Modeling and Calibration of a Variable Refrigerant Flow (VRF) System with a Dedicated Outdoor Air System (DOAS)

Dongsoo Kim1, Heejin Cho¹, Piljoo Im², and Sam J. Cox¹
¹Mississippi State University, Mississippi State, MS, USA
²Oak Ridge National Laboratory, Oak Ridge, TN, USA

This effort was supported by Samsung Electronics and U.S. Department of Energy.

Oak Ridge National Laboratory is managed by UT-Battelle, LLC, for the U.S. Dept. of Energy under contract DE-AC05-000R22725.

Abstract
With increased use of variable refrigerant flow (VRF) systems in the U.S. building sector, there have been gaining interests in capability and reliability of various building energy modeling tools to simulate VRF systems. This paper presents modeling and calibration of a VRF system with a dedicated outdoor air system (DOAS) by comparing the measured data from a real building and system. Modeling and calibration of a VRF-DOAS model were performed using the whole-building simulation, U.S. DOE’s EnergyPlus version 8.1, with the measured data collected from an occupancy simulated research building, Flexible Research Platform (FRP), at Oak Ridge National Laboratory (ORNL). The initial building model was built, and the original EnergyPlus code was modified to model a specific DOAS installed in the FRP. 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.

Literature Review
Im and Munk [1] 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). Byner et al. [2] compared the analytical study between VRF and VAV systems and evaluated the energy savings potential of VRF systems. Their simulation results showed that VRF systems could consume about 38%-63% less energy usage for cooling purposes. Raustad [3] validated against field data measured at a multi-zone building. It was found that about 72% of all the simulated energy use fall within 25% of the measured data, and a coefficient of variation of the mean square error (CV) of BEEPE, was about 21% between measured and simulated total energy use. Hong et al. [4] developed a new VRF simulation model based on physics in EnergyPlus version 8.4. With their comparison between measured and simulated results, normalized mean bias errors (NMBEs) were 2.8% and 4.5% for cooling and heating operations.

2 Target Building Description

(a) Two-story flexible research platform (FRP)
(b) VRF equipped outdoor unit
(c) Dedicated outdoor air system (DOAS) unit
(d) VRF equipped indoor unit

3 Calibration Approaches

Step 1: EnergyPlus source code modification

Step 2: Building load calibration
- Weaken data update
- Infiltration update
- Interior light intensity schedule update
- Plug load intensity schedule update

Step 3: VRF-DOAS system calibration
- DOAS using the modified version of EnergyPlus 8.1
- VRF outdoor air (OA) set point temperature
- VRF operation schedule update
- Heating and cooling COPs of the VRF system update

4 Results Analysis

(a) Measured versus simulated hourly delivered loads

\[ \text{Loaddifference} = I_{\text{measured}} - I_{\text{Simulated}} \]  \hspace{1cm} (1)

(b) Hourly comparison of HVAC energy use between measured and simulated data

(c) Hourly comparison of the whole-building energy use between measured and simulated data

5 Conclusion

Modeling and calibration of a VRF system with a DOAS were performed using a modified EnergyPlus program based on the measured data from FRP. The calibration processes in three main stages: (1) VRF-DOAS source code modification of EnergyPlus 8.1, (2) building load calibration, and (3) VRF-DOAS system updates for final calibration until the statistical comparison shows acceptable match under the criteria defined in the ASHRAE Guideline 14-2014. The calibration results show that hourly CV-RMSE and NMBE would be 15.7% and 3.8%, respectively. The results also show that the whole-building energy usage after calibration of the VRF-DOAS model is 1.3% (19.8 kW) lower than that of the measurements during comparison period.

Reference

Contact Information
Dr. Heejin Cho, Mississippi State University; 1-662-325-1959, cho@msstate.edu
Dr. Piljoo Im, Oak Ridge National Laboratory; 1-865-241-2313, piljoo@ornl.gov