EASI ZERo project: Envelope material system with low impact for zero energy buildings and renovation

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Abstract. The EASI ZERo project aims to contribute to achieve the European Union's deep renovation target of 3% by 2030 and the 2050 climate neutrality goal thanks to the implementation of efficient and replicable solutions that would accelerate deep renovation practices. Since building envelope materials are a crucial part of renovation process, the focus is on developing easy-to-install envelope components for the near-zero energy balance and CO_2 emissions of buildings. The aim is to provide a holistic solution for the total envelope, including façades, roof, openings and even renewable energy generation and storage. The system includes bio-sourced and recycled insulation components, low-carbon paints and plasters, and lightweight, zero-emission frames for windows and doors. The system also features affordable and integrated PV tiles for roofing and thermal storage materials to regulate heating and cooling. The components used for the project are manufactured locally and are easy to install. The project will provide relevant information and digital tools to ensure that the materials used are environmentally sustainable (via Life Cycle Analysis), socially responsible, and economically viable. Real use cases will be considered to demonstrate the capacity of the integrated solution EASI ZERo system to reach the target in terms of greenhouse gas emission, energy efficiency, sustainability and affordability. Ultimately, the EASI ZERo project aims to provide a circular and reusable solution for deep building renovation.

Keywords: Envelope material, deep renovation, zero energy balance, bio-source materials

1 A project for zero energy & low carbon building renovation

1.1 Introduction and aim of the project

Deep renovation is defined as a one-step process to realize the full potential of a building to reduce its energy demand, based on its typology and climatic zone. It achieves the highest possible energy savings and leads to very high energy performance, with the remaining minimal energy needs fully covered by renewable energy. The current annual deep renovation rate stands at only 0.2% on average in the EU. This figure must drastically increase to reach 3% by 2030 and be maintained up to 2050 to reach the goal of 2050 climate neutrality defined for the EU [1]. Therefore, there is a strong need for

efficient and replicable solutions that would accelerate these deep renovation practices and help achieve 2030 and 2050 goals.

EASI ZERo system consists of insulation components based either on bio-sourced materials or from recycled and reused materials. The system includes a selection of versatile bio-sourced insulation materials showing high level of thermal performance. Materials cover either external insulation or internal insulation, on façade and roofs. Bio-sourcing and recycling bring great environmental value to our system. Material sources are wood, used wood pieces, grown mycelium or recycled construction waste. A general life cycle assessment will provide environmental, social and economic impact information and for each component. All this information will feed in tracking records of materials and building's history through associated **passport** implementation.

1.2 Project description

The project started in December 2022 and it is financed by European Unions's Horizon Europe research funding. Three years and half are planned to develop the project and produce an efficient and easy renovation system. The research team includes 16 participants from France (Liten Cea, Edilians, Elithis Solutions), Denmark (Teknologisk Institut, Bollerup Jensen), Germany (Fraunhofer Institute, Sievert Baustoffe, Leipfinger Bader) Spain (Acondicionamiento Tarrasense, Indresmat, Pintures) Norway (Hunton Fiber, Sintef), Italy (Mogu) and Belgium (Buildings Performance Institute Europe) (Fig. 1.). Partners involved in this project represent the complete building construction and renovation value chain: material manufacturers and providers, insulation systems promoters, laboratory and standardization experts, engineers for building renovation design. Such kind of organization is expected to generate maximized synergies between partners and accelerate the roll out of innovative highly efficient insulation products, with all aspects from materials to design and installation recommendation. The project shall therefore bring validated replication strategies embedding technical, marketing and environmental value altogether.

The project concept provides an inclusive solution for all energy losses to achieve low loss building envelope. Eight various technical solutions in response of each energy loss source. This implies low energy consumption for the building and when complemented by a renewable energy source as solar PV, the renovated building will reach zero energy balance. The material package we propose is adaptable to any kind of building and main climate situation in Europe. The optimized solution picks materials and components in the toolbox with the help of a simple methodology to reduce CO_2 emission and energy consumption in a significant way. All these materials are manufactured or re-used with low CO_2 emitting and low energy processes. Fig.1. reports an overview of the partners involved in the project and some of the materials involved in the renovation system.

Fig. 1. components to resolve energy loss in a building and the participants in EASI ZERo project.

Project objectives

The project aims to provide durable performance gain for thermal insulation by tailoring manufacturing processes, developing new additives, and incorporating mineral microstructures, with the goal of achieving higher performance at limited or zero additional cost, and verifying the materials' durability and performance through laboratory, pilot, and real-world tests. The attended gain on thermal performance is by 20% on material's thermal resistance Low embodied energy and CO_2 of EASI ZERo bio-based components will be developed, targeting a reduction of 30% in the embodied energy and CO_2 emissions savings. Attended results is also easy, fast and reliable installation of panels, accessories and finishing materials, with a reduction of installation worktime of about 30%.

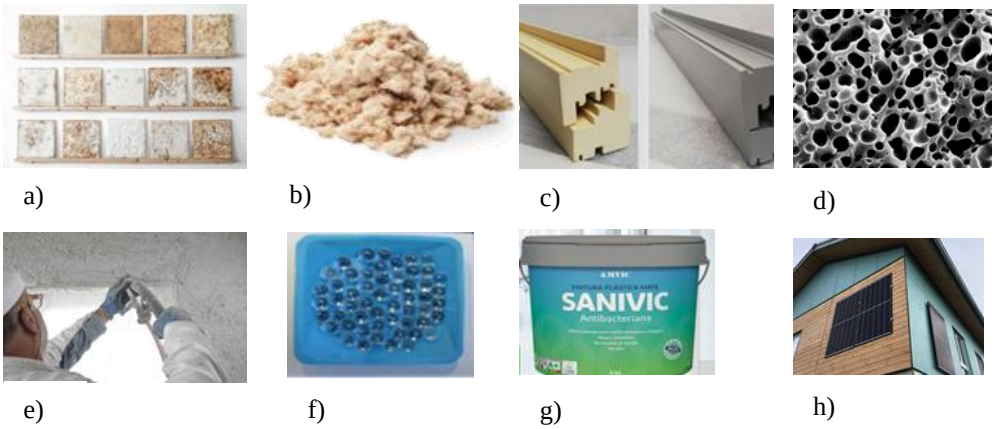
The target value on energy consumption is to stay lower than 50 kWH/m²/yr, and less than 4 $kgCO_2/m^2/yr$ for carbon emission.

The project will contribute to the circular economy via recycling and savings of material resources thanks to design for renovation allowing re-used for more than 80%. A low short payback time through the affordable material system and installation processes will be evaluated, with a target of 7 years.

An inclusive set of high-performance innovative materials

The primary outcome of the project is an inclusive and versatile package of insulation materials to, which would provide a complete solution for the renovation of any typology of buildings in any European climate zone. A short description of the material proposed in the project is here reported and in Fig. 2.

a) Mycelium-based product shows good comfort enhancement, reduced carbon emissions and embodied energy, but affordability and insulating performance and lifetime have to be further developed in the project.
b) Wood-fibres shows good insulation property and low embodied energy, but can improve carbon impact with zero-carbon binding agents and get real zero carbon. Bio-based thick panels for indoor and outdoor applications will be proposed for use cases.
c) Biopolymer, PUR (polyurethane) in our project show good properties for easy spray application and profiles manufacturing showing high thermal resistivity lightweight and mechanical stiffness to replace aluminium or PVC, which impacts the environment. We propose further development for industrial maturity, aspect and low embodied carbon and energy.
d) Waterglass foam is an innovative material type with excellent insulating properties due to its fine nanostructure and low embodied energy, that will enable highly insulating filling and singular points treatment, production at pilot scale with long lifetime.
e) Insulation render comes with high lifetime, with actual limitations in CO_2 impacts and high potential in thermal resistivity and capacitance. The most performing render actually incorporates expensive aerogels that will be replaced by our foam glass highly insulating aggregates.
f) Phase change materials (PCM) are usually flammable organics. Non-flammable PCM beads with 2-3 times higher storage capacity are actually available in the laboratory. Their incorporation in renders and hollow bricks will bring a new functionality, which then will be able to store energy and help comfort management in the building.
g) A paint will also be developed to capture VOCs and enhance the Internal Air Quality in buildings. Some products are already available to prevent bacteria's development and new additives will be used to obtain this health protection for building users and inhabitants.
h) Finally, PV panels will allow bringing buildings to near-zero energy buildings level. PV offers a renewable energy source allowing zero energy balance over year for a standard residential house. Renovating the roof with colored PV tiles or the façade with tight cladding system is possible at with an integrated mounting system.



a) b) c) d)

e) f) g) h)

Fig. 2 High-performance innovative materials. a) Mycelium-based product, b) Wood-fibres, c) Biopolymer, PUR (polyurethane), d) Water glass foam, e) Insulation render comes with high lifetime, f) Non-flammable phase change materials, g) Painting to capture VOCs and enhance the Internal Air Quality and h) colored PV tiles or façade with tight cladding system.

Project methodology

To achieve its ambitious goals, the project will first establish requirements thanks to various stakeholders implication.

The materials described previously will be further developed to enhance their physical properties, together with reduced elaboration costs ; components based on the assembly of several materials, or BIPV components will then be developed.

Prototyping and lab testing will ensure good performance. Upscaling of the production processes will allow for further testing at wall and experimental building scales. This phase will show both technical feasibility and proof of the real behavior of materials and developed assemblies exposed to weather conditions.

Numerical modeling will also be carried out at building scale to determine the effect of the renovation packages on building energy consumption and prove the efficiency of the solutions proposed. Models will be validated thanks to real scale experiments, then real use cases will be implemented.

Three real occupied buildings will be monitored and a complete energy diagnosis will be carried out; then numerical simulation will be done to evaluate various retrofit strategies for each building (energy, cost, LCA…).

All along the project, LCA will be done to evaluate the materials and improve their carbon footprint during the development phase, and global LCA of building renovation wil show the relevance of proposed solutions.

1.3 Conclusions and perspective

The EASI ZERO project aims to create a system for the easy renovation of buildings towards near-zero energy consumption and carbon emissions. This goal are achievable thanks to a set of ambitious innovations we describe hereafter. The first innovation is the inclusivity of the proposed package, relying on bio-based materials on one side and a high level of circularity on the other side. Together with easy installation and design methodology to set up by the renovation players, these strong assets bring high environmental value in the building sector.

References

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