Research on Electricity Supply and Demand Forecasting and Management in the Overseas Retail Electricity Industry

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I. Research Background

In the wave of electricity industry reforms, our country's electricity industry is expected to be divided into power generation, transmission and distribution, and retail electricity. After the second phase of legislation, the industry is moving towards market liberalization for traditional power generation and general retail electricity, deregulating electricity purchase and sales. In light of these changes in policy requirements and market conditions, public retail electricity providers are expected to face the challenges of open competition and customer churn. Therefore, the effective arrangement of power resource configurations to achieve a comprehensive electricity purchasing strategy has become a crucial development goal for public retail electricity providers.

After separating generation and transmission/distribution industries, the public retail electricity providers have to handle tasks such as long-term annual production and sales planning, optimal generation estimation for power units, mid-term power procurement, and short-term scheduling. With the establishment of trading platforms, renewable energy will also impact the scheduling of other power units. Therefore, accurate methods for forecasting renewable energy are essential. The direction of suitable strategies relies on the results of forecasting models, and better accuracy in load forecasting and renewable energy generation forecasting will greatly benefit the electricity purchasing, deployment, and planning of public retail electricity providers.

II. Research Content

Based on the international practices and the practical experiences of our team, this study concludes the variables and data sources for supply and demand forecasting. We propose the framework design of our country's short-, medium-, and long-term load forecasting models and renewable energy generation forecasting models. This includes neural network models for short-

term load forecasting, statistical models for medium- and long-term load forecasting, machine learning models for short-term solar and wind power generation forecasting, and machine learning methods for medium- and long-term renewable energy generation forecasting.

Using the proposed methods for modeling and testing, we incorporate relevant electricity consumption information, economic indicators, population data, income data, climate data, and other relevant indicators for our country's short-, medium-, and long-term load forecasting and renewable energy generation forecasting. The results of the forecasting models are then integrated into the Taiwan Power Company's SAS platform interface, serving as important reference points for TPC's retail sector's future electricity purchasing plan.

III. Research Findings

1. Short-Term Load

With the identified forecasting factors, including AMI load data, net generation, and apparent temperature, a neural network model was trained via the SAS platform. From January to June 2021, the MAPE for five major categories ranged from approximately 6% to 12%, with the total load MAPE falling between approximately 7% to 10%. Due to the relatively sizeable short-term electricity consumption fluctuations in the consumer staples and metal industries, capturing their usage patterns is much more challenging. However, with more stable power usage patterns, the information electronics and petrochemical industries exhibited relatively accurate predictions.

2. Medium and Long-Term Load Forecasting

Key variables such as cooling degree days, industrial production index, and economic growth rate were selected based on the characteristics of the five major industry categories. The MAPE results for medium and long-term load forecasting 2021 fell within reasonable ranges, with mid-term forecasts ranging from 3.22% to 10.38% and long-term forecasts ranging from 0.8% to 9.25%. The load pattern for the consumer staples industry was relatively stable, resulting in smaller prediction errors. The metal manufacturing industry, affected by the particular circumstances of the COVID-19 pandemic in 2021, showed improved predictions after adjustments were made. In addition, the mid-term and long-term total

load forecasting also successfully captured the load pattern, resulting in a relatively low forecasting error.

3. Short-Term Solar Power Generation Forecasting

Short-term solar power generation forecasting considered factors such as installed capacity, site location, and short-term changes in meteorological factors, with global horizontal irradiance being the most critical. Temperature had a slight impact on the efficiency of solar panels. The study incorporated meteorological forecast data from various models, including Weather Risk's high-resolution regional model (WR-WRF). The model demonstrated a great forecasting performance on short-term solar power generation, with an average MAPE of 3.7% within 24 hours.

4. Medium and Long-Term Solar Power Generation Forecasting

The study used historical meteorological data, installed capacity, and generation data to build a machine learning model. Long-term meteorological data (TMY) was introduced, and estimated installed capacity for each county was used to produce forecasts. The model closely followed the efficiency trend of actual power generation, with some peak values not ultimately captured, resulting in an overall MAPE of approximately 5%, within a reasonable range.

5. Short-Term Wind Power Generation Forecasting

Short-term wind power generation is influenced by meteorological factors such as wind speed, wind direction, and air density, with wind speed being the decisive factor. The study employed the Weather Risk Company's WRF numerical forecast model and a hybrid use of machine learning models. The model demonstrated a great forecasting performance on short-term wind power generation, with an average MAPE of 5.6% within 24 hours and the ability to capture changes in peak values during high wind speeds.

6. Medium and Long-Term Wind Power Generation Forecasting

Wind speed had the highest correlation with wind power generation among weather variables. In addition to wind speed, generation was closely related to installed capacity. Predicting the efficiency of power generation per unit of installed capacity, multiplied by the estimated installed capacity, yielded the projected total generation. Using

past unit generation efficiency for each wind farm and conducting individual correlation analyses with Taiwan's total wind power generation provided reference weights for model construction. The MAPE for medium and long-term wind power generation forecasts fell within reasonable ranges.

IV. Conclusion

This research observed that regression and time series methods effectively capture the seasonal patterns of monthly loads, and the prediction results generally fall within reasonable ranges. The use of R for forecasting demonstrated relatively better performance. Daily loads are influenced by weather and industry characteristics. The load patterns of consumer staples and metal manufacturing industries fluctuate much more and are more challenging to capture.

Regarding renewable energy generation, due to the characteristics of solar and wind data, regression and machine learning models for solar power trends and GBM methods for wind power trends produced predictions within reasonable ranges. These models particularly excelled in capturing intra-day hourly generation fluctuations.

The establishment of forecasting models is a multi-stage process. In light of the limitations and challenges encountered during the research, efforts were made to overcome and improve, and recommendations were proposed. These include exploring more flexible and advanced modeling tools (such as R and Python), refining variable processing methods or data quality, and trying different model methods to compare results. Continued refinement and adjustment in the future are expected to enhance accuracy further.