Ref. Ares(2024)7237377 - 11/10/2024

This project is funded by the European Union.

EASI ZERo

GA n°101091531

Deliverable

ENVELOPE MATERIAL SYSTEM WITH LOW IMPACT FOR ZERO ENERGY RENOVATION AND CONSTRUCTION

Deliverable ID	**D7.1**
Deliverable name	**Circular strategies for new construction materials**
Deliverable description	Task 7.1 will support WP2, starting with an Eco-design approach, developing more circular material/products, and providing to WP3 and WP4 partners 1) strategies, 2) solutions and 3) design options to enhance building circularity and sustainability within a life cycle approach (circularity principles at design stage, use a sustainable, reused, recycled resources, new circular business models, life extension of products and buildings, enhance reusability and recyclability of materials at buildings end of life).

WP	7	Eco-Design and Sustainability Assessment
Task	7.1	Circularity requirements for insulation materials/products & eco-design

Dissemination level[1]	PU
Nature[2]	R

Due delivery date (Annex 1)	31/05/2023
Actual delivery date	31/07/2024

Lead beneficiary	LTAT
Proprietary project reference	Not applicable
Proprietary document reference	Not applicable
Contributing beneficiaries	DTI, SINTEF, INDRE, MOGU, HUNT

[1] Dissemination level: **PU** = Public, fully open, **SEN** = Sensitive, limited under the conditions of the Grant Agreement
[2] Nature of the Deliverable: **R** = Report

Version Management			
Filename	EZ0_D7.1_M6_V2.docx		
Author(s)	Carlos Larraz, Marco Mori		
Approved by task leader	Carlos Larraz	**Visa**	✓
Approved by WP leader	Carlos Larraz	**Visa**	✓
Approved by Coordinator	Philippe Thony	**Visa**	✓
Authorized by Coordinator	Philippe Thony	**Visa**	✓

Version	Date	Author(s)	Modification[3]
V0	31/05/2023	Carlos Larraz, Marco Mori	First draft
V1	01/06/2024	Carlos Larraz, Marco Mori	Finalised initial version
V2	29/07/2024	Carlos Larraz	Corrections according to monitor's comments
VF	29/07/2024	Carlos Larraz	Second version to be submitted

EC-Grant Agreement	**101091531**
Project acronym	**EASI ZERo**
Program	HORIZON EUROPE
Client	HADEA
Start date of project	01 December 2022
Duration	42 months
Disclaimer	Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Coordinator – Administrative information	
Project Coordinator name	Philippe Thony
Project Coordinator organization name	CEA
Address	CEA | INES campus | F-73375 Le Bourget-du-Lac
Phone Numbers	+33 784515240 - +33 784515240
Email	philippe.thony@cea.fr
Project web-sites	https://www.easizero.eu

[3] Creation, Modifications, Final version for evaluation, Revised version following evaluation, Final.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

Glossary

C2C: Cradle to Cradle
C2G: Cradle to Gate
C2Gr: Cradle to Grave
C2S: Cradle to Site
EU: European Union
G2G: Gate to Gate
GHG: GreenHouse Gas
LCSA: Life Cycle Sustainability Assessment
WP: Work Package

1. Executive summary

1.1 *Description of the Deliverable content and objectives*

The first part of this deliverable describes three important concepts for the EASI ZERo project, these concepts are “circular economy”, “eco-design” and “life cycle assessment”. Then, we report the application of the eco-design concept to the building industry. The third section is dedicated to circular strategies based on the Rs principles of circular economy. Finally, the reader can see some conclusions from the research analysis.

This deliverable pursues the objective of supporting work package 2 with circular strategies for the new construction materials of EASI ZERo project. This work package will help the development of two others (WP3 and WP4) so that it is clear the influence and importance on the utility and the success of the report. The best this report is done, the best can support WP2. Hence, the better WP2 is developed, the best designs will be done in WP3 and WP4.

2. Technical content

2.1 *Introduction*

According to "A new Circular Economy Action Plan" European Commission (2020a), the construction sector demands a lot of resources, consuming around 50% of extracted materials around the world. Greenhouse gas emissions from material extraction, product manufacturing, building construction and renovation imply approximately around 5-12% of overall gas emissions. Therefore, it is responsible for 35% of the waste generated in the EU. Improving the different processes of the construction sector could reduce these emissions by up to 80%. The built environment clearly influences various economic sectors and the quality of life of the population (p. 11).

The building renovation rate of the EU stock is approximately 11%, nowadays. However, only 1% of all renovations focus on energy efficient. The renovations that achieve at least a 60% of reduction in energy consumption, are approximately 0.2%/year (in some areas, energy renovations are nearly non-existent). At the current renovation rate, achieving net-zero carbon emissions in the building sector would take centuries (European Commission, 2020b, p. 2), in this contest in 2020 the EU commission launched the "Renovation Wave" program (European Commission, 2020b), in order to accelerate the adaptation of the existing building stock to more efficient buildings.

As side effect, a greater renovation rate will imply a greater resource consumption and waste production, with the risk of increase even more the impact the construction sector has on GHG emissions and sustainability in general. It is the reason why the European Commission has also adopted a strategy for the renovation of buildings in Europe based on the following key principles to ensure the sector's sustainability (European Commission, 2020b, pp. 3–4):

1. **Energy efficiency first**; it refers to prioritize cost-efficient energy efficiency measures in energy planning, policy, and investment decisions to improve both energy demand and supply. This includes implementing cost-effective end-use energy savings, demand response initiatives, and improving the efficiency of energy conversion, transmission and distribution.
2. **Affordability**, to everyone, especially lower-income households and vulnerable populations.
3. **Decarbonization and integration of renewables** to produce energy on-site or nearby. The use of energy system at local and regional level may help to heating, cooling and transport decarbonization.
4. **Lifecycle thinking and circularity**. Reducing the environmental impact of buildings requires not only improving energy efficiency but also circularity of the materials and components of the building and the devices that consume or produce energy.
5. **High health and environmental standards**; which means to facilitate the equal access of people to high air quality, good water management, disaster prevention and protection against climate-related hazards.

6. **Tackling the twin challenges of the green and digital transitions together**. The combination of smart buildings and energy distribution systems allow improving energy efficiency production and the use of green technologies at house, district or city level.
7. **Respect for aesthetics and architectural quality**.

2.2 *Main concepts*

To effectively support WP2 of the EASI ZERo project, it is essential to take into account the following three key concepts: Circular Economy, Eco-design and Life Cycle Assessment.

2.2.1 Circular economy

The European Statistical Office defines circular economy as an economic model that "aims to maintain the value of products, materials and resources for as long as possible. … by returning them into the product cycle at the end of their use". Reducing the products we discard will also minimize raw materials extraction, with an overall benefit for our environment. The Circularity of a product begins at the first stage of its lifecycle, the product design (EUROSTAT, n.d.).

Figure 1 shows the process of circular economy during the life cycle of a product, it has six stages. The first one is called sustainable design (also known as eco-design). The design stage significantly impacts the entire lifespan of a product. Beneficial improvements positively influence subsequent stages, while mistakes have negative repercussions. Once the design is finished and in addition with the extraction of raw materials, the second stage of circular economy begins, the production.

It is impossible not to pollute during production, but the better technology and the fewer the types of raw materials used, the less pollution there will be. The production chain tends to reduce the economic, energy and material costs.

Afterwards, a product must be distributed to the users. Although it is not possible to predict precisely how a product will be distributed, factors such as size and assembly capability can influence transportation costs.

Then, the product is used by consumers. Over time, it may lose certain properties that affect its functionality. If the design is well executed, the product can be easily reused or repaired (both technically and economically), thereby extending its durability.

When reuse or repair is not an option, the different materials/components of the product should be easily separable and collectable. The better the separation of the different components of the item, the more materials can be recycled and the less residual waste is produced.

Finally, the cycle is complete when the product's recycling materials are reused in the manufacture of new products.

Figure 1: Circular economy scheme of the life cycle of a product. Source: European Parliament Research Service[4].

2.2.2 Eco-design

"More than 80% of the environmental impact of a product is determined at the design phase" (European Commission, 2012, p. 3), so that the design becomes the most important stage in circular economy, and eco-design is the methodology to enhance the design for more sustainable products. An error in this first stage has a major impact on the rest of the product's life cycle. The eco-design methodology, as represented in Figure 2, is a continuous process that runs through all design phase, starting with an initial measurement of the impacts generated, providing improvement strategies, and verifying the final improvements generated.

There are many variables to consider when designing, such as ease of raw material sourcing, number of components, complexity of production, product distribution, recyclability, etc... This report

[4]https://www.europarl.europa.eu/topics/en/article/20151201STO05603/circular-economy-definition-importance-and-benefits

presents a first attempt at eco-design solutions for each of the different products selected for the EZ0 project.

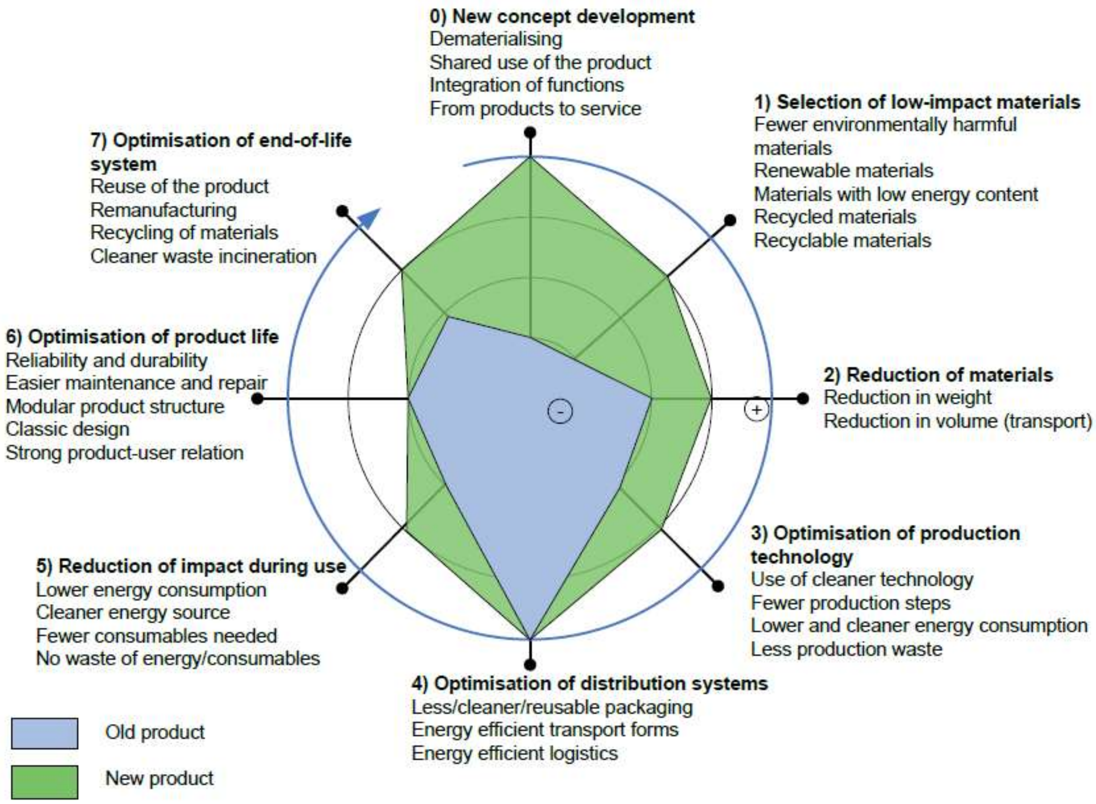

Figure 2: The eco-design strategy wheel (Brezet, H.; Van Hemel, C.) [5]

2.2.3 Life Cycle Assessment

Currently, there are many different ways of designing, but when it comes to eco-design, the concept of Life Cycle Assessment (LCA) is involved in all of them. A LCA is an evaluation tool used to analyze the environmental impact of a product, process or activity throughout its life cycle, taking into account energy and material inputs.

Over the years, different approaches to LCA have been developed with different boundaries. These approaches define the scope of the assessment and determine which stages of the product life cycle are considered (Figure 3). These approaches are: Gate to Gate (G2G), Cradle to Gate (C2G), Cradle to Site (C2S), Cradle to Grave (C2Gr), and Cradle to Cradle (C2C).

[5] Figure from (Huulgaard and Remmen, 2012)

G2G is an approach in LCA that focuses on a specific value-added process within the production chain of a product. It considers the environmental impact from one gate to another gate, excluding the upstream and downstream stages. G2G has a relatively short lifespan and provides a partial view of the product's lifecycle.

C2G covers the entire lifecycle of a product from the extraction of raw material (cradle) to production (gate). It includes activities such as material extraction, transportation, processing of materials and manufacturing. C2G assesses the environmental impact of a product until it leaves the production facility.

C2S extends the scope of C2G by including assembly and transportation activities of the product from the manufacturing site to its intended destination or construction site. It considers the environmental impact associated with these activities in addition to the stages covered in C2G.

C2Gr encompasses the complete lifecycle of a product, starting from its raw material extraction (cradle) to its disposal or end-of-life stage (grave). It includes C2S scope in addition to the use phase, maintenance, and eventual disposal of the product. C2Gr aims to evaluate the environmental impact of a product throughout its entire lifespan, from creation to disposal.

Finally, C2C approach focuses on designing products that can be recycled, reused or safely returned to the environment at the end of their life cycle. It emphasizes the eco-design to make products environmentally friendly and able to be continually recycled in a closed-loop system. (Çimen, 2023, p. 4).

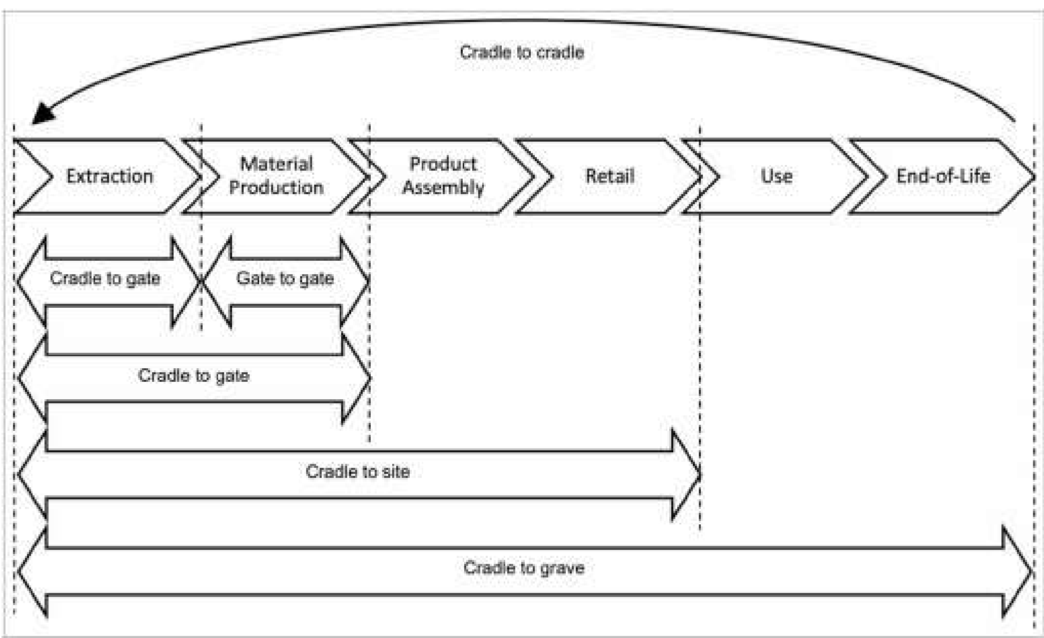

Figure 3: LCA approaches.

2.3 *Considerations of eco-design in building industry*

Building life cycle stages (Figure 4) differ a bit from those of products explained in section 2.2.1. Due to the specific characteristics of buildings, a distinct lifecycle framework is necessary to understand their impact on the environment, society, and economy, as these impacts vary across different stages. Meanwhile a product use to be produced in a factory and then distributed to the users, each building is produced in a specific location and can't be move from there (except mobile homes).

The lifecycle of a building can be divided into four main parts and one supplementary: Product stage, construction, use, end of life and, if it's possible, recovery of some materials from the building.

In the product stage, the raw materials needed for the construction of the building, are collected and processed into secondary materials. After that, these are transported to a factory where a set of construction products are manufactured with them.

The next stage is construction. The construction products are transported to the specific location where the construction of the building takes place. Then, the different construction activities, such as the assembly and installation of building components, take place.

Afterwards, the building is used. The use stage of the building implies the maintenance of the facilities, the reparations in case of damage of a component, the replacements when an item can't be repair and the refurbishments needed, as well as the management of the operational energy and water use.

Finally, during the end-of-life stage, the building is unoccupied and demolished. The waste generated is transported to waste processing plants. Some materials from this waste are recycled and the rest are disposed.

The supplementary stage takes place if it is technically and economically feasible. Some materials and components are recovered front the building and reuse or recycle for another purposes.

Understanding and managing the various stages of the building lifecycle is essential for making informed decisions regarding sustainable construction practices, resource utilization, energy efficiency, and waste reduction. It enables stakeholders to address environmental and social impacts, promote economic viability, and ensure long-term sustainability.

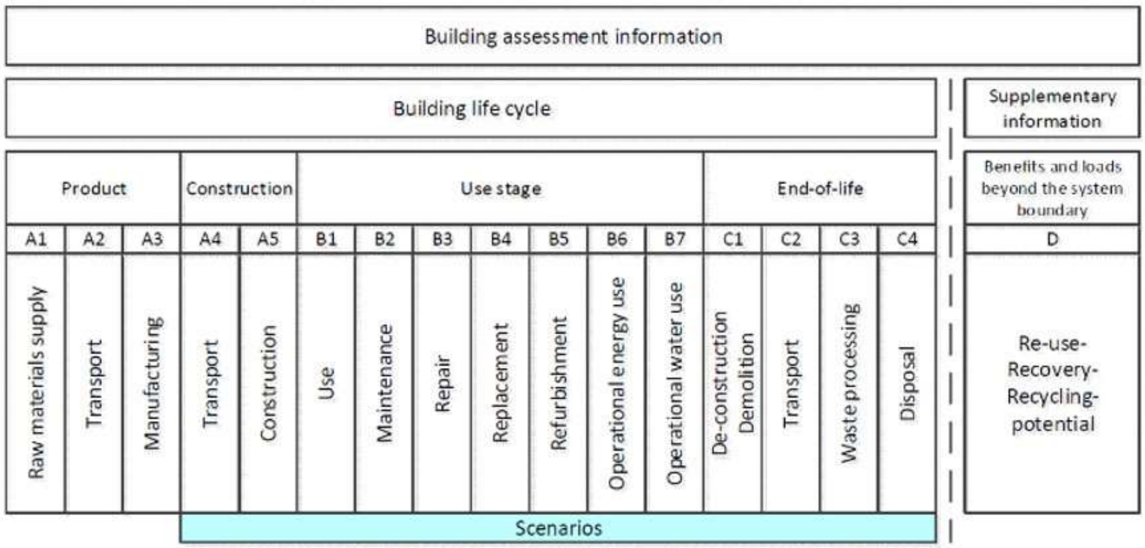

Figure 4: Building life cycle stages from EN 15978:2011.

The eco-design concept depends on the economic sector. According to the European commission, there are three main parameters to consider in the eco-design process on the construction sector: durability of the building and its components, adaptability to its use and reduction and high-quality management of waste.

2.3.1 Durability of buildings and its components

In the context of eco-design, the "durability of buildings and its components" refers to the capacity of a building and its components to delay deterioration over time while maintaining their functionality for the users. To do so, it important to focus on the design and construction stages to ensure that buildings have a long lifespan and need minimal maintenance or replacement of components.

Durability is an important aspect of eco-design because it directly impacts the sustainability and environmental performance of a building. A durable building minimizes the need for frequent repairs, replacements, or renovations, which reduces the consumption of resources such as materials, energy, and water throughout its lifecycle. It promotes resource efficiency by maximizing the use of building materials and reducing waste generation.

Durability is closely linked to the quality and performance of a building. Buildings with well-designed, durable components provide better resistance to weather, wear, and aging, which contributes to occupant comfort, safety, and satisfaction. It ensures that the building remains functional and performs as intended throughout its lifespan.

In the eco-design framework, considering the durability of buildings and their components is fundamental to create sustainable and resilient built environments. It involves selecting appropriate materials, designing for durability, implementing proper maintenance strategies, and considering the expected lifecycle performance of the building to minimize environmental impacts, optimize resource use, and enhance overall building performance (European Commission, 2020c).

2.3.2 Adaptability to its use

In the context of the eco-design, "adaptability" means the ability of a building for accommodating changes in use, functionality, or technology during time its lifespan. It involves designing and constructing buildings that can easily and efficiently adapt to evolving needs, preferences, and environmental conditions throughout their lifecycle.

Adaptable design anticipates and prepares for future changes and advancements in technology, energy systems, regulations, and user requirements. It allows for the integration of new technologies, systems, or energy-efficient features without significant disruption or costly modifications to the building. This future-proofing aspect ensures that the building remains relevant and sustainable over an extended period.

In the eco-design framework, considering adaptability is crucial for creating buildings that can evolve with changing needs and circumstances, maximize resource efficiency, and enhance long-term sustainability. It involves strategic design choices, such as modular construction, flexible layouts, and the integration of smart technologies, to ensure buildings can adapt to future challenges, minimize environmental impacts, and provide ongoing value to occupants and stakeholders (European Commission, 2020c).

2.3.3 Reduction and high-quality management of waste

In the context of the eco-design, "reduction and high-quality management of waste" refers to strategies and practices aimed at minimizing the generation of waste during the lifecycle of a building and ensuring that any waste produced is managed in an environmentally responsible and efficient manner. It involves designing, implementing, and optimizing waste management processes to achieve waste reduction, recycling, and proper disposal.

The primary objective is to minimize the generation of waste throughout the lifecycle of a building, starting from the construction phase to the operation and eventual decommissioning. This can be achieved through various strategies, such as using efficient construction methods, optimizing material usage, and implementing waste prevention measures during the building's operational phase.

The second objective is the high-quality management of waste, which implies the recycle and reuse of materials during the lifespan of the building to reduce their environmental impact. It involves implementing recycling programs and using components of the building that can be easily disassembled and reused at the end of their life. It also takes into account the management of waste that cannot be recycled or reused and must be discarded.

The reduction and high-quality management of waste minimizes the environmental footprint of buildings during their lifespan and save resources. (European Commission, 2020c).

2.4 *Circular strategies for new construction materials: The Rs principles*

The Rs principles refer to a set of guidelines or principles that focus on sustainable consumption and resource management. The name "Rs principles" is derived from the initial letter "R" of each principle, and it is commonly used to refer to the key actions or strategies that individuals, businesses, and communities can adopt to promote sustainability.

The Rs principles are often associated with waste management and resource conservation, and they provide a framework for responsible consumption and environmental management. These principles aim to shift away from a linear "take-make-dispose" model of resource consumption towards a more circular and sustainable approach. The Rs principles are practical guidelines that help to minimize environmental impact, conserve resources, and promote sustainability.

2.4.1 14´Rs principles

There are many Rs principles regarding the building life cycle environment. In 2021, Yuan and Tang analyzed 10 Rs principles for Green design of a general product (Yuan and Tang, 2021, pp. 1–4). In 2023, Çimen identified 22 Rs principles but these were clarified into 14 for the construction industry after studying them and eliminating conflicts in their understanding (Çimen, 2023, p. 8). The 14 Rs principles are briefly defined below, taking into account the studies of the authors mentioned above.

R1 Refuse: this principle opposes introducing a new product or process when an existing one can sufficiently serve the purpose, especially if the new option is unnecessary or unsustainable. It minimizes the waste production by refusing to use materials such as single-use plastics and non-recyclable products.

R2 Rethink: the principle re-evaluates our actions concerning what we buy and how we dispose of them and seeks ways to do things more sustainably.

R3 Reduce: It aims to achieve more with fewer resources for the same product without compromising functionality, either by optimizing resources or designing products for multiple uses. It requires that design follows the next characteristics:

1. The design of the product obeys the rule -suitable is good
2. Product design should be simple in everything, aiming for the simplest structure, process, packaging, etc…
3. Design activities should be efficient, but not careless, an error in design may lead to the subsequent production or cause of thousands of times the loss.

R4 Re-use: this principle tries to create products that can be reused multiple times and are durable enough to prevent waste. It requires the following in the design:

1. The product should be designed to be durable. To enhance the reliability of reusable parts, manufacturers should focus on extending the product's lifespan and warranty period, rather than opting for frequent replacements.
2. Reusable parts should be easily collected and tested to improve the reuse process.
3. Avoid designing disposable products, as they offer the lowest cost-performance ratio and contribute significantly to environmental pollution.
4. Product design strive for standardization, serialization, generalization and modularization.

R5 Repair: It is essential that the components of the product are easy to repair if damaged. This requires the product to be designed for easy disassembly (DFD). In Design for Disassembly, the product structure must be considered. Key criteria for disassembly design mainly include:

1. The product can be designed taking into account the ease with which damage can be noticed and facilitate easy maintenance.
2. Implement a modular design approach, especially for components that are reusable or contain toxic materials, to ensure they are easy to disassemble.
3. Reduce the number of parts, simplify the structure of parts, simplify the manufacturing and recycling process.
4. Use standard materials to minimize the variety of materials used and reduce the inclusion of metal inserts in plastic components.
5. Utilize standardized parts, reduce the number of fasteners, and aim to use the same fastening method wherever possible.
6. Prevent parts from aging due to pollution and corrosion by sealing any toxic materials.

R6 Refurbish: it is the process of restoring an old or discarded product to a functional and updated state. This involves replacing damaged components and updating the product so that it looks new. The primary goal of refurbishing is to extend the item's lifespan, allowing it to serve its intended purpose once again. Refurbishment helps minimize waste generation and conserve resources. Consequently, it contributes to the reduction of carbon emissions associated with the production and disposal of new goods.

R7 Re-Manufacture: restores and enhances used or discarded products to their original condition with full functionality retained. Green re-manufacturing design technology mainly includes:

1. Simplify the process.
2. Realise a quality control.

R8 Repurpose: it is the concept of finding alternative uses for items that were not the original ones. It implies thinking creatively and finding new ways to utilize items that might otherwise be discarded and managed as waste. By repurposing, we can extend the lifespan of objects and reduce waste generation. Repurposing can be applied to a wide range of objects, from everyday household items to larger structures or materials.

R9 Renew: it focuses on utilizing green, renewable energy sources and environmentally friendly materials. It emphasizes the use of materials that are biodegradable, recyclable, or compostable. Green materials are sourced sustainably, minimizing harm to ecosystems and biodiversity. They are also free from toxic substances and pollutants, reducing environmental and health risks. By choosing green materials, we can reduce waste, minimize pollution, and promote a more sustainable and circular economy.

R10 Refill: this principle implies making products consumable through the use of refillable containers, instead of relying on one-time disposable usage.

R11 Replant: It aims to create universal, standardized, and interchangeable components that can be easily disassembled, recovered, and reintegrated into new products or processes. The concept of universal, standardized, and interchangeable components enables efficient disassembly and separation of materials, making it easier to recover valuable resources and recycle them effectively. It also promotes modularity and compatibility, allowing components from different products or systems to be easily integrated or replaced. By designing products with universal and interchangeable components, it becomes easier to repair, refurbish, or recycle them when they reach the end of their useful life.

R12 Replace: This principle focuses on finding and developing more environmentally friendly and socially responsible materials that can serve as substitutes for materials with negative impacts on the environment and human health. The principle recognizes that certain materials used in various industries or products may have detrimental effects throughout their lifecycle, such as high carbon emissions, resource depletion, toxicity, or difficulty in recycling. To address these issues, the principle emphasizes the importance of identifying and adopting sustainable material alternatives that can achieve similar or better performance while reducing environmental and social impacts.

R13 Recycle: This concept means to reclaim or reprocess items or materials that have expired from their purpose, so they may once again be made into something useful, and reduce the necessity of raw materials extraction, manufacturing and energy use. There are two types of recycling cases:

1. Primary recycling; it means that waste products are recycled to produce the same type of new product consumption, for example the recycled paper.
2. Secondary recycling; in which waste resources are converted into raw materials for other products, such as a mixture of various colored plastics to regenerate black plastic products.

Primary recycling is much more efficient than secondary recycling, and can reduce the consumption of raw materials better, which is the optimal route of circular economy. In order to facilitate product recycling, it is required that:

1. Different types of materials can be efficiently disassembled to simplify sorting and recycling, ensuring all raw materials can be reused effectively.
2. Utilise raw materials that are recyclable and sourced from reused materials.
3. Avoid the use of non-recyclable raw materials and have greater caution in using toxic or harmful substances.

R14 Recover: this concept focuses on utilizing biodegradable or waste materials through various thermal or biological processes to generate energy, heat, fuel, or compost. It means that the performance of waste products is easy to detect and recover.

The Recover principle aims to extract value from waste materials and promote their utilization instead of sending them to landfill or incineration without any recovery of resources. It involves implementing processes that allow for the recovery of energy or the transformation of waste materials into useful resources.

Thermal processes, such as incineration or pyrolysis, involve the controlled combustion of waste materials to generate heat or produce energy in the form of electricity or steam. These processes can be used to harness the energy content of waste and reduce dependence on non-renewable energy sources.

Biological processes, such as composting or anaerobic digestion, are based in the decomposition of organic waste materials by microorganisms. Composting uses organic waste to produce nutrient-rich compost that can be used as a soil amendment in agriculture. Anaerobic digestion uses organic waste to produce biogas (composed primarily of methane) that can be used as a renewable energy source.

2.5 ***Materials/products studied***

During the development of the materials and products of this project, some R principles have been already applied, however, more R principle should be applied if possible. In order to guide the EasiZero products development, under the concept Eco-design, the partners involved in the materials development had been engaged. The circular design strategies were presented to each partner that at this stage were dealing with material development, they were MOGU (Mycelium), HUNTON (wood fiber), Indresmat (sprayable BIOPUR). This interaction was meant to define with them the adoption of circular strategies in their work, as well as challenging and inspiring their research, to be the most circular and sustainable as possible.

This is the first step in the overall Eco-design approach, that will continue through T7.2, evaluating the EasiZero products sustainability with a simplified LCA, at month 24, that will give further feedback of the degree of sustainability to the consortium.

2.5.1 Mycelium-based thermal insulating panels

R1 Refuse: the mycelium panels are produced in a sustainable way, eliminating unnecessary processes and waste. Thanks to the innovative mycelium-based technology, production is completely natural, it means that they do not use machinery for production.

R4 Reuse: the panels can be reused.

R9 Renew: mycelium is a biodegradable material and its production needs a small quantity of energy.

R11 Replant: the panels are standardized through production with molds that can guarantee industrial production. They are also interchangeable thanks to their modular design that allows to respond to the needs of each specific project.

R12 Replace: the insulation panels are made by mycelium which is a biodegradable material, instead of conventional insulation materials such as glass wool or polyurethane.

R13 Recycle: the panels are 100% recycle.

R14 Recover: mycelium grows on low value substrates, coming from the agro-industrial industry. Fungal mycelium acts as reinforcement to the matrix structure, creating a 100% plastic-free material composite.

2.5.2 Wood-fibre insulation panel

R2 Rethink: the current efforts are on replacing the binding agent with a bio-based binding agent. While trying to find the right binder, they also will consider how this binder is produced, how it will affect our end-product, our process (energy consume, processing time etc.).

R4 Reuse: If handled properly, the panels will be possible to reuse.

R5 Repair: nowadays, it is believed that it will be more cost efficient to use broken parts as raw material in existing process.

R6 Refurbish: as in R5, nowadays, it is believed that it will be more cost efficient to use broken parts as raw material in existing process.

R9 Renew: green energy is used to produce the insulation panels. Regarding the use of green materials, as mentioned above, they are doing efforts on replacing the binding agent with a bio-based binding agent.

R12 Replace: this panels seems to be more sustainable than many of its competitors and they are trying to improve the degree of sustainability by replacing the binding agent for a bio-based one.

2.5.3 Sprayable PUR insulation foam

R1 Refuse: when producing the foam, they refuse toxic and unsustainable additives (halogenated flame retardants, hazarous and unsustainable blowing agents), organic solvent-based demolding agents and solvent-paint.

R3 Reduce: they reduce the number components in our formulations as unnecessary additives.

R9 Renew: low energy is required for production and biobased materials are used for creating the foam.

R13 Recycle: they recycle material from rigid polyurethane to be used in the foam.

3. Conclusions

The built environment, has a substantial impact on various sectors of the economy and plays a crucial role in the quality of life and sustainable development. It consumes around 50% of all extracted material. The construction sector generates, in the EU, the 35% of the total waste generation, approximately.

To create products in the industry with minimal environmental impact, it is essential to consider the concept of the circular economy. The circular economy is an economic model that focuses on preserving the value of products, materials, and resources by reintroducing them into the production cycle after their initial use, while minimizing waste generation. This model consists of six stages: sustainable design (the most important), production, distribution, consumption/reuse /repair, collection and recycling.

While up to 80% of products environmental impacts are determined at the design phase, eco-design is necessary to be considered. Eco-design involves incorporating sustainability considerations into the design process. One useful tool for evaluating the sustainability of a product is Life Cycle Assessment (LCA). Over time, different approaches have been developed for conducting LCA, each with its own set of boundaries and considerations. These approaches determine the scope of the assessment and specify which stages of the product's life cycle are taken into account. These approaches can be: Gate to Gate (G2G), Cradle to Gate (C2G), Cradle to Site (C2S), Cradle to Grave (C2Gr), and Cradle to Cradle (C2C).

In the context of eco-design in the building industry, there are three key parameters to be considered during the design process: durability of components, adaptability to its use, and reduction and high-quality management of waste.

The Rs principles are a set of guidelines that helps to eco-design. They serve as a framework for promoting more environmentally friendly practices in product development. For the building framework, 14 R principles may be applicable: Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Renew, Refill, Replant, Replace, Recycle and Recover.

Some developers of EASI ZERo products have been engaged, to check whether they already applied any of these 14Rs principles to its materials/products, or there are any other R principle that they didn't considered but can be applied. Not all the Rs principles can be applied to a material/product, it depends on the nature, the characteristics and the aim of the material/product.

This was the first step of the Eco-design approach, that will further be developed in WP7, through T7.2, with continuous feedback on products sustainability, to those partners that are involved in WP3 and WP4.

4. References

Çimen, Ö. (2023) 'Development of a Circular Building Lifecycle Framework: Inception to Circulation'.

European Commission (2012) 'Ecodesign your future'.

European Commission (2020a) 'A new Circular Economy Action Plan'.

European Commission (2020b) 'A Renovation Wave for Europe- greening our buildings, creating jobs, improving lives'.

European Commission (2020c) 'Circular Economy Principles for buildings design'.

EUROSTAT 'Circular economy: Policy context'. Available at: https://ec.europa.eu/eurostat/web/circular-economy/information-data/policy-context.

Huulgaard, R.D. and Remmen, A. (2012) 'Eco-design Requirements for Televisions'.

Yuan, Q. h. and Tang, L.Y. (2021) 'The Principles in Green Design'.