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

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The Evaluating a High Ambition Pathway for Decarbonization in the Republic of Korea report identifies key decarbonization strategies for the Republic of Korea. This technical appendix documents the methods and approach used in this analysis. Please see the full report here.

Modeling method

Global Change Analysis Model (GCAM-CGS)

The Global Change Analysis Model (GCAM-CGS) is a global market equilibrium model that combines economic, energy, land use, and climate systems to analyze the interactions between human activities and global environmental changes. It is designed to assess the impacts of various policy scenarios and technology options on energy use, land use change, greenhouse gas emissions and climate change.[1] GCAM-CGS is a dynamic recursive model, meaning that decision-makers do not know the future when planning today. After it solves each period, the model then uses the resulting state of the world, including the consequences of decisions made in that period – such as resource depletion, capital stock retirements and installations, and changes to the landscape – and then moves to the next time step and performs the same exercise. GCAM-CGS operates in 5-year time-increments, with each new period starting from the conditions that emerged in the last. GCAM-CGS has previously been used to examine impacts of mitigation policies and technology deployment on greenhouse gas emissions.[2,3]

GCAM-CGS tracks emissions of 16 different species of GHGs and air pollutants from energy, agriculture, land use, and other industrial systems. In GCAM-CGS, the world is disaggregated into 32 economic regions, the resolution at which socioeconomics, energy, and market processes (including global trade) are modeled. Water flows and land use are modeled in more than 200 and 300 regions, respectively. The Earth system model (i.e., carbon-cycle climate module) Hector is the climate model within GCAM-CGS.[4] GCAM-CGS is a hierarchical market equilibrium model. The equilibrium in each period is solved by finding a set of market prices such that supplies and demands are equal in all simulated markets.

Scenarios used in this analysis

Overall scenarios

We used a bespoke version of the Net Zero 2050 scenarios from NGFS 2024 for the *High Ambition* scenario for the Republic of Korea. The NGFS scenarios are not forecasts, but aim at exploring the bookends of plausible futures.[5] The scenario narratives are regularly updated and expanded to reflect the most recent developments and technological ones (e.g. the availability of CDR), as well as delays in policy implementation within regions and globally. Most scenarios employ a top-down, economy-wide, emissions constraint based on transition pathways at the regional level.[6]

The *High Ambition* variant assumes that the 40% 2030 NDC target is achieved domestically, without reliance on international offsets, achieving a higher ambition than the original 2030 commitment. For 2035, it follows an ambitious path with similar reduction rates from 2030-2035 than are required from 2023-2030. The steeper reduction in this scenario reduces cumulative CO_2 emissions from Korea, and thus its contribution to global peak temperature. Furthermore, it increases the chances of reaching the net-zero GHG target in 2050 by leaving more time for the reduction of the last emissions, and also is in line with observed S-curve behaviour of many technology adoption processes. The scenario is adjusted in 2025 to better account for the latest data.

The Net Zero 2050 scenario has a 50% chance of limiting average global warming to below 1.5 deg C by 2100, with an overshoot of 0.2°C around mid-century. Global CO_2 emissions reach or approach zero in 2050 and countries with a political commitment to a net zero target defined before February 2023 meet this target before or after 2050. Some jurisdictions such as the US, EU, UK, Canada, Australia, Korea and Japan reach net zero for all GHGs.

Additional figures and tables

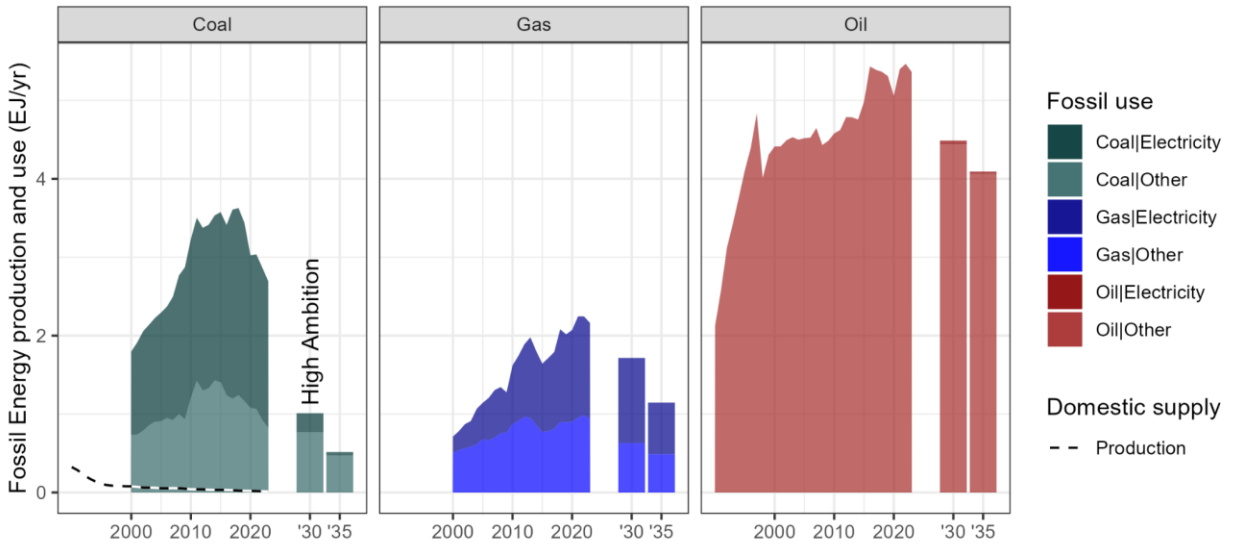

Figure S1. Republic of Korea's fossil energy production and use. Source: Statistical Review of World Energy Data.[7] Gas and production data not included in the dataset for Republic of Korea.

Table S1. Key power sector metrics across scenarios.

Year/ Scenario	Solar + Wind % of total elec generation (Installed capacity, GW)		Coal % of total elec generation (Installed capacity, GW*)		Gas % of total elec generation (Installed capacity, GW*)	
	11th BEP[8]	*High Ambition*	*11th BEP*	*High Ambition*	*11th BEP*	*High Ambition*
2023[9]	*5% (29 GW)*	*5% (29 GW)*	*33% (40 GW)*	*33% (40 GW)*	*27% (47 GW)*	*27% (47 GW)*
2025	n/a	20% (62 GW)	n/a	28% (37 GW)	n/a	26% (43 GW)
2030	18.8% (78 GW)	47% (140 GW)	17% (32 GW)	4% (5 GW)	25% (59 GW)	24% (38 GW)
2035	26% (108 GW)	65% (207 GW)	13% (28 GW)	1% (1 GW)	15% (65 GW)	14% (22 GW)

Note: *Capacity values of coal and gas plants denote the total capacity with constant operating hours at today's level in the respective categories. The same emissions reductions can also be achieved through reduced utilization of coal and gas plants to support the integration of increasing penetration of solar and wind, which results in higher capacity.

Table S2. Electricity capacity and generation mix[10]

	Installed capacity (% of total)					Electricity generation (% of total)					
	2019	2020	2021	2022	2023	2019	2020	2021	2022	2023	2024
Coal	30%	28%	28%	27%	27%	42%	37%	36%	34%	33%	30%
Gas	34%	33%	32%	31%	32%	27%	28%	30%	28%	28%	29%
Other fossil	3%	3%	3%	2%	2%	1%	1%	1%	1%	1%	1%
Nuclear	18%	18%	17%	17%	17%	25%	28%	26%	28%	29%	30%
Total RE	15%	18%	20%	22%	23%	5%	6%	7%	8%	9%	10%
Hydro	*1%*	*1%*	*1%*	*1%*	*1%*	*0%*	*1%*	*1%*	*1%*	*1%*	*1%*
Solar	*10%*	*13%*	*15%*	*17%*	*18%*	*2%*	*3%*	*4%*	*4%*	*5%*	*5%*
Wind	*1%*	*1%*	*1%*	*1%*	*1%*	*0%*	*1%*	*1%*	*1%*	*1%*	*1%*
Biomass	*2%*	*3%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*3%*	*3%*	*3%*

Table S3. Recent solar and wind deployment[11]

Annual Solar & Wind Capacity Additions in Korea (GW)								
	2016	2017	2018	2019	2020	2021	2022	2023
Solar	1.03	1.56	2.48	3.8	4.6	3.94	2.82	2.97
Wind	0.22	0.14	0.21	0.07	0.15	0.08	0.19	0.26
Total Solar + Wind	**1.25**	**1.7**	**2.69**	**3.87**	**4.75**	**4.02**	**3.01**	**3.23**

Table S4. Recent coal builds and current pipeline[12]

Annual Coal Capacity Additions in Korea (GW)										Current Pipeline as Jan 2025 (GW)	
	2016	2017	2018	2019	2020	2021	2022	2023	2024	Under construction	Pre-Construction
Coal	6	6	0	0.3	0	3	1	1	1	1	0

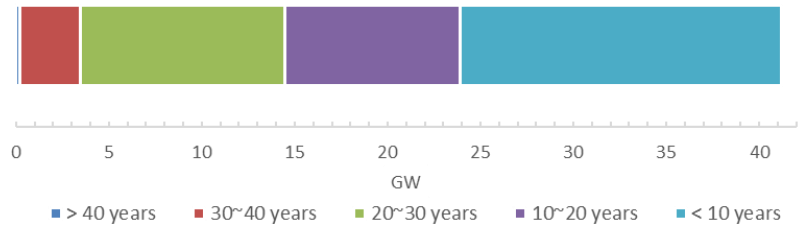

Figure S2. Coal power capacity by vintage group[13]

Table S5. Recent gas builds and current pipeline[14]

	Annual Gas Capacity Additions in Korea (GW)									Current Pipeline as Jan 2025 (GW)	
	2016	2017	2018	2019	2020	2021	2022	2023	2024	Under construction	Pre-Construction
Gas	0.5	4.3	1.2	1.8	0.3	0.8	0.6	2	1.6	2.7	16.2

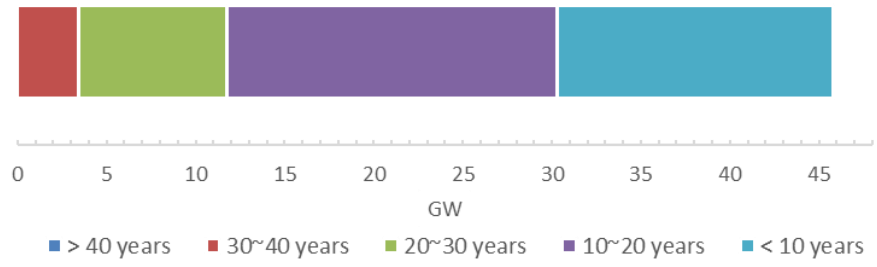

Figure S3. Gas power capacity by vintage group[15]

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[11] Ember, "Electricity Data Explorer - Open Source Global Electricity Data," 2024.

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