Recent Developments in the Next-Generation Korean Energy Management System : Deep Learning-based Forecasting of Distributed Renewable Generation

Jae-Kyeong Kim, Ph.D., 2025. 09. 12

KERI

KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE

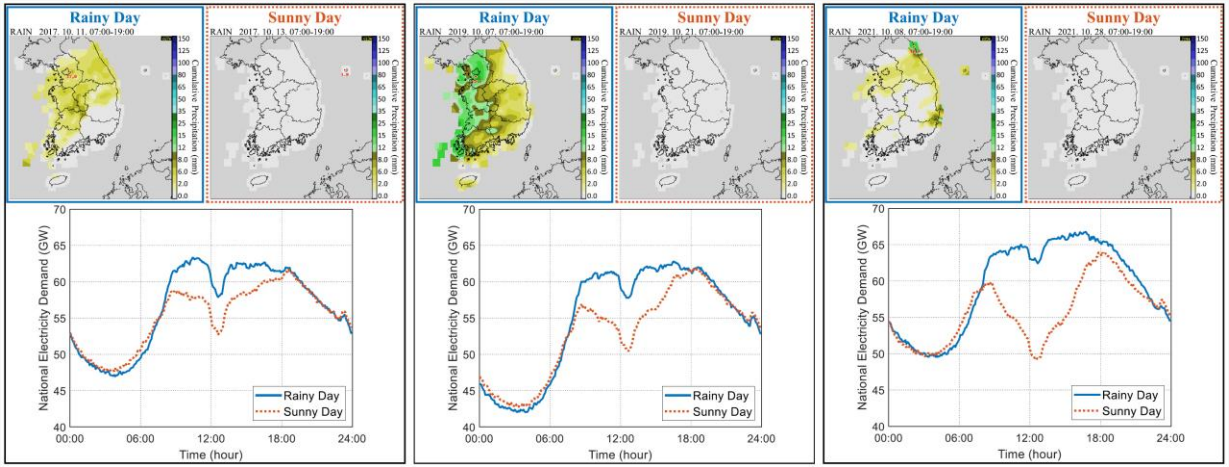
INDEX

Research Background: Increased Distributed Renewable Generations in Korea

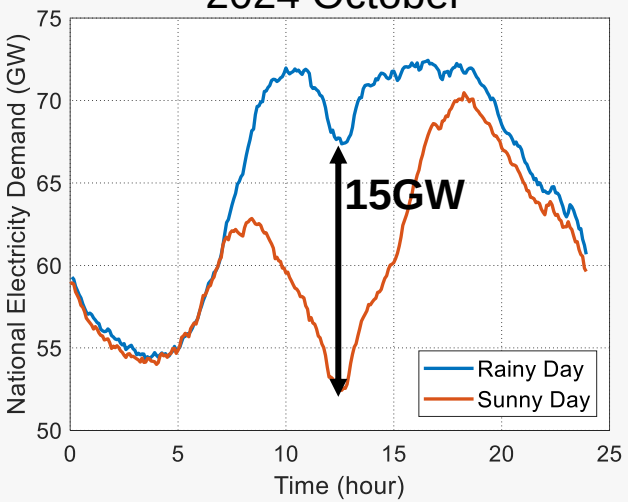
- **Increased distributed renewable generation** in Korea
  - Mainly, PV generation connected to the distribution grid
- Transmission system operator cannot exactly know the generation information
  - These resources are called as **behind the meter (BTM) generation**

The load variability due to BTM leads to operational challenges in Korea

2017 2019 2021

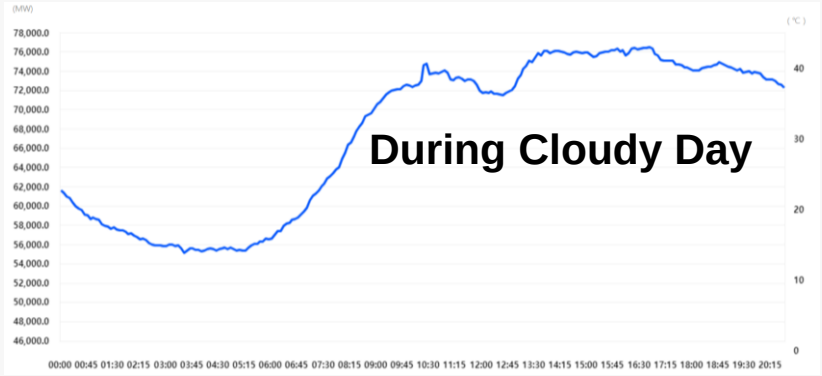


2024 October

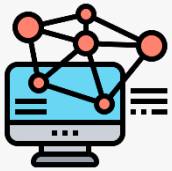


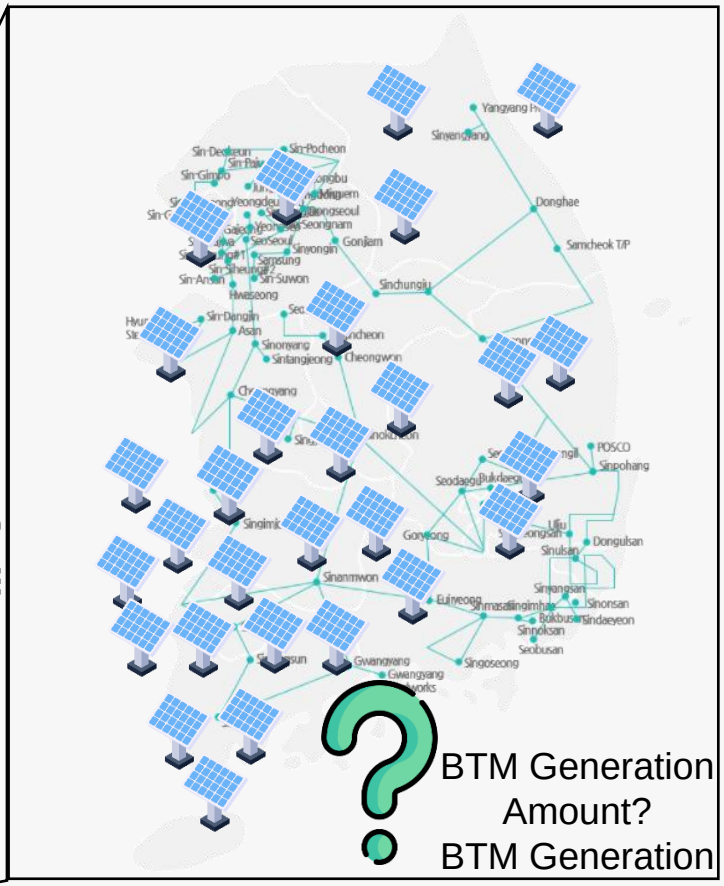
Research Background: Unknown Information of BTM

- BTM is included in the load in real-time operation



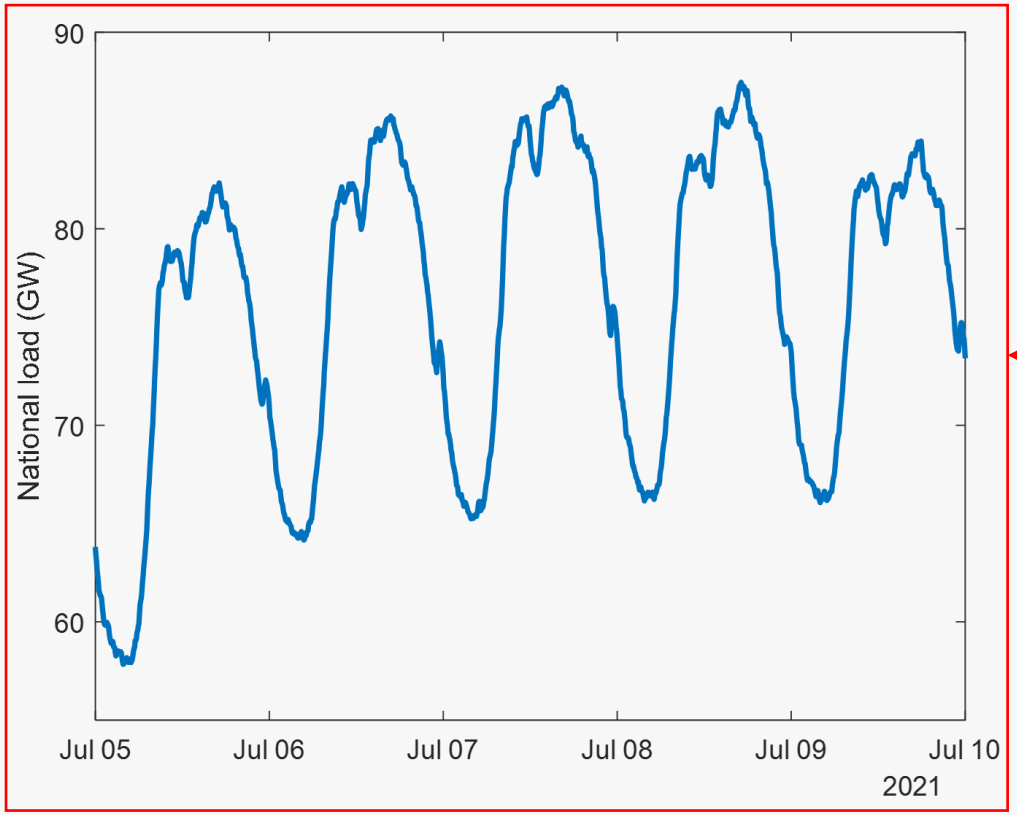
Energy Management System





Research Motivation: Repetitive Load Patterns

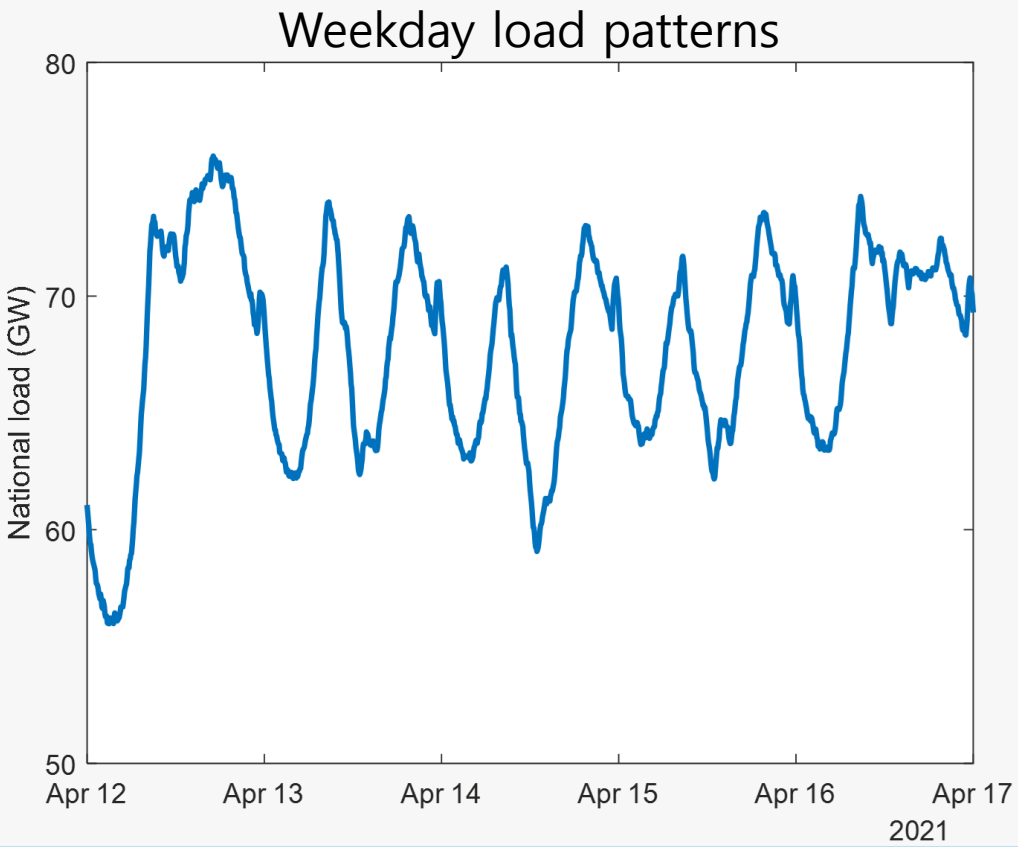
- Load patterns in monsoon season



Research Motivation: Repetitive Load Patterns

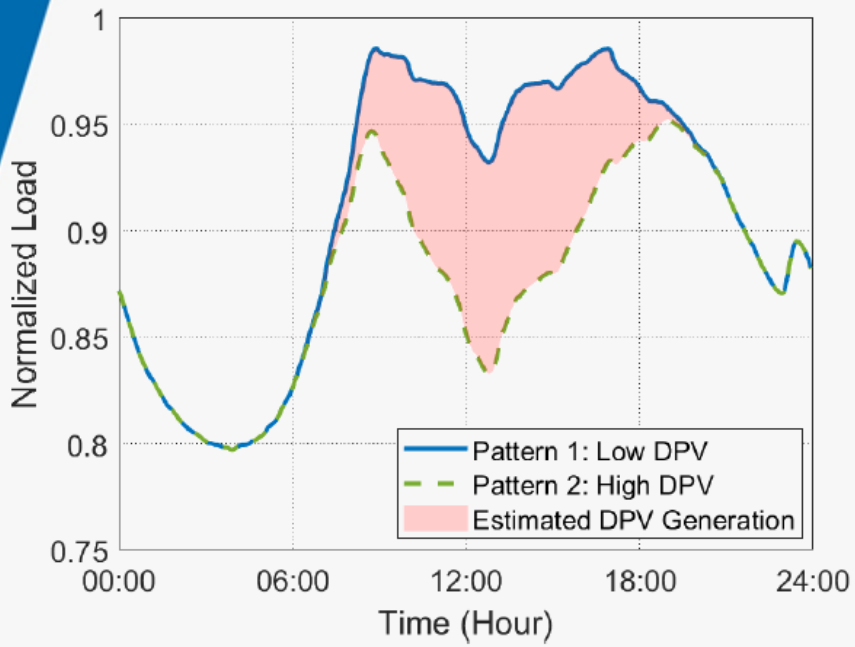
□ Spring sunny days load patterns

: Similar shapes **excluding the daytime**

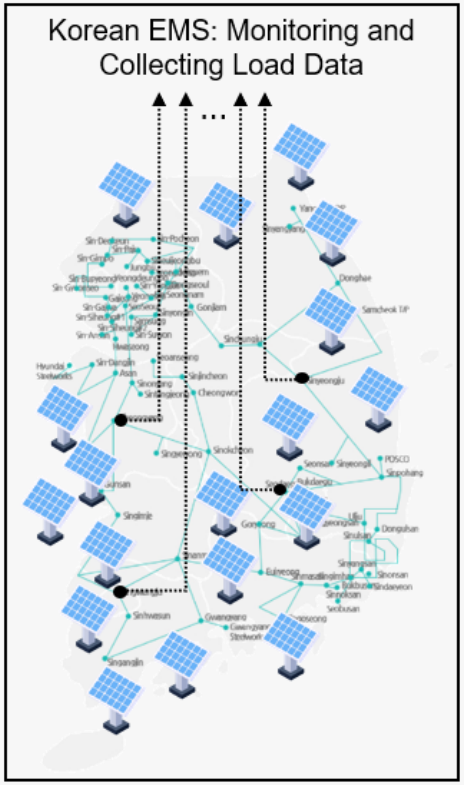


Proposed Method for Estimating Each BTM Generation

- Main Idea: the electricity consumption has repetitive patterns with or without BTM (Distributed PV, DPV) generations



The concept of the proposed method for estimating BTM Generation



Load Pattern Extraction
Extracting representative load patterns for each load in Korean power system

Reference Load Identification
Identifying the presence of DPV in each load by analyzing differences between representative load patterns

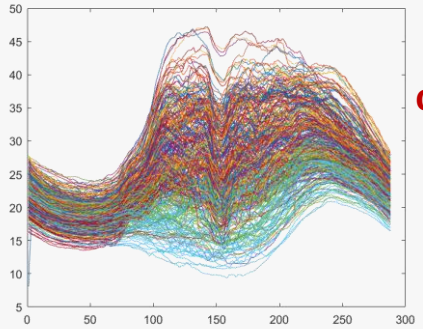
Net-load Forecasting Model
Developing a net-load forecasting model for loads identified as incorporating DPVs

Forecasting DPV Generation
Estimating DPV generation using the reference load pattern and the forecasted net-load

The overall process of the proposed method

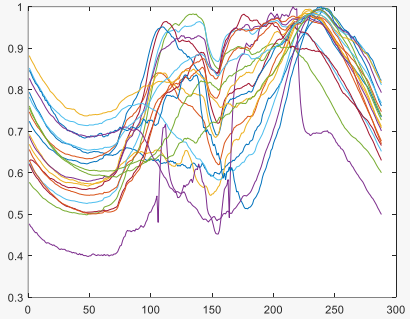
Key Process of the Proposed Method: Pattern Identification

- Identification of reference load patterns for each load based on accumulated load data

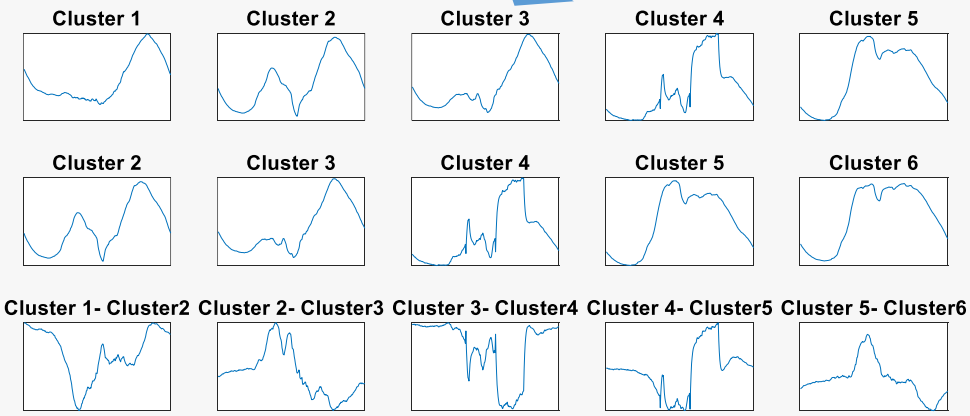


Accumulated data for Load A

k-means clustering



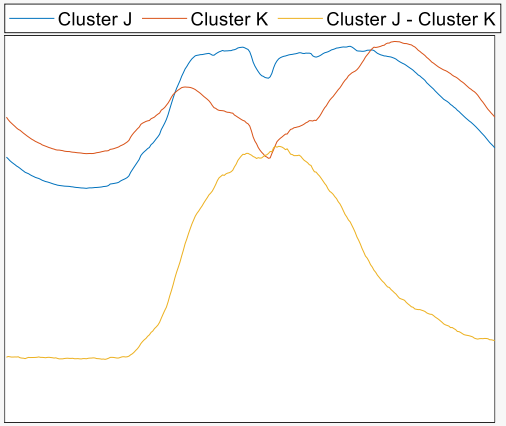
Representative patterns for Load A



Comparative analysis of representative patterns

Determination of BTM existence
: Meets the pre-defined criteria?

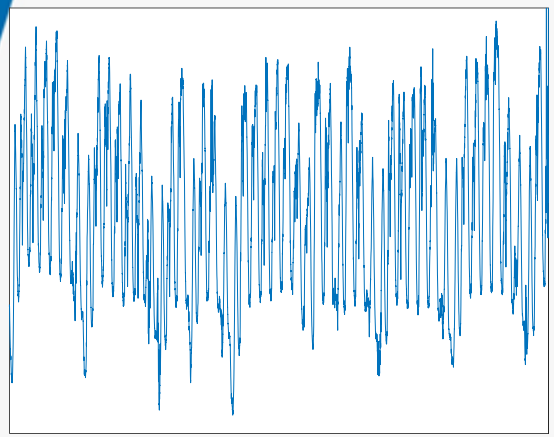
Cluster J: High-BTM Load Pattern
Cluster K: Low-BTM Load Pattern



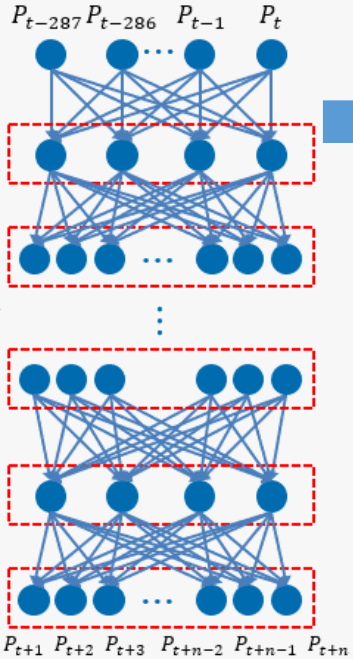
Identification result of reference load

Key Process of the Proposed Method: Net-load forecasting

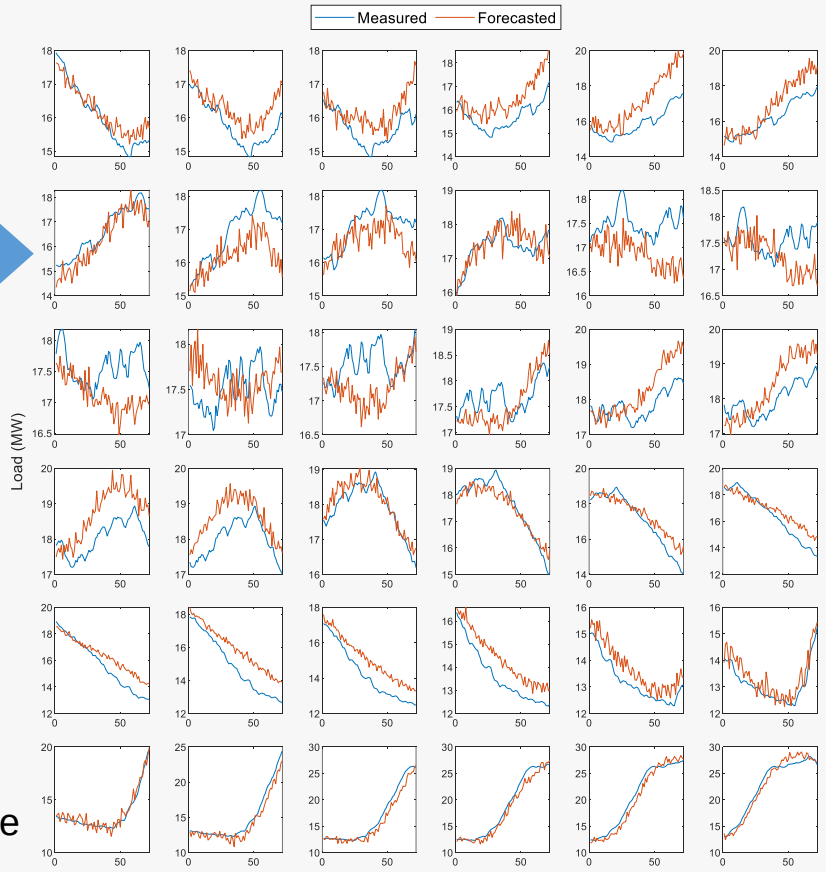
- Development of net-load forecasting model for BTM-identified loads



Accumulated net-load data for Load A



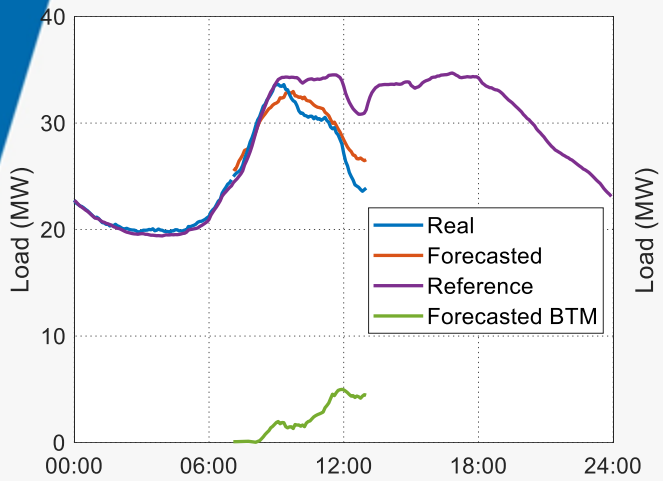
Deep learning model structure



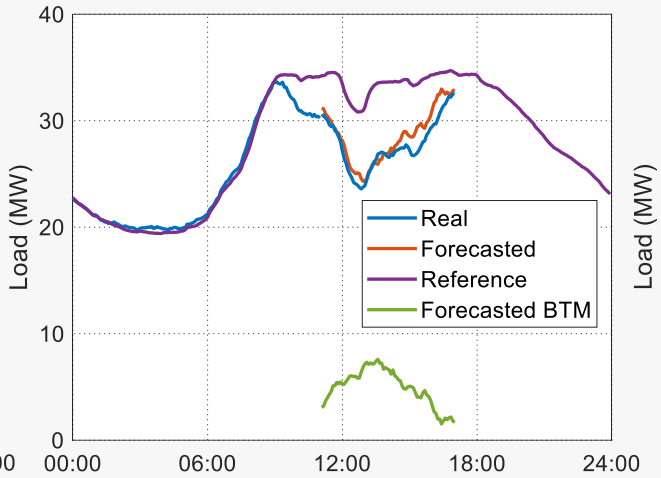
Result of net-load forecasting

Case Study Result for Load A

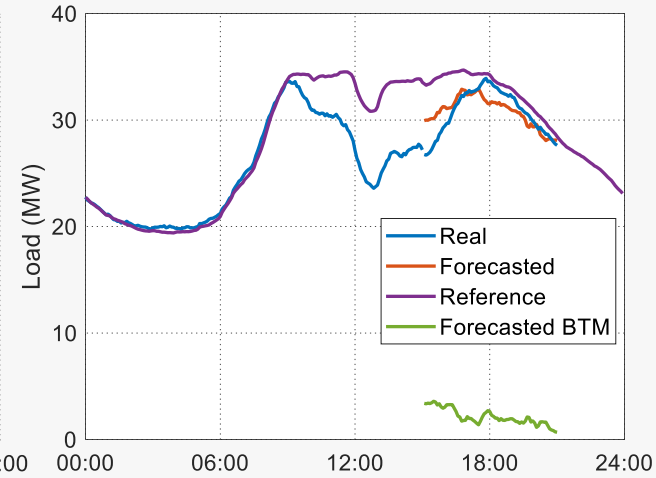
□ BTM estimation result at 06:15, 11:15, and 15:15



Estimation result at 06:15



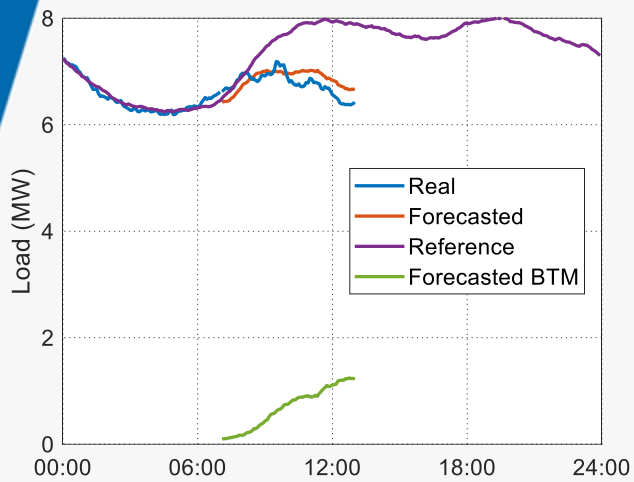
Estimation result at 11:15



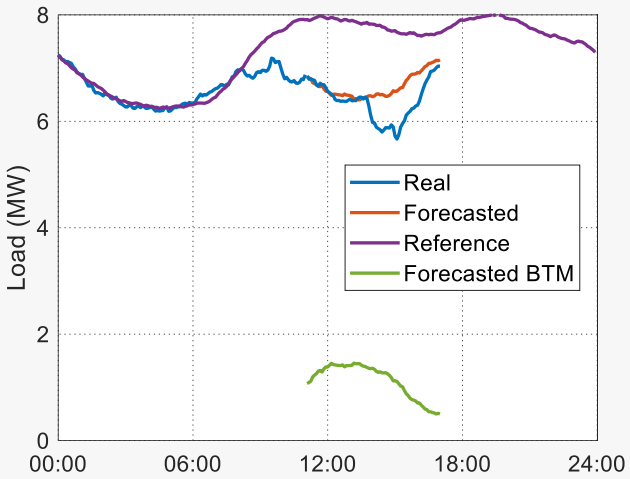
Estimation result at 15:15

Case Study Result for Load B

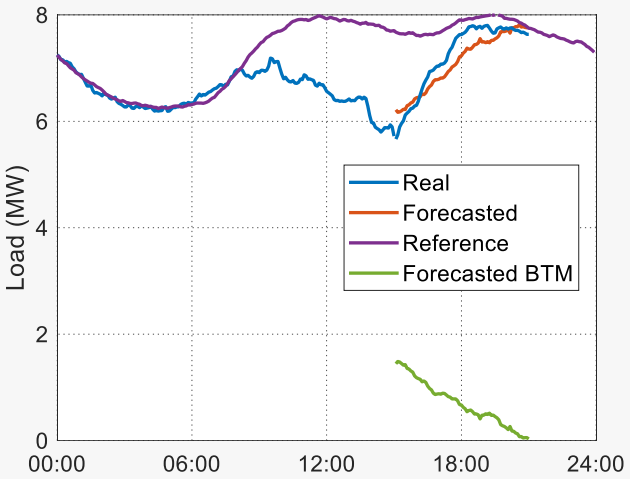
□ BTM estimation result at 06:15, 11:15, and 15:15



Estimation result at 06:15



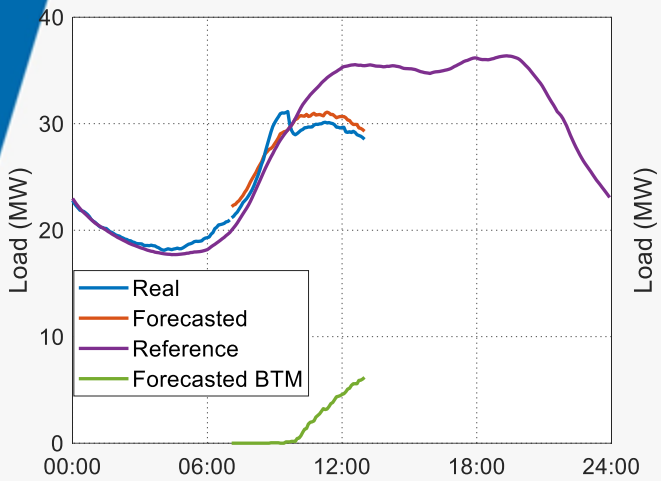
Estimation result at 11:15



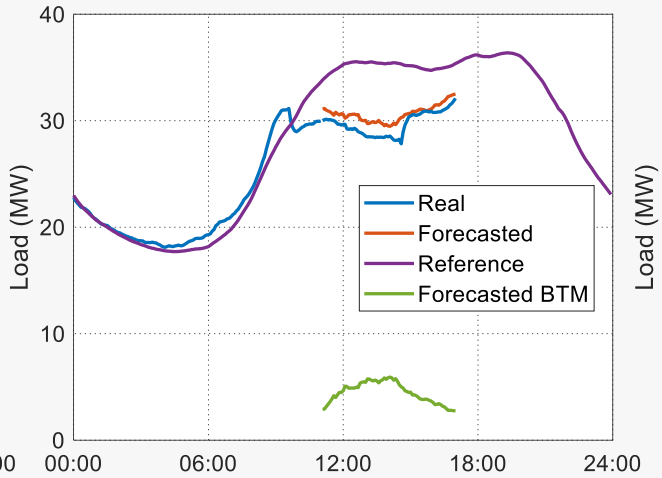
Estimation result at 15:15

Case Study Result for Load C

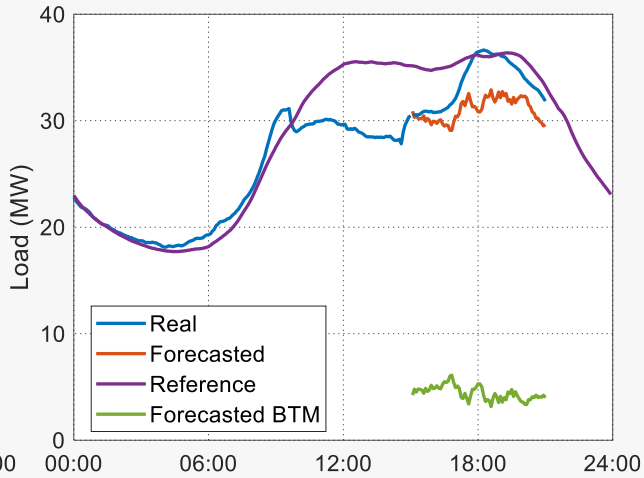
□ BTM estimation result at 06:15, 11:15, and 15:15



Estimation result at 06:15



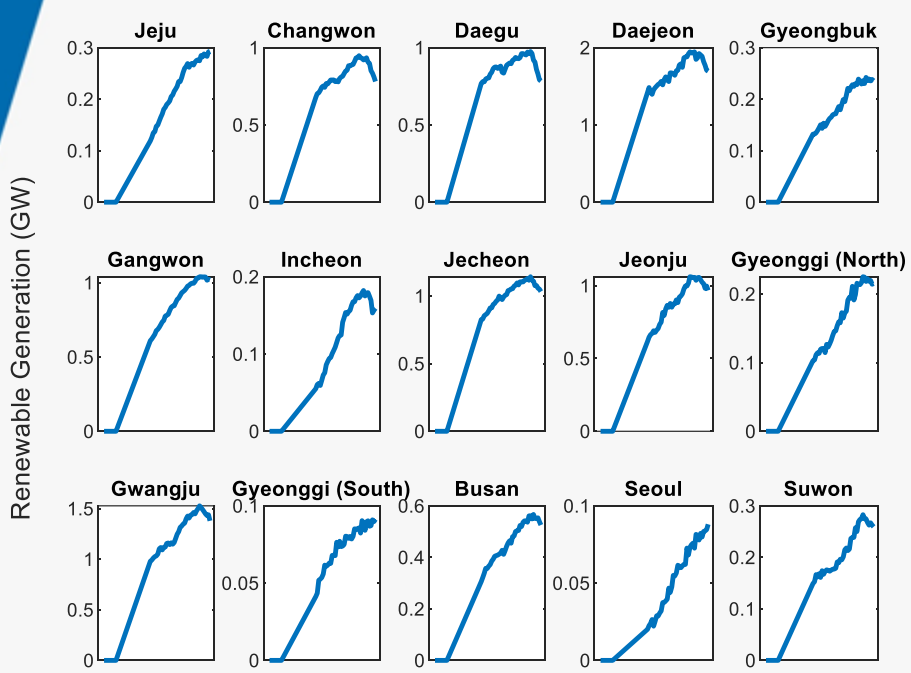
Estimation result at 11:15



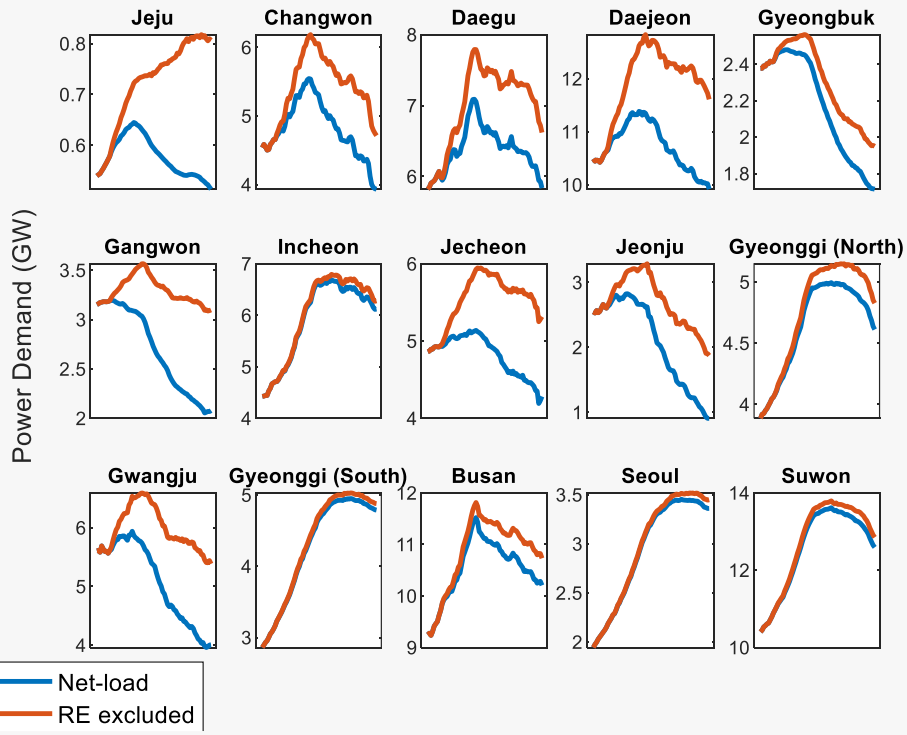
Estimation result at 15:15

Regional Aggregation Result for BTM Estimation

- BTM generation and each location could be estimated.



Regional Aggregation Result of BTM generation

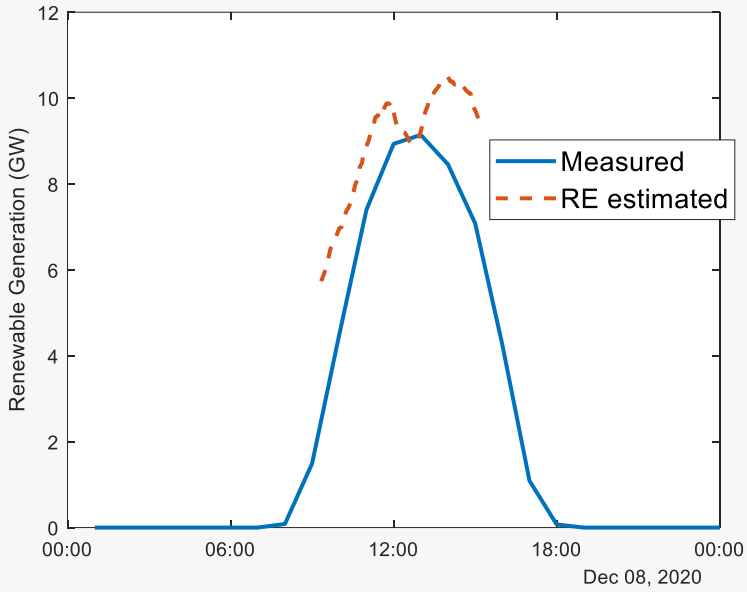


Regional Aggregation Result of Net-load and Real-load excluding BTM Generation

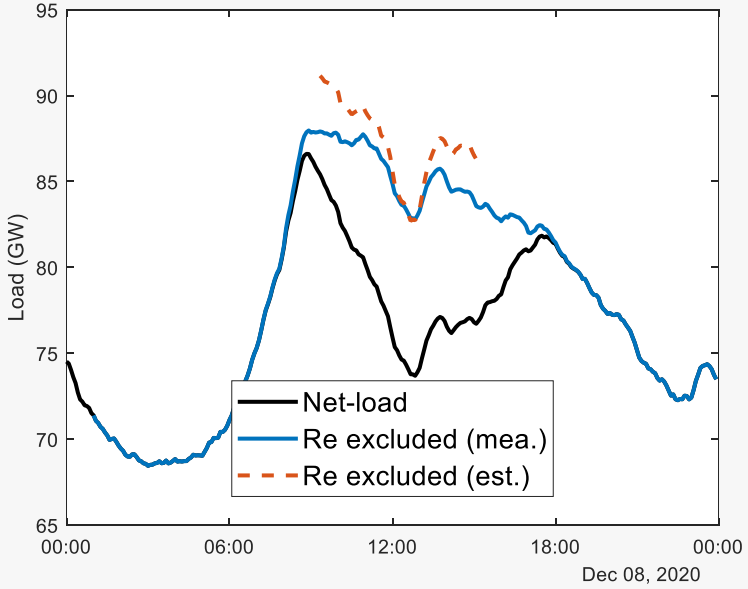
Aggregation Result for BTM Estimation

□ Comparison of Nationwide PV Generation Forecasts

- Application to Real-Load Estimation in Korea



Comparison of total BTM estimation result and current practice* in Korea



Comparison of Net-loads with and without considering BTM (using forecasted BTM)

*Current practice (Measured)
: total BTM generation is forecasted using assumed total capacity of PV installation

Summary

- The proposed method estimates both the location and output of BTM generation
- This supports operators in managing risks from renewable variability
- Accurate net-load forecasting is crucial
  - Future work will focus on improving it using advanced algorithms

KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE

Thank you for your attention!

Any questions?