ENVIRONMENTAL IMPROVEMENT OF CONSTRUCTION PROJECTS BY REUSE AND RECYCLING

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ABSTRACT

Environmental impacts of the construction industry are of high relevance worldwide. A possible way to lower the environmental impact is to raise the recycling quota in the end-of-life-phase, the recycling content of the input materials and to enable reuse of construction materials. Data is based on European case studies conducted within the FP7-funded ZeroWIN project. The paper presents GWP-results for the improvement of three different materials compared to the state of the art. Reuse could be identified as best option to reduce the impact on climate change.

INTRODUCTION

The environmental impacts of the construction and demolition industry are of major importance worldwide as 60% of the extracted raw materials from lithosphere are consumed in this sector (Durão et al., 2011). Therefore new innovations or environmentally sound construction networks can enable high emission reductions if these ideas will be applied in a wider context.

One of the biggest problems of improving the construction sector are the very heterogeneous conditions which means that most of the buildings are different in design and function with high influence of the geographically context. It is obvious that the use of timber instead of concrete for the construction of a house would show environmental benefits. However, such capital changes are often impossible as the design is already given or restricted by legislative and technical reasons. To overcome these limitations environmental improvements on a material specific level are necessary. An important basic principle for all environmental innovations of construction products is to fulfill the quality requirements as least as good as conventional products.

A contribution to this research is done in the course of the project “ZeroWIN” funded by the EU 7th Framework program. The project`s goal is to enable the use of present waste flows as by-product or recycling material flows in the future. Five case studies in three EU-countries are the basis for the development and implementation of reuse and recycling measures in the construction and demolition phase of buildings.

This paper is presenting results of the impact on global warming potential (GWP) of three construction materials comparing a status quo scenario to possible improvements by raising the input- and output-related recycling content of the products.

METHOD AND MATERIALS

The method of life cycle assessment (LCA) is applied for the calculation of the environmental impacts of the status quo – presenting the state of the art - and improved scenarios. Impacts are calculated mid-point-related choosing Recipe as methodology for the life cycle impact assessment. This paper is focusing on GWP results only, whereas the underlying study is considering AP, HTP, ODP and other categories (Obersteiner et al., 2010). The functional unit is defined by 1 ton of a specific construction material.

The end-of-life (EOL) phase is most important in the considered scenarios. The outputs of secondary materials and products are different for all scenarios. Therefore attention was laid on methodological aspects of environmental credits from recycling and reuse to enable a proper comparison. The calculation is based on the recycling potential method described in Pflieger and Ilg (2007). The recycling potential describes the ecological value of a material´s accumulation in the technosphere. It states how many environmental burdens may be avoided in relation to a new production of the material (avoidance of primary metal production). The same methodology is applied vice versa if the recycling material content of the material is higher than the EOL recycling. Thus burdens have to be allocated for stopping the recycling cycle. Allocation of burdens was necessary for input materials with a "reuse- or recycling-origin". Therefore the allocation procedure given in the ILCD-handbook (European Commission, 2010) and described in Pertl et al. (2011) between the first and second life of a product was applied. Waste processing was allocated to the first product until a change from a negative to a positive market price is achieved. Emissions from final disposal on landfill or by incineration are considered including credits for energy from waste incineration and landfill gas treatment.

The life cycle inventory was developed by the support of the case study partners from construction industry. Data on materials and transport distances was delivered directly from partners and completed by literature research. Most material related datasets are taken from two different databases namely ecoinvent 2.2 (Frischknecht und Jungbluth, 2007; Hischier et al., 2010) and GaBi 5.0 (PE-International, 2011). As supportive tool GaBi 5.0 was used.

RESULTS

The scenarios are created based on the given examples in practice by the case study partners. Table 1 is showing the differences between the scenarios. Two parameters are varying which is the recycling quota in the EOL phase and the recycling material content of input materials in the production phase. If a reuse quota is assumed, than the recycling quota or material composition is given for the remaining material (e.g. 15% blocks are reused and 85% blocks are recycled by a quota of 95%). The substituted primary materials are gravel for concrete blocks, blast oxygen furnace (BOF) steel for steel and gypsum and low quality paper for gypsum plasterboard. In scenario Improved A 100% electric arc furnace (EAF)-steel is used. This type of steel consists of nearly 100% recycled steel and can be therefore seen as 100% recycling content.

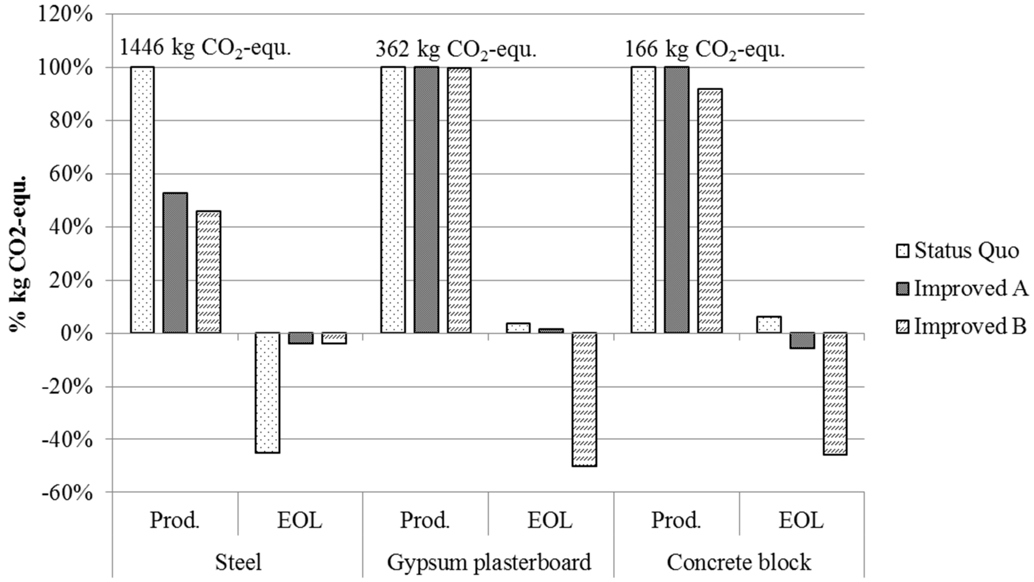
Reuse enables a 50% emission reduction, due to the assumption, that a reuse product has the same properties as a new product (Pertl et al., 2011) and can be reused for the same average lifetime than the new product. Material which is not recycled or reused is disposed according to the legal framework (landfill or incineration). The authors are aware that a recycling quota of 100% is impossible in practice. Nevertheless this assumption was done to understand the bandwidth of possible effects.

Table 1. Scenario description for three construction materials

Material	Phase	Status Quo	Improved A	Improved B
Steel	Prod.	37% EAF, 63% BOF	100% EAF	100% EAF 25% reused steel
	EOL	95% recyc. quota	100% recyc. quota	100% recyc. quota
Gypsum plasterboard	Prod.	25% recyc. gypsum	25% recyc. gypsum	80% recyc. gypsum 100% recyc. paper
	EOL	100% landfill	100% recyc. quota	50% reuse 100% recyc. quota
Concrete block	Prod.	Standard concrete	Standard concrete	80% recyc. aggregate
	EOL	75% recyc.	15% reuse 95% recyc. quota	100% reuse

Results in figure 1 are showing the production and EOL impacts on GWP for improved scenarios of the selected materials in relation to the status quo production impact. The results on steel show high improvement potential in the production phase if EAF steel is used. For gypsum plasterboard the high recycling content in “Improved B” is generating an impact reduction of 0.3% only. The same low effect can be seen for the production of concrete blocks. It is obvious that high impact reductions in the EOL phase are only possible by reuse. In the recycling scenarios of gypsum plasterboard and concrete blocks the EOL impacts are nearly negligible. The applied recycling potential method leads to higher impact reduction if steel with higher BOF (primary route) content is recycled.

Figure 1. Comparison of GWP-results (% kg CO_2-equ.) for 1 ton of construction material



DISCUSSION AND CONCLUSIONS

The three materials presented in this study can be seen as core materials of the construction industry. Concrete which is not presented in the paper shows comparable results to concrete blocks. It can be noticed that the already very high recycling rates in the status quo disable improvement possibilities in the EOL phase. The recycling content in e.g. steel products enables very low production related emissions but due to the method of recycling potential additional improvement in the EOL phase by raising the recycling quota is limited. For these three materials higher recycling material content in the production does not lower the GWP impact significantly as the energy demand and related environmental impacts for recycling (e.g. crushing of concrete) are comparable to the efforts of the extraction of primary materials (e.g. gravel or gypsum).

The only solution to overcome these barriers is to implement possibilities of reuse for construction materials whenever possible. Depending on the reuse quota emission reductions up to 50% are possible. This result leads to research demand in the future. On the one hand existing construction sites have to be screened with the focus on reusable materials. On the other hand the idea of Design for Reuse should be better implemented especially for buildings with an expected short lifetime.

The presented results are valid for countries with a well-developed recycling system only and cannot be transferred to countries where landfilling is the common way of disposal.

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