Studies in Social Science Research
ISSN 2690-0793 (Print) ISSN 2690-0785 (Online)
Vol. 7, No. 2, 2026
www.scholink.org/ojs/index.php/sssr

Original Paper

Korea-EU Cooperation on Energy Transition: Current Status, Motivations and Challenges

Huawen Shen[1]

[1] School of International Studies, Dalian University of Foreign Languages, Dalian, 116044, China

E-mail: 15998027205@163.com

Received: May 24, 2026 Accepted: June 8, 2026 Online Published: June 12, 2026

doi:10.22158/sssr.v7n2p49 URL: http://dx.doi.org/10.22158/sssr.v7n2p49

Abstract

The Russia-Ukraine conflict has intensified the global energy security crisis. As economies highly dependent on energy imports, the EU and South Korea are jointly facing the dual pressures of ensuring energy supply and meeting climate goals. In 2023, the two sides formally established a "Green Partnership," becoming the world's first transcontinental strategic alliance for green transition covering the entire clean energy industrial chain. This paper systematically examines the progress of Korea-EU cooperation in areas such as clean energy technologies, supply chain resilience, and international standard-setting, and analyzes the internal drivers of their cooperation, which lie in similar policy and institutional foundations, complementary technology and industrial structures, and shared opportunities for green economic development. However, the cooperation is also constrained by multiple factors: South Korea's domestic policies are prone to vacillation due to party turnover, weakening policy continuity; the EU's Carbon Border Adjustment Mechanism and localization requirements have increased compliance costs for Korean companies; and geopolitical pressures such as the Sino-US rivalry have triggered risks of restructuring critical mineral supply chains. The progress and dilemmas of the Korea-EU Green Partnership provide a reference for understanding the cooperation logic of middle powers in the global energy transition.

Keywords

Korea-EU Green Partnership, energy transition, carbon neutrality, supply chain resilience

1. Introduction

Since the outbreak of the Russia-Ukraine crisis in 2022, global energy supply chains have been severely disrupted, rapidly elevating energy security to a core strategic concern for nations. As traditionally the largest importer of Russian pipeline gas, the EU saw its energy imports from Russia plummet after the

crisis erupted, confronting the dual pressures of a severe supply gap and soaring prices. The sharp decline in imports from Russia forced the EU to substitute with liquefied natural gas in the short term, but this brought with it challenges such as infrastructure bottlenecks and intensified competition in the global natural gas market. South Korea, as the world's fourth-largest importer of fossil fuels, relies heavily on oil and LNG imports from the Middle East and has long endured pressures of price volatility and supply disruptions triggered by geopolitical risks. During the surge in international energy prices in 2022, South Korea's trade deficit widened significantly and energy import costs soared, exposing the vulnerability of its highly externally-dependent energy structure. Both sides have committed under the Paris Agreement to limiting the global average temperature rise to within 1.5°C above pre-industrial levels, have set the goal of achieving carbon neutrality by 2050, and have formulated their respective 2030 greenhouse gas emission reduction targets. As 2030 draws nearer, under the dual pressures of energy security threats and climate governance goals, promoting the green transformation of their energy systems has become a common strategic choice for both the EU and South Korea to safeguard national security and fulfill international commitments. For the EU, accelerating the deployment of renewable energy, enhancing energy efficiency, and reducing dependence on foreign fossil fuels is not only the direction of current climate policy but also the core pathway to achieving strategic energy autonomy in the aftermath of the Russia-Ukraine crisis. For South Korea, as a pioneer in legislation with its Framework Act on Carbon Neutrality and Green Growth, it has pledged to achieve carbon neutrality by 2050. However, the reality of an energy structure heavily reliant on imported fossil fuels means it faces a more complex problem in its energy transition: how to achieve its established emission reduction targets while ensuring energy security and balancing economic costs. This sense of urgency under the dual pressures of energy security and climate governance has driven the EU and South Korea to transcend traditional cooperation frameworks and move toward deep strategic alignment. The two sides selected each other as "Green Partners" and established the world's first transcontinental strategic alliance for green transition covering the entire industrial chain because their strategies demonstrate a high degree of synergy, while their technological advantages exhibit strong complementarity. Their cooperation has moved from a macro vision to concrete practice, broadly encompassing areas such as climate policy alignment, clean energy technologies, strengthening the resilience of critical mineral supply chains, and the joint formulation of green standards. However, as this transcontinental strategic alliance advances rapidly, it inevitably faces multiple tests including rule coordination, cost-sharing, and geopolitical games. In light of this, this paper systematically examines the current status, motivations, and challenges of their cooperation, which contributes to a better understanding of partnerships in the global green transition process.

2. Current Status of Korea-EU Energy Transition Cooperation

To address common challenges, South Korea and the EU formally concluded a "Green Partnership" in 2023. The signing of the EU-Korea Green Partnership Agreement marked the official launch of the world's first transcontinental strategic alliance for green transition covering the entire industrial chain

(European Commission, 2023). The two sides are cooperating in key technological areas of green transition, such as offshore wind power, hydrogen energy, semiconductors, and batteries. At the same time, in the area of supply chains, a dialogue mechanism has been launched aimed at strengthening the resilience of green supply chains and enhancing discourse power over supply chain standards.

2.1 Establishment of the Green Partnership

The partnership between South Korea and the EU is reflected in the synergy of climate policy, market mechanisms, and external green assistance. First, at the level of climate policy coordination, both sides reiterated in the agreement their commitment to the Paris Agreement goal of limiting the global average temperature rise to within 1.5°C above pre-industrial levels and to achieving climate neutrality by 2050, and confirmed their respective 2030 greenhouse gas emission reduction targets—the EU plans a 55% reduction and South Korea plans a 40% reduction—and emphasized accelerating the global decarbonization process through concerted action (Delegation of the European Union to the Republic of Korea, 2023). These legal or policy commitments form a highly consistent policy foundation for both sides. Second, in terms of market mechanisms, their choice of similar instruments demonstrates synergy. As early as 2016, the EU provided South Korea with technical assistance worth €3.5 million to help establish East Asia's first national Emissions Trading System (ETS), laying a historical foundation for this cooperation (Joo, Paavola, & Van Alstine, 2023). Currently, the two sides are promoting the institutional alignment of the EU's Carbon Border Adjustment Mechanism with South Korea's Emissions Trading System, with the core issues being the coordination of carbon pricing differences and emission accounting standards. If mutual recognition of rules is achieved, it will effectively reduce the carbon compliance costs of South Korean products exported to the EU, reserving an institutional interface for broader carbon market linkage between the two sides in the future. Finally, the two sides are cooperating on external green assistance by leveraging complementary strengths, which offers considerable room for cooperation. In the field of energy technology, South Korea possesses strong industrialization capabilities at the application end, such as advanced manufacturing technology, electric vehicles, hydrogen energy, and semiconductors, while the EU has advantages in renewable energy integration, energy system design, and green finance frameworks. With complementary strengths, the two sides have demonstrated strong potential for cooperation in jointly supporting the green transition of third countries. Under the framework of the United Nations Framework Convention on Climate Change (UNFCCC), each side provides assistance to third-world countries in green transition, with South Korea typically offering direct technical support and project implementation, while the EU focuses on providing funding and institutional capacity building (Kim, Jeon, & Lee, 2024). This complementarity creates space for joint action in third-country markets.

The two sides are also reshaping the global low-carbon economic order through rule export and supply chain coordination. Another strategic implication of the Korea-EU Green Partnership lies in transforming the bilateral mechanism into a lever for reshaping the global low-carbon economic order and enhancing the discourse power of both sides in international climate governance. The first path is rule export.

Through the dialogue mechanism, the two sides are promoting the mutual recognition of rules between CBAM and K-ETS, aiming not only to build an institutional interface for carbon market linkage but also to attempt to construct a prototype carbon pricing alliance. At the level of multilateral coordination and third-country cooperation, the agreement mentions that the two sides will cooperate in supporting the green transition of third countries. This cooperation has a distinct outward orientation and geostrategic implication, with the goal of promoting the jointly developed accounting methods, carbon pricing models, and market access standards to broader regions, thereby strengthening the rule-making discourse power of both sides in global climate governance. The second path is supply chain coordination. Through joint action in third-country markets, the two sides can export the EU's green institutional standards and South Korea's clean energy technologies, fostering low-carbon production capacities in developing regions that conform to the norms of both sides, thereby reshaping the distribution of nodes in the global green supply chain.

2.2 Cooperation in the Technology Sector

First in the area of renewable energy technology cooperation, both sides are focusing on offshore wind power and grid stability technologies. Under the partnership framework, enterprises from both sides have engaged in substantive cooperation in key energy technology fields, leveraging their complementary strengths. In the wind power sector, South Korean companies are cooperating with EU companies to develop offshore and onshore wind power projects. EU companies have provided leading wind power technology and management experience, while South Korea has provided large-scale application scenarios and market access. South Korean and EU companies are cooperating to construct offshore wind farms in South Korea's coastal areas. Notably, Doosan Heavy Industries & Construction of South Korea has cooperated with Siemens Gamesa of the EU to build a floating offshore wind cluster in Ulsan Port, South Korea (Doosan Energy, 2024). The Ulsan coastal area has announced a long-term vision to build up to 6 GW of floating wind capacity by 2030, with currently advancing projects including the 750 MW Bandibuli project, a collaboration between Equinor, Siemens Gamesa, and Doosan. Only the 750 MW project has a signed memorandum of understanding as of mid-2026. The two sides have established a joint venture to jointly take charge of project investment, construction, and operation. Cooperating in the form of a consortium, Doosan is responsible for turbine foundations, the local supply chain, and site preparation, while Siemens Gamesa provides technology and management experience to support the operation and maintenance of the power plants. This project adopts Siemens Gamesa's advanced offshore wind technology, including large direct-drive turbines and intelligent monitoring systems. The successful implementation of this project will significantly enhance South Korea's competitiveness and technological accumulation in the Asian offshore wind power sector. In terms of improving energy efficiency, enterprises from both sides have carried out project cooperation in the smart grid field. Korea Electric Power Corporation (KEPCO) signed an agreement with ABB of the EU in 2024, planning to build a smart grid demonstration project in the Jeju Island area of South Korea. This project aims to deploy a high-inertia flywheel synchronous condenser system to address the issue of grid frequency

instability caused by the fluctuation of renewable energy sources, represented by wind and photovoltaic power generation, thereby enhancing the grid's capacity to host intermittent power sources. The project can achieve real-time monitoring and optimized management of the grid in South Korea, improving the grid's operational efficiency, level of intelligence, and reliability. The success of this project could enhance the operational efficiency of the Jeju Island grid, reduce curtailment caused by renewable energy fluctuations, lower grid frequency deviation, and improve the reliability of Jeju's isolated grid. The above two cases share a common feature: EU enterprises provide core equipment and technology, while South Korea provides local manufacturing capabilities and project implementation, forming a transnational division of labor in renewable energy technology encompassing R&D, manufacturing, and application.

Second, cooperation has been launched in the hydrogen energy and fuel cell sector. South Korea is at a leading level in fuel cell applications, while the EU is among the global frontrunners in green hydrogen electrolyzer research and development as well as hydrogen energy infrastructure planning (Han & Ahn, 2021). The two sides have jointly constructed multiple hydrogen production facilities and transport pipelines, promoting the large-scale application of hydrogen energy. Moreover, their complementary strengths are further demonstrated in specific project cooperation: Hyundai Motor, through the joint venture Hydrospider, is constructing hydrogen production facilities in Switzerland to supply fuel for fuel cell trucks in the European market. Hyundai Motor provides market demand and application scenarios, while Linde Group is responsible for the design, construction, and operation of the hydrogen production facilities. The two sides also collaborate with the South Korean government and relevant EU institutions to seek policy support and financial assistance. The project employs advanced water electrolysis technology for hydrogen production, capable of producing high-purity hydrogen, which makes South Korea one of the few countries globally with large-scale hydrogen production facilities, providing a crucial guarantee for the promotion of hydrogen fuel cell vehicles and also boosting the penetration rate of the European hydrogen truck market, which is projected to reach a market value of €820 billion by 2030 (Bravo Diaz et al., 2024). Doosan Group of South Korea signed an agreement with Cummins in 2019 to jointly develop hydrogen fuel cell systems for commercial vehicles, initially focusing on the North American market and later expanding to demonstration projects in South Korea and the EU (Doosan Innovation, 2025). Doosan's solid oxide fuel cell (SOFC) technology has been certified by DNV and is planned for application in the maritime sector. This system features high efficiency and low emissions and has been demonstrated and applied in some cities in South Korea and the EU. Cummins provides electric powertrain technology, and the jointly developed systems have been tested on bus routes in cities such as Seoul and Busan. Their cooperation is not merely a commercial activity; it has objectively enhanced the capability coupling of various links in the hydrogen energy industrial chains of both South Korea and the EU.

Third, in the nuclear energy sector, South Korea has reached cooperation with EU member states that recognize nuclear energy as a clean energy source. On November 18, 2022, the 25th Korea-France Joint Coordinating Committee on Nuclear Energy was convened, and South Korea's Ministry of Science and

ICT agreed to cooperate with the French Atomic Energy Commission (CEA) on a total of 27 technical cooperation agendas in the three areas of R&D, nuclear safety, and industry in Paris, France (Ministry of Science and ICT [South Korea], 2022). France's nuclear power technology is highly competitive globally, while South Korea has strengths in indigenous nuclear power technologies such as the APR1400, meaning nuclear power cooperation between the two countries is expected to achieve synergy. In addition to France, Poland also regards nuclear power as an important energy resource. Leveraging its leading nuclear energy technology, South Korea reached relevant agreements with Polish companies and submitted a proposal to participate in the construction of a nuclear power plant in Poland. On April 21, 2022, Korea Hydro & Nuclear Power (KHNP) visited Poland's Ministry of Climate and Environment, the main government department for constructing new nuclear power plants, and submitted a project proposal, starting comprehensive activities to win the project. KHNP signed agreements with three Polish companies on mutual cooperation in establishing supply chains, communication channels, and research areas. Meanwhile, KEPCO also signed nuclear power cooperation agreements with six Polish companies in the fields of engineering, machinery, electricity, and construction. However, the nuclear energy cooperation between the two sides has also revealed a certain degree of vulnerability: the contract for Korea Hydro & Nuclear Power at the Dukovany Nuclear Power Plant in the Czech Republic could not be finalized because EDF reported to the European Commission that the South Korean government provided "illegal subsidies" to the company, which allegedly violated EU competition rules (Zachová, 2025). This shows that although complementary strengths exist, the EU's internal competition rules and commercial competition among its member states can still become obstacles to cooperation.

2.3 Cooperation in the Supply Chain Sector

South Korea and the EU are cooperating in the area of supply chain resilience through the establishment of dialogue mechanisms, aimed at strengthening the resilience of critical mineral supply chains. Critical minerals refer to metal and mineral resources that are essential for the sustainable development of modern society now and for a considerable period into the future, yet are subject to high risks in terms of stable supply. They primarily include rare metals, rare earth metals, dispersed metals, and some rare and precious metals. Among them, rare earth elements (such as neodymium, praseodymium, dysprosium, etc.) are key materials for green technologies like electric vehicles, wind turbines, and high-efficiency motors, and the stability of their supply chains directly determines the progress of the energy transition. Currently, China accounts for 70% of global rare earth production, with South Korea importing 88% of its neodymium-iron-boron (NdFeB) magnets and the EU importing 98% of its rare earth resources from China. South Korea and the EU have established a dialogue mechanism on critical mineral supply chains, aiming to enhance the stability of rare earth element supplies for both sides (Sun, 2024). The two sides have renamed the original "Industrial Policy Dialogue" to the "Supply Chain and Industrial Policy Dialogue (SCIPD)," formally incorporating supply chain security issues into the permanent agenda of their bilateral economic dialogue. The two sides also established the "Korea-EU Green Alliance," aiming to further strengthen their own supply chain resilience through promoting green technology cooperation

(Jiang, 2025). It is important to note that cooperation between South Korea and the EU in the area of supply chain security currently remains focused on information sharing and risk warning, and substantive mechanisms such as joint reserves have yet to be formed (Choi, 2024).

South Korea and the EU are also actively seeking discourse power in the formulation of green supply chain standards. The Korean Agency for Technology and Standards (KATS) and the German Institute for Standardization (DIN) have established a joint working group to jointly promote the formulation of international standards in the fields of hydrogen energy and batteries. This move intends to leverage the "Brussels Effect" to promote European and Korean standards globally, thereby gaining a regulatory advantage in the future green industry competition (Bradford, 2012). South Korea and the EU also cooperate on the formulation of international standards for clean energy. A meeting was held between South Korea and Germany in November 2024, where the Korean Agency for Technology and Standards and the German Institute for Standardization established a joint working group focusing on international standards for hydrogen energy and batteries, with cooperation areas including hydrogen purity, storage and transportation safety, fuel cell performance testing, and full life-cycle carbon emission accounting (Ministry of Trade, Industry and Energy [South Korea], 2024). South Korea's participation in the formulation of clean energy standards within the EU region helps both sides leverage the "Brussels Effect" to externalize internal EU regulations (Li & Liu, 2023), play a leading role in the global clean energy industry standard system, reshape the clean energy supply chain with jointly formulated green standards, and adjust international competition rules in the green industry sector. In terms of progress, however, a relatively long time cycle is required from standard initiatives to adoption by international standardization organizations, and the cooperation between the two sides remains at an early agenda stage.

3. Drivers of Korea-EU Energy Transition Cooperation

3.1 Similar Policy Objectives and Instrument Choices Provide an Institutional Foundation for Cooperation, Facilitating Its Development

First, on the issue of global environmental governance, South Korea and the EU share similar policy objectives and both seek to enhance their international discourse power by supporting the green transition of other countries (Kang, 2023). The convergence of policy objectives at the legislative level means that the long-term direction of their energy transitions will not be fundamentally reversed by changes in government, providing a policy foundation for long-term energy cooperation and the construction of basic energy infrastructure. Climate change is a common challenge facing both sides. According to the Paris Agreement, keeping the global temperature rise well below 2°C and pursuing efforts to limit it to 1.5°C is the common responsibility of all countries worldwide (United Nations, 2015). Both the EU and South Korea are signatories to the Paris Agreement, their respective carbon neutrality goals are reflected in their own legislation, and their emission reduction targets show a convergent pace (Cao, Deng, & Zhang, 2026). Through the Framework Act on Carbon Neutrality and Green Growth passed in 2021,

South Korea legislatively committed to the long-term goal of achieving carbon neutrality by 2050, and according to its 2050 Carbon Neutrality Scenario, it plans to reduce net greenhouse gas emissions from 727.6 million tons in 2018 to 7.5 million tons. The EU, through the European Green Deal, established its goal of achieving climate neutrality by 2050, and amended the European Climate Law to raise its 2030 greenhouse gas reduction target to 55% (Zhang et al., 2021). While formulating their own emission reduction and carbon neutrality commitments, both sides are also actively fulfilling the international obligation to "keep the global temperature rise within 1.5°C." This forms the policy foundation for their cooperation. Both sides regard energy cooperation as a necessary pathway to fulfill international commitments, and the promotion of cooperation agendas by either side is more likely to gain domestic political and industrial acceptance due to its legitimacy, lowering the threshold for initiating cooperation.

Second, in terms of policy instrument choices, both sides have adopted the Emissions Trading System (ETS) as a core policy tool. To achieve its emission reduction targets, South Korea's core measure is the Korea Emissions Trading System (K-ETS), which reduces corporate carbon emissions through market mechanisms (Lee, 2012). The EU, as the world's largest carbon market, uses the EU Emissions Trading System, which covers 45% of its emissions, as its core instrument for controlling corporate carbon emissions (Joo, Paavola, & Van Alstine, 2023). It is worth noting that the design of the K-ETS drew upon the framework of the EU Emissions Trading System, giving the two carbon markets an inherent compatibility advantage. This places both sides within the same discursive system when conducting climate policy consultations, saving the time cost of choosing policy instruments and allowing them to directly negotiate around the specific parameters of carbon markets, thus accelerating the cooperation agenda. In the process of building the K-ETS, South Korea not only borrowed from the EU framework, but the EU also provided direct technical support during its construction. This advantage of institutional homology means that the consultation costs and technical barriers for future carbon market linkage or coupling between the two sides are far lower than for countries without any carbon market mechanism. Once the connection of their carbon markets is realized, it will not only create a unified carbon price signal for enterprises on both sides and reduce cross-border compliance costs, but is also more likely to pioneer a transcontinental carbon pricing alliance between South Korea and the EU, thereby substantially enhancing their discourse power in the formulation of global carbon pricing rules.

Third, regarding the choice of alternative energy sources, both sides have set their sights on hydrogen energy, regarding it as an important renewable energy source in the transformation of their energy structures. In January 2019, South Korea released its Hydrogen Economy Roadmap, planning to make hydrogen fuel cell vehicles and fuel cell power generation pillar industries, aiming to build South Korea into a global leader in the hydrogen economy (Wang, 2021). The plan initially involved using grey hydrogen to replace fossil fuels, gradually covering the entire industrial chain of transportation, energy production, and industry. In February of the same year, the EU also released its Hydrogen Roadmap for Europe, planning to promote the decarbonization of industry, transportation, and the building sector in phases through the development of green hydrogen, with the goal of making hydrogen a pillar of the

energy transition and achieving climate neutrality for the European continent. This similar choice of technological pathway means that the two sides do not need to debate whether the other is "betting on hydrogen energy" but can directly enter into specific cooperation topics such as technical standard alignment and the division of labor in the hydrogen energy industrial chain. South Korea possesses industrial strengths in hydrogen fuel cell vehicles and fuel cell power generation, while the EU has leading advantages in green hydrogen production, electrolyzer technology, and the planning of transnational hydrogen pipeline networks. The two sides can directly divide labor in the industrial chain based on their respective comparative advantages, thereby accelerating the efficiency of producing substantive outcomes from their cooperation.

3.2 Complementary Technological Strengths of South Korea and the EU

The EU's strengths are concentrated in the field of clean energy. To address the energy supply gap caused by the Russia-Ukraine conflict, the EU launched the REPowerEU Plan, urgently seeking alternatives to natural gas, with hydrogen and offshore wind power identified as core replacement energy sources. Through the REPowerEU Plan, the EU aims to accelerate energy independence, planning to reduce dependence on Russian fossil fuel imports and increase the share of renewable energy to 45% by 2030 (up from 22% in 2022) (Lee & Lee, 2023). In wind power technology, the EU's wind power installations account for 34% of the global installed capacity. In its utilization of hydrogen energy, the EU places great emphasis on "green hydrogen" produced via water electrolysis and holds a leading position in the research and development of green hydrogen electrolyzers. Facing energy security threats, and in order to safeguard energy security in the transportation sector, the EU has chosen to promote new energy vehicles, represented by hydrogen fuel cell vehicles, as a substitute for traditional fuel vehicles. However, as the core technology of new energy vehicles, EU enterprises' hydrogen fuel cell technology is relatively backward, representing a typical catch-up industry with low supply chain autonomy. The EU's electric vehicle market is second only to China's, ranking second globally, yet the global market share of batteries produced in the EU is only 3% (Han & Ahn, 2021).

South Korea's strengths, on the other hand, lie in the field of hydrogen fuel cell vehicles. South Korea's LG Energy Solution, Samsung SDI, and SK On are among the world's top 10 battery manufacturers. South Korea's hydrogen fuel cell vehicle fleet accounts for 39% of the global total (as of H1 2023). The Hyundai NEXO holds over 50% of the global market share in this field, and in the hydrogen fuel cell sector, Samsung SDI and LG Energy Solution also hold a global market share of up to 35%. However, South Korea's technologies in clean energy-related fields are relatively backward, and cooperation with the EU can leverage the EU's technological strengths to help South Korea achieve its long-term carbon emission reduction goals. With an energy import dependency exceeding 93%, South Korea faces severe supply security pressures. Confronted with supply crises, the South Korean government also regards hydrogen energy and renewable energy as important alternative energy sources for its energy transition. The South Korean government plans to increase the proportion of renewable energy generation from 7.5% in 2021 to 30% by 2030, and to invest 35 trillion won (approximately US$26 billion) in hydrogen

infrastructure, including 70 liquid hydrogen refueling stations and 30,000 hydrogen-powered vehicles. However, South Korea's hydrogen energy currently relies on grey hydrogen produced from fossil fuels. To achieve its emission reduction targets, it must gradually replace grey hydrogen with green hydrogen. In its 2021 Carbon Neutrality and Green Growth Strategy, South Korea also raised its green hydrogen production target to 1 million tons by 2050.

South Korea and the EU have formed clear complementary advantages in the upstream and downstream segments of the industrial chain, and cooperation helps each side compensate for its own technological shortcomings. By choosing to cooperate with the EU, South Korea can leverage the EU's clean energy technology strengths to help ensure the stability of its own energy supply while simultaneously achieving its emission reduction targets. The EU possesses mature technologies in wind turbine manufacturing, offshore wind farm operation and maintenance, and electrolyzer manufacturing. South Korea's cooperation with the EU can directly fill its technological gap in the large-scale production of green hydrogen, helping South Korea switch the foundation of its hydrogen energy from grey hydrogen to green hydrogen, thereby simultaneously addressing the two strategic objectives of energy security and carbon neutrality. By choosing to cooperate with South Korea, the EU can leverage South Korea's technological strengths to reinforce its own applied technologies in the battery industry. Through cooperation, the EU can introduce South Korea's high-performance fuel cell technology into the EU, or embed it into the EU's new energy vehicle supply chain through means such as establishing factories directly or engaging in joint venture production, thereby rapidly enhancing the EU's competitiveness in hydrogen fuel cell vehicles and battery manufacturing. This would resolve the predicament where its transport decarbonization has been hampered by backward core component technologies.

3.3 Korea-EU Cooperation Provides Economic Development Opportunities for Both Sides

The EU's vast market offers substantial business opportunities for South Korean companies. For South Korean enterprises, the EU is not only the world's second-largest new energy vehicle market after China, but also a blue ocean with massive battery demand. According to the EU's "Fit for 55" package, the EU will effectively ban the sale of internal combustion engine vehicles by 2035. This radical transport decarbonization target signals surging demand for electric vehicles and hydrogen fuel cell vehicles (Ahn, 2022). However, the EU's domestic battery industrial chain has long been weak, with a global market share of only about 3%, and the EU has shown strong interest in building a battery ecosystem. On April 9, 2019, the European Commission published a report titled "Implementation of the Strategic Action Plan on Batteries: Building a Strategic Battery Value Chain in Europe." According to the Commission's report, demand for batteries is expected to grow rapidly as the transition to green energy advances (Ahn, 2020). South Korea, on the other hand, possesses significant industrial strengths and market share in hydrogen fuel cell technology. South Korean companies have strong industrial advantages in hydrogen fuel cells and power batteries—Hyundai, LG, Samsung, and other Korean battery manufacturers are all among the world's top 10 battery producers, and they rely heavily on export markets. This "EU has the market, South Korea has the technology" landscape drives a "market-for-technology" mode of cooperation. South

Korean companies can deeply embed themselves into the EU's green industrial system through direct investment in factories, technology licensing, or joint venture production, converting the EU's vast end-market into enormous and sustainable economic gains for themselves. At the same time, this helps the EU rapidly address its shortfall in battery self-sufficiency and accelerate the green transition of its transport sector, thus achieving complementarity between market scale and technological dividends at the bilateral level.

The energy transition not only helps address climate change but can also drive the development of related industries and create new economic growth points. Cooperation between the two sides allows them to share market scale and promote each other's economic development. The EU's Net-Zero Industry Act explicitly states that by 2030, domestic clean technology production capacity must cover at least 40% of market demand (Sun, 2023). This compels the EU to bring in mature technology partners to jointly build capacity, providing a policy window and substantial orders for South Korean new energy companies to localize production in Europe. In parallel, the South Korean government's "Green New Deal" plans to invest 73.4 trillion won in renewable energy expansion and digital infrastructure (Quan & Yao, 2022). As the world's ninth-largest energy consumer, South Korea's massive investment demand for offshore wind power, smart grids, and green hydrogen production facilities also provides a high-value-added export market for the EU's technologically advantaged wind turbine and electrolyzer manufacturers (U.S. Energy Information Administration, 2020). By choosing each other as partners, South Korea and the EU not only help directly drive the green upgrading of traditional industries such as equipment manufacturing, infrastructure construction, and transportation, but also help stimulate joint research and development and commercial deployment in frontier technology fields such as hydrogen energy storage and transport, carbon capture, and next-generation batteries, creating a large number of high-quality jobs and promoting economic development for both sides, achieving a result where one plus one is greater than two.

4. Challenges Faced by Korea-EU Energy Transition Cooperation

4.1 Discontinuity in South Korea's Domestic Policy and Difficulties in Aligning Governance Models Hinder Deeper Cooperation

First, South Korea's energy policy is highly susceptible to the influence of party rotation, exhibiting a pronounced "pendulum effect," which undermines policy continuity and long-term expectations. After Yoon Suk Yeol took office in 2022, the previously planned phase-out of nuclear energy was completely overturned in favor of a nuclear power expansion policy. The construction of Shin Hanul Units 3 and 4 was resumed, with plans to increase the share of nuclear power in the electricity mix to over 30% by 2030. The previous administration had set a target of 30.2% renewable energy share by 2030, while the Yoon Suk Yeol government signalled a revised planning figure of around 21.6% for renewable power generation by 2030, while the nuclear target was raised to 32.4%, viewing nuclear power as one of the important pathways to achieving its emission reduction goals (Lee & Morgan, 2024). With the change of government in 2025, the incoming Lee Jae-myung administration did not fully inherit the energy policies

of the previous Yoon Suk Yeol government. After taking office, the Lee Jae-myung administration adopted a selective utilization approach to nuclear energy, opposing the construction of new large-scale nuclear reactors while supporting the development of small modular reactors (SMRs) to maintain industrial competitiveness and power supply security, and retaining existing nuclear power plants (Mao, Jian, & Miao, 2025). While this approach still reflects South Korea's dependence on nuclear energy, it differs from the Yoon administration's policy of comprehensively revitalizing nuclear power. The shift in nuclear energy utilization policy from comprehensive revitalization to selective utilization has a clearly discernible transnational transmission path: the political endorsement that large-scale nuclear cooperation projects initiated with EU member states during the Yoon administration relied upon has partially lapsed, causing earlier technical interfacing and commercial negotiations to stall. The vacillation in nuclear energy policy is not an isolated case. Deep-seated differences between conservatives and progressives on climate governance policies make South Korea's energy planning an unreliable basis for decision-making by multinational enterprises. When the policy direction is perceived as uncertain, current cooperation investments tend to become conservative, making it more difficult to deepen cooperation in energy sectors beyond hydrogen.

Second, differences in energy governance models between South Korea and the EU can create obstacles to cooperation. South Korea's energy governance model is a top-down decision-making system, in which the government plays a dominant role in energy governance and holds decisive power over issues such as market structure and policy direction (Kim, 2013). The Korea Electric Power Corporation (KEPCO), which operates the national transmission grid, plays a leading role in energy governance. Unlike South Korea's top-down energy governance model, the EU's approach involves establishing a top-down goal framework through rule-setting, which is then implemented bottom-up by member states and enterprises according to their own circumstances, ultimately forming a governance system. However, the governance system that ultimately takes shape is actually the product of compromises reached after extensive bargaining among multiple parties within the EU. On the one hand, the multi-party bargaining process within the EU requires a relatively long time cycle, which means that policies pursued by South Korea during cooperation cannot be swiftly implemented, thereby generating resistance to cooperation. The negotiation process for South Korea's association to Horizon Europe lasted about three years (from around 2022 to mid-2025), which is within the typical range for such international research agreements. Although the extended process created some uncertainty for Korean stakeholders, the concrete "waiting and opportunity costs" have not been quantified (Joo, Paavola, & Van Alstine, 2023). This difference in governance models translates into communication costs and execution frictions when the two sides advance specific projects in their cooperation, which necessitates deeper, higher-level policy dialogues to ensure that the outcomes of cooperation are complementary rather than mutually draining.

4.2 EU Trade Protectionism Affects Cooperation

First, the asymmetry in carbon pricing sovereignty between South Korea and the EU exposes rifts in their cooperative relationship. The EU strictly enforces its carbon tariff policy, also known as the Carbon

Border Adjustment Mechanism (CBAM), which refers to a special tariff imposed on imported high-carbon products, including steel, aluminum, cement, fertilizers, and glass products. These materials are critical to the EU's green transition, digital transformation, and defense and aerospace industries. The core principle of this policy is to require imported products to bear costs corresponding to the carbon emissions generated during their production processes, thereby balancing the differences in carbon emission costs between domestic and imported products. The imposition of carbon tariffs aims to reduce global carbon emissions, prevent carbon leakage, and protect the competitiveness of domestic high-carbon industries (Cho et al., 2024). The EU is the first region to implement a carbon tariff policy. In December 2022, the European Parliament and the European Council reached an agreement to launch the transitional phase of the Carbon Border Adjustment Mechanism from October 1, 2023, with the transition period lasting until the end of 2025, formal collection starting on January 1, 2026, and full implementation before 2034. The EU has adopted this legislation to support domestic enterprises, but it has also led to restrictions on South Korea's access to resources such as lithium and nickel in European countries (Lim, 2024). The carbon price in South Korea's carbon market (K-ETS) averaged approximately 9,400–9,900 KRW (about US$6.6–7.0) per ton in 2025, while the EU ETS carbon price averaged approximately €73–74 per ton in 2025 and fluctuated between €70 and €85 in 2024–2025, though it temporarily exceeded €80 in some months. South Korea's steel industry exports approximately 15% of its total output to Europe. If the EU strictly enforces CBAM, preliminary estimates suggest that South Korean industries exporting to Europe could face additional compliance costs exceeding US$1 billion annually. This effectively shifts the EU's emission reduction costs outward through trade channels. Although South Korea and the EU have plans to align the carbon prices of their respective carbon markets through consultation, no substantive progress has been achieved to date, and the problem of increased export costs for South Korea resulting from different carbon pricing remains. The carbon tariff policy has been unilaterally designed and implemented by the EU, with South Korea as a passive recipient of the rules, exposing structural asymmetries and rifts that persist within the institutional framework of the bilateral Green Partnership.

Second, with the rise of trade protectionism in the EU, South Korean companies are also confronting a series of policy restrictions. As Korean automakers, represented by Hyundai and Kia, continue to gain a growing market share in the European market, South Korean brands accounted for approximately 16% of EU electric vehicle sales as of 2024. Meanwhile, South Korean battery manufacturers such as LG Energy Solution, SK On, and Samsung SDI are constructing large-scale factories in European countries like Poland and Hungary. To protect the market share of local enterprises, the EU has enacted the Batteries Regulation, which stipulates that the proportion of locally produced components within the EU must exceed 70% for parts not containing batteries, and that batteries with a capacity greater than 2 kWh must provide a carbon footprint declaration (Regulation (EU) 2023/1542, 2023). By continuously raising compliance thresholds and localization requirements for supply chains, South Korean companies face higher costs to maintain their competitive advantage and market share. Furthermore, the EU has

introduced policies to support domestic automakers, and through the "European Battery Alliance" (EBA), it supports European local battery enterprises via multiple means, including funding, regulations, technology, and market instruments (Fumany et al., 2026). This means South Korean battery companies will face even more intense competition in the European market, compressing their market share and profit margins. Battery enterprises are under dual pressure: on the one hand, compliance costs and supply chain adjustment costs; on the other hand, competition on the same track against local enterprises enjoying EU public funding support, resulting in a de facto unequal competitive position for South Korean companies in the EU. A contradiction has emerged between the EU's pursuit of "strategic autonomy" in green industries and the Korea-EU "partnership." While the EU needs South Korea's technology to accelerate the green transition in the transport sector, it also employs institutional design to ensure that the high ground of future long-term value chains is occupied by local enterprises. This approach of "short-term utilization and long-term substitution" blurs the role positioning of South Korean companies. South Korean enterprises cannot help but feel anxious about their own role: are they equal partners, or are they merely regarded as short-term transitional suppliers? This uncertainty is not merely a question of increased costs; it will further impede the deepening of cooperation and affect the deepening of mutual trust in the bilateral partnership.

4.3 The Impact of Geopolitical Conflicts and Great Power Rivalry

Geopolitical conflicts have driven up the costs of traditional energy imports, squeezing the funding sources for Korea-EU cooperation projects. The surge in energy import costs triggered by international geopolitical conflicts has forced both the EU and South Korea to expend substantial fiscal resources to maintain short-term energy security, ultimately diminishing their capacity to deliver on long-term green cooperation investments. Both South Korea and the EU are still in the process of energy transition, and as new energy sources have yet to fully cover their energy needs, they still need to import traditional energy to ensure supply security. Frequent geopolitical conflicts in recent years have led to rising prices in the international energy market and escalating costs for imported energy. The Russia-Ukraine conflict, along with renewed turbulence in the Middle East, has destabilized global energy supply chains. On the EU side, given its long-term dependence on Russian energy supplies, the Union was forced to prioritize energy security after the outbreak of the Russia-Ukraine conflict. To fill the gap left by Russian natural gas imports, the EU shifted its natural gas imports to the United States and the Middle East. However, due to volatility in the international energy market, peak gas prices reached €300/MWh in 2022. Massive gas price expenditures have squeezed the funding for Korea-EU cooperation projects—the joint hydrogen project between Poland and South Korea, for instance, had its financing suspended due to gas price fluctuations. As current new energy technologies are insufficient to fully support South Korea's energy demand, South Korea has also been forced to slow down its own energy transition process. South Korea's energy supply security is primarily affected by geopolitical conflicts in the Middle East. With 96% of its energy dependent on imports, its most important energy import region is the Middle East—in 2023, 73% of its crude oil came from the region (U.S. Energy Information Administration, 2023).

Affected by the Red Sea shipping crisis, international oil price fluctuations have forced South Korea to postpone the decommissioning of coal-fired power plants to ensure stable energy supply. This, however, has caused South Korea's decarbonization progress to conflict with its originally planned carbon neutrality timeline, thus slowing the pace of its energy transition.

Against the backdrop of trade rivalry between the two major powers, China and the United States, Korea-EU cooperation also faces the risks of capital diversion and the weakening of supply chain stability due to political alignment. On the one hand, in the context of Sino-US trade competition, the United States began implementing the Inflation Reduction Act (IRA) in 2023, aiming to direct US investment in energy security and climate change over the next decade, develop onshore green industrial production, stimulate green consumption, support and protect domestic manufacturing, and boost emerging industries such as new energy vehicles (Lee & Lee, 2023). The incentives this act provides for foreign companies to build factories in the US have attracted enterprises from both South Korea and the EU to invest in the US (Yea, 2025). This will also lead to a portion of the investment funds that South Korea and the EU would otherwise direct toward each other being diverted, further squeezing the funding sources for bilateral projects and hindering the further development of their cooperation. On the other hand, for the purpose of political alignment, South Korea and the EU have chosen to jointly join the US-led "Minerals Security Partnership" (MSP), which aims to promote the so-called "diversification of critical mineral supply chains and reduce concentrated dependence on a single source country." The politically driven rapid adjustment of supply chains and unilateral reduction of rare earth imports will lead to a severe rare earth supply gap for both South Korea and the EU, hindering the production of green technology necessities such as cathode materials for power batteries, thereby affecting their energy transition progress. This also reflects the dilemma faced by South Korea and the EU as middle powers: in the process of great power competition reshaping global supply chains, under the pressure of geopolitical alignment, both sides find it difficult to choose the most efficient pathways to acquire critical resources, thus affecting the smooth progress of cooperation.

5. Conclusion

Through a systematic analysis of the institutional framework, technological cooperation, and supply chain collaboration of the Korea-EU "Green Partnership," this paper finds that the two sides have made substantial progress in areas such as offshore wind power, hydrogen energy, nuclear energy, and batteries, forming a complementary cooperation model characterized by "EU front-end technology R&D and South Korean industrial project implementation." The deep driving forces of this cooperation stem from the convergence of institutional goals, the complementary advantages of industrial structures, and the mutual expectations of incremental markets created by the green transition. However, the cooperation process faces three challenges. First, the "pendulum effect" in energy policy triggered by domestic party turnover in South Korea weakens the policy stability required for long-term technological cooperation. Second, the EU's unilateral trade protection measures, represented by the Carbon Border Adjustment Mechanism,

the Critical Raw Materials Act, and the Batteries Regulation, have damaged the originally complementary interest structure of the two sides, subjecting South Korean companies to the dual pressures of rising compliance costs and unequal competitive positions. Third, geopolitical conflicts and great power competition squeeze the fiscal space and strategic attention for cooperation through energy price fluctuations, capital diversion, and the politicization of supply chains. The progress and limitations of the Korea-EU Green Partnership not only reveal the potential and predicaments of cooperation among middle powers in the global energy transition but also provide lessons for the institutional design of cross-regional climate governance partnerships.

Fund Project

This article is a phased achievement of the basic scientific research project of 2024 Annual Liaoning Provincial Social Science Planning Fund General Project: Research on the Role Positioning of South Korea in the Process of NATO's Asia-Pacificization and Its Impact on China (Grant No. L24BGJ001).

References

Ahn, S. W. (2020). EU member states' response to climate change in the transport sector: Focusing on the electric vehicle strategies of the French government and Renault. *Journal of European Integration Studies*, *11*, 237-258.

Ahn, S. W. (2022). EU transport sector carbon neutrality policy and battery industry. *European Studies*, *40*(4), 45-68.

Bradford, A. (2012). The Brussels effect. *Northwestern University Law Review*, *107*(1), 271-332.

Bravo Diaz, L., et al. (2024). *Fuel cell technology in the European Union: Status report on technology development, trends, value chains & markets* (pp. 38-39). Publications Office of the European Union.

Cao, C., Deng, S., & Zhang, Q. (2026). Practice of international carbon emissions trading markets and its enlightenment to China: Based on the experiences of the EU, North America, New Zealand and South Korea. *Jiangsu Science and Technology Information*, (4), 1-5.

Cho, B. K., Jung, H., Chung, J. B., et al. (2024). Implications of the carbon border adjustment mechanism on South Korean industries: Challenges and policy recommendations. *Journal of Cleaner Production*, *444*, 141278.

Choi, S. (2024). *Supply chain risks in EU-South Korea relations: Semiconductor industries*. Istituto Affari Internazionali (IAI).

Delegation of the European Union to the Republic of Korea. (2023, March 10). *Republic of Korea: 19th Joint Committee with the European Union takes place in Brussels*. https://www.eeas.europa.eu/eeas/republic-korea-19th-joint-committee-european-union-takes-place-brussels_en

Doosan Energy. (2024, October 16). *Doosan Energy, SGRE, and Equinor sign agreement to promote Ulsan Bandibul 750MW floating offshore wind project*.

https://news.goalfore.cn/latest/detail/72381.html

Doosan Innovation. (2025, April 8). *Doosan further solidifies its position in global hydrogen power generation market by mass-producing 300kW-class SOFC*. https://news.goalfore.cn/latest/detail/72381.html

European Commission. (2023, May 22). *European Green Deal: EU and Republic of Korea launch Green Partnership to deepen cooperation on climate action, clean energy and environmental protection*. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_2816

Fumany, M., Nguyen-Tien, V., Li, N., et al. (2026). The EV transition: The impact of the EU battery directive on critical material supply, recycling and battery costs. *Resources Policy*, *112*, 105787.

Han, H. J., & Ahn, S. W. (2021). EU climate change response and automotive industry: Implications for cooperation with Korea in electric vehicle battery sector. *EU Studies*, *57*, 167-193.

Jiang, Y. (2025). Strategic rapprochement between the EU and South Korea in the context of intensifying geopolitical rivalry. *Contemporary Korea*, (4), 54-64.

Joo, J., Paavola, J., & Van Alstine, J. (2023). The divergence of South Korea's Emissions Trading Scheme (ETS) from the EU ETS: An institutional complementarity view. *Politics & Policy*, *51*(6), 1155-1173.

Kang, S. (2023). Differentiation strategy: South Korea's quest for global green growth leadership. *Journal of International Strategic Studies*, (3), 77-92.

Kim, T. K., Jeon, J. H., & Lee, D. (2024). A comparative analysis of the climate change mitigation efforts of Korea and Germany: Implemented technology and financial mechanism projects under the UNFCCC. In S. Klingebiel, T. Kalinowski, & N. Keijzer (Eds.), *Emerging trends in international development and climate policy: A focus on Korea and Germany* (pp. 113-122). Palgrave Macmillan.

Kim, V. (2013). *The implementation of green growth policy in Korea: Context, performance, and future* (Doctoral dissertation, pp. 46-47). Seoul National University.

Lee, H., & Lee, J. S. (2023). Resetting the energy-transition paths amid the dual crises: The EU-South Korean responses to the war in Ukraine and US-China rivalry. *Asia Europe Journal*, *21*(4), 607-623.

Lee, M. S. (2012). The limits and possibilities of environmental cooperation between the EU and Korea. *EU Studies*, *32*, 5-31.

Lee, T., & Morgan, S. (2024). Nuclear energy policy swing: Expansion and contraction in South Korea. *Journal of Future Politics*, *14*(2), 79-120.

Li, X., & Liu, X. (2023). The geopolitical turn of the EU's clean energy supply chain restructuring. *International Forum*, (5), 98-115.

Lim, H. J. (2024, May 20). *Main contents of the EU CRMA and direction for response*. Industry Analysis Division.

Mao, J., Jian, Y., & Miao, Z. (2025, June 16). Prioritizing transition: Energy strategy orientation of South Korea's new administration. *China Energy News*, p. 6.

Ministry of Science and ICT (South Korea). (2022, November 19). *Strengthening Korea-France nuclear cooperation*. https://www.msit.go.kr/bbs/view.do?sCode=user&mId=113&mPid=112&bbsSeqNo=94&nttSeqNo=3181214

Ministry of Trade, Industry and Energy (South Korea). (2024, November 25). *Strengthening clean energy standard cooperation between Korea and Germany*. https://kr.mofcom.gov.cn/jmxw/art/2024/art_775c88ab3fe441a988fc5efc3f9e313f.html

Quan, J., & Yao, X. (2022). Research on energy transition in South Korea. *China Petroleum and Chemical Standard and Quality*, *42*(23), 115-118.

Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries. (2023). https://eur-lex.europa.eu/eli/reg/2023/1542/oj/eng

Sun, Y. (2023). EU energy policy: Development process, effects and prospects. *Deutschland-Studien*, *38*(3), 45-63.

Sun, Y. (2024). Analysis of EU economic security strategy and its impact on China: From “open strategic autonomy” to comprehensive “de-risking”. *European Studies*, (2), 21-40.

U.S. Energy Information Administration. (2020). *Country analysis executive summary: South Korea* (pp. 1-2). Washington, D.C.: EIA.

U.S. Energy Information Administration. (2023). *Country analysis brief: South Korea* (p. 12). Washington, D.C.: EIA.

United Nations. (2015). *Paris Agreement*, Article 2, para. 1(a).

Wang, S. (2021). Why does South Korea have the confidence to lead the hydrogen economy? *China Ship Survey*, *(11), 52-55.*

Yea, S. (2025, December 24). *Supply chain stability and strategic investment subsidies* (World Economy Brief No. 25-32). Korea Institute for International Economic Policy. https://www.kiep.go.kr/gallery.es?mid=a20301000000&bid=0007&act=view&list_no=12168

Zachová, A. (2025, May 27). *Pushback over Korea’s nuclear power ambition in Europe*. Euractiv. https://www.euractiv.com/news/pushback-over-koreas-nuclear-power-ambition-in-europe

Zhang, Y., Guo, M., Lan, T., et al. (2021). Analysis and reflection on South Korea’s implementation of the Green New Deal. *Jilin Financial Research*, (3), 46-49.