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Life-Cycle Assessment of Residential Buildings: Addressing the Influence of Commuting

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Abstract : Due to demands of a growing urban population, it is crucial to manage urban development and its associated environmental impacts. While most of the environmental analyses have addressed buildings and transportation separately, both the design and location of a building affect environmental performance and focusing on one or the other can shift impacts and overlook improvement opportunities for more sustainable urban development. Recently, several life-cycle (LC) studies of residential buildings have integrated user transportation, focusing exclusively on primary energy demand and/or greenhouse gas emissions. Additionally, most papers considered only private transportation (mainly car). Although it is likely to have the largest share both in terms of use and associated impacts, exploring the variability associated with mode choice is relevant for comprehensive assessments and, eventually, for supporting decision-makers. This paper presents a life-cycle assessment (LCA) of a residential building in Lisbon (Portugal), addressing building construction, use and user transportation (commuting with private and public transportation). Five environmental indicators or categories are considered: (i) non-renewable primary energy (NRE), (ii) greenhouse gas intensity (GHG), (iii) eutrophication (EUT), (iv) acidification (ACID), and (v) ozone layer depletion (OLD). In a first stage, the analysis addresses the overall life-cycle considering the statistical model mix for commuting in the residence location. Then, a comparative analysis compares different available transportation modes to address the influence mode choice variability has on the results. The results highlight the large contribution of transportation to the overall LC results in all categories. NRE and GHG show strong correlation, as the three LC phases contribute with similar shares to both of them: building construction accounts for 6-9%, building use for 44-45%, and user transportation for 48% of the overall results. However, for other impact categories there is a large variation in the relative contribution of each phase. Transport is the most significant phase in OLD (60%); however, in EUT and ACID building use has the largest contribution to the overall LC (55% and 64%, respectively). In these categories, transportation accounts for 31-38%. A comparative analysis was also performed for four alternative transport modes for the household commuting: car, bus, motorcycle, and company/school collective transport. The car has the largest results in all impact categories. When compared to the overall LC with commuting by car, mode choice accounts for a variability of about 35% in NRE, GHG and OLD (the categories where transportation accounted for the largest share of the LC), 24% in EUT and 16% in ACID. NRE and GHG show a strong correlation because all modes have internal combustion engines. The second largest results for NRE, GHG and OLD are associated with commuting by motorcycle; however, for ACID and EUT this mode has better performance than bus and company/school transport. No single transportation mode performed best in all impact categories. Integrated assessments of buildings are needed to avoid shifts of impacts between life-cycle phases and environmental categories, and ultimately to support decision-makers.

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