Interreg Sudoe

EUROPEAN UNION

IMIP_
Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based Panels

European Regional Development Fund

D2.3.1
Study on cascading use of interlocking panels

IMIP-SOE3/P3/E0963

Project funded by the Interreg Sudoe programme through the European Regional Development Funds (ERDF)

PROJECT CONTEXT

Project acronym	IMIP
Project title	Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based Panels
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Working Package (WP)	WP.2 Design and manufacture of interconnected modules
Deliverable	D2.3.1 Study on cascading use of interlocking panels
Summary	This report describes how the IMIP modules will be disassembled for future uses in construction or for its recycling for different uses.
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CONTENT

INTRODUCTION

This work is contemplated in the IMIP project of the INTERREG SUDOE Program, within Working Package 2: (WP2 Design and manufacture of interconnected modules). The study is carried out specifically on Portugal, France and Spain.

The analysis focuses on future potential uses of disassembled parts.

From the perspective of the circular economy, the principle of material efficiency and cascading use in the technological cycle helps ensure sustainable sourcing and use of the wood in the system. The interconnected modules have been designed based on the possibility of reusing itself or their components once buildings are dissembled for any reason. Furthermore, all the materials could also be recycled separately after their end-of-life. This is due each are natural and renewable raw materials: cork and wood so environmental criterions are fulfilled for IMIP panels.

EU policy is based on the environmental improvement of building construction, use and end-of-life phases. Traditionally, the building sector has been using high polluting and high-energy demanding materials and processes. Wood and cork engineering products in prefabricated versions, are suitable substitutes of those. The European Commission, to generate momentum for action, has published the Circular Economy Action Plan (COM 2020) where considers the necessity of designing sustainable products (2.1), climate-neutral and resource-efficient through, among others, increasing recycled content, while reducing carbon and environmental footprints. This document also defines the key product value chains, among which are construction and buildings responsible for over 35% of the EU´s total waste generation, encourage Governments to promoting frameworks for setting of carbon reduction targets and the potential of carbon storage, paying special attention to insulation materials which produce a growing waste stream. Wood products including cork are clearly suitable to fulfil these objectives. All these initiatives deal to the expansion of the recycling sector in the EU.

The framework of the IMIP project is summarized in table 1.

Table 1: Programme and Project objectives and results.

Programme specific objective	To improve energy efficiency policies in public buildings and homes through the implementation of networks and joint experimentation.
Project main objective	To support the change towards a low carbon economy using bioproducts (wood and cork) for smart, sustainable, and inclusive growth with a special focus on the public construction sector.
Project specific objectives	To design, validate and implement a new ecological construction system to improve energy efficiency in public buildings. Related activities are: - To design an ecological construction system based on innovative wood and cork products supporting a low carbon economy, - To test prototypes, - To develop an Information and Communication Technology for design, modelling, and evaluation of potential construction solutions, - To compare the modular and interconnected insulating panels designed with currently used insulating panels, - To disseminate results and to train prescribers.
Programme result indicator	Percentage of actors in the energy efficiency sector participating in transnational cooperation projects.
Project results	An interconnected modular system of insulating panels made of wood and cork to improve energy efficiency of buildings, including their entire life cycle. A BIM plug-in to analyse the environmental benefits of bioproducts used in construction (carbon storage and substitute effect).

IMIP panels

Several panels have been defined throughout the development of WP2 tasks. Following them and their components are described for better understanding of their cascade use (figure 1-4 and table 2).

- Panels type A: 1 layer of CLT63+ ribs of sawn timber. Insulation of cork (figure 1).

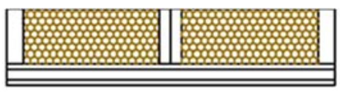

Figure 1

- Panels type B (and E): 2 layers of 45mm SWP-OSB, insulation of black cork expanded (figure 2).

Figure 2

- Panels type C: 2 layers of CLT63 and ribs of sawn timber. Insulation of granulated cork (figure 3).

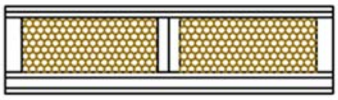

Figure 3

- Panels type D: 1 layer of CLT88 and insulation of black cork expanded (figure 4).

Figure 4

Table 2: Summary IMIP panels components

	Type A	Type B	Type C	Type D	Type E
Upper layer		CLT42 (SWP+OSB+SWP)	CLT63	CLT88 (Dw) CLT63 (Dr)	CLT42 (SWP+OSB+SWP)
Isolation	BCEB, 100	BCEB, 150	GC	BCEB, 150	BCEB, 100
Ribs	60*120 (x2)	-	60*200 (x4)	-	-
Lower layer	CLT63	CLT42 (SWP+OSB+SWP)	CLT63	-	CLT42 (SWP+OSB+SWP)

NOTE: Values are in mm. CLT: Cross Laminated Timber. BCEB: Black cork expanded boards. OSB: Oriented Strand Board. Dw: IMIP panel type D for walls. Dr: IMIP panel type D for roofs.

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OBJETIVES

The objective of this analysis is to determine future potential uses and describe how the IMIP modules will be disassembled for future reuses in construction or for its recycling for different uses.

In the first section, we defined the principles this research followed.

In the second section, future uses for the construction systems developed in the IMIP project after their first use of their useful life were defined. One of the reasons for this reuse is to extend the useful life of the raw materials and systems over time, as well as to make compatible systems that can be assembled and disassembled repeatedly to optimize their use.

In the third section, the report studies the cascading use of the interlocking panels from its first use to cradle. The cascading use is the main principle of the sustainability idea of cradle to cradle of the IMIP system.

In the fourth section, the end-of-life is analysed.

Last section of the report concludes with the main ideas.

RESEARCH PRINCIPLES

Cradle-to-Cradle

The cradle-to-cradle analysis is a strategy that will prevent companies from later, after launching their product on the market, from having to develop an initiative to reduce its negative environmental impact and for its proper functioning the concept is based on three principles.

1. Waste is equal to Resource: products and services must be designed in such a way that once their useful life is over, all the elements that compose it can be used as resources. This system eliminates the concept of waste because they are equivalent to resources.
2. Renewable energies: the design of the products or services must also integrate renewable energy systems.
3. Diversity - Natural systems function and thrive through complexity. This means that instead of creating solutions to manage the environmental impact after the project is launched, from the beginning, the diversity of designs that have a local focus, that promote a better function, must be supported and promoted.

The growing trend of increasing cradle-to-cradle analysis demonstrates its popularity in recent years, motivating companies and their respective value chains to work under a more sustainable structure and even to create new economic models, as in the case of the circular economy.

This report focuses on potential future uses of IMIP panels after its main use that will be defined depending on the state of the extracted wood based on two main areas:

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WASTE WOOD CLASSIFICATION

Nowadays, there is no commonly applied international classification of wood waste. Management of the wood waste so streams differ among countries, depending on national regulations and waste classifications if do.

In this context, the UNECE/FAO (The United Nations Economic Commission for Europe) one of five regional commissions of the United Nations, has developed a project related to a wood waste classification. According to the still Draft Catalogue of wood waste classifications (UNECE, ECE/TIM/EFC/WP.2/2021/Inf.5), Spain, France and Portugal classifications are the next:

Spain

In Spain there is no national classification for wood waste or recovered timber being adopted the European List of Waste (OJEU 2018), usually used in management facilities. Table 3 shows the most common classification that apply to wood (Llana et al., 2020). European Wood Codes (EWC) starting with 17 are assigned by construction and demolition companies in-situ and starting with 19 are assigned by wood waste management facilities during processing.

Table 3. European system of waste classification (OJEU)

EWC	MATERIALS
170201	Wood non-hazardous (when wood waste is segregated in-situ, skips containing only wood)
170903	Construction and demolition wastes containing hazardous substances (mixed or segregated wood waste in the skips)
170904	Mixed construction and demolition wastes non-hazardous (when wood waste is mixed in the skips with other materials)
191206	Wood containing hazardous substances
191207	Wood other than that mentioned in 191206 (this code is assigned to 170201 skips arriving at waste management facilities or is assigned to wood from 170904 skips after it is segregated from other materials in the facilities)

The process of recycling depends on the origin of waste wood streams which received a code (table 2) and the facilities decide on the treatment for wood recovery, examining the values of hazardous substances on site.

France

France has a waste law including the Environment Code. This law refers to the European List of Waste adopting classification codes for waste wood according to the European Union ones (OJEU 2018). Also, the Facilities Classified for Environmental Protection (ICPE) provides a classification system of wood waste (table 4) which is harmonized also with the Agency for the Ecological Transition (ADEME 2018) related to wood fuels for energy sector.

Table 4. ICPE system of wood waste classification

ICPE Code	ADEME Code	MATERIALS
2910-A	3-A	Unpainted and untreated wood to be used as biomass fuel
2910-B	3-B	Wood treated with low-concentration chemical additives below limit value concentrations
2771	3-C	Wood treated with low-concentration chemical additives above limit value concentrations
2770	3-D	Treated and hazardous wood waste

The waste producer or holder can either carry out the recovery himself or hand over the waste to an intermediate operator, or the operator of a recovery, or to a recycling facility.

Portugal

Portugal also adopted the European Waste Framework Directive using the European List of Waste for wood waste classification since there is no national classification for wood waste or recovered timber. Therefore, the European List of Waste (OJEU 2018) was adopted as legal basis.

The classification in place consists basically in sorting hazardous from non-hazardous wood waste.

A. REUSED

1 Extracted IMIP panels in perfect condition for structural uses

Extracted IMIP panels that sanitary condition and structural behaviour are held may be employed in some of the compatible construction systems described in D221 deliverable.

1.1 Compatible wood systems for IMIP panels reused

1.1.1 Wall forming systems

A.1 Frame Wall

A1.1 Framing

A1.2 Wall System

A.2 Solid Timber Wall

A.3 Panels or Plated Systems

3.1 Sip Structural Insulates Panels

A.4 CLT for Walls

4.1 CLT

4.2 CLTI panels with insulation

A.5 Timber Block Walls

5.1 Modular System

1.1.2 Horizontal structure

B.1 Platform Frame (rib systems)

B.2 CLT Cross Laminated Timber, flooring and slabs

1.1.3 Roof forming systems

C.1 CLT Cross Laminated Timber for roof

C.2 Sip Panels for roof

C.3 Sandwich Panels

1.2 Compatible Mixed systems for IMIP panels reused

1.2.1 Steel structure + IMIP panels

1.2.2 Reinforce concrete + IMIP panels

1.2.3 Load-bearing walls + IMIP panels

2 IMIP panels recovered in good condition for non-structural uses

The IMIP panels can also be incorporated in other not structural uses if the panels are in a good sanitary condition.

Figure 5. Non-structural uses of IMIP panels

Panels can be reused in buildings but without structural function, as decorative walls, coatings and celling, incorporating insulation (figure 5).

Panels that are reused after recovery are trimmed and damaged parts removed, transported to site, fitted, and can be reassembled on site in new designs as furniture, for example, as tables, wardrobes or chairs.

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B. RECYCLING

1 Recycling components for structural or non-structural uses

Disassembled panels constituted by CLT, cork, OSB boards and beams that are recovered in good condition, can be reused itself or as components of other products for walls, floors, furniture, coatings and ceilings. Previously, it is important to carefully remove nails or screws and grading properly if they are for structural purpose.

Its thickness and length can be adapted to the demands of each project since the beginning in its first use. Panels made from CLT are generally assembled and cut in production, already providing for the joints, openings and perforations specified in the design.

Common recycling uses are:

Construction, interior lining, floors, concrete moulds, construction industry as web plates for beams, fixtures and fittings as a base material for parquet floors as and a base material for covering strips, furniture industry, furniture frames.

Cork is also a 100% natural and biodegradable product but its positive environment impact can be further expanded through recycling (Amorin). This product can be ground into granules for multitude of uses as covering, other insulation products, sports surfaces, tennis balls, shoes or aircraft components. Also, cork dust is a neutral source of energy.

2 Wood extracted in good quality without benefits of use as boards or degraded wood with the possibility of use for composites industry.

Wood extracted in good quality without benefits of use as boards (structural or non-structural) may be chipped to produce engineered wood products like LSL, LVL, PSL, OSB, MDF or particleboards (see D1.3.1) (figures 6-11).

This wood recycled process need previously a wood grade, cleaning and treated in recycling plants. Pieces of solid wood will be found mixed with laminate material, plywood and even treated timber. This poses a big challenge when recycling because they must all be separated. It is a labor-intensive process that is also time-consuming. The wood is weighed and pass quality control, then is sorting in accordance with the waste wood grades and loaded into a powerful primary wood shredder that breaks the pieces through a variety of processes. The recyclable material is separated as metals, etc. and secondary shredding (fine The product varies in size and the vibrating screener performs well in sorting out the products. Various sizes of the results are applied to different uses. The oversized pieces are re-circulated and the fine material is used as compost or animal beddings. The size in between the two is used in broad mills. The process is efficient in ensuring that the products are not wasted (RecycledAid, UK).


Figure 6. MDF boards


Figure 7. Particle boards


Figure 8. Fibre boards


Figure 9. Wood fiber cement board


Figure 10. Oriented Strand Board (OSB)


Figure 11. Laminated Veneer Lumber (LVL)

The produced boards could have different applications:

- Furniture backs and drawer bottoms

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- Wall cladding
- Interior doors
- Manufacture of gifts, frames and household items
- Laminated curved structures
- Packaging
- Non-load-bearing use in dry conditions
- Boards for non-load-bearing use MDF (Thin) L-MDF (Light)

Light materials are popular. In furniture production in particular, people are increasingly concerned about combining low weight with good technical properties. Light MDF is precisely the right combination. It has a density of around 600 kg/m³, significantly lower than the standard MDF, allowing for greater flexibility in the development of furniture solutions.

3 Heavily weathered wood

This product can only be used for energy purposes, such as pellets.

3.1 Biomass pellets

Reduction of greenhouse gas emissions to the atmosphere and independence of global economy from fossil fuels are the main reasons to use renewable resources for energy production. Biomass plays dominant role in the production of "green" energy (figure 12). Biomass was responsible for approximately 96.9 million metric tons of energy generated from renewable resources in the European Union in 2019 (Eurostat 2019). Latent energy potential of biomass derives from solar energy. Biomass consists of the organic matter created during photosynthesis process from water and carbon dioxide, with a participation of the sun.

Figure 12. Wood pellets

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There are three forms of energy that can be extracted from biomass (The Schumacher Centre of Technology & Development 2005):

1- Biogas - methane, obtained in the process of anaerobic fermentation of plant feedstock, animal waste and municipal waste.
2- Liquid biofuels - organic matter derived from production waste (bagasse) or energy crops (e.g. rape), that undergo chemical and physical processes in order to obtain ethanol and vegetable oils, which can be used as motor fuel.
3- Fuel in solid form - dry mass collected from the trees (figure 11), plantations of energy crops, grasses, crop residues and other consumer and industrial waste of organic origin that is treated and used for direct combustion.

C. END-OF-LIFE

1 Heavily degraded wood without the possibility of use in the wood industry and wood ash

1.1 Used for compost

Figure 13. Compost

According to the Renewable Energy Directive 2018/2001/EU one of the goals of the EU is to raise for 2030 the proportion of renewable energy to 32% of the total energy consumption. Among other measures, the construction of biomass combustion plants has been encouraged, and therefore increasing amounts of wood ash are starting to accumulate.

Composting is a useful way of transforming livestock waste into organic fertilizer (figure 13), which is proven to increase soil nutrient levels, and thus crop yield. Remains from production and slaughter of small ruminants can become a source of important elements for plant growth, such as N, after microorganism-driven decomposition.

Throughout Europe, increasing amounts of wood ash are produced from biomass incineration plants. Most of these ashes are currently landfilled, despite their nutrient and micronutrient contents. The aim is to find a way to return wood ash from biomass incineration plants into the natural cycle of matter.

FINAL CONCLUSION

If we take into account the basic principle of reducing as much as possible the environmental impact of the construction sector, the use of low impact materials is a relevant option. To understand and find materials with a positive effect on the environment like carbon storage, we must apply principles such as the cradle-to-cradle analysis.

The use of wood for construction is one of the best examples of the cradle-to-cradle principle since wood is a natural organic material with a carbon storage and substitution effect behaviour. This mitigation effect can be used in the industry in in different product life phases. The IMIP project tries to uphold this principle.

The products derived from the research of this project, such as wood panels, CLTs, boards, beams, cork and wood-based compounds from the Interreg-SUDOE area has a value as a sustainable construction system. In addition, the use of these materials in different stages of the product's life, especially at the end-of-use, is an example of recycling and the development of the cradle-to-cradle system.

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