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Circular Economy in the built environment using Life Cycle assessment: a case study

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Background

The construction sector is one of the world's largest contributors to the increasing global environmental impact and accounts for 25-40% of the global carbon dioxide emissions. In attempts to reduce the environmental impact emerging from the construction sector, the focus has mainly been on the operational stage of a buildings service life. However, since the construction sector is a large consumer of natural resources and generates large amount of waste materials, the concept of circular economy is increasing as a mean to reduce the environmental impact of a buildings service life. Circular economy focuses on resource efficiency through reducing, reusing, recycling and recovering. To ensure that circular economy does in fact reduce the environmental impact caused by life cycles in a buildings service life, this study aims at developing environmental data on the topic.

Objectives

- Generate data on the Global Warming Potential (GWP) of five cases of circular building components
- Quantify the environmental benefits of introducing circular building components compared with conventional ones

Methods

Life cycle assessment (LCA) is a common approach to assess environmental performance throughout the life cycle of a product, a service or an activity. In this study, LCA is applied to five circular building components and to five corresponding conventional building components assumed to provide the same functionality and quality. The conventional building components include:

- *1 m^3 of concrete, 25 MPa, using natural gravel as aggregate (not reinforced)*
- *1 m^2 of brick wall*
- *1 m^2 of thermal window*

In this study solely the production (A1-A3), the End of Life (C3-C4) and the potential for reusing/recycling (D) of the material are considered. Additionally, the study applies the cut-off allocation method cf. EN15804 and EN 15978.

Circular scenarios

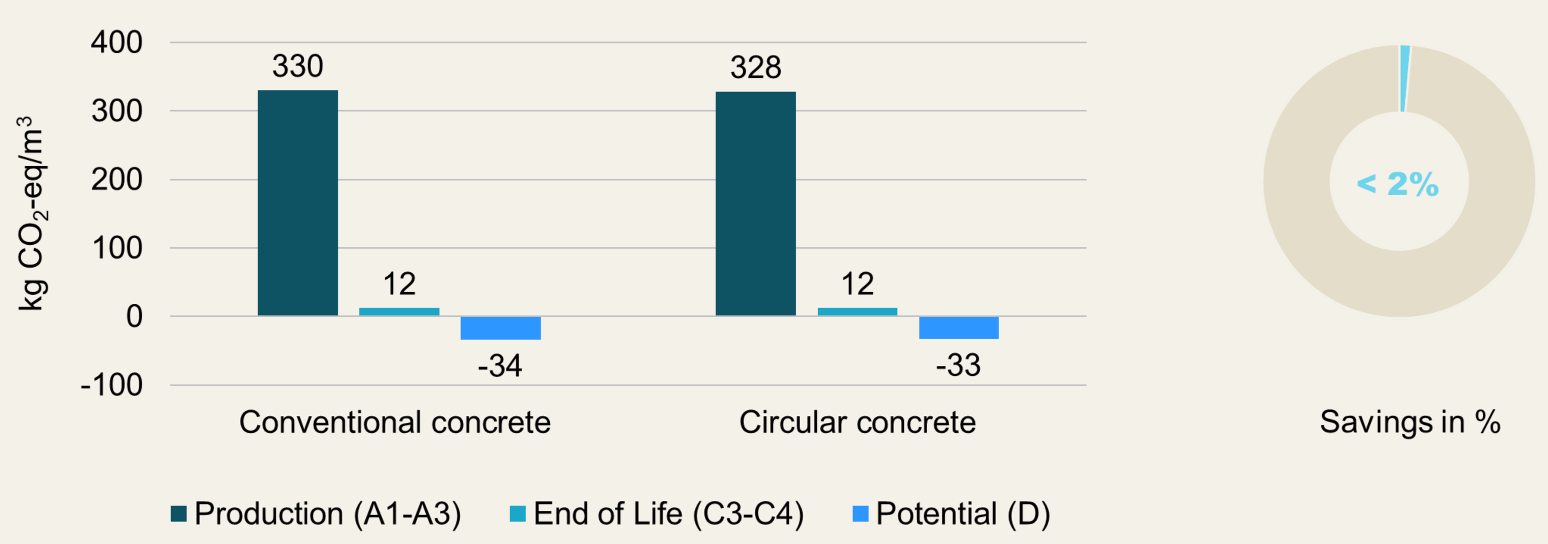
- *100% recycled concrete aggregate*
  1 m^3 of concrete, 25 MPa, is produced replacing 100% of the natural aggregate with crushed concrete and without reinforcement. At End of Life the concrete is recycled as road filling.
- *Reused exterior concrete wall elements*
  1 m^3 of concrete elements are cut out of an existing building and reused in a new building as they are. At End of Life the concrete elements are recycled as road filling.
- *Wall façade using reused bricks*
  1 m^2 of brick wall cladding are produced using recycled bricks and conventional mortar. At End of Life the bricks and mortar are recycled as road filling.
- *Recycled brick wall façade elements*
  An existing brick wall, including mortar, is cut up into elements of 1 m^2 and strengthened with concrete and reinforcement at the back for support. The elements are then used as wall cladding in a new building. At End of Life the brick wall elements are recycled as road filling.
- *Reused thermal glazing in window*
  1 m^2 of thermal window are produced using two recycled thermal panes. The window frame is made of wood. At End of Life the panes are landfilled and the wood frame incinerated.

Results

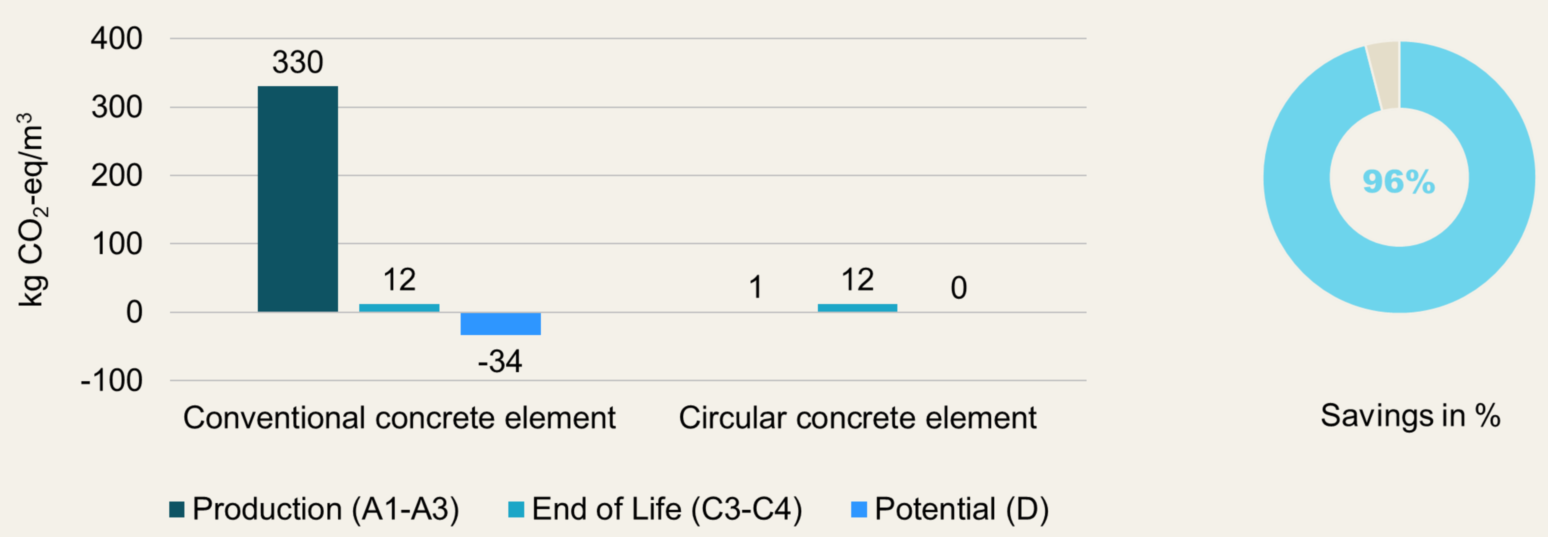
The results of the study are presented in the diagrams below. The environmental performance in Global Warming Potentials, **GWP (kg CO2-eq/unit)**, are presented in the diagrams to the left for the circular and conventional building component respectively. The diagrams to the right shows the potential savings of introducing a circular building component compared to a conventional building component. The savings are estimated as the difference in GWP between the circular and conventional scenario for all considered life cycles divided by the GWP for the conventional scenario. The final savings are shown in percentage.

The results show that the main environmental impact is in the production phase in all scenarios, both the conventional and the circular ones. Additionally, we see from the results that the End of Life phase as well as the potential environmental benefits for recycling has only minor influence on the results in two out of five cases. Finally, the results show that the savings of introducing a circular building material varies greatly - from below 2% to 97% depending on the considered scenarios.

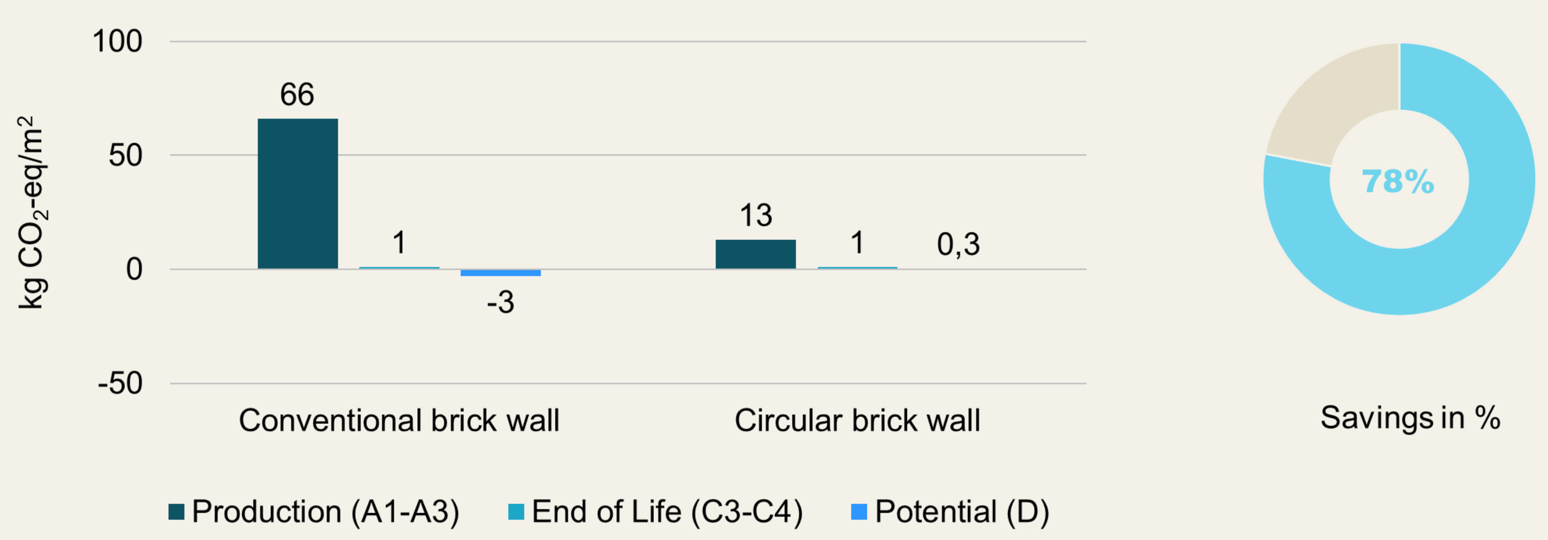
Circular scenario: 100% recycled concrete aggregate



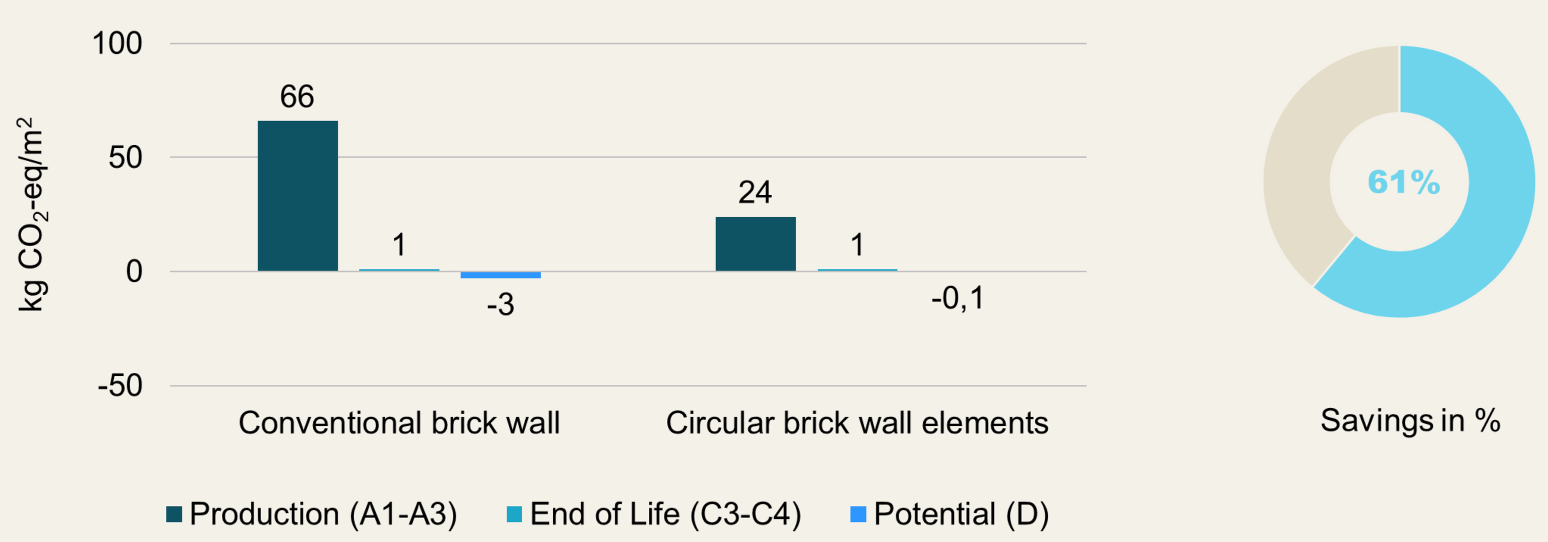
Circular scenario: reused exterior concrete wall elements



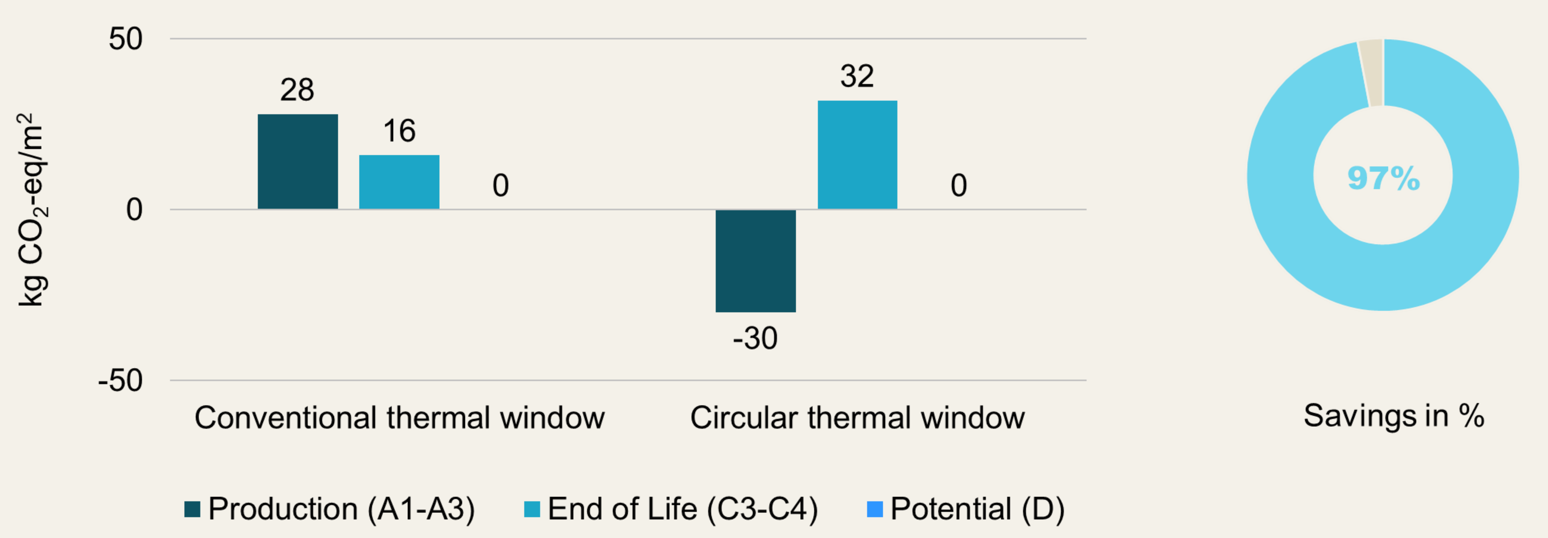
Circular scenario: wall façade using reused bricks



Circular scenario: recycled brick wall façade elements



Circular scenario: reused thermal glazing in window



Conclusion

From this study we find that circular economy has the potential to reduce the GWP of a building, however that the potential highly depends on the scenarios considered and the applied methodology. The goal of this study was to generate data on five cases of circular building materials some of which are only recently introduced to the construction sector. Because of this, it was not possible to find complete information on processes and materials for all circular scenarios resulting in general data being used. These uncertainties affect in some cases the results to such an extent that the conclusion when comparing the circular scenario to the conventional scenario is changed. Likewise is it possible that uncertainties and shortcomings in the modelling of the conventional scenarios can affect the results to a different conclusion. This emphasizes that environmental data on circular as well as conventional building components lack development and that a sensitivity analysis would be highly relevant to conduct as further work. Only by establishing data on circular economy we can utilize the full potential and ensure that erroneous decisions are avoided when introducing circular economy in the construction sector.

Key findings

- Circular economy has the potential to reduce the GWP of building materials
- The results are highly sensitive to the circular scenario and the modelling practices
- There is a risk of choosing solutions with an increased environmental impact if data on circular building materials are not developed

References

Andersen, C., & Birgisdóttir, H. (2019). *Livscyklusvurdering for cirkulære løsninger med fokus på klimapåvirkning: Forundersøgelse.* SBi, Nr. 2019:08

VIA University College and Danish Building Research Institute (2019). *Dialogværktøj – Cirkulær værdiskabelse i den eksisterende bygningsmasse*

Birgisdottir, H., & Madsen, S. S. (2017). *Bygningers indlejrede energi og miljøpåvirkninger: Vurderet for hele bygningens livscyklus*. SBi, Nr. 2017:08

Eberhardt, L. C., Birgisdóttir, H. & Birkved, M. (2018). *Potential of Circular Economy in Sustainable Buildings.* IOP Conference Series: Materials Science and Engineering

Lendager, A. & Vind, D. L. (2018). *A changemaker's guide to the future*

World Green Building Council (2019). *Bringing embodied carbon upfront*

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