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Impacts of parameter values interactions on simulated energy balance of residential buildings

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Abstract

In this study we use dynamic simulation to explore the interactive impacts of different uncertain parameter values in energy balance modelling of existing and improved variants of a Swedish multi-storey residential building. We modelled variations as well as interactive influence of different simulation assumptions and parameters encompassing outdoor microclimate, building thermal envelope and technical installations including household equipment. The results indicate that the interactive influence of the parameters on calculated space heating of buildings seems to be small and relatively more evident for a low-energy building than for a conventional building. The influence of the interactions between the parameter combinations becomes more evident as several parameters are varied simultaneously. The results also indicate that calculated space heating demand of a building is noticeably influenced by how heat gains from household equipment and technical installations are modelled. The calculated final energy for space heating for the analysed building versions varied between 13-43% depending on the energy efficiency levels for household equipment and technical installations as well as their interactions with other parameter values variations. This study shows the importance of appropriate input parameters and assumptions for building energy balance calculation.

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Keywords: Energy balance simulation; input data; parameters and assumptions; residential buildings; space heating demand

1. Introduction

Typically, the operation stage dominates the lifecycle impacts of buildings and presents large opportunities for energy and greenhouse gases emissions reductions. Space heating accounts for the single largest share of the total final

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operation energy use in buildings in most European Union countries, and is reported to represent 60% of the total final operation energy use in the Swedish residential sector [1]. Robust analysis of buildings' energy balance is essential to adequately estimate the energy required to operate a building. Dynamic energy balance simulation software that can accurately model the final energy demand of buildings are essential, due to the complex interaction of the different factors influencing buildings thermal performance. Harvey [2] reviewed different building simulation software and suggested that integrated dynamic energy simulation tools are often less used because large amounts of input data are typically required when using such tools. To ensure quality assurance, various standard tests have been developed for validation of building simulation tools [3, 4].

Most studies (e.g. [5, 6]) on the influence of simulation input data on modelled energy balance of buildings have focused on the effect of variation of single parameter values and assumptions. Fewer studies have analysed the implication of variations and interactions of multiple parameters values and assumption. In this study, we use dynamic simulation to explore the interactive impacts of different uncertain parameter values in energy balance modelling of existing and improved variants of a Swedish multi-storey residential building. We modelled variations as well as combinations of different simulation assumptions and parameters encompassing outdoor microclimate, thermal envelope and building technical installations including household equipment.

2. Analysed building

The analysed building is a 3-storey concrete-frame building containing 27 apartments and a basement, with total heated living floor area of 2000 m^2. The building was constructed in 1972 in the Kallinge area of Ronneby municipality, Sweden, and it is described in details in [7]. An improved building is then modelled with cost-optimal thermal envelope properties, based on [8], but otherwise identical to the existing building. Table 1 shows the thermal properties for the existing and improved building variants.

Table 1. Thermal Properties of the building components

Description	**U-value (W/m^2K)**					**Air leakage**
	Ground floor	External walls	Windows	Doors	Roof	($l/s\ m^2$) at 50 Pa
Existing	0.26	0.35/0.34/0.31	2.90	3.00	0.11	0.8
Improved	0.26	0.12	1.20	1.20	0.06	0.6

3. Energy balance simulation

We use dynamic hourly simulation program to model the energy balance of the building variants and to explore the impact of parameter values variation and interactions on the simulated energy balance of the building variants. Our simulation is based on screened input data from Swedish studies, reports and the building code.

3.1. Simulation program

We simulated the annual final energy use of the buildings, using the VIP-Energy software [9]. This software calculates the space heating, ventilation, domestic hot water, and household and facility management electricity use of a building based on the building's physical characteristics, internal and solar heat gains, occupancy pattern, outdoor climate, indoor temperature, heating and ventilation systems, etc. The whole building dynamic energy balance program with multi-zone calculation features allows for detailed thermal bridges and heat storage capacity modelling as well as one-, two- and three-dimensional modelling of building thermal envelope components.

3.2. Reference parameter values and assumption

To model the reference energy balance of the building variants, we use the 2013 weather data for the Swedish city of Ronneby (latitude 56.26, longitude 15.27) and assume an indoor temperature of 22 ^oC in the apartments and 18^oC in the common areas of the building including stairwells and corridors. Table 2 shows principal values used to calculate the energy balance of the building variants.