

Assessment of Korea's 2038 Generation Capacity Mix from a Firm Power Perspective

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1. Introduction

The rapid expansion of variable renewable energy (VRE), electrification, and electricity-intensive industries is increasing the importance of dependable capacity in power-system planning. As weather-dependent generation grows, nameplate capacity alone becomes less informative about how much supply can be delivered during critical periods.

This issue is particularly relevant in Korea, where firm power is not always clearly distinguished from related concepts such as baseload generation, dispatchability, and effective capacity. Firm power refers to the dependable contribution a resource can make when electricity is required, whereas baseload describes an operating pattern and dispatchability refers to the ability to control output.

This study evaluates Korea's projected 2038 generation capacity mix by comparing the nameplate and effective capacity values reported in the Eleventh Basic Plan for Long-Term Electricity Supply and Demand. Accordingly, the present study does not estimate firm capacity itself but examines the planned mix from a firm power perspective using the effective-capacity values adopted in the Plan. The contribution of this study is to quantify how the composition of the 2038 mix differs when assessed in terms of nameplate and effective capacity, thereby highlighting a distinction that may be obscured when the mix is discussed primarily in terms of nameplate capacity.

2. Firm Power and Effective Capacity

Firm power is best understood as an attribute of supply assurance rather than as a specific generation technology [1]. Its recognized quantity depends on system conditions, reliability criteria, and the relevant critical period [2].

Effective capacity in the Korean planning framework provides a practical indication of how much of a resource's installed capacity is expected to contribute during peak conditions. Although it does not represent probabilistic firm capacity, it provides a useful basis for comparing installed capacity with recognized capacity contribution.

This distinction is particularly important for VRE, whose installed capacity and peak-period contribution may differ significantly. Accordingly, the analysis compares nameplate and effective capacity in terms of

their absolute values, accreditation ratios, and shares in the projected generation capacity mix.

3. Data and Methods

The analysis uses the 2038 summer capacity data reported in the Eleventh Basic Plan [3]. For each generation source i , the accreditation ratio is calculated as

$$r_i = \frac{E_i}{N_i} \times 100(\%)$$

where N_i is nameplate capacity and E_i is effective capacity. A descriptive capacity difference is calculated as

$$D_i = N_i - E_i$$

This value indicates the difference between installed capacity and capacity recognized under the Plan's peak-contribution assumptions.

It should not be interpreted as a reliability deficit or as the amount of backup capacity required by the system. The shares of each resource in total nameplate and effective capacity are calculated as:

$$S_i^N = \frac{N_i}{N_{total}} \times 100(\%), S_i^E = \frac{E_i}{E_{total}} \times 100(\%)$$

where N_{total} and E_{total} denote the total nameplate and effective capacities, respectively.

The nameplate and effective capacity values used in the analysis are summarized in Table I. These values reflect the peak-contribution assumptions adopted in the Eleventh Basic Plan; accordingly, the derived accreditation ratios, including the 100% value for nuclear, are specific to the Plan's assumptions and should not be interpreted as generic technology-specific capacity credits.

The analysis is descriptive. It does not explicitly consider chronological load risk, forced outages, correlations among renewable resources, storage duration, or the penetration-dependent capacity value captured by effective load-carrying capability (ELCC).

Table I: Nameplate and Effective Capacity of Korea's 2038 Generation Capacity Mix [3]

Source	Nameplate (GW)	Effective (GW)	Accreditation Ratio (%)
Nuclear	31.7	31.7	100
Coal	22.7	22.3	98

Source	Nameplate (GW)	Effective (GW)	Accreditation Ratio (%)
LNG	66.5	66.5	100
Renewables	119.5	13.3	11
New energy	3.9	3.0	77
Pumped storage	10.4	10.4	100
Other	0.7	0.4	57
Total	255.4	147.5	58

4. Results and Discussion

As shown in Table I, the projected 2038 generation capacity mix contains 255.4 GW of nameplate capacity but 147.5 GW of effective capacity, corresponding to an overall accreditation ratio of approximately 57.8%.

The largest difference occurs in renewable generation. Renewables account for 119.5 GW, or 46.8% of total nameplate capacity, but only 13.3 GW, or 9.0% of total effective capacity. This does not imply that renewables lack energy or reliability value; rather, it reflects their limited contribution under the peak-contribution assumptions used in the Plan.

The generation capacity mix therefore looks substantially different depending on the metric used. From a nameplate-capacity perspective, renewables become the largest resource category. From an effective-capacity perspective, however, LNG, coal, and nuclear account for a much larger share of the effective-capacity mix than of the nameplate-capacity mix.

Coal and LNG together account for 88.8 GW, or 60.2% of effective capacity, while nuclear contributes 31.7 GW, or 21.5%. These results indicate that the projected system continues to rely heavily on resources with high accreditation ratios for recognized peak-period capacity.

These results highlight two planning considerations. First, increasing VRE penetration is likely to increase the value of complementary flexibility resources, including storage, demand response, transmission reinforcement, and flexible generation. Second, decarbonization will require attention to how the dependable capacity contribution currently provided by carbon-intensive resources can be maintained with low-carbon alternatives.

Nuclear power already represents a substantial low-carbon component of the effective-capacity mix, while other low-carbon firm options may also play a role depending on their technical, economic, and deployment conditions. The present analysis does not compare these technologies directly and therefore does not identify an optimal portfolio.

A more rigorous assessment should incorporate probabilistic reliability methods and penetration-sensitive capacity accreditation, such as ELCC, particularly for VRE and storage [4].

5. Conclusion

The 2038 generation capacity mix appears substantially different when evaluated by effective rather than nameplate capacity. This finding suggests that future generation planning should consider not only installed capacity but also the dependable capacity contribution of individual resources and portfolios. As renewable penetration increases, flexibility resources and low-carbon firm capacity will become increasingly important for maintaining adequacy while reducing power-sector emissions.

Further analysis using probabilistic and ELCC-based methods is required to quantify these contributions more rigorously.

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REFERENCES

- [1] U.S. Energy Information Administration, Glossary: Firm Power and Nonfirm Power, Washington, DC, accessed Aug. 2026.
- [2] International Renewable Energy Agency, Firm Capacity in Central America: Definitions and Implications for Variable Renewable Energy, Abu Dhabi, 2023.
- [3] Ministry of Trade, Industry and Energy, The Eleventh Basic Plan for Long-Term Electricity Supply and Demand (2024-2038), Sejong, Korea, Feb. 2025 (in Korean).
- [4] C. Paik, Y. Chung, and Y. J. Kim, "ELCC-based capacity credit estimation accounting for uncertainties in capacity factors and its application to solar power in Korea," *Renewable Energy*, vol. 164, pp. 833-841, 2021, doi:10.1016/j.renene.2020.09.129.