

Start- end date: 15-02-2022 / 15-07-2022	 Universidade Federal de Viçosa	
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Problem / assignment

The current BIPV(T) modeling on Revit does not include circularity benchmarks on it, precluding the assessment and the decision-making regarding circularity since the early design stage. On this scenario, this research work aims to evaluate the applicability of Revit plugins, that assess a building's circularity indicators, into BIPV(T) context and develop a tutorial about its functionalities and how they work.

Used methods / project phases

The approach of this research work consists of the following steps:

- [1] At this stage, desk research will be done, with interviews with experts and searches on the internet, articles, reports, to find suggestions of available circularity Revit plugins. Each one of them will be evaluated regarding its inputs, used database, used formulas, user-friendship, applicability to BIPV(T) systems, and what kind of result they deliver.
- [2] At this step, a case study will be developed. Based on the Revit model of a demo project, the level of circularity of a building will be analyzed using each one of the plugins under study. Then, a comparison will be developed between the results obtained by each plugin. Previously, will be compared the level of circularity of the building in its zero-situation and in its BIPV(T)-situation, using each one of the plugins.
- [3] In the last step, all the work progress will be documented and a tutorial regarding the plugins under study and the assessment of the level of circularity will be developed.

Results

The development of this work aimed to answer some research questions and its results are shown below.

1. What are the indicators to assess the level of BIPV(T) technologies applied in the building sector?

To assess the level of circularity of buildings and its components, such as BIPV(T) technologies, there are few assessment models for building circularity, like MCI (EMF, 2015b) or BCI (Verberne, 2016). There are also other indicators, related to intrinsic properties of used materials, such as percentage of virgin mass, percentage reused/recycled material, percentage of renewable material, material's toxicity, embodied energy, and the main indicator applied in this study, the embodied carbon.

2. Which Revit plugins are available, what do these plugins assess and how are these plugins assessing circularity regarding its used formulas and database?

The plugins capable of assessing the level of circularity of buildings, which are open access and free, found available for the development of this study was Tally, Carbo Life Calculator and One Click LCA. All three calculate in common the embodied carbon indicator.

Results

Furthermore, both Tally and One Click LCA assess the level of several environmental impacts, such as acidification potential, eutrophication potential, ozone depletion potential, smog formation potential, and energy demand.

All plugins under study work similarly. The project elements are identified by its Revit category and its volume. Then, from the material selection made by the user, it is calculated that element's mass and embodied carbon. Tally uses GaBi 2018 database and its methodology is consistent with ISO 14040-14044, ISO 21930:2017, ISO 21931:2010, EN 15804:2012, and EN 15978:2011. The calculation methodology of Carbo Life Calc, in turn, follows the instructions of EN 15978:2011, RICS, and The Institute of Structural Engineers, while One Click LCA, provides several databases, including European e Netherlands.

3. How accurate are their results and what are the reasons of their deviation?

The results of embodied carbon calculated by the three plugins were considered accurate, once that adopting a confidence level of 95%, the margin of error is $19,836 \pm 3,626$. This range encompasses the reference value of embodied carbon of 23,021 calculated by the spreadsheet. When analyzing the roof renovation, by including BIPV(T) system, the results were also satisfactory. Both the increase in the embodied carbon of the product stage of the renewed roof and the total embodied carbon of the building were close using each one of the plugins.

4. What are the requirements of the Revit model, i.e. level of detail of the geometric model, to conduct an accurate assessment of the level of circularity?

In order to obtain accurate results, it is important that the Revit model has a certain level of detail in relation to the existing building or whose construction is studied.

For instance, the model used in this study has a significant level of detail, which can be seen, for instance, by the walls applied in the project which each one of them was modeled taking into account its thickness, internal structure type of brick. The concrete floors, in turn, were modeled according to their actual thickness, including their finishing layer. The roof structure, was modeled considering different types of beam profiles, in order to get as close to the real construction as possible. And that level of detail was maintained even in the most minute elements, such as the thickness of the door and the glass window.

In addition, it is important to properly select the materials from the plugins database to make sure the analysis is being done correctly.

Extra info / advice / link to final document and presentation

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