The Forecast and Benefit Analysis for the Suppression of Demand Response on Day and Night Peak Load

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1. Research Background

To respond to the trend of energy transition, Taiwan Power Company (TPC) has actively promoted the renewable energy development in recent years to achieve Taiwan's 2050 net-zero emissions goal. However, as renewable energy in the generation mix gradually increases, it has begun to have an impact on the power system. In addition to the daily peak load, an evening peak load now emerges because the system's net load (after subtracting photovoltaic generation) rapidly increases as solar power generation sharply declines in the early evening.

To address the impact of these changing load patterns on Taiwan's power system, TPC has adjusted both the peak/off-peak periods of time-of-use (TOU) and the content of demand response (DR) load management measures. TPC evaluates the effectiveness of these new measures in curbing both daily and evening peak loads on the power system and forecasting the performance of demand-side management over the next 15 years. This information, combined with TPC's long-term load forecasts, serves as a reference for refining various ongoing measures.

2. Research Content

(1) Case Studies on Demand Response Measures of International Utilities

This study serves as a reference for TPC's adjustment of demand response measures by collecting and analyzing the promotion of demand response initiatives within the power companies of the United States (California), Japan, and Australia. The case studies include an introduction to their respective electricity markets, system load and net load profiles, implemented demand response programs (including both price-based and incentive-based types), applicable customer segments, and policy approaches for advancing demand-side management (DSM) measures.

(2) Establishment Model for Estimating and Predicting the Effect of Demand-Side Management on Daily /Evening Peak Loads Suppression

This study establishes an applicable evaluation model for the effectiveness of demand-side management in curbing daily and evening peak loads under the new time-of-use rate periods. This was achieved after reviewing both domestic and international estimation and forecasting models for DSM and considering TPC's existing evaluation methodologies.

Using the aforementioned model, the study forecasts the performance of TPC's DSM measures for the next 15 years. This projected performance is

then further estimated through to 2050, incorporating the context of net-zero transition initiatives and TPC's long-term forecasting needs.

(3) Establishment of a Cost-Benefit Analysis Model for Demand Response Load Management Measures

This study establishes a cost-benefit analysis (CBA) framework applicable to the Taiwan context through literature review and comparison. Based on this framework, this study developed a CBA model for TPC's existing demand response load management measures. The model is used to analyze the costs and benefits of the measures implemented in recent years and to evaluate their effectiveness.

3. Research Findings

(1) Results of Demand Response Load Forecasting and Estimation

This study proposes two estimation models: the restored-load evaluation method and the new peak-and-off-peak time-of-use (TOU) performance evaluation method. This study also utilizes an ARMAX model to predict future performance.

The restored load evaluation method forecasts the cumulative performance of evening peak load curtailment. According to the model estimations, the cumulative performance of demand-side management in curtailing evening peak loads is projected to reach 7,994 MW by 2038 and 9,669 MW by 2050.

The new peak and off-peak time-of-use performance evaluation method uses either national load or segmented data for prediction. The results indicate that if estimated using national load data, the DSM curtailment performance is suggested to be approximately 1,550 MW in 2038 and 1,837 MW in 2050. If estimated using segmented load data, the performance is approximately 1,517 MW in 2038 and 1,719 MW in 2050.

(2) Results of Cost-Benefit Analysis

This study is based on the five cost-benefit test methods established by the U.S. Federal Energy Regulatory Commission (FERC). It selects cost and benefit items suitable for the Taiwan context and evaluates the costs and benefits from the perspectives of the customer, the utility, and society.

Research findings indicate that implementing demand response measures from 2021 to 2023 can reduce electricity consumption by 0.58-0.91 TWh. This results in net benefits for customers ranging from NT$1.97 billion to NT$2.47 billion, for the utility from NT$0.94 billion to NT$1.53 billion, and for society from NT$3.03 billion to NT$4.10 billion (detailed in Table 1). These outcomes demonstrate positive impacts of TPC's demand response measures from customer, utility, and society perspectives.

Table 1　Net Benefit Analysis of Demand Response Implementation (2021–2023)

Year	Curtailed Electricity (GWh)	Customer Net Benefit (billion TWD)	Utility Net Benefit (billion TWD)	Societal Net Benefit (billion TWD)
2021	0.63	1.985	0.960	3.026
2022	0.58	2.096	0.936	3.158
2023	0.91	2.466	1.533	4.097

Source: Compiled by this study