INNOVATIVE PRODUCT DESIGN AND RECYCLING: COMPARATIVE SUSTAINABILITY ASSESSMENT OF THE BUILDING MATERIAL POLLI-BRICK

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ABSTRACT

In recent years, the number of reportedly sustainable or eco-friendly products has skyrocketed. One of the promising products in that number includes POLLI-Brick, a recycled building material designed to provide an environmentally friendly and sustainable alternative to common building materials. To measure this claim, the product must be evaluated over the entire product life with thorough assessment.

This case study assesses the functional and environmental performance of POLLI-Brick in comparison with its competitor TEXLON System. Through three assessments exploring areas of the building materials' life cycles, results indicate POLLI-Brick as the more environmentally sustainable product than TEXLON System. The case study shows that innovative product design, such as with POLLI-Brick, can reduce a product's environmental impact while increasing its efficacy.

INTRODUCTION

Accounting for over 30 percent of the global carbon footprint (UNEP DTIE Sustainable Consumption & Production Branch, 2009) and using up approximately 60 percent of all resources consumed in the world (Edwards, 2005), the construction sector is a critical contender to address in fighting climate change. From the choice of building material to the different construction processes to the energy consumed during the use phase of the building, the industry and its impacts on the environment are extremely diversified. Therefore, there are evident opportunities for improvement including the implementation of environmentally friendly technology.

In 2010, the Taiwan based design and architecture firm MINIWIZ developed POLLI-Brick, a new building material that is made from 100 percent recycled post-consumer Polyethylene Terephthalate Polymer. POLLI-Brick is most commonly used as a translucent sustainable curtain wall system or insulated interior partition with options for embedded lighting. Due to its honeycomb-like, self-interlocking structure it is "extremely strong, while weighing only one-fifth of standard curtain wall systems" (MINIWIZ, 2011). By using recycled post-consumer PET bottles as a building material, MINIWIZ is tackling three environmental problems at the same time: waste accumulation, resource scarcity and greenhouse gas emissions. As MINIWIZ is looking to launch POLLI-Brick into the German market, it is necessary to assess if the production process in Germany can facilitate the sustainable attributes of POLLI-Brick, similar to the production in Taiwan.

This paper examines POLLI-Brick's functional properties and environmental impact, in order to find out how POLLI-Brick's environmental performance ranks against its competitor TEXLON System.

MATERIALS AND METHODS

First, a comparative performance analysis is conducted to show potential operative advantages and disadvantages. This includes comparing different properties (thermal insulation, sound insulation, fire protection, weight, UV-resistance, translucency). qualitatively and quantitatively. Then, an energy analysis is conducted, using a model to simulate a practical application and compare the two building materials by energy used during the operation phase of the building. Following the functionality assessment, POLLI-Brick's environmental performance is analyzed through a cradle-to-gate life cycle assessment (LCA). Using the software GaBi 4, the LCA explores POLLI-Brick's environmental impact in several impact categories following the CML 2001 baseline. Like the functionality assessment, the LCA is designed to compare POLLI-Brick to TEXLON System. Since the information on TEXLON System is provided through an Environmental Product Declaration (EPD), the LCA of POLLI-Brick is conducted according to the same Product Category Rules (PCR), the EPD was created upon, as well as similar product specifics.

To provide a full life cycle assessment for POLLI-Brick in terms of a realistic application, POLLI-Brick's environmental performance over the whole life cycle is assessed using the model, which was designed for the energy analysis mentioned above. The simulation model was chosen to resemble a realistic project so that the results could be transferred to actual ventures. Based on the results of the assessments, areas for improvement as well as potential applications of POLLI-Brick are identified. This paper does not provide a generic life cycle assessment of POLLI-Brick. The LCAs conducted in this paper only report on the environmental impacts of a potential production process of POLLI-Brick in Germany, regarding the simulated model and the PCR. This paper also does not go into any detail considering the structure of the building used in the case study scenario or cover financial aspects. Other complex calculations such as Life Cycle Costing are not within the scope.

RESULTS

The functionality assessment showed significant advantages to POLLI-Brick in terms of thermal (+95 percent) and sound insulation (+70 percent), whereas TEXLON System proved to be the lighter building material, weighing about 75 percent less. The performance of the other properties is either close to equal (fire protection, transparency/translucency) or not comparable (UV resistance, wind pressure).

The results of the energy simulation showed a significant difference between the two building materials. Due to its better thermal insulation properties, POLLI-Brick used between 13-20 percent less energy than TEXLON System (depending on the scenario). Additionally, TEXLON System constantly uses up energy, as it requires constant provision of air to keep up the internal pressure in the cushions. Therefore, POLLI-Brick clearly shows the better performance in terms of energy consumption during the operational phase. The environmental assessment showed no distinct advantage for either material across all seven impact categories. POLLI-Brick displayed clear advantages in four categories (on average 30 percent less contribution), whereas TEXLON System outperformed POLLI-Brick in the other three (on average 25 percent less contribution), although one of them only by four percent. However, TEXLON System was significantly more economical in water and power consumption.

DISCUSSION

In summary, in the production and manufacturing phase of the products, both building materials show advantages and disadvantages, but there is no distinct trend in terms of which building material would be preferable, apart from the water and power consumption, which is clearly in favor of TEXLON System. However, considering the whole life cycle of a building material, in this case 25 years, the impact (e.g. greenhouse gases) of the production and manufacturing is small compared to the relevance of the operational phase, which accounts for 70-90 percent of the total energy use (cf. Rønning & Lyng, 2011). Looking at the functional properties and the operational phase, POLLI-Brick outperforms TEXLON System, especially when considering the full lifespan of 25 years. The advantage in the energy consumption during the operational phase (18873000 MJ) clearly outweighs the total energy necessary for the production, manufacturing, disassembly and disposal of the simulation model. The difference in the energy consumption during the operational phase is even more significant, when considering a building life cycle of 75 years, which includes three full life cycles of POLLI-Brick and TEXLON, which in return could multiply the different consumption values and would make the difference even bigger.

For POLLI-Brick, most of the impacts can be associated with the production of polycarbonate granulate and power generation. Therefore, it would benefit the product's environmental performance to redesign the product or the production process regarding the use of polycarbonate and look for more environmentally friendly solutions than polycarbonate, e.g. secondary material. Though there are only a few products from secondary materials that meet the requirements, it could be beneficial to consider these options.

The aspect of TEXLON System using less water and power in the production process seems to point towards TEXLON System being the favorable option for short term projects, such as pavilions, exhibitions or other non-permanent constructions. When looking at short term projects though, it is important to consider the aspect of a building material going through multiple short term uses over its lifespan. For short term applications, building materials need to be sturdy enough to bear the stress of multiple mounting and transports and they need to be easy to install. Due to its flexible modular structure, its high strength and its sturdy material, POLLI-Brick can be easily mounted and dismounted and endure mounting and transport strains over its lifetime. TEXLON System's ETFE foils are not as strong and sturdy as POLLI-Brick and its mounting and dismounting process appears to be less universal than POLLI-Brick's.

CONCLUSIONS

Although the results of this study should not be considered universally valid, they indicate that for the applications presented in this paper, POLLI-Brick is a more sustainable building material than TEXLON System. Moreover, the paper shows that the exclusion of life cycle stages can lead to flawed or biased results. The operational phase is especially important for building materials, as their performance indirectly causes a secondary impact and their life cycle is significantly longer than that of other products. POLLI-Brick shows that innovative solutions tackling these issues can have a significant impact on the environmental performance of a product.

In the case of POLLI-Brick, its production process in Germany and the comparison to TEXLON System, it would be advisable to conduct a comparative cradle-to-grave life cycle assessment of POLLI-Brick and TEXLON System, using more primary data from actual producers. This way, both life cycle assessments could be executed as similar as possible to guarantee a high level of comparability and thus produce more valid results. Specific attention should be paid to the optimal allocation of environmental burdens from secondary material. Furthermore, the use-phase of both building materials should be assessed in more detail, investigating both general environmental impacts during the operational phase, as well as different benchmarks for universally transferable types of buildings and construction.

The results of this paper also show that statements on the environmental superiority of one building material over another need to be developed carefully, as current frameworks leave room for individual adjustments, which can reduce the validity of comparative assessments. However, LCA, PCR and EPD are good ways to investigate building materials and identify advantages or disadvantages when comparing them.

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