Proceedings of the 2022 Winter Simulation Conference
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QUANTIFIED PERFORMANCE GAP BETWEEN SIMULATED VS. ACTUAL ENERGY USE OF BUILDINGS

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ABSTRACT

It has been widely acknowledged that building energy simulation tools play a role for optimal building energy design and accurate energy prediction. However, building's thermal behavior is affected by uncertain factors (e.g. indoor and outdoor environments, occupant behavior, and simulation parameters) and thus the performance gap between predicted vs. actual energy use is non-negligible. This paper presents *the quantified* performance gap for 152 commercial and educational buildings in South Korea. It is concluded that the performance gap is significant and more efforts must be made for quantification of the uncertainty and stochastic decision making.

1 INTRODUCTION

Building energy simulation has been used for optimal design and control of building systems as well as retrofit decision making (IBPSA proceedings 1987-2021). However, building's thermal behavior is influenced by different types of uncertain factors, e.g. indoor and outdoor environments, occupant behavior, etc (Hopfe 2009). In addition, in the process of simulation modeling, many uncertainties are involved; (1) simulation parameters (e.g. convective heat transfer coefficient, the ratio between convective vs. radiative heat transfer), (2) model form uncertainty by simplification of the 3-D heat transfer phenomena, and (3) scenario uncertainty (occupant/lights/equipment). Recently, a mismatch called *performance gap* between simulated vs. actual energy use has been pointed out (de Wilde 2014). With this in mind, the authors collected relevant data regarding simulated vs. actual energy use of 152 buildings in South Korea and aimed to present the *degree of the performance gap* in South Korea.

2 METHODOLOGY

In South Korea, an architectural database (including building name, address, type, etc), a building energy efficiency certification database (including building name, certification date, predicted energy use, calculated ratings (10 ratings from 1+++[less than 80 kWh/m^2·yr] to 7[from 610 to 700 kWh/m^2·yr]), and a building energy database (building address, monthly electric and gas use) are open to public by the Korean government. The authors retrieved the aforementioned databases as illustrated in Figure 1. After the retrieval, the authors selected 152 buildings that were energy-certificated in 2013-2020 and analyzed the performance gap between predicted ($EUI_{predicted}$, kWh/m^2·yr) vs. EUI ($EUI_{measured}$, kWh/m^2·yr). As the first step, the authors quantified the performance gap of four types of buildings (office, school/laboratory, hotel, and retails) based on mean bias error (MBE), mean absolute error (MAE), and the coefficient of variation of the root mean square error (CVRMSE).

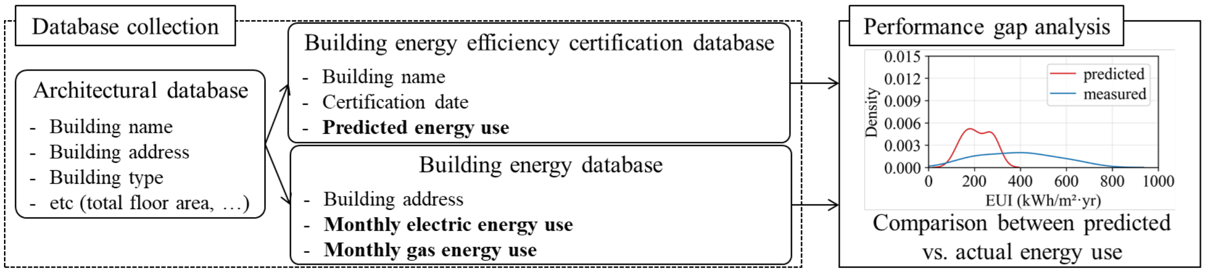
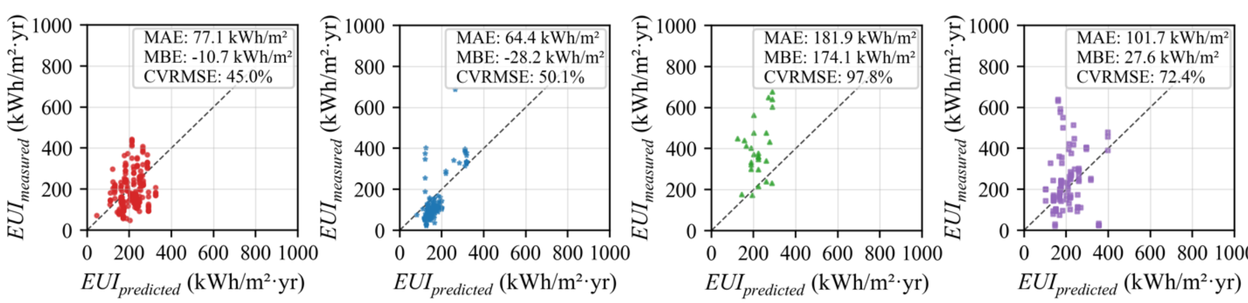


Figure 1: Quantification process of performance gap.

3 RESULTS AND CONCLUSION

Figure 2 shows the comparison between $EUI_{predicted}$ and $EUI_{measured}$ by building types. The calculated MAEs range from 64.4 (school/lab) to 181.9 (hotel) kWh/m^2·yr. The degrees of minimum and maximum MAEs are significant compared to the existing Korean energy certificate rating system (10 ratings ranging from 80 to 700 kWh/m^2·yr). The MBEs of hotel/retail buildings are 174.1 kWh/m^2·yr and 27.6 kWh/m^2·yr, respectively. This indicates that the both building types tend to consume more energy than predicted. It is speculated that the energy use of the aforementioned buildings are influenced by daily operations, and occupant behavior (change of setpoint temperatures). The MBEs of office/school/laboratory buildings are -10.7 kWh/m^2·yr and -28.2 kWh/m^2·yr, respectively. These types of buildings tend to use less energy than predicted. Please note that the calculated CVRMSEs range from 45.0% and 97.8%, which are much higher than the ASHRAE recommendation (monthly energy prediction: < 15%)(ASHRAE Guideline 14-2014).
It is found that the energy performance gap of 152 buildings is non-negligible. In order to bridge the gap, special attention should paid in the design process to objective/transparent quantification of the aforementioned uncertainty and rationalization of the national building energy certificate rating system.



(a) office (b) school/laboratory (c) hotel (d) retails

Figure 2: Performance gap between the $EUI_{predicted}$ and $EUI_{measured}$ by building types

ACKNOWLEDGMENTS

This work is supported by the Korea Agency for Infrastructure Technology Advancement(KAIA) grant funded by the Ministry of Land, Infrastructure and Transport (Grant RS-2022-00141900).

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