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Christian Doppler Laboratory "Anthropogenic Resources"
TU Wien, Institute for Water Quality and Resource Management
Karlsplatz 13/226
A-1040 Vienna, Austria

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IMPROVING CIRCULARITY OF BUILDUING COMPONENTS – A CASE STUDY ON THE ENVIRONMENTAL PERFORMANCE OF FAÇADE SYSTEMS OF PREFABRICATED TIMBER BUILDINGS

Sabine DWORAK[24], David LANER

Institute for Water Quality and Resource Management, TU Wien, Karlsplatz 13/226-2, 1040 Vienna, Austria

Introduction

Construction and demolition waste have been designated a priority waste stream by the European Union, due to increasing amounts and high potential for increasing re-use and recycling levels (European Commission 2017). Design for renovation, design for re-use, and design for recycling are important concepts in this context, where the largest gains in resource efficiency are typically associated with measures enabling longer product lifetimes (Thomsen et al. 2009). Because the market share of pre-fabricated houses has been growing steadily in Austria (in 2015 around one third of newly erected houses were pre-fabricated, Interconnection Consulting 2017), measures to improve circularity in the pre-fabricated building sector are urgently needed.

The goal of the present study was to assess the environmental impact of three alternative façade systems for a pre-fabricated timber wall. Therefore, a conventional composite façade system (made up of expanded polystyrene, fibres, plaster) was compared to two versions of a ventilated façade (which is optimized for higher durability, lower maintenance and easier disassembly).

Methods

Life Cycle Assessment (LCA) was used to evaluate the environmental impact of a conventional cladding system (glued expanded polystyrene with plastering, version A) and a newly developed ventilated façade (in two variations, respectively with mineral cladding and plastering (version B.1) or planking (version B.2)). One square meter of a prefabricated single family house wall over a lifespan of 60 years (with replacement of the conventional version after 30 years) was assessed. Both systems had, by design, the same thermal conductivity. The LCA does not include erection, use, dismantling/demolition, because these phases are considered to be the same independent of the façade alternative. For the same reason, identical parts of the wall are neglected in the assessment. Four different End-of-Life (EoL) treatment scenarios, defined based on current legal standards and technologies, were considered in the evaluation:

- *Status Quo*: Represent the most likely treatment options for different waste streams currently in Austria.

[24] sabine.dworak@tuwien.ac.at

- Recycling (*REC*): maximum recycling of wastes, re-use of mineral wool.
- Energetic Biomass Use (*EBU*): Untreated wood waste is directed to thermal utilization, mineral wool is re-used.
- Waste-to-Energy Plant (*WtE*): All combustible material is treated in a state-of-the-art WtE plant, the mineral fraction landfilled

Data for all relevant energy and material flows were gathered. The material demand (incl. upstream losses) was derived from primary data provided by a company specialized in high quality pre-fabricated dwelling buildings, which are customized to a high degree. Additional data on material and energy flows was extracted from common LCA databases (such as ecoinvent v3.3, Ecoinvent Association 2017) and specific ones for building materials (e.g. ÖKOBAUDAT, BBR 2018). Two impact categories were considered in the LCA. The global warming potential (GWP) over 100 years and the cumulative energy demand (CED) of non-renewables.

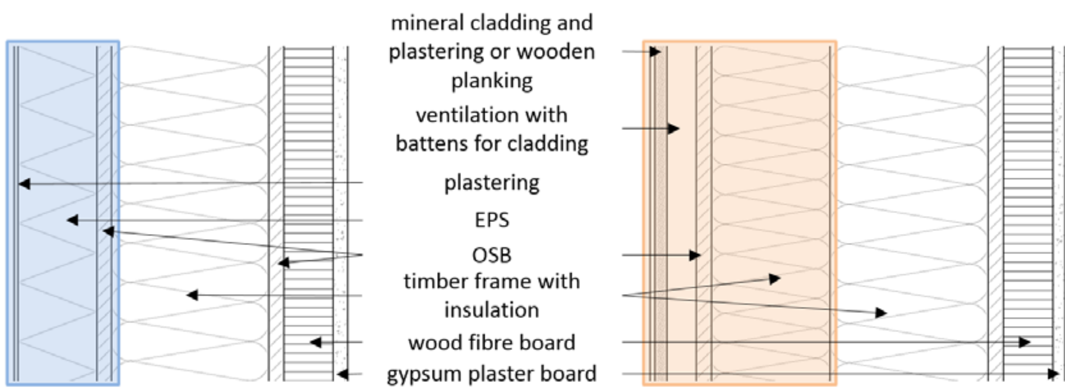

Figure 35 Compared wall systems, in LCA considered parts highlighted, left: construction with composite façade (version A), right: ventilated facade (versions B.1 and B.2)

Results and discussion

The material intensity of the ventilated façade (B.1 and B.2) was substantially higher than the material intensity of the conventional façade (A) (see Figure 36, left). This was due to the broader wood frame with an additional layer of mineral wool insulation (cf. Figure 1). However, despite the higher mass, the ventilated system performed better in terms of both impact categories, GWP and CED (cf. Figure 36, middle and right). The different composition and the possibility to separate the fractions by dismantling enabled better treatment and more efficient recycling. The lowest impacts were achieved for the ventilated façade with wood planking (B.2). This is due to the relatively low impact of wood use given GWP and CED, because wood is a renewable energy source and binds CO_2. This results in low impacts of wood production and thermal utilization, because only impacts related to harvesting, handling, conditioning, and transport are considered.

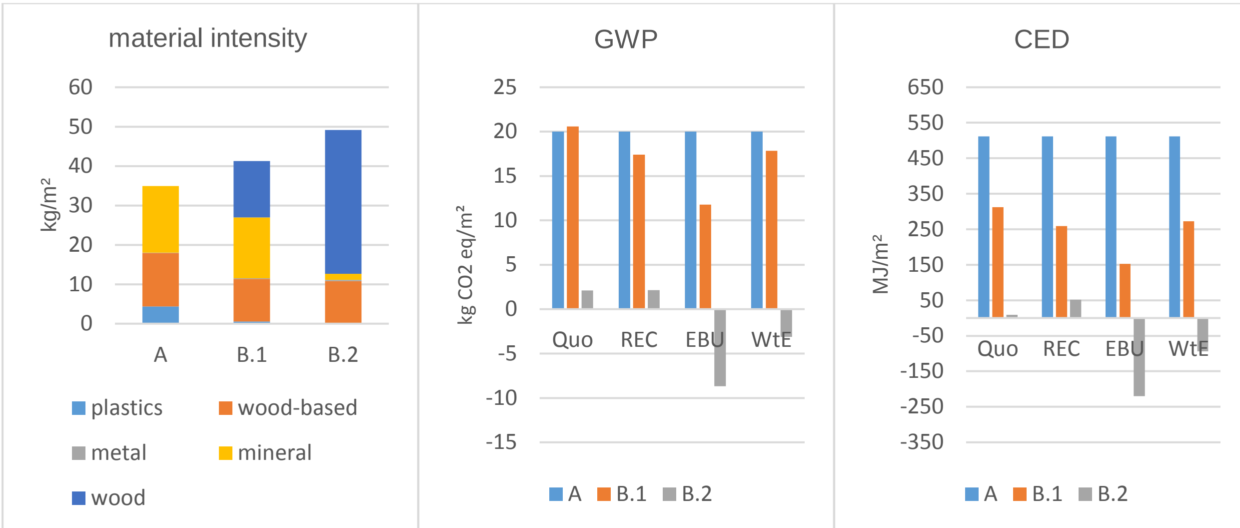

Figure 36 **Reults: left: Material input for assessed cladding systems, middle and right: LCA indicators Global Warming Potential (GWP) and Cumulated Energy Demand (CED) of different disposal options for assessed cladding systems**

Conclusion

The present study showed that despite a higher material demand, the ventilated façade system performed better than the conventional composite façade in terms of GWP and CED. The high mass share of wood and the improved disassembly options allow higher quality utilization of building waste materials. Hence, due to optimized design, more material (and waste) can mean less environmental impact.

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