Life Cycle Assessment of an ETICS system composed of a natural insulation material: a case study of a system using an insulation cork board (ICB)

Marta Matos, Liliana Soares
ECOCHOICE
marta.matos@ecochoice.pt, liliana.soares@ecochoice.pt

Luis Silva, Pedro Sequeira
Saint-Gobain Weber Portugal
luis.silva@saint-gobain.com, pedro.sequeira@saitn-gobain.com

Joaquim Carvalho
Amorim Isolamentos, SA

ABSTRACT: External thermal insulation composed systems (ETICS) are insulation solutions available in the market with indisputable advantages regarding mechanical, thermal and hygrometric performance. These characteristics result in a reduction of energy consumption associated to heating and cooling of buildings with a consequent contribution to sustainability in buildings. Nevertheless, it is also necessary to evaluate these systems under international standards regarding the use of raw materials, production processes, transport to the construction site, use stage and end of life. This evaluation is then translated into potential environmental impacts distributed in different impact categories. This paper shows an overview of the Life Cycle Assessment (LCA) study developed to obtain an Environmental Product Declaration (EPD) according to EN 15804 and ISO 14025 of an ETICS system with an insulation cork board, presented by Saint-Gobain Weber Portugal. In this paper, a critical analysis of results is also provided, suggesting a set of potential improvements for each impact category.

1 INTRODUCTION

1.1 *Life Cycle Assessment (LCA) Type area*

As society becomes more concerned about global warming and other environmental issues, people start to become more aware of their day-to-day choices and are looking to find ways to minimize their negative impact on the environment. These increasing concerns with environmental issues triggered a subsequent demand from companies in ways of assessing the impacts of their activities in the environment. They are now investigating ways of improving the environmental performance of their products by substituting raw materials by recycled ones, reducing energy consumption and adopting strategies on pollution control. The LCA is one of the tools that have been used in the construction industry since the 1990s to evaluate the “cradle-to-grave” impacts of its activities. This approach considers the activities from the extraction of raw materials from the earth, the production process, the transportation to the construction site, installation, use and end-of-life stages. This evaluation is a great way to have a global view of the environmental impacts of the product in its whole life-cycle and to understand the conflicts between selection of products and processes, making it easier for the consumers or decision-makers to choose between the product or process that implies least environmental impacts.

1.2 *Environmental Product Declarations (EPD)*

According to ISO 14025:2006, the EPDs are environmental declarations that show quantified environmental information about the life cycle of a product to allow comparison between products that are used to performing the same function. This standard establishes the principles and specifies the procedures for developing EPDs and other Type III environmental declarations (verified by a third independent party) and programs.

EN 15408:2012 is a later European standard that, in accordance with ISO 14025, was created to provide the structure or core Product Category Rules (PCR) to ensure that all EPDs of construction products, construction services and construction processes are derived, verified and presented in a harmonized way.

2 METHODOLOGY

2.1 *Structure of the study*

The presented study was developed in compliance with the principles in ISO 14025 and EN 15804 standards. The main structure of the LCA study is divided in 4 chapters:

(1) Goal and scope, where it is defined the objectives of the study, the functional unit used, the product's description and application and also the boundaries of the system analyzed.

(2) Inventory Analysis, where it is identified and quantified the energy, water and resources used, the emission of pollutants into the air, water and soil and waste production. In this stage it is also indicated the calculation procedures and requirements considered in collection of data and use of average data.

(3) Impact Assessment, where the inputs and outputs of the system are translated into potential environmental impact, divided in different impact categories.

(4) Interpretation, where the results of the inventory analysis and the impact assessment are analyzed and discussed, considering the uncertainty and assumptions used in the study.

3 GOAL AND SCOPE

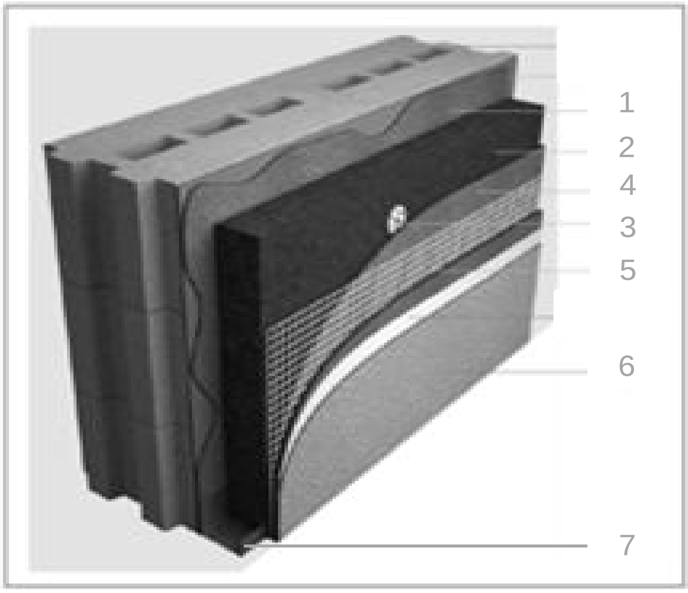
The developed study aims to determine the environmental impacts of the ETICS system with an insulation cork board from Saint-Gobain Weber in order to obtain an EPD on the basis of EN 15804 and ISO 14025. The information on the EPD is intended, mainly, for business-to-business communication. The results of this study will also be used in the improvement of the production process, since the LCA should identify the critical areas and opportunities of improvement. As this EPD will also be available on the website of the program operator, it can consequently be used in business-to-consumer communication.

3.1 *Declared/Functional unit*

Both the inventory and impact assessment stages of this study were developed considering a unit that may be used to compare other composite heat insulation systems. According to the recommendations of the EPD program chosen and other PCR documents, the functional unit adopted to develop this EPD of ETICS system is 1 m^2 of composite heat insulation system with the specified composition and construction parameters of the product.

3.2 *Product description*

The product analyzed is an ETICS system named Weber.therm Natura consisting on different components as indicated on Figure 1 and Table 1.



1 - Mortar adhesive: weber.therm naturcork

2 - Insulation board: weber.therm cork (from Amorim Isolamentos)

3 - Mechanical fixings

4 - Mortar coating (2 layers): weber.therm naturcork

5 - Fiber mesh cloth: weber.therm normal

6 - Finishing: weber.rev natural

7 – Metallic profile weber.them start

Figure 1. Weber.therm Natura system

Table 1. Main components of Weber.therm Natura

Material	Components/function	Quantity per m[2] of system
Weber.therm Naturcork	Mortar adhesive used for bonding and coating ETICS systems composed by hydraulic lime, white cement, kaolin, mineral fillers, resins, synthetic fibers and special additives. Produced in Saint-Gobain Weber plant in Aveiro.	11 kg
Insulation board of ICB (110 kg/m^3)	Insulation Cork board produced by Amorim Isolamentos in Vendas Novas.	4,4 kg
Weber.rev Naturkal	Mineral lime based colored finish for interior and exterior walls. Hydraulic lime, hydraulic binder, fillers, synthetic fibers and specific adjuvants. Produced in Saint-Gobain Weber plant in Carregado.	3 kg
Metallic profile Weber Therm start	Alluminum profile which has the dual function of aiding the assembly of the beginning of the system and provides protection against the penetration of moisture and external aggressions from below.	0,194 kg
Metallic screws with plastic dowels	Steel screws used for fixing the aluminum profile with a plastic dowel	4 units
Plastic fixings	Plastic nails with plastic caps used for fixing the insulation boards	8 units

3.3 *Area of application of the construction product*

The construction product in analysis can be applied for the following purposes:

- External thermal insulation in building façade walls, incorporating insulating boards of natural origin;
- Functional rehabilitation (waterproofing, cracking and aesthetics) and improved thermal insulation of facades in buildings with incorporating insulating boards of natural origin.

3.4 *System limits*

The EPD developed about this ETICS product covers the information module A1-A3 which corresponds to the product stage, comprising the following main stages (in line with EN 15804):

- A1 raw material extraction and processing, processing of secondary material input (e.g. recycling processes)
- A2 transport to the manufacturer
- A3 manufacturing

This product stage includes the provision of all materials, products and energy, as well as waste processing up to the end-of-waste state or disposal of final residues. The system boundary includes also those processes that provide the material and energy inputs into the system and the following manufacturing and transport processes up to the factory gate, as well as the processing of any waste arising from those processes.

Additionally, includes information modules A4-A5 referring to the construction stage, according to EN 15804 which comprises:

- A4 transport to the construction site
- A5 installation in the building

These stages include the transport of the finished product and additional materials to the construction site, energy and ancillary materials required during installation and waste processing up to the end-of-waste state or disposal of final residues during the construction stage.

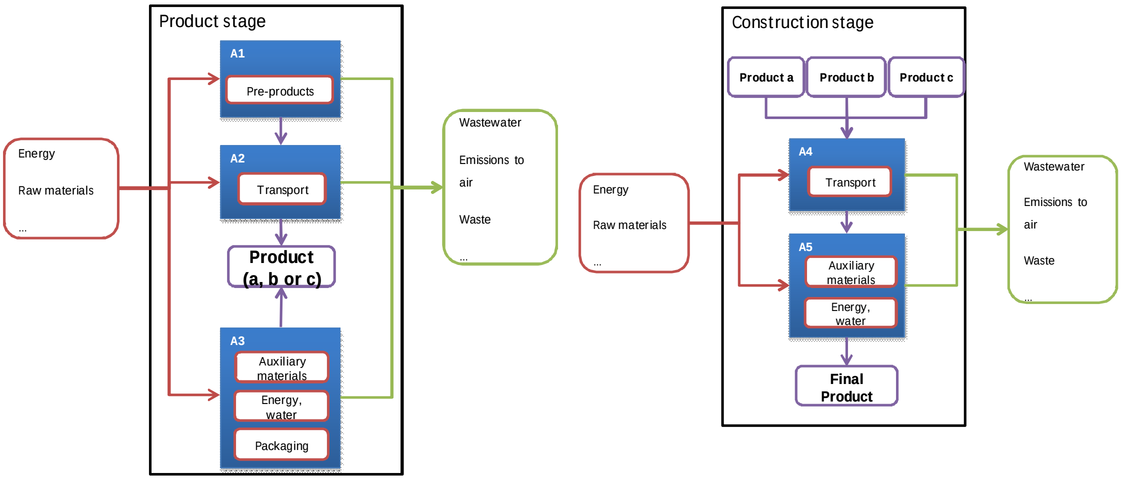


Figure 2. Production and construction stages (module A1-A3, A4 and A5)

Based on presented methodology, it should be considered that were not considered stages as use period and end of life. The main reason is related to the initial purpose of focusing only on the production and application process which are very defendant from the producers behaviors.

4 LIFE CYCLE INVENTORY ANALYSIS

4.1 *A1-A3: Product stage*

4.1.1 *Production of ICB*

ICB is a natural product since the cork granules are aggregated solely by the action of the natural resins contained in cork. The production process begins by grounding raw cork into granules with the appropriate size that are placed in an autoclave. Under the effect of pressure and superheated steam the granules expand and are agglomerated, originating blocks. This process occurs only with the natural resin (suberin) of the raw material, meaning that it does not require any extra use of any adhesives. Once formed, the blocks are forwarded to cooling stage, where recycled water is injected at a temperature of approximately 90 ° C. The stabilization phase, requiring no use of energy, occurs by placing the blocks in the tunnel and then in a natural ventilated space. After the stabilization period, the blocks are ground and cut according to the desired thickness and then packaged.

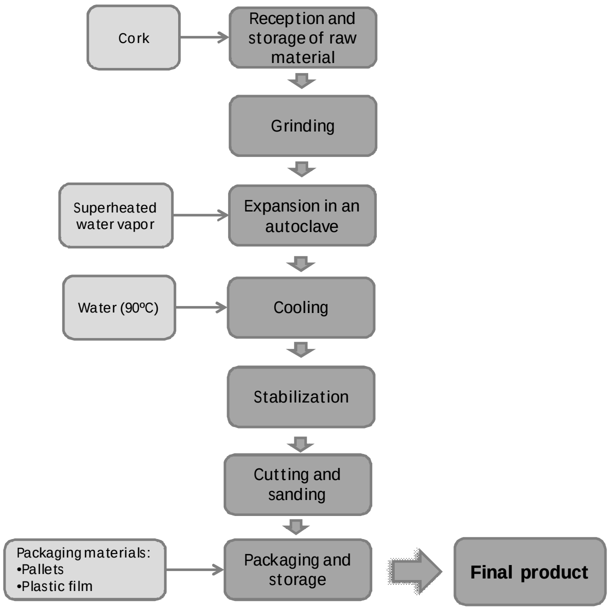


Figure 3. Production process of ICB

4.1.2 *Production of mortar products*

The raw materials are received in tankers, bags or big-bags. Storing bulk materials in silos can be made directly or through pneumatic conveying system.

The final powder product is obtained from the mixture of different components, following a pre-established formulation. The dosage of the raw materials can be carried out by different systems, namely by gravity through the continuous fluidization of the material, a worm screw with frequency controller and volumetric dosage through a rotary valve. The weighing of the different components is performed within one of the three weighing hoppers.

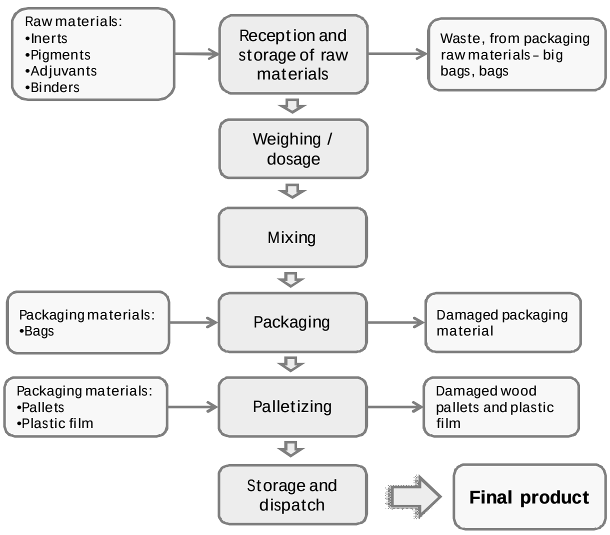


Figure 4. Mortar products production

Once dosed the components are discharged into the empty blender through pneumatic valves for homogenization. The mixing time varies depending on the specific composition of the product. After this, the product falls into the hopper of the blender and is then discharged.

The last stage consists in packing and palletizing the product. Regarding powders products, they are packed in bags through electric equipment and then placed on a pallet (palletized). Finally, the pallet and bags are wrapped in a plastic film and covered with a plastic bag.

4.2 *Module A4: Transport to the construction site*

To support the modeling of the construction scenario it was made a demonstration of the installation of the product on the premises of Saint-Gobain Weber, in Carregado Plant. For this scenario, it was considered that all the products would be transported from their respective production units to Carregado.

4.3 *Module A5: Installation*

The application of the system consists mainly in 6 stages, from fixing the aluminum profile to application of the final coating (Figure 5). To model this application, it was made a demonstration of the installation of one system in a wall with the dimensions 2,72m x 2,20m. With this procedure it was possible to understand the amount of products, energy and water used in the process and the eventual production of waste and wastewater.

The first stage consists in fixing the aluminum profile Weber.therm start. This profile has the dual function of aiding the system's assembly (keeping it horizontal and ensuring the support of the insulation boards), and also to assure protection against the penetration of moisture and external damage.

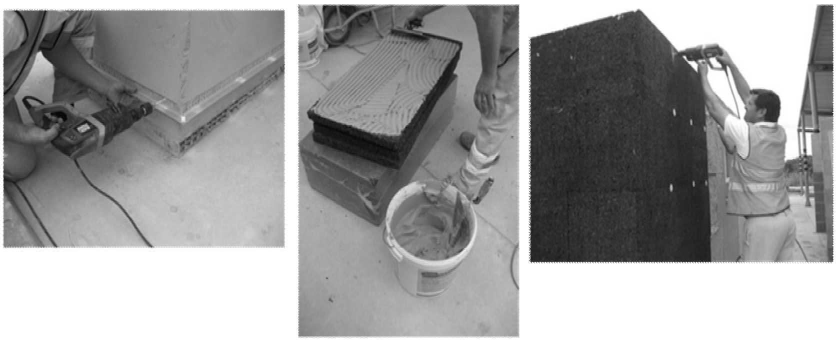


Figure 5. Screwing the aluminum profile, application of Weber.therm Naturcork and fixing insulation boards

This stage is followed by the installation of insulation boards that are glued to the wall with cement mortar Weber.therm Naturcork. The insulation boards are then fixed with plastic screws Weber Therm SPIT, usually 6 per m^2 of wall. The coating of insulation boards will be made with the application of mortar Weber.therm Naturcork in, at least, two layers, incorporating a reinforcement fiber glass mesh (Weber.therm Normal mesh). Final coating will contribute to waterproofing, protection and decoration and it is used Weber.rev Naturkal, using a stainless steel trowel, according to the desired appearance.

5 LIFE CYCLE IMPACT ASSESSMENT

The results of the Life Cycle Assessment are expressed into 6 impact categories through characterization factors, using the method CML 2012. These impact categories are:

- Global Warming Potential (GWP)
- Depletion Potential of the Stratospheric Ozone Layer (ODP)
- Acidification Potential of land and water (AP)
- Eutrophication Potential (EP)
- Photochemical Ozone Creation Potential (POCP)
- Potential for abiotic depletion of resources – elements for non-fossil resources (ADPE)
- Potential for abiotic depletion of resources – fossil fuels (ADPF)

5.1 *Global analysis*

Figure 6 shows the global impacts of the ETICS system from module A1 to A5.

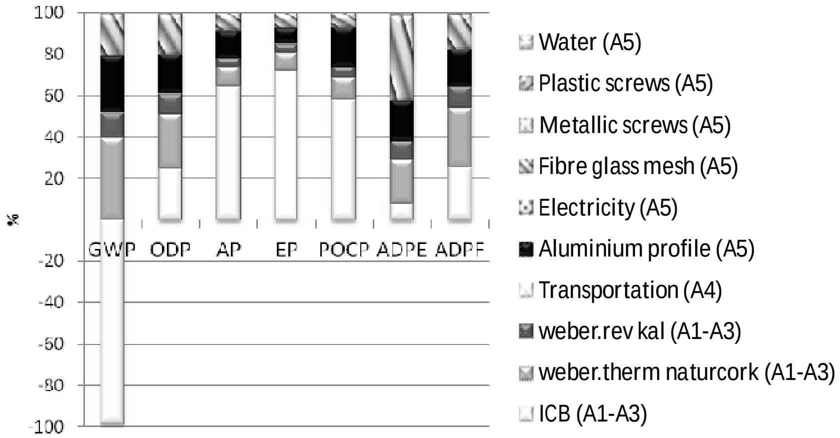


Figure 6. Impact assessment: module A1-A3, A4 and A5

Regarding the GWP category, ICB is the component with lowest impacts and actually a positive impact, due to carbon dioxide fixation. In this category, Weber.therm Naturcork has the highest impacts due to the production of hydraulic lime, cement and the polymer. The impacts associated with the aluminum profile and fiber glass mesh are linked to the use of electricity and other fossil fuels' combustion.

ODP category is affected almost equally by ICB, Weber.therm Naturcork, the aluminum profile and the fiber glass mesh. In all cases, the pollutants resulting from the combustion of fossil fuels are the main contribution for this potential effect.

The potential impacts in AP, EP and POCP categories are greatly due to the emission of pollutants during the production of thermal energy and electricity.

Category of ADPE is mostly affected by the use of the fiberglass mesh, associated to the production of nylon 66.

Impacts on ADPF category are almost equally due to the use of ICB, Weber.Therm Naturcork, aluminum profile and the fiberglass mesh. These potential impacts are all associated to consumption of energy from combustion of fossil fuels.

5.2 *Module A1-A3*

The potential impacts of the production stage A1-A3, which are the one with higher impacts, are indicated in Figure 7, in percentages of impacts per component.

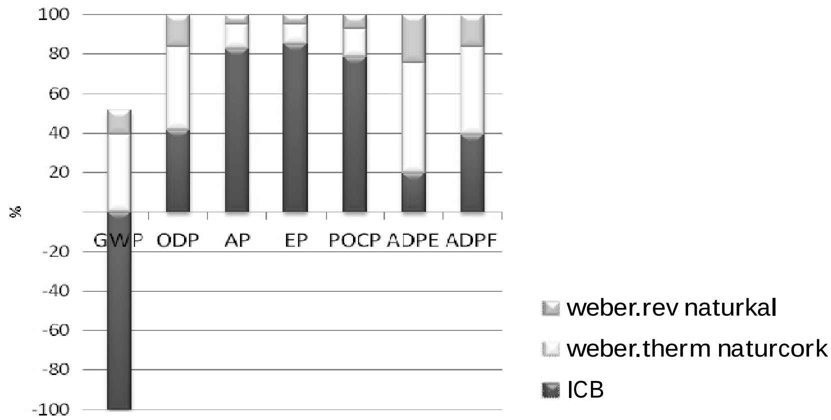


Figure 7. Impact assessment: module A1-A3.

From the results, it should be emphasized the global positive impact in the category of GWP. This occurs due to the use of cork that contributes to fixation of carbon dioxide during photosynthesis. The negative impacts are associated to the use of the mortar products. Production of clinker and hydraulic lime are the processes that represent the most significant negative impacts in this category, due to the emission of pollutants during combustion of fossil fuels to produce energy.

Results also indicate that an improvement of the system performance includes the need to work on both cork board and mortars associated. Related to ICB, in order to minimize the energy impact, it is possible to adopt strategies to reduce the emission of pollutants into the atmosphere. Currently, it is possible to reduce the emission of nitrogen oxides (NOx) by different technologies, namely:

- Selective catalytic reduction, using ammonia vapor to convert nitric oxide to free nitrogen and water using a catalyst bed
- Selective non-catalytic reduction, where ammonia or urea is injected in to the high temperature zone of the flue gas forming also water, nitrogen and in case of urea, carbon dioxide
- Oxidation catalysts, where several pollutants like NOx, CO and hydrocarbons are oxidized.

Carbon monoxide control can also be made by using an oxidation catalyst, although there are specific operating conditions to use this technology.

On the other hand, considering mortars and impact of the main binder (Portland cement or hydraulic lime) as the main factor to most of the impact factors, actions can be done to reduce their influence such as partial replacement by recycled material like slag or fly ash.

6 CONCLUSIONS

The LCA of Weber.therm Natura has led to the identification of the critical stages and components regarding the overall environmental performance of the product. With this information it is possible to develop goals and strategies of improvement that can range from the substitution of materials, changes in production processes and optimization of the transport operations of the various components to the building site. As we can see from the global chart, the product analyzed has almost null impact in global warming due to the use of ICB as an insulation material. Cork is a natural product from the cork oak which contributes to the sequestration of about 4.8 million tons of CO_2 per year, about 5% of emissions of Portugal (Corticeira Amorim). This contribution is extremely beneficial since the reduction of the greenhouse effect continues to be one of the greatest challenges to human activity. On the other hand, as we can see by looking at the results, the impacts associated with the production of thermal energy from burning cork still have a very significant impact on other impact categories.

Regarding mortars contribution, is visible their higher impact even if using binders as hydraulic lime, which demystifies a common myth related to the use of this binders.

The main issue for both materials is that is possible to continue focus actions in order to minimize the impacts. So, is clearly recommendable a continuous work on the presented recommendations, checking the improvements on LCA analysis.

REFERENCES

Curran, M. A. 2006. *Life Cycle Assessment: Principles and Practice*, Reston (Virginia):U.S. Environmental Protection Agency

EN 15804:2012, *Sustainability of construction works* - *Environmental product declarations* - *Core rules for the product category of construction products*

EN ISO 14025:2010, *Environmental labels and declarations — Type III environmental declarations — Principles and procedures (ISO 14025:2006)*

Spitzner, M.H., *Thermal insulation of buildings: materials, properties and systems*, The annual Insulation Conference 2003, Dubai, 2003.

O guia weber 2012, Saint- Gobain Weber Portugal.

Resource Systems Group, Inc., 2001, *Air Pollution Control Technologies for Small Wood-Fired Boilers*, Vermont

Pereira1, J. S., Correia, A.P., Mateus, J.A., Aires, L.M.I., Pita, G., Pio, C., Andrade, V., Banza, J., David, T.S., Rodrigues, A., David, J.S., *O sequestro de carbono por diferentes ecossistemas do Sul de Portugal*, Lisboa: Instituto Superior de Agronomia