The Korean REC Spot Market Price Forecasting Based on AI-based Statistical Methodologies

Jong-Bae Park, Konkuk University, +82-2-450-3483, jbaepark@konkuk.ac.kr
Sung-Hee Lee, BRFrame Inc., sungline@brframe.com
Woo-Nam Lee, Korea Electrotechnology Research Institute, wnlee@keri.re.kr
Manho Joung, Sempra Energy, mjoung@sempra.com
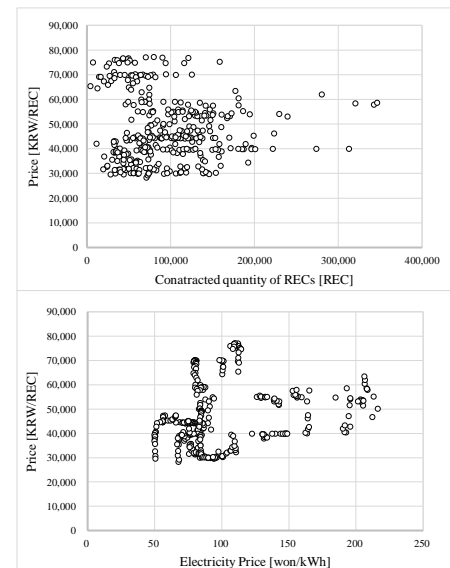Da-Han Lee, Konkuk University, +82-2-458-4778, timeflaw@konkuk.ac.kr

Overview

Korea's renewable energy dissemination policy has been implemented based on the Renewable Portfolio Standards (RPS) since 2012. In Korea, the obligatory target under the RPS is not for power distribution companies, but for power generation companies with generation facilities of 500 MW or more. As of 2022, 24 power generation companies are following the obligation. In 2022, the mandatory supply ratio is 12.5% of the previous year's base generation, which is about 58.7 TWh based on the thermal power generation and corresponds to 78.7 million Renewable Energy Certificates (RECs). The obligated supplier fulfills the obligation by procuring RECs through long-term contracts, self-constructions, and the REC spot market. The most important indicator in procurement of RECs is the REC spot price, which is determined by direct and indirect influences such as market shape, REC demand and supply, levelized cost of energies (LCOEs) of renewable generations, and electricity market price. Among them, the spot market was opened for the smooth fulfillment of the obligations of the supplier, and trades are conducted twice a week (Tuesday and Thursday). In this study, major factors affecting the REC spot market price were identified using AI-based statistical techniques targeting the Korean REC spot market, and the short-term REC price was predicted based on the model.

Methods

The REC price can be theoretically estimated by subtracting the System Marginal Price (SMP) from the LCOE (Levelized Cost of Electricity) [1]. However, this estimation formula does not reflect the various policies and factors of the renewable business so the results may be distorted in real-world transactions. New REC spot market price estimation methods have been proposed to overcome this problem [2-4]. However, forecasting is difficult due to the correlation between the REC price and potential future business environments and policy changes. In this study, we propose REC spot market analysis models that comprehensively reflect the renewable energy industry environment and national policies in Korea's electricity ecosystem. The proposed models perform REC spot market simulations that comprehensively utilize various factors, including national energy and electricity policies, renewable energy plans, electricity markets, oil prices, and economic indicators such as exchange rates.

Figure 1. Correlation between REC price, quantity and SMP

The main influencing factors of the simulation models are as follows:

1. REC spot market: AI-based statistical estimation

2. Electricity market: SMP estimation based on energy supply and demand

3. Renewable energy status: dissemination status and national renewable energy dissemination goal

4. REC selection contract: AI-based bidding, statistical patterns for transactions

5. National energy policy: policy direction, such as a change in supply obligation quota

6. Economic indicators such as oil prices and exchange rates: forecasts of indicators by national institutions

Time series-based AI algorithms [5] can be used for short-term price estimation. We adopt a recursive estimation model to estimate the price for one month into the future and use the estimated price for training. We extend the short-term predictions beyond 12 months using a re-sampling methodology (Gibbs sampling and bootstrapping) and construct a simulation model based on the econometric model [6-7]. We use the Feature Permutation Importance Method [8] to analyze the importance of influence factors. The model is validated based on the minimum mean absolute error (MAE) between the actual and the estimated REC prices.

Results

We trained a time series-based AI model to estimate short-term REC spot transaction volume and transaction amount using data up to March 2022, and tested the model on the next three months of data (from April to June 2022). Compared to the average, the resulting MAE volume and amount were 12.8% and 8.2%, respectively, which were relatively large errors compared to the average transaction volume and average transaction amount of the historical data. This suggests that interpreting the REC spot market only through trend analysis may cause distortion. Thus, it would be reasonable to develop and apply an AI-based in-depth model that heuristically reflects changes in policy goals.

Conclusions

The composite analysis conducted in this study uses a scenario-based comprehensive simulation model. Scenarios are established according to the order of importance of influencing factors and policy implications derived from past policy performance. In the simulation model, it is possible to provide not only future estimates of important factors, but also the predicted simulation results of the REC spot market in consideration of the characteristics such as renewable energy dissemination policies and changes in the electricity market and energy policy. Through this study, it is possible to analyze the impact of policy implications such as the renewable energy dissemination policies and RPS according to the scenarios. It is expected that the cause analysis will provide a basis for reflecting on the impact of new policies in the future.

References

[1] S. Y. Kim, S. Y. Park (2020), Long-Term Estimation for REC Price, TLG on 1(6) The Lantau Group.

[2] C. Y. Lee (2015), Development and operation of price prediction methodology for REC Price of Renewal Energy, Basic Research Report 2015-12 Korea Energy Economics Institute.

[3] J. Bryan et al. (2015), Estimating the Price of ROCs, The Electricity Journal, 28(1), 49-57.

[4] M. Hustveit et al .(2017), Tradable green certificates for renewable support: The role of expectations and uncertainty, Energy, 141, 1717-1727.

[5] C. Wang, M. Baratchi, T. Bäck, H. H. Hoos, S. Limmer, M. Olhofer(2022), Towards Time-Series Feature Engineering in Automated Machine Learning for Multi-Step-Ahead Forecasting, Engineering Proceedings. 18(17) 1-11.

[6] D. J. Eck(2017), Bootstrapping for Multivariate Linear Regression Models, Statistics and Probability Letters 134.

[7] A. B. Mantz(2016), A Gibbs sampler for Multivariate Linear Regression, Monthly Notices of the Royal Astronomical Society, 457(2) 1279-1288.

[8] L. Breiman(2001), Random Forests, Machine Learning, 45(1), 5-32.