Clean Energy Pragmatism as a Spark for US-South Korea Relations

By Elan Sykes

Introduction

Climate change and threats to energy security and supply chains present global challenges that no single country can solve alone. Moreover, as US-China competition intensifies and draws in shared trading partners, policymakers and private investors around the world are struggling to adjust. Cooperation between allies like the United States and South Korea, or the Republic of Korea (ROK), can serve as an engine for progress in the face of these growing challenges.

The United States and South Korea—both early in the process of enacting meaningful domestic climate policy and committed to cooperation on climate as well as energy security and supply chain resilience—are uniquely positioned to harness their alliance capabilities and advanced industries to overcome obstacles in the clean energy transition. Clean energy pragmatism, defined here as a willingness to use a range of politically viable and flexible policy tools to drive technology deployment and encourage private innovation and investment in all potential clean energy solutions, should serve as the animating principle of US-South Korea climate cooperation.

This paper will first explore clean energy pragmatism in the bilateral context and apply its framework to three technologies: batteries, hydrogen, and nuclear power. The US-ROK alliance has successfully produced massive joint investments in the beginning and end stages of the battery supply chain. Both are members of the multilateral Minerals Security Partnership (MSP) to cooperate with resource-rich countries in supplying critical raw inputs. Additionally, joint investment between US and Korean firms in battery cell and pack assembly are larger than those of any other US ally, yet both countries will need to expand refining capacity that turns raw minerals into usable materials for batteries in the critical "midstream" step currently dominated by China. In clean hydrogen, joint research to drive innovation, push down the cost of equipment, and align accounting

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standards would help cultivate the sector into a cost-competitive climate solution and replacement for existing carbon-intensive hydrogen. Cooperation on nuclear power has been successful between the two governments but contentious in the private sector. Resolving these roadblocks and working together on expansion and exports could provide both countries with a vital source of reliable, zero-carbon electricity to fuel new load growth from electrification, new climate applications in hydrogen and direct-air capture, and rising demand for information and communication technology (ICT).

Bilateral and Multilateral Commitments to Climate Cooperation

The United States and South Korea are two of the world's largest economies, powered by energy systems releasing the second- and eleventh-most greenhouse gas (GHG) emissions in the world.[1] Their respective domestic climate and energy policies remain contested but have seen major transformation under current leadership. The US Congress passed, and President Joe Biden signed into law, the Inflation Reduction Act (IRA), which included the largest public appropriation for clean energy in US history, along with the bipartisan Infrastructure Investment and Jobs Act (IIJA) and CHIPS and Science Act, that is driving massive new investments across a wide range of technologies. Initial estimates suggest a total public investment of USD 790 billion in IRA clean energy spending and an annual emissions reduction of roughly 40 percent by 2030.[2] Those modeled emissions projections depend on an unprecedented pace of deployment, which could face constraints due to long permitting timelines and slow-moving electric grid expansion and interconnection.[3] More importantly, the fate of the entire IRA under the second Donald Trump presidency remains unclear. Nobody can predict whether private energy sector support, subsidized investments in Republican districts, or technology competition with China will win the fight to protect its core policies from factions of the Republican party that pursue energy policy through a culture war lens or represent fossil fuel producing districts.

In Korea, President Yoon Suk-yeol and the People Power Party (PPP) have retained much of Korea's long-standing climate policy regime, including topline targets for net-zero emissions by 2050, green spending plans, and the country's cap-and-trade system (Korean Emissions Trading Scheme, or KETS), while adjusting interim GHG targets and reversing a major plan from the previous Moon Jae-in administration to phase out nuclear power and rapidly deploy renewables. Both the earlier renewables-focused Ninth Basic Plan for Long-Term Electricity Supply and Demand (BPLE) and the Yoon administration's current Tenth BPLE would partially phase down coal generation by 2030.[4] Notably, the Tenth BPLE goes further in coal reduction and cuts the projected renewable share of the 2030 generation mix, making up the difference with additional liquefied natural gas (LNG) imports and nuclear power expansion. Internationally, President Yoon has sought to recruit public-private partnerships in a new Carbon-Free Alliance, led by former Intergovernmental Panel on Climate Change (IPCC) Chair Lee Hoe-sung, to encourage the consumption of all sources of zero-carbon energy, including renewables, nuclear, and hydrogen, though only Korean firms have thus far joined.[5]

Following the PPP loss in the 2024 National Assembly elections and a Supreme Court ruling against President Yoon's interim climate targets, the foreseeable future of Korea's climate policy will require pragmatism and cooperation, not just with international partners but also with the domestic opposition. Finding ways to reduce polarization and credibly commit to the continued use of nuclear power will be necessary if Korea wishes to maintain its export-oriented industrial sectors and produce sufficient clean electricity to support them.

Neither the United States nor South Korea will be able to develop all of these technologies alone, nor could they direct all the capital necessary to deploy clean energy at the scale and pace required to meet global climate targets and mitigate the worst impacts of climate change. The IRA has unleashed huge Korean investments in US battery and electric vehicle (EV) factories, and the US-Korea free trade agreement (FTA) allows Korean products to claim higher subsidies than producers from countries without FTAs, like China or the European Union. Korea's export-oriented production of primary industrial materials, such as steel and chemicals, and heavy or advanced machinery, including ships and electronics, serves a vital role in providing like-minded democracies with alternative supply chains not controlled by China.

Presidents Biden and Yoon have met several times and affirmed their commitment to cooperation across a slew of security, economic, and technology policy areas. During bilateral state visits in May 2022 and April 2023, the two leaders have repeatedly stressed the importance of clean energy cooperation not just for decarbonization but also for economic growth, energy security, and supply chain resilience in a shifting geopolitical world. In their leaders' joint statements, both presidents have highlighted nuclear energy, critical battery materials, and clean hydrogen as areas ripe for bilateral cooperation.[6] They have also mentioned collaboration on green shipping, carbon capture, utilization, and storage (CCUS), methane mitigation from existing fossil fuels, accelerating EV deployment, and related non-energy technologies such as semiconductor manufacturing that are crucial to the sector.[7] At the ministerial level, US Secretary of Energy Jennifer Granholm has met with officials from the ROK Ministry of Trade, Industry and Energy (MOTIE) to discuss bilateral cooperation on climate change, energy security, and research, development, and demonstration (RD&D).[8]

Cooperation between the United States and South Korea also takes place within wider international institutional efforts. Outside of global arrangements like the UN Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, the United States and South Korea frequently contribute to multilateral, regional, and subject-specific cooperative efforts. Both countries are members of the Group of 20 (G20), which hosted a summit in 2023 for climate and environment ministers that called for additional climate finance and the tripling of renewable energy deployment—though the statement is not binding.[9] Since 2010, Washington and Seoul have been members of the Clean Energy Ministerial, a voluntary body that holds annual meetings between top energy policymakers from 26 member countries, which hosts working groups to coordinate policy across the energy system, including EVs, battery storage, hydrogen, and nuclear innovation.[10] Shared regional efforts, from trilateral summits with Japan to annual meetings for Asia-Pacific Economic Cooperation (APEC) and the Indo-Pacific Economic Framework (IPEF), offer a range of interested parties—including the United States, South Korea, and many of their close neighbors and trading partners—the opportunity to deepen collaboration on core clean energy policy objectives.

APEC, a regional body with wide membership from the Indo-Pacific, includes China and Russia and thus does not constitute a climate-leading body composed of friendly democracies. Nonetheless, APEC allows for the exchange of information and policy through regular leader-level and ministerial summits, including on clean energy cooperation.[11] The 2023 APEC Summit in San Francisco adopted the theme of "Creating a Resilient and Sustainable Future for All." President Yoon used the occasion to tout Korea's support for various clean energy technologies and promoted Korea's Carbon-Free Alliance, which calls for the private sector to use carbon-free power from nuclear generators in addition to renewables.[12] The Golden Gate Declaration that resulted from the summit called for the tripling of global renewable capacity and employing similar targets for other climate mitigation technologies in line with carbon reduction goals.[13]

IPEF, on the other hand, offers more promise for tangible cooperation on climate.[14] Composed of four pillars, IPEF seeks to deepen economic cooperation across a range of policy areas—one whole pillar of which is dedicated to clean energy while the others are dedicated to trade policies, supply chain resilience, and transparency and anti-corruption measures.[15] Negotiations for the clean economy pillar concluded in November 2023 and included an exhaustive list of shared, non-binding clean energy aspirations along with two investment funds and an initial subject-matter Cooperative Work Programme (CWP) on hydrogen policy.[16] An IPEF summit this past June announced additional CWPs for clean electricity and carbon markets along with an investment fund and a forum for public-private consultations with investors and project developers.[17] IPEF's direct investment fund for official development assistance-eligible countries, the "Catalytic Capital Fund," received USD 33 million in startup funding from the United States, South Korea, Japan, and Australia, while the first investor forum identified USD 6 billion worth of investment-ready projects and a total of USD 23 billion in potential projects for regional governments and private investors to examine.[18] Pillar II, which covers resilient supply chains, could include helpful exchanges of information for clean energy cooperation as the United States has suggested the inclusion of critical minerals, batteries, nuclear energy, hydrogen, and many other relevant energy technology supply chains on its list of covered sectors.[19] Still, stalled negotiations on the trade pillar and the flexible nature of IPEF leave its ultimate utility up to participants.

Pragmatic Clean Energy Cooperation

Despite their meaningful progress, both the United States and South Korea will need to maintain active engagement in the energy and climate policymaking process throughout the energy transition as global markets, technology development, and political priorities continue to change. Successful cooperation requires not only shared goals but also compatible domestic politics and continued attention paid to dynamic private markets. By embracing pragmatic policy tools to boost technology development and deployment in critical battery materials, clean hydrogen, and nuclear power, the United States and South Korea can grow their economies and speed up the transition not just for their own energy systems but also through exports to other climate-ambitious trading partners.

The United States and South Korea, together with the EU, Japan, and China, collectively account for 90 percent of recent clean energy patents, and OECD research suggests strong positive outcomes from international cooperation on climate technologies.[20] Solving climate change will require the adoption of a wide range of technologies in different applications across the entire economy, and some of these technologies are closer to mass production and adoption than others. Certain technologies work as drop-in replacements for an existing process, while others will require local contextualization, which is just as important for policy design.[21]

This paper focuses on specific technologies and technology-specific policies, but several principles apply generally to pragmatic climate and energy security policies. The first is that global international agreements face serious structural limitations due to incentive misalignment. Pragmatism would not call for the UNFCCC or Paris Accord to be revoked, but coalition-based or bilateral approaches starting with a core of like-minded countries seeking to cooperate can unlock much more incentive-compatible progress than consensus-based multilateral negotiations among a larger mix of countries.[22]

Second, domestic policies should strive for technology inclusivity and wide economic coverage where possible. Broad, inclusive tax credits like the US clean energy generation tax credits will subsidize all sources of zero-carbon power generation starting in 2025 rather than vary compensation by technology type. Even better is GHG pricing with broad coverage, which rewards those who reduce emissions wherever they are economical to avoid, rewarding any investors, workers, and consumers who do so. Still, carbon pricing systems are sensitive to political pressure in the United States, and outcomes for the policy worldwide depend not just on the price but also on important implementation questions. Which sectors are covered, which entities are responsible for paying a fee or securing a permit, and how the system treats energy-intensive industries are also crucial factors.[23]

Major domestic policy shifts, though, will likely not be driven by bilateral cooperation as much as by domestic politics and the response to global dynamics.[24] Thus, the third principle requires focusing on support for politically viable technology-specific policies and forms of information exchange that unlock gains without major overhauls to US or South Korean environmental policy regimes. The latter includes ensuring the availability of reliable data, agreements on accounting standards, and exchanges of research, technical expertise, and analysis of market conditions. Aligning market and climate policy rules to ensure participation on a level playing field can help lessen the impact of fragmenting global markets and supply chains. Policy design, implementation, and analysis with shared outcomes in mind can also provide policymakers with iterative feedback from a larger set of markets and help them reach a better understanding of optimal next steps.

There are many technology-specific measures that both the United States and South Korea could take to benefit their climate progress. Energy as a sector is capital-intensive and dependent on fixed infrastructure, and because of its social and economic importance, energy technology faces a wide range of tech-specific policy and market failures that are best addressed with contextual rather than broad policy treatments.[25] Early-stage research needs public support because private researchers under-invest in areas where they will not be able to capture all the gains from their work. For nascent technologies like green hydrogen or direct-air capture, obstacles include proving the technology's basic performance and the industry's economic and political viability despite significant market and financial barriers to investment. For mostly ready technologies like EVs or solar panels, private finance and policy support are boosting uptake, but the obstacles to mass adoption include not just financial costs but also infrastructure constraints like the lack of public chargers or electric grid capacity.

Solving these innovation market failures requires cooperation among democratic countries with advanced technological-industrial ecosystems like the United States and South Korea. Battery supply chains, clean hydrogen capital equipment, and constructing new nuclear power plants all face a collection of these roadblocks. The following sections will address each, starting with respective US and Korean domestic policies, cooperative initiatives, and forward-looking policy recommendations.

Battery Supply Chains

Batteries have taken a prominent role in the energy transition toward decarbonizing transportation and energy storage. Policy tools to spur wider adoption of batteries among various end-users, like EV subsidies and grid battery procurement, have aided this process, but as demand grows, supply chains for raw materials, refining, component production, and assembly of cells and packs cannot keep up. Meanwhile, new entrants are discouraged by China's dominant market power and willingness to impose export restrictions on input minerals in short supply.

Battery supply chains start with various raw minerals that are processed down into usable refined materials, assembled into components like cathodes and anodes, and grouped together into active cells for final assembly. The term "critical minerals" is a broad term that includes minerals used not just in the energy transition but also in other advanced technology sectors like aerospace, semiconductors, and products with sensitive defense applications. The concept of "criticality" depends on context, is dynamic in the long run, and encompasses a variety of supply risks, including geopolitical, economic, and other uncertainties. Newly growing demand for battery inputs like lithium hydroxide, graphite, and nickel, among many others, have combined with familiar commodity market boom-bust cycles and supply-side constraints to create unpredictable price fluctuations. The International Energy Agency (IEA) produces a price index for energy transition minerals that tracks battery inputs along with rare earth elements and copper, and prices through 2024 are far below the peak of March 2022.[26] Low prices benefit consumers in the short run, but their volatility does not augur well for investment in upstream production that will be necessary as consumer and policy demand grows over the coming decades. The IEA predicts that the demand for critical mineral inputs will double by 2030 under current policies.[27]

Less appreciated than mining or final battery assembly, the "midstream" step of refining raw ores into highly refined, pure, and usable products is an energy-, knowledge-, and capital-intensive process that varies by mineral type, ore source, and customer needs. China's monopolistic control over refined transition materials ranges from being in the top three of copper and nickel production to majority control (65 percent) of lithium and nearly 100 percent of the world's graphite and rare earths.[28] Neither the United States nor South Korea ranks in the top three refiners for any of the six critical mineral processing markets tracked by the IEA, and China has recently shown a willingness to exploit this vulnerability with restrictions on graphite and rare earth exports.[29]

Policy support for scaling up battery production in the United States includes demand-side measures like the IRA's enlarged EV tax credits (up to USD 7,500 per vehicle) and various policies covering the upstream supply chain from both the IRA and IIJA. US battery producers can choose between a production credit that subsidizes battery and critical mineral production or an investment credit that applies to advanced energy manufacturing facilities.[30] The US EV credit limits subsidies with components sourced from "Foreign Entities of Concern" (FEOCs), which includes China, for batteries starting this year and for mineral inputs starting in 2025. On top of changes to the tax code, new grants and loans have also started to flow to private partners in the sector. The US Department of Energy (DOE) has issued USD 2.8 billion out of USD 3 billion in funding for material processing, and its Loan Programs Office provides concessional finance for automotive factory conversion, for which USD 1.7 billion in loans were announced this past July.[31]

Korea also produces batteries domestically, hosting major global producers such as SK On, LG Energy Solutions, Samsung SDI, and EV manufacturer Hyundai.[32] Korean battery production currently constitutes 37 percent of the global market share, and battery exports totaled USD 9.7 billion in 2022, of which the United States was the top destination.[33] Korea has subsidized EV adoption with varying direct subsidies and indirect support via charger installations since 2011. Overhauled rules in February this year reduced subsidies for cars using Lithium Iron-Phosphate (LFP) batteries, which are cheaper but lower range and mainly produced in China compared to Nickel-Manganese-Cobalt (NMC) batteries that Hyundai produces.[34] The government has also subsidized Battery Energy Storage Systems (BESS) in various forms since 2011 and has installed 1.6 GW of capacity by 2019.[35]

In RD&D, Korea's 2022 National Technology Nurture Plan ranks batteries as a top priority, and recent budget adjustments have boosted battery and EV research budgets.[36] Upstream, the Yoon government maintains a list of 33 critical minerals to watch—of which ten are designated "strategic" high priorities—with an eye toward building a global supply chain map, arranging memorandums of understanding (MOUs) with supplying partner countries, and funding domestic projects in production and recycling.[37] Additional subsidies to the supply chain that were recently announced include the Battery Alliance, a public-private partnership started in 2022 with KRW 50 trillion (USD 35 billion) of public financing over the next eight years in order to seek 40 percent of global market share by 2030, and another round of support announced in 2023 for KRW 38 trillion (USD 28.8 billion) toward investment subsidies, critical minerals, and advanced research and development.[38] Korea has also initiated bilateral agreements with a wide range of trading partners, including Kazakhstan, Uzbekistan, Turkmenistan, and Vietnam, and held a 48-country Korea-Africa Summit, which produced an agreement to cooperate on future critical mineral dialogues and a number of bilateral agreements.[39]

Internationally, the United States and South Korea have moved together and on complementary pathways to build new connections with resource-rich countries and like-minded importers concerned about energy security, environmental, social, and governance (ESG) conditions in the mining industry, and the scale of mineral demand needed for decarbonization. Batteries and critical mineral supply chains have been raised as areas of key cooperation at both US-South Korea state visits, as well as in the Phnom Penh and Camp David trilateral meetings with Japan. During President Yoon's April 2023 state visit to the United States, bilateral commitments included an MOU on battery supply chains, which was followed by Korea's announcement of USD 5.3 billion in support of Korean investment in North American battery supply chains.[40]

In addition to leader-level affirmations of cooperation, multiple ministerial dialogues and MOUs have been launched between US and Korean government agencies. An MOU between the Export-Import Bank of the United States (EXIM) and the Korea Trade Insurance Corporation (K-SURE) in 2022, an MOU between EXIM and K-EXIM during COP28 in December 2023, and MOUs between the US DOE's Loan Program Office, K-EXIM, and K-Sure all prominently feature critical mineral and battery supply chain investment.[41] A public-private event co-hosted by the Department of State and MOTIE in November 2023 with the Carbon-Free Alliance and the US-based Clean Energy Buyers Association included several members of the Korean battery industry, and US Secretary of Commerce Gina Raimondo and ROK MOTIE Minister Ahn Duk-geun have held two joint Supply Chain and Commercial Dialogues (SCCD) and called for a staff subcommittee specifically for critical minerals.[42]

In addition to such dialogues, the two countries have also ensured conversations about battery supply chain resilience include diplomatic and security concerns. A call between the US National Security Advisory Jake Sullivan and ROK National Security Advisory Cho Tae-yong in December 2023 launched a bilateral Next Generation Critical and Emerging Technologies (CET) Dialogue covering critical mineral and battery supply chain investments, research, and cooperation, and the decade-long US-ROK Energy Security Dialogue held by the US Department of State and the ROK Ministry of Foreign Affairs now stresses the importance of cooperation on battery supply chains both bilaterally and through the MSP.[43]

The two countries have shown a willingness to maintain flexibility in their joint approach to building out the battery supply chain. Following difficulties sourcing FEOC-compliant graphite, Korean battery producers received a two-year extension from the United States in May 2024 to continue using Chinese graphite while the Korean government announced KRW 9.7 trillion (USD 7.1 billion) in support for graphite supply chains.[44] Together, battery supply chain projects announced since the passage of the IRA total USD 103 billion—Korea ranks first among all sources of post-IRA foreign investment in the United States, including nearly USD 20 billion in Korean battery firm projects.[45]

Korea is also the current and second-ever chair of the MSP, a coalition of 14 countries and the European Union, launched by the United States in 2022.[46] Together, the MSP has actively collaborated at the ministerial and working levels, including a Korea-led deep dive on graphite supply chains, establishing an MSP Finance Network that includes US EXIM, the US International Development Finance Corporation, K-EXIM, K-Sure, the Korea Mine Rehabilitation and Mineral Resources Corporation (KOMIR), and Korea Institute of Geoscience and Mineral Resources (KIGAM), and welcoming 15 resource-rich countries into a new MSP Forum.[47] The IPEF countries, whose agreements on pillars two and three cover supply chain resilience and clean energy, have called for "building a better understanding of the challenges and vulnerabilities of the region's supply chains and securing more diversified and sustainable sources of critical inputs, including critical minerals or materials, for clean energy technologies."[48] At the inaugural IPEF Clean Energy Investors Forum mentioned above, a Malaysian battery factory was presented among the billions of dollars worth of potential investments, and the Catalytic Capital Fund, which includes both the United States and Korea as founding funders, announced its operational launch.[49]

Recommendations

As capacity investment ramps up alongside subsidies for battery production, the United States and South Korea should focus on the constrained segments of the supply chain that mine and refine critical minerals (along with recycling used batteries) to ensure sufficient inputs downstream. Public financial and regulatory support for investments in processing should serve as the primary tool for a US-Korea battery supply chain strategy. On top of direct financial subsidies, the establishment of joint trading benchmarks for minerals like graphite not yet included on major commodity exchanges would boost transparency and reduce friction for market participants, leading to greater certainty and, thus, legible risks for enticing investment.[50]

While China dominates mining and processing, the "N-1 supply chain risks" of losing access to the top supplier for most critical battery inputs would stymie deployment in the United States, South Korea, and allies like the European Union and Japan.[51] To hedge against these risks and smooth commodity price fluctuations, exploring and planning for the potential establishment of strategic stockpiles for key minerals—modeled after the US Strategic Petroleum Reserve or the IEA's oil reserve requirements—could also induce greater investments and provide security against short-term supply disruptions.[52]

Finally, the two countries should maintain subsidies for the demand side and align rules for product standards and carbon accounting. Adoption subsidies for battery applications, whether through EV tax credits or grid storage investments, will help ensure that investments along the supply chain continue to scale at a necessary pace and avoid demand slumps that render production capacity uneconomic. As batteries are made in different countries by firms using various chemistries and different charging characteristics, importing governments and users will require heightened assurance on safety issues and the climate impacts of different production methods.

The latter has become an area of intense focus in global climate policy with the EU's adoption of its Carbon Border Adjustment Mechanism (CBAM), which will initially apply to six primary industries and potentially expand in the future, and

US proposals for carbon intensity accounting through the PROVE IT Act or various carbon border fee bills. France and Korea have already entered negotiations to establish a shared accounting method for embodied carbon in Korean EVs, and policies that require supply chain measurement may become more common in the future.[53]

Batteries made in China are produced with three times the carbon intensity of US batteries, and the overall carbon intensity and lifetime "payback period" for EVs is highly dependent on the battery's embodied carbon.[54] Agreeing on carbon accounting has proven difficult—even for simple industrial products like steel and aluminum—so preparations for more complex manufactured products with global supply chains like EVs that collect and share carbon intensity and supply chain data and methodologies early in the scaling-up process can help establish a solid foundation for future cooperation.

Hydrogen

Hydrogen is the world's lightest element and a useful molecule for chemical processes such as fertilizer production and oil refinement. Hydrogen is generally made from natural gas in steam reformers, which involves two major sources of GHGs: upstream methane leaks from gas extraction and carbon dioxide released during the production process.[55] This production is carbon-intensive, so policymakers and clean industrialists hope to replace it with a combination of several decarbonized production methods, including "green" hydrogen produced by electrolyzers powered with clean electricity, "blue" hydrogen made with CCUS-equipped steam-reformers, and potentially significant geologic stores of natural hydrogen. Existing demand for hydrogen is indifferent to production methods, so replacing existing applications of this "gray" hydrogen with cost-competitive clean hydrogen would serve as an exciting carbon abatement opportunity. In the future, though, clean hydrogen may see additional applications if large volumes of clean hydrogen can be produced and utilized in energy generation, storage, transportation, buildings, and industry.

Unfortunately for hydrogen, several of these applications have seen competing technologies take off at a rapid scale. Clean hydrogen projects have been slow to deploy, and demand forecasts have been revised down because of a combination of policy obstacles and market developments, especially higher-than-expected costs.[56] Less than 1 percent of hydrogen consumed in 2022 was produced with low-carbon methods, and less than 1 percent went to new applications as opposed to existing users.[57] Policymakers have struggled to sift through existing data and modeling on the projected impact of major new electricity demand from sources like green hydrogen electrolyzers, and the global market for hydrogen risks fragmentation along different accounting standards before it is even born. Thus, the top priorities for US-Korea clean hydrogen cooperation should include domestic policies to encourage clean hydrogen demand, investment in advanced industrial applications and long-duration energy storage, and alignment on carbon accounting.

US energy officials have been interested in hydrogen since the 1970s energy crisis, but the Biden administration's tenure marks the first period in US history of serious fiscal or regulatory investment in clean hydrogen. The IIJA included USD 8 billion in funding for regional clean hydrogen hubs, supporting seven production clusters spread across the country for geographic and technological diversification and setting aside USD 1 billion for demand-side support.[58] The IRA includes a new production tax credit for clean hydrogen production that grants a USD 3/kg subsidy for fully zero-carbon hydrogen produced through any pathway, though blue hydrogen producers will have to choose between claiming credits for the carbon captured and stored during production (45Q) or the hydrogen produced (45V).

Despite these generous subsidies, the US clean hydrogen economy has not yet taken off, as disputes during the regulatory implementation process have prevented investors from making final investment decisions. The problem stems from the scale of subsidies, the scale of electricity needed to match production, and the lack of agreement over clean electricity procurement standards.[59] Electrolyzers are expensive, energy-hungry machines that pulse electricity through water to generate hydrogen, so their scale of electricity demand is projected to have major impacts on overall electricity demand and demand for clean electricity in particular.[60] The Biden administration tried to establish rules that would require hourly matched clean electricity accounting to prevent increases in emissions, but many potential industrial hydrogen producers have argued that the US grid is unprepared to properly account for the hour-by-hour sources of electricity powering an electrolyzer connected to broader power grids.[61] All clean hydrogen projects in the United States are now effectively on hold because private capital will not commit to such policy-dependent investments without sufficient certainty regarding the eligibility rules and lack of policies to spur demand.[62]

Meanwhile, South Korea's hydrogen policies have been a major focus of the past two governments. Under President Moon, the 2019 hydrogen roadmap and an additional suite of standards, sectoral goals, infrastructure, and R&D laid out ambitious plans to use significant quantities of hydrogen for power, transport for light- and heavy-duty Fuel Cell Vehicles (FCEVs), and several pilot cities' heating needs over the next several decades.[63]

Since President Yoon's inauguration, the new government released a report identifying South Korea as the top market for growth in FCEVs, hydrogen refueling stations, and fuel cell capacity and amended the Hydrogen Act to add a Clean Hydrogen Portfolio Standard (CHPS) for major hydrogen and electricity producers and consumers and create new definitions for zero-carbon, low-carbon, and general hydrogen and derivative products.[64] The Hydrogen Economy Commission, chaired by Prime Minister Han Duk-soo, also issued a hydrogen innovation policy titled "3Up" to scale up production, build up infrastructure, and level up advanced technology for the sector and later added plans for a new clean hydrogen certification system, FCEV deployment, R&D, and the industry's needs for materials, parts, and equipment.[65] The CHPS policy phases the requirements for selling and purchasing quotas of gray and clean hydrogen over time depending on firm size, and auctions for the general market started in August 2023.[66] Korea's clean hydrogen exchange, launched in May 2024 as the first clean hydrogen bidding market in the world, should help buyers and sellers identify each other as the CHPS requirements for clean hydrogen come into force by 2027.[67]

The US and Korean governments have eagerly expressed interest in cooperating on clean hydrogen. As a land-rich renewables and natural gas producer, the United States has several major advantages in producing hydrogen if its equipment for generating, transmitting, storing, and using it can achieve workable prices. Meanwhile, South Korea has excelled at utilization policies in transportation and power and hosts major industrial firms that may be willing to operate pilot and demonstration projects for next-generation applications in hard-to-abate industries.[68] At the leader level, clean hydrogen was mentioned in joint statements from both US-Korea state visits and the Phnom Penh and Camp David trilateral statement, in addition to the Tenth Energy Security Dialogue.[69] The April 2023 state visit marked the agreement of an MOU on hydrogen between the two governments, which included private sector participants from both countries, and an additional MOU between Lawrence Livermore National Laboratory and the Korea Advanced Institute of Science and Technology (KAIST) signed in September 2024 focuses on hydrogen R&D specifically.[70]

The United States and South Korea also work together in several multilateral bodies to address hydrogen. The premier international body working on hydrogen policy is the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE). It was founded in 2003 by the United States, includes Korea as a member, and hosts regular meetings on exchange policy and industry updates from member countries.[71] Since 2018, the IPHE has been working to develop methodologies for hydrogen carbon accounting in both the production and transport phases.[72]

IPEF has also established a regional hydrogen initiative as its first CWP and, as of March 2024, has begun sharing information and methodologies on carbon intensity at the ministerial and working levels.[73] The Clean Energy Ministerial also hosts a working group for hydrogen policy, which includes an initiative on international hydrogen trade in which both the United States and Korea participate with a group of global ports including Ulsan and Houston.[74] As members of the Global Methane Pledge and the DOE's international methane monitoring working group, both countries have committed to rapid reductions of methane emissions and, while not the focus of this paper, could use the Pledge and working group's progress to align members on blue hydrogen GHG intensity accounting.[75]

Recommendations

Discussions about aligning standards are not guaranteed to reach alignment itself. In order for clean hydrogen to succeed as a climate solution, the industry and concerned governments like the United States and South Korea must not only align on accounting standards and definitions but also work to reduce capital costs, increase clean electricity generation to meet growing demand, and incentivize the purchase of clean hydrogen despite price premiums.

The two countries could greatly benefit from the clean hydrogen industry's eventual success if the technology and costs improve or if new applications for decarbonization become cost-competitive. Joint support for RD&D projects could help both countries make additional progress in these areas. RD&D should focus on the scale and cost of production for equipment and materials including electrolyzers and their components, storage tanks, and distribution networks along with end-use capital equipment that use hydrogen for applications in industry, heavy transportation, and other sectors.

For hydrogen as a molecule, the optimal approach would combine innovation policies to lower the cost of low-carbon hydrogen and fiscal incentives to drive adoption among current hydrogen users. For hydrogen as an energy carrier, the most promising avenue for further RD&D would be spurring demand through support for new pilot and demonstration projects to help reduce costs and de-risk investment in hydrogen utilization projects for sectors with few replacement options. These include high-heat industrial processes and long-duration, inter-seasonal storage for which substitutions are either infeasible (e.g., inter-seasonal battery storage) or unsuited to further expansion (geographic constraints on pumped hydropower storage).[76]

Whether FCEVs take off as a competitor to EVs or high-temperature industrial firms develop hydrogen pathways over electrified or heat-battery-based production will ultimately depend on technological advancement. Thus, investment in R&D at all stages of the production and consumption process would assure US-Korea readiness without committing wholeheartedly to a particular end-use or production pathway. Either way, the rise of an international clean hydrogen market requires alignment on carbon accounting. Uncertainty and investment delays in the United States demonstrate its importance, but agreeing on a methodology for green hydrogen has proven difficult, even within the United States—to say nothing of the rest of the world with its wildly different electricity systems and data quality. For two early adopters, though, a shared carbon intensity methodology and research agenda would shape the United States and South Korea into formidable players in the market as the world starts to turn policy roadmaps into real volumes of clean hydrogen over the coming decades.

Nuclear Power

Civilian nuclear power is an extremely energy-dense, long-lasting, and controversial electricity source. Nuclear power plants do not emit carbon dioxide, but accidents like Chernobyl, Three Mile Island, or Fukushima raise the salience of radiation risk, leading to a lack of consensus on the value of nuclear energy within the climate community. But for steady, large, and predictable energy users like heavy industries, import-dependent countries operating fossil plants, and land-constrained electricity grids with few places to expand solar, wind, geothermal, or hydropower, nuclear plants offer an extremely compelling combination of values: efficient land-use footprint, zero emissions, constant production, and inertia to connected grids. Technological innovation requires abundant energy, especially in the age of energy-specific innovations like clean hydrogen, which will require vast quantities of electricity, and newly energy-hungry end-users like data center operators. For these reasons, the UNFCCC parties decided at COP28 to commit to tripling global nuclear power capacity by 2050.[77]

The US electricity grids and energy use profiles vary widely by region and operator, but many states use nuclear power as their primary power source, and a variety of new policy tools hope to spur growth in the industry after decades of stagnation, cost overruns, and delay.[78] South Korea, on the other hand, operates a much smaller set of grids as a geographically isolated country dependent on fossil imports to power an economy built around energy-intensive export industries. After periods of decline, both countries appear on the cusp of finally unleashing a new generation of high-density, extremely safe reactor designs—if only the two countries could resolve private-sector IP disputes, align export rules, and enact policies designed to ensure industry certainty of buildout at scale.

The US nuclear energy policy is driven by the DOE and Nuclear Regulatory Commission, which are responsible for broader program implementation in the energy system and for reactor design, safety, and permits, respectively. After three decades without a new nuclear reactor built in the United States, Southern Company's Vogtle Reactors 3 and 4 opened in 2023 and 2024, and new momentum from the IIJA and IRA has created limited optimism in the US industry.[79] The IIJA included a USD 6 billion appropriation for Civil Nuclear Credits (CNCs) for plants at risk of retirement due to market conditions in recognition of the value older nuclear plants have in providing zero-carbon energy and appropriated USD 2.4 billion in grants for the Advanced Reactor Demonstration Program, which funds next-generation reactor designs, construction cost-sharing, and risk-reduction research, in addition to several smaller infrastructure and site survey programs.[80] The IRA's tech-neutral clean electricity tax credits apply to new nuclear plants, which can claim either an investment credit of 30 percent or a USD 25/MWh production credit, along with a USD 15/MWh credit for existing plants to complement the IIJA CNC funding.[81] Additionally, the IRA included USD 700 million in funding for domestic High-Assay, Low-Enriched Uranium (HALEU) supply chains, which should provide a much-needed boost to advanced reactor designs requiring fuel that can no longer be sourced from Russia.[82]

Domestic nuclear deployment has also struggled under what industry associations and independent analysts argue is an unnecessarily long and expensive approval process for new reactor permits that does not effectively assure safety, given newer designs and outdated requirements.[83] Several nuclear-specific legislative attempts to rectify these delays have passed in Congress on a bipartisan basis.[84] As the US nuclear industry plans for expansion and extends the maintenance of the existing fleet, questions remain over the cost of building new nuclear capacity in the coming years, safety and waste disposal concerns, and the effective implementation of NRC reforms.

South Korea's nuclear policies have undergone a more intense political fight than in the United States. Nuclear power is the single largest source of electricity consumed in the country as of 2023.[85] Following the Fukushima nuclear disaster in Japan and safety scandals at KEPCO's Kori plant in 2013, the popularity of nuclear power dropped—by 2019, President Moon planned a nuclear phase-out policy to shut down the fleet over 45 years in conjunction with a plan to expand renewables.[86] Safety concerns are understandable, and goals for expanding renewable generation are commendable. But South Koreans should look to the United States and Japan as examples. Microsoft recently announced an agreement to restart the Three-Mile Island reactor, and Japan has restarted 12 reactors since 2015 after the shutdown that followed Fukushima.[87] A policy to phase out a grid's largest source of carbon-free power at a time of global disruptions in the energy market while also affirming ambitious commitments to drive down carbon emissions in a country as geographically constrained as Korea would risk significantly impeding the country's energy transition and energy-intensive export industries. Without additional clean firm generation and advanced grid technologies, Korea's grid lacks sufficient inertial resources to add renewables—especially at the pace and scale President Moon had envisioned—while still providing the frequency support and other ancillary services crucial to the operational function of electricity grids.[88]

Since his term began, President Yoon has reversed the phase-out policy. The Tenth BPLE called for an increase in nuclear generation up to 231 TWh, or 35 percent of power, by 2036, along with a still-ambitious renewables target of 31 percent.[89] Shin Hanul Reactor units 3 and 4, previously stalled under President Moon, received construction permits this September.[90] While the Moon administration did not actively plan to end civilian nuclear exports, Korea had not produced any reactors for export since 2009. Under the current administration, President Yoon has actively pursued new markets and deeper cooperation with the United States on exporting reactors.

For US and South Korean public officials, cooperation on nuclear exports is a shared priority with a deep history. Korea's first reactor was provided by the United States under the 1962 "Atoms for Peace" initiative, and Kori-1, the first commercial-scale reactor, was built with designs by the US-based Westinghouse.[91] In 2015, the two countries renewed their 1970s-era agreement on civilian nuclear power to increase cooperation on design and marginally lessen restrictions on fuel enrichment and reprocessing in Korea—which were related to concerns over Korea's potential nuclear weapons proliferation rather than civilian safety—while establishing a High-Level Bilateral Commission to cover fuel supply, enrichment, reprocessing, and private sector collaboration.[92] Since Presidents Biden and Yoon have been in office, the two leaders have worked closely on nuclear power expansion. In their May 2022 joint statement, the two presidents committed to "greater nuclear energy collaboration and accelerating the development and global deployment of advanced reactors and small modular reactors by jointly using export promotion and capacity building tools, and building a more resilient nuclear supply chain," and they jointly announced South Korea's decision to join the US coalition for global small modular reactors (SMR) deployment, "FIRST."[93] Their April 2023 leader-level statement and the Phnom Penh statement with Japan also call for greater civilian nuclear cooperation.[94]

While government progress is welcome, cooperation in the private sector between US and Korean firms has encountered obstacles. A successful bid by Korea Hydro & Nuclear Power (KHNP) to build reactors for Czechia over Westinghouse (and French nuclear developer EDF) is stuck in a legal challenge regarding KHNP's right to license shared technology for export.[95] President Yoon visited Czechia for a summit in September 2024 to finalize the reactor deal, but Westinghouse and KHNP have not resolved their dispute.[96] Westinghouse and KHNP both contributed to the design of the APR-1000 reactor, based on an original AP-1000 design by Westinghouse, and signed a nongovernmental MOU in 2016 to "promote technological exchange," but this has not allayed the IP dispute.[97] KHNP recently received a favorable ruling in a US federal district court that will certainly be appealed by Westinghouse, and a Czech appeal by Westinghouse and EDF was preliminarily rejected by competition authorities.[98] Bilateral government discussions between the US DOE and Department of State and South Korean MOTIE and MOFA have engaged in the issue since August and announced a provisional MOU on November 1, 2024 that includes reference to exports without concrete details available to the public.[99]

Recommendations

The dispute is between two private firms, so all policymakers can do is attempt to resolve the KHNP-Westinghouse situation amicably. Policymakers should, however, try to work with the private sector to smooth over such disputes with persuasion where possible and establish trusted, shared forums for dispute resolution as well as forward-looking policies to plan for future joint exports.

Market and political shifts left nuclear power stagnant for decades in the United States and for years in Korea. Investors, future nuclear engineers and other expert workers in the supply chain, and major power consumers will not plan to count on expanded nuclear reactor fleets if policies change rapidly and introduce massive risks to such a long-lived asset class. The scale of future electricity demand due to the electrification of transportation and heating and new sources of demand like clean hydrogen mean that all sources of zero-carbon energy will likely be needed over the coming decades. While the United States and South Korea could both stand to expand renewables, both would benefit from public policies that commit to long-term buildout of not just one-off reactors but an entirely new fleet that can reliably procure equipment, inputs, and workers.

Research and demonstration projects in the advanced nuclear sub-sector are also crucial. Small Modular Reactors (SMRs), many of which plan to use prefabricated replicable designs, may help bring the cost curve down faster than larger and relatively more bespoke plants. Advanced reactors, both large and small, add many new built-in safety advantages compared to older, conventional reactor designs, and advances in fuel variety, production, reprocessing, and permanent storage would aid the whole supply chain and lifecycle to ensure continued access to domestic or trusted sources of supply and end-of-life management.

Conclusion

Clean energy pragmatism can help guide the United States and South Korea on a path of cooperation toward prosperous and decarbonized world leadership. With a suite of democratically driven and market-informed policy tools to unlock advances in critical mineral processing and battery production, clean hydrogen accounting and equipment manufacturing, and new nuclear power plant construction, these two countries can live up to joint commitments made by the respective leaders and officials to invent the growing green energy systems of the future.

Policy design and implementation are never complete unless a problem is entirely solved, and climate change is not a problem that can be solved over a single presidential term. Political shifts, such as the results of the 2022 US congressional midterms or 2024 Korean National Assembly elections that brought opposition legislators into the majority of both countries and the aftermath of Trump's victory in the 2024 US presidential election, hold the potential to either undo progress or help spur new action. Attention to the dynamic challenges of climate politics, policy implementation, and collaboration with the private sector and shared global allies will help ensure continued leadership for the United States and South Korea through their current presidential terms and beyond, through the entire energy transition.

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