Evaluating a High Ambition Pathway for Decarbonization in the Republic of Korea

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The Republic of Korea (South Korea) is a major economy and manufacturer of global exports. South Korea's total greenhouse gas (GHG) emissions, including land use, land use change, and forestry (LULUCF), peaked in 2018 and declined by 12% in 2023 from the peak level, mostly driven by reduced coal consumption in power generation.[1,2] A large share of emissions still comes from electricity, which comprises 38% of total GHG emissions in 2022, followed by industry (18%) and transport (16%).[3] Emissions from LULUCF in South Korea are small, only comprising around 1% of total GHG emissions.[4] South Korea's 2030 Nationally Determined Contribution (NDC) target commits to a 40% reduction in total GHG emissions from 2018 to 2030, with 13% of total emissions reduction to be achieved through international offsets, and aims to reach net-zero GHG emissions by 2050.[5] These targets cover all GHG emissions from all sectors, although the 2018 base year excludes LULUCF emissions.

As South Korea develops its next NDC target for 2035, it is important to understand the current progress toward its near- and long-term climate goals and identify opportunities for enhanced action across all sectors of the economy. While overall emissions have been declining, continuing the current reduction rate between 2018 and 2022 is insufficient to meet the 2030 NDC target. Achieving the 2030 target without offsets would require doubling the average annual reduction rate since emissions peaked, from 2% per year between 2018 and 2022 to 4% per year for 2023-2030. From the 2030 NDC to the 2050 net-zero goal, emissions reduction efforts need to be maintained and accelerated.

South Korea has laid out key transition strategies that heavily focus on technologies with high political, economic, or environmental uncertainties, including nuclear, ammonia, and hydrogen, while falling behind in the deployment of renewables and electric vehicles (EVs), which are widely proven to be cost-competitive.[6,7] In 2024, renewables (wind and solar) accounted for only 6% of total power generation, one of the lowest values among both G20 and OECD countries, with solar and wind deployment slowing

in recent years—from over 4-5 GW per year in 2018-2020 to just 3 GW per year in 2022-2023.[8] Additionally, existing policies place too much emphasis on hybrid cars compared to EVs, as half of the new sales target for low emission vehicles (51% in 2025 and 83% in 2030) is expected to be met by hybrid cars, compared to 24% from EV and 9% from hydrogen vehicles.[9]

Global 2035 Ambition Analysis

The first Global Stocktake, the five-year assessment mechanism under the Paris agreement, concluded that the world is not on track to reach the climate goal of limiting warming to 1.5°C. Global emissions of GHGs have increased after the 2020 COVID dip, reaching an all-time high in 2023.[10] To keep the global climate goal within reach, there is a real urgency to stop and reverse emissions growth and achieve significant reductions over the next decade. The upcoming development and submission of new national climate targets (NDC 3.0) for 2035 offer an opportunity to set the highest possible ambition within each country's context, with absolute emissions reduction targets that cover all GHG emissions from all sectors of the economy.

According to the Center for Global Sustainability's global analysis on 2035 ambition,[11] *High Ambition* country pathways with accelerated climate action beyond current trends can deliver a 35% reduction in global GHG emissions by 2035 from the 2023 level, compared to a 7% reduction in 2030 with existing country NDCs. This pathway, if followed by ambitious fast emission declines to net-zero carbon dioxide (CO_2) after 2035, leads to a peak temperature of 1.7°C with median likelihood, overshooting the 1.5°C target. The analysis also highlights that electricity generation drives the largest CO_2 emissions reductions globally through 2035, with a tenfold increase in wind and solar capacity and a halving of unabated fossil power generation. Additionally, targeted methane abatement across sectors could reduce global methane emissions by 35% from 2020 levels, contributing more than one-third of total GHG reductions when measured in its 20-year global warming potential.[12]

This report is the first country-specific deep-dive analysis that builds off of prior global analysis[13] to identify emission pathways and key decarbonization strategies for South Korea.

This report outlines a plausible high-ambition, economy-wide GHG emission pathway for South Korea through 2035, using an open-source global integrated assessment model (the Global Change Analysis Model, GCAM-CGS) and integrating bottom-up sectoral analyses that focus on technologies with proven track-records of allowing fast decarbonization progress in many countries. It also details priority policy actions for key sectors and examines the role of subnational actors in achieving these targets. This approach allows a deeper understanding of country specific and global aggregate mitigation potential that reflects high ambition with near-term practicality, providing important complementary information to top-down ambition assessments.

Emissions trajectories

Our modeling analysis (Figure 1) indicates that South Korea's 2035 target under the *High Ambition* pathway entails a 61% reduction in total GHG emissions from 2018 levels, achieved entirely through domestic efforts. In this scenario, GHG emissions, including LULUCF, decline to slightly exceed the 40% reduction 2030 NDC target and then continue to decrease steadily toward net-zero by 2050.

Such a pathway also offers immense benefits in terms of energy security, given that Korea currently imports nearly all of its fossil fuel use (see Figure S1 in Appendix).

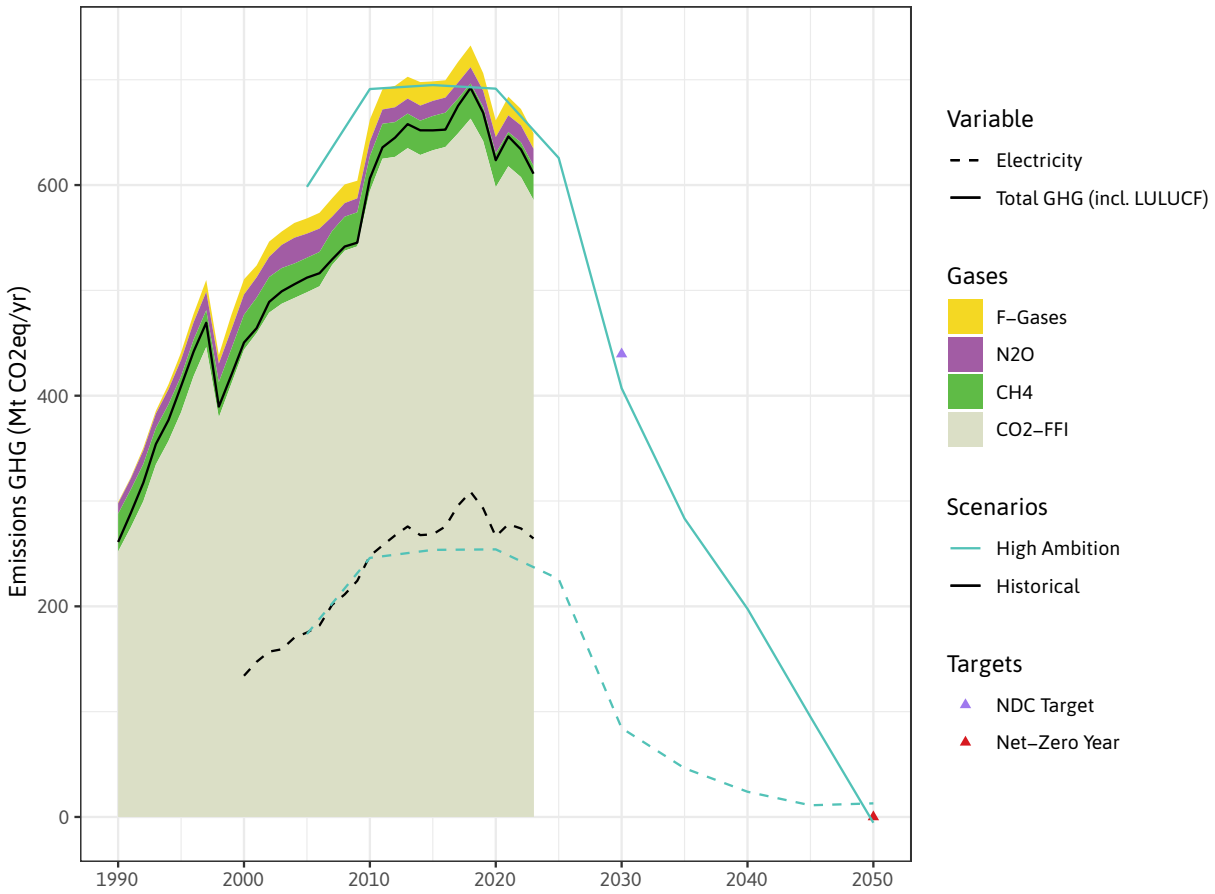

Figure 1. South Korea GHG including LULUCF emission pathways across scenarios. Historical data is from PRIMAP-hist[14] (solid black line for total GHG, including LULUCF) and Ember[15] (dashed black line for electricity supply GHG emissions). Colored triangles mark the official 2030 NDC and net-zero targets. Pathway data includes LULUCF emissions and is based on the NGFS Phase V[16] scenario developed using GCAM-CGS. For additional information on how the *High Ambition* scenario was designed, please refer to the appendix.

Table 1. Total GHG emissions reductions by 2035 under a *High Ambition* pathway for South Korea and other relevant comparable countries with declining emissions or released or proposed 2035 NDCs, relative to their respective NDC base years and 2023 levels. For countries other than South Korea without an official 2035 NDC target, the *High Ambition* pathway from CGS' prior global analysis was used.[17]

Country	Type of Target	Base Year	2035 emissions % change from base year (incl LULUCF)	2035 emissions % change from 2023 (incl LULUCF)
South Korea (*High Ambition*)	CGS assessment[18]	2018	**61%***	54%
United Arab Emirates (UAE)	Official NDC target	2019	**47%**[19]	51%**
United Kingdom	Official NDC target	1990	**81%**[20]	61%**
Japan	Official NDC target[21]	2013	**60%**[22]	47%**
EU27BX	CGS assessment	1990	**73%**	57%
United States	CGS assessment	2005	**64%**	55%
Australia	CGS assessment	2005	**71%**	59%

* For South Korea, the base year excludes LULUCF emissions, as noted in their NDC.
** Not included in NDC, estimated for this analysis using PRIMAP historical data.

South Korea's *High Ambition* pathway implies a reduction in GHG emissions from its peak-year (2018) levels including LULUCF by 2035 (Table 1) that broadly aligns with efforts proposed by other countries for their 2035 NDC. While countries such as the United Kingdom (UK) are targeting GHG emissions reductions around 80% from its peak-year (1990) level, countries like Japan are proposing reductions of 60% from its peak-year (2013) level, and South Korea's *High Ambition* pathway would land around that range.

Priority Policy Actions

To achieve the *High Ambition* pathway, policy actions in South Korea can focus on the following areas to deliver meaningful emissions reductions through 2035, including:

- **Power sector:** Accelerating renewable deployment with wind and solar contributing 47% of total generation by 2030 and 65% by 2035; canceling new coal and gas projects; and phasing out coal by 2035.
- **Industry:** Reducing steel emissions through the phase-out of blast furnaces and the deployment of hydrogen-based direct reduced iron (DRI) and electric arc furnaces (EAF); adopting fuel and material conversion in cement production; and using bio-naphtha as a feedstock for petrochemicals.

- **Transportation:** Focusing on EVs instead of hybrid cars in the new vehicle sales target with more policy incentives; accelerating bus electrification within cities; and updating building codes for high-rise buildings to include specific requirements for charging infrastructure.

Power sector. Decarbonizing the power sector presents significant potential and is a key strategy for emissions reduction through 2035 not only within the power sector, but also for electrifying end-use sectors, like industry and transportation. Rapidly expanding renewables, particularly solar and wind, would be a more robust approach to significantly reduce power sector emissions. To achieve this, it is essential to enhance renewable energy targets, eliminate bureaucratic hurdles, streamline planning and implementation processes, and provide stronger policy incentives. Increasing energy storage and modernizing the electricity grid will be critical for expanding renewable energy capacity. As a major global supplier of batteries and a signatory on the COP29 Global Energy Storage and Grids Pledge, South Korea can develop policy and regulatory frameworks to expand both domestic and global deployment of ESS.[23,24] Additional measures include expediting the planned coal phaseout ahead of the 11th Basic Electricity Plan (BEP) schedule and halting the expansion of LNG infrastructure to avoid locking in fossil fuel infrastructure.

Under the *High Ambition* scenario, emissions from electricity generation decrease by 81% between 2020 and 2035, with accelerated solar and wind deployment, cancellation of new coal and gas projects, and a coal phaseout by 2035 (Table S1). Specifically, power sector transitions under the *High Ambition* pathway include:

- Share of renewable energy generation (solar and wind) increases from 6% in 2023 to 47% by 2030 and 65% by 2035, with buildouts of 15 GW/year from 2025 to 2030, and 13 GW/year from 2030 to 2035 (which would be comparable to the past build-out rate achieved in the Netherlands on a per-capita basis, a country with the same population density).[25]

- Share of coal generation decreases from 33% in 2023 to 4% by 2030, nearly phasing it out by 2035 (1%). Any new addition of coal capacity faces substantial stranded asset risk, including the 2 GW currently under construction.

- Share of gas generation declines from 28% in 2023 to 14% by 2035, with no new gas expansion, by canceling 14 GW of pre-construction projects.

- Other technologies with uncertain emissions reduction potential or economic viability, such as ammonia and hydrogen would cement South Korea's import dependency (as South Korea imports virtually all fossil fuels used, see Figure S1), but are not needed if solar and wind are deployed at rates that other OECD countries have achieved.

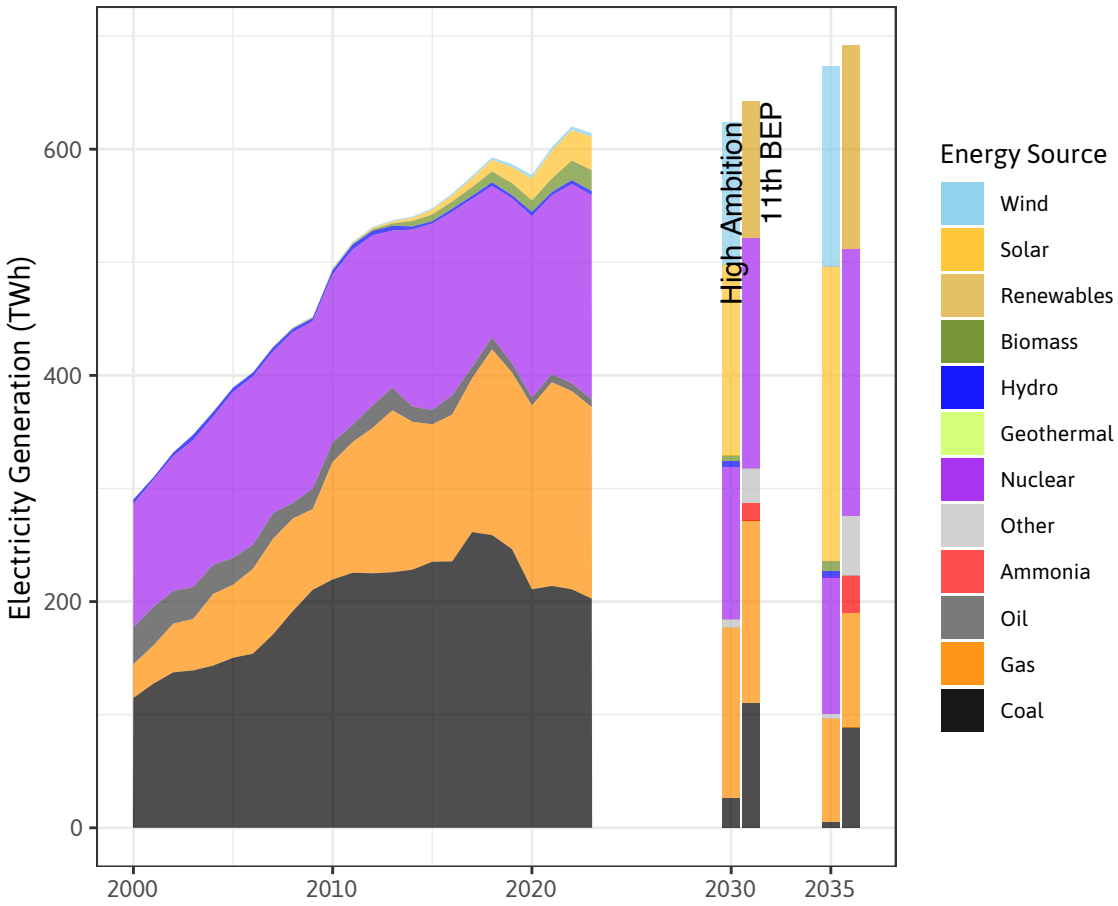

Figure 2. Electricity generation in South Korea by technology for historical years and modeled projections for 2030 and 2035. Historical data is sourced from Ember,[26] while scenario data is from GCAM-CGS (*High Ambition*), and South Korea's 11th BEP.[27]

Industry. South Korea's industrial sector is the second-largest emitter of GHG[28] and the largest consumer of electricity, playing a critical role in the country's economy.[29] Key industries such as steel and automobiles are export-oriented and thus are largely affected by new climate policies in importing regions (especially those directly targeting imports, like the EU's carbon border adjustment mechanism, CBAM). Accelerating the deployment of decarbonization technologies, more efficient processes, and improved products can help these industries to remain competitive during the global low-carbon transition.[30]

Enhancing mitigation efforts in steelmaking, petrochemicals, and cement industries is crucial to achieving a higher ambition.[31] Near-term strategies include the phase-out of blast furnace and the adoption of technologies like hydrogen direct reduced iron (DRI) and electric arc furnaces (EAF) in production[32], fuel and material conversion (to waste synthetic resin, and from raw limestone to slag cement) for cement production,[33] and bio-naphtha as a feedstock for petrochemicals.[34] Additionally, enhancing collaboration with major industry actors, strengthening South Korea's Emissions Trading System and energy efficiency standards, and eliminating the use of international offsets would further drive emission reductions.

Transportation. South Korea aims to have 51% of new car sales be from low emissions vehicles, which include electric cars, hydrogen cars, and hybrid cars by 2025, increasing to 83% by 2030.[35] The share of battery EV (BEV) sales for light-duty vehicles has been increasing in recent years and reached 8.5% in 2022, but declined slightly in 2023,[36] highlighting the need for implementing policies that further expand EV deployment. South Korean car manufacturers are expanding the availability of EV models, with considerable success in export markets.

To further reduce emissions from transportation, key strategies include prioritizing more efficient and faster scaling of BEVs over hybrid cars in new sales targets and accelerating bus electrification within cities.[37] Additional measures involve reducing car use by promoting public transportation, walking, and cycling,[38] as well as expanding green transportation by building more charging infrastructure, updating building codes for high-rise buildings specifically for charging infrastructure requirements, and providing incentives to favor the use of low-emission vehicles.[39]

Discussion and Conclusions

South Korea can enhance its climate ambition by adopting comprehensive policies in the power, industry, and transportation sectors, achieving a 61% reduction in GHG emissions, including LULUCF, from 2018 levels by 2035 under the *High Ambition* scenario. To strengthen these efforts, additional measures should include removing the reliance on international offsets of uncertain efficacy in the 2030 and 2035 NDCs and re-evaluating the country's ambitious hydrogen deployment strategy. Limiting reliance on international offsets would enhance the credibility of climate targets by focusing on domestic emissions reductions, while reassessing the economic viability and emissions reduction potential of hydrogen and ammonia would allow South Korea to prioritize deploying proven, cost-effective technologies such as wind and solar power plants and EVs to achieve greater climate ambition. South Korea, as a country with above average per-capita emissions, can support decarbonization in other countries through other means than offsets.

Subnational action can also play a vital role in achieving more ambitious climate targets. Despite South Korea's centralized governance structure, provinces have the potential to drive emissions reductions, particularly in the power, industry, and transportation sectors. This can be accomplished through measures such as siting policies, incentives to support a circular economy in industrial hubs, and green transportation initiatives at local and metropolitan levels. Specific areas of focus include revising distance regulations for power generation,[40] reforming the power market to fit a renewable-based energy system,[41] promoting sustainable supply chains and industrial park symbiosis, and updating building codes for high-rise buildings to expand charging infrastructure and incentivize the adoption of lower-emission vehicles.[42] Engagement with international coalitions can further enhance the ambition and accountability of local governments in South Korea by fostering collaboration and aligning local climate actions with global standards. Subnational leaders are essential in driving the ambition of national NDCs, as their localized initiatives—complementing national efforts—demonstrate practical solutions, advocate for stronger policies, and ensure that local successes contribute to broader national and global climate goals.

Enhancing South Korea's 2035 NDC ambition requires technological advancements, policy frameworks to drive rapid transformation across sectors, and strong commitment from both national and subnational actors. Achieving even greater emissions reductions than those outlined in this report is possible by accelerating the phase-out of coal and gas power plants in the power sector and advancing electrification

in buildings and industries (see additional charts and figures in the Appendix). By pursuing higher climate ambition, South Korea can establish itself as a global leader in emissions reduction, influencing both regional efforts in Asia and international progress toward the 1.5°C target.

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