# A PATH TO NET ZERO

## OPPORTUNITIES FOR U.S.-ROK TECHNOLOGY COLLABORATION

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## *Opportunities for U.S.-ROK Technology Collaboration*

*Kyungjin Boo, Sang Keon Lee, June Park, and James E. Platte*

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As the wide-ranging effects of climate change on ecosystems, societies, and the global economy become increasingly clear, the need for international cooperation to address climate challenges is likewise growing. Whether through melting glaciers, harsher and longer wildfire seasons, or more severe storms, the impacts are global, and the response to the changing climate must be global as well. As two of the world's most advanced economies, with a strong tradition of cooperation, the United States and the Republic of Korea (ROK) are working to lead the way on global efforts to address climate change and build energy systems to both mitigate and adapt to these changes.

The ROK has taken a prominent role, launching its "2050 Carbon Neutral Strategy" in December 2020. Despite a global pandemic, the plan commits to using "green innovations and advanced digital technologies" to achieve carbon neutrality by 2050.[1] Playing to the strengths of the South Korean economy, it emphasizes technological solutions such as improved carbon removal methods and synthetic fuels created from green hydrogen. With the election of President Yoon Suk-yeol in the spring, the country has also seen a resurgence in calls for nuclear energy to play a role in its plan for carbon neutrality.

In the United States, the Biden administration has made action on climate change a priority, rejoining the Paris Agreement within hours of taking office. At the Leaders' Summit on Climate in April 2021, President Joe Biden set the goals of reducing greenhouse gas emissions by 50% across the U.S. economy by 2030 and achieving net-zero emissions by 2050.[2] Following the passage of the Inflation Reduction Act in August 2022, the United States will invest over $300 billion toward combating climate change through subsidies for renewable energy sources and electric vehicles (EVs), alongside research into groundbreaking technologies for hydrogen and nuclear energy.

The United States and ROK have a history of partnering on cutting-edge initiatives, from smart cities to safer nuclear power. In a joint statement, Presidents Biden and Yoon emphasized that bilateral cooperation on technologies like nuclear power, EVs, and the hydrogen economy would be vital for reaching their climate goals.[3] Both nations have also made efforts to promote environmental change beyond their borders and sought to align their respective regional strategies (the U.S. Indo-Pacific Strategy and the South Korean New Southern Policy) to better incorporate shared climate change and energy security goals in developing Asian economies. The speed of technological innovation and the urgency of action to address climate change have coalesced to make the coming decade critical to the future of the world's climate resiliency.

Yet the ability to meet these shared goals will depend on developing policy and energy market capacities to keep pace with developments in technology and an increasingly urgent need for action. By exploring how U.S.-ROK cooperation can position both countries to achieve their goals, this National Bureau of Asian Research (NBR) report aims to chart a future path for this long-standing partnership in a new era of climate action. Funded by the Korea Foundation, it

1 Government of the Republic of Korea, "2050 Carbon Neutral Strategy of the Republic of Korea: Towards a Sustainable and Green Society," December 2020, https://unfccc.int/sites/default/files/resource/LTS1_RKorea.pdf.

2 "President Biden's Leaders Summit on Climate," White House, Fact Sheet, April 23, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/23/fact-sheet-president-bidens-leaders-summit-on-climate.

3 "United States–Republic of Korea Leaders' Joint Statement," White House, Press Release, May 21, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/21/united-states-republic-of-korea-leaders-joint-statement.

is part of a year-long program titled "U.S.-Korea Technology Cooperation for Climate Change Mitigation: The Path to Net-Zero." This program examined areas where new technologies or better policies can lead to a cascade of reduced emissions, such as advances in EV batteries unlocking the potential to decarbonize the transportation sector or cutting-edge nuclear reactors providing baseload power and facilitating even greater renewable energy generation. By interviewing leading technology and policy experts from both the United States and South Korea, NBR identified four key subjects for research: the developing hydrogen economy, nuclear power, eco-friendly smart cities, and private sector hurdles in the EV battery market. NBR then commissioned four essays by scholars with expertise on these issues, who presented their preliminary findings at a hybrid roundtable discussion held online and in Seattle on June 14, 2022. Feedback from participants at the event informed the authors' research into how the United States and ROK can better align their policies and cooperate on these critical issues.

In the report's first essay, Kyungjin Boo of Seoul National University examines the nascent hydrogen economy and its role in a net-zero future. In his analysis, Boo highlights how the ROK and United States have complementary strengths. While South Korea has focused on fuel cells for cars, the United States' advantage lies in hydrogen production. Because a chief advantage of hydrogen is its ability to serve as an energy carrier, the two countries should use this natural synergy to lay the groundwork for a global hydrogen economy by setting standards and establishing safety norms to facilitate both the supply and demand sides of the hydrogen future.

The second essay by James E. Platte of the School of Advanced Military Studies looks at the long history of and prospects for civil nuclear cooperation between the United States and ROK. Platte suggests that nuclear energy can help both countries reach net zero, but the coming decade is critical for establishing a sustainable place for nuclear energy beyond 2030. The election of President Yoon and Russia's invasion of Ukraine mean that collaboration is both more likely and more necessary than in the past. Platte suggests that the time is ripe for cooperation on developing advanced small modular reactors, alongside collaborative efforts on securing new sources of low-enriched uranium and decommissioning older reactors.

The third essay, written by Sang Keon Lee of the Korea Research Institute for Human Settlements, considers the emerging concept of the eco-smart city, and advocates for leveraging technology and the "big data" revolution to simultaneously achieve a carbon-neutral urbanized future. Lee makes the case that easy access to data, artificial intelligence, and public-private partnerships can help promote net-zero goals in decision-making by both the government and citizens. For the United States and South Korea, collaboration on best practices for creating eco-smart cities would not only benefit their own populations but also help provide solutions for developing countries undergoing rapid urbanization.

The final essay by June Park of Princeton University explores the intensely competitive private sector landscape in renewable energy technology by examining a major trade and intellectual property dispute between LG Energy Solutions and SK Innovation, two key players in EV battery technology. Park argues that the limits of bilateral cooperation will be tested as the market for EVs grows because U.S. and ROK private sector interests will not always align with government policy directions. She asserts that policymakers must focus on setting standards for safety and preparing a legal structure to handle future disputes to avoid a possible roadblock to net-zero transportation.

These essays cover technologies at various stages of development. Some, such as nuclear power, stem from decades of collaboration; others, such as EV batteries, are experiencing huge growth (and growing pains); and some, such as hydrogen and smart cities, lie at the cutting edge of new energy systems. Yet the clear policy priorities of involving private sector and citizen stakeholders and acting quickly in a decisive decade are emphasized throughout the report. For either the United States or the ROK to reach a net-zero society by 2050, the technology to facilitate this change must be established in the next ten years. While care must be taken to ensure that collaboration is fruitful on both sides, the prospects for cooperation on achieving these climate goals are great. Moreover, U.S.-ROK cooperation could confer benefits beyond the two nations as these key technologies become more mature and regularly deployed.

This NBR Special Report was made possible by the generous support of the Korea Foundation, whose efforts to advance bilateral relations have greatly improved the policy and cultural exchanges between the United States and the ROK. NBR hopes that this report will continue the long tradition of enhancing discourse between the two nations. Additionally, over the past twelve months, we have interviewed and spoken with numerous U.S. and Korean scholars, technology experts, and policy leaders on the prospects for cooperation in clean energy technology. There are too many people to list individually, but the roundtable and this report would not have been possible without their contributions.

Finally, this report could not have been produced without the work and support of NBR's staff, especially Ashley Johnson, Audrey Mossberger, Chihiro Aita, Micah Sindelar, and Arsalan Ahmed. From their leadership in coordinating a hybrid event amid another Covid-19 surge in the spring to their help with researching authors and key topics for the project, this is the culmination of a year of work from them and numerous others. I hope that you find the report as informative, insightful, and enjoyable to read as it has been to work on.

Thomas Lutken
*Project Manager, Energy and Environmental Affairs, NBR*

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# U.S.-ROK Collaboration for a Hydrogen Economy

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# EXECUTIVE SUMMARY

This essay examines the potential for hydrogen-based energy technologies and considers opportunities for international cooperation to establish a hydrogen economy, particularly through bilateral collaboration between the Republic of Korea (ROK) and the U.S.

## MAIN ARGUMENT

In recent years, major economies have announced hydrogen roadmaps to shift the energy paradigm toward hydrogen to reach their targets of carbon neutrality. However, individual countries' efforts alone are insufficient to realize a hydrogen economy; multilateral and bilateral cooperation are needed as well. The U.S. has taken a balanced approach between the production of blue and green hydrogen and the consumption of hydrogen for mobility and power generation. This approach contrasts with that of the ROK, which has emphasized the private sector's involvement in developing the hydrogen economy, with a focus on fuel-cell technology for power generation and mobility. Interviews with South Korean experts identified four potential areas of cooperation with the U.S.: (1) production, storage, and delivery (the supply side of the hydrogen economy), (2) power generation, mobility, and fuel-cell use (the demand side), (3) hydrogen production based on nuclear small modular reactors, and (4) standardization and certification.

## POLICY IMPLICATIONS

- Multilateral and bilateral cooperation are needed for a cost-effective transition toward a hydrogen economy. Now is the time for the ROK and the U.S. to start cooperating to become global leaders.
- On the supply side, hydrogen production based on small modular reactors is an option with great potential for U.S.-ROK cooperation.
- On the demand side, fuel cells for mobility and power generation present great potential for cooperation in terms of fuel-cell electric vehicles, hydrogen charging stations, and combined heat and power generation as a distributed energy resource.
- Standardization for safety and ease of commerce among important players in the hydrogen supply chain, coupled with proactive national agendas supporting international cooperation, will be key during this period of industrial development of the global hydrogen economy.

Carbon neutrality has emerged as a global agenda for fighting climate change since the new climate regime was established following the Paris Agreement in 2016. Yet, even before carbon neutrality was proposed as a global target to reduce climate change, hydrogen had already attracted attention as a next-generation clean energy carrier. Governments and companies around the world are now rushing to transition to a hydrogen economy to overcome the climate crisis. Hydrogen is regarded as an eco-friendly and practical energy carrier. It is also the most abundant element on Earth. According to the Hydrogen Council, hydrogen will account for 18% of global energy use by 2050 and have a market size of $2.5 trillion, contributing to a reduction in annual $CO_2$ emissions of 6 billion tons and creating 30 million jobs.[1] In recent years, major economies have announced hydrogen roadmaps, giving momentum to the global shift to hydrogen-based energy systems.

A hydrogen economy moves away from the current fossil fuel–oriented energy system to a hydrogen-oriented one. This shift requires a fundamental transition in the global energy system in both upstream supply chains (production, storage, and transportation) and downstream demand sectors (industry, transportation, and residential/commercial energy use). As a result, the efforts of individual countries are not sufficient to achieve a hydrogen economy. Instead, realizing this goal requires cooperation among developed countries as well as between developed and less developed countries.

In this context, this essay focuses on international cooperation for a hydrogen economy, particularly bilateral collaboration between the Republic of Korea (ROK) and the United States. The first two sections look at current developments within the public and private sectors of the ROK and the United States to assess the areas and scope of cooperation between the two countries. The essay then considers international cooperation toward a hydrogen economy before deriving policy implications from such bilateral and multilateral cooperation. The conclusion identifies areas of cooperation between the ROK and the United States on both upstream and downstream components of hydrogen as a fuel source along with measures to advance the global shift to a hydrogen economy.

## Hydrogen Initiatives within the United States

The United States traditionally develops and implements policies based on the "market mechanism," leaving most business operations to the private sector with minimum government intervention. Nevertheless, the United States has been making quiet but significant progress in developing hydrogen as a key energy carrier based on a national strategy for a hydrogen economy. The United States has provided financial support to private initiatives that focus on innovative emerging technologies and market development. For example, the Office of Fossil Energy in the Department of Energy (DOE) created a strategic plan to provide R&D for hydrogen technologies. As a follow-up to a series of the DOE's initiatives, the Fuel Cell and Hydrogen Association, a major industry group, published its "Road Map to a U.S. Hydrogen Economy" for the development and commercialization of innovative technologies and opening new emerging markets.[2] Below are examples of hydrogen initiatives taking place in the United States.

[1] Hydrogen Council, "Hydrogen Scaling Up: A Sustainable Pathway for the Global Energy Transition," November 2017.

[2] Fuel Cell and Hydrogen Energy Association, "Road Map to a U.S. Hydrogen Economy: Reducing Emissions and Driving Growth Across the Nation," 2021.

*H2@Scale Initiative*. The H2@Scale Initiative is a "multi-year initiative to fully realize hydrogen's benefits across the economy" launched in 2016 by the DOE's Energy Efficiency and Renewable Energy Office through its Hydrogen and Fuel Cell Technologies Office. The initiative has allocated $33 million to support innovative hydrogen and fuel-cell R&D, infrastructure supply chain development and validation, and cost-analysis activities. Activities that result from this funding opportunity announcement will support the H2@Scale vision.

*Road Map to a U.S. Hydrogen Economy*. As noted above, a coalition of major companies and organizations involved in oil and gas, electric power, automotive, fuel cells, and hydrogen published the "Road Map to a U.S. Hydrogen Economy," which envisions how the United States will continue to take global leadership in the rapidly evolving and expanding hydrogen economy.[3] The road map is organized into four key phases: 2020–22, 2023–25, 2026–30, and post-2030. Each phase sets specific milestones for the deployment of hydrogen across applications and identifies the key enablers required. The latter are categorized into policy enablers, which are incentives to encourage private sector investment in the hydrogen market, and hydrogen supply and end-use equipment enablers.

*1-1-1 Goal*. The United States plans to create more than four hydrogen industry hubs across the country through large-scale investments. To this end, the government will provide $8 billion of federal funding from 2022 to 2026 to improve and commercialize water electrolysis technologies and invest in clean hydrogen production, transportation, and storage. The 1-1-1 Goal aims to lower the price of clean hydrogen, which combines green and blue hydrogen, from $5 per kilogram (kg) in 2020 to $2 per kg in 2026, and eventually $1 per kg within ten years.[4] The budget of the initiative is larger than that of the charging infrastructure for electric vehicles ($7.5 billion), and is even greater if combined with the budget for carbon capture, utilization, and storage linked to blue hydrogen.

*Energy Earthshots Initiative: Hydrogen Shot*. In June 2021 the DOE launched the Energy Earthshots Initiative to accelerate breakthroughs in clean energy solutions within the decade. The first Energy Earthshots program—the Hydrogen Shot—seeks to reduce the cost of clean hydrogen by 80% to $1 per kilogram within one decade. In July 2021 the DOE announced $52.5 million to fund 31 projects to advance next-generation clean hydrogen technologies and support the Hydrogen Energy Earthshots Initiative. The 31 projects "will focus on bridging technical gaps in hydrogen production, storage, distribution, and utilization technologies, including fuel cells."[5]

*H2USA*. H2USA is a public-private partnership formed by automakers, hydrogen energy suppliers, fuel-cell developers, fuel-cell associations, and federal agencies, along with the DOE, that aims to increase the number of hydrogen-powered vehicles in the United States. The U.S. government's hydrogen budget allows for the use of natural gas, coal power, and nuclear power plants as well as renewable energy for hydrogen production. While Europe has emphasized green hydrogen production, the United States has leaned on using its natural resources such as shale gas and carbon capture and storage technology. Hydrogen utilization has been diversified into transportation sectors such as automobiles, electricity, and private and commercial facilities. The DOE and the state of California have also established a public-private partnership to implement

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[3] Fuel Cell and Hydrogen Energy Association, "Road Map to a U.S. Hydrogen Economy."

[4] "Hydrogen Shot," U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, https://www.energy.gov/eere/fuelcells/hydrogen-shot. Blue hydrogen is hydrogen produced from fossil fuels using carbon capture, utilization, and storage, whereas green hydrogen is produced from renewable energies.

[5] Ibid.

hydrogen policy, launching the California Fuel Cell Partnership, which is a state-level equivalent of H2USA.[6]

## Hydrogen Initiatives within the ROK

### *Domestic Initiatives*

In 2005 the ROK established the Master Plan for Hydrogen Economy, which identified hydrogen and fuel-cell technology as a new engine for "low carbon green growth."[7] In January 2019 the ROK announced the Hydrogen Economy Vitalization Roadmap, which aims to make the country a world-class hydrogen leader by 2040.[8] As follow-ups, it has crafted a series of action plans: the Hydrogen Economy Standardization Strategy Roadmap, Hydrogen Technology Development Roadmap, Future Automobile Industry Development Strategy, and Hydrogen Demonstration City Promotion Strategy.[9] Most significantly, the Hydrogen Economy Promotion and Hydrogen Safety Management Law, the first of its kind in the world, was enacted in 2021. All these policy measures have laid the foundation for the continuous and systematic promotion of the hydrogen economy nationwide. Within this framework, the government launched H2KOREA as a control tower to manage and coordinate the full-scale development of a hydrogen economy.

According to the 2050 Carbon Neutral Energy Technology Roadmap released in December 2021, 197 core technologies from 13 areas were selected to achieve the nationally determined contribution by 2030 and carbon neutrality by 2050.[10] The list included several hydrogen-based technologies, such as hydrogen turbine and ammonia-based carbon-free power generation, fuel cell–based integrated power generation, renewable energy–based green hydrogen production-transport-storage-dispatch-refueling technologies, and eco-friendly refineries with hydrogen/ammonia fuel. The ROK government also announced the Energy International Joint Research Roadmap, which is designed to secure core materials and source technologies through international joint research activities with leading countries in carbon-neutral technology and to pioneer promising overseas markets based on secured technologies.[11] As for hydrogen and fuel cells, one prominent concern is how to secure and develop source technologies of green hydrogen production as well as ensure safety in the hydrogen value chain (production, delivery, storage, and end uses). Another concern is how fuel-cell technology at the commercial stage can improve life expectancy and production cost before its entrance into the global market.

Despite domestic efforts to increase production, importing hydrogen converted from electricity generated by renewable energy is a strategic option for South Korea to supply hydrogen on a large scale. Shipping hydrogen overseas is expected to become a global trade. By helping achieve a stable supply and demand of hydrogen as well as stabilizing prices, importing hydrogen can

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6 The state of California has a target of deploying 100 million hydrogen vehicles along with one thousand refueling stations by 2030. The state also has a plan to produce and deliver hydrogen by utilizing surplus electric power of wind power generation and the existing natural gas infrastructure. According to the Wind2H2 Project (2007–10) led by the DOE, hydrogen will be produced by electric power generated by wind power and transported through the natural gas pipeline. California Fuel Cell Partnership, "A California Fuel Cell Revolution: A Vision for 2030," August 2019, https://cafcp.org/blog/california-fuel-cell-revolution-vision-2030.

7 Government of the Republic of Korea (ROK), "The Master Plan for Hydrogen Economy," September 2005.

8 Government of the ROK, "Hydrogen Economy Roadmap of Korea," January 2019.

9 Ministry of Trade, Industry and Energy (ROK), "Hydrogen Standardization Strategy Roadmap," 2021.

10 Government of the ROK, "2050 Carbon Neutral Strategy of the Republic of Korea: Towards a Sustainable and Green Society," December 2020.

11 Government of the ROK, "Energy International Joint Research Roadmap," December 2021.

contribute to a reduction of greenhouse gas emissions in the ROK, foster related industries such as hydrogen transport, and enable Seoul to lead the hydrogen economy. In this context, the South Korean government has formed the Green Hydrogen Overseas Business Organization led by the Ministry of Trade, Industry and Energy. The initiative comprises 30 organizations (including 5 public corporations and 16 private corporations in the shipbuilding and petrochemical industries) to promote the supply of green hydrogen from overseas and build an acquisition base for hydrogen imports in 2030. Construction of the hydrogen acquisition base is scheduled to start in 2022 along with the development of technologies and infrastructure such as hydrogen liquefaction and storage, transport ships, and liquefaction plants.

### *International Cooperation to Develop the ROK's Hydrogen Economy*

Currently, many hydrogen experts in the ROK emphasize that a framework for international cooperation must be established as soon as possible to ensure a stable hydrogen supply chain from production to end use.[12] According to the government's roadmap, hydrogen-electric vehicles, charging stations, and fuel-cell power generation will continue to increase.[13] Already, new mobility options—including trains, ships, and construction machinery fueled by hydrogen—are fast emerging, accelerating the demand for hydrogen. Thus, the ROK should be prepared in advance for a potential hydrogen supply shortage in the coming years. Domestic and international action plans are needed to stably produce and supply hydrogen now that the scope of hydrogen use in every sector is to be expanded under the Ministry of Land, Infrastructure and Transport's Hydrogen Demonstration City plan.

*Control towers for international cooperation*. The ROK has emphasized the need for international cooperation in areas such as hydrogen production and supply, standardization, and technology development. The ROK has positioned itself as a strong player in hydrogen mobility and fuel-cell cogeneration, but it is not yet strong enough to respond to the global market. In this context, the ROK needs control towers to coordinate the implementation of its hydrogen economy alongside global efforts.[14] A control tower refers to a public organization responsible for implementing the plan for a hydrogen economy, including coordination among stakeholders. H2KOREA is the ROK's current control tower. At present, international cooperation on hydrogen is still in its infancy. Many experts are thus calling for the establishment of an agency to oversee the development of the ROK's domestic hydrogen economy. This agency would monitor the domestic hydrogen economy; provide opportunities for domestic institutions, organizations, and industries to promote joint projects through international cooperation; and lay the foundation for leading international cooperation between countries, institutions, and organizations. In addition to the management and supervision of the domestic hydrogen economy, establishing an institution would help the ROK keep up with the global trend.

*Standards and certification*. In order to become the first mover of the hydrogen economy, it is important for the ROK to proactively develop international standards and cooperate with leading players such as the United States, the European Union, Japan, and China. International standards

[12] This is because hydrogen supply is stable only when the four beats of by-product hydrogen, extraction hydrogen, water electrolysis, and overseas imports are simultaneously promoted rather than prioritizing one over the others. In this regard, cooperation among nations or among institutions and organizations is necessary, and long-term joint technology development is required for extensive hydrogen imports and exports.

[13] Ministry of Trade, Industry and Energy (ROK), "Hydrogen Economy Roadmap of Korea," June 2020.

[14] Hydrogen Convergence Alliance, https://h2korea.or.kr.

must be developed with a focus on safety in the areas of hydrogen refueling stations and fuel-cell use cases. In December 2018 the Korea Agency for Technology and Standards hosted the first Hydrogen Economy Standardization Forum, which could be a model for implementing future standards.[15] As a follow-up to this forum, the ROK developed the Roadmap for Standardization Strategy of Hydrogen Economy in 2019, which proposed a mid-term target of establishing international standards by 2030 along with Korean Industrial Standard certification in the mobility and the energy sectors.

## Possible Areas for U.S.-ROK Cooperation

The ROK has not yet seriously considered or studied hydrogen cooperation with the United States. Instead, cooperation on the hydrogen economy has primarily been considered with hydrogen-exporting countries  such as Australia, Canada, Germany, and Russia. Both the United States and ROK, however, would benefit from hydrogen cooperation.

To attain the goal of the 2050 Carbon Neutral Strategy, the ROK and the United States should introduce hydrogen as an energy carrier across the entire value chain of hydrogen supply and demand. The growing hydrogen economy will spur the development of new trade relations and place new demands on the global governance of energy, which would then require analysis of the opportunities and challenges of the emerging hydrogen economy through a geopolitical lens. The growing hydrogen economy also requires international dialogue with stakeholders in government, business, and civil society.

This section draws on in-depth talks with experts within each link of the hydrogen value chain throughout the entire life cycle of hydrogen to provide policy options for achieving these goals. The South Korean experts surveyed suggested the following promising areas for U.S.-ROK cooperation:

- On the supply side, an area for cooperation is the production, storage, and delivery of hydrogen, including hydrogen production based on small modular reactors (SMRs).
- On the hydrogen demand side, the two countries could cooperate on utilizing fuel cells for power generation and mobility.
- Standardization and certification is another promising area for cooperation.

### *Hydrogen Supply Chains*

*Hydrogen production*. The United States primarily produces green hydrogen via water electrolysis powered by renewable energy, particularly wind power. Similarly, the ROK plans to produce green hydrogen with 3 gigawatt (GW) water electrolysis facilities out of 9 GW floating offshore wind farms using platforms of a gas field off Ulsan.[16] Additionally, several companies in the United States are engaged in blue hydrogen production via liquefied natural gas. Green and blue hydrogen production are both opportunities for cooperation through mutual investment. In

15 According to the Hydrogen Standardization Strategy Roadmap, South Korea will propose more than fifteen international standards for the hydrogen economy through international cooperation with the United States, Japan, and the EU. The U.S. Fuel Cells Technology Committee introduced standards developed through role allocation and cooperation between the American Society of Mechanical Engineers, National Fire Protection Association, American Gas Association, and Society of Automotive Engineers International in the areas of performance, safety, and interoperability.

16 City of Ulsan, "Announcement of the Vision of Floating Offshore Wind Power," May 6, 2021.

the United States, low-cost hydrogen production (the 1-1-1 Goal) and storage are the main targets for investment. Businesses in both countries are also exploring opportunities for cooperation in hydrogen production by water electrolysis, high-temperature water electrolysis with anion membranes, and the use of liquid organic hydrogen carriers to convert hydrogen to ammonia for easier storage and export.

*Nuclear hydrogen production*. Hydrogen production based on SMRs and very high temperature reactors (VHTRs) has become economically feasible. The ROK holds great R&D experience in developing the SMR with a scale of 50–100 megawatts (MW) that can be a good option for distributed hydrogen production.[17] Upon achieving economic feasibility, this technology can open possibilities for technological cooperation between South Korea's Doosan Heavy Industry and Korea Hydro and Nuclear Power (KHNP) and the United States' NuScale Power Module (totaling 60 MW). KHNP can introduce and demonstrate a prototype of a commercial SMR, while Doosan Heavy Industry can construct a commercial-scale SMR power plant. Meanwhile, NuScale Power can provide basic and core technologies of the SMR. Samsung Electronics is also internally considering participation in this SMR-based hydrogen project, potentially making the project even more successful.[18]

### *Fuel Cells: Hydrogen Mobility and Power Generation*

In addition to the upstream or production-storage-transportation phase of the supply chain, the downstream or consumption phase also has great potential for U.S.-ROK cooperation. Despite the United States being one of the world's first movers in hydrogen-based transportation, South Korea has emerged as a global leader. While the United States has monopolized core source technologies for fuel cells, the ROK is stronger in application technology. Both countries can thus make equity investments into promising technologies. Fuel cells, as clean energy technologies in mobility and power generation, are a key area for cooperation. They can be used in a variety of vehicles, including in forklifts, trucks, ships, motorcycles, and unmanned aerial vehicles.

While government-to-government cooperation on hydrogen has yet to move forward, private companies have already begun to establish joint ventures.[19] The United States has source technologies of fuel cells for power generation, while the ROK's strength is on the application and commercialization side—complementary areas that create an ideal environment for U.S.-ROK cooperation to jointly develop a business model. South Korea's active cooperation with the state of California on hydrogen mobility provides a model for future cooperation. The California Public Utilities Commission initiated the Self-Generation Incentive Program to provide incentives supporting existing, new, and emerging distributed energy resources. Through the program, hydrogen cars and hydrogen charging stations are actively expanding in California, opening opportunities for ROK firms to enter the state's market.[20] For instance, Hanwha recently sought

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17 Korea Hydro and Nuclear Power, "A Feasibility Study on Technological Applicability of Nuclear-Based Hydrogen Production," 2009.

18 Ministry of Science and ICT, "Hydrogen Technology Development Roadmap 2.0," May 2022.

19 Hyundai Motor and Bloomberg Media Studios have jointly implemented a hydrogen economy campaign—i.e., fuel cells for power generation. A bad example is a legal dispute between Fuel Cell Energy and POSCO Energy in which the joint venture failed and was settled in a legal dispute. Hyosung Heavy Industry has shown an interest, but the Ministry of Trade, Industry and Energy has been lukewarm—even negative—being concerned about the possibility of recurrence of past cases. Nevertheless, cooperation is still possible.

20 The Self-Generation Incentive Program "provides rebates for qualifying distributed energy systems installed on the customer's side of the utility meter. Qualifying technologies include wind turbines, waste heat to power technologies, pressure reduction turbines, internal combustion engines, microturbines, gas turbines, fuel cells, and advanced energy storage systems." California Public Utilities Commission, "Self-Generation Incentive Program," http://www.cpuc.ca.gov/sgip.

to enter the hydrogen charging station market in cooperation with Nikola Corporation. SK Group and Plug Power also signed a strategic partnership agreement on February 15, 2021, valued at $1.6 billion, to supply hydrogen fuel-cell systems, hydrogen refueling stations, and electrolyzers to the ROK and other Asian markets.[21]

### *Standardization and Certification*

As an emerging market with new technologies, hydrogen-based mobility is a promising area for both domestic and global standardization and certification. Given the ROK's strength in producing fuel-cell electric vehicles and the United States' experience in engineering electric vehicles, the two countries have opportunities to cooperate with each other in developing related standard codes and certifications, such as a mutual recognition agreement. The United States has signaled an intention to develop hydrogen standardization and mutual recognition agreements for certification as an option for cooperation between the countries' institutions. The DOE is an especially important player in monitoring hydrogen storage and transportation safety, collecting data on the safety of hydrogen storage/transportation facilities and equipment, and sharing this knowledge among domestic as well as foreign organizations. These safety concerns are a promising area for future cooperation on standardization and certification.

## Conclusion

The upstream industry of the hydrogen supply chain, including production, storage, and transportation, offers potential for U.S.-ROK cooperation. However, in the downstream industry, hydrogen power generation and hydrogen mobility create even more opportunities for the two countries to cooperate. The most promising area for cooperation in the upstream hydrogen industry is in SMRs/VHTRs for clean hydrogen production. More than anything else, hydrogen mobility and power generation based on fuel cells in the downstream offer great potential for cooperation in the global market. Hydrogen-based mobility, which includes hydrogen cars, fuel-cell vehicles, and hydrogen charging stations, has attracted investment from both countries to gain a competitive edge in the mobility sector. In the power generation sector, fuel cells open a promising and potentially profitable area of cooperation on distribution and scalable combined heat and power. Finally, standardization and certification for hydrogen and fuel-cell technologies could present a good opportunity for the United States and ROK to preemptively dominate the global hydrogen market.

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[21] Lee Jong-soo, "SK to Advance into the Asian Hydrogen Market with Plug Power," Monthly Hydrogen Economy, February 26, 2021, https://www.h2news.kr/news/article.html?no=8810.

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# U.S.-ROK Cooperation on Nuclear Energy: An Agenda for Nuclear Growth by 2030

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**NOTE:** Opinions, conclusions, and recommendations expressed or implied within are solely those of the author and do not necessarily represent the views of Army University, the U.S. Army, the U.S. Department of Defense, or any other U.S. government agency.

# EXECUTIVE SUMMARY


Stronger bilateral cooperation in civil nuclear energy between the U.S. and the Republic of Korea (ROK) will help the domestic nuclear industries in both countries actualize positive growth by the end of this decade and meaningfully contribute to achieving net-zero emissions targets.

## MAIN ARGUMENT

The Biden administration set a goal for the U.S. to achieve a net-zero emissions economy by 2050, and South Korea has similar aspirations to decarbonize its economy. In order to contribute to these goals, the domestic nuclear industries in both countries must see growth by the end of this decade. There should be an increased focus on how the two countries can cooperate bilaterally on nuclear energy to actualize growth and meet their respective domestic decarbonization goals. The inauguration of Yoon Suk-yeol as the new president of South Korea, along with increasing urgency to meet targets for reducing carbon emissions and Russia's invasion of Ukraine, could reinvigorate U.S.-ROK cooperation in nuclear energy.

## POLICY IMPLICATIONS

- U.S.-ROK cooperation in three areas of nuclear energy could be especially important in the coming years: development and deployment of advanced small modular reactors, capacity to produce high-assay low-enriched uranium, and the operation and decommissioning of existing reactors.
- Bolstering the nuclear industries in the U.S. and South Korea will require increasing government-to-government cooperation, expanding corporate partnerships, and increasing investments in nuclear energy. Existing public-private relationships and the High-Level Bilateral Commission can help coordinate these activities.
- Bilateral cooperation should include robust dialogue on how to resolve difficult political issues, such as where to site new nuclear reactors or facilities to manage spent nuclear fuel. Nonetheless, even with such cooperation, central and local governments in both countries will still be responsible for resolving these issues for their jurisdictions.

The United States and the Republic of Korea (ROK) have a long history of cooperation in civil uses of nuclear energy, dating back to the 1950s. This cooperation has evolved from the U.S. exports of turnkey nuclear reactor technologies to South Korea to ROK-led corporate partnerships in the global nuclear reactor export market. The U.S.-ROK nuclear energy relationship has recently faced uncertainties due to economic struggles in the U.S. commercial nuclear sector and former South Korean president Moon Jae-in's policy to phase out nuclear power. The inauguration of Yoon Suk-yeol as the new president of South Korea in May 2022, along with an increasing urgency to meet targets for reducing carbon emissions and the impacts of Russia's invasion of Ukraine, could reinvigorate U.S.-ROK cooperation in nuclear energy. In particular, bilateral cooperation in three areas of nuclear energy could be especially important in the coming years: the development and deployment of advanced small modular reactors (SMRs), the capacity to produce high-assay low-enriched uranium (HALEU), and the operation and decommissioning of existing reactors.

This essay first examines the potential and need for increased U.S.-ROK collaboration in the nuclear energy sector this decade to aid in goals to achieve net-zero emissions. It then assesses the three key areas outlined above and highlights existing best practices or gaps in the relationship and ways to build on current foundations. Finally, it offers considerations for next steps to strengthen bilateral efforts in the near term.

## The Decisive Decade for Nuclear Energy

Just as important as the focus of U.S.-ROK civil nuclear cooperation is the timeline for when significant developments need to happen. The Biden administration's National Climate Task Force declared the 2020s as "the decisive decade for the world to confront climate change and avoid the worst, irreversible impacts of this crisis."[1] The task force also set goals for the United States of carbon pollution–free electricity by 2035 and a net-zero emissions economy by 2050. Meeting these ambitious goals will require the development and large-scale deployment of carbon-free energy technologies to replace fossil fuels across all sectors of the economy. The previous administration of Moon Jae-in also laid out ambitious plans for South Korea to decarbonize the country's economy. Even though new president Yoon Suk-yeol has pledged that his administration will conduct an energy policy review, South Korea is likely to still seek to reduce reliance on fossil fuels.

Nuclear power could be an important part of a carbon-free energy mix, but if it fails to see new growth by 2030, then other carbon-free energy technologies could push nuclear power out of the race to a net-zero emissions economy by 2050. Timescales to transition energy systems are in the order of decades, which means that the transition to carbon-free energy systems by 2050 must be well-founded by the end of this decade. The timeline to develop, license, and build new nuclear power plants can range from five to ten years. Consequently, nuclear power needs to show some growth by 2030 to contribute to meeting the goal of a net-zero economy. The window of opportunity for nuclear power is both opening and closing in the United States and South Korea.

The inauguration of Yoon as president on May 10, 2022, appears to have opened the window for increased U.S.-ROK civil nuclear cooperation to achieve this goal. During his term, Moon instituted a policy to phase out nuclear power in South Korea by requiring that existing nuclear

1 "National Climate Task Force," White House, https://www.whitehouse.gov/climate.

reactors enter decommissioning after 40 years of operation and that no new reactors be built. During the presidential campaign, Yoon said that he opposed Moon's nuclear phaseout policy and would review South Korea's energy mix targets. He even suggested expanding the use of nuclear power, aiming for it to provide around 30%–35% of the country's electricity in 2030.[2]

Despite Moon's policy to phase out nuclear power domestically, his administration continued to support nuclear technology exports. A May 2021 joint statement between Presidents Moon and Joe Biden committed the two countries "to develop cooperation in overseas nuclear markets, including joint participation in nuclear power plant projects."[3] Yet a domestic nuclear phaseout likely would reduce South Korea's competitiveness in the export market, and areas for cooperation with the United States would also be limited both domestically and internationally. Without a domestic market, South Korea likely would see a decrease both in its nuclear-related labor force and in manufacturers certified to produce components for nuclear reactors, which would weaken the broad industrial base necessary for nuclear reactor construction. Thus, Yoon's election should provide a boost for South Korea's domestic nuclear industry, improve export competitiveness, and expand areas for U.S.-ROK cooperation, providing an opportunity right in the middle of this decisive decade to confront climate change and potentially secure the future of nuclear power in both countries.

## Key Areas for Nuclear Energy Cooperation

While the Moon-Biden joint statement from last year focused on cooperation on nuclear exports to third countries, increased focus is needed on how the United States and South Korea can cooperate bilaterally on nuclear energy to meet their respective domestic decarbonization goals. As mentioned in the introduction, there are three areas for cooperation that are particularly important: the development and deployment of advanced SMRs, HALEU production capacity, and operation and decommissioning of existing reactors.

### *Development and Deployment of Advanced SMRs*

The first area of cooperation is the development and deployment of advanced SMRs. The existing fleets of commercial reactors in both South Korea and the United States comprise large-scale reactors that are designed to provide stable baseload power for the electricity grid. Except for four heavy water reactors in South Korea, all are light water reactors (LWRs). These reactors have successfully provided carbon-free electricity generation for several decades in both countries. Nevertheless, there does not appear to be strong demand for building more of these types of reactors, especially in the United States, largely due to high upfront capital costs. The recent attempts to build large LWRs in the United States do not provide much reason for optimism. Construction on two new LWRs each at the VC Summer nuclear power plant in South Carolina and the Vogtle nuclear power plant in Georgia began in 2013. The project at VC Summer ceased in 2017, and while construction continues at Vogtle, those two reactors are well behind schedule and

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2 Bryan Cheong and Jon Christian, "South Korea's Presidential Election and Energy Implications," Global America Business Institute, March 10, 2022, http://thegabi.com/wp-content/uploads/2022/03/Korean-Presidential-Election-Brief-1.pdf.

3 "U.S.-ROK Leaders' Joint Statement," White House, Press Release, May 21, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/05/21/u-s-rok-leaders-joint-statement.

over the initial budget estimate. These experiences led to the bankruptcy of Westinghouse Electric Company and dampened hopes for building additional large LWRs in the United States.

Even as these larger reactors face challenges, there is optimism for advanced SMRs. There is no common definition of an SMR, but it generally has one-third or less of the generating capacity of a traditional LWR, with capacities ranging from tens of megawatts up to around 300 megawatts. SMRs can be based on traditional LWR technologies, but they also can use other coolants, such as gas, liquid metal, or molten salt. SMRs have been touted for a variety of uses, including power generation, process heat, and desalination. Thus, SMRs could contribute to decarbonization across various economic sectors. The U.S. Department of Energy has promoted the development of advanced SMRs for several years, citing "relatively small physical footprints, reduced capital investment, ability to be sited in locations not possible for larger nuclear plants, and provisions for incremental power additions" as among the main advantages of SMRs over traditional LWRs.[4]

Collaboration between South Korean and U.S. firms on SMR development is already under way. For example, Doosan Enerbility and Samsung C&T both recently completed agreements with NuScale Power related to the construction of NuScale's 50-megawatt SMR.[5] NuScale plans to begin operating its first SMR in the U.S. state of Idaho by 2029 and is exploring other opportunities in Europe and Asia. SK Group is considering investing a 10% stake in TerraPower, which plans to build its first demonstration reactor in Wyoming by 2028.[6] Finally, Hyundai Engineering & Construction signed an agreement for the turnkey supply of an SMR in 2021 from Holtec International, which is considering building an SMR in New Jersey.[7]

U.S. and ROK nuclear firms have experience collaborating on reactor export projects. For example, U.S.-based Westinghouse provided technical, engineering, and component support services to the South Korean firms that designed and built the Barakah nuclear power plant in the United Arab Emirates.[8] With South Korea's more recent success in nuclear reactor construction, it only makes sense that U.S. nuclear design firms would look to South Korean firms for construction and component supply. Moreover, the provision of South Korean financing, such as SK Group's interest in TerraPower, could prove vital to actualizing SMR deployment in the United States by 2030.

A good next step would be for U.S. firms such as NuScale to explore options for siting an SMR project in South Korea, despite facing competition from domestic SMR designs. However, with South Korean firms planning to provide construction, component, and financing services, even U.S.-based SMR designs would benefit South Korean nuclear firms. Selecting an existing U.S.-based design that is already moving toward deployment could speed up SMR deployment in South Korea. The Yoon administration should set a goal of starting construction on an advanced SMR by 2027, which would put the country on a similar timeline to SMR deployment in the United

4 "Advanced Small Modular Reactors (SMRs)," U.S. Department of Energy, Office of Nuclear Energy, https://www.energy.gov/ne/advanced-small-modular-reactors-smrs.

5 Sonal Patel, "Doosan Kicks Off NuScale SMR Production for Idaho Nuclear Project," *Power*, April 26, 2022, https://www.powermag.com/doosan-kicks-off-nuscale-smr-production-for-idaho-nuclear-project; and Hong Yoo, "Samsung C&T Partners with NuScale to Enter Global SMR Market," *Korea Herald*, May 10, 2022, http://www.koreaherald.com/view.php?ud=20220510000548.

6 Heesu Lee, "SK May Invest in Nuclear Firm Including Bill Gates' TerraPower," Bloomberg, April 11, 2022, https://www.bloomberg.com/news/articles/2022-04-12/sk-may-invest-in-nuclear-firm-including-bill-gates-terrapower#xj4y7vzkg.

7 "Holtec and Hyundai Finalise SMR Design and Deployment Agreement," World Nuclear News, November 24, 2021, https://www.world-nuclear-news.org/Articles/Holtec-and-Hyundai-finalise-SMR-design-and-deploym.

8 Mark Holt, "U.S. and South Korean Cooperation in the World Nuclear Energy Market: Major Policy Considerations," Congressional Research Service, CRS Report for Congress, R41032, June 25, 2013, https://crsreports.congress.gov/product/pdf/R/R41032.

States. Siting such a project would be challenging, but South Korea could explore similar options as U.S. SMR siting plans, such as at national laboratories or existing power plant sites.

### *Increased HALEU Production Capacity*

The nuclear industries in both countries have faced challenges with siting and financing before, but a new challenge related to fuel supply has now arisen due to Russia's invasion of Ukraine and subsequent economic sanctions imposed on Russia by the United States and its allies. Russia's Techsnabexport (Tenex) supplies around 20% of low-enrichment uranium (LEU), which is typically enriched to between 3% and 5% for U.S. LWRs, and it signed a new contract in 2020 to supply uranium enrichment services for South Korean LWRs through 2030.[9] Moreover, most of the advanced nuclear reactors under development in the United States require high-assay LEU, enriched to between 5% and 20%.[10] The United States currently has no capacity to produce HALEU, and Russia was expected to supply this uranium for at least the initial advanced SMRs in the United States. There are new calls in the United States to increase domestic uranium enrichment capacity, including for HALEU production, so that advanced SMR deployment is not delayed due to the political or economic effects of the war in Ukraine.

The U.S. Department of Energy has two programs—the Strategic Uranium Reserve and HALEU Availability Program—that could address this need to increase domestic uranium enrichment capacity. Congress has already increased funding for the latter program for fiscal year 2022.[11] The HALEU Availability Program would commit the Department of Energy to buy some of the first batches of HALEU, thereby supplying needed market certainty both for uranium enrichment providers to produce HALEU and for advanced SMR developers to proceed with deployment plans. Time is of the essence here, as processing a license to modify an existing uranium enrichment facility or to build a new facility would take two to four years.[12] The only licensed enrichment facility in the United States is operated by Urenco and can produce up to 5.5% LEU. Centrus Energy's license to produce up to 20% HALEU at a demonstration project site will end later this year, and the firm said it would take four years to bring a commercial facility online after securing funding or purchase commitments.

Thus, increasing HALEU production capacity is another area where South Korea and the United States could deepen their civil nuclear cooperation. South Korea has no uranium enrichment capacity and would need permission from the United States in order to enrich uranium, per the terms of the two countries' 123 Agreement from 2015. Yet, as with advanced SMR development, South Korea could provide financing to help increase U.S. uranium enrichment capacity. For example, TerraPower's Natrium reactor requires HALEU, and SK Group could further support TerraPower's deployment plans by investing in or signing a purchase agreement for U.S.-produced HALEU.[13] Other advanced SMR designs, including those by NuScale, Holtec, and the Korea Atomic

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9 Paul Day, "U.S. Urges Haste on Domestic HALEU Plan as Russia Faces Isolation," Reuters Events, March 22, 2022, https://www.reutersevents.com/nuclear/us-urges-haste-domestic-haleu-plan-russia-faces-isolation; and "Russia's Tenex Wins Tender for Fuel Supply to South Korea," *Nuclear Engineering International*, January 25, 2020, https://www.neimagazine.com/news/newsrussias-tenex-wins-tender-for-fuel-supply-to-south-korea-7653727.

10 "What Is High-Assay Low-Enriched Uranium (HALEU)?" U.S. Department of Energy, Office of Nuclear Energy, April 7, 2020, https://www.energy.gov/ne/articles/what-high-assay-low-enriched-uranium-haleu.

11 Daniel Moore, "Russian Uranium Dominance Leaves U.S. Scrambling to Catch Up," Bloomberg Law, March 11, 2022, https://news.bloomberglaw.com/environment-and-energy/russian-uranium-dominance-leaves-u-s-scrambling-to-catch-up.

12 Day, "U.S. Urges Haste on Domestic HALEU Plan as Russia Faces Isolation."

13 "Frequently Asked Questions," Natrium Power, https://natriumpower.com/frequently-asked-questions.

Energy Research Institute's SMART SMR, use standard LEU. Thus, South Korean investments in expanding any uranium enrichment capacity in the United States would be beneficial.

The 123 Agreement also established the High-Level Bilateral Commission specifically to address issues such as "assured stable fuel supply."[14] A meeting of the commission to address this uranium enrichment challenge for advanced SMR deployment could explore such opportunities for South Korean support for domestic LEU and HALEU production in the United States. Increasing U.S. enrichment capacity, in partnership with South Korean firms, would also help the United States and South Korea present a more competitive, full-service package for nuclear reactor exports to third countries, which is something the nuclear industries in both countries have desired for many years.

### *Operation and Decommissioning of Existing Reactors*

While there should be much focus over the next five years on supporting advanced SMR deployment and related fuel supply, the existing fleets of nuclear reactors in both the United States and South Korea should not be ignored. Many of these reactors are slated to operate for decades to come, but others will be shut down and enter decommissioning in the coming years. Both operating and decommissioning legacy reactors present opportunities for advancing U.S.-ROK civil nuclear cooperation.

For operating reactors, the U.S. and ROK nuclear industries have worked to increase fleetwide capacity factors, and reactor capacity factors have topped 90% in both countries in recent years.[15] This does not leave much room for improvement. Nonetheless, continued sharing of best practices in reactor operations can help ensure that existing reactors continue to operate with high-capacity factors. In addition, South Korea can learn from how U.S. reactors continue operating beyond 40 years. Initial reactor licenses in both countries are for 40 years, but many reactors in the United States are now slated to operate up to 60 years or more. As South Korea's reactor fleet ages, reactor operators and regulators in both countries should increase information exchanges on safe, efficient reactor operations beyond 40 years.

Not all reactors will operate beyond 40 years, and safely decommissioning reactors is an important part of the nuclear industry's long-term viability. The first two reactors to shut down in South Korea came recently in 2017 and 2019.[16] The Moon administration announced plans in 2019 to bolster South Korea's decommissioning capabilities, but this development is still in the early stages and will require several more years to acquire the necessary technologies.[17] Partnering with U.S. firms that have significant decommissioning experience, such as Holtec, could speed up South Korea's acquisition of decommissioning technology. Such corporate partnerships also could bolster U.S.-ROK nuclear reactor exports by offering better end-of-life services to customers.

Related to reactor operation and decommissioning is spent nuclear fuel (SNF) management, which is a challenge that the nuclear industry has struggled to address for decades. Neither the

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14 "U.S.-Republic of Korea (ROK) Agreement for Peaceful Nuclear Cooperation," U.S. Department of State, Bureau of International Security and Nonproliferation, Fact Sheet, https://www.state.gov/remarks-and-releases-bureau-of-international-security-and-nonproliferation/u-s-republic-of-korea-r-o-k-agreement-for-peaceful-nuclear-cooperation.

15 "Nuclear Power in South Korea," World Nuclear Association, June 2022, https://world-nuclear.org/information-library/country-profiles/countries-o-s/south-korea.aspx; and "U.S. Nuclear Industry," U.S. Energy Information Administration, April 18, 2022, https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php.

16 "Nuclear Power in South Korea."

17 Kang Yoon-seung, "S. Korea to Foster Nuclear Plant Decommissioning Industry amid Phaseout Policy," Yonhap News Agency, April 17, 2019, https://en.yna.co.kr/view/AEN20190417000900320.

United States nor South Korea has a long-term SNF management plan in place, but the two countries recently concluded a ten-year joint fuel cycle study on using pyroprocessing and sodium-cooled fast reactors (Pyro-SFR) to process and better manage SNF.[18] Development and deployment of a Pyro-SFR system is a long-term project. In the meantime, the United States and South Korea could work together on expanding the use of dry casks for interim storage of SNF. Siting interim and long-term storage facilities for SNF is an ongoing challenge that could be addressed through technological cooperation and information exchanges. Doing so is necessary for the current and future viability of nuclear power.

## Conclusion

The current decade could be decisive for the future of nuclear power in South Korea and the United States. Although there are always difficult political challenges associated with nuclear power, leaders in both Seoul and Washington have shown support for it as part of their plans to achieve their decarbonization goals, including maximizing the use of existing reactors and helping the deployment of advanced SMRs. Yet, if nuclear power cannot make significant advancements by 2030, then other carbon-free energy technologies could push out nuclear power as a significant contributor to a net-zero emissions economy in both countries.

Strengthening bilateral cooperation on advanced SMR development and deployment, U.S. LEU and HALEU capacity, and existing reactor operations and decommissioning (including related SNF management) would help nuclear power maintain its place in a net-zero-emissions economy. Moreover, securing the future of nuclear power in their home markets will help improve U.S.-ROK joint competitiveness in nuclear reactor exports to other countries and broaden nuclear power's role in addressing climate change globally. But there is little time to waste before this window of opportunity for nuclear power starts closing, so U.S. and ROK leaders must act now.

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[18] Hae-Sung Lee, "U.S., Korea Approve Nuclear Fuel Recycle Technology," *Korea Economic Daily*, September 2, 2021, https://www.kedglobal.com/%5bexclusive%5d-energy/newsView/ked202109020004.

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# The Eco Smart City: Can We Catch Two Rabbits at Once?

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# EXECUTIVE SUMMARY


This essay examines the emerging concept of the eco smart city in South Korea, compares it with existing smart cities, and considers policy implications for both U.S. and South Korean cities.

## MAIN ARGUMENT

The eco smart city project is an attempt to catch two rabbits—carbon neutrality and the fourth industrial revolution—at once in the urban space. The project aims to combine the two policies that have been promoted separately in South Korea: the eco city policy in response to the new climate regime and the smart city policy for securing competitiveness in the era of the fourth industrial revolution. It attempts to generate synergy by transforming the conflicting paradigms into a complementary relationship between the two approaches. The ultimate goal is to reduce greenhouse gas emissions and create green jobs by applying the technological innovation of smart cities to the climate crisis response.

## POLICY IMPLICATIONS

- The eco smart city project is expected to contribute to the realization of the 2050 carbon-neutral society declared by the South Korean government. To this end, cross-ministerial governance is important for the integrated promotion of the related projects of each ministry and the efficient use of the budget.
- To achieve project sustainability, diverse support and leadership from the government are essential, including nurturing start-ups from the initial stages, developing business models, and encouraging voluntary citizen participation.
- Consensus building and joint pilot project initiatives for the realization of eco smart cities, especially in developing countries, will be promising opportunities for cooperation modalities between the U.S. and South Korea.

The world is desperate to catch two rabbits these days. The first rabbit is carbon neutrality in the new climate regime. The rapid pace of economic development has resulted in the immense destruction of nature and the pollution of the environment. Experts warn that little time and few opportunities are left to recover. Humanity's failure to catch this rabbit could trigger the sixth mass extinction event on Earth. The second rabbit is the fourth industrial revolution. Information and communications technology (ICT), represented by the internet, cloud, big data, and mobile, is bringing unprecedented levels of productivity and innovation across the economy, society, and industry. The fourth industrial revolution is also referred to as the "data revolution" and is dramatically improving quality of life through super connectivity and artificial intelligence (AI).

These two rabbits mainly inhabit cities. The urban population is currently 3.5 billion people—nearly half of the human population—and is projected to rise to 5 billion by 2030. While cities only take up 3% of the Earth's surface, they are a key area of environmental pollution, accounting for 60%–80% of energy consumption and more than 75% of carbon emissions.[1] Therefore, to achieve carbon neutrality, efforts to save energy and emit less carbon in urban areas are especially pertinent.

Cities are also suffering from various issues such as traffic congestion, crime, natural disasters, and environmental pollution due to rapid urbanization in recent decades. Attempts to solve these problems using the second rabbit, the fourth industrial revolution, are accelerating around the world. Cities are where most data, which is the core fuel of the fourth industrial revolution, is generated, processed, and consumed. To facilitate this, integrated platforms have been established to transform cities into spaces for innovation—in essence, what smart city projects represent. Many countries around the world, including the Republic of Korea (ROK), are investing their public and private resources at maximum capacity in promoting smart city initiatives in urban areas regardless of size.

This essay examines the role for eco cities in the Korean New Deal and analyzes the key components of an eco smart city that differentiate it from the existing smart city concept. The essay then considers policy options for South Korea, including the potential for future U.S.-ROK collaboration to promote eco smart city initiatives in developing countries.

## The Eco Smart City

### *The Green and Digital New Deal Policy of South Korea*

The two waves of the new climate regime and the fourth industrial revolution are coming in at the same time and are expected to continue for around the next 30 years. Traditionally, these two megatrends have been guided by mutually exclusive interests, with the former representing environmental values and the latter representing economic values. As these values collide, it has been difficult to balance them in crafting national policies. However, the ROK government recently announced the Korean New Deal as a growth engine for the country, which consists of two axes: the Green New Deal and the Digital New Deal.

1 Korea Research Institute for Human Settlements, *Eco-Smart City Initiatives for Coping with Global Climate Change* (Yeongi-gun: Korea Research Institute for Human Settlements, 2021).

The eco smart city project addresses both issues at once in the urban space by combining two policies that have been promoted separately in South Korea: the eco city policy in response to the new climate regime and the smart city policy for securing competitiveness during the fourth industrial revolution. The eco smart city project is an attempt to reduce greenhouse gas emissions and create green jobs by applying the technological innovation of smart cities to the climate crisis response.

More broadly, the eco smart city pursues the United Nations Sustainable Development Goal 11 to "make cities inclusive, safe, resilient and sustainable."[2] It aims to fulfill its vision for building sustainable cities with happy citizens through a strategy that leads "from 6C zero to 6S full."[3] According to this strategy, the prerequisite for true happiness is met by eliminating six factors that make citizens unhappy (6C): $CO_2$, casualty, contagion, congestion, crime, and complaint. Next, the strategy focuses on fulfilling six happiness factors (6S): sustainability, solidity, santé (health), smartness, safety, and satisfaction. These paired concepts encompass maximizing urban sustainability by reducing environmental pollution, ensuring public safety through measures such as disaster warning systems, and helping citizens lead healthy lives by protecting them from diseases. In addition, the eco smart city concept actively utilizes smart infrastructure and technologies to prevent crime and provide highly customized services for citizens in various areas such as transportation and public administration.

### *Elements of the Eco Smart City*

The eco smart city project is differentiated from existing smart city projects in that it aims to implement the following seven elements in an integrated manner: the hierarchy of the goal system, inclusive service provision, eco-friendly urban structural reform, an eco-friendly mobility paradigm shift, net-zero emissions, citizen governance, and a monitoring system of key performance indicators (KPIs).

*Hierarchy of the goal system*. The ultimate goal of the eco smart city project is to build a carbon-neutral and healthy city. While existing smart city projects pursue a variety of goals for each service area, the hierarchy or priorities among these goals have typically been unclear. The eco smart city has simple and clear goals to reduce greenhouse gas emissions and enable citizens to live healthy and happy lives. Such goals were set because they are the best metrics for the sustainability of the natural and settlement environments of modern cities. The progress toward achieving these two ultimate goals is assessed by a series of detailed KPIs.

*Inclusive service delivery*. While existing smart city projects provide services mainly for ordinary citizens with digital literacy, the eco smart city prioritizes special services for socially underprivileged citizens who are digitally vulnerable. It focuses on enabling vulnerable citizens to enjoy and engage in city life as much as other citizens by harnessing ubiquitous technologies such as invisible sensors and the Internet of Things so that the benefits of services are evenly distributed without marginalizing certain groups.

*Eco-friendly urban structural reform*. Existing smart city projects tend to be software-oriented through the city's information centers. However, the goal of carbon neutrality will not be achieved without the fundamental improvement of urban infrastructure. Therefore, on top of software, the eco smart city will also promote hardware improvement and remodeling projects by enhancing the

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[2] United Nations, "Sustainable Development Goal 11," 2015, https://sdgs.un.org/goals/goal11.

[3] National Research Council (Republic of Korea), "Eco Smart City Initiatives for Coping with Global Climate Change," 2021.

eco-friendliness of buildings and infrastructure to reduce greenhouse gas emissions. In addition, green infrastructure like parks and green corridor provisions will work for reducing heat islands and urban flooding caused by climate change. It is also advantageous to build eco smart towns, which adapt the eco smart city concept to a smaller scale.

*Eco-friendly mobility paradigm shift*. Mobility projects in existing smart cities have focused on reducing traffic congestion and accidents as an extension of the smart transportation system that has been promoted so far. By contrast, mobility in the eco smart city focuses on eco-friendliness. Specifically, the focus is on using eco-friendly energy sources, promoting eco-friendly modes of transportation, and establishing an eco-friendly operation system as well as a data collection system that can monitor and inspect its performance. To achieve these goals, services must be developed that utilize innovative technologies such as autonomous vehicles, drone delivery, shared vehicles, and personal mobility.

*Net-zero emissions*. Existing smart cities focus on the pursuit of energy efficiency and savings through measures such as smart grids and metering. Going one step further, the eco smart city aims to achieve net-zero carbon emissions. On top of various technology developments for conserving energy, the ultimate goal of the eco smart city is to achieve energy self-sufficiency by maximizing the use of new, renewable, and recycled energy.

*Citizen governance*. Existing smart city projects are typically aligned with the project framework set by the central government. As uniform projects for each selected local government are promoted, few mechanisms exist for communicating the opinions of local residents and businesses. Among current smart city projects, there has also been a lack of clarity and effectiveness in the division of roles among the central government, local governments, private sector companies, and citizens. Under the slogan "Smart City by Smart Citizen," the eco smart city positions citizens to closely engage as the owners of the project from planning to development and evaluation through activities such as making decisions, expressing opinions, experiencing trial services, and participating in simulations using formats such as blockchains and living labs. Efforts to distribute governance between the public and private sectors for this purpose will become a core element of this project.

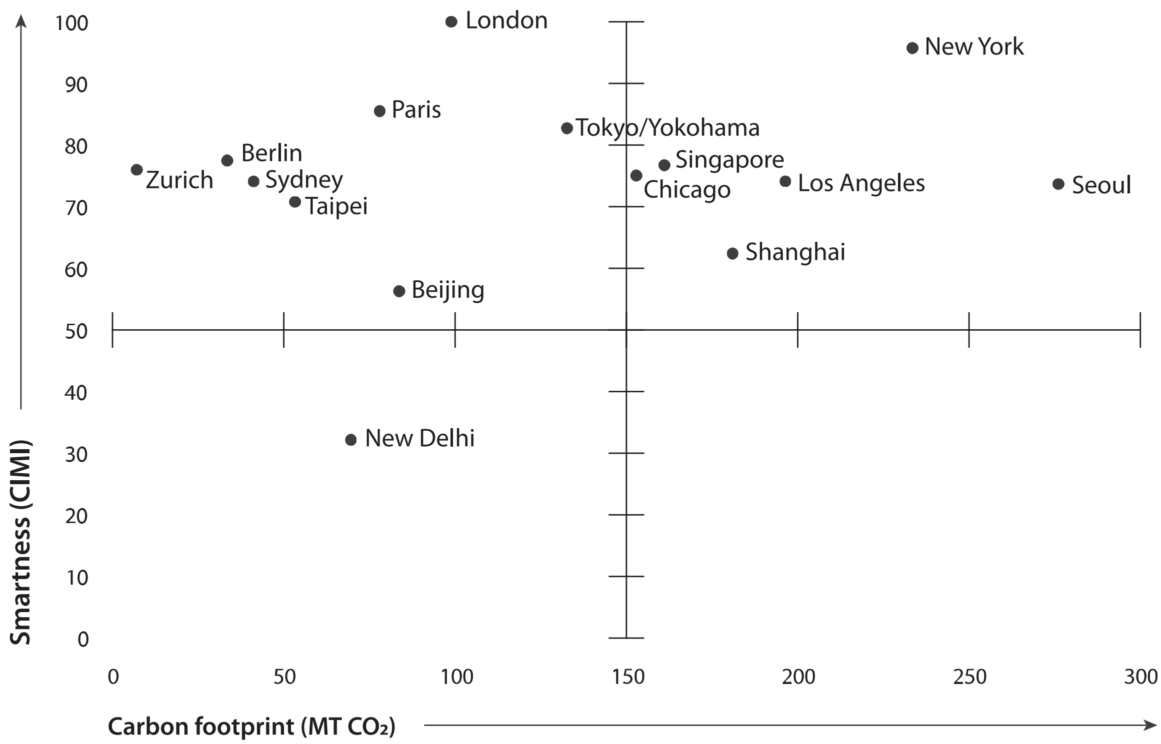
*KPI monitoring system*. Existing smart city projects have had significant limitations in measuring project performance. Data collection has been difficult due to the ambiguous performance indicators and because detailed statistics are often either not collected or based on past data. To address these issues, it is important to develop suitable indicators and build a system that enables real-time monitoring using ICT. A key element of the eco smart city project is to establish a KPI monitoring system to assess progress using various technologies, including a virtual simulation with a digital twin, big data analysis, and AI. Indicators such as the energy efficiency index, tracking of $CO_2$ emissions per citizen, and the net-zero performance index are the core monitoring targets for assessing the level of eco smart city development.

## U.S.-ROK Cooperation for the Eco Smart City Project

Since the 1990s, South Korea has mainly referred to the U.S. system in building its information technology sector, ensuring compatibility and interoperability among systems by referring to U.S. standards. Likewise, in smart city development, South Korea has been actively following the strategy of the U.S. government by encouraging major cities and technology holding companies to voluntarily participate through large-scale budget support from the central government and creating synergies based on public-private partnerships. Since 2019, South Korea has built a close cooperative relationship with the United States by leveraging the creativity of the private sector through the world's leading information technology companies and actively promoting the smart city challenge projects of the United States, such as the Columbus smart city project.

However, in terms of carbon neutrality, cities in the United States and those in South Korea are in a comparable position. As shown in **Figure 1**, New York, Los Angeles, Chicago, and Seoul have high scores in smartness but also high levels of carbon emissions, which contrasts with advanced European cities that have good results in both indices. While ROK and U.S. cities tend to be smarter than European cities, they are lagging in terms of eco-friendliness.

FIGURE 1 Select cities by smartness and carbon footprint




SOURCE: Daniel Moran et al., "Carbon Footprints of 13,000 Cities," *Environmental Research Letters* 13, no. 6 (2018); and IESE, Cities in Motion Index, 2020, https://citiesinmotion.iese.edu/indicecim/index.eng.html.

## *Zurich as a Case Study*

Since the early 2000s, many advanced European cities have actively promoted eco city projects with high effectiveness. Zurich has been making efforts to reduce the rise in global temperatures to less than two degrees Celsius, as outlined in the Paris Climate Agreement. This overarching goal is a key first step in establishing a true eco smart city hierarchy of priorities. The 2000-Watt Society's agenda aims to, among other goals, reduce the city's energy consumption by one-third by 2050 (from 6,000 to 2,000 watts per person) and maintain the total annual greenhouse gas emissions at one ton. To achieve this goal, Zurich has implemented various policies to pursue resource-friendly production and consumption in five strategic areas: consumption, residential environment, buildings, energy supply, and mobility. In pursuit of efficient urban development and high-quality residential environments, which are both key components of an eco smart city, these policies also include remodeling eco-friendly buildings, increasing renewable energy consumption and waste recycling, and reducing transportation pollution. In fact, the 2014 performance analysis showed that this agenda led to a reduction of energy use per person by 800 watts, a decrease of carbon emissions by 1.5 tons, and an increase in the share of renewable energy use from 11% to 19%.[4] This type of performance analysis demonstrates the importance of utilizing a concrete KPI monitoring system when designing an eco smart city.

Many other cities in Western Europe are actively participating in similar carbon reduction initiatives and establishing themselves as global models. These efforts aim to reduce national expenditures on purchasing energy from abroad and to invest the savings in regional development instead. The objective is to improve energy efficiency using current green and smart technologies and establish a regular monitoring system—both key elements of a true eco smart city. To realize the eco smart city concept, cities in both South Korea and the United States can benchmark the European approach of promoting voluntary participation by citizens and encouraging pro-environment ways of thinking. The concluding section considers several policy options for South Korea.

## Policy Options for a Successful Eco Smart City Project in South Korea

In a climate crisis that is worsening day by day, humanity is already headed for catastrophe. The future is uncertain unless we recognize the seriousness of the situation and change our environment into a virtuous cycle as much as possible. The eco smart city project is expected to contribute to achieving the ROK government's goal of a carbon-neutral society by 2050. To this end, above all, it is important to establish cross-ministerial governance for the integrated promotion of related projects and the efficient use of resources. In particular, duplication and blind spots must be eliminated on a larger scale through closely examining coherence among projects currently promoted at various institutions.

In addition, it is essential to refine the goals and clarify priorities. The ultimate goals of these projects should be reducing greenhouse gas emissions and promoting health. A detailed KPI system should be established to regularly monitor whether the goals are being achieved. For this purpose, technological competence should be leveraged in areas such as digital twins, AI, and big data. A specialized management organization should also be established that can monitor the achievement of targets every year until 2050 and assist with smooth implementation.

Smart city projects in the past have mostly had a top-down approach led by the public sector. However, the eco smart city model requires a self-sustaining ecosystem through a partnership between the public and private sectors. The ultimate goals of the eco smart city cannot be achieved through one-sided, supplier-centered technology development and service provision. To achieve

4 Stadt Zürich, "Roadmap 2000-Watt Society," November 2016.

project sustainability, diverse support and leadership from the government are essential and require nurturing start-ups from the initial stage, developing business models, and encouraging voluntary citizen participation.

Furthermore, the "glocalization"—that is, the pursuit of both globalization and localization—of the eco smart city concept should be sought in parallel so that South Korea can share experiences and provide customized solutions to developing countries suffering from serious problems caused by rapid urbanization. The United States and South Korea have the potential to be collaborative partners in promoting eco smart city initiatives in developing countries if they can build on synergies in capabilities. Consensus-building forums and pilot project initiatives between U.S. and ROK official development assistance institutions might be a promising first step in further developing such cooperation.

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# Geoeconomics and Politics in Lawsuits on Electric Vehicle Batteries

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## EXECUTIVE SUMMARY

This essay examines the policy landscape and the extremely competitive nature of renewable energy in the electric vehicle (EV) battery industry in energy cooperation between the U.S. and South Korea.

### MAIN ARGUMENT

As digitization accelerates and climate change is increasingly emphasized in the policy agenda, EVs are gaining traction in the transition toward a sustainable future. Washington has high hopes for joint ventures (JVs) between U.S. automakers and South Korean EV battery producers, which have pledged to build new plants for EVs and EV battery manufacturing in the U.S. However, very little policy attention is paid to the limits of cooperation. The case of LG vs. SK that was adjudicated by the U.S. International Trade Commission (USITC) foreshadows the potential legal conflicts looming in the industry in the next decade—not just between South Korean players or even between U.S. and South Korean JVs, but also with Chinese and Japanese players. The complexity of the Inflation Reduction Act raises further concerns that cooperation could become mired in lawsuits without greater policy attention to these challenges.

### POLICY IMPLICATIONS

- Given the business interests that may vary from government policy directions, future conflicts in the EV and battery industries could become litigious.
- The LG vs. SK case at the USITC is a prelude to such cases. Given this prospect, the South Korean legal system may accommodate a system akin to "e-discovery" in the coming years for its firms to conduct litigation at home, diversifying the platform for lawsuits.
- So long as "strategic" trade is preferred to "fair" trade by U.S. policymakers in key industries, including semiconductors, government pressure to line up companies in its favor regardless of jurisdiction may backfire due to the potential mismatch of business and government interests.

With accelerated digitization and an increased emphasis on climate change in the policy agenda today, electronic vehicles (EVs) are gaining traction in the transition toward sustainable futures. A critical component of EV production is batteries, which are essential to electrify transportation.[1] As the diversity of EV models attracts customers, more policy emphasis is placed on the durability, longevity, safety, and stability of EV batteries. While South Korean battery makers have joined with U.S. automakers to supply EV batteries, this partnership is at risk of future lawsuits due to its limited nature and growing geopolitical tensions over strategic trade to counter the dominance of Chinese firms in the industry.

Since before 2020, EV batteries—and the rare earth elements (REEs) that they consist of—have been of concern to the U.S. International Trade Commission (USITC). The USITC is an independent agency that was established in 1916 to adjudicate on industrial issues and international trade issues—notably regarding imports claimed to injure a domestic industry or violate U.S. intellectual property rights. The USITC had been eyeing the EV battery industry with a specific emphasis on the breakdown of the supply chain, ranging from battery cells and modules to battery packs.[2] The United States did not invest much in the EV battery industry during the Trump administration, but instead focused on fossil fuels.[3] In 2021, EV batteries and large-capacity batteries broadly became one of the core components addressed in the supply chain review by the White House at the outset of the Biden administration as the Covid-19 pandemic continued.[4]

This essay analyzes three key areas of this issue: geoeconomics (REEs required for EV battery manufacturing), legality (the "e-discovery" system), and domestic politics (lobbying on Capitol Hill). The first section includes a brief reflection on the recently passed Inflation Reduction Act (IRA), which South Korean EV and battery producers have maintained potentially violates both the Korea-U.S. Free Trade Agreement (KORUS FTA) and World Trade Organization (WTO) rules (national treatment and nondiscrimination).[5] After unravelling the LG vs. SK case in the second section, the essay considers the domestical political dimension. It calls for more acute policy attention to the legal nature of future tech conflicts, given that company interests will not align solely with those of governments, and raises concerns that conflict is inherent in the current

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[1] Batteries used for EVs range from the 2022 Tesla Y Model's 55 kilowatt-hour (kWh) "Blade batteries" of lithium iron phosphate cells from China's BYD that are produced in Germany to the 2023 Hyundai IONIQ 6's 53–77.4 kWh nickel-cobalt-manganese lithium batteries that are produced in South Korea by LG Energy Solution or SK On for all non-China markets and by CATL for the Chinese market. See Mark Kane, "Report: BYD-Powered Tesla Model Y Receives EU Approval," InsideEVs, August 12, 2022, https://insideevs.com/news/604025/byd-tesla-modely-eu-approval; and Michael Herh, "Samsung SDI Not Listed as Battery Vendors for HMG: Hyundai Motor Group Places Big Battery Orders with LG and SK," BusinessKorea, May 6, 2022, http://www.businesskorea.co.kr/news/articleView.html?idxno=92258.

[2] David Coffin and Jeff Horowitz, "The Supply Chain for Electric Vehicle Batteries," *Journal of International Commerce and Economics* (2018); Sarah Scott and Robert Ireland, "Lithium-Ion Battery Materials for Electric Vehicles and their Global Value Chains," USITC, Working Paper, June 2020, https://www.usitc.gov/publications/332/working_papers/gvc_overview_scott_ireland_508_final_061120.pdf; and Gregory M. LaRocca, "Global Value Chains: Lithium in Lithium-Ion Batteries for Electric Vehicles," Office of Industries, USITC, Working Paper, July 2020, https://www.usitc.gov/publications/332/working_papers/no_id_069_gvc_lithium-ion_batteries_electric_vehicles_final_compliant.pdf.

[3] The Obama administration began investment in EVs at the federal level, but without resorting to heavy reliance on subsidies and industrial policy, as China has done. See "President Obama Announces $2.4 Billion in Funding to Support Next Generation Electric Vehicles," U.S. Department of Energy, March 19, 2009, https://www.energy.gov/articles/president-obama-announces-24-billion-funding-support-next-generation-electric-vehicles; and "Fact Sheet: Obama Administration Announces Federal and Private Sector Actions to Accelerate Electric Vehicle Adoption in the United States," White House, July 21, 2016.

[4] The White House report on building resilient supply chains includes EV batteries as one of the core components of future growth, with analysis on large-capacity batteries by the U.S. Department of Energy. See White House, *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100-Day Reviews under Executive Order 14017* (Washington, D.C., June 2021), https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.

[5] The IRA includes a final assembly requirement, limiting the tax credit for purchasing an EV to those vehicles assembled in the United States. The full text of the IRA is available at https://www.congress.gov/bill/117th-congress/house-bill/5376. For the final text of the KORUS FTA, see https://ustr.gov/trade-agreements/free-trade-agreements/korus-fta/final-textsee. The WTO rules are available at https://www.wto.org/english/docs_e/legal_e/legal_e.htm.

ROK-U.S. cooperation on EV batteries. Thus, cooperation may be short-lived due to overwhelming competition not just with Chinese players (notably CATL and BYD) but also with corporate actors from South Korea and Japan within the overall EV industry.[6]

## Geoeconomics: Lagging U.S. Capabilities amid Competition with China

As EV sales rise, the demand for EV batteries will come from passenger vehicles, placing pressure on the supply chain for REEs such as lithium, cobalt, manganese, and nickel.[7] Given China's control of a vast quantity of REE deposits that are required for EV battery production—notably its majority ownership of mines for cobalt in the Democratic Republic of the Congo (which possesses 53.3% of the world's known deposits)[8] and lithium in Chile (which possesses 55.5% of the world's known deposits)[9]—EV battery producers have long relied on China as the main source of REEs. While China's dominance in EV battery technology and production is mostly due to Chinese government subsidies based on industrial policy, Washington's lack of investment in EV batteries has left the United States falling behind by several years in the industry.

As noted above, during the Trump administration the United States prioritized fossil fuels and shale gas exports abroad. While shale gas exports and fracking continued under the Biden administration, the United States faced a situation in which it increasingly relied on EV batteries made in China to meet clean transportation goals. Given that EV battery production is spearheaded by the three major East Asian economies—China, South Korea, and Japan—the United States came to the realization that it will be unable to compete with China in EV batteries if it does not partner with South Korean and Japanese firms. Amid growing geopolitical tensions with China, U.S. automakers and South Korean EV battery producers have formed partnerships and joint ventures (JVs). Examples include SK On and Ford's five-year JV BlueOval SK LLC, which would establish battery plants in Tennessee and Kentucky,[10] and a U.S. Department of Energy joint loan totaling $2.5 billion to LG Energy Solution and General Motors to build EV battery factories in Ohio, Tennessee, and Michigan.[11] The provisions in the IRA of 2022 reveal the United States' wariness about the dominance of Chinese EV batteries and its intentions to restrict U.S. subsidies to EV batteries that contain Chinese materials in an effort to limit Chinese expansion in the U.S. EV market. The passage of the IRA has already spurred competition and lobbying among companies and JVs for better positioning in the U.S. market and beyond. For instance, Hyundai's IONIQ 5 and 6, both produced in South Korea, will not qualify for U.S. government subsidies for

6 Shoichiro Taguchi, "Toyota to Invest $5.3bn to Make EV Batteries in U.S. and Japan," *Nikkei Asia*, August 31, 2022. https://asia.nikkei.com/Business/Automobiles/Toyota-to-invest-5.3bn-to-make-EV-batteries-in-U.S.-and-Japan.

7 Colin McKerracher et al., "Electric Vehicle Outlook 2022," Bloomberg New Energy Finance, https://about.bnef.com/electric-vehicle-outlook; and M. Stanley Whittingham et al., "Enabling Future of AI: Battery to Semiconductor" (conference presentation, Chey Institute for Advanced Studies, Seoul, 2021).

8 International Renewable Energy Agency (IRENA), *Renewable Energy Market Analysis: Africa and Its Regions* (Abu Dhabi: IRENA, 2022), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Market_Africa_2022.pdf.

9 Robert Rapier, "The World's Top Lithium Producers," *Forbes*, December 13, 2020, https://www.forbes.com/sites/rrapier/2020/12/13/the-worlds-top-lithium-producers/?sh=2814e0ef5bc6.

10 "Ford, SK On Finalize U.S. Joint Venture on EV Batteries," Reuters, July 14, 2022, https://www.reuters.com/business/autos-transportation/ford-sk-finalize-us-ev-battery-joint-venture-2022-07-14.

11 Jack Ewing, "Energy Department Will Lend G.M. and LG $2.5 Billion to Build Battery Factories," *New York Times*, July 22, 2022, https://www.nytimes.com/2022/07/25/business/energy-department-gm-lg-battery-loan.html.

EVs under the IRA.[12] This has caused South Korea's Ministry of Trade, Industry and Energy to voice the concerns mentioned above that the IRA violates both the KORUS FTA and WTO rules.

## Legality: LG Energy Solution vs. SK Innovation at the USITC

The dispute between LG Energy Solution and SK Innovation illustrates that in an intensely competitive industry, such as the production of EV batteries, even companies of the same nationality would go to court to gain leverage in global market shares. Moreover, when companies operate on foreign soil, such as the United States, the platforms for adjudication are diversified. LG strategically chose the USITC as its platform for adjudication rather than U.S. federal or district courts, or the courts of South Korea, because of the USITC's e-discovery system.[13] Another factor was the level of compensation for punitive damages that complainants may receive, which exceeds that of South Korean courts, where the median of compensation packages is 11% of what is offered by U.S. courts.[14]

On April 29, 2019, LG Energy Solution (then called LG Chem) filed a complaint with the USITC against SK On (under SK Innovation) for violation of subsection (a)(1)(A) of Section 337 of the Tariff Act of 1930. The law in question regulates the importation into the United States or the sale within the United States after importation of certain products by reason of the misappropriation of trade secrets, which could substantially injure an industry in the United States.[15] The case could be filed because both companies operate in the United States as well as in South Korea. LG alleged that SK On had poached some core 76 engineers with knowledge of its EV battery production technology, while SK On argued that the engineers transferred over to SK from LG voluntarily.

LG moved for an order entering default judgment against SK On for contempt of Order no. 13, which granted in part the motion to compel forensic examination of SK's computer system due to spoliation of evidence, triggering the USITC's e-discovery system. On February 14, 2020, the administrative law judge at the USITC issued the subject an initial determination in Order no. 34, finding that the respondents spoliated evidence and that SK was in default. In response, SK filed a petition on March 11, 2020, for the USITC to review the initial determination, which LG opposed.

On April 17, 2020, the USITC agreed to review the initial determination in its entirety, which involved seeking briefings on remedy from both parties, interested government agencies, and any other third party and the public.[16] LG and SK filed their opening briefs on the issues under review

12 The IRA amends the previous Qualified Plug-in Electric Driver Motor Vehicle Credit into what is now the Clean Vehicle Credit. See "IRC 30D New Qualified Plug-in Electric Drive Motor Vehicle Credit," Internal Revenue Service (IRS), August 16, 2022, https://www.irs.gov/businesses/irc-30d-new-qualified-plug-in-electric-drive-motor-vehicle-credit. The IRA adds a new requirement for final assembly in North America that took effect on August 16, 2022. See "Plug-in Electric Drive Vehicle Credit (IRC 30D)," IRS, August 16, 2022, https://www.irs.gov/businesses/plug-in-electric-vehicle-credit-irc-30-and-irc-30d. The U.S. Department of Energy lists EV models produced in 2022 and projected in 2023 that would qualify for the Clean Vehicle Credit. See U.S. Department of Energy, Alternative Fuels Data Center, https://afdc.energy.gov/laws/inflation-reduction-act.

13 The e-discovery system, as amended by the U.S. Federal Rules of Civil Procedure in 2006, extends the scope of paper documents of discovery to electronically stored information produced with computers or mobile phones and smartphones, such as recordings, e-mails, and videos. See "Federal Rules of Civil Procedure," U.S. Courts, December 1, 2020, https://www.uscourts.gov/rules-policies/current-rules-practice-procedure/federal-rules-civil-procedure.

14 Shim Jae-hoon, "Wae hangug gieobdeul-eun migug beob-won-eulo ganeuga: 4cha san-eobhyeogmyeong sidaeui gugjesosong kiwodeu ligeoltekeuwa jeonjajeung-geogaesi" [Why Korean Companies Go to U.S. Courts: Legal Tech and Electronic Evidence Disclosure, Keywords in International Litigation in the Era of the Fourth Industrial Revolution], Cloud9, 2020.

15 USITC, "Notice of Institution of Investigation in the Matter of Certain Lithium Ion Batteries, Battery Cells, Battery Modules, Battery Packs, Components Thereof, and Processes Therefore," Inv. No. 337-TA-1159, May 29, 2019, https://www.usitc.gov/secretary/fed_reg_notices/337/337_1159_notice_05292019sgl.pdf.

16 USITC, "Notice of Institution of Investigation," Inv. No.337-TA-1159, April 17, 2020, https://www.usitc.gov/secretary/fed_reg_notices/337/337_1159_notice_04172020sgl_0.pdf.

on May 1, 2020, and SK even requested a public hearing before the USITC. On May 12, 2020, both parties filed reply briefs on the issues under review. Certain non-parties also submitted their reply comments on remedial orders and public interest, many of which held vested interests from the government or industry.

The policy relevance of the case for the renewable energy transition and the American jobs at stake from the potential closure of the SK EV battery plant in Georgia made the case a politically sensitive one. The USITC decided to extend the target date for completion of the investigation from December 10, 2020, to February 10, 2021, given the change of government from the Trump administration to the Biden administration.[17] Thus, President Joe Biden would be granted time after his inauguration to consider whether to overturn a potential USITC ruling within the 60-day period.

On February 10, 2021, the USITC affirmed the administrative law judge's initial determination and found that SK had committed a violation of Section 337 of the Tariff Act of 1930. The court ruled that the following remedy is appropriate: (1) a limited exclusion order prohibiting the entry of certain lithium-ion batteries and related components, and (2) cease and desist orders directed to SK. The remedial orders effectively meant that SK On would close down its EV factory in Georgia and would allow the company's partners time to transition to new domestic suppliers (four years for Ford's EV F-150 program, and two years for Volkswagen of America).

Biden was left with the decision of whether to overturn the USITC ruling.[18] The two parties, however, eventually came to a last-minute, out-of-court settlement of $1.8 billion on April 10, 2021, just one day before the 60-day period for the president to overturn a USITC ruling would have lapsed. In the event that Biden vetoed the ruling, LG was preparing to file another lawsuit, this time in the European Union, given that both firms also operate in Europe. All told, the legal battle lasted from June 2019 to February 2021, with both sides lobbying the U.S. Congress and Biden administration to help decide the case in their favor before they finally agreed to settle under mounting pressures.

## The U.S. Domestic Politics of EV Batteries and Responses from South Korea

During the USITC case, both parties pursued separate cases on patents, citing violation of Section 337 of the Trade Act of 1930. SK On won its case (No. 337-TA-1179) on February 12, 2021,[19] while LG lost its case (No. 337-TA-1181) on June 3, 2021.[20] SK On's successful patent case gave it a small boost at a time of low morale due to the loss of the larger trade-secret theft case (No.

17 USITC, "Notice of Commission Decision Extending the Target Date for Completion of the Investigation," Inv. No. 337-TA-1159, December 9, 2020, https://usitc.gov/secretary/fed_reg_notices/337/337_1159_notice_12092020sgl.pdf.

18 USITC, "Notice of the Commission's Final Determination Finding a Violation of Section 337; Issuance of a Limited Exclusion Order and Cease and Desist Orders; Termination of the Investigation," Inv. No. 337-TA-1159, February 10, 2021, https://www.usitc.gov/system/files/secretary/fed_reg_notices/337/337_1159_notice_02102021sgl.pdf.

19 USITC, "Certain Pouch-Type Battery Cells, Battery Modules, and Battery Packs, Components Thereof, and Products Containing the Same; Commission Determination Not to Review an Initial Determination Granting Complainants' Motion to Amend the Complaint and Notice of Investigation and Terminate the Investigation as to Certain Claims Based on Withdrawal of the Complaint," U.S. Federal Register, February 12, 2021, https://www.federalregister.gov/documents/2021/02/12/2021-02878/certain-pouch-type-battery-cells-battery-modules-and-battery-packs-components-thereof-and-products.

20 USITC, "Certain Lithium-Ion Battery Cells, Battery Modules, Battery Packs, Components Thereof, and Products Containing the Same; Commission Determination to Grant a Joint Motion to Terminate the Investigation on the Basis of a Settlement Agreement; Termination of the Investigation," U.S. Federal Register, June 3, 2021, https://www.federalregister.gov/documents/2021/06/03/2021-11621/certain-lithium-ion-battery-cells-battery-modules-battery-packs-components-thereof-and-products.

337-TA-1159), leading the company to initially pursue a strategy to lobby the incoming Biden administration to overturn the USITC ruling instead of negotiating an out-of-court settlement with LG. Notably, a U.S. presidential veto of a USITC import exclusion is extremely rare, having been used only once in 2013 by then president Barack Obama in a dispute between Samsung and Apple over consumer electronics.[21]

Politicians and companies with vested interests in SK On's EV battery plant operation actively engaged in the process. U.S. lawmakers conducted considerable outreach to their constituents about the possibility that SK On might need to close its operations in Georgia, which is a swing state in U.S. politics.[22] Georgia governor Brian Kemp asked the president to veto the USITC ruling,[23] and Senator Raphael Warnock of Georgia stated that the ruling seriously threatened his constituencies at the nomination hearing of Polly Trottenberg for deputy secretary of transportation.[24] Three House representatives of Georgia and Tennessee (where the Volkswagen plant is) sent letters to LG and SK On appealing for them to settle the case. Then South Korean prime minister Chung Sye-kyun also called for the two companies to reach a settlement, noting that the feud is "embarrassing" and "counterproductive" and would only benefit competing EV battery makers from China and Japan.[25]

Volkswagen and Ford, for their part, presented statements before the USITC expressing concerns that their EV production hinged on the ruling and pleading for the commission to not issue an import exclusion order for SK On. Volkswagen even asked that its grace period be extended from two years to four years, which was the grace period granted to Ford. Ford, which was in a partnership with both SK On and LG, urged the two companies to settle. Eventually, the outpouring of political and corporate concerns led the two parties to reach an out-of-court settlement.[26]

## Policy Implications for the United States and South Korea

Even though the USITC case between LG and SK On has been settled, there remain potential venues of conflict that arise from the implementation of the IRA or other efforts to address the energy transition, particularly when new technology is involved. While the IRA may be a political win for Democrats, the complexity of the legislation is already raising concerns. Continued foreign political lobbying in Washington by EV battery producers and EV makers is likely, especially if they do not qualify for subsidies under the IRA. While South Korean EV battery producers may benefit from the legislation, given their presence in the United States, Hyundai's Georgia plant

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21 Obama nixed the USITC ban on the sale of some Apple products through a veto via the U.S. Trade Representative, which falls under the executive branch. This decision also demonstrates the nexus of domestic politics, government, and industry in tech lawsuits. USITC, "Disapproval of the U.S. International Trade Commission's Determination in the Matter of Certain Electronic Devices, Including Wireless Communication Devices, Portable Music and Data Processing Devices, and Tablet Computers," Inv. No. 337-TA-794, https://ustr.gov/sites/default/files/08032013%20Letter_1.PDF.

22 "U.S. Election Becomes Inflection Point for LG-SK Battery Feud," *Korea Times*, October 27, 2020, https://www.koreatimes.co.kr/www/tech/2020/10/419_298327.html.

23 "LG, SK Urged to Settle Dispute: Georgia Governor Asks U.S. President to Veto USITC Ruling," BusinessKorea, February 15, 2021, http://www.businesskorea.co.kr/news/articleView.html?idxno=60386.

24 David Shepardson, "U.S. Will Review Impact of SK Innovation Ruling on Biden Green Transportation Goals," Reuters, March 3, 2021, https://www.reuters.com/business/sustainable-business/us-will-review-impact-sk-innovation-ruling-biden-green-transportation-goals-2021-03-03.

25 "Chung Sye-kyun chongni 'LG-SK baeteori sosong, bukkeureoun il'" [Prime Minister Chung Se-kyun "LG-SK Battery Lawsuit Is an Embarrassment"], *Korea IT Times*, January 29, 2021, http://www.koreaittimes.com/news/articleView.html?idxno=103440.

26 Steven Mufson, "South Korean Battery Makers Reach Last-Minute Settlement," *Washington Post*, April 11, 2021, https://www.washingtonpost.com/climate-environment/2021/04/10/south-korean-battery-makers-reach-last-minute-settlement.

will only be finished in 2025 and will be discriminated against until EV production starts there. The IRA will create as much as a $7,500 price difference between EVs with tax credits and those without one. The time sensitivity of the issue is related to the significance of first-mover advantage on the U.S. EV market. Moreover, the law is intended to exclude China from the supply chain, and EV battery producers will need to find other options for sourcing their REEs for batteries.

U.S. policymakers should consider the following three implications as they work to address these and other challenges.

*Focusing on clarity in policymaking and delivery*. The U.S. government needs to clarify its priorities with the IRA—whether sidelining China in a protectionist manner or pursuing its net-zero carbon emissions goals. In the current form, the legislation is likely to generate discontent from South Korean players. Similar legal measures against steel imports in the form of tariffs and exemption quotas were made under Section 232 by the Trump administration to confront "dirty steel from China," which brought about concerns from U.S. allies. South Korea's quotas remain unadjusted, while those imposed on the United Kingdom, EU, and Japan have been lifted.[27]

*Bracing for lawsuits for private and public entities alike*. As JVs and company operations become widespread across jurisdictions, both private and public entities should brace for the potential lawsuits that may arise as the tech conflict is intensified and exacerbated. Small and medium-size enterprises that do not have extensive legal support or capacity may be at greater risk, in both the United States and South Korea.

*Prioritizing safety as the main interest in standard setting in JV collaboration*. Taking the lives of both South Korean and U.S. citizens into consideration, there have been numerous reports of EV accidents that resulted in deaths and casualties, because of either lithium battery issues or autopilot errors. If the two countries are determined to collaborate on achieving net-zero emissions, JVs between the United States and South Korea should focus on developing safer EVs and battery technology.

[27] "Trump Administration Tariff Actions: Frequently Asked Questions," Congressional Research Service, CRS Report for Congress, R45529, May 15, 2020, https://sgp.fas.org/crs/row/R45529.pdf; and "A Proclamation on Adjusting Imports of Steel into the United States," White House, May 31, 2022, https://www.whitehouse.gov/briefing-room/presidential-actions/2022/05/31/a-proclamation-on-adjusting-imports-of-steel-into-the-united-states-3.

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