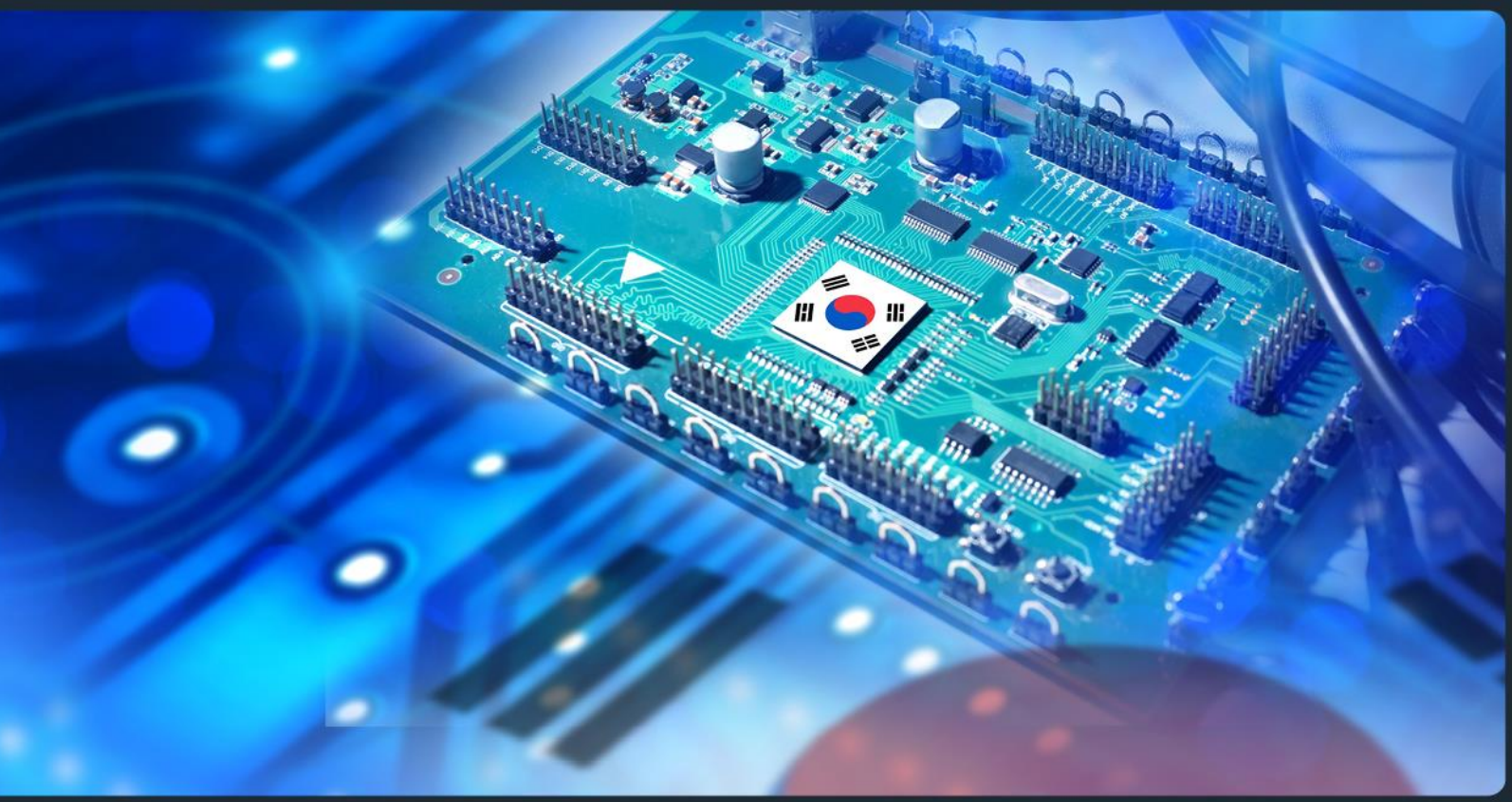
August 2024

Institute for Energy Economics and Financial Analysis

South Korea's Economy Risks Missing Out on Global Transition to Renewables

Boosting renewables would benefit key economic sectors like the booming semiconductor and AI industries

Michelle (Chaewon) Kim, Energy Finance Specialist, South Korea



Contents

Figures and Tables

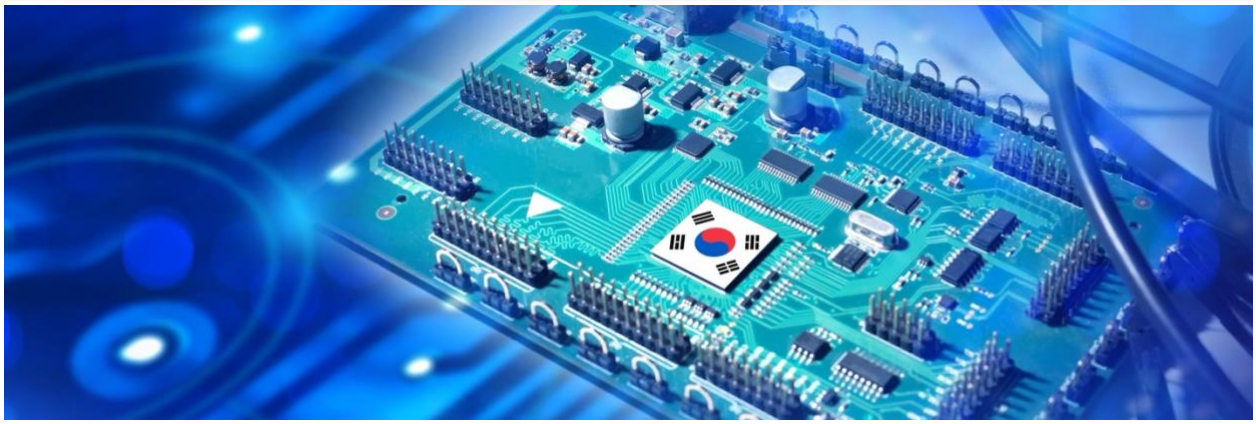
Key Findings

Renewable energy is emerging as the frontline for national competitiveness, encompassing factors like geopolitical influence, national security, industrial leadership, access to financing, and public well-being. Despite a pledge to achieve net-zero by 2050, South Korea's renewable energy made up a mere 9.64% of the country's power generation mix in 2023, lagging far behind world averages.

Despite aiming to reduce reliance on LNG, South Korea's 11th Basic Plan for Long-Term Electricity Supply and Demand (BPLE) still prioritizes fossil fuels and speculative Small Modular Reactors (SMRs), to meet the growing power demand from semiconductor clusters and Artificial Intelligence (AI) data centers. This could be a high-cost, high-risk, and high-carbon strategy.

Using LNG-fired electricity to power semiconductor clusters and AI data centers could expose South Korea to substantial industry-trade and finance-capital risks amid strengthening decarbonization trends, such as the RE100 initiative, Carbon Border Adjustment Mechanism (CBAM), and Scope 1, 2, and 3 regulations.

By tripling its renewable energy, as pledged at the 2023 United Nations Climate Change Conference (COP28), South Korea can meet the growing electricity demand from emerging semiconductor clusters and AI-driven data centers and remain globally competitive.



Executive Summary

Despite a pledge to achieve net-zero by 2050, South Korea's renewable energy made up a mere 9.64% of the country's power generation mix in 2023, lagging far behind the averages of the world (30.25%), the Organization for Economic Cooperation and Development (OECD) (33.49%), and even Asia (26.73%). The status of renewable power in South Korea contrasts with the global trend where renewable energy generated a record 30% of the world's electricity in 2023, driven by a strong growth in solar and wind.[1]

South Korea's excessive reliance on fossil fuels creates vulnerabilities beyond environmental damage. Renewable energy is emerging as the frontline for global competitiveness, encompassing factors like geopolitical influence, national security, industrial leadership, access to financing, and public well-being.

The race to develop and deploy renewable energy sources is the defining energy challenge of this century. It mirrors the historical dominance of fossil fuels such as coal in the Industrial Revolution of the 18th-19th century and oil in the World Wars and Middle East conflicts of the 20th century. In 2024, global investment in clean energy will be double that of fossil fuels.[2]

This fear of missing out on the financial advantages resulting from the benefits of renewables is driving countries and regions like the U.S. and E.U. to invest heavily in domestic renewable energy development through supportive policies, such as the Inflation Reduction Act (IRA) and the Net-Zero Industry Act (NZIA).

This report explores the potential risks that South Korean industries, particularly the semiconductor sector, could face as a result of missing out on global efforts to deploy renewable energy and address climate change.

Semiconductors play a vital role in the national economy, accounting for over 20%[3] of South Korea's total exports. Global semiconductor buyers are increasingly concerned about their supply chain's carbon intensity, and are seeking out manufacturers who actively reduce their carbon footprint.

South Korean companies will, therefore, be highly exposed to global decarbonization trends in key semiconductor markets. In addition to the increased risk, this report investigates whether tripling South Korea's renewable energy, as pledged at the 2023 United Nations Climate Change Conference (COP28), can meet the growing electricity demand from the emerging semiconductor clusters and artificial intelligence (AI)-driven data centers.

[1] Ember. Global Electricity Review 2024. May 2024.
[2] International Energy Agency (IEA). Investment in clean energy this year is set to be twice the amount going to fossil fuels. 06 June 2024.
[3] Korea Institute for International Economic Policy. Analyzing South Korea's Semiconductor Industry: Trade Dynamics and Global Position. 19 March 2024. Page 02.

SK Hynix, a major chipmaker, plans to procure electricity for new foundry facilities in the Yongin semiconductor cluster from 2027, from energy affiliate, SK E&S, via liquefied natural gas (LNG)-fired combined heat and power (CHP), which is a high-risk strategy.

The chipmaker is a member of RE100, a global initiative of over 400 companies aiming to meet 100% of their electricity demand with renewable sources by 2050. Despite the company's renewable energy goal, its current 30% achievement falls short of the global average (50%). Procuring electricity from an LNG fuelled power plant, with an asset life of 25 years or more, could jeopardize SK Hynix's RE100 target and market competitiveness, especially when U.S. customers are prioritizing manufacturers who use renewable energy.

U.S. fabless companies that outsource the manufacture of their semiconductor designs to third parties are potential clients for SK Hynix and could choose suppliers using renewable energy. Given the highest share of RE100 membership is in the U.S., SK Hynix and other chipmakers with a high carbon footprint could potentially lose market share if buyers avoid doing business due to environmental preferences.

The situation is complicated beyond the U.S as well. The E.U.'s Carbon Border Adjustment Mechanism (CBAM) could tax imports based on embedded carbon emissions. Although currently exempt, the energy-intensive nature of semiconductor production raises the potential for future inclusion. Europe's CBAM initiative, coupled with South Korea's carbon tax on LNG, could hurt the competitiveness of South Korean semiconductor technologies if manufacturers do not adopt cleaner supply chain practices.

Financial risks to the South Korean semiconductor industry are also increasing. Upcoming International Financial Reporting Standards Sustainability Standards (IFRS S2)[4], requiring companies to disclose climate-related risks and opportunities, will include the disclosure of Scope 1, 2, and 3 greenhouse gas (GHG) emissions. High GHG emissions could limit access to or increase the cost of financing and capital for South Korean chipmakers. Additionally, both downstream customers and upstream suppliers may hesitate to conduct business due to stricter reporting requirements related to Scope 3 GHG emissions.

South Korea's semiconductor industry stands at a crossroads. Embracing renewable energy is critical to safeguard its economic competitiveness and secure future suppliers and customers within the upstream and downstream supply chains.

This report finds that tripling renewable energy by 2030 could fully meet the increased electricity demand from emerging semiconductor clusters and AI-driven data centers.

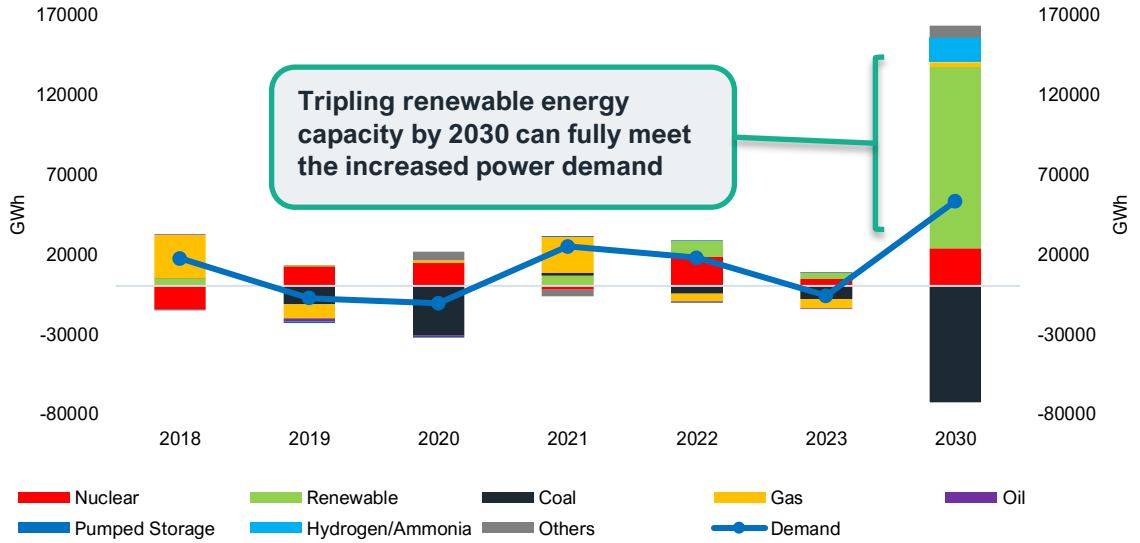
Despite aiming to reduce reliance on LNG, South Korea's 11th Basic Plan for Long-Term Electricity Supply and Demand (BPLE) guideline still prioritizes fossil fuels, coupled with nuclear generation

[4] IFRS. IFRS S2 Climate-related Disclosures.

from speculative Small Modular Reactors (SMRs), to meet the growing power demand from semiconductor clusters and AI data centers. This could prove to be a high-cost, high-risk, and high-carbon strategy.

This report finds that renewable sources — which include wind, solar, conventional hydropower[5], and other sources[6] — could meet the additional electricity needs of the AI and semiconductor sectors. Tripling renewable energy capacity by 2030 can generate 113,434 gigawatt hours (GWh) of net increment of renewable power compared to 2023, exceeding the projected power demand increase of 53,168GWh.[7] Ultimately, a portfolio of renewable generation and storage technologies tailored to the demand of key growth industries will be critical for achieving carbon neutrality by 2050.

Figure 1: Tripling Renewable Energy Capacity to Meet AI and Semiconductor Power Demand



Note: Renewable energy generation in 2030 was estimated based on the COP28 pledge, which aims to triple capacity by 2030 compared to 2023 levels, as well as average operation rates of renewable power plants in 2023. Other estimated power generation data in 2030 is from the 11th BPLE, KEPCO, and KEEI. All power generation data from nuclear, coal, gas, oil, and pumped storage is from the real output from 2013 to 2023 from KEPCO and KEEI. The demand in 2030 was based on the total power generation estimated in the 11th BPLE implementation guideline. The data for renewable energy includes conventional hydropower but excludes pumped storage.
Source: IEEFA calculations; MOTIE; KEPCO; KEEI.

[5] This does not include pumped storage and small hydro in South Korea.
[6] Renewable energy sources in South Korea also include fuel cells, Integrated Gasification Combined Cycle (IGCC), and waste-to-energy under the Renewable Energy Act of Korea.
[7] Net electricity demand increment in 2030 compared to 2023, based on MOTIE's 11th Basic Plan for Long-Term Electricity Supply and Demand (BPLE) implementation guideline. Note: The COP28 pledge to triple renewable energy does not specify a baseline year but does include a target to achieve at least 11,000 GW by 2030. This report uses 2023 as a baseline, in accordance with: International Renewable Energy Agency (IRENA). Tracking COP28 outcomes: Tripling renewable power capacity by 2030. 19 March 2024. Page 8.

An excess of 55,706GWh in gas-fired power would be created by 2030 if new LNG-fired power plants requested by various industrial sectors, including semiconductor clusters, are built. South Korea needs to phase out gas-fired power by 2035 to meet its climate targets.[8] Building more LNG plants contradict the country's net-zero goal and increases the risk of stranded assets.

These findings demonstrate that the increased electricity demand from semiconductor clusters and AI data centers does not justify expanding new fossil fuel-based power generation in South Korea.

Accelerating renewable electricity deployment is critical for South Korea's future. It safeguards economic competitiveness and ensures long-term sustainability for the vital semiconductor and AI sectors, while promoting geopolitical influence, national security, and public well-being.

IEEFA suggests the following recommendations for South Korea to secure its place as a leader in industry and environmental sustainability through a comprehensive and unified policy approach.

Key Recommendations

- Reduce reliance on fossil fuels in the power mix and expedite the transition to clean energy sources.
- Meet the COP28 pledge of tripling renewable energy by 2030 instead of continuing fossil-fuel based power generation to meet the growing electricity demand from semiconductor clusters and AI data centers.
- Implement stronger policy measures to accelerate renewable power deployment with a cohesive and holistic policy framework rather than fragmented and overlapping policies.
- Accelerate the renewable energy transition to safeguard geopolitical influence, national security, industrial leadership, access to financing, and public well-being.

Introduction

South Korea's renewable energy deployment has remained stagnant despite tripling its capacity pledges at COP28.[9] As of 2023, less than 10%[10] of the country's electricity generation comes from renewable sources. Overall, renewable energy accounted for less than 6% of South Korea's total energy supply in 2022.[11]

[8] Climate Analytics. Clean Power in South Korea. March 2023. Page 05.
[9] IEA. Tripling renewable power capacity by 2030 is vital to keep the 1.5°C goal within reach. 21 July 2023.
[10] KEPCO. Monthly Power Statistics Report. 10 May 2024.
[11] Korea Energy Agency. Distribution statistics production.

South Korea's historical reliance on fossil fuels to provide energy security has hampered its renewable energy deployment. The belief that fossil fuels guarantee stable and affordable energy has stunted the development of renewables, which are perceived as expensive and unreliable.

This view has been challenged by the Russia-Ukraine war in early 2022 which disrupted global gas markets and caused a surge in fossil fuel prices, particularly LNG. This resulted in higher import costs and increased energy bills for South Korea, questioning the perception of fossil fuels as a stable and affordable energy source.[12]

Moreover, the growing international push for decarbonization through initiatives like RE100[13], CBAM[14], and Scope 1, 2, and 3 regulations, raises concerns that South Korea's lagging renewable energy deployment could have significant financial consequences. Additionally, with grid parity for renewables expected by 2027[15], South Korea risks missing out on potential cost reductions by delaying its transition, which may make its exports less competitive.

The global energy sector is undergoing a significant transformation, with renewable energy poised to play an increasingly prominent role. In addition, the renewable energy sector will likely become the battleground for geopolitics, energy security and hegemony, industrial and technological leadership, and capital access. Globally, electricity generation from wind and solar is expected to surpass coal-fired power by early 2025.[16] In 2024, global investment in clean technologies will be twice that of fossil fuels. Investment in solar power alone now exceeds all other generation technologies combined.[17]

Despite these trends, several major South Korean companies recently requested approvals for new LNG-fired power plants. These companies claim that increasing electricity demand from data centers, semiconductor clusters, and other industrial complexes necessitates additional LNG plants. Companies like SK E&S, Hanwha Energy, POSCO International, GS E&R, and Hanyang plan to build a combined capacity of around 4,700 megawatts (MW) of new LNG-fired plants for captive use.

The 11th BPLE implementation guideline also prioritizes nuclear power from SMRs and LNG-fired CHP plants to meet the rising electricity demand rather than renewable sources.

IEEFA believes South Korea's continued reliance on fossil fuels and delayed development of renewables could aggravate missed opportunities for its economy, industry, and population. The country would benefit from increased renewable energy integration and avoid becoming uncompetitive in the global geopolitical and industrial landscape.

[12] IEEFA. South Korea's Power Trilemma. 21 March 2024.
[13] RE100. About Us.
[14] European Commission (EC). Carbon Border Adjustment Mechanism.
[15] KOSIF. Renewable Energy Demand in South Korea: A 2030 Forecast and Policy Recommendations. March 2023. Page 11.
[16] New York Times. The Clean Energy Future Is Arriving Faster Than You Think. 18 August 2023.
[17] International Energy Agency (IEA). Investment in clean energy this year is set to be twice the amount going to fossil fuels. 06 June 2024.

The following sections examine the factors hindering renewable energy development, the challenges posed by continued reliance on fossil fuels, and the potential economic and industrial disadvantages of falling behind in the global transition to clean energy.

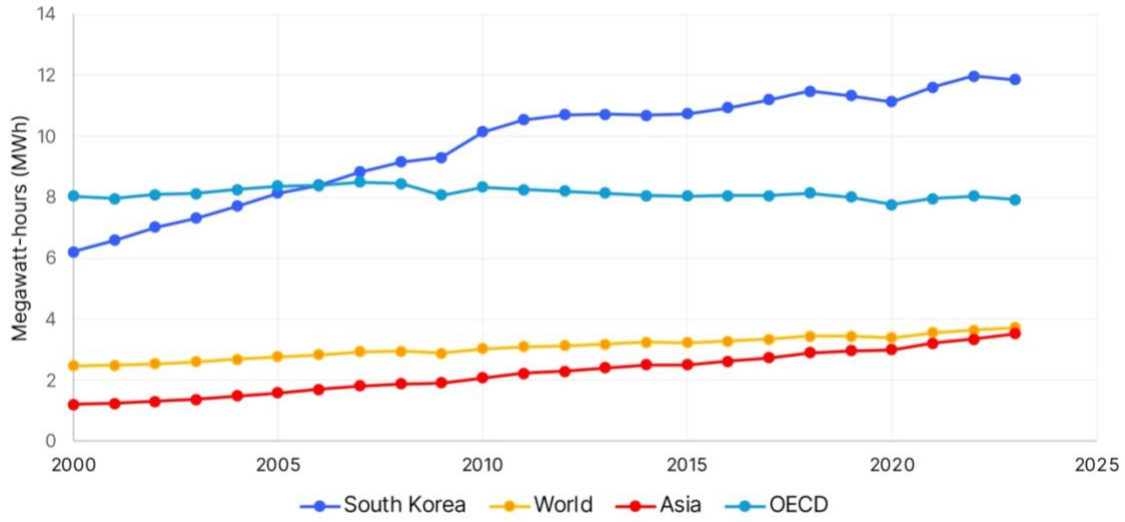
Lagging Renewable Energy Deployment

The South Korean economy has grown rapidly since the Korean War in the 1950s because of swift industrialization and technological innovation. In 2024, South Korea has the 14th largest Gross Domestic Product (GDP) in the world and is ranked among the top 20 in GDP per capita.[18] Within Asia, South Korea is the fourth-largest economy based on GDP and the fifth-largest based on GDP per capita.[19]

However, South Korea's remarkable economic growth and industrial development have come at a cost. The country has seen a sharp rise in CO_2 emissions, ranking as Asia's fourth-largest emitter based on total emissions and per capita emissions in 2021.[20]

The country relies heavily on a high-carbon, fossil fuel-backed industrial sector, coupled with high energy consumption driven by relatively low electricity prices.[21] South Korea's electricity demand per capita in 2023 was 11.85 megawatt hours (MWh), more than triple the world (3.73MWh) and Asia (3.52MWh) averages, and 50% higher than the OECD average (7.92MWh) (Figure 2).

Figure 2: South Korea's Electricity Demand Per Capita in 2000-2023 (MWh)



Source: Ember.

In 2021, as an advanced Asian economy and member of the Group of 20 (G20) and OECD, South Korea became the 14th country to pledge to achieve carbon neutrality by 2050 in its Nationally Determined Contributions (NDCs).

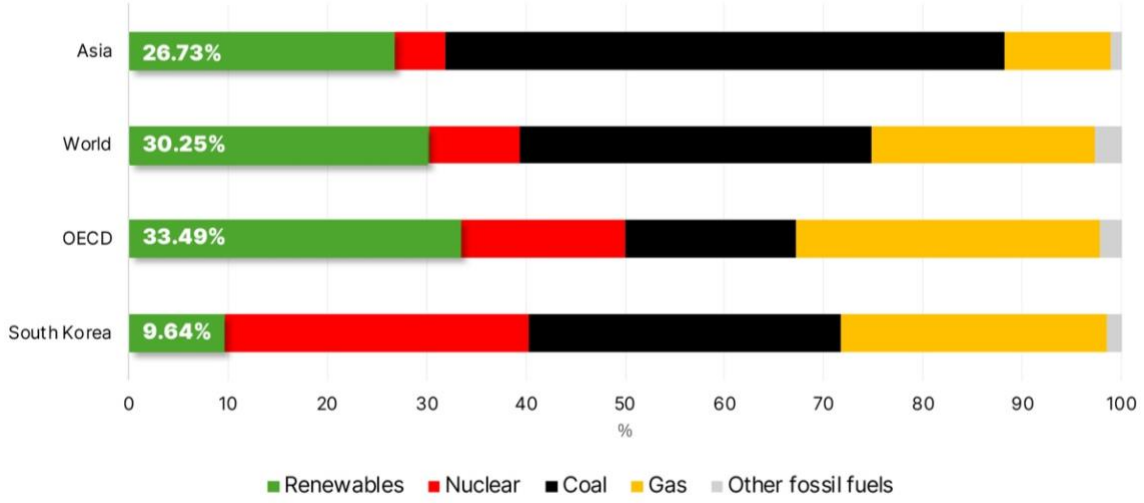
[18] International Monetary Fund (IMF). GDP per capita, current prices.
[19] International Monetary Fund (IMF). GDP per capita, current prices.
[20] International Energy Agency (IEA). Korea – Emissions.
[21] IEEFA. South Korea's Power Trilemma. 21 March 2024. Page 22.

By 2030, the country aims to reduce GHG emissions by 40% and plans to halve methane emissions.[22] Furthermore, South Korea joined the international effort at COP28, pledging to triple renewable energy capacity and double energy efficiency by 2030.[23]

Despite ambitious decarbonization targets, South Korea's renewable energy deployments have lagged significantly.

South Korea's renewable electricity — which includes wind, solar, conventional hydropower[24], and other sources[25] — accounted for a mere 9.64% of the power generation mix in 2023, falling far short of the world (30.25%) and Asia (26.73%) averages (Figure 3). Meanwhile, the share of wind and solar generation was just 5.3% in 2023.[26]

Figure 3: South Korea's Renewable Electricity in Power Mix, 2023 (%)

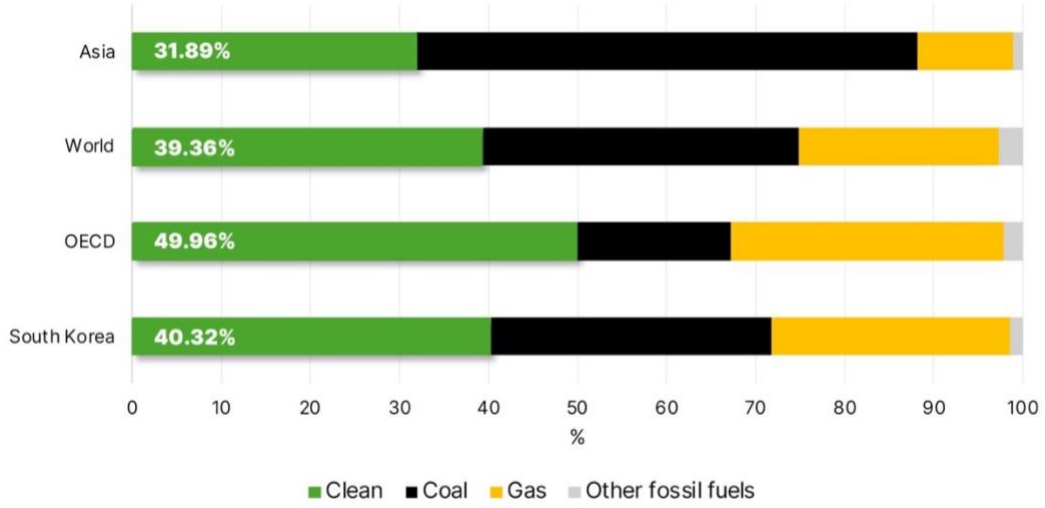


Note: Data for South Korea's renewables include conventional hydropower but excludes pumped storage and is based on KEPCO's data.
Source: IEEFA; KEPCO; Ember.

Even with the inclusion of nuclear power generation, South Korea's share of clean electricity (40.32%) falls short of the OECD average (49.96%) (Figure 4).

[22] South Korean Government. 1st Carbon neutral green development roadmap. April 2023.
[23] IRENA. Tracking COP28 Outcomes, Tripling renewable power capacity by 2030. March 2024.
[24] This does not include pumped storage and small hydro in South Korea.
[25] Renewable energy sources in South Korea also include fuel cells, Integrated Gasification Combined Cycle (IGCC), and waste-to-energy under the Renewable Energy Act of Korea.
[26] Ember. Electricity Data Explorer. Accessed: 09 July 2024.

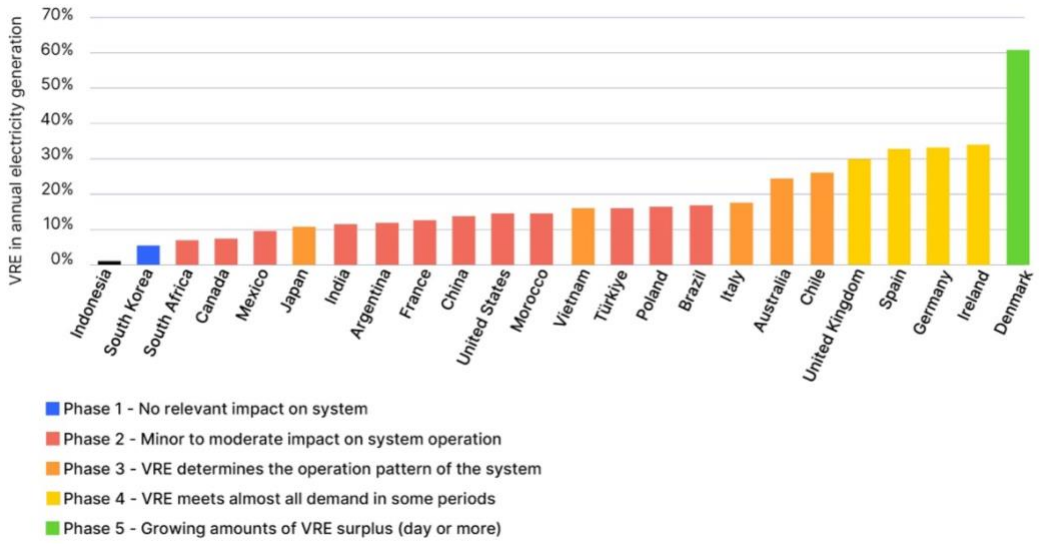
Figure 4: South Korea's Clean Electricity in Power Mix, 2023 (%)



Note: Clean energy includes wind, solar, conventional hydropower, bioenergy, nuclear, and other renewables. Data for South Korea's renewables include hydropower but excludes pumped storage and is based on KEPCO's data.
Source: IEEFA; KEPCO; Ember.

The International Energy Agency (IEA) classifies countries into six variable renewable energy (VRE) integration phases. Phase 1 indicates that a country is at the earliest deployment stage, with VRE technologies like wind and solar having no meaningful impact on power system operations. South Korea is at Phase 1 alongside Indonesia and lagging behind most OECD countries[27] (Figure 5).

Figure 5: IEA VRE Phase Comparison by Country

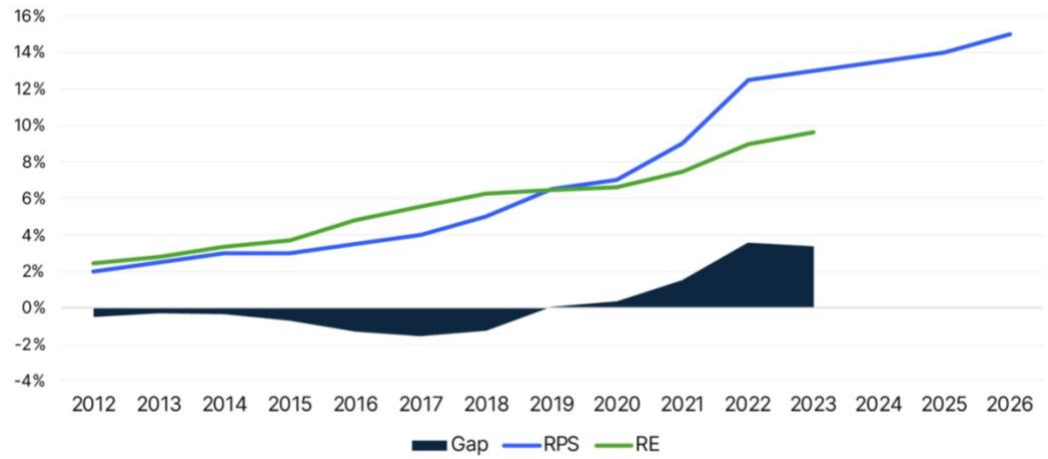


Source: IEA. Renewables 2023 – Analysis and forecast to 2028. January 2024. Page 77.

[27] IEA. Renewable Energy Progress Tracker. 04 June 2024.

Since 2019, the gap between South Korea's Renewable Portfolio Standard (RPS) — which mandates that utilities procure a specific share of electricity from renewables[28] — and actual renewable energy generation has widened. Despite this policy, the share of renewable electricity in the power mix remains far below the mandated levels (Figure 6).

Figure 6: South Korea's RPS Mandate vs Renewable Energy (RE) Power Generation (%)



Source: Korea Energy Agency; KEPCO.

South Korea's renewable energy generation status contrasts with the global trend which shows a record 30% of electricity in 2023 was produced by renewable power, driven by strong growth in solar and wind generation.[29]

The International Renewable Energy Agency's (IRENA) 1.5°C scenario[30] requires roughly 68% of global power generation to come from renewable sources by 2030.[31]

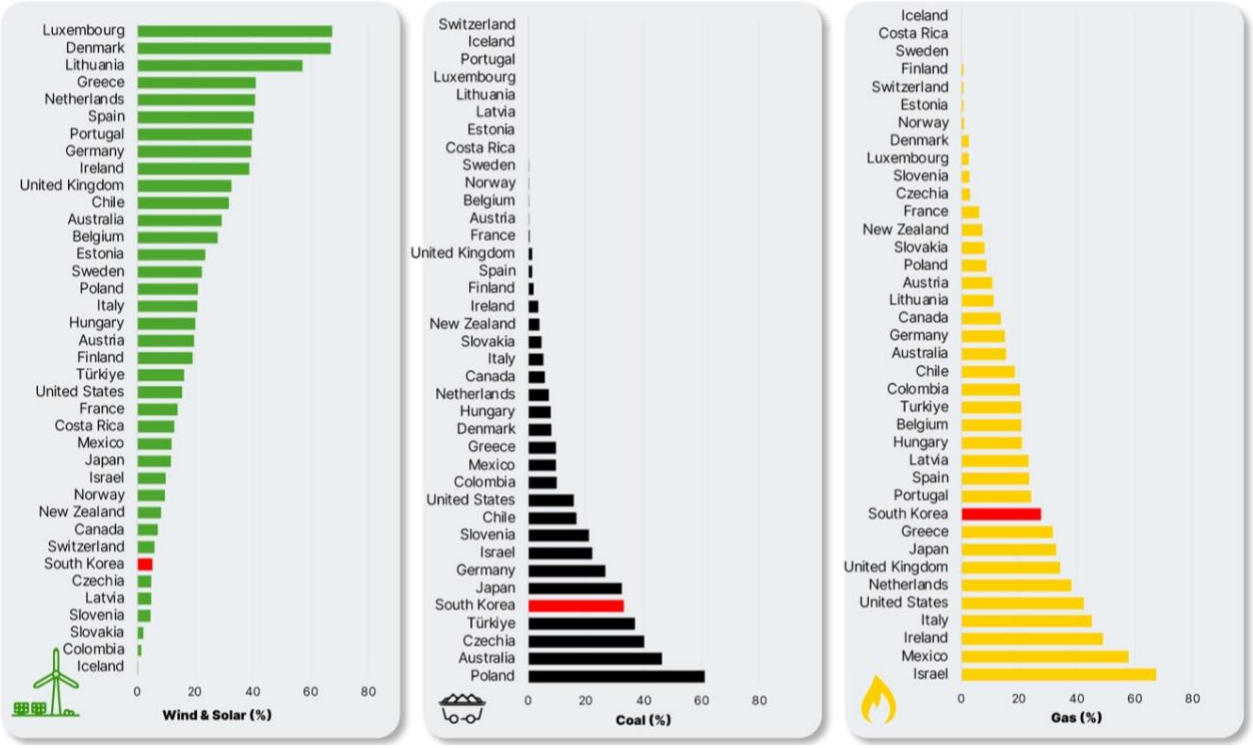
By contrast, South Korea's recently released 11th BPLE implementation guide, issued in May 2024, outlines that renewable electricity will increase to 21.6% of the power mix by 2030 and 32.9% by 2038.[32]

South Korea's wind and solar power generation is ranked 32nd out of 38 OECD members, whereas coal and gas ranked 5th and 10th respectively (Figure 7). South Korea trails other countries by at least 15 years in reaching the 30% threshold for renewable electricity generation.

[28] South Korea introduced RPS in 2012, mandating more than 500MW of scale of generators to produce specific percentages of electricity with renewables via renewable power generation or Renewable Energy Certificate (REC) purchases.
[29] Ember. Global Electricity Review 2024. May 2024.
[30] IRENA's 1.5°C scenario outlines a pathway to limit global temperature rise to 1.5 degrees Celsius above pre-industrial levels by 2050.
[31] IRENA. Tracking COP28 outcomes: Tripling renewable power capacity by 2030. March 2024. Page 08.
[32] MOTIE. 11th Basic Plan for Long-Term Electricity Supply and Demand implementation guideline. 31 May 2024.

> **South Korea trails other countries by at least 15 years in reaching the 30% threshold for renewable electricity generation.**

Figure 7: South Korea's Wind/Solar, Coal and Gas Power Rankings in OECD, 2023 (%)

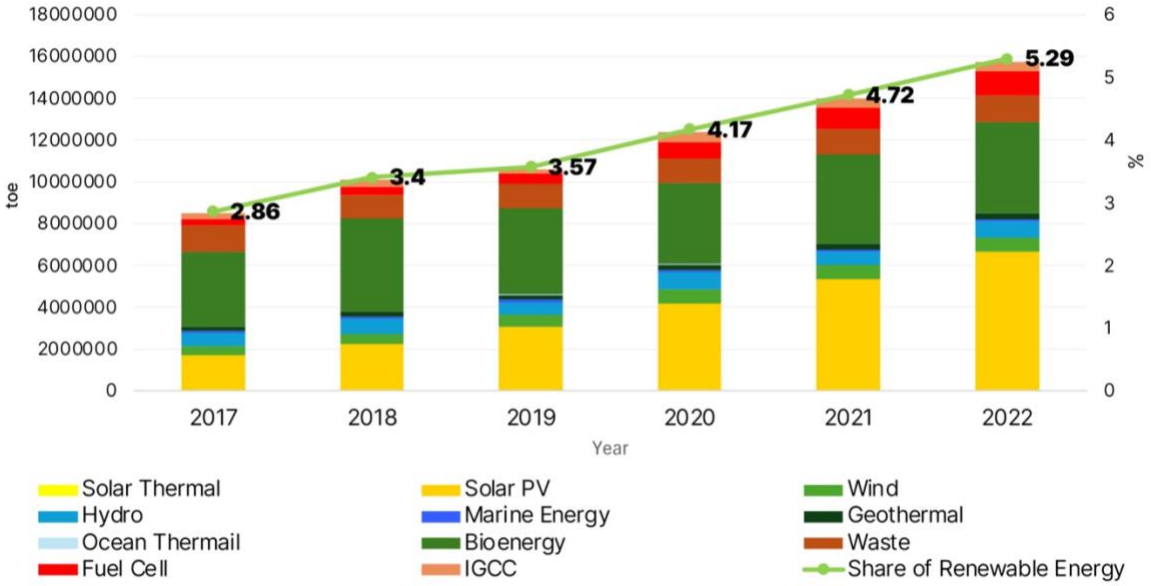


Note: Data for Iceland and Israel is from 2022.
Source: Ember.

Meanwhile, South Korea's share of renewable energy in the total energy supply in 2022 was 5.29%, far lower than renewable power (Figure 8).

Since South Korea's methodology for categorizing renewable energy technologies includes hydrogen, fuel cells, integrated gasification combined cycle (IGCC), and waste-to-energy – many of which have potential fugitive CO_2 emissions – the real proportion of zero-carbon renewables in the energy mix is likely much lower when using IEA or other international classifications.

Figure 8: South Korea's Share of Renewable Energy in Total Energy Supply (toe, %)



Note: Renewable energy sources in South Korea include fuel cells, IGCC, and waste-to-energy under the Renewable Energy Act of Korea.
Source: Korea Energy Agency.

South Korea's renewable energy deployment has lagged behind other countries because of industry and public resistance to energy transition, financing constraints, and inconsistent government policies.

Since 2021, several South Korean industry associations and companies, including the Independent Power Producers Association (IPPA) and state-owned utility, Korea Electric Power Corporation (KEPCO), have voiced skepticism about the renewable energy transition, citing technical and economic feasibility concerns.[33]

Fossil fuel subsidies further hinder South Korea's transition to renewable energy. According to International Monetary Fund (IMF) data, fossil fuel subsidies amounted to around US$162 billion (bn), or 8.1% of the GDP in 2023.[34]

A significant obstacle to deploying renewable energy is the delay in grid integration due to an inadequate transmission and distribution network. Out of 48,182MW of renewable energy connection applications submitted between 2018 and August 2023, only 62.8% have completed grid connection

[33] Influence Map. Energy Transition.
[34] IMF. IMF Fossil Fuel Subsidies Data: 2023 Update. 24 August 2023. Page 27.

and commenced commercial operation.[35] This means that approximately 17,924MW of renewables have not been permitted to connect to the grid.

South Korea's renewable energy transition faces additional hurdles at the local level due to resistance from the public. An increasing number of local governments are restricting solar and wind power installations due to conflicts with residents. These concerns include land degradation and potential environmental impacts[36] on local communities.[37]

The permit processes for renewable energy projects, particularly offshore wind farms, are also cited as a roadblock. The government has not designated sites for offshore wind development. Without a national site licensing system, developers have to identify, study, and get permits for offshore project sites themselves.

Developers must negotiate with fishermen, local government, and other stakeholders from the beginning of the project development cycle. The ability of a project to connect with the grid is also uncertain as the national transmission utility has not allotted interconnection points for offshore supply cables or provided information on how much capacity could be accepted.[38] Such complexities in the approval process significantly delay or terminate project development.

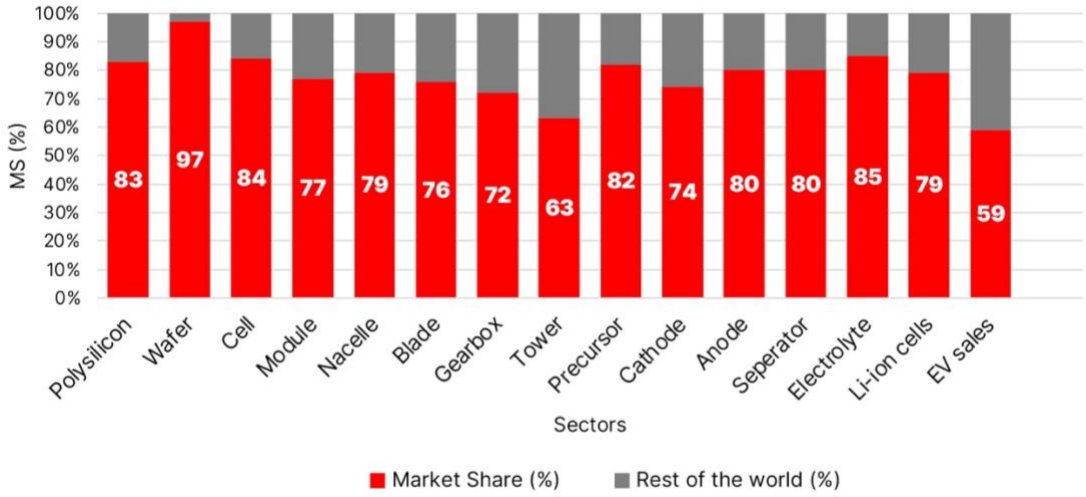
The Risks of a Delayed Renewable Energy Transition

South Korea's heavy reliance on fossil fuels and delayed renewable energy deployment creates vulnerabilities beyond environmental concerns. The ongoing war in Ukraine has underscored the geopolitical risks associated with depending on a limited number of suppliers for energy resources. Disruptions in global energy markets can lead to price volatility and supply instability, jeopardizing economic and energy security.

Recently, concerns have grown about China's dominance in the renewable energy sector. Over the past decade, China has become a global leader in renewable energy advancing rapidly in technologies, economies of scale, and cost competitiveness. This raises questions about potential supply chain vulnerabilities and price fluctuations for South Korea as it seeks to expand its renewable energy deployment[39] (Figure 9).

[35] Next Group. 2050 Climate neutrality roadmap for Korea_K-map scenario 2.0_Repowering Korea's technological leadership in favour of a clean economy. 01 April 2024. Page 09.
[36] South Korea's renewable energy push faces resistance at the local level due to public concerns about aesthetics, noise, potential health impacts, and land use changes, including disruption to scenic views and potential property value effects. While some concerns are valid, unsubstantiated health fears also play a role.
[37] Next Group. 2050 Climate neutrality roadmap for Korea_K-map scenario 2.0_Repowering Korea's technological leadership in favour of a clean economy. 01 April 2024. Page 08.
[38] IEEFA. The Asia Pacific Renewable Supply Chain Opportunity. 27 June 2024.
[39] Wood Mackenzie. Not made in China: the US$6 trillion cost of shifting the world’s cleantech manufacturing hub. 12 February 2024.

Figure 9: China's Market Shares in Cleantech Value Chains in the World (%)



Source: Wood Mackenzie.

In 2023, more than 50% of global installed solar and wind capacity was in China. The country recorded the world's highest annual capacity addition in the renewable energy sector over the last decade.[40]

Achieving competitiveness in renewable energy generation is crucial for addressing climate change and is also a critical factor in enhancing national and industrial competitiveness, gaining geopolitical influence, increasing energy security, and improving trade risk management and global capital access.

The race to develop and deploy renewable energy sources is the defining energy challenge of the 21st century. It mirrors the historical dominance of fossil fuels such as coal in the Industrial Revolution of the 18-19th century and oil in the World Wars and Middle East conflicts of the 20th century.

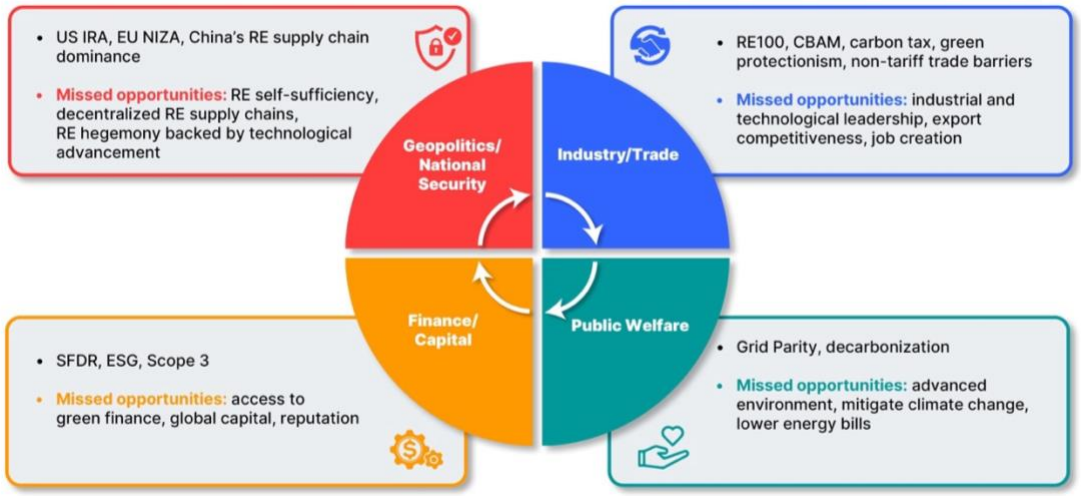
The global energy landscape is shifting. The power struggle among nations is unfolding in the renewable energy sector, with countries adopting onshoring and nearshoring strategies to secure industrial competitiveness and internalize supply chains.[41]

The rapid rise of China's renewable energy sector has sparked a fear of missing out among key players like the U.S. and Europe. These concerns include the potential loss of geopolitical influence, national security, industrial leadership, access to financing, and public well-being (Figure 10).

In response to China's dominance, the U.S. and E.U. have implemented more robust policy measures to support their renewable energy development.

[40] Ember. Global Electricity Review 2024. May 2024.
[41] Financial Times. The global industrial arms race is just what we need. 26 June 2023.

Figure 10: Missed Opportunities of a Delayed Renewable Energy (RE) Transition



Source: IEEFA.

Carbon-neutral technologies are now featured in geopolitical power struggles. In 2022, the U.S. Biden administration introduced the Inflation Reduction Act (IRA), which aimed to create a domestic renewable energy supply chain. The IRA allocated US$128bn in tax credits for investment in clean energy, including solar and battery technologies.[42]

Similarly, in 2023, the E.U. announced the Net-Zero Industry Act (NZIA) to promote critical carbon-neutral technologies and encourage industries[43] to build internal renewable energy value chains.[44]

Meanwhile, South Korea proposed the Act on Special Measures for Protecting and Enhancing the Competitiveness of the Carbon Neutral Industry, which is pending approval in the National Assembly.

South Korea has also enacted several laws since 2023, including the Special Act on the Nurturing of National Strategic Technologies, the Act on Partial Amendment to the Tax Special Limitation Act, and the National Resource Security Act.

However, these measures overlap significantly and require a unified approach. Compared to the American IRA or European NZIA, South Korea needs a similarly comprehensive policy that integrates national and energy security, industrial competitiveness, and renewable energy development holistically (Table 1).

[42] Korea Institute for Industrial Economics & Trade (KIET). Comparative Analysis of Carbon Neutral Industrial Policies. 28 September 2023. Page 64.
[43] Solar photovoltaic and solar thermal, onshore and offshore renewable, battery/storage, heat pumps and geothermal energy, electrolyzers and fuel cells, sustainable biogas/biomethane, carbon capture and storage, and grid technologies.
[44] European Commission. The Net-Zero Industry Act: Accelerating the transition to climate neutrality.

Table 1: South Korea's Renewable Energy Laws

Legislation	Description	Proposed Date	Enacted Date	Current Status
Act on Special Measures for Protecting and Enhancing the Competitiveness of the Carbon Neutral Industry (Bill No. 20675)	Provides support measures for nurturing 10 carbon-neutral industries (batteries, hydrogen, solar, wind, recycling, eco-vehicles, carbon capture and storage (CCS), carbon capture, utilization, and storage (CCUS), eco-plastics, bio). Supports measures include tax breaks, deregulation, financial aid, public projects, and human resource development.	15 March 2023	-	Under deliberation
Special Act on the Nurturing of National Strategic Technologies	Nurture 8 key strategic technologies (next-generation batteries, hydrogen, CCS, CCUS, artificial intelligence (AI), robots, next-generation semiconductors, bio (potentially including biofuels, biomaterials, etc.) critical for securing a stable supply of national resources and promoting the development of carbon-neutral industries.	-	21 March 2023	In effect
Act on Partial Amendment to the Tax Special Limitation Act	Modifies the existing Tax Special Limitation Act, likely with the aim of strengthening tax support for attracting investment in carbon-neutral industries (renewable energy such as solar, wind, etc., electric vehicles and charging infrastructure, hydrogen production and utilization, recycling and resource recovery technologies, other technologies contributing to carbon neutrality goals)	-	11 April 2023	In effect
Draft Law on Amending Petroleum and Alternative Fuels Act		11 July 2023	-	Under deliberation at House Committee on Industry, Trade, and Resources
Act on National Resource Security (Act No. 20534)	Selects and invests in 8 key strategic technologies (batteries, hydrogen, CCS, CCUS, AI, robots, semiconductors, bio) Attracts investment (KRW400 trillion by 2030) through tax breaks, deregulation. Expands R&D (over KRW12 trillion annually) and human resource development (100,000 annually).	-	01 June 2023	In effect

Source: IEEFA.

Case Studies

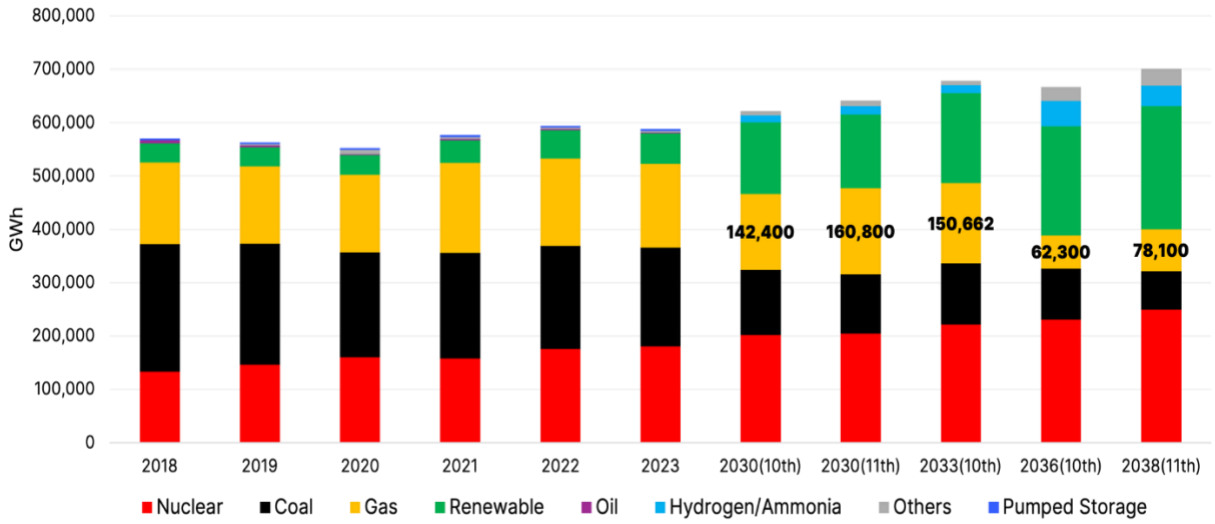
The following section presents two case studies investigating potential risks that could arise from a slow deployment of renewable energy, particularly from the perspectives of industry/trade and finance/capital. These examples aim to inform policymakers, industry decision-makers, and the public in South Korea about the urgency of transitioning to renewable energy.

Case Study 1: Financial Risks for the LNG-Powered Semiconductor Sector

In early June 2024, the South Korean government announced the implementation guidelines for the 11th BPLE. The plan prioritizes unproven SMRs and CO_2-emitting LNG-fired power plants to meet the projected increase in electricity demand by 2038. Notably, the plan does not emphasize renewable energy sources.

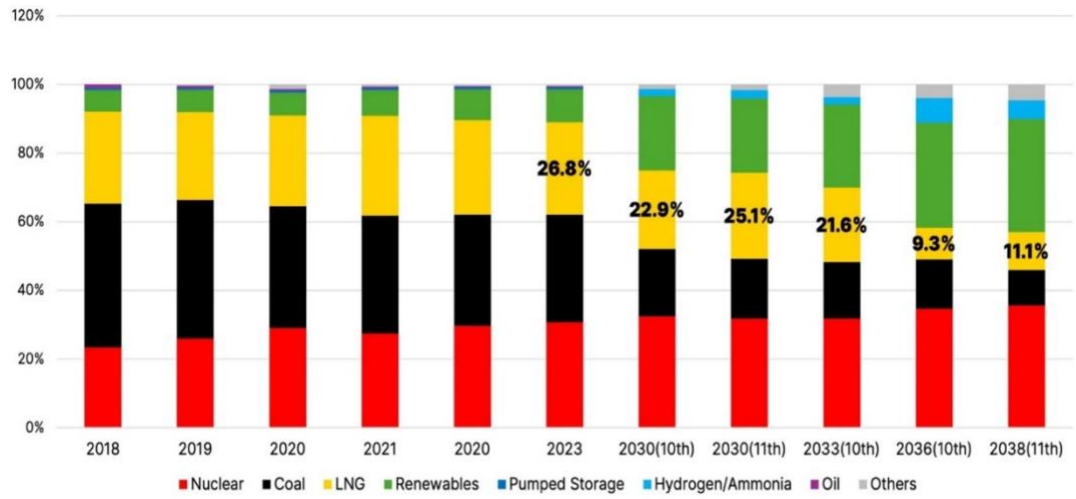
Despite aiming to reduce LNG in the power mix for 2030, the 11th BPLE increases the LNG share from 22.9% in the 10th BPLE to 25.1%. This translates to a rise in absolute LNG-fired power generation by 18,400GWh (a 13% increase), highlighting South Korea's continued heavy reliance on fossil fuels for electricity generation. The 10th BPLE planned to reduce LNG in the power mix to 9.3% by 2036, while the 11th BPLE targeted reducing it to 11.1% by 2038 (Figures 11 and 12).

Figure 11: South Korea's Annual Power Generation by Energy (GWh)



Source: MOTIE; KEPCO.

Figure 12: South Korea's Current and Projected Power Mix (%)



Source: MOTIE; KEPCO.

The government's decision coincides with rising requests for new LNG-fired power generation licenses from industry sectors, particularly those involving semiconductor clusters and AI-driven data centers.

Companies such as SK E&S, Hanwha Energy, POSCO International, GS E&R, and Hanyang plan to build a combined capacity of around 4,700MW of new LNG-fired power plants, including CHP for captive use.[45]

Table 2: South Korean Companies' LNG-fired Power Generation Plans

Company	Capacity (MW)	Purpose
***SK E&S-KOMIPO**	1200	Yongin Semiconductor Cluster
Hanwha Energy	1000	Yeosu/Gunsan Industrial Complex CHP
POSCO International	496	Gwangyang CHP
GS E&R	515	Gumi National Industrial Complex CHP
Hanyang	495	Myodo CHP
Daejeon CHP	495	CHP
****Hyundai Steel**	499	Steel Maker
Total	4700	

**SK E&S and KOMIPO plans joint LNG-fired power plant projects.*
***Hyundai Steel plans LNG-fired power plant.*
Note: CHP is combined heat and power, which is widely used in South Korea's industrial sectors.
Source: MOTIE; KEPCO.

[45] EKN. MOTIE: New LNG power plants limited to coal-to-gas switching", growing concerns from IPPs. 01 May 2024.

SK E&S had requested a 1.2 gigawatts (GW) LNG-fired CHP plant to supply electricity to its affiliate, SK Hynix, one of South Korea's largest semiconductor producers, which will participate in the Yongin semiconductor cluster.[46] The Ministry of Trade, Industry and Energy (MOTIE), however, disapproved the plan in 2024 as it would increase the share of LNG generation in the power mix and increase the burden on the national power grid.[47]

Nevertheless, SK E&S agreed to build a joint LNG-fired CHP project with Korea Midland Power (KOMIPO), a subsidiary of the state-run utility KEPCO.[48]

Using non-renewable electricity for semiconductor manufacturing could expose SK Hynix to difficulties in securing vital investments and trade disadvantages compared to competitors who prioritize renewable energy sources.

SK Hynix has been a member of the RE100 initiative since 2020, thus demonstrating its commitment to renewable energy. RE100, a global corporate renewable energy initiative led by the Climate Group in partnership with the Carbon Disclosure Project (CDP)[49], aims to accelerate the shift towards zero-carbon electricity grids. This influential business network unites companies worldwide who have pledged to transition their entire electricity consumption to renewable sources by 2050.[50]

SK Hynix aims to achieve 100% renewable electricity use by 2050 as part of its RE100 commitment. However, with only 30% realized by 2022, the company lags behind the global average of 50%, raising concerns about the pace of its progress.[51]

SK Hynix's decision to procure electricity for the Yongin semiconductor cluster from the 1.2GW LNG-fired CHP plant via SK E&S would make it difficult to achieve the RE100 renewable energy goal by 2050. SK Hynix plans to construct four fabrication facilities (fabs)[52] in the Yongin cluster by 2050, with the first one operational by 2027.[53]

This reliance on fossil fuels for such a large-scale project creates challenges for achieving their 100% renewable energy goal by 2050. RE100 downstream fabless companies that require their upstream fab companies to meet RE100 standards could cause non-compliant South Korean

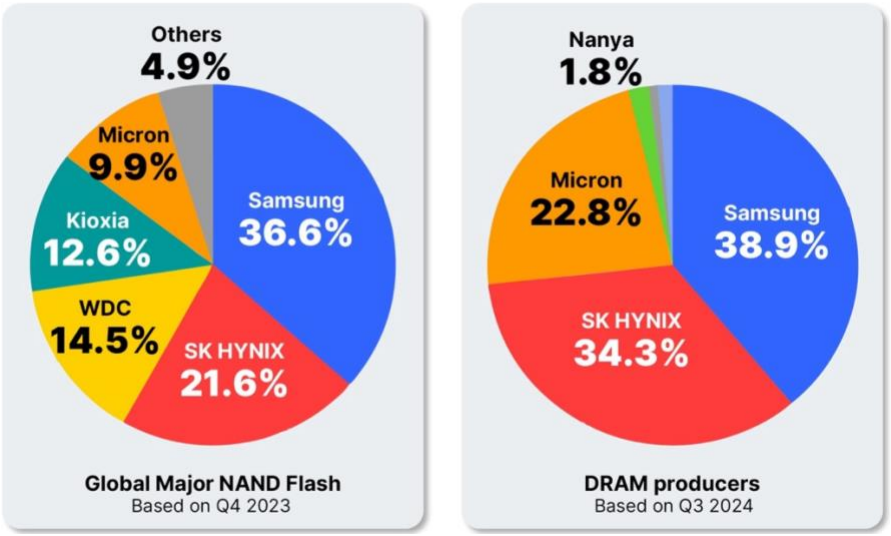
[46] The Yongin Semiconductor Cluster is expected to house the world's largest state-of-the-art semiconductor production facility and about 200 semiconductors fabless, materials, components, equipment, and companies. As a result, the new power demand is expected to exceed 10GW by 2050 when the industrial complex and corporate investment are completed. MOTIE. Yongin Semiconductor Cluster Power Supply Ready Without Disruption. 07 July 2024.
[47] Kyunghyang. LNG CHP faces shrinking ground due to government brakes, 13 May 2024.
[48] The JoongAng. SK E&S finds way to supply electricity and heat to the Yongin semiconductor cluster. 05 June 2024.
[49] The Carbon Disclosure Project (CDP). About Us.
[50] RE100. About Us.
[51] RE100. RE100 Annual Disclosure Report. 27 March 2024. Page 68.
[52] Fab is an acronym for fabrication facility, also commonly referred to as a foundry. It is a specialized factory where semiconductor devices, such as integrated circuits (ICs), are manufactured.
[53] SK Hynix. SK Hynix Sustainability Report 2023. 30 June 2024. Page 07.

foundry[54] manufacturers to lose market share.[55] Due to the prominence of U.S. fabless companies, like Qualcomm, Nvidia Corporation, and Xilinx, Inc., American policy changes significantly impact the global foundry market.

This could further weaken the competitiveness of South Korean foundry manufacturers' exports in an aggressive global semiconductor market. In 2023, SK Hynix was ranked as the second largest dynamic random-access memory (DRAM) and NAND Flash producer in the world. However, its position could change in the coming years as the importance of renewable energy rises (Figure 13).

The company aims to expand into the foundry sector by building fab facilities in the Yongin cluster. The market is currently dominated by Taiwan Semiconductor Manufacturing Company (TSMC) and Samsung Electronics.

Figure 13: Global Major NAND Flash and DRAM Producers and Market Shares (%)

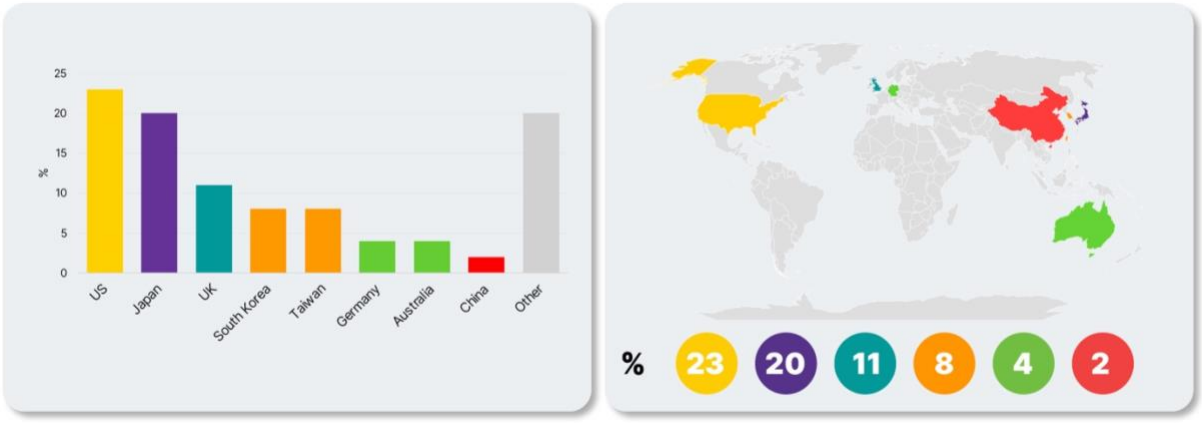


Note: Data of NAND Flash is based on Q4 2023, while DRAM data is based on Q3 2024. SK Hynix's NAND Flash market share is combined with its affiliate.
Source: Trend Force; Statista.

Semiconductors make up more than 20% of South Korea's total exports.[56] The U.S. is the fifth-largest export destination for South Korean semiconductors and is home to 428 RE100 member companies (Figure 14).[57] There would be significant consequences if U.S. fabless companies were to switch chip suppliers from South Korean firms to others.

[54] A foundry is a company that specializes in operating fabs. They own and manage the fabrication facilities and their manufacturing processes. Foundries typically do not design their own chips; instead, they offer their chip-making services to others, such as fabless companies.
[55] KDI. Impacts of the RE100 Initiative on Major Korean Export Industries. 2021. Page 44.
[56] Korea Institute for International Economic Policy. Analysis of the export/import structure and global status of the Korean semiconductor industry. 29 February 2024. Page 06.
[57] Climate Group RE100. Members.

Figure 14: RE100 Membership by Country in 2023 (%)

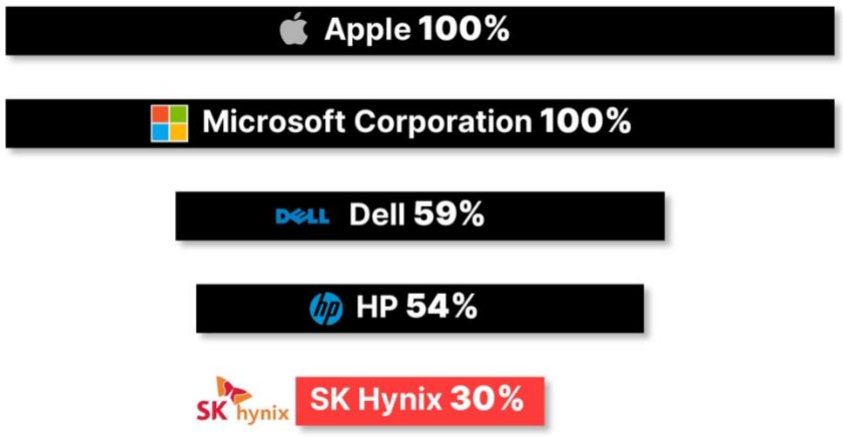


Source: Climate Group RE100.

SK Hynix's market share could face a substantial loss if U.S. customers in computers, smartphones, graphics cards, and AI-powered data centers were to prioritize suppliers with higher renewable energy adoption rates. The U.S. is a critical market for SK Hynix and lagging in this area could make the company a less attractive option for environmentally conscious customers.

Many of the company's existing and potential U.S. end-users have progressed quickly in adopting renewable electricity. SK Hynix's 30% figure also appears inflated because it includes the 100% renewable energy achieved in overseas facilities (Figure 15).[58]

Figure 15: SK Hynix's Existing & Potential Customers in the U.S. and RE100 Progress Rates (%)



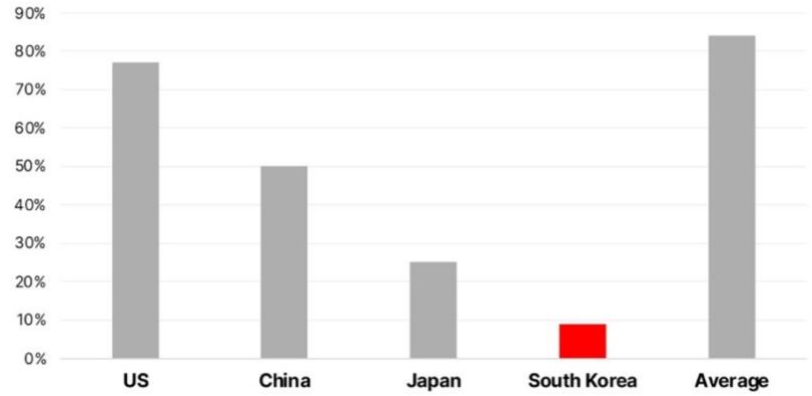
Note: Self-reported data based on 2022. SK Hynix's progress rate includes overseas facilities, which achieved 100% progress.
Source: Climate Group RE100.

[58] SK Hynix achieved 100% RE in manufacturing facilities in the U.S. and China in 2022. SK Hynix. SK Hynix Sustainability Report 2023. 30 June 2024. Page 46.

U.S. customers represent roughly 8% of South Korea's total semiconductor exports to overseas markets.[59] There would be a significant impact if those customers switched from South Korean suppliers to ones from other countries.

South Korea's semiconductor industry may decline if the European Union (E.U.), Japan, and China further strengthen their RE100 mandates. These countries are already outpacing South Korea in renewable energy adoption, and stricter regulations could lead to environmentally conscious customers reducing the market share for South Korean chipmakers (Figure 16).

Figure 16: RE100 Members’ Renewable Electricity Adoption Rates by Country (%)



Source: Climate Group RE100.

Sustainability concerns extend beyond South Korea's semiconductor industry and U.S. customers. Companies across various sectors participating in the RE100 initiative, driven by a desire to mitigate climate-related costs and risks, may increasingly require supply chain partners to adopt similar climate commitments.[60]

South Korea's economy, where exports account for roughly half of the GDP, faces significant headwinds in the global marketplace. South Korean companies could lose market share if other countries are perceived as more committed to renewable energy, potentially impacting national economic growth and job creation.

In addition, the E.U.’s upcoming CBAM and carbon taxes will add further pressure on exports. The E.U. is South Korea’s third largest export destination, accounting for around 10% of South Korea’s total exports in 2022[61], and is a significant market for semiconductors.[62]

A recent Korea International Trade Association (KITA) survey found that 16.9% of 610 South Korean manufacturing exporters reported being requested to use renewable energy from suppliers. The

[59] KIEP. South Korean Semiconductor Industry’s export/import structure and global competitiveness analysis. 29 February 2024. Page 06.
[60] IEEFA. South Korea’s Power Trilemma. 21 March 2024. Page 35.
[61] Delegation of European Union to the Republic of Korea. 2023 EU-Korea Trade and Investment Relations.
[62] Delegation of European Union to the Republic of Korea. 2023 EU-Korea Trade and Investment Relations. Page 07.

pressure is even higher for exporters to the E.U., with 28.3% of respondents indicating similar requests.[63]

The CBAM, proposed in 2021, aims to prevent "carbon leakage" by taxing imports into Europe based on embedded carbon emissions. It requires exporters of certain goods, including iron, steel, aluminum, cement, hydrogen, electricity and fertilizer, to report the embedded carbon emissions of their products to the E.U. from October 2023 to December 2025. This precedes full implementation in 2026, when importers must buy CBAM certificates to offset emissions.

While semiconductors are currently exempt from the CBAM, the energy-intensive nature of their production raises concerns for South Korea's chip industry. The E.U.'s focus on consistency across sectors with high embedded carbon emissions suggests that semiconductors could be included in the CBAM's scope soon.

The cost of the CBAM certificate will be calculated by multiplying the weekly average of the E.U. Emissions Trading System (ETS) price with the embedded emissions per ton of imported goods. A larger gap in carbon pricing will result in higher CBAM costs for imported goods into the E.U. On 11 July 2024, the KAU24, a South Korean ETS index price, was ₩8,900/tCO2e (US$6.45/tCO2e),[64] a considerable disparity with the E.U. ETS price of around €67.91/tCO2e (US$73.52/tCO2e).[65] If the E.U. CBAM was modified to include chips, that US$67/tCO2e difference would need to be offset before South Korean made chips could be imported to the E.U., making those chips prohibitively expensive.

The CBAM is one form of carbon tariff potentially equalizing carbon pricing between the E.U. and non-E.U. countries.[66] If other countries adopt similar mechanisms and the scope of CBAM expands, it could lead to a convergence in carbon prices across different countries.

As a result, South Korea's relatively low ETS price may face upward pressure after 2026, which will likely also result in higher LNG import costs. Higher carbon prices would directly impact the cost of electricity from LNG-fired power plants which emit carbon dioxide when burning LNG.

Additionally, CBAM implementation could increase production and trade costs of emission-intensive fossil fuels in the international supply chain, potentially leading to higher import costs for fossil fuels used in South Korea's power generation.

Consequently, increased reliance on fossil fuels could further elevate power generation costs, increasing electricity prices. Carbon taxes on LNG could split the global market into two segments: a

[63] KITA. Status and Challenges of RE100 Implementation by Manufacturing Export Companies, 24 April 2024. Page 21.
[64] Korea Exchange (KRX). Emissions Market Information Platform – Price Inquiry.
[65] Trading Economics. EU Carbon Permits.
[66] World Bank. Trade Watch. December 2021. Page 03.

premium market for regions with carbon pricing mechanisms, like Europe, South Korea, and Japan, and a market with lower prices for emerging Asian economies without such mechanisms.

This could lead to a significant recalibration of LNG prices, with higher costs in premium markets. Consequently, the CBAM and other carbon taxes could raise production costs for LNG-dependent industries, such as the South Korean semiconductor cluster.

The potential inclusion of semiconductors in the E.U.'s CBAM, combined with increasing LNG import costs, would be a double disadvantage for South Korea's semiconductor industry which relies on fossil fuel-based power. The CBAM costs on the sale of semiconductors into Europe and higher LNG procurement costs resulting from the domestic carbon pricing mechanism would impact South Korean companies' competitiveness in the global market.

The CBAM may also prompt E.U. customers to switch suppliers from South Korean semiconductor companies powered by LNG with a higher carbon footprint to others using renewable power. Production costs could further rise if additional fuel costs imposed by the EU's CBAM is factored in the procurement of LNG-fired power.

Similar to RE100, compliance with the CBAM extends beyond the semiconductor industry. Other industrial sectors involved in European trade could face pressure to adopt greener practices. This emphasizes the potential for significant risk premiums for companies that delay renewable power adoption.

Companies lagging in renewable energy adoption could also face difficulties securing financing and capital. In January 2024, the IFRS S2 Climate-related Disclosures came into effect, requiring the reporting of climate-related risks and opportunities under Scope 1 and 2.[67, 68]

As a result, SK Hynix, which plans to purchase around 6.3 terawatt-hours (TWh)[69] per year of LNG-fired power from SK E&S might face Scope 2 climate-related financial exposures caused by indirect emissions from purchased energy.

Additionally, from 2024 onwards, the IFRS S2 introduces mandatory disclosure of Scope 3 emissions.[70, 71] This would also apply to the South Korean semiconductor sector which operates globally.

Scope 3 emissions, as defined by the GHG Protocol, represent the broadest category of greenhouse gas emissions, encompassing all indirect emissions throughout an organization's value chain. This

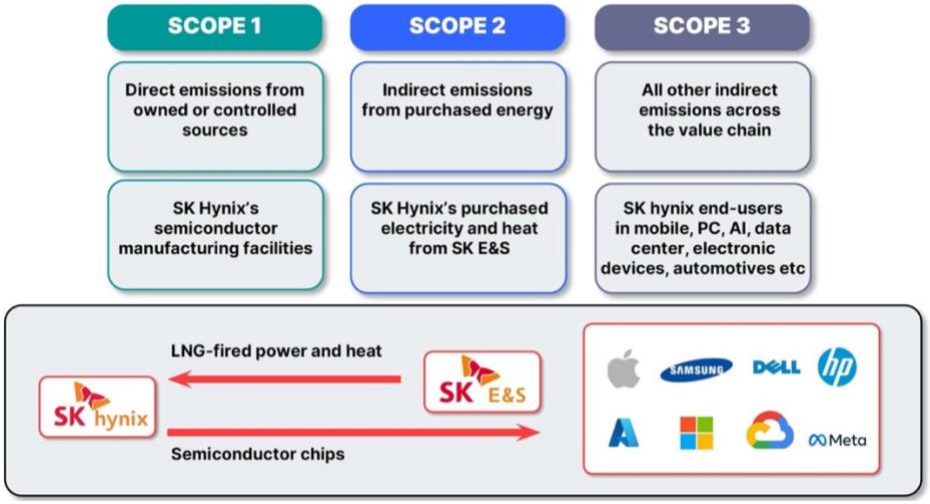
[67] IFRS. IFRS S2 Climate-related Disclosures.
[68] This is subject to be endorsed by local jurisdictions. PWC. Viewpoint. 07 March 2024.
[69] Calculation based on the capacity of 1.2GW and efficiency rate of around 60% using the formula 'Electricity generated (kWh) = Capacity (MW) x Efficiency (%) x Operating hours (hours) / 1000'.
[70] GHG Protocol. Corporate Standard.
[71] The exact implementation timeline would vary depending on jurisdictions and regulations.

includes emissions associated with purchased goods and services, business travel and employee commuting, waste and wastewater disposal, and use of sold products.

Once the regulations come into effect, South Korean semiconductor companies with high GHG emissions could face difficulties procuring feedstocks and parts as upstream suppliers will need to request the carbon footprint of South Korean semiconductor manufacturers for their own Scope 3 reporting. As a result, suppliers may be averse to selling to downstream chip makers with high emissions within their supply chains.

In addition, downstream end-users of South Korean semiconductors, such as data centers and electronics manufacturers, could be incentivized to switch chip suppliers due to Scope 3 reporting requirements. They may prioritize sourcing chips from lower emissions manufacturers to improve their sustainability footprint (Figure 17).

Figure 17: SK Hynix's Scope 1, 2, and 3 Exposures



Source: IEEFA.

Semiconductor companies powered by LNG could face mounting pressure due to stricter regulations like IFRS S2 Sustainability Disclosure and the growing green finance movement. Disclosure requirements for Scope 1, 2, and 3 emissions may raise concerns among investors and lenders, making it harder for these companies to access financing and capital.

Foreign equity investors have held a significant stake (54%) in SK Hynix as of December 2023.[72] Thus, external investors influence a majority of SK Hynix's ownership. The increasing focus on Environmental, Social, and Governance (ESG) factors is leading to stricter climate reporting mandates worldwide. Foreign investors may divest their holdings if SK Hynix cannot meet these reporting requirements or demonstrate a strong commitment to sustainability.

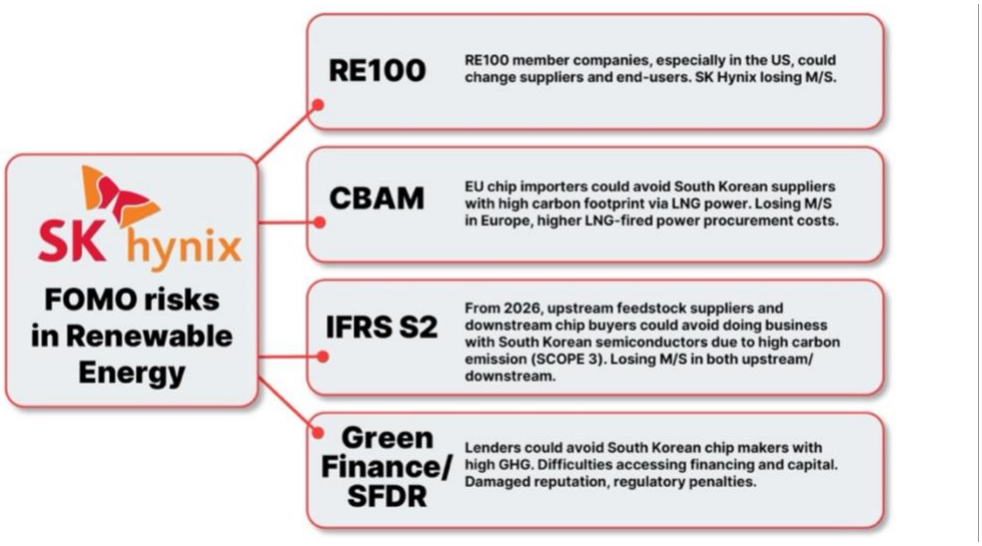
[72] SK Hynix. Ownership Structure.

The expanding green finance movement, exemplified by policies like the E.U.'s Sustainable Finance Disclosure Regulation (SFDR)[73], could challenge SK Hynix's funding abilities. Brazil, China, Taiwan, and the U.K. have already implemented ESG reporting regulations, and similar measures are under consideration in South Korea and many other countries.

Strengthening global ESG regulations would limit SK Hynix's access to international capital, expose the company to regulatory penalties, and affect its reputation.

Given SK Hynix's relatively advanced RE100 progress compared to its South Korean counterparts, such as Samsung[74], many companies in other sectors will likely face substantial financial risks and losses due to delayed renewable energy adoption (Figure 18).

Figure 18: Financial Risks of a Delayed Renewable Energy Transition



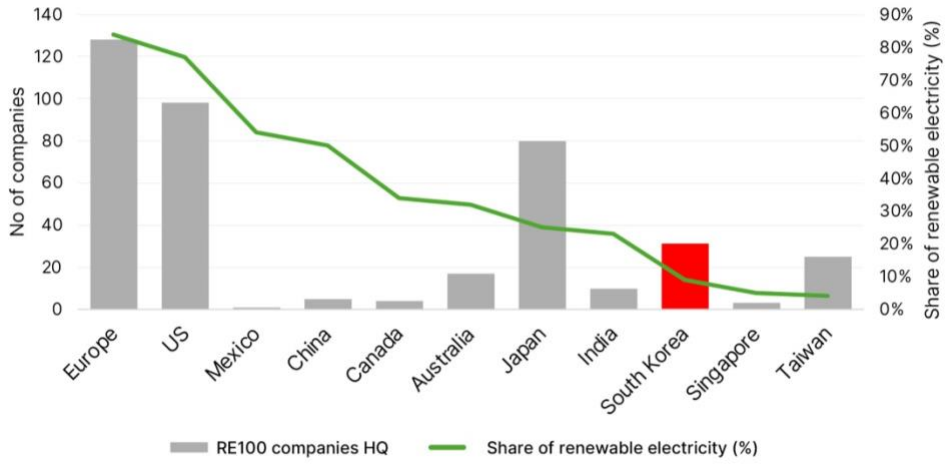
Source: IEEFA

Transitioning to renewable energy sources and prioritizing sustainability practices would be critical for SK Hynix's long-term financial health, reducing operational costs, enhancing brand reputation, and positioning the company as a competitive player in a global market increasingly focused on environmental responsibility (Figure 19).

[73] The EU's Sustainable Finance Disclosure Regulation (SFDR), introduced in 2021, aims to increase transparency and accountability in the financial sector's reporting of sustainability risks and factors. Under the SFDR, all financial entities operating within the E.U., including asset managers, financial advisers, and investment banks, must disclose sustainability risks and factors in their investment decisions.

[74] Samsung has achieved less than 10% of renewable energy adoption as of 2022. Climate Group. RE100 Annual Report 2023. Page 68.

Figure 19: RE100 Progress Rates by South Korean Member Companies (%)



Source: Climate Group RE100.

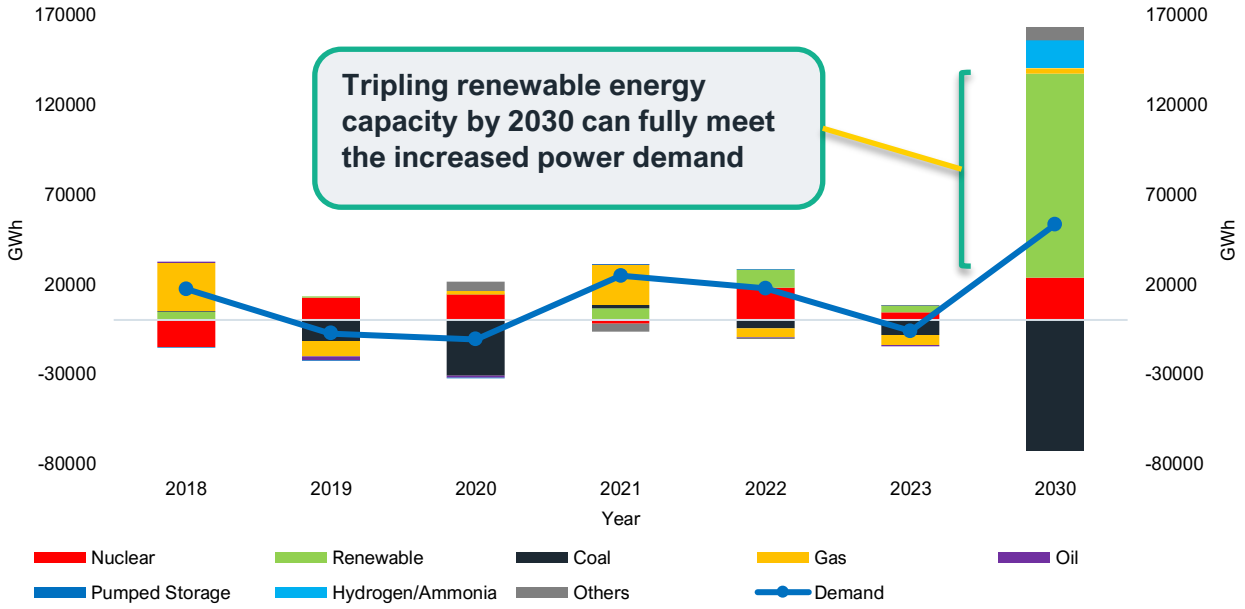
Case Study 2: Tripling Renewable Energy Capacity to Meet AI and Semiconductor Power Demand

As highlighted in Case Study 1, at least seven companies plan to build new natural gas-fired plants for various purposes, including supplying electricity and heat to semiconductor clusters, industrial complexes, captive power generation, and new business ventures.

The need to meet the rising electricity demands of AI, data centers, and high-tech semiconductor clusters was cited as justification for expanding LNG-fired power generation.

However, IEEFA found that the increased power demand from these new sectors is overstated and tripling renewable energy capacity, as pledged by the country at the COP28, can fully meet the increased power demand in 2030 without relying on new LNG-fired power plants (Figure 20).

Figure 20: Scenario 1: Tripling Renewable Energy Capacity by 2030



Note: Renewable energy generation in 2030 was estimated based on the COP28 pledge, which aims to triple capacity by 2030 compared to 2023 levels, as well as average operation rates of renewable power plants in 2023. Other estimated power generation data in 2030 is from the 11th BPLE, KEPCO, and KEEI. All power generation data from nuclear, coal, gas, oil, and pumped storage is from the real output from 2013 to 2023 from KEPCO and KEEI. The demand in 2030 was based on the total power generation estimated in the 11th BPLE implementation guideline. The data for renewable energy includes conventional hydropower but excludes pumped storage.
Source: IEEFA calculations; MOTIE; KEPCO; KEEI.

Assuming existing power plant buildout plans proposed in the 11th BPLE remain on track[75], tripling renewable energy capacity by 2030 could fully meet the projected electricity demand.

The net increment of renewable power generation compared to 2023 could reach 113,434GWh by 2030. This projected level of renewable energy generation would be more than sufficient to meet the anticipated net increase in power demand, estimated to be around 53,168GWh in 2030.[76] In other words, renewables could potentially fulfill additional power needs and contribute to the overall electricity mix. Appendix 1 provides an overview of the projections used in this assessment.

Even considering the 10.6GW new power generation capacity needed by 2038 due to the surge in power demand from semiconductors and data centers as highlighted in the 11th BPLE[77], the

[75] KEPCO. Power Plant Buildout Plan for Q1 2024. 23 May 2024.
[76] Based on the 11th Power Market Demand Supply Plan Implementation Guideline.
[77] MOTIE. 11th Basic Plan for Long-Term Electricity Supply and Demand Implementation Guideline. 31 May 2024.

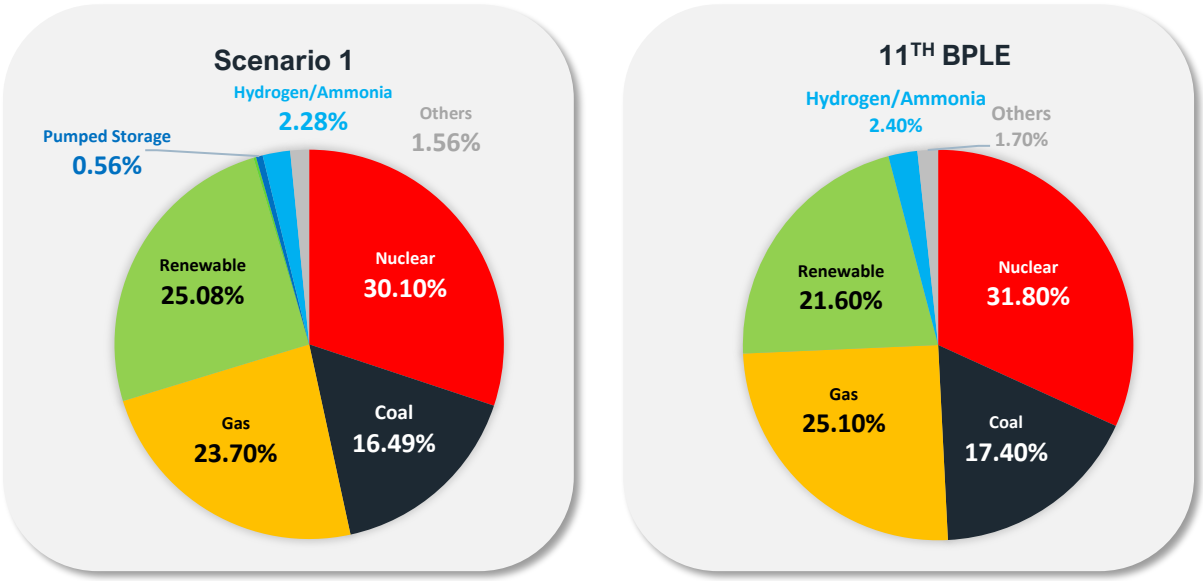
calculated maximum annual power generation of 92,856GWh[78] can be fully met by the 113,434GWh net increment.

If South Korea fulfills its COP28 pledge to triple renewable energy capacity by 2030, renewable power alone could meet the increased electricity demand from AI-driven data centers and mega-scale semiconductor clusters.

Under Scenario 1, the net increment in gas-fired power generation was estimated at 3,008GWh, which is compatible with the 11th BPLE's aim to reduce the share of LNG in the power mix to 11.1% by 2038.

The share of LNG in the power mix in 2030 is projected to be 23.70%, within the 25.10% target set by the 11th BPLE. Additionally, the share of renewables in the power mix is predicted at 25.08%, which aligns with the 21.60% target of the 11th BPLE (Figure 21).

Figure 21: Projected Power Mix - Scenario 1 vs 11th BPLE (%)

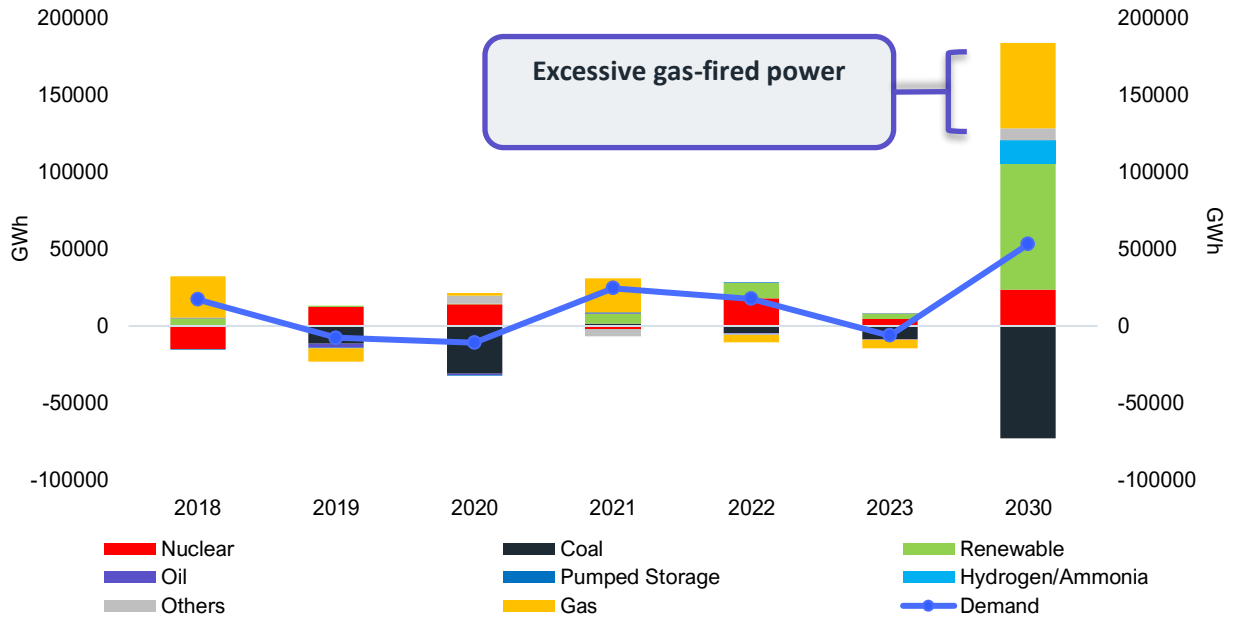


Source: IEEFA calculations; MOTIE; KEPCO; KEEI.

[78] This calculation assumed operation rates are 100% using the formula 'Total Energy Generated (GWh) = 10.6 GW * 8760 hours = 92,856GWh.'

The unfolding of a different situation (Scenario 2), with planned LNG-fired power generation capacity as requested by multiple companies (Case Study 1) fully operational by 2030, could result in an excess of 55,706GWh in net gas power generation[79] (Figure 22).

Figure 22: Scenario 2: Requested LNG-fired Power Plants Capacity Fully Operational

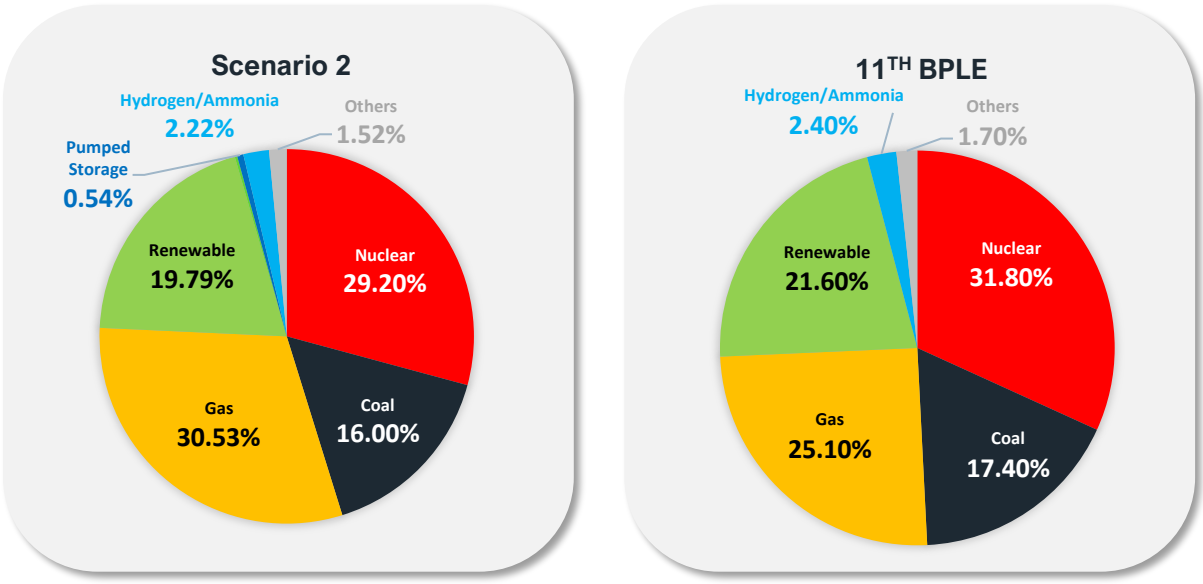


Source: IEEFA calculations; MOTIE; KEPCO; KEEI.
Note: Gas-fired power generation was calculated based on the requested LNG-fired power generation capacity, annual average operation rates in 2023. Other estimated power generation data in 2030 is from the 11th BPLE, KEEI, and KEPCO. All power generation data from nuclear, coal, renewable, oil, and pumped storage is from the real output from 2013 to 2023 from KEPCO and KEEI. The demand in 2030 was based on the total power generation estimated in the 11th BPLE. The data for renewable energy includes conventional hydropower but excludes pumped storage.

Based on Scenario 2, LNG would account for around 30.53% of the power mix in 2030, exceeding the 22.9% target set in the 10th BPLE and the 25.1% target of the 11th BPLE. Given that the targeted share of LNG in the power mix will decline to 11.1% by 2038, the widening gap between the NDCs goal will raise significant concerns about the country's decarbonization roadmap (Figure 23).

[79] This scenario assumes that all the requested LNG-fired CHP capacity is incorporated into the national grid system. In general, the power generation for captive consumption, which is not connected to the national grid, is not reflected in the power mix announced by MOTIE in South Korea.

Figure 23: Projected Power Mix - Scenario 2 vs 11th BPLE (%)



Source: IEEFA calculations; MOTIE; KEPCO; KEEI.

LNG plants typically have a lifespan exceeding 25 years. Therefore, the economic viability of building new LNG-fired power plants is questionable, especially considering the growing focus on promoting renewable energy.

According to Climate Analytics, South Korea needs to phase out gas-fired power generation prior to 2035 to achieve NDC targets.[80] Growing stranded asset risks in fossil fuels could damage the country's economic viability.[81] Thus, building new LNG-fired power plants to meet increased electricity demand from semiconductor clusters and AI data centers is unwarranted.

[80] Climate Analytics. No room for new gas in South Korea. November 2022. Page 13.
[81] Mark Carney. Values: Building a Better World for All. 16 March 2021.

Conclusion

South Korea, a nation propelled by rapid economic growth and technological advancement, was expected to become a renewable energy transition leader alongside the U.S., Europe, China, and Japan.

Unlike geographically centralized fossil fuel systems, South Korea relies heavily on imported fossil fuels. Renewable energy could offer greater stability in supplies and autonomy backed by an abundant and decentralized resource distribution system.[82] An indigenous and widespread renewable energy system is based on technology availability, manufacturing capability, demand and supply management flexibility, and a modernized infrastructure. By contrast, fossil fuels are concentrated in a limited number of countries, assets, and infrastructures, susceptible to geopolitical disruptions and price volatility.[83]

Several factors have hindered South Korea from harnessing the potential and opportunities in the new renewable energy landscape, including inefficient and fragmented policies, limited industrial strategies, disinterested investors, and public resistance. These roadblocks stalled South Korea's potential to become a frontrunner in the renewable energy sector.

The future of renewable energy promises to be a geopolitical battleground, impacting energy security, industrial leadership, access to capital, and public well-being. While South Korea lags in its transition, competitor nations like China, the U.S., and European countries are gaining advantages with proactive and holistic approaches.

This fear of missing out on renewables is escalating rapidly. Policy frameworks such as the U.S. IRA and the E.U.'s NZIA, stricter emission regulations like the CABM and IFRS S2, and initiatives such as RE100 and the green finance movement have placed South Korea at a disadvantage.

Recognizing and addressing the fear of missing out related to renewable energy is critical for the success of South Korea. The country's delayed renewable energy transition could have unfavorable effects on geopolitics and national security, industry and trade, financing and capital, and public well-being, resulting from missed opportunities and socio-economic penalties.

The two case studies in the report analyzed the adverse consequences of a delayed renewable energy transition for LNG-powered semiconductor companies and industries, and found that tripling renewables could meet the increased electricity demand from semiconductor clusters and AI-driven data centers.

[82] IRENA. Geopolitics of the Energy Transition. 2024. Page 29.
[83] IRENA. Geopolitics of the Energy Transition. 2024. Page 25.

A proactive approach from policymakers, industry leaders, and the general public can ensure the long-term sustainability and competitiveness of South Korea's vital industrial sectors in semiconductors and emerging AI.

Prolonged reliance on fossil fuel-based power for these industrial sectors will place the country at a significant disadvantage. A faster transition away from fossil fuels to renewables will contribute to South Korea's energy security, industrial leadership, and global economic competitiveness.

Key Recommendations

- South Korea should reduce reliance on fossil fuels in its power mix and expedite the transition to clean energy sources.
- Meet the COP28 pledge of tripling renewable energy by 2030 instead of continuing fossil-fuel based power generation to meet the growing electricity demand from semiconductor clusters and AI data centers.
- Implement more robust policy measures to accelerate renewable power deployment with a cohesive and holistic policy framework rather than fragmented and overlapping policies.
- Accelerate the renewable energy transition to safeguard geopolitical influence, national security, industrial leadership, access to financing, and public well-being.

Appendix 1: Methodologies for Scenario 1

Table 3: A: Power Generation Capacity by Energy Sources (MW)

Year	Nuclear	Coal	Gas	Renewable	Oil	Pumped Storage	Others	Total
2017	22529	36709	37854	10976	4139	4700	0	116907
2018	21850	36970	37851	13413	4307	4700	0	119091
2019	23250	37003	39550	16058	3864	4700	912	125337
2020	23250	36853	41170	20545	2247	4700	426	129191
2021	23250	37338	41201	24855	2160	4700	515	134019
2022	24650	38128	41201	28137	920	4700	457	138193
2023	24650	39168	43191	31396	857	4700	457	144421

Source: KEPCO, KPX, MOTIE, KEEI
Note: The data for renewable includes hydropower but excludes pumped storage.

Table 4: B: Power Generation by Energy Sources (GWh)

Year	Nuclear	Coal	Gas	Renewable	Oil	Pumped Storage	Hydrogen/ Ammonia	Others	Demand
2017	148427	238799	126039	30817	5263	4186	-	-	553530
2018	133505	238967	152924	35598	5740	3911	-	-	570647
2019	145910	227384	144355	36392	3292	3458	-	2249	563040
2020	160184	196333	145911	36527	2255	3271	-	7681	552162
2021	158015	197966	168378	43096	2354	3683	-	3316	576809
2022	176054	193231	163575	53182	1966	3715	-	2678	594400
2023	180477	184932	157792	56717	1488	3784	-	3045	588232
2030	204200	111900	160800	170151	1488	3784	15500	10600	641400

Source: IEEFA calculations; KEPCO; KPX; MOTIE; KEEI.
Note: Power generation and demand data from 2017 to 2023 are from KEPCO and KEEI's annual statistics. Power generation by nuclear, coal, gas, oil, pumped storage, hydrogen/ammonia, and others in 2030 are from MOTIE's 11th BPLE, KEEI, and KEPCO. Power generation by renewables in 2030 is calculated based on the following formula. The data for renewable includes conventional hydropower but excludes pumped storage.

$$(\alpha \times \beta \times \gamma \times \delta) \div \varepsilon \times \theta$$

α: Power Generation Capacity by Renewable in 2023.
β: 3 (tripling renewable capacity)
ɣ: 24 (hours)
δ: 365 (days)
ε: 1000 (conversion factor from MW to GW)
θ: Annual average operation rates of renewables in 2023.
Assumption: Power Generation Capacity by Renewable in 2030 is tripled from 2023 based on South Korea's COP28 pledge. The operation rates of renewables in 2030 remain same as 2023's.

Table 5: C: A Change in Power Generation by Energy Sources (GWh)

Year	Nuclear	Coal	Gas	Renewable	Oil	Pumped Storage	Hydrogen /Ammonia	Others	Demand
2018	-14922	168	26885	4781	477	-275	-	-	17117
2019	12405	-11583	-8569	794	-2448	-453	-	-	-7607
2020	14274	-31051	1556	135	-1037	-187	-	5432	-10878
2021	-2169	1633	22467	6569	99	412	-	-4365	24647
2022	18039	-4735	-4803	10086	-388	32	-	-638	17591
2023	4423	-8299	-5783	3535	-478	69	-	367	-6168
2030	23723	-73032	3008	113434	0	0	15500	7555	53168

Source: IEEFA calculations

Note: The data for renewable includes conventional hydropower but excludes pumped storage.

Appendix 2: Methodologies for Scenario 2

Table 6: A: Power Generation Capacity by Energy Sources (MW)

Year	Nuclear	Coal	Gas	Renewable	Oil	Pumped Storage	Others	Total
2017	22529	36709	37854	10976	4139	4700	0	116907
2018	21850	36970	37851	13413	4307	4700	0	119091
2019	23250	37003	39550	16058	3864	4700	912	125337
2020	23250	36853	41170	20545	2247	4700	426	129191
2021	23250	37338	41201	24855	2160	4700	515	134019
2022	24650	38128	41201	28137	920	4700	457	138193
2023	24650	39168	43191	31396	857	4700	457	144421
2024	27450	41268	46567	31916	857	4700	457	153215
2025	28850	41268	47629	32774	857	4700	457	156535
2026	28850	41268	49139	34815	857	4700	457	160086
2027	28850	41268	51539	36518	857	4700	457	164189
2028	28850	41268	53241	38979	857	4700	457	168352
2029	28850	41268	53739	42794	857	4700	457	172665

Source: KEPCO; KPX; MOTIE; KEEI.

Note: Data from 2024 to 2029 are from MOTIE's BPLE as well as KEPCO's annual power generation capacity update.

Table 7: B: Power Generation by Energy Sources (GWh)

Year	Nuclear	Coal	Gas	Renewable	Oil	Pumped Storage	Hydrogen/ Ammonia	Others	Demand
2017	148427	238799	126039	30817	5263	4186	-	-	553530
2018	133505	238967	152924	35598	5740	3911	-	-	570647
2019	145910	227384	144355	36392	3292	3458	-	2249	563040
2020	160184	196333	145911	36527	2255	3271	-	7681	552162
2021	158015	197966	168378	43096	2354	3683	-	3316	576809
2022	176054	193231	163575	53182	1966	3715	-	2678	594400
2023	180477	184932	157792	56717	1488	3784	-	3045	588232
2030	204200	111900	213498	138400	1488	3784	15500	10600	641400

Source: IEEFA calculations; KEPCO; KPX; MOTIE; KEEI.

Note: Power generation and demand data from 2017 to 2023 are from KEPCO and KEEI's annual statistics. Power generation by nuclear, coal, renewables, oil, pumped storage, hydrogen/ammonia, and others in 2030 are from MOTIE's 11th BPLE, KEEI, and KEPCO. Power generation by gas in 2030 is calculated based on the following formula:

$$"\{(\alpha + \beta) \times \gamma \times \delta\} \div \varepsilon \times \theta$$

α: Power Generation Capacity by Renewable in 2029.
β: 4700 (LNG-fired Power Generation Capacity Planned by South Korean Companies)
γ: 24 (hours)
δ: 365 (days)
ε: 1000 (conversion factor from MW to GW)
θ: Annual Average operation rates of gas-fired power plants in 2023.
Assumption: All new LNG-fired power plants requested by companies are approved and reflected in the national power mix. The operation rates of gas-fired power plants in 2030 remain the same as in 2023.
Assumption: Power generation capacity by renewable in 2030 is tripled from 2023's based on South Korea's COP28 pledge.

Table 8: A Change in Power Generation by Energy Sources (GWh)

Year	Nuclear	Coal	Gas	Renewable	Oil	Pumped Storage	Hydrogen /Ammonia	Others	Demand
2018	-14922	168	26885	4781	477	-275	-	-	17117
2019	12405	-11583	-8569	794	-2448	-453	-	-	-7607
2020	14274	-31051	1556	135	-1037	-187	-	5432	-10878
2021	-2169	1633	22467	6569	99	412	-	-4365	24647
2022	18039	-4735	-4803	10086	-388	32	-	-638	17591
2023	4423	-8299	-5783	3535	-478	69	-	367	-6168
2030	23723	-73032	55706	81683	0	0	15500	7555	53168

Source: IEEFA calculations.
Note: The data for renewable includes conventional hydropower but excludes pumped storage.

About IEEFA

The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

About the Author

Michelle (Chaewon) Kim

Michelle is an Energy Finance Specialist, South Korea, at IEEFA. Over the past 16 years, she has worked across various energy and commodity sectors in Singapore and South Korea. Before her tenure at IEEFA, Michelle spent more than 12 years at S&P Global Commodity Insights and HIS Markit in Singapore, where she served as a senior market analyst focusing on oil, LNG, and petrochemicals. She was also an assistant director at Ernst & Young on the Energy M&A Advisory team in South Korea. She holds a Bachelor's degree in Sociology from Yonsei University in Seoul, and a Master of Science in International Business from the University of Birmingham in the UK.
mkim@ieefa.org

Institute for Energy Economics and Financial Analysis