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The transient house heating condition—the daily changes of the building envelope response factor (BER)

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Abstract

The current paper presents a logical extension of previous work [Lukić N. The transient house heating condition—the building envelope response factor (BER). Renewable Energy 2003;28:523–32.]. The daily changes of the earlier introduced building envelope response factor (BER) are shown, under transient heating conditions, during the first three heating days after a long non-heating period. Four simulation cases were studied: two-layered thermal-insulation-concrete house walls where the thermal-insulation had in, out and middle position according to inside of house and one-layered concrete house walls. Three different behaviors of central radiator heating system were simulated. The BER factor is considered an important pointer on influence of house walls to heating/cooling energy consumption and thermal comfort during transient conditions. In numerous simulations, using BER factor presentation, the start heating-period was investigated up to the achievement of defined thermal comfort inside the building walls. Alongside of the expected start peak, local peaks and off-peaks of BER factor appeared during first three heating days. Recognition of the daily changes of BER factor could enable aims, lower energy consumption and a rapid achievement of good thermal comfort. In this attempt, a building envelope, as a passive source of energy, is a critical factor.

Keywords: Dynamical model of house; Transient condition; Response factor

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Nomenclature

BER	building envelope response factor, W °C h^2
DH	degree-hour number, °C h
Q	heating energy, kW h
T	temperature, K, °C
Superscripts	
n	moment of calculation time
Subscripts	
d	daily
eh	electical heater
h	hourly
m	mean
oa	outside air
t	total
whi	inlet hot water temperature

1. Introduction

The number of designed building energy software tools available highlight their importance. For example, 215 such tools were found among International Energy Agency countries in 1995 [2]. These tools use: (1) energy parameters [3], (2) physical laws [4–9] and (3) performance data [10–12] to predict building energy performance. The physical models use three basic methods [7]: numeric [4,6], harmonic [8], and response [5,9]. These thermal building models are used for the calculation of different types of buildings: single and multiple zones; thermally light and heavy; low and high rise [3]; and residential and office buildings [3,13]. Also the building models integrate models of HVAC systems [8,11], of airflow in buildings [14], and of passive solar, photovoltaic and combined power and heating systems [15]. These models use either simulation or sensitivity analysis to design and retrofit a building, and evaluate its heating and cooling performance [13,16]. These models can be either cheap to use such as the one zone model of BRE-ADMIT [17] or ZID [1,6], on costly and time consuming, such as DOE-2 [16,18,19], BLAST [20], TRNSYS [21], BUNYIP [22], ESP [15] and recently designed EnergyPlus [23–25].

A thermal comfort prediction in a relatively stable thermal environment is one of the most important objectives of many investigations. However, the conditions, where indoor air temperature is more or less under a defined level, appear quite often even in a stable thermal environment. For buildings and rooms, where continuous heating, start heating periods or unpredictable thermal condition are not required, the variations of defined thermal parameters are always present. Those periods and transient conditions are our investigation field.

During realized simulations in Ref. [1], using the thermal building software tool ZID described in Refs. [1,6], the recently introduced building envelope response factor (BER) is taken as one value for one heating day. In this paper, our intention is to describe