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PREDICTABILITY OF BUILDING ENERGY SIMULATION FOR EXISTING BUILDINGS

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ABSTRACT

Uncertainty analysis of building energy simulation models has been actively studied over the past two decades. Uncertainty analysis is performed in the belief that reflecting the influence of uncertain variables in the simulation process can reduce the performance gap between simulation prediction and the reality. If the monthly energy use for at least three years are similar under similar weather conditions, the energy use can be regarded as *being predictable* and the uncertainty analysis helps. However, it is important to investigate whether the opposite case might exist that the monthly energy use of a building is unpredictable (not repeating) under similar weather over several years. In this paper, the predictability of 3,157 buildings' energy use was analyzed using K-Spectral Centroid distance and Maximal Information Coefficient. As a result, a significant portion of buildings are outside of the range of the uncertainty analysis, meant by 'being unpredictable' by a simulation model.

1 INTRODUCTION

In particular, forward and backward uncertainty analyses (Monte-Carlo, Bayesian calibration) have been applied to many building energy simulation models. Uncertainty analysis is performed in the belief that reflecting the probabilities of uncertain variables in the building simulation model can reduce the performance gap between building energy use and energy prediction. If monthly building energy use of a building is repeated for several years under similar weather, then the building's energy use can be regarded as predictable. The opposite is regarded as 'unpredictable' and this study intends to investigate the predictability for monthly energy use of 3,157 existing buildings located in Seoul, South Korea. Monthly energy use data for three years (2013-2015) were collected for this purpose.

2 METHODOLOGY

In this study, K-Spectral Centroid distance (K-SC distance) is used for assessing the repeatability (shape similarity and difference) of two time-series data (Yang 2011). The repeatability of building energy use was assumed to be true when the K-SC distance were less than or equal to 0.15 (Figure 1). Firstly, the degree of the correlation between monthly energy use data and monthly outdoor dry-bulb temperature (T_{db}) was analyzed using Maximal Information Coefficient (MIC). MIC is a correlation measure between two variables with satisfying what can capture interesting functional relationships and can give same scores to equally noisy relationships of different types (Reshef 2011). In this paper, it is assumed that if MIC is 0.9 or higher, there is a causality between monthly T_{db} and monthly energy use of a building.

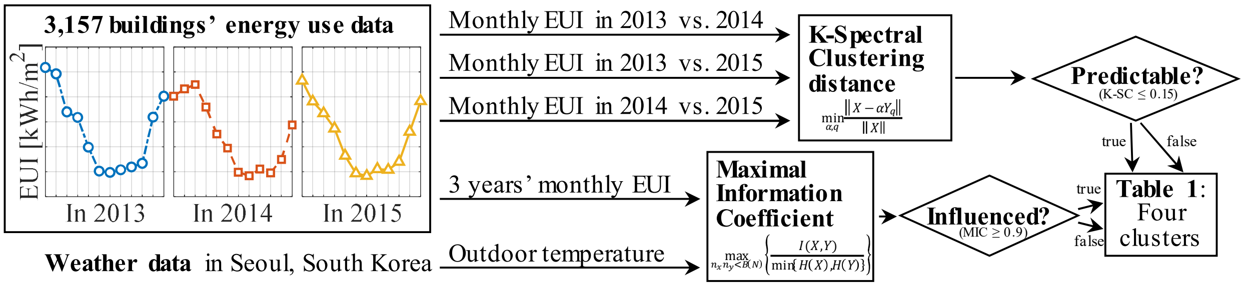

Figure 1: 'Predictability' analysis process of this study.

3 RESULTS AND CONCLUSION

As a result, 3,157 buildings located in Seoul, South Korea, were grouped into four clusters (Figure 1, Table 1). Buildings in Cluster #1 a similar monthly energy use pattern over the three years and found to be highly affected by T_{db}. In other words, the causes of energy use in buildings in Cluster #1 (e.g., weather, occupant behavior, electric equipment and lighting, etc.) have repeated in the same pattern for the past three years, implying the possibility of the reliable simulation prediction. 986 buildings (31.2%) belong to Cluster #2, characterized by not 'repeated energy use' but being highly related to T_{db}. Interestingly, the rate of seasonal energy use (heating and cooling energy use) of Cluster #2 buildings was higher (approximately 70.6%) than those in other clusters ranging from 37.9% to 56.6%. Therefore, it can be assumed that as the energy use in Cluster #2 buildings were highly sensitive to T_{db}, and high uncertainty was found as non-repeatability. 533 buildings (16.9%) belong to Cluster #3 and have the smallest ratio of the seasonal energy use as 37.9%, and the energy use is least affected by T_{db}. Finally, the percentage of buildings in cluster #4 is 38.9% (1,229 buildings), and the these buildings' energy use is unpredictable.

Table 1: Number of buildings in four clusters.

	K-SC ≤ 0.15 (predictable)	K-SC > 0.15 (unpredictable)	Total
MIC ≥ 0.9	**[Cluster #1]** 409 buildings (13.0%) energy use repeated for three years, being influenced by T_{db}	**[Cluster #2]** 986 buildings (31.2%) energy use not repeated for three years, being influenced by T_{db}	1,395 (44.2%)
MIC < 0.9	**[Cluster #3]** 533 buildings (16.9%) energy use repeated for three years, not being influenced by T_{db}	**[Cluster #4]** 1,229 buildings (38.9%) energy use not repeated for three years, not being influenced by T_{db}	1,762 (55.8%)
Total	942 buildings (29.9%)	2,215 (70.1%)	3,157 (100%)

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