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ENVIRONMENTAL PERFORMANCE OF INNOVATIVE WOOD BUILDING SYSTEMS USING LIFE-CYCLE ASSESSMENT

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ABSTRACT: Buildings have a significant impact on the environment. Life-Cycle Assessment (LCA) is a scientific methodology of accounting for these potential impacts throughout the life of a good or a service. There are several software tools based on LCA. The objective of the project is to evaluate the strengths and limitations of two LCA software, Athena and SimaPro, in the assessment of innovative timber buildings. The results, based on the analysis of a case study, show how the potential impacts varies depending on the method used.

KEYWORDS: Life-Cycle Assessment, Timber Building, Environmental impact, Glulam, Athena, SimaPro

1 INTRODUCTION

According to the US Environmental Protection Agency [1], buildings consume 12% of water, 30% of raw material, 68% of electricity, 39% of energy; they generate 30% of green house gases and 30% of wastes in the USA.

Life Cycle Assessment (LCA) is the most comprehensive environment assessment tool available. It is defined as: Evaluation of the potential environmental impact of a product, service or system in relation to a particular function, considering all stages of its life cycle [2].

2 RESEARCH OBJECTIVE

The objective of the project is to evaluate the strengths, limitations and the needs for future development of two LCA tools, Athena[3] and SimaPro[4], to analyse innovative timber buildings. They are studied in two perspectives, the building designer perspective (engineer or architect) and that of the LCA expert (analyst or research scientist).

3 METHODOLOGY

- Analyse the case study: a 6 storey building with a glulam or a concrete structure;
- Determine functional unit and calculate bill of materials (BOM) and operation energy;
- LCA of the case study with Athena (version 4.2.0410)
  1) by assemblies; 2) by materials;
- LCA of the case study with SimaPro (version 7.3.3)
  1) with only embodied energy in materials and operation energy;
  2) complete LCA;
  3) sensitivity analyses.

3.1 CASE STUDY

The case study is the six-storey office building of FondAction in Québec City, a glulam post and beam structure with wooden floor decking. It is the highest contemporary such wood building in North America. The functional unit and more important analysis parameters were defined to consider a possible comparison between various scenarios (Table 1).

Table 1: *Functional unit of the case study*

Scenario	Functional unit	Reference flux	Parameter
Glulam	Construction and operation of a 6-storey office building 50 years in Quebec city	1 building	Construction design Materials life-span Thermal resistance of the envelope

4 RESULTS

4.1 ATHENA

Athena modelling was done in two ways: first by assemblies using the integrated dimensioning tool and then by materials using calculated bill of materials (BOM). Athena calculations include standard maintenance cycles.

Athena compares 7 midpoint indicators and using its own integrated database and impact assessment method. The LCA results show up to 10% difference between the two modeling methods (Figure 1).

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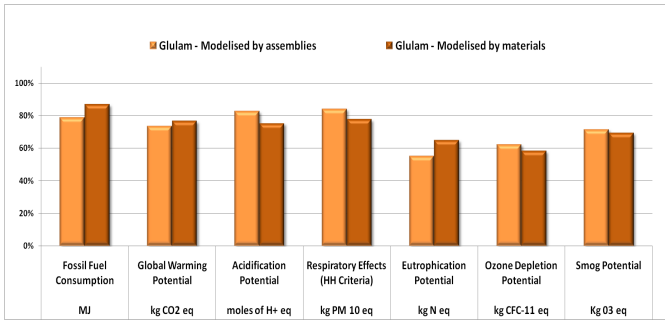

Figure 1: *Midpoint indicators with Athena 4.2.0140*

4.2 SIMAPRO

SimaPro contains several databases and impact assessment methods which allow considering a diversity of midpoint and endpoint indicators. Figure 2 presents the potential impacts at the endpoint indicators calculated for the Impact 2002+ LCIA methodology. It shows less than 8% difference between the complete LCA results and the potential impacts obtained for the partial LCA considering only material manufacturing and operating energy.

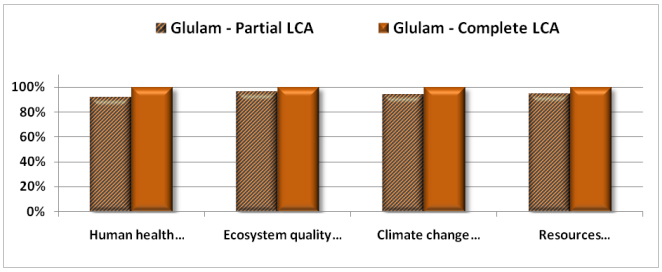

Figure 3: *Endpoint indicators with SimaPro (Impact 2002+)*

With SimaPro, a further analysis of the midpoint indicators and their contribution to the endpoint indicators lead to a better understanding of the calculated potential impacts. SimaPro also allows visualizing the network of contributing processes to the various impact indicators (Figure 3).

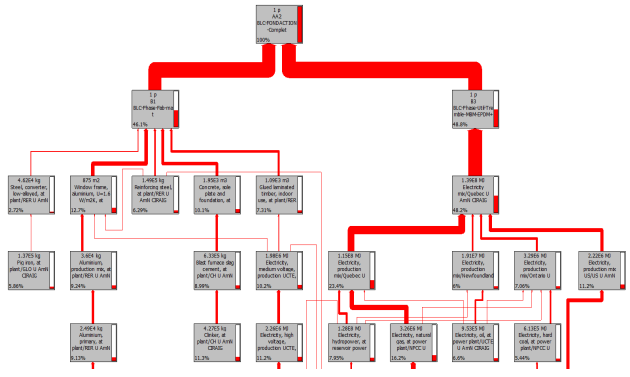

Figure 3: *Network of contributing processes for climate change indicator*

5 DISCUSSION

Athena allows to perform a building summary LCA in few hours. With SimaPro the data collection and analysis requires weeks.

For Athena, the most important improvement proposed relates therefore to the flexibility of modeling and the transparency of LCA results. The user often needs the possibility of choosing amongst default materials, life span of products and required maintenance cycle to better model a specific building. Regarding LCA results, the assumptions considered should be made more readily available, and it should be made possible for the user to know the most important contributor to a specific result.

For SimaPro, the availability of database and processes better representing the Quebec or Canadian context is needed. As an example, it would be important to take into account regional construction techniques, as well as forestry practices.

The needs for future researches also relate to life cycle impact assessment methods (LCIA). Indeed, some indicators, such as land-use change, require more scientific work to be able to represent the potential environment impacts with more accuracy, in specific contexts.

6 CONCLUSIONS

The study shows that the choice of impact assessment method is critical to LCA results, and therefore emphases the importance of knowing the most important contributing processes affecting the final results. Much remains to be done to represent the impact of material production in its geographical diversity.

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