Feasibility of the 2035 NDC Power Sector: A Quantitative Assessment of Renewable Expansion and Nuclear Generation Targets

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1. Introduction

The Government of the Republic of Korea announced its 2035 Nationally Determined Contribution (NDC)[1], positioning it as a key interim milestone toward achieving carbon neutrality by 2050. Among the sectoral targets, the power sector is widely regarded as a central pillar of NDC implementation because it typically offers comparatively large mitigation potential, and the decarbonization of the power supply becomes increasingly essential as electrification progresses in other sectors (industry, buildings, and transport). The power-sector pathway implied by the 2035 NDC can be interpreted as a combined strategy of (1) large-scale expansion of renewable energy capacity and (2) increased nuclear generation.

Nevertheless, recent annual additions of renewable capacity in Korea have remained at only a few gigawatts, while wind power expansion has been relatively slow due to permitting constraints, social acceptance issues, and grid-connection barriers. For nuclear power, although Korea has technical capabilities to achieve high capacity factors in the long run, substantial uncertainties remain, including commissioning schedules for new reactors, licensing for lifetime extensions of aging units, and capacity-factor variability attributable to safety and maintenance requirements.

Because the 2035 power-sector pathway relies heavily on renewable scale-up, the 2030 100-GW milestone serves as a practical intermediate checkpoint for assessing deployment pace and system readiness toward 2035. The present study quantitatively examines the scale of renewable expansion (annual capacity additions) and the nuclear generation target (the combination of installed capacity and capacity factor) required for the 2035 NDC power sector.

In particular, this study (1) estimates the required annual build rate to reach 100 GW of renewable capacity by 2030; (2) approximates land-area requirements under a solar-dominant expansion scenario; (3) derives the installed capacity and average capacity factor conditions needed to produce 234 TWh of nuclear generation in 2035; and (4) discusses operational risks from a power-system reliability perspective if grid reinforcement and flexibility resources are not scaled in parallel.

2. Methods and Results

2.1 Scope and Approach

The present study evaluates "power-sector feasibility" along three dimensions: (1) the physical feasibility of capacity expansion (build rate and land requirements), (2) the arithmetic feasibility of meeting generation targets (installed capacity × capacity factor), and (3) constraints from power-system operation (network limitations, flexibility constraints, and curtailment). For renewables, we use the policy target expressed in capacity (GW) to compute the implied annual build rate and estimate the land footprint under a solar-dominant case. For nuclear power, we back-calculate the average capacity factor required to meet the 2035 nuclear generation target of 234 TWh, given assumptions on installed capacity.

2.2 Renewable Expansion Target: Annual Build Rate and Land Requirements

Given that renewable expansion is presented as a core lever in the 2035 power-sector mitigation pathway, the 100 GW target for 2030 can be viewed as an intermediate milestone toward the 2035 goal; accordingly, the present study uses it as the reference point for assessing the required deployment pace. Assuming renewable installed capacity is 34 GW in 2024 and the policy objective is 100 GW by 2030, an additional 66 GW would be required over 2025–2030(6 years). This implies an annual average addition of approximately 11 GW. Such a build rate represents a substantial scale-up relative to recent deployment levels (roughly 2–4 GW/year for solar PV and 0.1–0.3 GW/year for wind).

To approximate land requirements under a simplified solar-dominant scenario, we assume a 400 W PV module has an area of 2.4 m^2 [2]. Using a ground coverage ratio of 0.4 and an additional 20% allowance for auxiliary space, the required land area for 1 MW of PV is approximated as 18,000 m^2 [2]. While this value is used as a baseline for simplicity, the effective land-use coefficient may vary depending on module efficiency, slope, array spacing, and the configuration of ancillary facilities. A sensitivity range (e.g., ±20–30%) can be considered when interpreting the results.

Under the assumption that 11 GW/year is achieved primarily through solar PV, the implied land requirement is approximately 198 km² per year(Since 1 MW of PV requires 18,000 m², 1 GW corresponds to 18 km²; thus 11 GW/year implies 198 km²/year). This corresponds to about 33% of Seoul's area (approximately 605 km²). Although this estimate involves several simplifying assumptions, it provides an order-of-magnitude quantification indicating that the annual deployment pace and the associated land/locational requirements are sizable.

Accordingly, policy design would benefit from a portfolio approach that includes: (1) expansion of distributed PV such as rooftop and parking-lot systems; (2) enhancement of social acceptance for floating PV and agrivoltaics; (3) balanced portfolio construction including wind power; and (4) parallel implementation of grid-connection investments to reduce curtailment.

2.3 Nuclear Generation Target: Capacity Factor Sensitivity

A recent media report[3] argued that achieving the 53% reduction pathway for the 2035 NDC would remain challenging even with extensive reliance on nuclear power. In response, the Ministry of Climate, Energy and Environment issued an explanatory note[4] stating that the 2035 NDC power assumptions are consistent with the capacity outlook in the 11th Basic Plan for Long-term Electricity Supply and Demand[5], and that the nuclear capacity factor assumption is similar to the 2024 level (82.7%).

In this paper, we approximate end-2035 nuclear installed capacity as 31.7 GW based on the capacity outlook in the 11th Basic Plan (e.g., 28.9 GW in 2030 and 35.2 GW in 2038), assuming two large reactors are included while SMRs are excluded. If Kori Unit 2—whose restarted operation is expected to terminate in 2033[6]—is excluded, the resulting installed capacity becomes 31.0 GW. Under this assumption, the capacity factor(CF) required to generate 234 TWh in 2035 is calculated as 86.2% (Using $E = P \times CF \times 8{,}760$ h, $CF = 234$ TWh / (31.0 GW × 8,760 h) = 0.862).

Achieving this level would require that two new reactors are completed without major delays and that all reactors approaching outage by 2029 obtain approvals for continued operation. Korea's reported nuclear capacity factor has only recently recovered to the low-80% range [7].

The nuclear generation target is sensitive to the following factors:

i. New-build schedules: If commissioning of specific units is delayed, installed capacity becomes insufficient, and compensating through capacity factor would require averages above 90%.
ii. Lifetime-extension licensing: If continued-operation approvals for aging units are not granted, effective capacity declines and the capacity factor required to maintain the same generation target increases sharply.
iii. Maintenance, safety, and supply chains: In periods with a larger share of aging units, outage duration/frequency, unplanned shutdowns, and tighter safety requirements can constrain achievable average capacity factors.

The present study provides a conditional assessment: if installed capacity is secured at approximately 31–32 GW, the target remains attainable within an average capacity-factor range of roughly 82–86%; however, if capacity falls into the 29 GW range, the required average capacity factor rises into the low-90% range, calling for careful examination of consistency with operational and maintenance realities. This sensitivity analysis indicates that the nuclear target is strongly dependent on simultaneous satisfaction of multiple prerequisites, and thus supports the policy value of faithful implementation of commissioning and lifetime-extension schedules, alongside consideration of complementary scenarios including flexibility resources, demand response, and low-carbon gas options.

2.4 Reliability Issues when Grid Reinforcement is Insufficient

A pathway that expands renewables and nuclear generation simultaneously entails several operational challenges from the power-system perspective.

i. Curtailment and congestion: If renewable capacity concentrates in particular regions, bottlenecks in transmission, substations, and distribution networks can prevent realized generation from increasing in proportion to installed capacity.
ii. Variability management and reserves: As the solar share increases, flexibility resources become more important to cover post-sunset supply deficits. Because nuclear power traditionally serves baseload functions, variability management requires complementary resources such as pumped hydro, energy storage systems (ESS), demand response (DR), and gas generation.
iii. Frequency and voltage stability: Expansion of inverter-based resources can reduce system inertia and short-circuit strength, increasing the need for grid-supporting devices (e.g., synchronous condensers) and more sophisticated operating rules (including ancillary service market design).

Therefore, power-sector feasibility depends not only on generation capacity targets but also on whether an integrated plan exists that includes networks, flexibility resources, and ancillary services. From a policy perspective, reporting "system acceptance targets" (e.g., annual connectable capacity, transmission commissioning volumes, and ESS/DR expansion) alongside “capacity targets (100 GW) and generation targets (234 TWh)” can improve both verifiability and implementability.

3. Conclusions

This study quantitatively evaluates the feasibility of the 2035 NDC power-sector pathway by examining renewable expansion (100 GW by 2030) and the nuclear generation target (234 TWh in 2035). For renewables, reaching 100 GW from 34 GW in 2024 requires a total of 66 GW over six years, implying approximately 11 GW of annual additions; under a solar-dominant scenario, the implied land requirement could reach roughly one-third of Seoul’s area per year. For nuclear power, generating 234 TWh is arithmetically consistent with an installed capacity of about 30–32 GW and an average capacity factor in the mid-to-high 80% range; however, feasibility is sensitive to commissioning schedules, lifetime-extension approvals, and maintenance/safety constraints.

These results are meaningful insofar as they quantify prerequisites and bottlenecks (land, permitting, grid, and flexibility) underlying the target pathway. Accordingly, future policy design would benefit from: (1) disclosure of annual pathways for capacity additions, grid interconnection, and network commissioning; (2) balanced renewable portfolio design (solar, wind, distributed PV, floating PV, and agrivoltaics); (3) management of nuclear-target sensitivities (transparent schedules and complementary scenarios); and (4) simultaneous expansion of flexibility resources and ancillary service market arrangements.

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