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In-use office building energy characterization through basic monitoring and modelling

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ABSTRACT

Due to the European Union energy reduction strategy, many in-use buildings will be energetically monitored in the coming years to obtain their main thermal characteristics to improve or prove their energy efficiency. This is difficult to do with a reduced set of sensors and a robust data analysis methodology. This paper is focused on proposing some modifications on the existing ISO 9869 method and co-heating method to make them usable with basic energy monitoring data of in-use buildings and obtain their main thermal characteristics: the Heat Loss Coefficient (HLC considers heat losses through envelope plus infiltration) and the solar aperture (S_a or gA-value) of the whole building.

Under the FP7 project A2PBEER an occupied big office building has been energetically monitored. This monitoring system has been designed and installed while the building was in operation. Using this monitored data a modified ISO 9869 method has been applied to some specifically selected cloudy and cold winter periods to obtain the HLC of the building. Taking this HLC as a reference, a modified co-heating method has been used to estimate both the HLC again and the S_a of the whole building. Although monitoring was carried out under very difficult conditions since the building was occupied, the proposed modifications on those two existing methods have delivered very reliable results with these two Key Performance Indicators (HLC and S_a) of the building under real operation conditions.

1. Introduction

According to the European Commission, buildings are responsible for the 40% of energy consumption in Europe. The goal proposed by the EU is decarbonisation in Europe by 2050 by reducing its CO_2 emissions by 80% and energy consumption by 50%. Bearing this goal in mind, one of the central aspects to deal with is reducing the energy consumption of buildings. Most of the buildings in Europe (both residential and tertiary buildings) have been constructed without considering the energy efficiency of the building as a main issue. This has two consequences: on the one hand, most buildings are very inefficient, and on the other hand, the real energy consumption of the buildings differ by up to 100% [1,2] compared to the design case. This is why, searching for performance indicators and monitoring techniques for energy-efficiency of occupied buildings is a priority nowadays. Thus, in the coming years, harmonised protocols supporting tools and systems to characterize the performance in real operational conditions will be developed. This is the main scope and innovation of this paper since two existing methods, the ISO 9869 and co-heating method, are modified to make them usable with data sets monitored on buildings operating under real conditions to obtain their main two thermal Key Performance Indicators (KPI): the in-use Heat Loss Coefficient (HLC) and the in-use solar aperture (S_a).

There are currently several groups involved in whole building modelling based on monitored data using advanced mathematical modelling techniques such as state-space modelling [3–6], ARMAX modelling [7,8] or RC modelling [9,10], which usually need for very specialized testing procedures such as the PRBS [3] and ROLBS [11]

Abbreviations: *HLC (Heat Loss Coefficient)*, considers the whole building heat losses through envelope plus infiltration per degree difference between indoors and outdoors temperature. HLC = UA + C_v [kW/ºC]; C_v, infiltration and/or uncontrolled ventilation heat losses coefficient [kW/ °C]; H_{sol}, horizontal global solar radiation [W/m^2] or [kW/m^2]; *K*, all the other heat gains inside the building (illumination, all other electrical devices consumption and heat gains due to people, solar gains and Q not included) [kW]; *KPI*, Key Performance Indicator, in this work referring to HLC and S_a; Q, all heating and ventilating systems energy inputs inside the building [kW]; $q_{i,s}$, heat flux density through the opaque building component, measured usually in the interior surface [W/m^2]; S_a *(Solar aperture)*, south vertical perfectly transparent surface, which lets coming in the same solar radiative energy as the whole building referred to the south vertical global solar radiation. Units [m^2]; T_i, indoor temperature [ºC]; T_o, outdoor temperature [°C]; *UA*, whole building envelope heat transfer coefficient [kW/°C]; V_{sol}, south vertical global solar radiation [kW/m^2]; $\Delta T = T_i - T_o$, air to air inside to outside temperature difference [°C].

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