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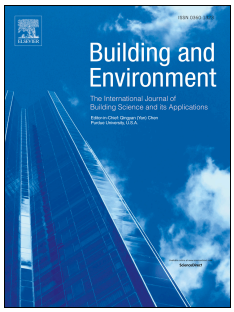

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A life cycle approach to optimizing carbon footprint and costs of a residential building

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Abstract

Finding life cycle optimized building designs is a challenging task. It requires the inclusion of all phases of the building life cycle in a single optimization problem. The present study demonstrates a life cycle simulation-based optimization approach, by including the operational carbon footprint (OCF) and embodied carbon footprint (ECF) of a building. Particularly, finding and analyzing the difference between life cycle (OCF+ECF) optimized design and operational (only OCF) performance-based optimized design is the primary goal of the current study. The life cycle optimization method is applied to a townhouse in Finland to determine carbon-cost optimal designs. Different options of building envelope insulation thicknesses, window types, heating systems, heat recovery units, and PV area are explored as design variables. It has been found that the heating system is a dominant design variable, which results in clearly separated pareto fronts for each system. Generally, a majority of the design variables' optimal values, obtained from OCF+ECF optimization, suggest thinner insulation for the building envelope and a larger PV area, compared to the optimal solutions from OCF optimization. In a carbon optimal solution, the share of ECF is 39% of the life cycle carbon footprint, whereas in a cost optimal solution, the share of ECF is 28% of the life cycle carbon footprint.

Keywords: Buildings, life cycle optimization, carbon footprint, embodied carbon, life cycle cost

List of abbreviations

AHU	Air handling unit
CAV	Constant air volume
DH	District heating
DHW	Domestic hot water
EPBD	European Performance of Buildings Directive
EU	European Union
ECF	Embodied carbon footprint
GHG	Greenhouse gas
GSHP	Ground source heat pump
IC	Investment costs
LCCF	Life cycle carbon footprint
LCC	Life cycle costs
LCA	Life cycle assessment
MC	Maintenance costs
NSGA	Non-dominated sorting genetic algorithm
OCF	Operational carbon footprint
OC	Operational costs
RC	Replacements costs