InDeWaG

Recommendation of glazing/coatings, polymers and frame materials selection according to LCA

-Report-

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1. Introduction

Within report a "recommendation of glazing/coatings, polymers and frame materials selection according to LCA" is given. Based on preliminary LCA results the footprint reduction potential for materials needed to build FFG facades is analysed. The report provides a first input for minimizing "grey" energy content and reducing the overall footprint of material use. The Life Cycle Assessment lies within Task 7.2 of InDeWaG project. Within this task, Fraunhofer will analyse different FFG designs regarding their ecological performance over the whole life cycle. The software SimaPro is used with the database ecoinvent 3.3, which holds data of the ecological performance of numerous materials, to calculate for instance the carbon footprint of a FFG including the manufacturing process, the lifetime of the façade and the recycling of the components. This task is strongly linked to the development and optimization of the FFG in order to minimize the greenhouse gas emissions by selecting the best-suited materials.

The report is providing input for WP 4 "Materials and components for FFG" and WP 5 "Construction & Production".

2. Results and Discussion

Having in mind an environmental impact that is as low as possible, there are several aspects to be considered for the design of the FFG. For all materials, aspects of environmental impact, costs and feasibility have to be weighed against each other.

In a preliminary study, the possibility of utilizing alternative construction materials has been assessed. Conventional glazing systems commonly utilize aluminium or stainless steel as frame materials because of their durability. However, especially for aluminium, raw-material extraction and production are usually energy-intensive processes with a high environmental impact. This Environmental Impact mainly results from the share from up to 60 % of fossil energy sources in the production mix for aluminium (Figure 1) as well as on the land consumption for bauxite mining.

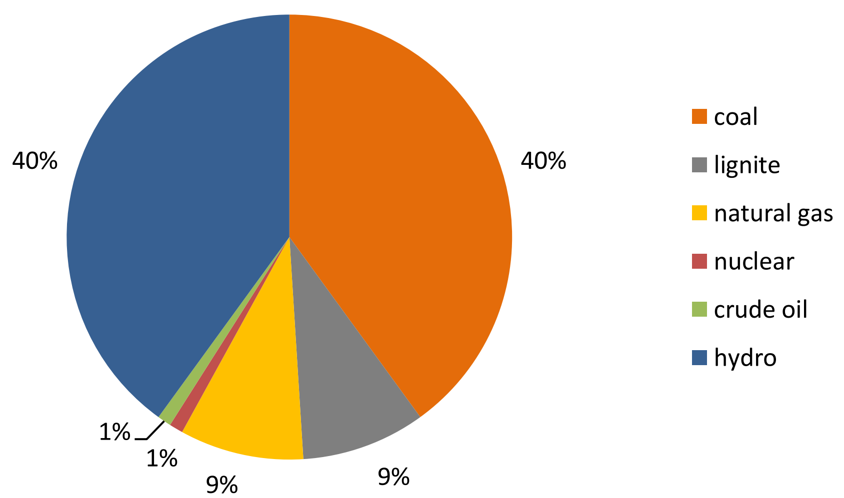

Figure 1 Energy mix for global aluminum production according to ecoinvent v.3.

As alternative materials for frame construction, the environmental footprint of a façade-frame system made of a wood-plastic-composite material, a glass-fibre reinforced polyamide and a chemically treated softwood have been assessed. The utilized LCA-Modell ReCiPe 2008 is especially suited for the comparison of clearly defined product alternatives, since it cumulates the environmental impacts on different impact categories to a single score that is easy to grasp and communicate.

Within this assessment, the façade system based on aluminium had the highest environmental impact over its whole life cycle; whereas the system based on wood had the lowest impact. However, the consideration of the products service life shows that as the lifetime of the product increases, its relative environmental impact decreases (Figure 2).

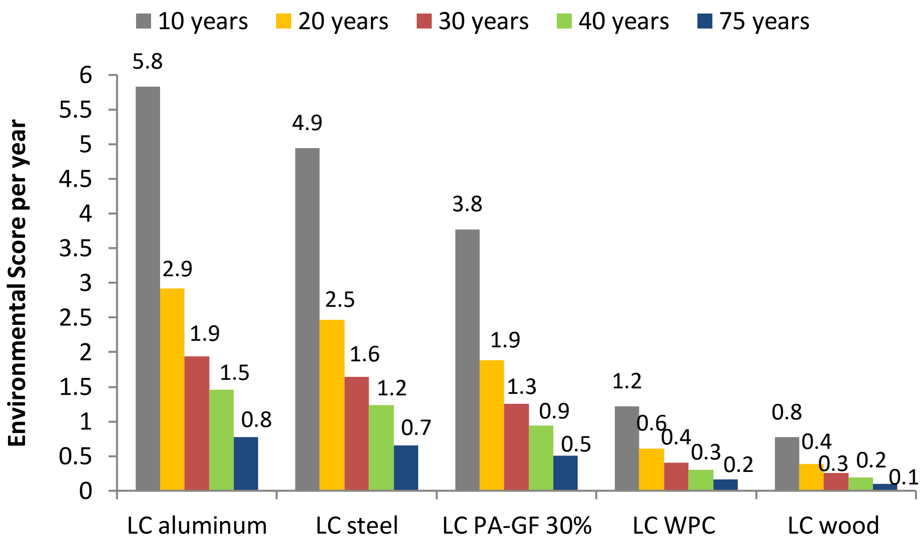

Figure 2 Environmental Score of five different Façade-Frame-Systems (ReCiPe 2008). One point on the single-score-scale represents the average yearly environmental impact of one European citizen. The comparison shows the environmental impact of a façade-system based on aluminum, steel, glass-fiber reinforced polyamide (PA-GF 30%), wood-plastic-composite and wood. LC=Life Cycle.

A sensitivity analysis revealed the vast influence that the end-of-life treatment has on the considered product systems (Figure 3). For the analysis, an aluminium recycling rate of 35 % has been considered. To double the recycling rate can almost cut in half the environmental footprint of the product system. Considering a recycling rate of 88 %, which is the common rate for steel products in building application, the aluminium façade frame becomes competitive to the composite and wood frames in the analysis.

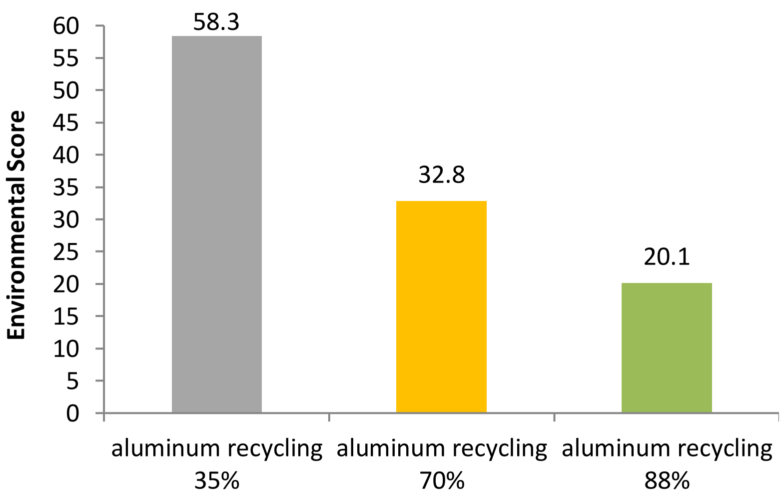

Figure 3 Environmental Score of the façade system based on aluminum from different scenarios for aluminum recycling rate (ReCiPe 2008). One point on the single-score-scale represents the average yearly environmental impact of one European citizen.

Based on the above findings, the following recommendations can be given:

Since the scope of WP 7 is not only to give recommendations based on environmental aspects but also to include cost and market opportunities, it can be recommended to utilize aluminium as frame material. Especially in the building sector, longevity of the products helps stabilize construction and maintenance cost and built customer trust. Its light weight can reduce emissions from transport and its longevity make it a competitive material considering that in building applications, a long lifetime should be ensured. When utilizing aluminium, it is recommended to design the façade in a way that allows complete material separation at the end-of-life of the product system to ensure a recycling rate that is as high as possible. To do so, different design options like the use of screwing instead of bonding should be considered in WP 6 “Construction & Production”.

In the focus of a reduced environmental impact, the glazing should be lightweight, to reduce emissions from transport and simultaneously save resources in the production phase. The use of laminated glass usually gives a higher strength to glazing applications; however, laminated or coated glass (commonly laminated with polyvinyl butyral PVB) cannot be recycled due to the lack of possibilities to separate the materials properly. Based on those findings, WP 6 and WP 7 should consider the possibility of using unlaminated, uncoated glass and weigh stability and cost aspects against these recommendations from the environmental point of view. An alternative could be tempered glass; a more detailed LCA would have to be performed to compare environmental impacts from the production of tempered glass that may arise from an increased energy demand to the production of untampered, laminated glass.

Not all adhesive interconnections can be replaced by mechanical connectors to ensure material separation. The pillars that will be used in between the glass sheets to help stabilize the fluid-pressures inside the system have to be connected by a transparent material in order not to influence the transparency and with that the aesthetics of the façade. It has to be an adhesive suitable for glass-to-glass gluing that is UV-stable, does not show yellowing and is resistant towards the water-glycol surrounding. These challenging requirements do not leave a lot of options regarding environmental design. A recommendation that can be given is to reduce the amount of pillars to the least possible amount required for stability. Similar conditions hold true for the structural silicone: It acts as an adhesive and sealant, which has to maintain its integrity as the façade is subjected to wind load and thermal stresses. It is of primary importance that there is no fluid-leakage from the façade. For this purpose, silicone as sealant is hard to replace without extra material use, which could itself result in a higher environmental impact. Again, it can only be recommended to reduce the use of structural silicone to a minimum in order to reduce resource use and to ensure material separation at the end of the products life.

In order to prevent a large amount of hazardous liquid waste, which would increase the negative environmental impact of the system to a large amount, only organic dyes can be considered for the FFG. Since a thorough literature research could not come up with a commercially available organic dye that fulfils the requirements of stability and longevity that are necessary for the system design. Organic dyes often contain aromatic molecular substructures which are often hazardous compounds themselves. As the expected degradation processes, which are light and temperature induced, lead to different possible degradation products, among which some will be hazardous and therefore the whole fluid has to be handles as hazardous or toxic waste. For this reason using a dyed fluid-filling is not recommended. Alternatively, a transparent water-glycol mixture is should be used. Glycols are commonly used in antifreeze formulations and are considered as biodegradable and non-toxic.

References

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