reduction can be granted for new construction, for renovations that are equivalent to new construction and for buildings that undergo a major energy renovation.





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The reduction is granted from the tax year following the year in which the E level was determined. This date is stated at the bottom of the 'EPC Construction'. If the home changes ownership, the new owner can also benefit from the reduction for the remainder of the term.

The calculated E-level must apply to the entire building. Only the original E-level on the EPC Construction determines the reduction. If, after determining the E-level, additional measures are taken to make the building even more energy efficient, this will no longer affect the granting of the reduction.

maximum E-level during (partial) reconstruction *	maximum E-level after major energetic renovation (IER)	reduction	duration of the reduction
E20	N/A, no 50% reduction in IER	50%	5 years
E10	E60	100%	5 years

The reduction is normally automatically granted on the tax bill. The Flemish Tax Authorities receive the necessary data from the Flemish Energy and Climate Agency (VEKA).

Walloon Region

In the Walloon Region, various forms of assistance are available to improve the energy performance of buildings:

1. Renovation grants

Home Grants: getting closer to the A label

Linked to carrying out a Housing audit, Home Grants cover renovation work aimed at improving energy and sanitation and safety in residential accommodation over 15 years old. The amount of premiums is calculated based on income, and the work must be carried out by a contractor.

Roofing grants and small works without audit

For minor energy-saving or health-related work costing less than €6,000 inc. VAT, or to renovate the roof, it is possible to qualify for a grant without having to carry out a home audit. The work covered ranges from roof replacement and insulation, to installing new windows and carrying out various health and safety repairs.

2. Zero interest loans

The Walloon Social Credit Society (SWCS) and the Housing Fund for Large Families of Wallonia (FLW) offer the possibility of subscribing to zero-interest loans (APR 0%) to finance construction works for renovation or energy efficiency. The fundable work includes:

- Housing audit (carrying out / monitoring)
- Roof (renewal / stabilization / insulation)
- Walls and floors (renewal / stabilization / drying / radon / dry rot or similar / insulation)
- Electricity (renewal / putting in order)
- Gas (renewal / putting in order)



This project has received funding from the European Union's Horizon Europe research and innovation program under grant agreement N°101091967



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- Exterior joinery (replacement of windows/doors)
- Boiler, biomass stove, domestic hot water (creation / renewal / improvement of installation performance)
- Photovoltaic panels
- Work aimed at remedying one or more causes of unsanitary conditions
- Work to secure the building against flooding
- Work to adapt housing to disability
- Others

3. Aid for low income households (MEBAR)

The MEBAR aid has been put in place for low-income households wishing to carry out work in their homes to improve energy efficiency (replacement of frames or exterior doors, insulation work, installation of a stove, installation of a boiler or water heater, etc.).

This aid, complementary to traditional bonuses, is of a maximum of €2,000 and can reach up to €4,000 in certain cases, subject to certain conditions relating to the nature of the work. They can be granted provided that the work is carried out in the applicant's main residence and that the latter's income does not reach the social integration income (RIS) increased by 30% (i.e. €2,133.08 per month for households, €1,578.37 per month for single people, and €1,052.25 per month for cohabitants).

9.1.2 France

Several local aid schemes exist in France to encourage the energy renovation of buildings:

- Subsidies from energy suppliers who are obliged to finance energy saving improvements (Economy Savings Certificates)
- Aid from local authorities, with a combination of local national and sometimes European funds (FEDER for example).
- Local investment support grants (DSIL) are available from regional prefectures.

The French Ministry's portal keeps up to date the list of numerous and constantly renewed [local aid](#), regional, municipal,...

9.1.3 Germany

At local level the funding and subsidies are comparably poor. To engage tenants that are not owners, low hanging fruit tools have been developed for this target group eg. so called 'Balkonkraftwerke' (balcony power plants i.e PV panels that are mounted on balconies) are funded up 75% based on local subsidy programs that are limited in volume and therefore always done after minutes when the call opens.

Some other green building promotion programs are provided by the local ESCs. The focus is almost 100% on electro mobility and loading facilities, extra subsidies are rare.

9.1.4 Lithuania

Institutions which are obliged to help renovation process in local level are regional Municipalities. They select apartment buildings which are most inefficient in energy-consuming and appoint Programme



D4.1

administrators who implement the renovation of these MFH. The essence of this model is that the homeowners themselves do not need to assume any organizational obligations, credit arrangements or project implementation risks. Program costs usually are financed by Municipalities and their staff helps in preparation of investment plans, design of renovation and supervision of construction works, organize loans for MFH communities. In necessary cases Municipalities provide additional financial support when renovation is concerned with special arrangements for disabled persons or renovation is extremely complicated.

9.1.5 Czech Republic

The local funding options in the Czech Republic are limited only to the replacement of old heating sources.

The new heating source must be energy efficient and low emission. This subsidy is available for low income, elderly, and handicapped applicants. The financing is granted through Operational Programme Environment at the regional level.

Type of heating source	Subsidy amount
Biomass boiler with automatic delivery of fuel	Up to 5 300 €
Heat pump	Up to 7 350 €

9.2 Government Grants and Subsidies

9.2.1 Belgium

In Belgium drawing up a long-term energy efficient renovation strategy is a regional responsibility.

9.2.2 France

The [Ministry of Ecological Transition](#) has set up the Energy renovation "[France Rénov](#)" program which offers financial aid to individuals and real estate owners in addition to educational tools and technical support.

Furthermore, a large amount of public financial support for energy renovation is centralised and allocated through ADEME and its regional offices, which also offers support for technical assistance. For example:

- The ACTEE programme, run by the Fédération nationale des collectivités concédantes et régies (FNCCR), provides tools (standard specifications, guides and training) and funding for energy audits and monitoring.
- The AMI (Calls for expressions of interest) supported by the region or department finance feasibility studies and provide access to repayable advances or subsidies.
- The CEE (Certificats d'économies d'énergie): levers for reducing the cost of renovation/energy efficiency work.
- The Banque des territoires finances energy renovation projects aimed at reducing consumption by 30% (GPI-AmbRE loan, from CDC savings funds). It also offers repayable advances to support energy efficiency works that generate savings with a payback period of less than 10 years.





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- The European Regional Development Fund (FEDER).
- Tax credits and specific loans (zero-interest eco-loans, "renovation advance" loans, etc.) also provide financial assistance for energy renovation.

9.2.3 Germany

Federal level

Since March 1, 2023, the federal government has been promoting the construction of particularly climate-friendly buildings with cheaper loans. The standard for this is *the Efficiency House 40*. The new regulation helps to reduce CO₂ emissions in the building sector and achieve Germany's climate goals. Because the program has been well received, the government has increased funding as climate-friendly construction is no longer an optional decision, but a must triggered by supporting building law adjustments. With a funding volume of around two billion, the federal government is now supporting climate-friendly new construction as well as the new home ownership promotion for families, which started on June 1, 2023. That is 888 million euros more than initially planned for both programs.

The new requirements promote environmentally friendly construction and better sustainability standards. The aim is to reduce the greenhouse gas emissions of a building from construction through operation to dismantling. In particular, the energy requirements of buildings should decrease and more renewable energies should be used. The amount of greenhouse gases emitted across the entire building sector is designed to fall to 67 million tonnes by 2030 to achieve national and European climate targets. The new funding requirements have been developed to match with these needs.

Funding is available for the construction or first purchase of a new building if it meets Efficiency House Standard 40. These new buildings receive even higher funding if they are also awarded the "Sustainable Building Plus" or "Sustainable Building Premium" quality seal. The costs for the structure as well as for the necessary technical systems, the specialist planning and construction support as well as the services for sustainability certification are eligible for funding. This includes, for example, the involvement of energy efficiency experts.

Both builders and all first-time buyers can apply for the funding. This includes natural persons, condominium associations, cooperatives, entrepreneurs, freelancers, non-profit organizations and municipalities. The federal government, states and their institutions and political parties are generally excluded. Municipalities and districts receive investment grants, for example for the construction of apartments, kindergartens or schools.

The funding is awarded by the *Kreditanstalt für Wiederaufbau (KfW)*. Basically, it supports construction projects through a loan that is cheap compared to the financial market. Grants can only be granted to municipalities. Private individuals, cooperatives, companies, and investors can apply for these loans through their local financing partners.

There are different interest rates depending on the duration of the loan: With a term of 35 years and a 10-year fixed interest rate, the effective interest rate is 0.90 percent p.a., although with a short term of 10 years (same fixed interest rate) the interest rate is only 0.01 percent p.a..

Country level funding. Example from Northrhine-Westfalia.

More than 6,000 applications gained over 100 million euros in funding based on a financing tool called progress.nrw-created by the land of Northrhine-Westfalia: Since the beginning of 2023, numerous citizens, companies and municipalities in North Rhine-Westphalia have benefited from the diverse funding



opportunities offered by the progres.nrw – Climate Protection Technology program. With the funding, the state government is specifically driving forward the expansion of renewable energies and the use of innovative technologies for energy efficiency and CO₂ reduction in North Rhine-Westphalia. In order to be able to process all applications for the funding program before the current framework directive expires at the end of the year, submission was possible until December 4, 2023. Due to changes to the European funding framework, a new funding guideline will be necessary in 2024. By now, caused by limited funding opportunities it is not clear if and how the uptake of this or a comparable program will be in 2024.

In principle, funding applications and the allocation of existing funding are processed in accordance with the chronological order in which the application was submitted.

Financial support for the installation and expansion of photovoltaic systems cannot be continued next year for the time being due to the strained budget situation. However, the state has already provided strong impetus, particularly for the expansion of solar energy in municipalities, with funding that is unique in the country: This year, 38 million euros have already been approved for 451 photovoltaic roof systems with battery storage on municipal buildings.

In addition, North Rhine-Westphalia is pushing forward the expansion of renewable energy with a community energy fund that will start on January 1, 2024 and support the preliminary planning costs of community energy projects. For new construction or renovation projects, it is also possible to receive funding for solar energy through **KlimaQuartier.NRW**. With the “More photovoltaics on commercial roofs” campaign, the state, together with other partners, is committed to increasing the expansion of solar energy in companies. The state has also launched a campaign with a focus on municipal actors to promote more photovoltaics in open spaces.

9.2.4 Lithuania

Main Governmental support for renovation managed by The Environmental Projects Management Agency under the Ministry of Environment of the Republic of Lithuania (EPMA) is a Multi apartment building renovation (modernization) programme (Fig.15). This programme approved by the government of the Republic of Lithuania in 2004. The programme is aimed to increase energy efficiency of multi apartment buildings with the highest level of heat energy consumption and housing maintenance costs. Furthermore, it is important to ensure that cumulative annual heating costs and return on investment cost after the renovation do not exceed the heating costs before renovation. All projects can get a credit for 20 years, where the interest rate will be fixed at 3% for first 5 years.

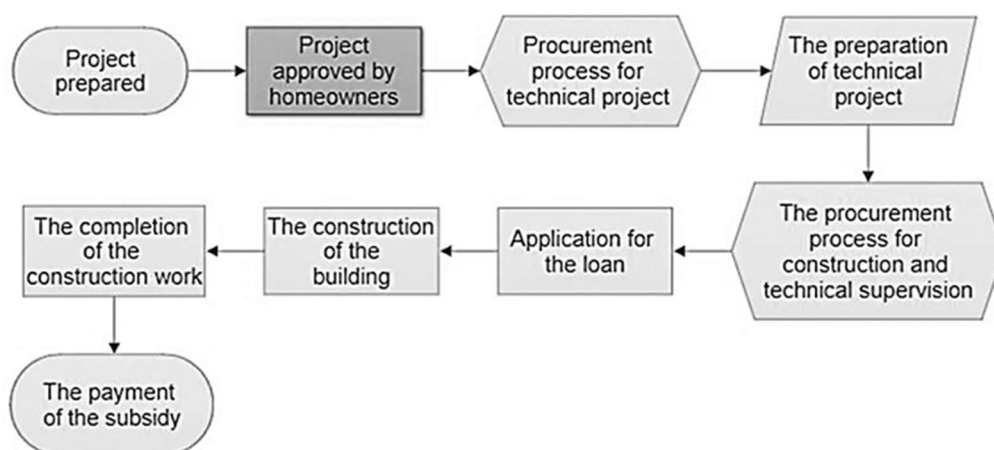


Figure 15 – Scheme of Multi apartment building renovation (modernization) programme in Lithuania



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EPMA use budget foundations of Lithuanian state and EU Modernisation fund established by European Investment Bank. System is arranged in such way that every community of MFH can receive 30% grant covering renovation construction costs. If renovation include renewable energy systems which increase energy efficiency of the building additional 10% will be granted. Extra 100% grant will be provided for administration (management) of the project, preparation of the technical project and arranging of technical supervision during the construction works.

9.2.5 Czech Republic

This year, the Czech Republic has launched a new initiative named **“Repair Grandma’s House”** program aimed at energy retrofits and reduction of carbon footprint. This program is primarily focused on the renovation of old family houses. This initiative is supported by European Union.

For this subsidy scheme the Czech government has allocated 50 billion CZK, which is one tenth of the total sum required for decarbonization of the Czech households by 2030. The main source of support will be the Modernization Fund which is sourced from emission allowance proceeds. The **“Repair Grandma’s House”** program is a part of the government’s strategy to make the country independent of fossil fuels and achieve carbon neutrality by 2050.

Despite the potential benefits, the program has faced criticism. Some experts and politicians argue that the funds are allocated to those who are not the neediest. Concerns have also been raised about climate justice, and the focus has been called to direct support towards people threatened by poverty who primarily live in rented housing. However, devising a grant tool that directly supports tenants during decarbonization remains a challenge.

While the “Repair Grandma’s House” program faces a few criticisms, it represents a significant step towards reducing greenhouse gas emissions in the Czech Republic. By focusing on comprehensive solutions for building renovations, it aims to achieve considerable energy savings and contribute to the national goal of carbon neutrality by 2050.

9.3 Private Investment

Residents who intend to modernize their individual residential house can apply to the Environmental Projects Management Agency and take advantage of financial support. In 2022, for example, 10 million Eur has been allocated to this measure from the Climate Change Program administered by the Ministry of Environment of the Republic of Lithuania.

10 Investment Mechanisms

10.1 Lowering Economic Barriers

Renovations can often come with a hefty price tag, posing significant economic barriers for many individuals. However, in response to this challenge, various financial and incentive models have been crafted to assist property owners in undertaking these renovations without bearing the entire financial burden themselves, <https://www.climatestrategy.es/press/ClimateStrategyWebinarPresentation.pdf>.

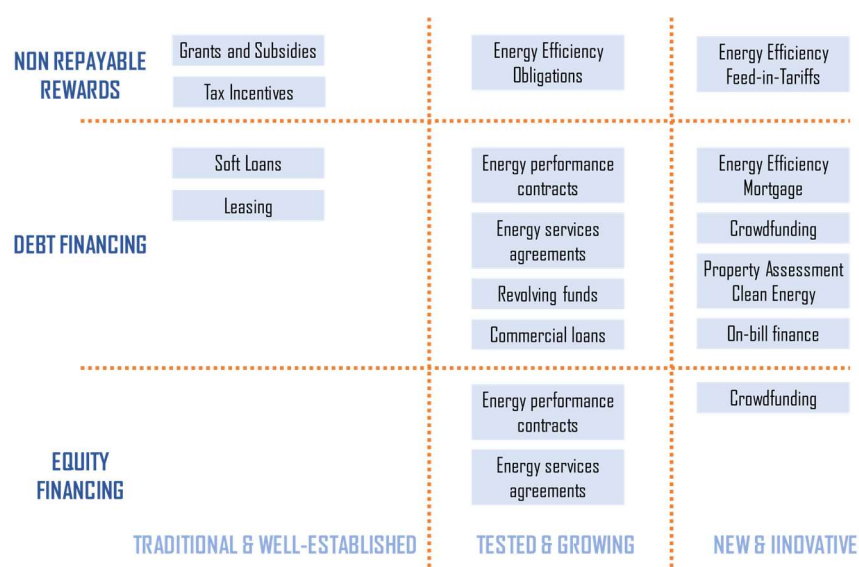


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These models aim to alleviate the strain on owners' budgets by offering diverse financial mechanisms and incentives. They might include grants, tax credits, low-interest loans, or even partnerships with private organizations. By leveraging these models, property owners have access to resources that can help make renovations more feasible and financially viable, thereby encouraging them to invest in improving their properties.

Table 18 below shows the public and private financial instruments which play a crucial role in lowering economic barriers for building renovation, Economidou, M., Todeschi, V. and Bertoldi.

Table 18 - Landscape of financial instruments supporting energy renovations in Europe



In the first line of that table, we can observe the public incentives, they are described shortly in the following. The rest of instruments will be explained more in detail in Section 10.2.

- **Grants and subsidies:** Governments often provide subsidies and grants to incentivize building owners to undertake renovations. These financial aids can cover a portion of renovation costs, making it more financially viable for property owners to invest in upgrades that improve energy efficiency or meet certain environmental standards.
- **Tax Incentives:** Governments may offer tax incentives, such as rebates or tax credits, to individuals or businesses that undertake building renovations. These incentives effectively reduce the overall cost of renovations, making them more attractive and financially feasible for property owners.
- **Energy Efficiency Obligations (EEOs):** EEOs are mandates for energy suppliers or distributors to meet energy savings goals through efficiency measures. In Europe, these policies drive entities to promote energy-efficient practices, often through subsidies for energy-saving appliances and incentives for building retrofits. EEOs aim to encourage conservation, reduce carbon emissions, and advance sustainability in line with Europe's environmental goals.
- **Energy Efficiency Feed-in-Tariffs (FITs):** incentivize energy efficiency improvements by offering payments for adopting energy-saving technologies or practices. Unlike traditional feed-in tariffs for renewable energy, these FITs specifically target efficiency measures, providing financial incentives to individuals or businesses. They aim to stimulate investments in energy efficiency, reduce overall consumption, and promote sustainability across Europe.



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By leveraging these financial instruments, governments and public institutions aim to lower the economic barriers associated with building renovations. These measures not only encourage sustainable and energy-efficient upgrades but also contribute to job creation, stimulate economic growth, and enhance the overall quality and efficiency of buildings across Europe.

Within the diverse landscape of Europe, the implementation of public financial schemes for various initiatives, particularly in the realm of building renovations and sustainability, showcases a nuanced approach. The region's commitment to addressing economic barriers to renovations is evident, yet the strategies employed often reflect a segmentation that caters to the unique socioeconomic landscapes and regulatory frameworks within individual countries. This segmentation highlights the adaptability and tailored nature of public financial instruments across Europe, where each nation's distinctive priorities, economic conditions, and policy frameworks influence the design and implementation of schemes aimed at fostering sustainable building upgrades.

This report primarily highlights public incentives rather than emphasizing energy efficiency improvements. The following table (Tab.19) offers an overview of all public financial and fiscal instruments applicable to the countries within the BIO4EEB consortium's scope.



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Table 19 - Overview of main public instruments supporting energy renovations in EU Member States

Member State	Sector covered	Measure Type			Number of measures	Notable examples
		Grants/ Subsidies	Loans / Soft loans	Tax Exemption /Reduction		
Germany	Residential				4	1) CO2-Gebäudesanierungsprogramm
	Commercial				4	2) Market Incentive Programme for Renewable Energies (MAP)
	Public				4	4) Energy Incentive Programme (APEE)
Italy	Residential				5	1) Ecobonus 2017 tax deduction scheme
	Commercial				3	2) Renewable Energy for Heating and Cooling and Small Interventions Increasing Energy Efficiency Support Scheme (Conto Termico 2.0)
	Public				4	
Spain	Residential				3	
	Commercial				1	1) PAREER programme
	Public				2	2) PIMA SOL programme
France	Residential				6	1) Energy Transition Tax Credit (CITE)
	Commercial				3	2) Social Housing eco-loan
	Public				4	3) Energy Saving Certificates
Belgium	Residential				11	1) Green loans for energy efficiency investments by households (Brussels)
	Commercial				4	2) Property Tax Reduction (Flanders)
	Public				4	3) Financial incentives for RUE investments in buildings (Wallonia)
Hungary	Residential				4	1) Warmth at Home Programme (WAH) (funded from carbon credits)
	Commercial				1	2) Energy Efficiency subsidies for public and local governmental buildings
	Public				2	
Netherlands	Residential				5	1) Subsidy schemes (IRE, MEI, UKR, Clean and Efficient Demonstration Projects)
	Commercial				3	2) Energy Investment Allowance (EIA)
	Public					
Lithuania	Residential				3	1) Programme for the renovation/upgrading of multi-apartment buildings
	Commercial				2	2) Programme for Improving Energy Efficiency in Public Buildings
	Public				1	
Czech Republic	Residential				5	1) Operational Programme Environment (2014-2020): Sustainable Use of Energy Sources
	Commercial				4	2) New Green Savings Programme 2014-2020
	Public				2	
Austria	Residential				4	1) Residential building subsidy("Wohnbauförderung")
	Commercial				2	2) Austrian Federal Government's Renovation Drive ("Sanierungsscheck")
	Public				2	



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In reviewing the financial and fiscal tools across various countries where the BIO4EEB real demo cases are located (Germany, Spain, France, Lithuania, and Czech Republic), an inclusive overview is provided, detailing pertinent information for each identified instrument:

- **Name of Measure:** The specific designation of the financial or fiscal instrument.
- **Policy Type:** Categorization of the policy structure governing the instrument.
- **Targeted Sector(s) and Actor(s):** Identification of the sectors and stakeholders aimed at benefiting from the instrument.
- **Implementation Period and Implementation Body:** Duration of implementation and the responsible entity overseeing its execution.
- **Website:** Online resource offering detailed information about the instrument.
- **Renovation Depth and Supported Interventions:** Specification of the extent of renovation and types of interventions supported by the instrument.
- **Budget:** Allocation of financial resources dedicated to the instrument's implementation.
- **Brief Description:** Concise explanation of the instrument's purpose and mechanism.

This comprehensive summary, see Annex A1, delves into the multifaceted aspects of public financial and fiscal instruments, offering insight into their scope, target, and potential impact within the BIO4EEB real demo cases' host countries.

10.2 Financing Models

Financing models for energy renovation encompass diverse approaches aimed at supporting sustainable initiatives. From Soft Loans offering favourable terms to stimulate development to Leasing providing equipment without large upfront costs, and Energy Performance Contracts ensuring guaranteed savings, each model serves a unique purpose. Energy Services Agreements and On-bill Finance focus on performance-based outcomes and integrating costs into utility bills, respectively. Resolving Funds and Commercial Loans support such initiatives through dedicated funds and conventional lending. Energy Efficiency Mortgages incentivize energy-efficient upgrades, while Property Assessment Clean Energy links financing to property tax assessments. Crowdfunding empowers communities to directly fund renewable projects, illustrating the variety and innovation in financing mechanisms driving Europe's transition to a more sustainable energy landscape.

Soft Loans

Soft loans in Europe for energy renovation serve as a crucial financial tool, offered by governments and institutions to encourage energy-efficient upgrades in buildings and infrastructure. These loans incentivize homeowners, businesses, and public entities to implement measures like better insulation, efficient heating and cooling systems, and renewable energy adoption. By providing favourable terms such as low interest rates, extended repayment periods, and potential subsidies, these loans aim to make energy projects financially viable. Their support plays a vital role in reducing energy consumption, cutting greenhouse gas emissions, and aligning with environmental regulations, fostering a greener future for Europe's buildings and infrastructure.

Leasing

Leasing for energy renovation in Europe introduces an accessible and innovative financial approach, enabling upgrades without immediate hefty investments. It involves leasing energy-efficient equipment—like solar panels or heating systems—where the lessor retains ownership while lessees the benefit. This method allows spreading renovation costs over time, making it budget friendly. Maintenance agreements





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ensure optimal performance, and easy technology upgrades at lease ends enhance efficiency. This model drives eco-friendly practices, aiding energy conservation and aligning with sustainability objectives. It supports Europe's mission to cut emissions, boost energy efficiency, and create greener, resilient structures.

Energy Performance Contracts (EPC)

Energy Performance Contracts (EPCs) in Europe drive energy renovation by facilitating improvements without initial capital investment. These contracts, between clients and energy services companies (ESCOs), fund and execute upgrades like lighting, heating, or renewables. EPCs guarantee energy savings over a set period, and payments to ESCOs are linked to achieved savings, creating a self-funding model. They swiftly modernize buildings, cut emissions, and align with EU energy efficiency directives. EPCs stimulate a sustainable energy services market, encouraging innovation and partnerships for greener infrastructure.

Energy Services Agreements (ESA)

Energy Services Agreements (ESAs) drive energy renovation in Europe by emphasizing ongoing services and performance improvements. These contracts between service providers and clients focus on delivering energy-efficient solutions and reducing consumption. ESAs offer a range of services, from audits to ongoing monitoring, with payments tied to achieved energy savings or performance metrics. In Europe, ESAs significantly promote energy efficiency by incentivizing effective energy management and transferring maintenance risks. They encourage collaboration for sustainable practices, fostering greener and more efficient built environments.

Resolving Funds (RFs)

In general, funds dedicated to energy renovation in Europe often come from various sources such as government grants, subsidies, public-private partnerships, or investment funds focused on sustainability. These funds are typically allocated to support and incentivize energy-efficient upgrades in buildings, infrastructure, and industries. They might cover a range of activities, including retrofitting buildings with energy-efficient technologies, promoting renewable energy adoption, providing financial support for energy audits, or facilitating research and development in green technologies.

Commercial Loans (CLs)

Commercial loans for energy renovation in Europe are standard financial tools provided by banks to support energy-efficient improvements in buildings and infrastructure. These loans target businesses, property owners, and organizations looking to invest in upgrades like renewable energy systems or insulation improvements. They follow traditional lending processes, considering creditworthiness and market-based interest rates. Some institutions may offer specific loan products tailored to energy projects, with incentives like reduced rates or extended repayment periods. These loans play a vital role in funding projects that cut emissions, enhance efficiency, and contribute to broader environmental goals, enabling long-term savings and improved sustainability.

Energy Efficiency Mortgage (EEM)

Energy Efficiency Mortgages (EEMs) incentivize energy-efficient improvements in European properties by offering favourable terms and incentives. These mortgages provide tailored features such as increased loan amounts or reduced interest rates for energy renovations. They're linked to a property's energy efficiency rating or expected savings from upgrades, rewarding owners for energy-efficient investments and reducing consumption and bills. EEMs encourage sustainable practices, contribute to emissions reduction, and support Europe's goal of a greener, more energy-conscious built environment.

Property Assessment Clean Energy (PACE)





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PACE financing in Europe offers an innovative way to fund energy-efficient upgrades by tying costs to property tax assessments, spreading payments over time. It covers various improvements like solar panels and insulation, and repayment stays with the property if sold. PACE's attractive terms, such as long repayment periods and competitive rates, appeal to property owners seeking sustainable upgrades. While its availability varies due to regulations, PACE significantly promotes energy renovation, aims to cut consumption and bills, and supports Europe's sustainability objectives where implemented.

On-bill finance

On-bill finance simplifies energy renovation funding in Europe by merging improvement costs into the property's utility bill. It enables property owners to access financing for upgrades without upfront capital. This model covers various projects like efficient appliances or renewable solutions, with repayments integrated into utility bills over time. Its advantage lies in convenience and accessibility, offering competitive rates and straightforward repayment structures tied to property bills. On-bill finance promotes affordability and immediate energy bill savings, driving the adoption of sustainable technologies and supporting Europe's energy efficiency and environmental goals where available.

Crowdfunding

Crowdfunding is an emerging financial model backing energy renovation projects in Europe, gathering funds from numerous contributors via online platforms. It supports various sustainable initiatives like solar panels or retrofits, offering incentives to attract backers. This model fosters community involvement and ownership in sustainability efforts by enabling direct participation in funding. Crowdfunding not only secures capital but also raises awareness about energy efficiency and renewable sources. It mobilizes resources for green projects, particularly when traditional financing is challenging. Engaging a wider audience, it aids carbon emission reduction and aligns with Europe's clean energy and environmental goals.

11 Conclusions

This deliverable is an outcome of activities that were in focus of the Subtask 4.1.2.

The involved partners elaborated a unique set of benefits and selling points of BIO4EEB products that are justified with key findings from scientific literature and laboratory test performed during the first year of BIO4EEB project.

The relevant stakeholders in demo-cases were identified, the suggestions for effective collaborative approach were made and the rules for community involvement were outlined.

The manufacturers of biobased materials described the key resources and processes and introduced their ideas about business models. They also performed initial cost and revenue analysis knowing that the figures are related to prototype phase and demo cases and must be updated later when higher TRL is reached.

The demo site managers defined pre-requisites of successful implementation and described the needs and possible barriers. Detailed overview of financial instruments and possible investment approaches was made.

The key points of this deliverable will be further elaborated and detailed in close cooperation with all involved project partners, the demo-site advisors, and all relevant stakeholders.



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Annexes



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Annex A1 Overview of financial and fiscal tools across BIO4EEB countries

In reviewing the financial and fiscal tools across various countries where the BIO4EEB real demo cases are located (Germany, Spain, France, Lithuania and Czech Republic), an inclusive overview in tables A1.1 - A1.5 is provided, detailing pertinent information for each identified instrument:

- **Name of Measure:** The specific designation of the financial or fiscal instrument.
- **Policy Type:** Categorization of the policy structure governing the instrument.
- **Targeted Sector(s) and Actor(s):** Identification of the sectors and stakeholders aimed at benefiting from the instrument.
- **Implementation Period and Implementation Body:** Duration of implementation and the responsible entity overseeing its execution.
- **Website:** Online resource offering detailed information about the instrument.
- **Renovation Depth and Supported Interventions:** Specification of the extent of renovation and types of interventions supported by the instrument.
- **Budget:** Allocation of financial resources dedicated to the instrument's implementation.
- **Brief Description:** Concise explanation of the instrument's purpose and mechanism.

Table A1.1 - Summary of public financial and fiscal instruments in Germany

Name of measure	CO2 building renovation programme (CO2-Gebäudesanierungs-programm)	Market Incentive Programme for Renewable Energies in Heat Market (Marktanreizprogramm für erneuerbare Energien im Wärmemarkt-MAP)	Energy Efficiency Incentive Programme	Energy Consulting Programme
Policy type	Loans/Others	Grants/Subsidies	Grants/Subsidies	Grants/Subsidies
Targeted sector(s)	Residential, Commercial, Public	Residential, Commercial, Public	Residential, Commercial, Public	Private households, Commercial, municipalities and non-profit organisations
Targeted actor(s)	Landlords, owner-occupiers, private and public companies, social organisations, municipalities	Housing associations, landlords, owner-occupiers	Housing associations, landlords, owner-occupiers	Private households, companies, municipalities and non-profit organisations
Implementation period	Since 2006	Since 1999	since 2016	Since 2008
Implementation body	Central government, financial institutions	Central government, financial institutions	Federal Ministry for Economic Affairs and Energy, KfW/BAFA	central government, financial institutions
Website	https://www.kfw.de/kfw.de-2.html	www.kfw.de www.bafa.de www.bmwi.de	N/a	www.bafa.de
Renovation depth	High	Medium	N/a	High
Supported interventions	Building envelope; technical building equipment	Renewable energy technologies for the production of heat and cooling, as well as certain heat storage facilities and local heating networks.	Ventilation systems, building envelope, replacement of inefficient heating systems with efficient ones, measures to optimise heat distribution systems	Energy efficiency
Budget	EUR 2 billion p.a.	The financial volume currently is EUR 320 million per annum.	The programme currently has a budget of EUR 165 million p.a.	EUR 45 million p.a.
Brief description	Low-interest loans combined with repayment grants and investment grants are given out for energy-efficient refurbishments of existing buildings as well as the construction of highly-efficient new buildings. To be eligible for funding, buildings must clearly exceed the legal requirements on energy efficiency that are laid down in the Energy Saving Ordinance that is, meet the "Efficiency House" standard for energetically ambitious buildings. Funding is then deployed on the basis of what level of the "Efficiency House" standard a building achieves. The programme is carried out by KfW Promotional Bank.	Intended to support the attainment of the goal of the Renewable Energies Heat Act by further expanding the deployment of technologies to use renewable energy in the heating/cooling sector. Two kinds of support are provided depending on the type and size of the installation: For small installations , primarily in existing buildings, investment grants are given out through the Federal Office for Economic Affairs and Export Control. Applications for such funding mainly come from private investors in the single-family or two-family homes segment. For larger installations , as well as for heat networks and storage, repayment grants are offered in the form of low-interest loans under the KfW Renewable Energies Programme.	Funding is deployed in the form of grants in the following areas: The installation of ventilation systems (ventilation package) in conjunction with measures to renovate the building envelope which are designed to prevent damage to the building (e.g. mould); The replacement of inefficient heating systems with efficient ones (heating package); this includes measures to optimise the heating system which address the entire efficiency potential of the heating system; the launch of innovative fuel cell heating systems onto the market.	With the Energy Consulting Programmes, the German government supports private households, companies, municipalities and non-profit organisations to make more efficient use of energy. A wide range of information, advice and support services is available and used intensively.

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Table A1.2 - Summary of public financial and fiscal instruments in Spain

Name of measure	PAREER +PAREER-CRECE+PAREER II Programme (Aid Programme for Energy Rehabilitation in Existing Buildings)	DUS Programme (Aid to local authorities for singular projects of local authorities improving the transition to a low-carbon economy)	PIMA SOL (Plan for promoting environmentally friendly behaviour in the tourism sector)	Programme of promotion of the improvement of the energy efficiency and sustainability of houses
Policy type	Subsidies and/or Loans	Grants/Subsidies	Grants/Subsidies	Grants/Subsidies
Targeted sector(s)	Residential; Public	Public existing buildings	Non-residential (hotel facilities)	Residential
Targeted actor(s)	Building professionals, general public, housing associations, landlords, manufacturers	Public	Hotel facility owners	Homeowners, public administrations, homeowners associations, housing associations, building companies, energy services companies.
Implementation period	2013 - 2019	2017 - 2020	since 2013	2008 - 2021
Implementation body	MINETUR, IDEA, central government	MINETUR, IDAE, Central Government	Ministry of Agriculture, Food and Environment (MAGRAMA), Climate Change Spanish Office (OECC), Central Government	Ministry of Development, central government
Website	https://www.idae.es/ayudas-y-financiacion/programa-de-ayudas-para-la-rehabilitacion-energetica-de-edificios-existentes	https://www.idae.es/ayudas-y-financiacion/para-proyectos-de-inversion-que-favorezcan-el-paso-una-economia-baja-en	https://www.mapama.gob.es/es/cambio-climatico/planes-y-estrategias/pima-sol.aspx	https://www.mitma.gob.es/arquitectura-vivienda-y-suelo/programas-de-ayudas-a-la-vivienda/programa-de-fomento-de-eficiencia-energetica-y-sostenibilidad-en-viviendas
Renovation depth	Medium	Medium	Low	High
Supported interventions	Insulation of building envelope, thermal and lighting installations, replacement of conventional energy for biomass or with geothermal energy in thermal installations.	Insulation of building envelope, thermal and lighting installations, replacement of conventional energy for solar, biomass or geothermal energy in thermal installations, photovoltaics	Building envelope (facade and roof) and windows, improved insulation, lighting and air-conditioning control systems, solar panel water-heating systems, passive air-conditioning systems based on better architectural design, more efficient heating and cooling equipment, use of geothermal energy and biomass for air-conditioning and efficient water-management systems.	-Improvement of building envelope (insulation, replacement of window frames and panes, new bioclimatic and shading devices) -Improvement of noises -Improvement of Radon concentration -Green building envelopes -Home automation or sensor systems
Budget	EUR 404 million (2014-2020)	EUR 987 million from 2017 to 2020 for all interventions (the whole programme objectives) not only for buildings	EUR 5.21 million (period 2013-2014). The latter would in turn, contribute another EUR 200 million with very advantageous interest rates and repayment periods.	EUR 101.32 million (2018-2021)
Brief description	This programme promotes comprehensive actions and integrated measures encouraging the improvement of energy efficiency and the use of renewable energies in the stock of existing buildings in the residential sector by awarding grants and repayable loans to projects involving the renovation of building envelopes and heating installations and to those which use biomass and geothermal energy rather than conventional energy sources.	The DUS Programme provides direct grants to local authorities for investment projects in the low-carbon economy. Projects should achieve a reduction in carbon dioxide emissions through the following types of actions: energy efficiency in buildings, public infrastructure and services. Sustainable urban mobility. Renewable energy technologies (thermal uses, electricity) are also supported by the programme. The aided actions should improve the total energy rating of the building by at least 1 letter measured on the carbon dioxide emission scale (kg CO ₂ /m ² year) compared to the initial energy rating of the building.	It is an initiative devoted to reducing greenhouse gas emissions (GHG) in the Spanish tourism sector through energy renovations of hotel installations. Renovation projects are to reach a minimum energy improvement rate that will translate in, at least, two letters higher on the energy rating or else, reach letter B.	iT Is orientated to encourage and promote the energy efficiency and sustainability in residential buildings and houses, either in cities or rural areas. In particular, subsidies are given to improve building envelope in residential buildings. The Programme finances rehabilitation of buildings and houses, urbanization of public spaces and construction of new blocks or houses previously demolished. Although some actions are related to energy efficiency reduction this programme is generally targeted to improve conservation.

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Table A1.3 - Summary of public financial and fiscal instruments in France

Name of measure	Existing Buildings Programmes	Preferential loans for energy saving measures (LDD)	Energy Transition Tax Credit (CITE) (ex- Sustainable Development Tax Credit)	Zero-rated eco-loan ("prêt à taux zéro")
Policy type	Grants/Subsidies; Tax relief	Loans	Tax incentives; Tax Exemption/Reduction	Loans/Others
Targeted sector(s)	Residential, Commercial, Public	Residential, Commercial, Public	Residential	Residential
Targeted actor(s)	Owner-occupiers	SEMs, individuals, co-properties and entrepreneurs	Owner-occupiers, building professionals	General public
Implementation period	Since 1975	Since 2007	since 2005	Since 2009
Implementation body	ADEME, the municipalities, ANAH (French Agency for Improvement of Existing Dwellings)	Directorate General for Energy and Raw Materials (Ministry of Ecology, Energy, Sustainable Development and Planning)	Central government	Central government, energy agencies, banks
Website	N/a	http://www.bfb.fr/Web/internet/content_particuliers.nsf/(WebPageList)/Les+modalites+de+fonctionnement+du+Livret+de+developpement+durable+sont+precisees?Open+Decret+n°2007-161+du+6+fevrier+2007+relatif+au+livret+de+developpement+durable	(Loi n°2005-781 du 13 juillet 2005 de programme fixant les orientations de la politique énergétique Lois de finances "Finance laws" 2005, 2006, 2009, 2010, 2011, 2012, 2014, 2015)	(Finance act for 2009 + article 108 of the Finance Act for 2016)
Renovation depth	N/a	N/a	High	Medium
Supported interventions	Heat insulation improvements, heating regulation, the replacement of boilers or in some instances the installation of a wood stove; help low-income homeowners improve their main residence; improve privately owned rented housing units; improve the rental housing units they own or manage for social welfare purposes.	Energy efficient boilers; thermal insulation (walls, windows, shutters); thermal regulation equipment; equipment producing energy from renewable sources; space and water heating equipment using wood or other biomass; heat pumps.	Thermal insulation materials; space and water heating (heating pump for heat generation); RES (energy equipment using renewable energy source)	- Outdoor walls insulation; Roof insulation; Outdoor window and door insulation; - Installation or replacement of heating or hot water equipment; - Installation of heating or hot water equipment, relying on renewable energy sources.
Budget	Large-scale funding system gathering private and public money to finance retrofitting operations will be implemented. The amount of this public financing for energy savings can be assessed at EUR 2 220 million (Fr 2.5 billion) in 1992. In the 2002 budget, building energy retrofits benefit from a tax reduction of 15% of expenses to a maximum of EUR 8 000 per family.	On 5th October 2006, the French Government announced the creation of a EUR 10 000 million fund for the funding of domestic energy conservation projects with low-interest loans.	About €1.6 billion/year	This loan is granted to landlords (occupiers or lessors) without any income condition. It could be used by co-owners in the limit of EUR 0.01 million per flat (or until EUR 0.03 million if the co-owners union launches "bunches of works").
Brief description	The incentives are as follows: - Tax reductions - Grants for housing improvements: this government subsidy is to help low-income homeowners improve their main residence if it is over 20 years old. - Grants from ANAH, the National Housing Improvement Agency: this grant aims at helping improve privately owned rented housing units built more than 15 years ago. - Grants for rental and social housing improvements (PALULOS): this grant assists organisations to improve the rental housing units they own or manage for social welfare purposes, rented to house low-income people, and which are more than 15 years old.	Preferential loans can be awarded to individuals, co-properties and entrepreneurs for the purchase and installation of energy efficient equipment. Applicants must provide the bank with documents from the equipment installer, certifying that the equipment and installation meets the required energy efficiency criteria. This financial measure is complementary to the 2005 tax credit scheme. The acquisition of domestic energy efficient equipment entitles the buyer to a price reduction (tax credit scheme) and a low-interest loan at the same time (LDD measure).	The "Energy Transition Tax Credit" or Crédit d'Impôt Transition Énergétique (CITE) in French, replaces the "Sustainable Development Tax Credit" (CIDD) launched in 2005 (and stopped on 31st August 2014). It supports owners, leaseholders or dwelling occupiers for free (main residence) who pay tax in France in purchasing efficient materials and equipment to limit energy consumption and greenhouse gas emissions. Amount of the global credit tax is limited over a 5-year period to: EUR 8 000 for a single person, widow or divorced; EUR 16 000 for a couple subject to joint taxation. These amount are increased EUR 400 per dependent child and to EUR 200 per child in alternate residence.	The zero-rated eco-loan scheme (eco-prêt à taux zero or Eco-PTZ) has been introduced by the "Finance law 2009" (loi de finance 2009) to allow landlords to get a loan to finance energy refurbishment works for their main residence. It is granted by banks which have concluded specific agreement with the French State under conditions fixed in the General Taxes Code (Code Général des impôts). The Tax free loan is aimed at individual owner-occupiers or landlords to finance major renovation work. It is also possible to combine the eco-PTZ loan with the CITE tax credit.

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Table A1.4 - Summary of public financial and fiscal instruments in Lithuania

Name of measure	Lithuanian Environmental Investment Fund	Upgrading of multi-apartment buildings	Energy efficiency improvement in the household sector (Special programme for climate change)	Programme for Improving Energy Efficiency in Public Buildings
Policy type	Subsidies	Grants/Subsidies; Loans	Grants/Subsidies; Loans	Grants/Subsidies
Targeted sector(s)	Residential, Commercial, Public	Residential	Residential	Tertiary
Targeted actor(s)	Energy Suppliers, Large Enterprises, SMEs	Owner-occupiers	Owner-occupiers	General public
Implementation period	Since 1999	2005-2020	since 2012	2014 - 2020
Implementation body	Central Government	Central government, financial institutions, local government	Central government, financial institutions	Central Government, Local Authorities
Website	(Lithuanian Environmental Investment Fund (Official Gazette 2003, No 85-3890; 2010, No 112-5700; 2011, No 46-2206))	http://amiestas.lt/teisine-baze/ (Decision of the Government N° 1213 of 23rd September 2004)	((1) THIRD ENERGY EFFICIENCY ACTION PLAN 2014 LITHUANIA; (2) Law on the Financial Instruments for Climate Change Management)	(Programme for Improving Energy Efficiency in Public Buildings)
Renovation depth	N/a	Medium	Low	N/a
Supported interventions	N/a	Energy efficiency measures such as reconstruction and change of heat and hot water supply systems; installation of equipment using renewable energy sources; improvement of heat isolation of pipe works; reconstruction of ventilation system; roof, walls insulation; change of outside doors, windows; modernization of data for housing Energy Saving	General (essential) repair of cold and hot water supply systems; change and replacement of heating and ventilation systems; change of windows and outside doors; insulation of roofs, floor and walls; installation of solar collectors, wind power plants, geothermal plants; installation of biomass boilers.	modernization of heating and hot water engineering systems; modernization and installation of cooling systems; insulation of roof; insulation of building envelopes; change of doors and windows; modernization of lighting; modernization of boiler houses in upgraded buildings
Budget	EUR 2.67 million during 2013-2016. Source of finances is 30% of taxes levied on environment pollution.	Agency of Lithuania (2017), an average cost of contracted works when modernizing multifamily houses is about 195 EUR/m2 in 2017, compared to 2016, when the price stood at about 191 EUR/m2, the price remained rather stable.	Budget and financial source: EUR 2.39 million in 2016 and using financial resources as they are provided in Law on Climate Change Financial Instruments.	Budget and financial source EUR 29 million: State funds, municipality budget, private funds, EU Structural Funds.
Brief description	The main focus of the Fund is on projects related to the reduction of atmospheric emissions of pollutants and greenhouse gases; support is also given to energy efficiency investments. The LEIF programme gives support to beneficiaries in the form of subsidies with maximum ceiling per beneficiary of no more than EUR 200 thousand for three years. The subsidy may cover up to 80 % of total eligible	The programme promotes energy upgrades of multi-apartment buildings and fuel cost reductions related to thermal energy in flats built up to the technical standards of construction valid up to 1993 by at least 20% by the end of 2020. That is, by 2020 the estimated annual cost of thermal energy (fuel) in these houses must be reduced by at least by 1000 GWh per year compared to 2005. This corresponds to a reduction of carbon dioxide emissions by at least 230 kt	The measure consists of two sub-measures: - sub-measure "Modernization of living houses to reduce at least 20 percent of energy consumption and to reach at least C energy efficiency class", which approved support for 720 projects during 2012–2016. Total sum of investment is EUR 4.1 million (174 projects are approved for the support in 2016). - sub-measure "Use of renewable energy sources in individual living houses"	With the view of the indicative national energy efficiency target for 2030, Lithuania has implemented "Renovation of public buildings belonged to central government" measure using the support of the EU structural funds for the period 2014-2020. The aim is to increase EE in public buildings, which are owned by state and municipalities. It is planned that till 2020, 700 thousand m2 of public buildings will be

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Table A1.5 - Summary of public financial and fiscal instruments in Czech Republic

Name of measure	Regeneration of pre-fabricated concrete buildings - PANEL, NEW PANEL and PANEL 2013+ Programmes	New Green Savings Programme	JESSICA Programme (Ministry of Regional Development)	Integrated Regional Operational Programme
Policy type	Loans/Others	Grants/Subsidies	Loans	Grants/Subsidies
Targeted sector(s)	Residential	Residential	Residential	Residential
Targeted actor(s)	Housing associations	Housing associations, owner-occupiers	Housing associations	Owner-occupiers
Implementation period	Since 2001	2014-2016	2014-2020	2015 - 2020
Implementation body	Central government, Ministry for Regional Development, State Housing Development Fund	Central government, Ministry of Environment, administered by the State Environmental Fund	Financial institutions	Central government, financial institutions
Website	http://www.sfrb.cz/programy-a-podpora/program-panel-2013/	http://www.usporozumem.cz/	https://www.iea.org/policiesandmeasures/pams/czechrepublic/name-128743-en.php	http://www.strukturalni-fondy.cz/cs/Microsites/IROP/Uvodni-strana
Renovation depth	Low	Medium	Low	Medium
Supported interventions	Building envelope, thermal insulation; regulation of the heating system; RES (modernisation of the heating system, including the use of renewable energy sources); HVAC (repair or modernisation of ventilation technology); repair of lightning rods and fire equipment and structures; control system (measurement of heat consumption for the heating system, hot water consumption, cold water consumption); acquisition of building energy performance certificate.	Subsidies for thermal insulation of building envelopes, replacement of windows and doors, thermal insulation of exterior walls, roofs, ceilings, floors, support for partial and comprehensive measures; Subsidies for the construction of new houses with very high energy performance;	Thermal insulation of building envelopes and of internal structures; removal of static disorders in load-bearing structures and of structural and functional defects; rehabilitation of foundations and substructure waterproofing; reconstruction of technical equipment of buildings; replacement or modernisation of enclosed and open balconies, including railings.	Support for energy efficiency, smart energy management systems, and the use of energy from renewable sources in public infrastructure, in public buildings and in housing, among other things.
Budget	EUR 23.28 million (CZK 600 million) for 2016	EUR 774 million from 2014 to 2020. The total annual investment (2016) is EUR 150 million; with EUR 80 million public and EUR 80 million private.	EUR 24 million from 2014 to 2015	EUR 680 million from 2015 to 2020. The total annual investment is EUR 200 million; with EUR 80 million public and EUR 120 million private.
Brief description	The Ministry of Regional Development programme, administered by the State Housing Development Fund, offers low-interest loans for repairing and modernising multi-family buildings. An emphasis is placed on comprehensive repairs so that owners spend financial resources in a purposeful manner. Programme is designed to provide financial support for reconstruction and modernisation of all types of blocks of flats.	The main objective of the program is to improve the environment by reducing emissions of pollutants and greenhouse gases (mainly CO ₂), as well as saving energy in final consumption and stimulating the economy of the Czech Republic with other social benefits. Promotes energy saving reconstructions of houses and apartment buildings, replacement of unsuitable heating sources and usage of renewable energy.	A programme of the Ministry for Local Development administered by the State Housing Development Fund focusing on the provision of low-interest long-term loans to revitalise deprived urban areas. This programme offers long-term low-interest loans for the reconstruction and upgrading of multi-family buildings in deprived zones (with a service life of 20 or more years). The measure covers only the deprived zones of 41 towns and cities with an Integrated Urban Development Plan.	A programme of the Ministry of Regional Development Focusing on for basic objectives of the Czech Republic's regional policy, as formulated in the Czech Republic's Regional Development Strategy for 2014-2020 to promote an increase in competitiveness and the harnessing of the economic potential of the regions (growth objective); to lessen the growing gaps in the negative regional differences (balancing objective); to reinforce environmental sustainability (preventive objective), to optimise the institutional framework for regional development (institutional objective).

Annex A2 Detailed cost and revenue analysis of Posidonia core panel

A2.1 Raw material cost

According to actual most promising formula for Posidonia core panel and considering the dimension of a single Posidonia panel (according to market typical dimension for similar products), raw material bill is the following:

Table A2.1 - Posidonia raw material bill – density 100 kg/m³

Panel dimensions [mm]	Panel thickness [mm]	Density [kg/m ³]	Posidonia [kg]	Bio-resin [kg]	Posidonia [kg/m ²]	Bio-resin [kg/m ²]
1200 x 600 *	100**	100	5,76	1,44	8	2

* hypothetical size (not definitive) in accordance with the average dimensions of similar panels on the market

** proposed thickness in accordance to the insulation thickness required by final product (adoption of 2 panel to reach desired thickness)

In the following cost analysis, also Posidonia core panel with 150 kg/m³ density was considered since thermal performances are similar to 100 kg/m³ density panel but compactness and mechanical property are better. Since the final product is still being defined, cost analysis has been performed considering also this version of the panel.

Table A2.2 - Posidonia raw material bill – density 150 kg/m³

Panel dimensions [mm]	Panel thickness [mm]	Density [kg/m ³]	Posidonia [kg]	Bio-resin [kg]	Posidonia [kg/m ²]	Bio-resin [kg/m ²]
1200 x 600 *	100**	150	8,64	2,16	12	3

In order to calculate raw material unitary cost, the amount of building surface to be insulated with BIO4EEB products should be considered. Actually **765 m²** of building surface has been considered for democases according to following data shared by project partners:

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Table A2.3 – Surface covered by BIO4EEB products.

SURFACE COVERED BY BIO4EEB (m2)		
Posidonia+foams into pref. Facades	Posidonia Panel + PECs+Foams	Bio- PUR Windows
62	58	20
0	220	40
30	120	0
180	95	13

Each panel is approximately 0.72 m² and each m² of building surface requires 2 panel. The total amount of panel is about **2125**.

Posidonia raw material cost can be considered equal to 0 since it is free collected from the beaches. Obviously the cost of transport and treatment must be taken into account but this cost item will be considered within the other cost items reported in this document.

Regarding Bio-resin, SOPHIA/Starcell started a dialogue with the resin supplier PROCHIMA in order to verify the possibility of purchasing the quantities of G-27 bamboo resin necessary for the project and obtain a better price than the list one. G-27 Bamboo is a bi-component resin and so the cost for each component is reported.

Table A2.4 - Posidonia raw material cost– density 100 kg/m³

[100 kg/m³ Density]	Amount for panel	Kg for panel [kg]	Unitary cost [€/kg]	Total cost [€]
POSIDONIA (treated)	2125	5,76	0	0
G-27 Bamboo component A)	2125	1,152	9*	22032
G-27 Bamboo (component B)	2125	0,288	9*	5508
TOTAL				27540
Cost per panel [€/unit]				12,96
Cost per m ² [€/m ²]				18,00

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Table A2.5 - Posidonia raw material cost – density 150 kg/m³

[150 kg/m ³ Density]	Amount for panel	Kg for panel [kg]	Unitary cost [€/kg]	total cost [€]
POSIDONIA (treated)	2125	8,64	0	0
G-27 Bamboo (component A)	2125	1,728	9*	33048
G-27 Bamboo (component B)	2125	0,432	9*	8262
TOTAL				41310
Cost per panel [€/unit]				19,44
Cost per m ² [€/m ²]				27,21

A2.2 Transportation cost

As stated in the previous paragraph, Posidonia can be collected at no cost on the beaches but must be transported to the panel production plant.

The amount of Posidonia to be collected and transported is 5 times the amount required to produce the panel due to the fact that during the drying process the mass is reduced by 80%. The planned transport strategy involves renting trucks with drivers. This strategy is the best for the purposes of the project as the costs associated with the purchase of trucks and the business risk are not justified by the limited amount of the panels necessary for the Demo-cases. Transportation costs for the bio-resin are included in the supply price.

Table A2.6 – Posidonia transportation cost

	Units	100 kg/m ³ panel density	150 kg/m ³ panel density
Total amount of Posidonia to be transported	[t]	61,2	91,8
Amount of Posidonia transported by one trip	[t]	5	5
Cost per trip (truck rent + fuel + driver)	[€]	600	600
N° of trip	[.]	12	18
Total cost for transport	[€]	7200	10800
Transport cost per panel	[€/unit]	3,38	5,08
Transport cost per m ²	[€/m ²]	4,69	7,05

A2.3 Production cost

Before starting the analysis of production cost, some points need to be made clear. At the time of drafting this document, only a preliminary design of the industrial production process has been performed and consequently some cost item could be only estimated. As well as the production plant with the related machinery has not been completely defined and so cost related to manpower and production equipment purchase could be only estimated. Furthermore, cost for equipment will not be spread on the price of the single panel because we are in the context of a research project. In the following a scheme of the production process has been reported (Fig.A2.1).

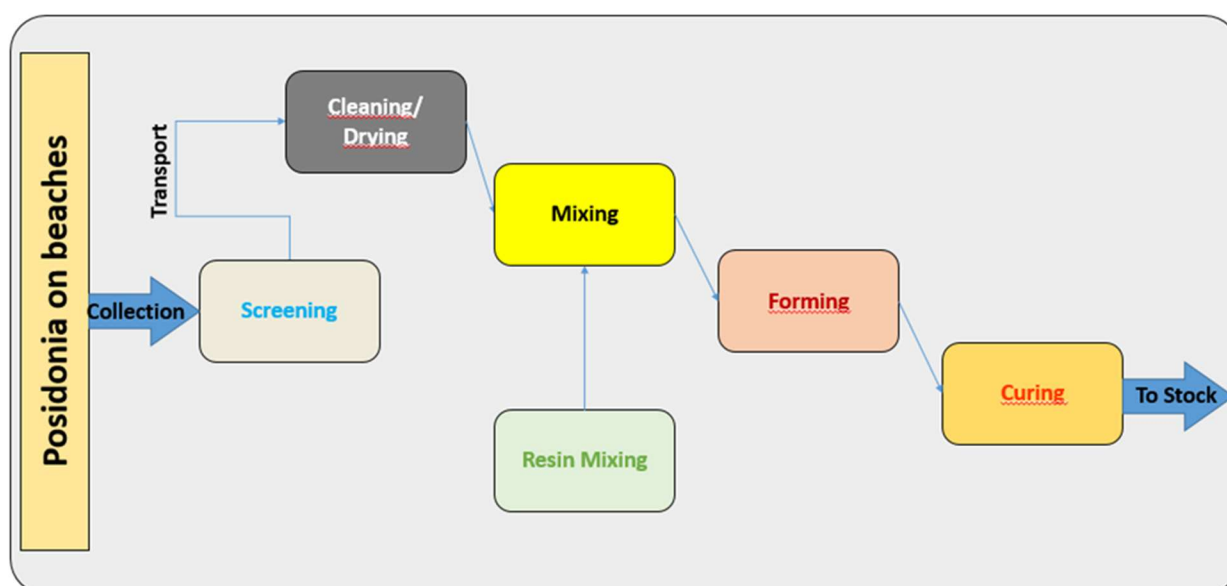


Figure A2.1 – Production process scheme

Screening phase

In this phase Posidonia is collected and mechanical screening is carried out with the aid of a vibrating system to separate sand from Posidonia to be utilized in the process. The vibrating system is a mixer with grates and for the scope of the project it is better to rent it from specific companies to reduce cost and business risk.

Table A2.7 – Posidonia screening costs

	Units	100 kg/m3 panel density	150 kg/m3 panel density
System screening capability	[t/day]	5	5
Rental cost per day	[€/day]	400	400
Manpower cost per day	[€/day]	400	400
Screening cost for 1t dried Posidonia	[€]	800	800
Screening cost per panel	[€/unit]	4,62	6,95
Screening cost per m ²	[€/m ²]	6,42	9,65

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Drying / cleaning phase

In this phase Posidonia is separated from any further waste by washing and subsequently collected inside a drier to remove the water content. During the process the weight of the Posidonia is reduced by 80%.

Table A2.8 – Posidonia drying/cleaning costs

	Units	100 kg/m3 panel density	150 kg/m3 panel density
Drier cost	[€]	5000	5000
Productivity (wet Posidonia processed)	[t/day]	0,250	0,250
Manpower cost	[€/day]	100	100
Electrical energy	[€/day]	10	10
Total cost for drying/cleaning 0,25t	[€]	110	110
Drying/cleaning cost per panel	[€/unit]	12,22	18,33
Drying/cleaning cost per m ²	[€/m ²]	16,97	25,4

Production phase (Mixing + Forming + Curing)

In this phase Posidonia is collected inside a particular system to be mixed with bio-resin. The is essentially a tank with rotating organs inside which favor the mixing of the Posidonia with the resin to be added. Given that the system is specific to the process, it was designed and built exclusively for the project. Another system is required to mix component A and component B to obtain the bio-resin to be mixed with Posidonia. The system includes an organ for dosing and mixing A and B components and an organ for introducing it into the tank. The productivity of the mixing phase includes productivities of three described systems.

Posidonia mixed with resin is placed in molds with dimensions of the panel to be realized and pressed with a press heated at 70°C. Posidonia and resin mix is manually put into molds. 6 molds will be used since the press is able to work simultaneously on 6 molds. Pressing time is 1.5 h. The possibility of using 2 overlapping molds is being analyzed, in that case 12 molds will be required. Production will be organized by shift.

Table A2.9 – Posidonia production cost

	Units	100 kg/m3 panel density	150 kg/m3 panel density
Mixing tank cost	[€]	10000	10000
Mixing system for resin cost	[€]	30000	30000
Resin injection system cost	[€]		
Molds total cost (6 molds/12 molds)	[€]	600/1200	600/1200
Full System productivity	[pcs/shift]	12/24 pcs/shift	12/24 pcs/shift
Manpower cost	[€/shift]	200/shift	200/shift

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Electrical energy	[€/shift]	50/shift	50/shift
Cost for 12/24 pcs production	[€]	250	250
Production cost per panel	[€/unit]	20,8/10,4	20,8/10,4
Production cost per m ²	[€/m ²]	28,9/14,5	28,9/14,5

A2.4 Storage cost

When calculating storage costs, it's taken in the account that the panels will remain in the warehouse for the time necessary for production plus 2 months and so about 4 months.

Table A2.10 – Posidonia storage cost

	Units	100 kg/m ³ panel density	150 kg/m ³ panel density
Warehouse cost (4 months)	[€/m ²]	16	16
Warehouse extension	[€/m ²]	50	50
N° pallets (1200x3000 mm)	[-]	6	6
Cost per pallet	[€/pcs]	50	50
Storage cost	[€]	1100	1100
Storage cost per panel	[€/unit]	0,51	0,51
Storage cost per m ²	[€/m ²]	0,71	0,71

A cost equal to 5% of the total costs will be added to include handling costs.

A2.5 Logistics cost

Logistic cost is intended the cost of shipping the panels to the partner who will produce the final products. The shipment of the panels can be carried out with two trucks with a total cost of **3000 euros**. Cost per panel is **1,4 euros/pcs**. Cost per m² is **1,96 euros/ m²**.

A2.6 Total cost calculation

Table A2.11 – Posidonia total costs per m²

Cost per m ²	Units	100 kg/m ³ panel density	150 kg/m ³ panel density
Raw material cost	[€/m ²]	18	27,21
Transportation cost	[€/m ²]	4,69	7,05
Screening cost	[€/m ²]	6,42	9,65
Cleaning /Drying cost	[€/m ²]	16,97	25,4

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Production cost	[€/m ²]	14,5	14,5
Storage cost	[€/m ²]	0,75	0,75
Logistics cost	[€/m ²]	1,96	1,96
Final unitary cost per m ²	[€/m ²]	63,29	86,52

Table A2.12 – Posidonia total costs per piece

Cost per panel	Units	100 kg/m ³ panel density	150 kg/m ³ panel density
Raw material cost	[€/pcs]	12,96	19,59
Transportation cost	[€/pcs]	3,38	5,08
Screening cost	[€/pcs]	4,62	6,95
Cleaning /Drying cost	[€/pcs]	12,22	18,33
Production cost	[€/pcs]	10,44	10,44
Storage cost	[€/pcs]	0,54	0,54
Logistics cost	[€/pcs]	1,41	1,41
Final unitary cost per panel	[€/pcs]	45,57	62,34

A2.7 Conclusion of Cost Analysis

The production costs of the panels to be used for the demo-cases refer to the prototype process, that is not designed for mass market. Therefore, the unit cost and the cost per m² are not commercial, but typical of a prototype.

To reach a cost of 45 €/m² with a density of 100, an industrial process should be implemented with “meaty investments” on the entire production flow.