Environmental impact of heating and ventilation systems in the LCA of a Flemish single-family dwelling

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ABSTRACT

In recent decades, efforts to reduce the operational energy use of buildings have led to the adoption of thermal insulation and more efficient heating and ventilation systems. However, this has increased the relative importance of embodied impacts, which stem from the production, transportation, installation, and disposal of building materials and technical installations. Life cycle assessment (LCA) is widely used to evaluate the environmental impact of buildings, but the embodied impact of heating and ventilation systems is often omitted or considered in a highly simplified manner, typically accounting only for primary components such as the generation system. Today, limited knowledge exists regarding which individual components of heating and ventilation systems are critical to include in LCA studies and how they contribute to the building's embodied and life cycle impact.
This study investigates (1) the significance of individual components in heating and ventilation system design, (2) the relative contribution of technical installations to embodied and life cycle impacts at the building level, and (3) the difference between a detailed approach (considering the generation system, emission system, distribution system, and other associated components) and a simplified approach (including solely generation systems). This research assesses the environmental impact of three heating systems and two ventilation systems in a Flemish single-family dwelling over a 60-year study period, following a cradle-to-grave approach. The heating systems analysed include a condensing gas boiler, a brine-water heat pump, and an air-water heat pump combined with underfloor heating. The ventilation systems considered are a demand-controlled exhaust ventilation system and a balanced ventilation system with heat recovery.
The findings indicate that a simplified approach, which accounts only for generation systems, underestimates the building's embodied and life cycle impact by 8–12% and 4–6%, respectively. Heating and ventilation systems contribute between 12–33% of the total embodied impact and 5–20% of the overall life cycle impact. The significance of individual components highly depends on the heating and ventilation concept. The study highlights that limited data on technical installations' embodied impacts hinders accurate LCAs. Expanding data availability would facilitate more frequent inclusion of technical installations in LCA studies and improve accuracy. Moreover, assessing the embodied impact of technical installations requires a large data inventory, making further detailed LCA studies essential for the development of simplified approaches that do not compromise the robustness of the results.

KEYWORDS

Life cycle assessment; Embodied impact; Heating systems; Ventilation systems; Single-family dwelling