CHALLENGES FOR KOREA IN PLANNING FOR NET ZERO EMISSIONS BY 2050 *REVERSING DENUCLEARIZATION*

Soogil Young

Abstract

President Moon Jae-in released two de-carbonization plans in October 2021—the 2050 Carbon Neutrality Scenarios and the Plan for the 2030 Nationally Determined Contribution (NDC) to cut greenhouse gas emissions. The business community and many energy experts were dismayed that the plans included a steep reduction in nuclear energy (from 23.4 percent of electricity generation in 2018 to 7 percent or less by 2050), given that nuclear energy is expected to remain Korea's most competitive energy source in the future. Moreover, the cut in the nuclear energy requires a steep rise in renewable energy from 6.2 percent to as much as 70.8 percent over the same period despite the many obstacles to large-scale increases in renewables. The abrupt decision, taken with no public discussion, to hike the NDC target from a 26.3 percent emissions cut by 2030 (relative to 2018) to a 40 percent cut also stirred public opposition. President Yoon who succeeded President Moon on May 9, 2023, will maintain the 2050 carbon neutrality target and the 40 percent NDC, but will abandon Moon's denuclearization policy and achieve carbon neutrality by promoting nuclear power and renewables. He proposes to work closely with the United States in his nuclear energy policy. President Yoon will reset Korea's decarbonization plan by launching a new 2050 Carbon Neutrality and Green Growth Commission, which will prepare the National Strategy for Implementation of Carbon Neutrality and Green Growth, followed by new 2050 Carbon Neutrality Scenarios and a new plan for the 2030 NDC. Ensuring a preparatory process based on open, participatory, and science-based public discussions will be key to the political sustainability of the emerging new plans.

Introduction

President Moon Jae-in declared on October 28, 2020, that Korea would achieve carbon neutrality, or more precisely, net zero greenhouse gas (GHG) emissions, by 2050, becoming the 14th country to adopt this goal. This declaration was spelled out in more detail in "The Implementation Strategy for 2050 Carbon Neutrality" (CNS) in December 2020.[1] This Strategy signifies Korea's pivot from its traditional carbon-intensive industrial development paradigm to a carbon-free approach. The CNS was followed on October 18, 2021 by the release of two 2050 Carbon Neutrality Scenarios prior to the Glasgow Climate Conference. This set the stage for Korea's revised "nationally determined contribution" (NDC) to the Paris Agreement goals, which set a 40 percent target for GHG emission reductions compared to 2018.

However, the Presidential election victory of opposition candidate Mr. Yoon Suk-yeol in March 2022 resulted in the unravelling of President Moon's decarbonization plans, which were highly controversial from the beginning. In particular, the energy mix proposed for 2050 as well as the feasibility of the 40 percent emissions reduction target for 2030 faced strong criticism. The latter was viewed by many in Korea as excessively ambitious compared to the previous commitment of a 26.3 percent cut. Consequently, the decarbonization plans emerged as a prominent political issue in the presidential campaign of Mr. Yoon, who promised to revamp them. The flash point was President Moon's pledge to phase out nuclear energy. Mr. Yoon, who promised that nuclear energy would continue to play a central role in Korea, won the March election, though with the narrowest margin in Korean history.

This paper begins by introducing the new paradigm to achieve carbon neutrality proposed by President Moon, followed by an overview of the architecture for policies to achieve carbon neutrality established by the Moon government. These two sections explain the institutional environment within which the Yoon government will have to maneuver to revise and implement decarbonization plans. The third section examines conflicting opinions regarding the 2030 NDC and 2050 Carbon Neutrality. The fourth section discusses how President Yoon proposes to resolve the dilemma he has identified, namely by abandoning his predecessor's denuclearization policy. The final section concludes by identifying the most critical challenges he faces in crafting and driving sustainable plans for decarbonization.

I. The Implementation Strategy for Carbon Neutrality: Creating a New Development Paradigm

The cost of transition to carbon neutrality may be very high for Korea

The CNS described the carbon neutrality goal as "challenging," reflecting three disadvantages that Korea has compared to other industrial countries:

- The gap between Korea's apparent peak year for GHG emissions (2018) and the 2050 target is relatively short compared to other industrial countries, such as the European Union (60 years) and Japan (37 years).
- Korea has a large manufacturing sector, at 28.4 percent of GDP in 2019, compared to 16.4 percent and 11.0 percent in the European Union (EU) and the United States, respectively. In addition, the share of energy-intensive industries in Korea was 8.4 percent of GDP, higher than the EU (5.0 percent) and the United States (3.7 percent).
- In terms of the energy mix, Korea's dependence on coal (40 percent) is much higher than other industrial countries, such as Japan (32 percent), Germany (30 percent), the United States (24 percent), the United Kingdom (2 percent) and France (1 percent) (Government of Korea, 2020).

Consequently, the cost of transition to carbon neutrality is likely to be high for firms and households. Firms fear that they will suffer a loss of competitiveness as industries undergo decarbonization and the energy system shifts from fossil fuels to new and renewable energy.[2] Households may face job losses and higher costs for electricity and heating.

A proactive response to the challenge of carbon neutrality offers great opportunities

Achieving carbon neutrality is a difficult, but inevitable, choice. Korea's unprecedented leap to developed, industrial country status and its resiliency demonstrated in its recovery from the 1997 Asian financial crisis, the 2008-09 global financial crisis and the COVID-19 pandemic suggest that the 2050 carbon neutrality is as much an opportunity as a threat. However, this requires a shift from "adaptively" approaching GHG emission reduction to "proactively" building a new economic and social

system that makes it possible to achieve sustainable economic growth and an improved quality of life during the transition to a carbon-neutral society. This amounts to a vision of "sustainable development."

II. Setting the Institutional Architecture: The Framework Act on Carbon Neutrality

The Framework Act on Carbon Neutrality and Green Growth was passed by the National Assembly in August 2021 and came into effect on March 25, 2022. It defines "government-led promotion of the transition toward carbon neutrality by 2050 along with harmonious development of the environment and the economy" as "the national vision." The Act replaced the Framework Act on Low Carbon Green Growth that had been in effect since President Lee Myung-bak proclaimed the "low carbon green growth strategy" in 2008 as "a pillar of Korea's new vision" for "sustainable growth which reduces both greenhouse gas emissions and environmental pollution." Lee's green growth strategy was geared to the rather vaguely defined vision of making Korea "one of the world's five green advanced countries by 2050."[3]

The legal framework is a critical parameter for the sustainability of decarbonization policies. The Framework Act set up an elaborate institutional architecture for establishing, changing and implementing carbon neutrality policies. One key element is the establishment of the "National Strategy for Carbon Neutrality and Green Growth," which is to focus on a sector-specific approach to decarbonization that sets targets for buildings, transportation, industries, business management, jobs, and technologies. The National Strategy also provides linkages with environmental, energy, territorial and maritime policies, and aims to ensure a just transition to a carbon-free society. The Framework Act requires the government to review the National Strategy every five years in the light of technological and social developments, both domestically and internationally. Such reviews should take into account the opinions of relevant experts and stakeholders, in part by holding public hearings.

Any revisions of the National Strategy should be submitted to the Cabinet and the 2050 Carbon Neutrality and Green Growth Commission for consideration. The Framework Act requires that the Commission consist of 50-100 members, including designated ministers and government officials and private-sector experts with relevant expertise representing various stakeholder groups. The private-sector members are appointed for two-year terms, renewable for one year. The Commission, along with its secretariat, are to act as a control tower steering the economy toward carbon neutrality by building a social consensus on strategic priorities and implementing policies. It coordinates with the office of the Prime Minister, who is one of its co-chairs alongside the private-sector counterpart. The Framework Act also requires the creation of Local Commissions on 2050 Carbon Neutrality and Green Growth at lower levels of government.

The Framework Act also mandates the government to set annual aggregate and sectoral reduction targets that will enable Korea to achieve its NDC goal, subject to renewal once every five years or whenever "necessary," subject to the principle of "progression beyond the current NDC" of the Paris Agreement. The Act also stipulates that the government review the NDC and the sectoral targets for 2030, as well as all annual targets, once every five years. The government may make adjustments between the five-year review cycle if warranted by social, technological, and other conditions. Any adjustments should take into account the opinions of relevant experts and stakeholders.

The first Basic Plan (2023~2042) and Local Basic Plans to be established by March 2023

To achieve the 2030 NDC target and carbon neutrality by 2050, the Framework Act also requires the government to establish and implement a 20-year "Basic Plan for National Carbon Neutrality and Green Growth" once every five years. The first Basic Plan must be released within a year of the implementation of the Framework Act (i.e., before March 25, 2023) and extend to 2042. It should include sectoral measures to achieve the NDC target and estimates of financial resources needed to transition to a carbon-neutral society, as well as how to mobilize them.

Under the Framework Act, cities and provinces should establish and implement their own local Basic Plans for five and ten years, taking into consideration the national Basic Plan. In preparing or revising local Basic Plans, local governments should enter into discussions with their respective Local Commissions for 2050 Carbon Neutrality and Green Growth, and submit them to the Minister of Environment, who then compiles the submitted plans and reports to the 2050 Carbon Neutrality and Green Growth Commission. The Framework Act also requires grassroot local government units to prepare Basic Plans.

The new framework imposes stringent conditions on establishing or revising decarbonization plans

During the presidential campaign, Mr. Yoon promised to revise the decarbonization plans set by President Moon. However, the architecture established by the Framework Act created a complicated process to establish, change, and implement decarbonization plans. It requires consistency between the three layers of planning from the national level to grassroot local autonomous governments. Moreover, as noted above, reviews are required every five years or even more frequently when deemed necessary. In particular, changing or setting decarbonization plans requires public hearings and discussions among experts and stakeholders and approval by the 2050 Carbon Neutrality and Green Growth Commission.

President Yoon will launch a new 2050 Carbon Neutrality and Green Growth Commission

President Moon launched the 2050 Carbon Neutrality Commission in May 2021 by decree. The 2022 Framework Act renamed it the 2050 Carbon Neutrality and Green Growth Commission and specified that its current members would be members of the new committee until new members are appointed. The current Commission consists of 18 minister-level officials and 77 appointed members from the private sector. President Yoon is expected to reshuffle the Commission, bringing in new members and a new private-sector chairperson, in the near future.

III. Controversies over the Plans for the 2030 NDC and 2050 Carbon Neutrality

The new NDC target upset both the business sector and environmentalists, though for different reasons

The business community had been preparing to reduce its GHG emissions by 26.3 percent by 2030 from the 2018 level, as pledged in Korea's existing 2020 NDC commitment. However, the 2021 Framework Act raised the bar by requiring that the NDC be set at or above 35 percent. On October 8, 2021, the Presidential Committee on 2050 Carbon Neutrality proposed that the NDC target be increased to 40 percent and the new target was adopted after only ten days of online public discussion. The business community, which had been excluded from the Committee's preparatory deliberations on the NDC, was shocked by the unexpectedly large increase in the target and the abruptness of the decision.

The 40 percent NDC goal actually overstates the target. It was calculated by dividing the planned net emissions in 2030 by the actual amount of gross emissions in 2018 ("a common international practice,", according to the government). The target implies a 36.4 percent reduction if calculated using the net amount of reductions in both years. To achieve the new NDC, Korea's emissions would need to be reduced at a 4.2 percent annual rate from 2018, the year of peak emissions, to 2030, a relatively fast pace compared to other countries: 2.0 percent annually for the European Union (to achieve a 55 percent cut from 1990), 2.9 percent annually for the United Kingdom (a 68 percent cut from 1991), 3.1 percent annually for the United States (a 51 percent cut from 2007), and 3.6 percent annually for Japan (a 46 percent cut from 2013).[4]

Korea's NDC seems particularly challenging given the large share of manufacturing in its economy. Industry and the transformation sector (electricity and heat generation) accounted for 73 percent of Korea's emissions in 2018. Moreover, Korea's leading industrial sectors, such as steelmaking, petrochemicals, cement, and semiconductors, are relatively carbon-intensive and highly energy-efficient. Indeed, Korea's industrial sector sharply reduced its emissions intensity from 869 tons per billion won of value added in 2000 to 391 tons in 2018 through aggressive investments to boost efficiency. The NDC plan includes a 14.4 percent cut in emissions by industry and a 44.4 percent cut by the transformation sector (Table 1). Korean business leaders argue that Korean industry's energy efficiency is among the world's highest based on its investment in new facilities, making further improvement highly challenging for the next 20 to 30 years. Industry is engaged in R&D for new technologies to further reduce emissions in carbon-intensive industries, such as hydrogen direct reduction for steelmaking, but the Korea Environment Institute (quoting the International Energy Agency)[5] stated that this technology for steelmaking cannot be deployed in earnest until after 2050.

Business organizations have strongly criticized the revised NDC target, arguing that an unrealistic emissions target would reduce Korea's international competitiveness, prompting firms to move production offshore, resulting in a fall in domestic production and employment. The Korean Enterprises Federation (KEF, which most representative of the business community), the Korean Chamber of Commerce, and Industry and the Federation of Korean Industries (FKI), an organization of big enterprises, have all criticized the plan as highly detrimental. To avoid a negative outcome, business leaders demand resetting the NDC plan, including the overall target.[6]

Table 1 2030 NDC Plan: Emissions Share and Rate of Reduction by 2030 by Sector

Sector	**Emissions in 2018,** Mt (Share)	**Emissions in 2030,** Mt (Cut from '18)
Total	727.6* (100.0%)	436.6* (-40.0%)
Transformation	296.6 (37.1%)	149.9 (-44.4%)
Industry	260.5 (35.8%)	222.6 (-14.4%)
Buildings	52.1 (7.2%)	35.0 (-32.8%)
Transportation	98.1 (13.5%)	61.0 (-37.8%)
Agri-Livestock-fish	24.7 (3.4%)	18.0 (-27.1%)
Waste	17.1 (2.4%)	9.1 (-46.8%)
Hydrogen	- -	7.6
Leakage	5.6 (0.8%)	3.9 (-30.4%)

*The volume of emissions in the base year (2018) is the gross volume while, in 2030, it is net volume, both in MtCO2eq.

Source: "Plan to Increase the 2030 NDC," Government of Korea, October 18, 2021.

Korea's NDC plan calls for significant changes in the fuel mix for electricity (Table 2) to achieve the 44.4 percent reduction in the transformation sector (electricity and heat generation). The share of coal power is to be halved from 41.9 percent in 2018 to 21.8 percent in 2030, accompanied by a reduction of LNG power from 26.8 percent to 19.5 percent. This will be offset primarily by a sharp increase in the share of new and renewable energy from 6.2 percent to 30.2 percent. The government's plan also emphasizes the need to improve demand management to cope with the expected increased for electricity from the ICT sector and electric vehicles. Nuclear power will increase its share of electricity only slightly to 23.9 percent under the plan.

The key to decarbonization in the industrial sector is the re-engineering of production processes to replace coal as the fuel and petroleum products as raw materials. Steelmaking, which accounted for 17 percent of Korea's GHG emissions and 30 percent of those by the industrial sector in 2019,[7] will shift from coke-based blast furnaces to electric furnaces, which produce steel from steel scraps. As for petrochemical products, the main raw material—naphtha from petroleum—will be replaced by bio naphtha and plastic wastes. Cement production will use synthetic resin waste instead of soft coal. Achieving the targeted 14.4 percent cut in emissions by industry requires electrifying fuels while pushing for higher efficiency for machinery across all industries.

Table 2 Planned Fuel Mix for Electricity in 2030 (Unit: TWh)

	Nuclear	Coal	LNG	New & renewables[1]	Ammonia[2]	Pumped water, etc.	Total
Power output	146.4	133.2	119.5	185.2	22.1	6.0	612.4
Share (%)	23.9	21.8	19.5	30.2	3.6	1.0	100.0
2018 share (%)	23.4	41.9	26.8	6.2	-	0.7	100.0

[1] New energy consists of hydrogen energy, fuel cell energy, liquified coal gas. Renewable energy consists of solar, wind, water, tidal, bio and waste energies.

[2] Generates electricity by combusting ammonia in the existing LNG turbine.

Source: "Plan to Increase the 2030 NDC for GHG Emission Reduction," Government of Korea, October 18, 2021.

Environmental groups are diametrically opposed to the business community in criticizing the government's plan. The Korean Federation for Environmental Movement (KFEM), an influential umbrella group for environmental NGOs, was highly critical of the proposal by the 2050 Carbon Neutrality and Green Growth Commission to hike Korea's NDC target for 2030 to 40 percent and demanded that it be increased to 50 percent. The KFEM's reaction is summarized by the headline of its press release: "Korea should upgrade its NDC target to 50%! The proposed target of 40% is too weak as a response to the climate crisis. Emissions in 2030 by industry are still too large and require a further reduction."[8] On the same day, the Climate Crisis Emergency Action group urged the government to set a higher NDC target to avert a climate crisis.[9] The KEFM's main criticisms of the NDC are:

- The Intergovernmental Panel on Climate Change (a UN body) recommended that countries reduce their emissions by 45 percent relative to 2010 to limit the rise in global temperature to 1.5ºC. For Korea, that is equivalent to a 50 percent cut from 2018. The 40 percent target for 2030 thus appears insufficient to meet the 2050 carbon neutrality goal.
- Coal, the main source of emissions in the transformation sector, should be completely eliminated by 2030 altogether, rather than just cutting it by half to 21.8 percent.
- The emission reduction goal for industry is only 14.5 percent, which allows the sector to emit as much as 22Mt in 2030. This reflects Korea's industrial-sector bias in its approach to decarbonization. Moreover, the difficulties with process re-engineering required to shift to clean fuels and raw materials during the next few decades may not be insurmountable, as claimed by industry.

Controversy over the 2050 carbon neutrality scenarios for electricity fuel mix

The business community was similarly disconcerted by the 2050 Carbon Neutrality Scenarios released by the government in October 2021 along with the new NDC plan. Korea's net zero emissions target is achieved in both Scenarios A and B by 2050, with the largest emission reduction in the transformation sector (Table 3). The business community sharply criticized the energy mix in these scenarios as unrealistic and a threat to the goal of carbon neutrality itself. A conservative newspaper's editorial even called the scenarios "science fiction."[10] Coal is completely eliminated in both scenarios, while the share of renewable energy rises from 6.2 percent in 2018 to 70.8 percent (Scenario A) or 60.9 percent (Scenario B) by 2050. LNG, 26.8 percent in 2018, is to be eliminated by 2050 in Scenario A or reduced to 5.0 percent by 2050. Also notable was the proposed cut in nuclear electricity's share from 23.4 percent in 2018 to 6.1 percent (A) or 7.2 percent (B) by 2050, as the number of reactors is reduced from 24 in 2018 to only a few in 2050.

The business community argues that raising renewable energy's share of electricity generation to more than 60 percent is unrealistic because of Korea's unfavorable natural conditions. Korea ranks 13th in the world in terms of population density. Forests account for 63 percent of its territory, agricultural fields for 19 percent, with the remaining 18 percent consisting of roads, residential areas, rivers, factories and buildings.[11] Conditions are thus unfavorable for the installation of wind turbines on land, which so far have been limited to only 1.76GW. Korea's topology is more favorable for solar panels, but securing appropriate sites is an enormous challenge. For purposes of illustration, to generate half of the renewable energy power projected by Scenarios A or B by 2050 with solar panels, Korea would need to install up to 300GW of such electricity. This would require the installation of approximately 10GW

per year by mid-century, 2.5 times faster than the recent pace. Moreover, it would require a combined area of 3,000 km^2, five times the area of the city of Seoul, by 2050. Securing such vast expanses would be next to impossible given regulations, such as for the environment and agriculture, as well as the ubiquitous problem of public acceptance of such projects by neighboring populations. Indeed, the installation of solar panels and wind turbines has often been blocked by concerns for the protection of forests and landscapes.

Offshore wind power should also play a large role, up to 100GW by 2050, to supplement the limited capacity of onshore wind power. This would require the installation of 10,000 wind turbines, fixed or floating, each with 10MW capacity on the seas surrounding the country. Korea currently has installed a combined total of 0.1GW of offshore wind turbines over the past decade. Installation has been slowed as many maritime areas are protected for military purposes, navigation and birds' migratory routes. In addition, fishermen want to protect their fishing zones. Overcoming such challenges would be an enormous challenge.

The poor quality of available renewable energy resources is also a serious constraint in Korea. Wind and sunshine conditions are weak, intermittent and variable, and their energy content is low. Wind power generation is possible for only six hours a day on average and solar power generation for only two hours a day.[12] Steady sunshine is scarce during the monsoon season of June and July. Maintaining a stable electricity supply based largely on renewable energy would require major innovations to secure sufficient supply flexibility, improved energy storage systems, and smart operating technologies, such as AI and digitalized networks. It would also require an appropriate business model, markets, regulations, and system management. Even with all of that, a power system heavily dependent on renewable energy increases the instability of the electricity supply, creating risks of frequent power failures, and threatening energy security. Financing the requisite investment would also be a huge challenge. Finally, an electricity system so dependent on new and renewable energy sources with no coal power and little nuclear energy would likely lead to high electricity prices. President Yoon's Transition Committee reported that electricity prices are expected to rise 4-6 percent every year on average and by five times by 2050 under the present Scenarios.[13]

The 2050 Carbon Neutrality Scenarios also include new energy sources to augment renewable energy. In Scenario A, carbon-free gas turbines, which use hydrogen and ammonia as fuel, are to account for 21.5 percent of power generation in 2050. However, this technology is yet to be developed. Its share is smaller in Scenario B, but fuel cell electricity makes up for the difference. Scenario B assigns a role to the "Northeast Asian Grid," an international power grid that is intended to leverage abundant solar and wind resources in Mongolia and Sakhalin. Such a grid, however, is currently just a hypothetical proposal that has been discussed for several years but faces uncertain prospects, in part, because of the complex geopolitics in the region.[14]

Table 3 Korea's 2050 Carbon Neutrality Scenarios: Power generation by source (In TWh and percentage of total)

Scenario	**A** (TWh) I %	**B** (TWh) I %
Nuclear	76.9 I 6.1%	86.9 I 7.2%
Coal	0.0 I 0.0%	0.0 I 0.0%
LNG	0.0 I 0.0%	61.0 I 5.0%
Renewable energy	889.8 I 70.8%	736.0 I 60.9%
Fuel cells	17.1 I 1.4%	121.4 I 10.1%
NEA grid[1]	0.0 I 0.0%	33.1 I 2.7%
Carbon-free gas turbines	270.0 I 21.5%	166.5 I 13.8%
By-product gas (H_2)	3.9 I 0.3%	3.9 I 0.3%
Sum	1257.7 I 100%	1208.8 I 100%
Emissions (MT)	0.0	20.7

[1] An international power grid that uses abundant solar and wind resources in Mongolia and Sakhalin.

Source: Republic of Korea (2021), *2050 Carbon Neutrality Scenarios*, October 18.

IV. Transitioning from Moon to Yoon's Approach to Decarbonization: "De-denuclearization"

The problems in the 2050 Scenarios, including its energy mix for electricity, are due to former President Moon's energy denuclearization policy, according to the business community and many energy experts. Moon's policy on nuclear energy was articulated in his June 2017 address at a ceremony marking the permanent closure of the Kori No.1 nuclear reactor, Korea's first and oldest nuclear plant. It began operations in 1978, opening Korea's era of inexpensive power supply. Korea's nuclear electricity supply grew rapidly, along with coal, to support industrialization. Moon said, "The permanent shutdown of Kori No.1 is the first step on the path towards a nuclear-free country. It is a great transition to a safer Republic of Korea… The Fukushima nuclear accident vividly illustrated that nuclear power plants are neither safe nor affordable nor environmentally friendly." He then presented his vision of a new energy policy centered around denuclearization of electricity as follows:

- Respect for lives and safety, and environmental sustainability as the highest value.
- Strong nuclear safety standards.
- No further construction of new reactors and no extension of the existing reactors whose certified service lives are due to expire.
- A phasing-down of coal power plants, including a moratorium on new coal power plants, and the closure of ten old coal power plants during his presidency.
- Strong promotion of solar and offshore wind powers along with an increase in LNG power.

President Moon's energy policy, announced one month after his inauguration was not the outcome of formal policy deliberations, but stemmed from his personal convictions.[15] He followed up his personal statement with the cabinet's a*d hoc* decision, "Energy Transformation (Denuclearization) Roadmap" in October 2017, which proposed cancelling the scheduled construction of six nuclear reactors, prohibiting the extension of the service lives of 14 old reactors and forcing the early closure for safety reasons of a reactor that was operating on an extended service life. The closure of the latter, the Wolsung Reactor No. 1, resulted in a scandal related to the economic feasibility study on whether to keep it open. The Board of Audit and Inspection determined that the officials in charge had fabricated the finding that there was no justification for continued operation of this reactor under pressure from the Office of the President.[16] It also found that President Moon had not sought the opinion of the Ministry of Trade, Industry and Energy (MOTIE), which is responsible for energy policies.

Under President Moon's Roadmap, the number of nuclear reactors would decrease from 28 in 2022 to 18 in 2031 and then 14 in 2038. This Roadmap was subsequently reflected in the 8th Electricity Demand and Supply Basic Plan (2019-2031) and the 3rd Energy Basic Plan (2019-2040). The consequent loss of electricity supply from nuclear reactors is to be offset by an increase in the share of renewable energy to 20 percent in 2030. Although President Moon's denuclearization policy was wholeheartedly supported by anti-nuclear activists and environmental groups, it was opposed by a broad range of stakeholders and opinion-makers, including energy experts and the business community, which values nuclear energy as a key source of inexpensive electricity, industrial competitiveness and a major enabler of Korea's decarbonization. They also see the export of Korea's advanced nuclear reactor technology as a promising new growth engine.

One of Mr. Yoon's ten campaign pledges as a presidential candidate was "to pursue a realistic approach to carbon neutrality and make Korea the world's most competitive nuclear energy country" by the "de-denuclearization" of energy sources. His Transition Committee has listed the following policy agenda for this purpose:[17]

1) Korea will honor its commitment to achieving carbon neutrality by 2050, as well as the NDC target of a 40 percent emissions cut by 2030.

- Abandon the denuclearization policy of the previous government and realize carbon neutrality by harmonizing new and renewable energy and nuclear electricity.
- Relaunch the construction of the Shinhanwool Reactors #3 & #4 as soon as possible, revitalize the ecosystem for nuclear electricity industry, and restore Korea's world-class prowess in nuclear electricity technology.
- Renew the operation of the nuclear reactors whose certified service lives expire before 2030, provided they meet the safety standards, to help meet the NDC emissions reduction target.

- Deploy nuclear electricity as a baseload power to maintain its share at a reasonable level.
- Seek convergence of public opinion based on science, technology, and data to establish the NDC implementation plan and a stage-wise optimal energy mix based on sensible cost estimates.
- Pursue an integrated management of the energy basic plan and other related plans based on the NDC target.

2) Work with the people in pursuing nuclear electricity policy.

- Seek convergence of public opinion based on science, technology, and information in pursuing nuclear energy policy by setting nuclear energy safety standards that are supported by the public and effective safety regulations to ensure safety in continuing the operation of reactors.
- Respect the expertise and independence of the Nuclear Energy Safety Commission in order to strengthen the foundation for safe utilization of nuclear energy.
- Revise the Korea-U.S. Nuclear Power Cooperation Treaty in order to secure the research foundation for reuse of spent nuclear fuels.
- Seek early adoption and steady implementation of the basic plan on high-grade radioactive spent materials.

3) Strengthen the Korea-U.S. Nuclear Power Alliance and export nuclear electricity plants:

- Operate a pan-governmental export support team for nuclear electricity plants.
- Actively utilize the "Korea-U.S. High-level Nuclear Power Council" to promote cooperation with the U.S. for nuclear plant exports.
- Promote exports of small modular reactors (SMRs) development projects and seek international cooperation on advanced regulations.
- Create 100,000 jobs by completing the export of ten nuclear plants by 2030.

4) Actively develop the next-generation nuclear electricity reactors such as the SMR and nuclear hydrogen technology.

- Promote the testing and commercial deployment of water-cooled SMRs to advance world SMR markets.
- Develop SMRs for carbon neutrality and export.
- Develop innovative SMRs that facilitate hydrogen production and linkage with renewable energy.

V. Challenges in planning for sustainable decarbonization

Although President Yoon has vowed to respect the NDC target and the commitment to carbon neutrality, he intends to revise the Implementation Strategy for 2050 Carbon Neutrality. In particular, he plans to reverse his predecessor's policy of denuclearization in order to boost nuclear energy's share of electricity to 30 percent or more. This would mean a much smaller share for renewable energy, thereby reducing transition costs for the economy and energy consumers. The first Basic Plan for Carbon Neutrality and Green Growth, which is due by March 2023, will follow this approach. The following three policy agendas are among the most critical challenges facing President Yoon's plans to achieve carbon neutrality by 2050.

To ensure the political sustainability of decarbonization plans

The most important measure of success of any decarbonization plan should be its political sustainability. The fact that President Moon's plans for the 2030 NDC and 2050 carbon neutrality are now being overturned within a year of their adoption by his successor testifies to this point. The momentum for such a reversal has been provided by the transfer of power from the progressive to the conservative party. The long-term sustainability of a policy platform requires public support that can withstand the change of government.

An example of the lack of sustainability of key policies is President Lee Myung-bak's "four major rivers project", a huge construction project undertaken over 2009-11. The objective was to 'restore' Korea's four main rivers which had grown shallow over decades from accumulation of earth and sludge,

resulting in the flooding of the communities in the river basins during the summer monsoons, as well as shortages of freshwater during the rest of the year. The 22 trillion won project included dredging the river bottoms, building 16 IT-controlled weirs and developing the river areas for recreational activities. The project was faced vociferous objections from opposition politicians and major environmental groups. Public opinion concerning the project remains polarized even today. The Moon administration's attempt to remove the newly built weirs was blocked by those supporting the project. The vulnerability of the four rivers project stemmed from the fact that it was launched despite the lack of public support.

The following three of the eight "basic principles of transition to a carbon-neutral society and green growth" specified in the Framework Act seem to constitute necessary conditions for political sustainability of the proposed transition:

- (3-3) Policies for reducing GHG emissions and adapting to climate crisis should be based on scientific forecasts and analysis of climate change and embrace all relevant areas and fields that are susceptible and sensitive to the climate crisis.
- (3-6) Transition to a carbon-neutral society should be utilized as an opportunity to overcome the climate crisis as well as to enhance the nation's economic growth engine, strengthen its international competitiveness, and create jobs by strengthening investment in, and support for, green technologies and green industries.
- (3-7) Ensure democratic participation of all citizens in the transition to a carbon-neutral society and promotion of green growth.

These principles highlight science, economic growth and job creation, and democratic participation as key necessary conditions for the political sustainability of decarbonization plans. Ironically, President Moon's 2050 Carbon Neutrality and Green Growth Commission more or less ignored these principles in preparing the 2030 NDC Plan and the 2050 Scenarios. The Commission has been widely criticized for this failure. Public hearings were few and perfunctory if any, allowing no meaningful public discussion of the two plans. As noted above, Mr. Lee Dong-kun, Vice-Chairman of the Korean Enterprise Federation, complained bitterly about the exclusion of the business community from deliberations. President Moon Jae-in followed a top-down approach to decarbonization planning, strongly dictated by his personal conviction.

The new 2050 Carbon Neutrality and Green Growth Commission that is expected to be launched soon will play a leading role in resetting the 2030 NDC plan and the 2050 Carbon Neutrality Scenarios, as well as in formulating the first Basic Plan. Given sharp differences of view among stakeholders, the process is likely to be arduous, entailing vociferous discussions among experts and business and environmental groups. The first Commission created by Moon was co-chaired by Professor Yoon Soon-jin, an expert on environment and energy and well-known as a staunch opponent of nuclear energy like the former president. As such, sharing President Moon's conviction, she precluded discussion of nuclear energy as an option from the public discourse that she chaired. The Commission she co-chaired with the prime minister did not include any nuclear energy experts. As a result, the decarbonization plans produced by the Commission failed to win support from a broad spectrum of stakeholders outside the Commission, many of whom were vocal in criticizing the positions taken by the Commission, including on nuclear energy in particular. Professor Yoon resigned from the Commission following President Yoon's election victory in protest of his advocacy of nuclear energy. This episode illustrates the importance of balancing the composition of the Commission, as well as the need to ensure open and transparent public discussions of all options for decarbonization in order to reach decisions that are durable over time. The stringent conditions on establishing or revising decarbonization plans discussed in Section II address this need and should be observed by the Yoon government in resetting Korea's decarbonization plans to avoid the fate of President Moon's.

Strengthening the institutional foundations for carbon neutrality: carbon price signals

There is much scope to accelerate the reduction of emissions even by 2030 by strengthening the institutional foundations for carbon neutrality. The national debate thus so far has been too focused on the 2030 Plan and the 2050 Carbon Neutrality Scenarios while neglecting the importance and urgency of enhancing market mechanisms. Such mechanisms are crucial to incentivize investment in new technologies and facilities, re-engineering, and demand management in support of energy and resource conservation, along with fiscal incentives, green finance and R&D support. The most pressing need is to strengthen carbon price signals. President Moon was negligent in pushing this unpopular agenda for fear of universal public pushback. The Yoon government argues that the Moon government suppressed electricity prices out of fear that raising these prices could be blamed on the denuclearization policy.[18]

Mr. Chung Seung-Il, the president of the Korea Electric Power Corporation, reported at a general assembly of the People's Power Party held in June this year that KEPCO requested increases in electricity prices 10 times under the previous government but none of those requests were accepted by the government on the ground that this would be inflationary.[19]

The most powerful mechanism for carbon pricing is Korea's emission trading system (ETS) that was introduced in 2015 and is now in its 3rd Plan Period (2021-2025). It applies to 684 firms above a certain size threshold and covers more than 74 percent of all emissions. However, it has been rather ineffective because only 10 percent of emission allowances were auctioned in 2021—an improvement over 0 percent in the first plan period (2015-2018) but far too low to be effective as a carbon pricing mechanism.[20] Prof. Yoo Seung-jik of Sookmyung University, a former Director of the Korea Greenhouse Gas Inventory and Research Center, which administers the ETS, has identified the government's excessive intervention in the ETS and its system of allowance allocation as the main problems.[21] He states that it is imperative to ensure full auctioning of allowances for the electricity sector and ensure that the price of the allowances is reflected in electricity prices rather than keeping the price low through subsidies.

The distortion of electricity prices encourages consumption and the waste of electricity and increases carbon emissions. Electricity is produced by six power companies that sell their output to the Korea Electric Power Corporation (KEPCO), the government monopoly. KEPCO then sells electricity to consumers (including businesses). Electricity prices to consumers are differentiated between sectors based on political considerations rather than by the cost of supply. Consequently, below-cost prices apply to some sectors, notably industry, farmers, educational institutions, and street lighting. Above-cost prices are paid by households and "general users" (all others).

Electricity prices are approved by the government, specifically the Ministry of Economy and Finance (MOEF) and MOTIE, which are responsible respectively for the stability of the prices of 'sensitive goods and services' and industry's international competitiveness. Since the government regulates electricity prices, the President bears the political responsibility in case these prices are raised, with a possible inflationary repercussion. As a result, electricity prices are kept rigid, insensitive to changes in demand or even in costs, and underpriced, despite occasional adjustments. There is no clear policy on when and how to adjust electricity prices,[22] which had been frozen by the Moon government until April 2022, its last month in office when a small increase was announced for the second quarter of the year, which included two months of the Yoon government. In addition to encouraging waste and carbon emissions, the distorted and suppressed prices keep KEPCO in chronic deficit. KEPCO reported a record deficit of 5.9TW in 2021 and it added a record deficit of 7.8TW in the first quarter of 2022.

During the presidential campaign, Mr. Yoon stated that he opposed those proposed price increases. But in June 2022, the Yoon government announced increases in electricity prices for the 3rd quarter, which for low-voltage residential homes would amount to an average increase of 3.2%. There is a need to develop a new paradigm on energy pricing, especially electricity, by letting the market rather than politicians, determine the price. A fundamental reform of electricity pricing is very long overdue. Bringing it under an independent commission is an often-discussed, but never seriously taken, option.

Solving the problem of disposal of nuclear waste

In December 2021, Ban Ki-moon, the former UN Secretary-General, and "200 Science-Technology Seniors" issued a statement addressed to the presidential candidates: "Planning for carbon neutrality based on nuclear energy phase-out will impose a heavy burden on the future generation. We should let the future generation stay with nuclear energy technology and industry, while promoting simultaneous development of renewable energy and safe utilization of nuclear energy." Indeed, safe utilization is the key to the durability of nuclear energy as a key to achieving carbon neutrality. Most intractable in this regard has been the problem of safely disposing of spent nuclear fuels from the 24 reactors currently in operation.

In searching for a permanent storage facility for spent nuclear fuels, the government developed a "Basic Plan for Management of High-level Radioactive Waste Materials" in 2016, which proposed a 12-year process for selecting disposal sites. The government has so far identified nine candidate sites but has failed to win the support of the local communities. Meanwhile, the spent fuels are being held at temporary facilities in the plants where they are produced, but those facilities are filling up rapidly. At the end of 2021, nuclear power plants in Korea held a total of 507,748 bundles of spent nuclear fuels in their temporary storage facilities, amounting to 98.1 percent of the total combined capacity. The government has yet to build 'interim' storage facilities, not to mention 'permanent' storage facilities.[23] The sites for these facilities need to be identified quickly so that they can be constructed in time. The Moon government left this problem untouched.[24] If the European green taxonomy is any indication, finding the solution to the

disposal of waste nuclear fuel will also be a key condition for inclusion of nuclear energy in the K-Taxonomy, thereby promoting green finance. The Yoon government will have to address this problem soon.

VI. Conclusion: What Lies Ahead?

President Moon's 2050 Carbon Neutrality and Green Growth Commission unsettled the Korean business community and most energy experts in October 2021 with its 2050 Carbon Neutrality Scenarios and the proposal to raise Korea's NDC target of carbon emissions in 2030 by 40 relative to 2018. The revision of Moon's decarbonization plans by President Yoon, his successor from the opposition conservative party, is probably an inevitable outcome of the fact that those plans lacked public support. President Yoon has pledged to honor the goal of carbon neutrality by 2050, as well as the 2030 NDC target. However, he will abandon his predecessor's denuclearization policy and realize carbon neutrality by harmonizing renewable energy with nuclear electricity. This new approach will be based on public support he proposes to build for his nuclear energy policy based on science and technology as well as information. Cooperation with the U.S. will play an important strategic role in his nuclear energy policy. Implementing his pledges will be the mission of the new 2050 Carbon Neutrality and Green Growth Commission that will be launched soon. Its work will begin with preparation of the National Strategy for Implementation of Carbon Neutrality and Green Growth, accompanied by new scenarios for carbon neutrality and a new plan to achieve the 2030 NDC. The integrity of all this work depends on an open, participatory and science-based process of public discussions, which is the key to the political sustainability of the decarbonization plans. The Commission will have to cope with many challenges, including strong pushback from the environmental community. The primary responsibility of the Commission is to ensure the integrity of the process.

On July 5, the government adopted "The New Government's Energy Policy Direction," which follows the content discussed above. It promises to translate it into concrete policies in the form of the National Basic Plan for Carbon Neutrality and Green Growth by March 2023 and other related legal plans. The Korean Federation of Environmental Movement immediately attacked the new government's plans, issuing a statement titled "Headlong Dash for Nuclear Electricity Can't Prevent Climate Crisis". This negative reaction from the environmental community indicates that it will not be easy for President Yoon to build a national consensus in support of his 'new energy policy'.

Author Identification

Soogill Young is the Honorary Chairman of SDSN Korea and the former Chairman of the Presidential Committee on Green Growth, Korea.

The author expresses his deep gratitude to Dr. Randall Jones, Non-Resident Distinguished Fellow at KEI, and Mr. Troy Stangarone, Senior Director and Fellow at KEI, for their thoughtful comments.

[1] Subsequently, the government submitted "Korea's Long-term Low Emissions Development Strategy" ('LEDS'), the English-language document based on the 2050 Carbon Neutrality Strategy, to the UNFCCC Secretariat, committing Korea to 2050 carbon neutrality.

[2] Korea's "Act for Promotion of Development, Utilization and Diffusion of New Energy and Renewable Energy" defines 'new and renewable energy' as follows:

- New energy: fuel cell, hydrogen, low-carbon coal gas and coal liquid.
- Renewable energy: solar light, solar heat, bio energy, wind, hydraulic and ocean power, and geothermal heat.

[3] In November, 2009, President Lee Myung-bak declared the adoption of GHG emissions reduction of 30 percent relative to the projected business-as-usual (BAU) emissions in 2020 as "Korea's voluntary commitment". In June, 2015, President Park Geun-hye declared the adoption of GHG emissions reduction of 37 percent relative to the projected BAU emissions in 2030, including the overseas reduction of 11.3 percent. This represented a considerable weakening of the emissions reduction commitment compared to that of President Lee.

[4] "2050 Carbon Neutrality Strategy of Korea," Government of Korea, 2020.

[5] "The Carbon Neutral Republic of Korea," Korea Environment Institute, 2021; "The Carbon Neutrality Strategy of the Steel Industry," International Energy Agency, 2020.

[6] From various sources including Korea Enterprises Federation (KEF) Permanent Vice-Chairman, Lee Dong-keun's opening speech at "The Forum on Korea's Carbon Neutrality Policies and the Appropriate Direction for Industrial Transition" held in Seoul on October 22, 2021 and organized by KEF.

[7] "The Steel Industry Will Lead Carbon Neutrality," *Dailyan*, June 11, 2021.

[8] "Press Release on the New NDC Target," Korean Federation for Environmental Movement, October 8, 2021.

[9] Climate Crisis Emergency Action Group, KBS News, 2011.

[10] "The Carbon Neutrality Scenarios, the Business-killer Science Fiction, Was the Work of Just One Sentence Spoken by President Moon Jai-in, A Layman!," *Chosun Ilbo Daily*, October 9, 2021.

[11] "Carbon-Neutral Korea 2050," Korea Environment Institute, 2021. The rest of this paragraph and the next draws on the same source.

[12] "An Interview with Seung-jik Yoo," *Chosun Ilbo Daily*, October 18, 2021.

[13] "The Transition Committee, 'Denuclearization will raise electricity prices'," *Maikyung Business Daily*, April 13, 2022.

[14] This was first proposed by Masayoshi Sohn, chairman of SoftBank (Japan), in 2011 under the name, "Asia Super Grid," which would connect Korea, China and Japan through power transmission lines. The main obstacle is the complicated geopolitical situation in the region surrounding the Korean peninsula.

[15] 7 On December 9, 2016, the National Assembly passed the bill to impeach President Park Geun-hye following nationwide candlelight mass demonstrations demanding her removal. On December 18, Mr. Moon Jae-in, former head of the opposition party, watched "Pandora," a nuclear reactor disaster movie, accompanied by Park Chung-woo, its director. Afterwards, Mr. Moon, shedding tears, said, "We should stop building nuclear reactors and go the way of denuclearization… We should not merely keep Pandora's box closed. We should remove the box... Cases of the failure of the Blue House to serve as an effective control tower in the face of a big disaster are familiar to us from the Park Geun-hye government. We can read the demand for the government's accountability for people's safety in people's candle-light protests," ("Moon Jae-in after Watching 'Pandora' says 'Korea Should Be Free of Nuclear Power'," *Yonhap News*, December 18, 2016). At the root of people's anger with President Park was the sinking of the Sewolho Ferry on April 16, 2014, off the Yellow Sea coast, which resulted in the drowning of 304 passengers, mainly high-school students on a springtime excursion to Jeju Island, who had been told to stay in their cabins. The government failed to launch any meaningful rescue operation for several hours after the ferry began to sink in broad daylight while President Park in the Blue House was not informed of the incident. President Park was impeached and fired by the Constitutional Court on March 10, 2017. Moon Jae-in won the consequent election and was inaugurated as President on May 10, 2017.

[16] Seven senior officials including the then-Minister of MOTIE (Ministry of Trade, Industry and Energy) are currently on trial on charges of "destruction of evidence" for this case which has developed into a serious political issue that possibly implicates not just the Minister of MOTIE but also President Moon himself. Two working-level officials are currently in jail. Criminal investigation of the case by the Prosecutor's Office is expected to be expedited under the new government.

[17] Environment Corporation homepage, https://www.keco.or.kr.

[18] "Electricity prices and gas pries will be raised 3.2% and 7%, respectively, next month", *The Joonang-Ilbo Daily*, June 28, 2022.

[19] *Ibid*.

[20] "President Yoon Seok-yul's Pledges - Nuclear Energy Policies: De-denuclearization, Carbon Neutrality, Korea-U.S. Nuclear Alliance, and the SMR," *The Issue Focus* March 14, 2022, https://issuefocus.co.kr/247

[21] "Reset Korea: Policy Agenda for the Next Government – Policies for GHG Emissions Reduction," *Joong-Ang Ilbo Daily*, November 24, 2021.

[22] Korea Energy Economics Institute, 2021.

[23] "There really is no room left for more spent nuclear fuels in the storage facilities," *Science Dong-Ah*, May 21, 2022.

[24] "The denuclearization government has missed the golden opportunity to address the nuclear waste disposal site problem, passing it over to the next government untouched," *Joong-Ang Daily*, February 12, 2022.