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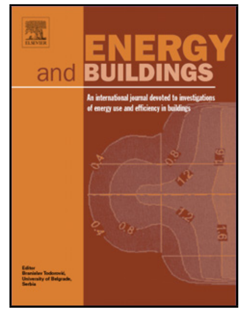

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Model calibration of a variable refrigerant flow system with a dedicated outdoor air system: A case study

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ABSTRACT

With increased use of variable refrigerant flow (VRF) systems in the U.S. building sector, interests in capability and rationality of various building energy modeling tools to simulate VRF systems are rising. This paper presents the detailed procedures for model calibration of a VRF system with a dedicated outdoor air system (DOAS) by comparing to detailed measured data from an occupancy emulated small office building. The building energy model is first developed based on as-built drawings, and building and system characteristics available. The whole building energy modeling tool used for the study is U.S. DOE's EnergyPlus version 8.1. The initial model is, then, calibrated with the hourly measured data from the target building and VRF-DOAS system. In a detailed calibration procedures of the VRF-DOAS, the original EnergyPlus source code is modified to enable the modeling of the specific VRF-DOAS installed in the building. After a proper calibration during cooling and heating seasons, the VRF-DOAS model can reasonably predict the performance of the actual VRF-DOAS system based on the criteria from ASHRAE Guideline 14-2014. The calibration results show that hourly CV-RMSE and NMBE would be 15.7% and 3.8%, respectively, which is deemed to be calibrated. The whole-building energy usage after calibration of the VRF-DOAS model is 1.9% (78.8 kWh) lower than that of the measurements during comparison period.

Keywords: Variable refrigerant flow; Dedicated outdoor air system; Building simulation; Calibration.

1. INTRODUCTION

1.1 Background and purpose

The building sector accounts for about 40% of the entire energy consumption in the U.S. [1]. The energy consumption used for heating, ventilation and air conditioning (HVAC) systems represents approximately 50% of the total energy usage of the building sector [2]. Variable refrigerant flow (VRF) systems are a well-developed and widely adapted HVAC technology in many Asian and European countries and provide several key benefits, including: energy efficiency, ease of installation, design flexibility, and easy maintenance [3][4][5].

As a VRF system is a still new HVAC technology in the U.S. marketplace, a number of recent studies have attempted to evaluate the energy performance of VRF systems and to identify the benefits of them. Most studies include field or laboratory empirical tests as well as simulation modeling analysis of the system performance or VRF control strategies [6]. Aynur [7] provides a good overview of VRF systems. Based on this detailed review, VRF systems serve high energy savings potential and better indoor thermal comfort when compared to traditional HVAC systems, such as variable air volume (VAV) and fan coil unit (FCU) systems, due to the operation in the individual control mode.

In terms of energy savings potential of VRF systems, Im and Munk [8] evaluated the energy performance of a multi-split VRF system in comparison to a typical RTU-VAV system installed in the Oak Ridge National Laboratory's Flexible Research Platform (FRP). Their empirical analysis showed energy savings of a VRF system were estimated to be around 20% over a RTU-VAV system during cooling period. Kim et al. [9] compared VRF systems with RTU-VAV systems to evaluate energy savings potential of VRF systems for 16 different climates in the U.S. Simulation results from their comparable study pointed out