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Considering Uncertainties of Input Parameters on Energy, Environmental Impacts and Life Cycle Costing by Monte Carlo Simulation in the Decision Making Process

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Abstract : The refurbishment of the building stock in terms of energy supply and efficiency is one of the major challenges of the German turnaround in energy policy. As the building sector accounts for 40% of Germany's total energy demand, additional insulation is key for energy efficient refurbished buildings. Nevertheless the energetic benefits often the environmental and economic performances of insulation materials are questioned. The methods Life Cycle Assessment (LCA) as well as Life Cycle Costing (LCC) can form the standardized basis for answering this doubts and more and more become important for material producers due efforts such as Product Environmental Footprint (PEF) or Environmental Product Declarations (EPD). Due to increasing use of LCA and LCC information for decision support the robustness and resilience of the results become crucial especially for support of decision and policy makers. LCA and LCC results are based on respective models which depend on technical parameters like efficiencies, material and energy demand, product output, etc.. Nevertheless, the influence of parameter uncertainties on lifecycle results are usually not considered or just studied superficially. Anyhow the effect of parameter uncertainties cannot be neglected. Based on the example of an exterior wall the overall lifecycle results are varying by a magnitude of more than three. As a result simple best case worst case analyses used in practice are not sufficient. These analyses allow for a first rude view on the results but are not taking effects into account such as error propagation. Thereby LCA practitioners cannot provide further guidance for decision makers. Probabilistic analyses enable LCA practitioners to gain deeper understanding of the LCA and LCC results and provide a better decision support. Within this study, the environmental and economic impacts of an exterior wall system over its whole lifecycle are illustrated, and the effect of different uncertainty analysis on the interpretation in terms of resilience and robustness are shown. Hereby the approaches of error propagation and Monte Carlo Simulations are applied and combined with statistical methods in order to allow for a deeper understanding and interpretation. All in all this study emphasis the need for a deeper and more detailed probabilistic evaluation based on statistical methods. Just by this, misleading interpretations can be avoided, and the results can be used for resilient and robust decisions.

Keywords : uncertainty, life cycle assessment, life cycle costing, Monte Carlo simulation
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