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Environmental footprint of external thermal insulation composite systems with different insulation types

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Abstract

In terms of upcoming energy directive for Nearly Zero Energy Houses (nZEB), we are very much focused on building skin and its properties. Not only thermal characteristics and design, but also durability and environmental aspects should play a role, when deciding on which system will be implemented. External Thermal Insulation Composite Systems or ETICS are generally made of adhesive, insulation, render with mesh reinforcement, primer and finish coat. In the following case study we have presented a life cycle assessment (LCA) study of three ETICS with different types of insulation: expanded polystyrene (EPS), mineral wool and wood fiber board insulation. The study complies to the standard EN 15804:2012. It was conducted in the program Gabi using the Gabi Professional 2012 Database. The scope of the study is covering the production phase (raw material supply, transport to the factory, manufacturing). We have compared the functional unit of 1 sqm of the ETICS system with U-value 0.27 W/m^2K taking into account different environmental impact categories. In the calculation the characterization factors proposed by Centre of Environmental Science (CML) at Leiden University were used. The comparison of ETICS shows the important impact of the insulation type used. Also there are some differences in the amount of other ETICS components applied, since changing the type of insulation affects the environmental footprint of the ETICS.

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Keywords: ETICS, life cycle assessment, nearly zero energy houses, insulation types.

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1. Introduction

The construction sector accounts for 40 % of the total energy consumption of Europe. In the recent years the focus of the building sector was how to reduce the energy consumption of the buildings. But by minimizing the operational energy, the energy embodied energy of the building became more important. Studies of low energy buildings have shown, that the embodied energy for production can account for 40-60 % of the total energy use in reference service life (RSL) of a building [1,2]. This increases the demand to perform analyses that do not deal just with the energy used in the operational phase of the building, but with the whole life cycle of the building, such as Life Cycle Assessment (LCA).

External Thermal Insulation Composite Systems or ETICS are widely used in buildings since 1990s [3]. The cladding system is made out of different layers: adhesive, insulation, render with mesh reinforcement, primer and finish coat. To ensure correct functioning of the system it is necessary to develop a working multi-layer system where the components are compatible with each other. Different insulation materials can be used in ETICS. This is important in terms of environmental footprint, for they have the biggest impact.

An additional advantage of ETICS beside energy savings is that it also prevents mechanical damage of the load bearing structure and its failure in tension because of temperature differences. Generally, the ETICS helps to protect climate and environment by reducing the CO2 emissions caused by the use of energy for heating and cooling. This system also increases the living comfort by reducing indoor temperature differences and reduces operational costs. Many different combinations of the ETICS components are possible. In the following study the insulation is the main difference between the different systems compared. There are also small differences in the quantity of other materials used in the system, since different insulations require different preparation or fixing. In the following study we will compare three ETICS with different insulation types in terms of environmental parameters.

The environmental impacts are different depended on the type of the façade system, the insulation materials used and the location of the building when analysing the whole life cycle of the building [4]. Researches comparing different insulation types most often show an advantage of the EPS or styrene based insulation upon other insulation types due to low material consumption and weight in most environmental impact categories [5–8]. Some also studied the environmental impact of innovative materials as cork, flax fibers or plant derived epoxy resin [9]. Most of the studies focus on the cradle-to-gate stage. Beside the environmental impact the economic indicators of the insulation materials are sometimes studied. Studies purpose additional indicators that evaluate the investment impact from the ecological point of view [10]. Insulation types used in ETICS influence the composition of the ETICS systems. For example, EPS insulation requires less render than soft insulations. This also affects the environmental footprint of the system. We have also performed a detailed analysis for three main components (render, primer, finish coat) to see how different components used in them influence their environmental footprint.

2. Methodology

The methodology used is based on the EN 15804 standard. This standard provides core product category rules for Type III environmental declarations for any construction product and construction service.Some results can be used in building assessment methods like LEED, BREAM, etc.

2.1. Functional unit and system boundaries

The defined functional unit is 1 m2 of a wall. The study focused on fixed thermal transmittance (U) parameter to the value 0.27 W/m^{2}K for all three cases. Thus, different thicknesses of insulation layer (EPS, mineral wool and wood fiber board insulation) were applied in the model. Other properties (for example sound performance, heat capacity) were not taken into account.

The included building life cycle stages based on standards EN 15804:2012 are covering stages A1 to A3. This is referred as the cradle to gate. The transport phase of raw materials is included in the used dataset or is modeled, but it does not significantly contribute to the result. The transport to the construction site is excluded from the scope of the study. Mass allocation is used in the study. Production waste and packing were excluded from the system boundaries.