Environmental and socio-economic benefits of circularity in real estate management

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Abstract. The environmental potential of reusing interior and building products (notably furniture, lighting, doors, windows, flooring and ceilings) has been calculated by a rather basic model based on life cycle approach. By making a calculation model available to housing and renovation companies in Sweden, a total of over 43000 items have been included in calculations as objects for reuse, stemming from about 130 renovation projects with a total waste saving of 800 tonnes of waste in the renovation stage. The first calculations of the corresponding avoided climate impact, from avoided waste management and avoided new product extraction and manufacturing, corresponds to around 1600 tonnes of CO2-equivalents. Translating this and other environmental aspects to monetary values with the EPS system, socio-economic savings is around 2.3 million Euro. Assuming the same composition of items for potential reuse from all renovation activities in Sweden and extrapolating to the total annual amount of building waste, the potential annual savings on the national scale is estimated to be 900000 tons of building waste and 1.3 million tons of CO2 equivalents, corresponding to around 7% of the total annual greenhouse gas emissions of the Swedish building sector. With the EPS evaluation, the total annual environmental benefit adds up to 600 million Euro. The calculation model is currently being refined to include a better coverage of logistics and refurbishment activities.

1 Introduction

The built environment consumes about 50% of the materials and generates about 20% of the greenhouse gas emissions globally, which makes it a central factor for transitioning toward a circular economy [1].

1.1 Reuse in the Swedish building sector

The sector yearly The Swedish building sector generates around 12 million tons of waste per year [2], and emits around 18 million tons of greenhouse gases (as CO2-equivalents) [3]. Today, under 2% of the Swedish construction and demolition waste goes to material recycling, while most (47%) is used as construction materials around landfills. Large

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fractions also go to landfill (36%) and to energy recovery (11%) [2]. Increasing the reuse levels plays a central role in reducing waste volumes, virgin resource extraction and the emission of greenhouse gases.

1.2 CCBuild – a knowledge and information sharing platform

One main barrier limiting reuse in practice is lack of knowledge regarding potential levels of reuse and its potential environmental effects [4]. CCBuild (Center for Circular Building) is a digital platform and a knowledge sharing network with the aim of increasing the reuse levels in the Swedish building sector [5]. The work presented here is based on findings so far on reusability of building products within CCBuild.

2 Estimating the potential benefits of reuse

The core element of the CCbuild platform is a product database that currently has three different applications: an inventory tool, a product bank and a marketplace. The inventory tool can be used to assist and record material inventories and collect data on products available for reuse. The product bank provides an overview of the products available for reuse within a specific project or organization based on entries from the inventory tool. The marketplace can be used to buy and sell products for reuse. A module of the tools is used to produce an assessment and communication of the environmental potential of reuse.
The current version of the CCBuild tools includes roughly 250 pre-defined construction products, lighting and furniture.
The assessment of the environmental potential of reuse is based on user input data regarding the product volumes available for reuse, among the pre-defined product types. The product types are coupled to default data for environmental performance and assumptions on material content based on data sources such as environmental product declarations (EPD), product sheets, construction product declarations (eBVD) and webshops.
If a CCBuild user wants to add a product that cannot be found among the pre-defined product types, it is added within the category “other”, in which case only the waste and resource potential indicator comes into play.

2.1 Calculating the environmental potential of reuse

In CCBuild reuse is assumed to replace the need to produce and transport a new product, as well as replacing the need to transport and manage waste of the existing product. Reuse is assumed to require additional transports. The following transport scenarios have been assumed, mainly as a way to include indicatively reasonable transport distances and modes:

- Manufacturing: 1 500 km (international) heavy truck
- Waste management: 30 km (local) heavy truck
- Reuse: 200 km (regional) light truck

Transports for raw material are included in the upstream data (RM). The impact from manufacturing is either included in the datasets or assumed to be a share of 20-30% of the impact on the raw material production. Reconditioning and storing are not accounted for in the current version.
The indicators of the environmental potential of reuse assessed within CCBuild are:

- Waste and resource potential (ton): the resource use and waste volumes avoided are presented as total volumes (ton), as well as divided into resource types (see 3.1.1)

- Climate mitigation potential (ton CO_{2eq}): The climate mitigation is presented as carbon dioxide equivalents (ton $CO_{2eq, 100\ years}$), excluding biogenic carbon [7]
- Environmental damage cost potential (EURO): The assessment uses EPS version 2015dx (excluding climate impacts from secondary particles) [8] and presents the environmental damage cost potential of reuse in terms of EURO of environmental damage costs avoided due to reuse.

2.2 Reused volumes

Results are calculated for reuse within CCBuild (2.2.1) as well as for the Swedish building sector in general (2.2.2).

2.2.1 Potential for reuse within CCBuild

The assessment of the reuse potential within CCBuild is based on user data for current reuse projects within CCBuild extracted from the product database in May 2020. In total, data on 130 reuse projects created by 33 different organizations including architects, property owners and reuse consultants were extracted from the system. Table 1 presents the number of product units within CCBuild as well as per average CCBuild project, divided into lighting, furniture, construction products and other. In total, the CCBuild product bank included 66079 product units at the time, all considered available for reuse. Of these, 43524 (66%) included the data and information necessary to assess their environmental reuse potential, notably estimated aesthetical and functional value as well as product and material category and mass, and for these products matching to environmental data was possible, adding up to 814 tonnes (see Table 2). For the remaining 34%, the information was too scarce to allow a robust matching against environmental data (for example lacking material type or mass), and these have therefore been excluded from further assessment.

Table 1. The environmental potential for reuse within CCBuild is based on the products available for reuse in CCBuild in May 2020, entered since the start in January 2019.

Product type	**No. of product units available in the CCBuild platform (May 2020)**	**No. of product units used in an average CCBuild project (May 2020)**
Lighting	5,506 (8%)	42
Furniture	6,559 (10%)	50
Construction products	31,459 (48%)	242
Other	22,555 (34%)	174
Total	**66,079 (100%)**	**508**

2.2.2 Potential for reuse on National scale

Ccbuild projects have only recorded in the CCBuild product bank the products from refurbishing projects deemed suitable for reuse. No records have been taken of the total waste amounts in these projects. Instead, the potential for reuse on national scale in the Swedish building sector is based on estimates of building waste reuse potentials at municipal recycling centers [6] combined with the national waste levels from the building sector. In [6] it is estimated that 19% of the construction products discarded as waste at recycling centers could be commercially reused and an additional 7% could be functionally reused. In our estimate, the numbers are rounded off to 20% (commercial, 600 000 tons) plus 10% (functional, 300 000 tons) of the non-hazardous wood and mineral waste (3 million tons/year).

3 Results

Based on the product volumes assessed to have a reuse potential within CCBuild (Table 1) and the Swedish building sector (Table 2), this section assesses the environmental potential for reuse within CCBuild (3.1) as well as in the Swedish building sector in general (3.2).

3.1 Environmental potential of reuse within CCBuild

3.1.1 Waste and resource use

Reusing the products available within CCBuild has the potential to reduce resource use with approximately 800 tons, and the waste volumes with the same amount. This equals an average waste and resource potential of around 6 tons per CCBuild project. Table 2 shows the division of material resources for the CCBuild product types construction products (631 tons), lighting (31 tons) and furniture (151 tons). The material resource content of the CCBuild construction products is similar to the national waste from the building sector, with approximately one-fourth of wood resources and the main fraction being mineral resources. The lighting products contain mainly metals, glass, plastics and electronics. The furniture category contains mainly wood, metals and plastics.

Table 2. Waste and resource potential for the products available for reuse within CCBuild.

Resource type	Construction products (ton)	Lighting (ton)	Furniture (ton)	Total (ton)
Glass	275 (44%)	6 (18%)	-	281 (35%)
Wood	131 (21%)	-	71 (51%)	209 (26%)
Metals	42 (7%)	21 (69%)	53 (35%)	117 (14%)
Plaster	97 (15%)	-	-	97 (12%)
Plastics	14 (2%)	2 (8%)	17 (12%)	34 (4%)
Stone	12 (2%)	-	-	12 (2%)
Tiles and porcelain	7 (1%)	-	-	7 (1%)
Electronics	-	1 (4%)	-	2 (0%)
Other	52 (8%)	0.3 (1%)	3 (2%)	56 (7%)
Total	**631 (100%)**	**31 (100%)**	**151 (100%)**	**814 (100%)**

3.1.2 Climate mitigation

Reusing the products available within CCBuild has the potential to reduce greenhouse gas emissions with approximately 1,600 tons of CO2eq. This equals an average climate mitigation potential of around 12 tons of CO2eq per CCBuild project. Table 4 shows the division of the climate mitigation potential between the different CCBuild product categories. The main potential can be found in reusing construction products (912 tons of CO2eq) and furniture (513 tons of CO2eq), with a more limited potential in lighting (173 tons of CO2eq). Of the construction products, the main potential can be found in inner walls (412 tons of CO2eq) and doors (194 tons of CO2eq).

3.1.3 Environmental damage cost

Reusing the products available within CCBuild has the potential to reduce environmental damage costs with approximately 2.3 million EURO. This equals an average environmental cost potential of around 17,000 EURO per CCBuild project. Table 5 shows the division of the environmental cost potential between the different CCBuild product categories. The main

potential can be found in reusing furniture (1.1 million EURO) and lighting (0.8 million EURO), with a more limited potential in construction products (0.4 million EURO).

Table 3. Climate and environmental damage cost savings potential for the products available for reuse within CCBuild.

Product type		Climate mitigation potential (tons of CO_{2eq})	Environmental cost potential (EURO)
Lighting		170 (11%)	770,000 (34%)
Furniture		510 (32%)	1,110,000 (49%)
Construction products	Doors	190 (12%)	85,000 (4%)
	Windows	110 (7%)	35,000 (2%)
	Grids and forging	30 (2%)	15,000 (1%)
	Flooring	60 (4%)	10,000 (0%)
	Inner walls	410 (26%)	185,000 (8%)
	Ceilings	90 (6%)	55,000 (2%)
	Bathrooms and kitchens	20 (1%)	10,000 (0%)
Total		**1,590 (100%)**	**2,275,000 (100%)**

3.2 Environmental potential of reuse in the Swedish building sector

Only a rough estimate can be made for the whole building sector, corresponding to the rough estimate in Section 2.2.2, as the detailed distribution among product types has not been studied in this case. Based on the potential reuse estimated in Section 2.2.2, and the assumption that the average climate and environmental damage cost saving per ton of reused product is the same as for the CCbuild sorted out products (about 2 tons of CO2eq/ton and 2800 EURO/ton, respectively), the annual climate impact saving if exploiting the full reuse potential would be 1 200 000 tons of CO2eq for the commercial reuse and another 600 000 tons for the functional reuse. The corresponding environmental damage cost savings potential would be 1 680 MEURO and 840 MEURO, respectively.

4 Conclusions

This paper presents an assessment of the environmental potential of reusing the products available within the platform CCBuild, as well as the environmental potential of reusing Swedish building and demolition waste. The products available for reuse within CCBuild includes both furniture, lighting and interior and exterior construction products such as doors, windows, flooring and ceilings.

Reusing the products within CCBuild has the potential to reduce resource use with over 800 tons, and waste volumes by the same amount. This corresponds to around 6 tons per average reuse project. The main material resources available for reuse within CCBuild are glass (35%), wood (26%), metals (14%) and plaster (12%). Reusing the products within CCBuild has the potential to reduce greenhouse gas emissions by approximately 1,600 tons of CO2eq, corresponding to around 12 tons of CO2eq per average reuse project. The product types with the most significant climate mitigation potential are furniture (32%), inner walls (26%), doors (12%) and lighting (11%). Lastly, reusing the products within CCBuild has the potential to reduce environmental damage costs by approximately 2.3 million EURO, corresponding to around 1,800 EURO per average reuse project. The product types with the most significant environmental cost potential are furniture (49%), lighting (34%) and inner walls (8%). As around one-third of the CCBuild products have been excluded from the assessment due to a lack of data, the environmental potential presented in in the paper is likely underestimated.

The environmental potential as calculated for the CCBuild construction products has been upscaled to a national level based on the total waste volumes from the Swedish building sector, assuming that 30% of the non-hazardous wood and mineral waste can be reused. Hence, the national potential to reuse is estimated to be 900,000 tons of building waste per year. This could potentially reduce greenhouse gas emissions with 1.8 million tons of CO2eq per year, corresponding to around 7% of the total greenhouse gas emissions of the Swedish building sector. Furthermore, it could potentially reduce the environmental damage costs by approximately 2.5 billion EURO per year. As a comparison, the turnover of the building and construction industry during 2020 was approximately 30 billion EURO.
The environmental potential of reuse presented in the paper does not take into account the environmental impact of reconditioning and storing in relation to reuse. This is due to the significant uncertainties regarding the extent and effects of these processes. However, it may result in an overestimation of the environmental potential of reuse. Furthermore, the assumption that 30% of the national building and demolition waste can be reused is highly uncertain. Today, this figure may be lower since the current building design is rarely adapted to enable deconstruction and reuse. However, in a future more circular society this figure should rather approach 100%, as a circular economy should not include any non-hazardous waste that cannot be recirculated back into society.

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