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Bottlenecks to Renewable Energy Integration in South Korea

Reforming grid, power purchase agreements (PPAs), and the Renewable Portfolio Standard (RPS) systems for qualitative renewable energy growth

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Contents

Figures and Tables

Key Findings

Renewable energy capacity in South Korea increased sixfold from 2013 to 2023. However, renewable electricity generation rose only threefold during that time. Underdeveloped grid transmission and distribution systems, ineffective Power Purchase Agreements (PPAs), and an inefficient Renewable Portfolio Standard (RPS) are obstacles to renewable energy generation.

Lagging electricity grid expansion and modernization are critical barriers to renewable energy integration in South Korea. Local communities' resistance to sites, and the Korea Electric Power Corporation's (KEPCO) financial constraints and grid monopoly, have obstructed the efficient implementation of grid projects.

South Korea's ineffective PPA and inefficient RPS systems hinder renewable energy growth. High costs, complex regulations, and KEPCO's monopoly prevent a self-sustaining, 'virtuous cycle' of investment, while the RPS system promotes indirect compliance through the purchase of Renewable Energy Certificates (RECs) rather than direct renewable generation. This increases costs, reduces investment, and limits direct renewable power generation.

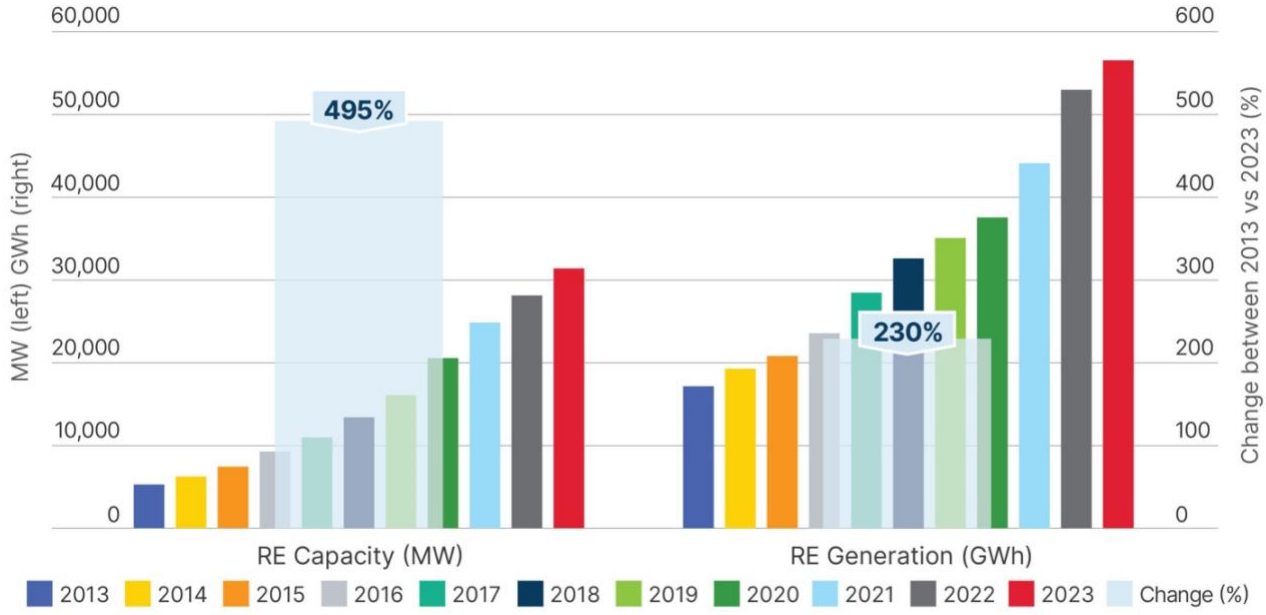
Amid increasing global pressure for decarbonization, South Korea needs to focus not only on expanding capacity but also on the quality and effectiveness of its renewable energy sector. This shift would also be pivotal for global competitiveness in emerging industrial sectors such as artificial intelligence and semiconductors.

Executive Summary

Several bottlenecks have hampered the integration of renewable energy in South Korea's national grid system. Despite the significant increase in the country's renewable energy capacity, inadequate transmission and distribution systems, ineffective Power Purchase Agreements (PPAs), and an inefficient Renewable Portfolio Standard (RPS) are obstacles to renewable energy generation.

According to data from the Korea Electric Power Corporation (KEPCO), renewable energy capacity increased sixfold from 2013 to 2023, while renewable electricity generation rose only threefold during the same period (Figure 1).

Figure 1: South Korea's Renewable Energy Capacity and Generation Increments (2013-2023)



Source: KEPCO.
Note: Renewable energy sources in South Korea refer to 'new and renewable energy,' which includes fuel cells and Integrated Gasification Combined Cycle (IGCC) under the Renewable Energy Act of Korea. The figures include general hydro and small hydro but exclude pumped storage.

As a result, South Korea's renewable energy transition is lagging behind other countries by at least 15 years. The renewable energy share in the power mix reached 10% for the first time in 2024. However, according to the 11th Basic Plan for Long Term Electricity Supply and Demand (BPLE), South Korea will achieve its 32.95% target only around 2038. This is far short of the 2023 levels for the world (30.25%), the Organization for Economic Cooperation and Development (33.49%), and Asia (26.73%).

One of the primary bottlenecks delaying renewable energy integration is inadequate grid expansion and modernization. Enhanced transmission infrastructure is needed since renewable energy is often generated far from where power is consumed.

One of the most significant barriers is the challenge of transmission siting, often caused by opposition from local residents, which can delay major grid construction projects by as much as 11 years.[1] Additionally, KEPCO's monopoly over transmission and distribution has obstructed the efficient implementation of grid expansion and modernization projects. These issues are compounded by a lack of resources due to the utility's persistent financial problems, further emphasizing the lack of competitiveness in South Korea's power market structure.

Electricity demand is expected to rise with the development of large-scale semiconductor clusters in Yongin and Artificial Intelligence (AI) data centers in Seoul and Gyeonggi provinces. However, delays in power grid construction and modernization raise concerns about an unstable power supply and a potential weakening of industrial competitiveness.

PPAs have been widely adopted in other countries for sustainability and decarbonization. They offer stable and predictable power purchase prices for consumers and guaranteed long-term revenues and investment incentives for producers.[2]

However, South Korea's PPA system has failed to establish a 'virtuous cycle'[3] that ensures a stable revenue stream for renewable energy suppliers. Such a mechanism would support the expansion of renewable energy generation, increase supply, and lower prices – thereby amplifying demand for PPAs.

The first challenge to the virtuous cycle of PPAs is the restrictive and complex rules and regulations caused by a bifurcated system, including direct PPAs and third-party PPAs. In direct PPAs, the renewable electricity provider acts as an intermediary between the renewable energy generator and the consumer, whereas in third-party PPAs, KEPCO acts as an intermediary. However, renewable energy providers acting as intermediaries for direct PPAs cannot procure additional electricity to cover any shortfalls.

This contrasts with practices in other countries, such as the United States (U.S.), Australia, and many northern European countries, where most PPA participants, including renewable energy generators, renewable energy providers, and consumers, are allowed to freely procure any shortfall from the market.[4]

[1] Yonhap. Power demand to double in 2051, power grid construction continues delaying. 06 May 2024.
[2] Climate Group. South Korea's PPA System: Status and Opportunities for Renewable Energy Development. March 2024. Page 3.
[3] South Korea's PPA system has failed to establish a 'virtuous cycle' (Figure 16) that ensures a stable revenue stream for renewable energy suppliers. This mechanism would contribute to expanding renewable energy generation, increasing supplies, lowering prices, and amplifying the demand for PPAs.
[4] Climate Group. South Korea's PPA System: Status and Opportunities for Renewable Energy Development. March 2024. Page 13.

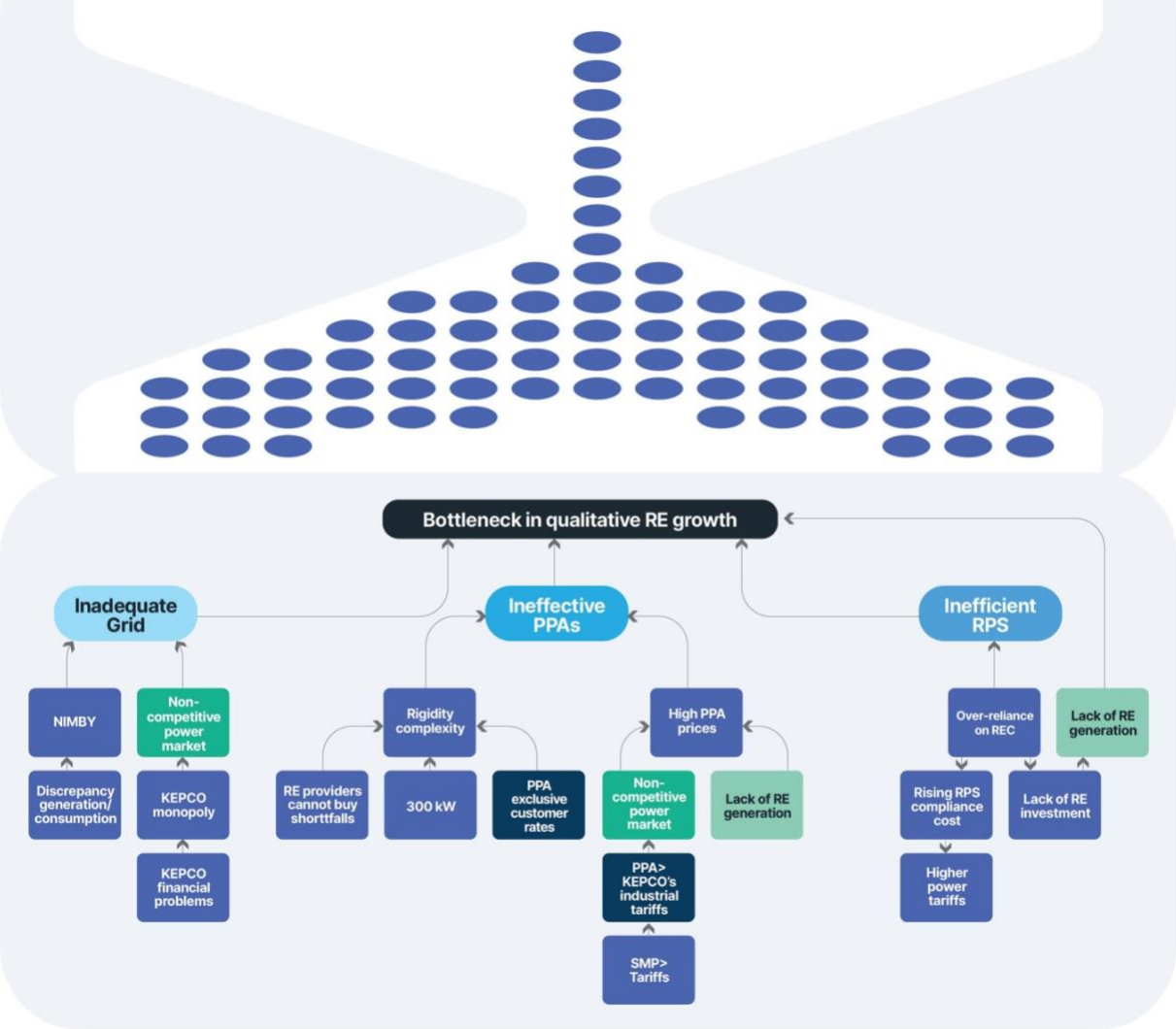
The second obstacle is the high price of delivered energy. Higher PPA prices disincentivize customers from choosing PPAs over KEPCO's lower industrial tariffs. Alternatively, they prefer indirect methods, such as purchasing renewable energy certificates (RECs), which do not facilitate the increase of renewable generation. Renewable energy PPA prices are generally lower than wholesale electricity prices in mature markets such as the U.S., Europe, and Australia. This pricing is supported by declining renewable energy technology costs, government incentives, long-term fixed-price purchase agreements, and the option for direct supply agreements between renewable energy generators and consumers.

PPA prices in South Korea are generally higher than market prices due to a distorted power market structure, limited renewable energy supply, and delayed grid parity — all of which stem from fundamental issues.

South Korea's RPS has also faced criticism for failing to promote renewable power generation directly. The overreliance on purchasing RECs to fulfill RPS obligations could sharply increase the financial costs associated with compliance. This could lead to suppressed investments and limited direct renewable power generation, especially for public entities.

The current RPS is incompatible with PPA regulations connecting consumers and renewable power generators. RPS fails to promote direct renewable power generation, and this ineffective system has also failed to address grid expansion and modernization inadequacies.

Figure 2: Bottlenecks in Qualitative Renewable Energy Growth



Source: IEEFA.

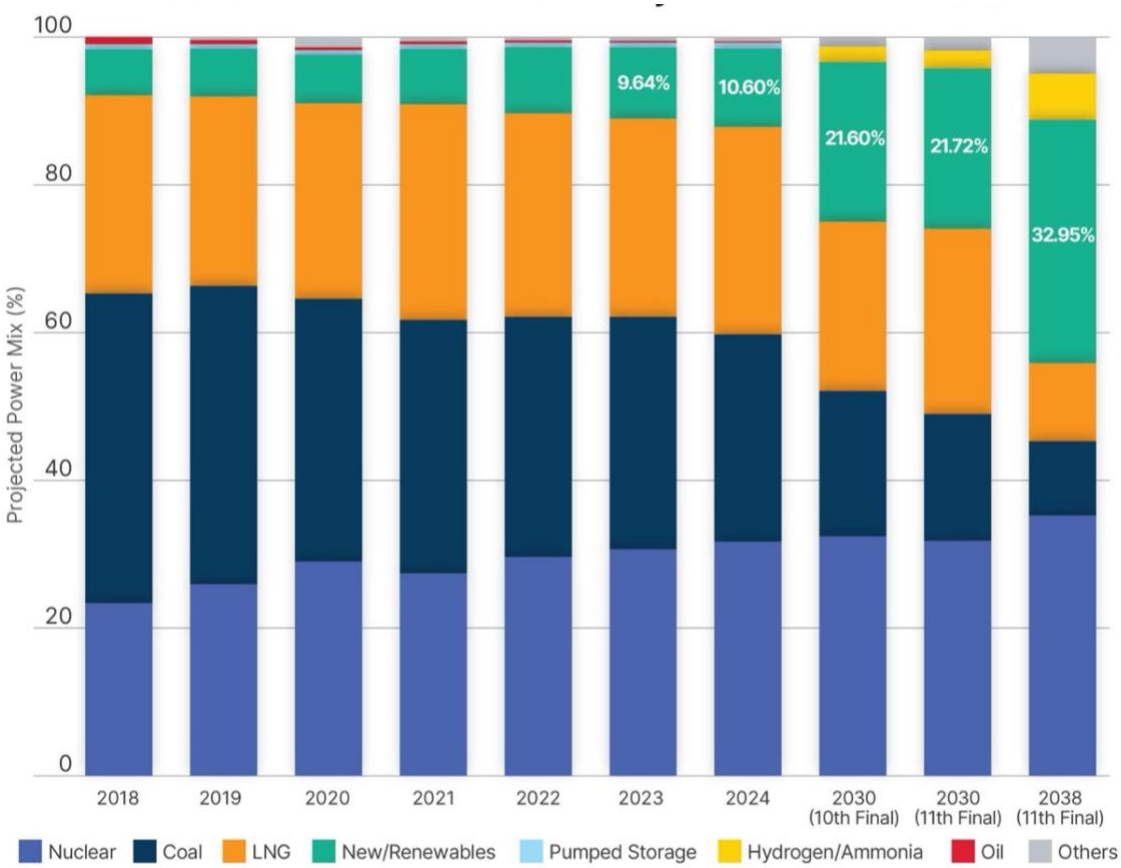
South Korea is implementing several reforms to address the three main challenges in renewable energy integration. However, as policies are interconnected, a more coherent and holistic approach is needed to accelerate the sector's qualitative growth.

Amid increasing global pressure for decarbonization, South Korea needs to focus not only on expanding capacity but also on the qualitative growth of its renewable energy sector. This shift would also be pivotal for global competitiveness in emerging industrial sectors such as AI and semiconductors.

Introduction

South Korea's renewable energy integration lags significantly behind other countries. Despite ambitious decarbonization targets and the pledge of tripling renewable energy capacity by 2030, renewable electricity, which includes wind, solar, conventional hydropower[5], and other sources[6], accounted for a mere 10.6% of the power generation mix in 2024 (Figure 3). This figure is overestimated as South Korea includes fuel cells and integrated gasification combined cycle (IGCC) under the new and renewable energy category. Most countries omit these technologies from their metrics.

Figure 3: South Korea's Current and Projected Power Mix (%)

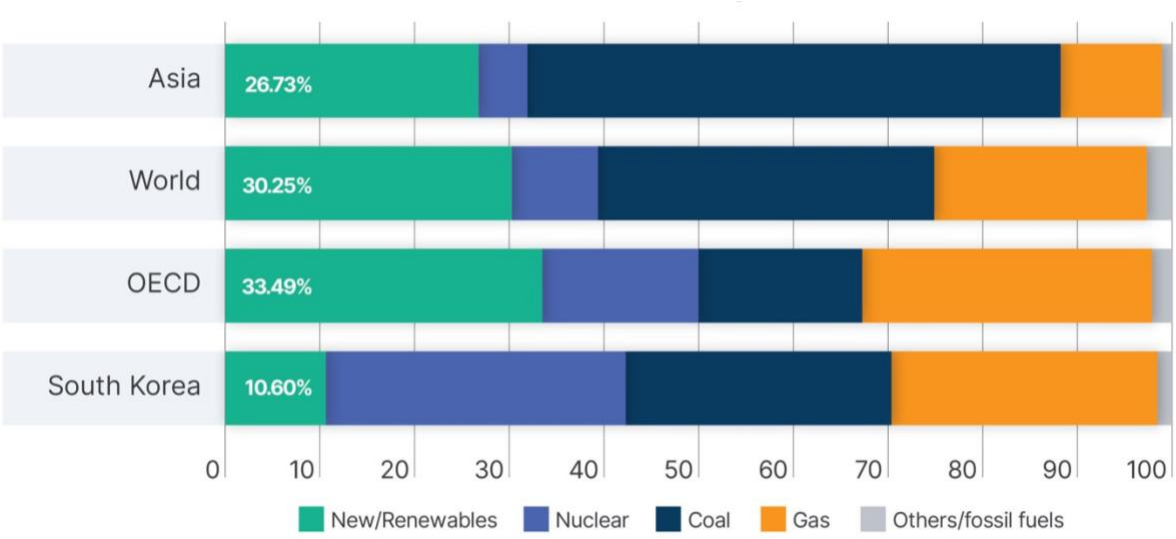


Source: MOTIE; KEPCO.
Note: The data from 2030 to 2038 is from the 11th Basic Plan for Long Term Electricity Supply and Demand (BPLE). Renewable energy sources in South Korea refer to 'new and renewable energy,' which includes fuel cells, Integrated Gasification Combined Cycle (IGCC), and waste-to-energy under the Renewable Energy Act of Korea. The figures from KEPCO include general hydro and small hydro but exclude pumped storage.

[5] This does not include pumped storage in South Korea.
[6] Renewable energy sources in South Korea also include fuel cells and Integrated Gasification Combined Cycle (IGCC) under the Renewable Energy Act of Korea.

In 2024, renewable energy accounted for over 10% of South Korea's power mix for the first time. However, the country is still far below the global average of around 30%.[7] According to the final 11th Basic Plan for Long Term Electricity Supply and Demand (BPLE)[8], South Korea is targeting 32.95% renewable energy by 2038. Nevertheless, it is still falling short of the averages of the world (30.25%), the Organization for Economic Cooperation and Development (OECD) (33.49%), and Asia (26.73%). This signals that South Korea's renewable energy transition lags at least 15 years behind other countries.

Figure 4: South Korea's Renewable Electricity in Power Mix (%)



Source: MOTIE; KEPCO; Ember.
Note: Renewables for South Korea in 2024 include new energy and conventional hydropower but excludes pumped storage. Data for 2023 OECD, world, and Asia averages are from Ember.

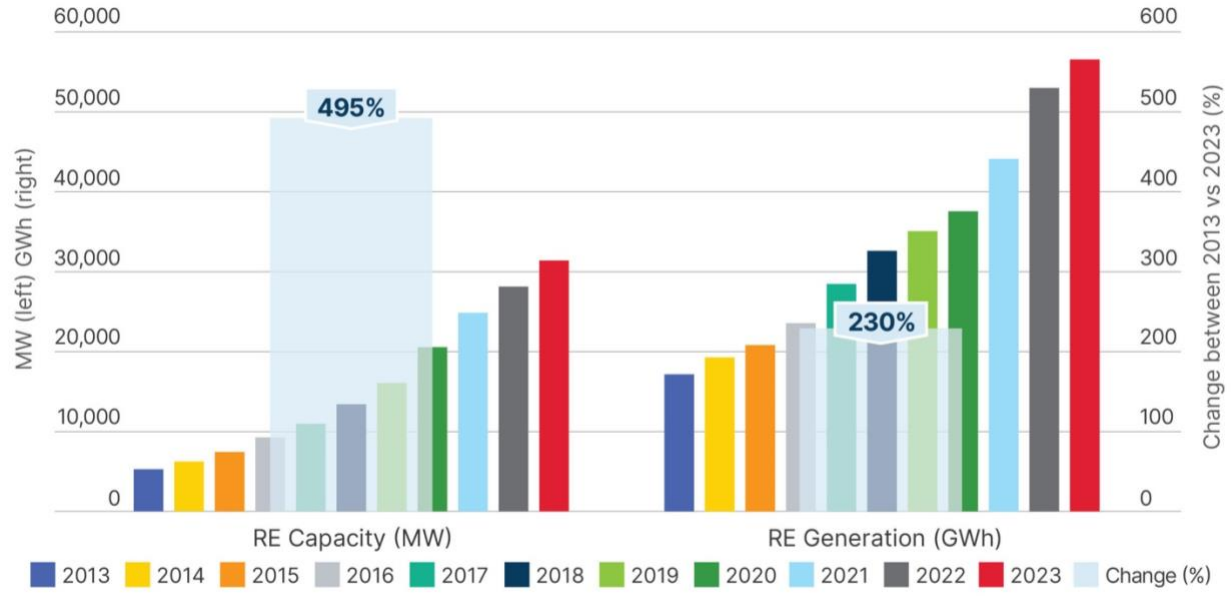
One of the primary barriers to scaling up renewable energy is the country's inadequate transmission and distribution infrastructure, which hinders its integration into the national grid.

Despite the significant increase in renewable energy capacity, the lack of transmission and distribution networks has led to frequent curtailments, causing actual renewable energy generation to remain low.

According to data from the Korea Electric Power Corporation (KEPCO), renewable energy capacity spiked 495% from 2013 to 2023, while renewable electricity generation rose only 230% (Figure 5). Furthermore, transmission and distribution facilities increased by just 14% and 22% respectively, during the same period (Figure 6).

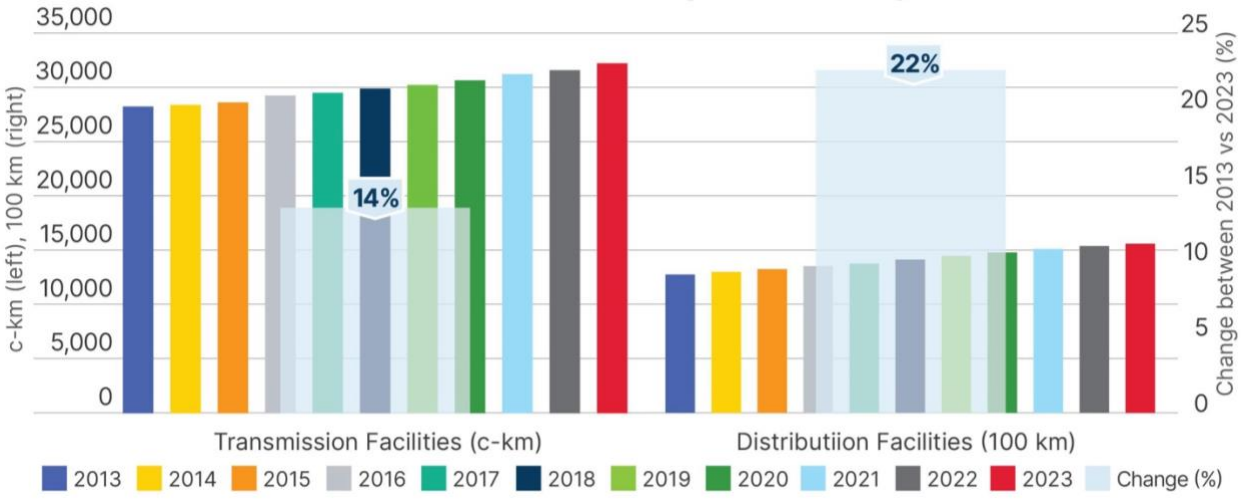
[7] As of 2023. Ember. Website.
[8] Ministry of Trade, Industry and Energy. 11th BPLE. 21 February 2025.

Figure 5: South Korea's Renewable Energy Capacity and Generation Increments (2013-2023)



Source: KEPCO.
Note: Renewable energy sources in South Korea also include fuel cells, Integrated Gasification Combined Cycle (IGCC), and waste-to-energy under the Renewable Energy Act of Korea. The figures include general hydro and small hydro but excludes pumped storage.

Figure 6: South Korea's Transmission and Distribution Facilities Increments (2013-2023)



Source: KEPCO.
Note: Transmission facilities refer to circuit kilometers (c-km).

The quantitative increase in renewable energy capacity has not translated to renewable energy growth in the national grid.

Continued underinvestment in the power grid increases risks to grid operations, which could be destabilized. This could threaten the consistent, high-quality power supply that industrial complexes

require, especially those in the emerging Artificial Intelligence (AI), semiconductor, and biotechnology areas. Additionally, the goal of carbon neutrality, valued by groups like the RE100[9], which has over 160 members in South Korea, with 36 headquartered there[10], would be difficult to achieve.

The Power Grid Act, addressing the expansion and modernization of the national grid system, was prepared in 2023. It passed the National Assembly plenary session in late February 2025 with bipartisan support.[11]

However, apart from grid expansion, South Korea faces several other critical bottlenecks in its renewable energy adoption. Key challenges include inadequate transmission and distribution systems, ineffective Power Purchase Agreements (PPAs), and an inefficient Renewable Portfolio Standard (RPS).

This report examines the main challenges slowing the qualitative growth[12] of renewable electricity integration in South Korea. It also explores potential solutions to help the country accelerate its adoption of renewable energy and stay competitive with other nations.

Key Bottlenecks in Renewable Energy Integration

Inadequate Transmission and Distribution

The expansion of transmission facilities has lagged behind the growth of renewable energy capacity, leading to frequent output control[13] or generation constraints[14], often referred to as curtailment. Consequently, the actual increase in power generation has been far lower than the growth in installed capacity (Figure 5).

Due to insufficient transmission and distribution facilities, the generation constraints for power generators across the East and West coasts of the country soared 603% and 62%, respectively, from 2019 to 2023.[15]

[9] RE100 is a global corporate renewable energy initiative led by the Climate Group in partnership with the Carbon Disclosure Project (CDP). Website.
[10] Climate Group. Website.
[11] Yonhap News. The 'Energy 3 Bills,' including the Power Grid Expansion Act, passed the National Assembly plenary session. 27 February 2025.
[12] Quantitative renewable energy growth refers to scale expansion only. Although renewable capacity increased sixfold between 2013 and 2023 in South Korea, actual renewable electricity generation rose only threefold. This gap highlights the lack of qualitative renewable energy growth, which refers to the effective integration of renewables into the power system to deliver tangible additionality in the energy mix. Factors such as an underdeveloped grid infrastructure, ineffective PPAs, and an inefficient RPS have hindered this qualitative progress.
[13] Active reduction of power generation by grid operators to maintain system stability. For example, a wind farm is ordered to reduce output due to grid congestion.
[14] Physical, economic, or regulatory limitations preventing full power generation. For example, a hydro plant cannot generate at full capacity due to low water levels.
[15] Munhwa. Due to the lack of transmission facilities, generation constraints surged 7-fold in the East coast. 08 October 2024.

Community opposition, referred to as the 'Not In My Back Yard' (NIMBY) phenomenon, is one of the primary factors delaying the development of transmission and distribution facilities in South Korea. This resistance from local residents has significantly impeded the timely expansion and modernization of essential infrastructure, delaying power grid construction plans up to 11 years[16] (Table 1).

Table 1: Major Power Grid Construction Delays

Plan	Initial completion	Delayed completion	Delayed duration (month)
500kV Eastcoast-Shingaphyeong HVDC (Shin-Hanul Nuclear Power Plant)	Feb-19	Jun-26	88
345kV Bukdangjin - Shintangjeong Transmission Line (Taean Terminal Point)	Dec-12	Jun-24	137
345kV Dangjin Thermal Power Plant - Shinsongsan Transmission Line (Dangjin	Jun-21	Dec-27	78
345kV Shin-Dangjin – Buk-Dangjin Underground Transmission Line (Taean,	Jun-21	Dec-25	54
345kV Godeok - Seoanseong Transmission Line (Semiconductor)	Apr-22	May-23	13
345kV Shin-Siheung – Shin-Songdong Underground Transmission Line (Bio)	Jun-23	May-28	59
345kV Shin-Jangseong Substation (Southwest Offshore Wind Power)	Apr-21	Jun-26	62

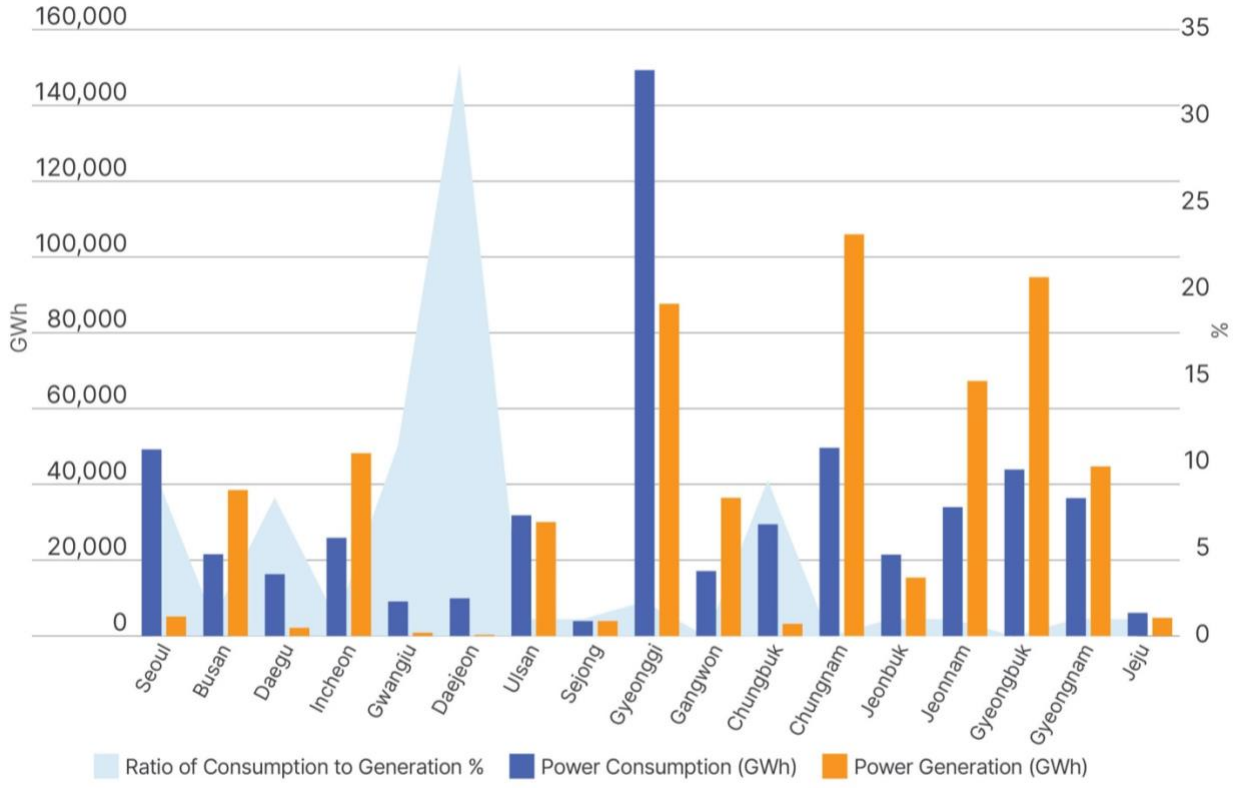
Source: KEPCO.

The separation between power generation and consumption locations can be attributed to local community opposition to constructing power transmission and distribution facilities.

Seoul, Daejeon, and Gyeonggi regions consumed electricity that was nearly 10-fold, 33-fold, and double the power generation, respectively (Figure 7).

[16] Yonhap. Power demand to double in 2051, power grid construction continues delaying. 06 May 2024.

Figure 7: Discrepancy between Power Consumption and Generation by Location in 2023



Source: KEPCO.

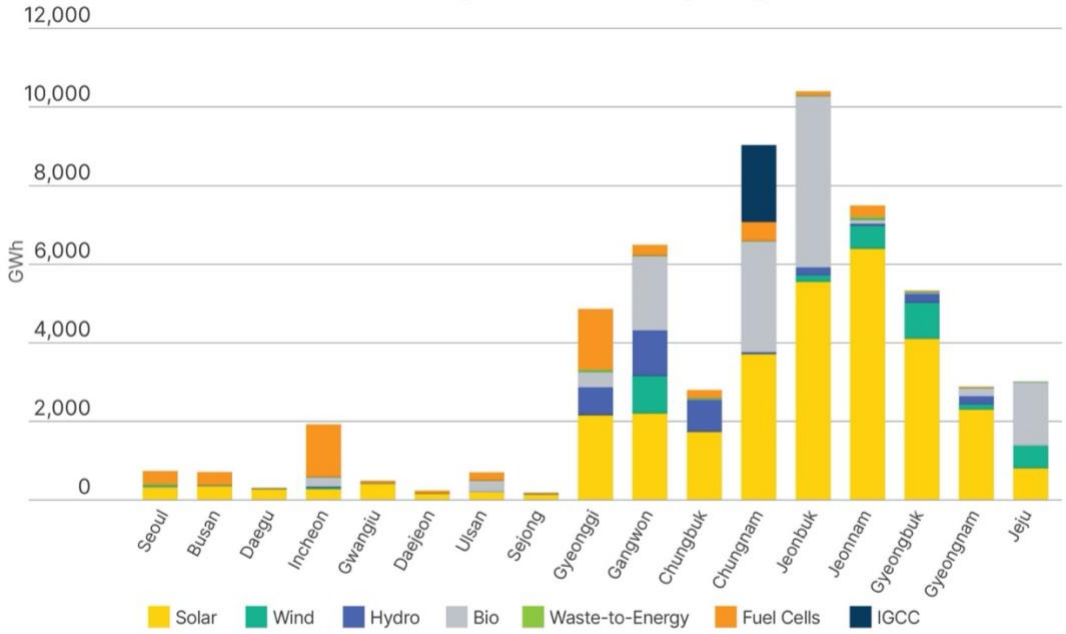
With electricity demand expected to rise due to large-scale semiconductor clusters in Yongin and AI data centers in Seoul and Gyeonggi provinces, power grid construction and modernization delays raise concerns about power supply instability and a potential decline in industrial competitiveness.

Renewable electricity generation is particularly distant from Seoul and Gyeonggi provinces and is concentrated in the country's southern parts[17], where the power demand is relatively low (Figure 8).

However, demand for renewable energy is growing in these regions, driven by the need to support semiconductor industries and AI data centers in meeting RE100 targets and environmental, social, and governance (ESG) goals, which are essential for remaining competitive globally.

[17] This includes Chungbuk, Chungnam, Jeonbuk, Jeonnam, Gyeongbuk, and Gyeongnam.

Figure 8: Renewable Electricity Generation by Region (GWh)



Source: Korea Energy Agency.
Note: Renewable energy sources in South Korea also include fuel cells and Integrated Gasification Combined Cycle (IGCC) under the Renewable Energy Act of Korea. The data is for 2022.

Another reason for the delay in power grid expansion and modernization is the lack of competitiveness in the power market structure. KEPCO monopolizes the transmission and distribution process and suffers from mounting debt.

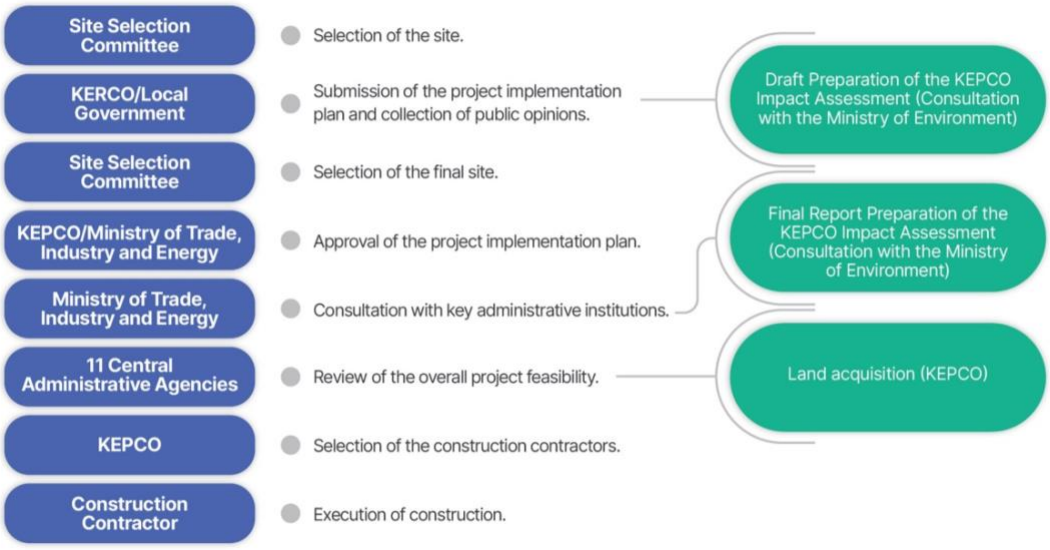
Competitiveness in the energy sector is often measured by efficiency[18], which can be calculated through the degree of cost reduction and product innovation by suppliers.[19] As efficiency increases, the customer surplus grows[20], leading to lower utility prices and stable energy supplies.

Using these concepts to analyze South Korea's delayed power grid system could be valuable, as the power market structure is characterized by a lack of competitiveness and efficiency, dominated by a monopoly state-run energy corporation.

So far, KEPCO has managed the entire process of constructing and maintaining the transmission and distribution facilities, which limits its ability to persuade local residents and provide fair compensation (Figure 9).

[18] Review of Environmental Economics and Policy. Bridging the Energy Efficiency Gap: Policy Insights from Economic Theory and Empirical Evidence, 2014. Vol. 8. Pages 18-38.
[19] According to the Austrian school of economics, evolutionary economics and classical liberalism, dynamic efficiency can be quantified by the degree of cost reduction and product innovation.
[20] Customer surplus is an economic concept that measures the benefit that consumers receive from purchasing a good or service at a price lower than their willingness to pay for it.

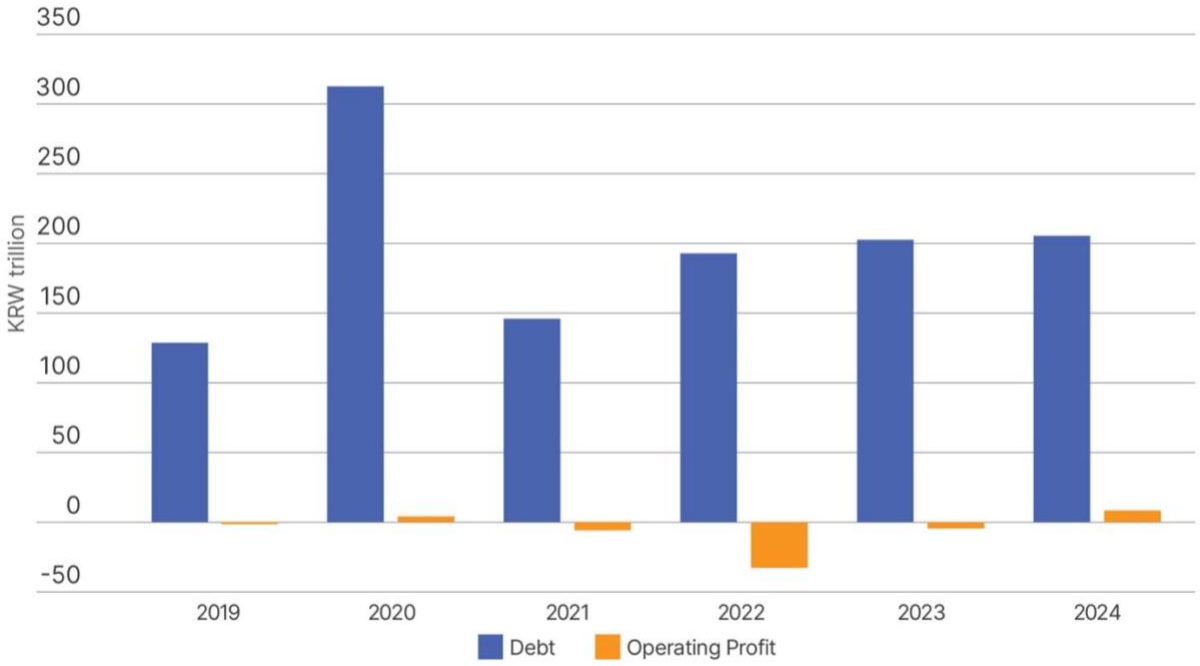
Figure 9: Transmission Tower and Substation Construction Procedure



Source: KEPCO.

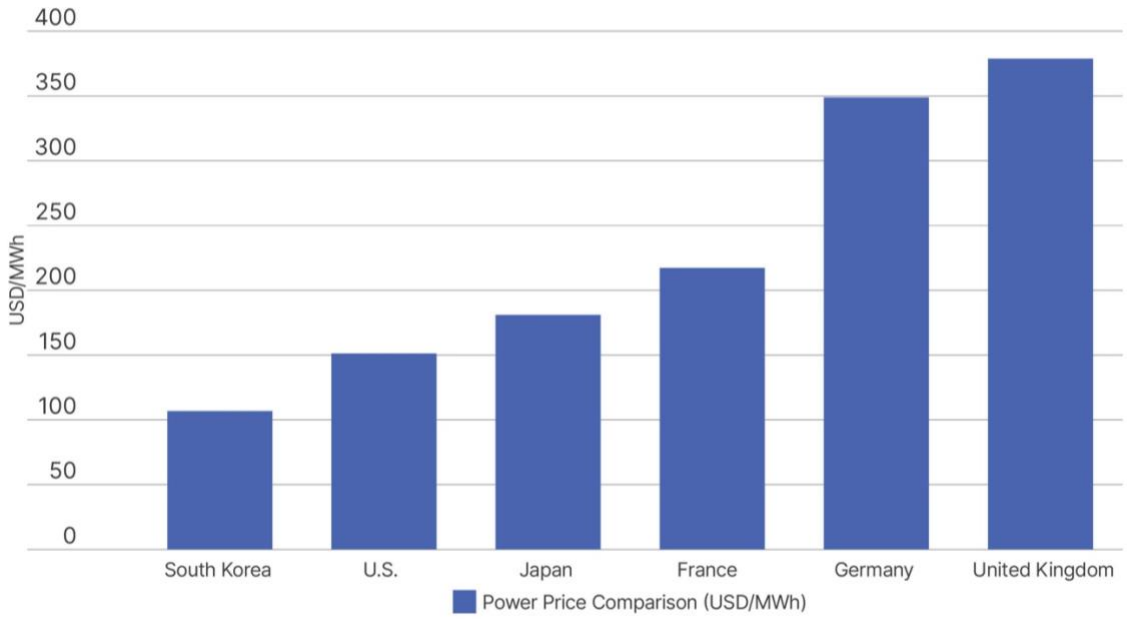
This challenge is further compounded by limited financial resources (Figure 10), particularly as electricity price increases are constrained in South Korea (Figure 11), making it difficult to secure funding for power grid expansion and modernization.

Figure 10: KEPCO's Debt and Operating Profit (KRW trillion)



Source: KEPCO.

Figure 11: Electricity Tariffs Comparison by Country (USD/MWh)



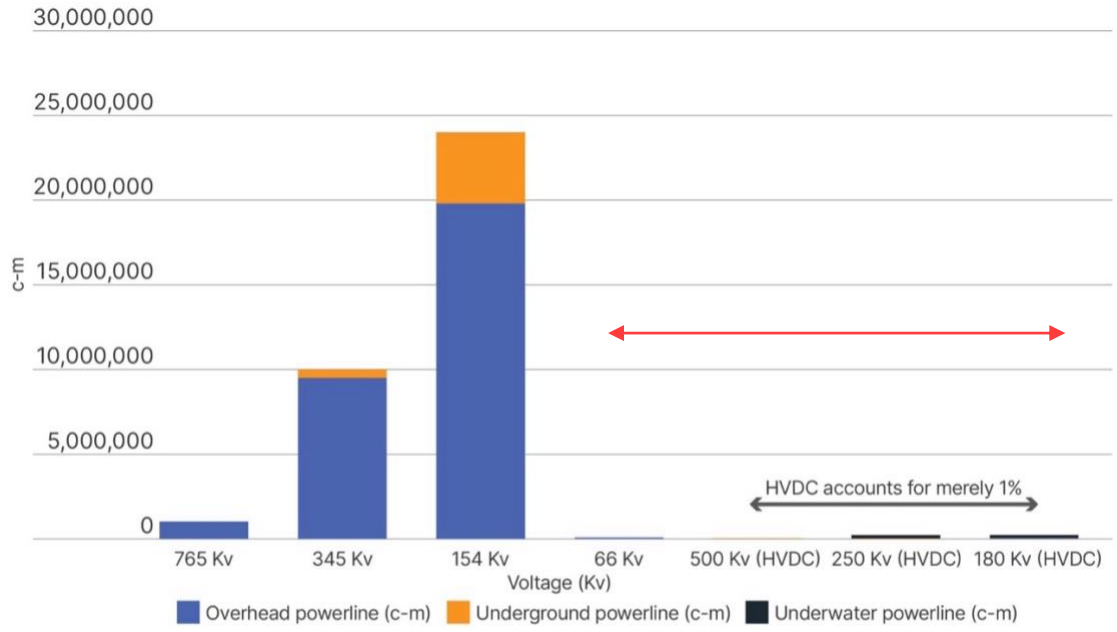
Source: IEEFA; KEPCO; IEA; Energy Prices and Taxes Statistics Database.
Note: The data is based on residential power tariffs in August 2023.

In May 2023, the government announced the 10th Long-Term Transmission and Substation Facility Plan, aiming to expand transmission lines by 1.6 times and substations by 1.4 times by 2036 compared to the previous year. According to KEPCO's estimates, this investment will cost approximately KRW56.5 trillion (approximately USD38.8 billion).[21] However, discussions on how to cover these costs have stalled as KEPCO's debt was KRW205.4 trillion as of 2024, which constrains its ability to commit to significant investments (Figure 10).

Currently, South Korea's transmission network is highly outdated. The adoption rates of underground cables (13%), high-voltage direct current (HVDC, 1%) transmission, and integration of smart grid management practices remain very low (Figure 12).

[21] Energy Economy. Semiconductors and renewable energy may become obsolete due to a severe lack of power grid infrastructure. 14 January 2025.

Figure 12: HVDC installation in South Korea (circuit-meter)



Source: KEPCO.

Continued underinvestment in the power grid increases the risk of operational instability. This could jeopardize the reliable, high-quality power supply that industrial complexes require, especially in the emerging AI, semiconductor, and biotechnology sectors. Furthermore, carbon neutrality, which is the goal of groups like the RE100[22], who have over 160 members in South Korea, may be difficult to achieve.

An Ineffective Power Purchase Agreement (PPA) System

In South Korea, several challenges concerning PPAs are affecting the adoption of renewable energy. These include complex rules and regulations, high prices, and KEPCO's grid monopoly.

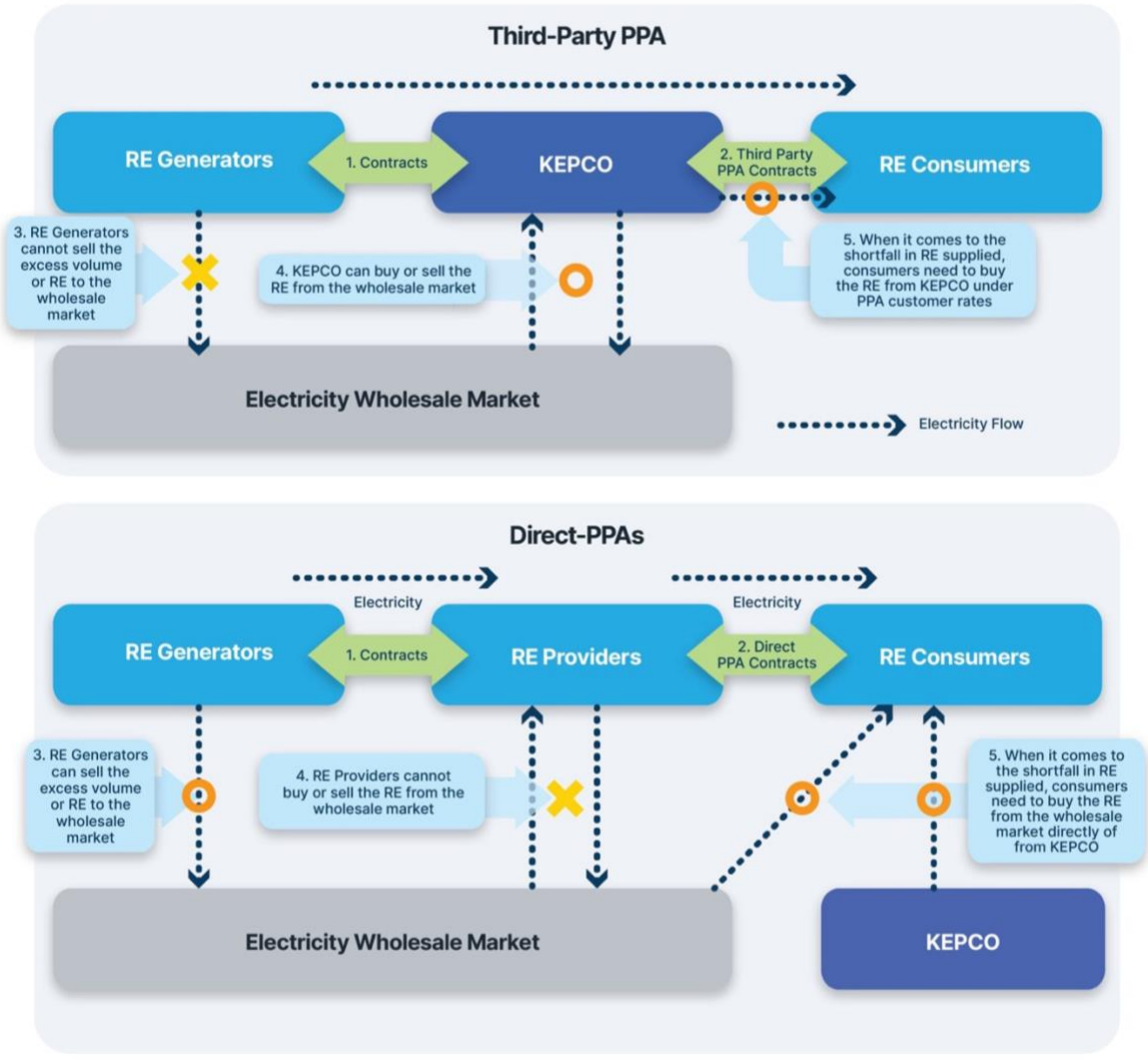
South Korea offers two types of PPAs: third-party PPAs, instituted in 2021[23], and direct PPAs, introduced in 2022.[24] The primary distinction between them lies in the role of intermediaries. In direct PPAs, the renewable electricity provider acts as an intermediary between the renewable energy generator and the consumer, whereas in third-party PPAs, KEPCO acts as the intermediary (Figure 13). Uptake of both types of PPAs has been slow due to complicated terms and implementation conditions.

[22] RE100 is a global corporate renewable energy initiative led by the Climate Group in partnership with the Carbon Disclosure Project (CDP). Website.
[23] The third-party PPA is arranged through KEPCO, which is acting as an intermediary. The renewable energy generators sell power to KEPCO, then KEPCO sells it to the renewable energy consumers.
[24] Today Energy. Widespread use of direct-PPA in the industry. 02 January 2025.

Under third-party PPAs, KEPCO buys electricity from renewable generators under long-term contracts and delivers electricity to consumers through the third-party PPAs using its grid. They cannot sell any excess volume of electricity generated to the wholesale market, unless permitted by agreements, while KEPCO can buy or sell the electricity from the market. When there is a shortfall in supply, consumers have to buy it from KEPCO under PPA customer rates.

In the case of direct PPAs, renewable energy providers enter into contracts with consumers, without KEPCO acting as an intermediary. Renewable electricity is delivered to renewable energy providers through KEPCO's grid. These generators can sell excess electricity to the wholesale market if not contractually committed. However, not all renewable energy providers can participate in wholesale market trading. When it comes to any shortfall in the energy supplied under direct PPAs, consumers have to buy it from KEPCO at industrial tariffs or procure it themselves.

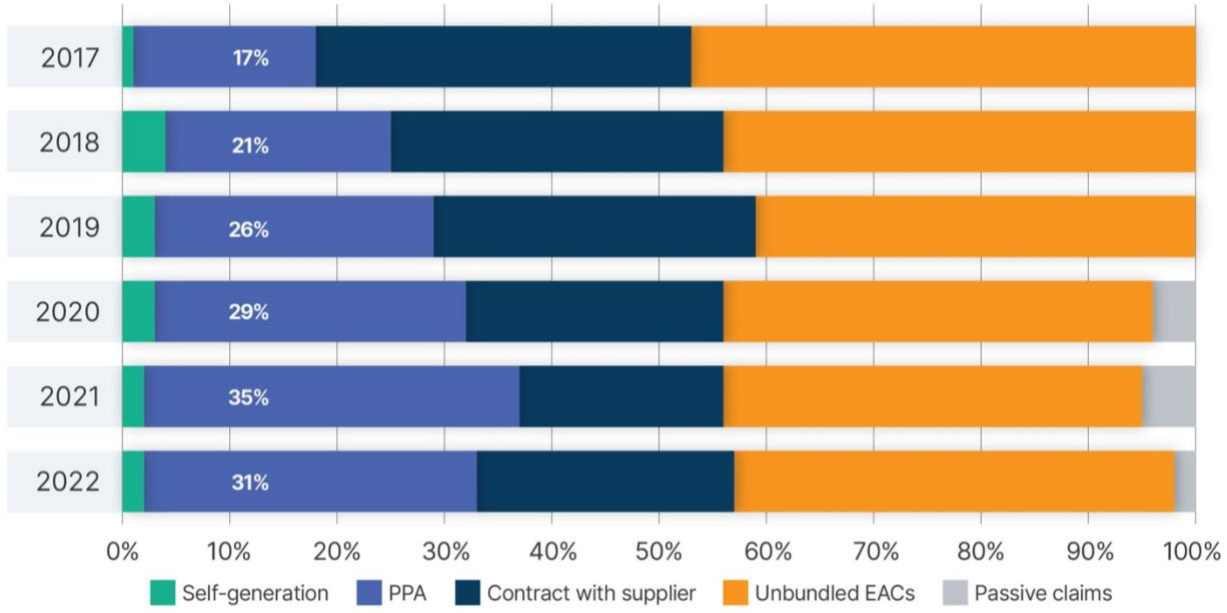
Figure 13: Third-Party PPA vs Direct PPA in South Korea



Source: IEEFA; Korea Energy Agency; Climate Group.

According to the Climate Group, around 31% of RE100 member companies worldwide procured renewable electricity under PPAs in 2022 (Figure 14). The top five global companies that use PPAs include Walmart (4,264 gigawatt-hours [GWh]), Anheuser-Busch InBev (2,370GWh), T-Mobile (2,355GWh), Nestle (1,959GWh), and Apple (1,693GWh).[25]

Figure 14: Global RE100 Procurement Type Mix, 2017-2022



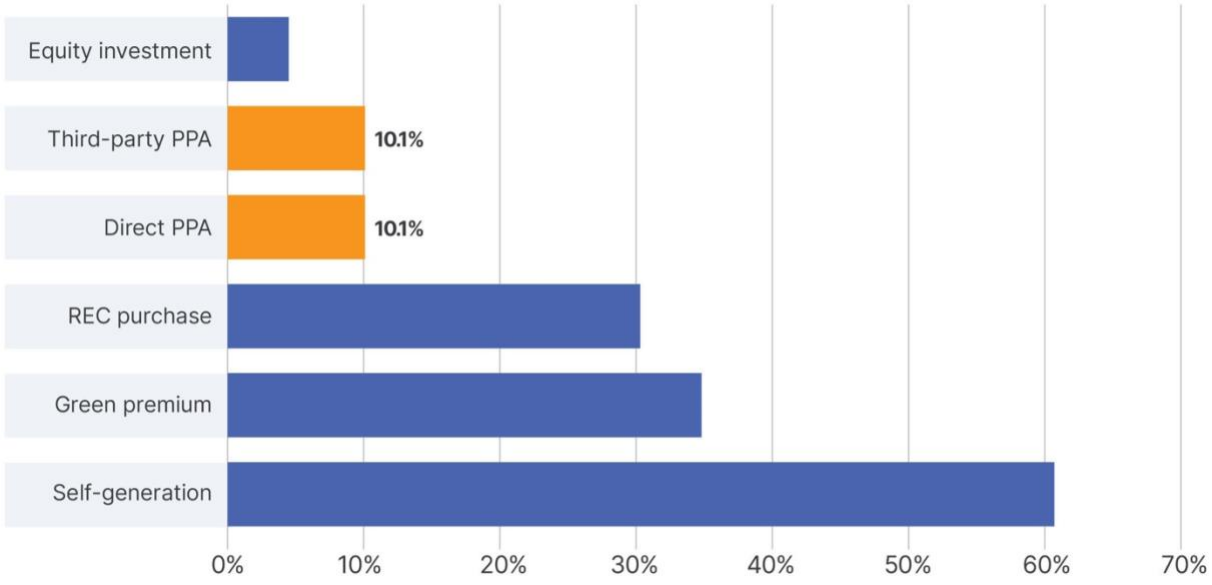
Source: Climate Group.
Note: Unbundled EACs refer to unbundled energy attribute certificates, which include RECs, and are separate from actual electricity generation.

Only around 20.2% of export-oriented companies in South Korea employed either direct PPAs (10.1%) or third-party PPAs (10.1%)[26], which contrasts sharply with global trends (Figure 15).

Government support and subsidies have led to a high share of self-generation, as many mid-sized companies and businesses have installed solar photovoltaic (PV) systems in their factories and office buildings. These installations are mostly grid-connected, allowing companies to use the electricity directly and meet RE100 targets at a lower cost.

[25] Climate Group. RE100 Annual Disclosure Report 2023. 06 March 2024. Page 17.
[26] The Korea International Trade Association (KITA) conducted a survey on RE100 awareness and response among 610 manufacturing export companies with export performance exceeding USD1 million since 2022. KITA. Export Companies' RE100 awareness and response in South Korea. 24 April 2024. Page 21

Figure 15: South Korea's RE100 Procurement Type Mix



Source: KITA.
Note: The response rates were based on multiple choices. The survey was conducted with 610 export companies based in South Korea, all of which have exported more than USD1 million since 2022.

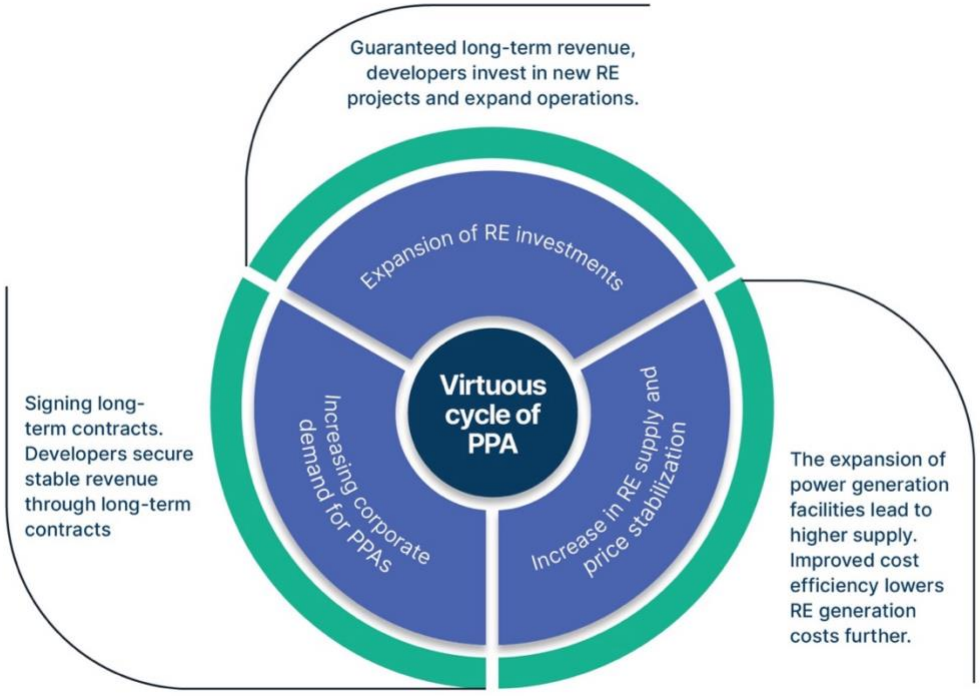
PPAs have been widely adopted to support sustainability and decarbonization globally. They offer stable and predictable power purchase prices for consumers and guarantee long-term revenues and investment incentives for producers.[27] Direct PPAs and self-generation are important in ensuring the 'additionality' of renewable energy generation and ultimately accelerating the transition to renewables.

However, South Korea's PPA system has failed to establish a 'virtuous cycle' (Figure 16) that ensures a stable revenue stream for renewable energy suppliers. This mechanism would contribute to expanding renewable energy generation, increasing supplies, lowering prices, and amplifying the demand for PPAs.

In particular, major global companies, especially in the semiconductor and AI data center sectors, such as SK Hynix and Samsung, are under increasing pressure to meet strict renewable electricity requirements across the global supply chain. However, they face significant challenges in accessing renewable energy within South Korea, mainly due to complex regulations and high costs. This contrasts with other countries where renewable energy prices are rapidly declining, raising concerns that South Korea's global firms may be incentivized to relocate operations abroad rather than continue expanding domestically.

[27] Climate Group. South Korea's PPA System: Status and Opportunities for Renewable Energy Development. March 2024. Page 3.

Figure 16: Virtuous Cycle of PPAs



Source: IEEFA.

Restrictive and complex rules and regulations are the first obstacle in the virtuous cycle of PPAs.

The role of the renewable energy provider as an intermediary in direct PPAs is weaker than that of KEPCO as an intermediary in third-party PPAs. This leads to various constraints that challenge the activation of direct PPAs.

In the current direct PPA system, if a renewable energy generator fails to meet the contracted energy amount, consumers must either purchase the shortfall from the wholesale electricity market on their own or have KEPCO supply the deficit. However, renewable energy providers, acting as intermediaries for direct PPAs, are not permitted to procure additional electricity to cover these shortfalls directly.

This restriction on the role of renewable energy providers reduces flexibility for consumers as they then have to bear supply uncertainty risks, making direct PPAs less attractive. Additionally, consumers must manage shortfalls by purchasing from the wholesale market independently, further complicating the process. This contrasts with the practice in other countries, where most PPA participants, including renewable energy generators, renewable energy providers, and consumers, are allowed to freely procure any shortfall from the market.[28]

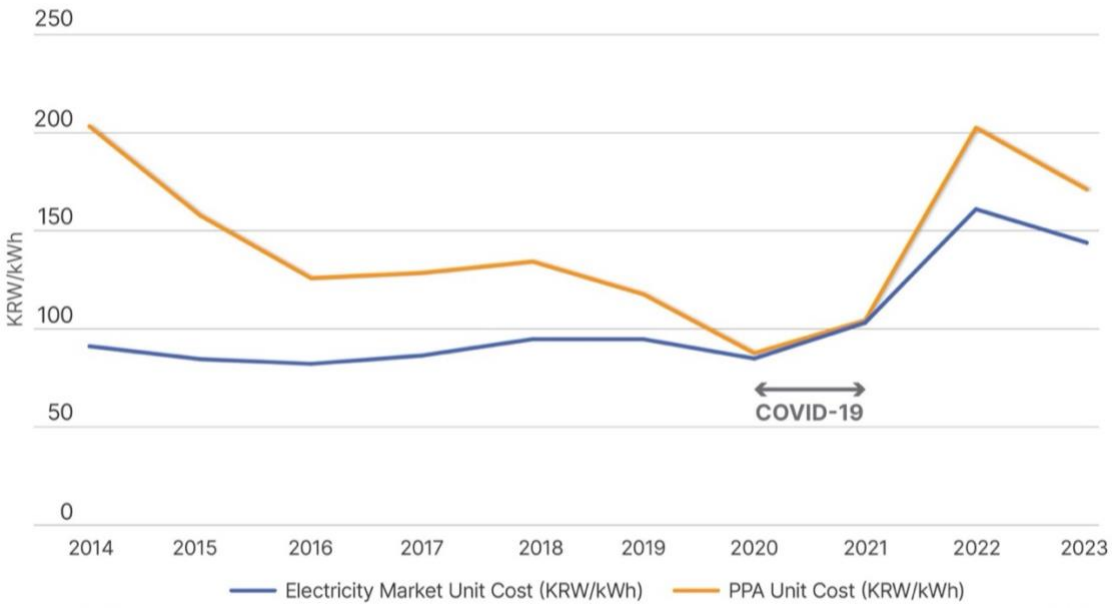
[28] Climate Group. South Korea's PPA System: Status and Opportunities for Renewable Energy Development. March 2024. Page 12.

Another significant limitation of both third-party and direct PPAs is that only customers consuming 300 kilowatts (kW) or more of high-voltage general or industrial electricity are eligible to sign a PPA.[29] Small-scale electricity users (including those in emerging sectors like AI data centers and other small and medium export manufacturers) that rely heavily on renewable energy to meet carbon neutrality goals, are excluded from participating in PPAs (Figure 15). This exclusion creates a barrier to renewable energy adoption, particularly in industries where achieving sustainability targets is crucial.

Although third-party PPAs appear more flexible due to KEPCO's role as an intermediary, there is also an inherent issue. When consumers need to purchase additional power, they may have to pay 'PPA exclusive rates'.[30] These charges were proposed by KEPCO in January 2023, placing customers at a disadvantage when compared to the utility's usual industrial rates. This could create an inequitable and ambiguous situation for third-party PPA consumers.[31]

High prices are the second obstacle in the virtuous cycle of PPAs. Except for the COVID-19 period, when the System Marginal Price (SMP) was highly volatile due to disrupted power generation supply chains, PPA prices were mostly higher than the wholesale electricity market prices, which factored in the SMP.

Figure 17: Comparison of Electricity Market vs PPA prices (KRW/kWh)



Source: KEPCO.

[29] Korean Law Information Center. Website.
[30] Electimes. The direct PPA pricing plan, which is supposed to lower electricity rates, actually results in higher rates in the majority of projects. 16 February 2023.
[31] The proposed rate change was met with resistance from the RE100-related industry, as the basic fee was more than 50% higher than KEPCO's existing electricity rates. As a result, the proposal has been indefinitely postponed and remains unresolved as of April 2025.

Higher PPA prices disincentivize customers from implementing PPAs and instead resulted in a stronger preference for KEPCO's lower industrial tariffs. Alternatively, they prefer indirect methods, such as purchasing renewable energy certificates (RECs), which do not facilitate increases in renewable generation. This contrasts with other mature markets, such as the U.S., Europe, and Australia, where renewable energy PPA prices are lower than wholesale electricity prices, supported by falling renewable energy technology costs, government incentives, and long-term fixed-price purchase agreements.

The primary reasons PPA prices in South Korea are generally higher than market prices include a distorted power market structure, limited renewable energy supply, and delayed grid parity.

South Korea's power pricing structure has traditionally been government-regulated to prioritize price stability. The aim is to reduce the taxpayer burden, support industrial production, and promote economic growth. Maintaining a low power tariff is also administratively significant.

Despite implementing the Fuel Cost Pass-Through Mechanism in 2021[32], intended to reflect fluctuations in fuel costs and ease KEPCO's financial burden, the system has had a limited impact. Although a fuel cost adjustment tariff was incorporated in the power tariff formula (Figure 18), KEPCO cannot solely determine changes in power prices based on its financial results.

Figure 18: South Korea's Power Tariff Structure

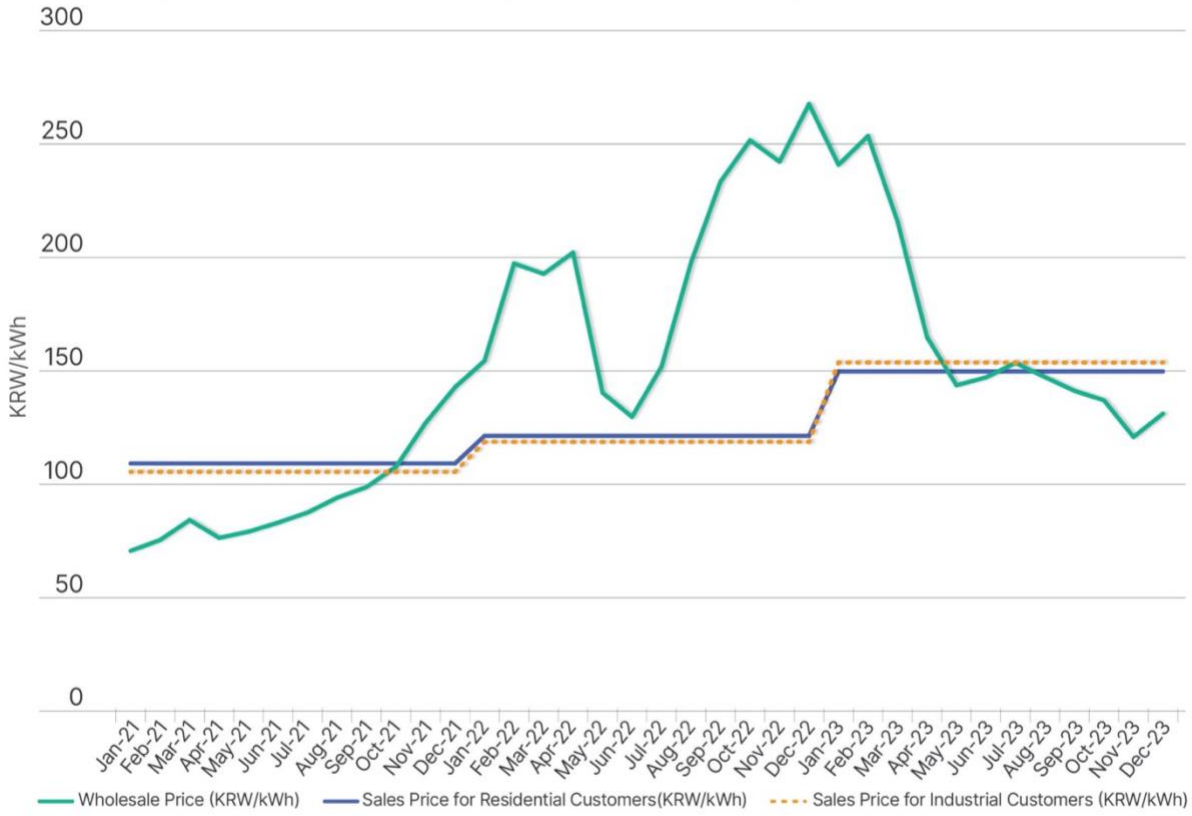
Source: IEEFA; KEPCO.

Consequently, although power tariffs have increased in South Korea since Russia invaded Ukraine, the prices charged remain artificially lower than those in other countries due to a government-regulated electricity tariff system.[33] The pass-through has not been permitted, leaving KEPCO to shoulder the financial burden and preventing customers from discovering actual fossil fuel costs.

KEPCO's sales prices for industrial customers, who are the potential PPA buyers, have mostly been maintained lower than wholesale power prices or SMPs (Figure 19). As a result, corporations have little incentive to implement PPAs with renewable power generators at higher prices.

[32] Despite South Korea implementing a "Fuel Cost Pass-Through Mechanism" in January 2021, which intended to mitigate KEPCO's financial burden by reflecting the fluctuation of fuel prices for power generation, its long history of control over electricity bills has nullified the new policy. IEEFA. South Korea's Power Trilemma. March 2024. Page 9.
[33] IEEFA. South Korea's Power Trilemma. March 2024. Page 20.

Figure 19: Wholesale Power Prices vs KEPCO's Sales Prices for Industrial Customers (KRW/kWh)



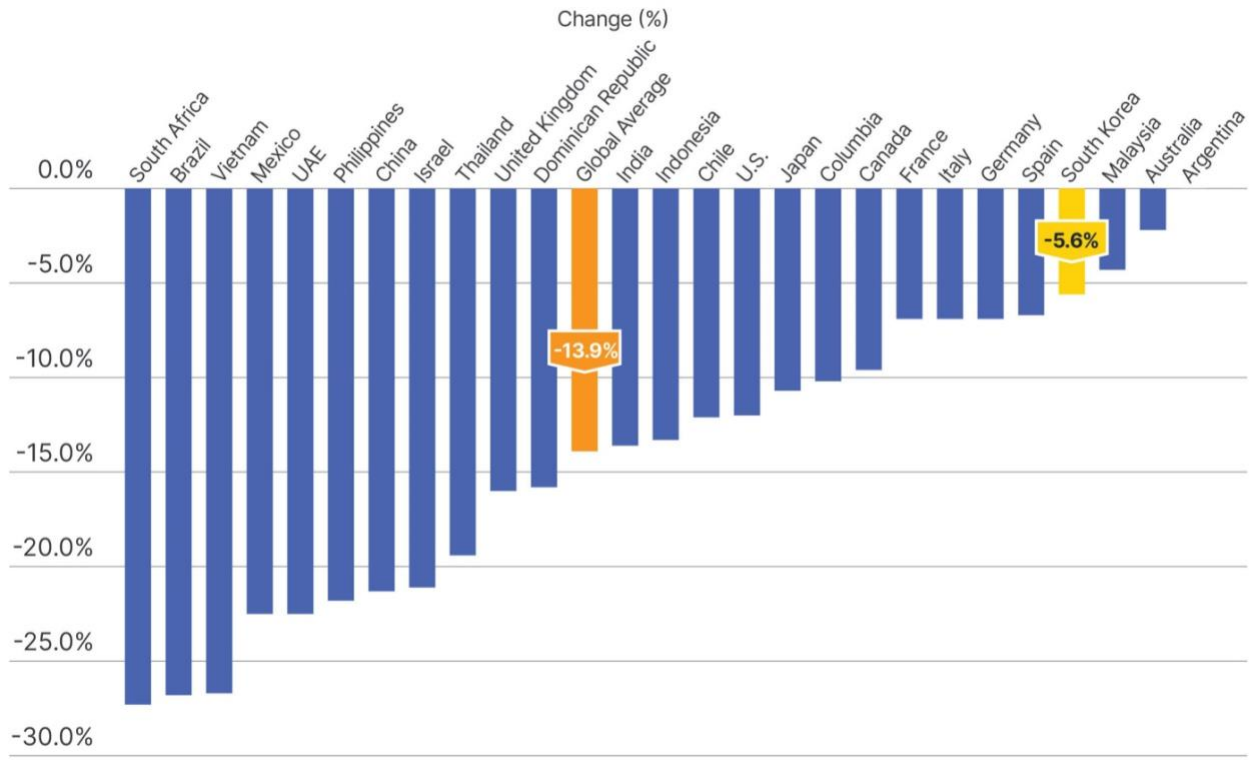
Source: KESIS; KEPCO.
Note: Wholesale price is total SMP.

Lastly, the lack of renewable energy supplies and delayed grid parity add upward pressure to PPA prices.

Buyers and sellers should establish direct PPA prices depending on demand and supply. However, the limited renewable energy supply continues to create a seller's market, where the prices are set by them, often including upfront capital expenditure (capex) and a risk premium to compensate for generation, financing, and regulatory uncertainties.

Relatively high capex and delayed grid parity in South Korea have increased PPA prices. Despite the global average solar PV capex falling 13.9% between 2023 and 2024, South Korea's fell by a negligible 5.6%, according to Bloomberg New Energy Finance (Figure 20).

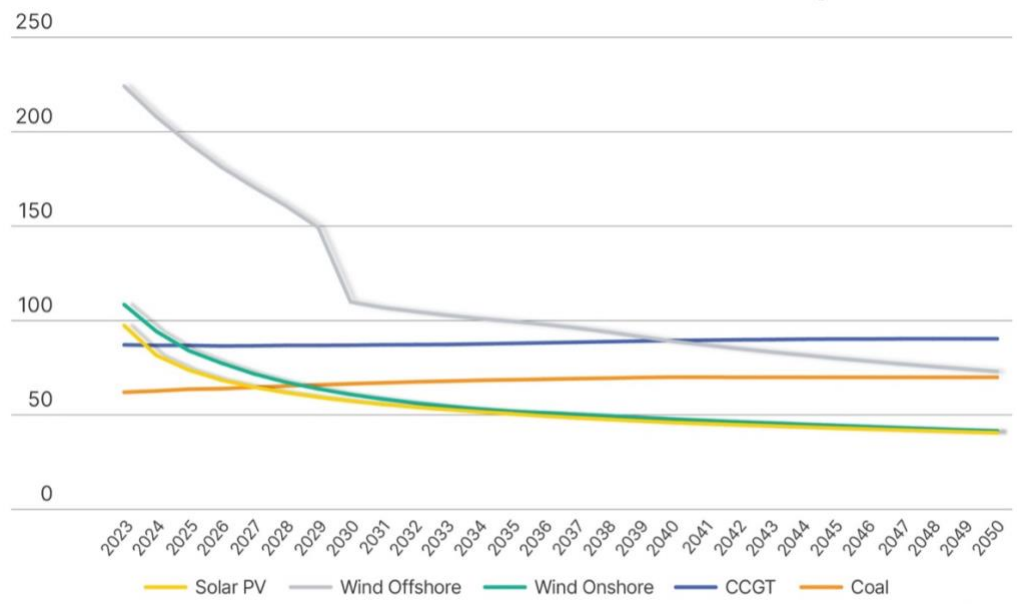
Figure 20: Change in Solar PV Capex by Country, 2023 vs 2024 (%)



Source: BloombergNEF.

As a result, South Korea is only expected to achieve grid parity by 2027-2028, when solar PV electricity generation costs equate to coal-fired power. The levelized cost of energy (LCOE) for solar is projected to fall exponentially to USD64.76 per megawatt-hour (MWh) in 2027 compared with the LCOE for coal at USD64.6/MWh. This contrasts with other Asian countries where the LCOE for solar dropped below USD40/MWh in 2025. The complex permitting regulations, high land and labor costs, elevated imported equipment prices, and grid congestion have delayed the path to grid parity in South Korea. The LCOE for onshore wind will likely achieve grid parity in 2029, with the cost falling below coal (Figure 21).

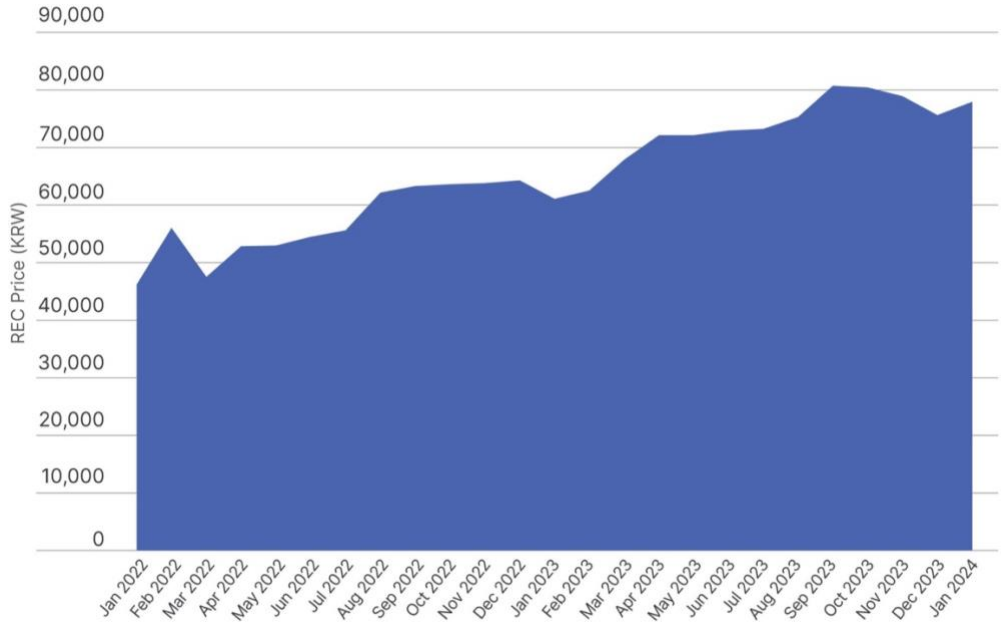
Figure 21: Levelized Cost of Energy (LCOE) Forecast in South Korea (USD/MWh)



Source: IEEFA, BloombergNEF.

Rising REC prices, an alternative to PPAs, also establish a price floor during negotiations, leading to higher PPA costs. In South Korea, limited renewable energy supplies continue to push up REC prices, while the demand for sustainability and decarbonization grows, creating a cycle of higher prices and constrained supply.

Figure 22: Monthly Average Renewable Energy Certificate (REC) Price (KRW)



Source: Korea Energy Agency.

Inefficiencies in the Renewable Portfolio Standard (RPS)

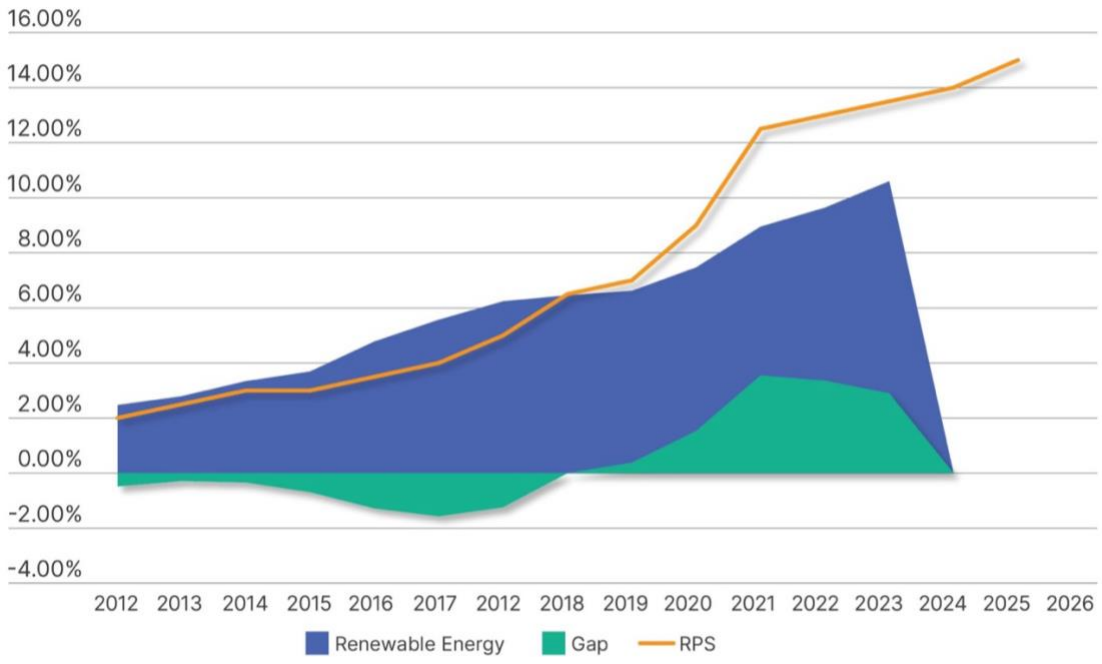
South Korea's RPS has faced criticism for failing to promote renewable power generation directly. Instead, it has allowed power generators to fulfill their obligations by purchasing RECs, an indirect approach that does not necessarily lead to actual renewable energy addition.

South Korea implemented the RPS in 2012 to accelerate renewable energy adoption. The RPS[34] mandates that power generators[35] exceeding 500 megawatts (MW) capacity should maintain a specific proportion of renewable energy in their generation mix.[36] As of January 2024, 29 Generation Companies (GENCOs) and Independent Power Producers (IPPs) fall in this category.[37]

The mandated proportion of renewable power generation under the RPS has steadily increased as decarbonization goals strengthen, rising from 2% in 2012 to 13.5% in 2024. It is projected to reach 15% in 2026.

Despite an ambitious RPS target, the gap between the RPS-mandated volume of renewables and actual generation is widening (Figure 23).

Figure 23: RPS Mandate vs Renewable Energy Power Generation (%)



Source: Korea Energy Agency; KEPCO.

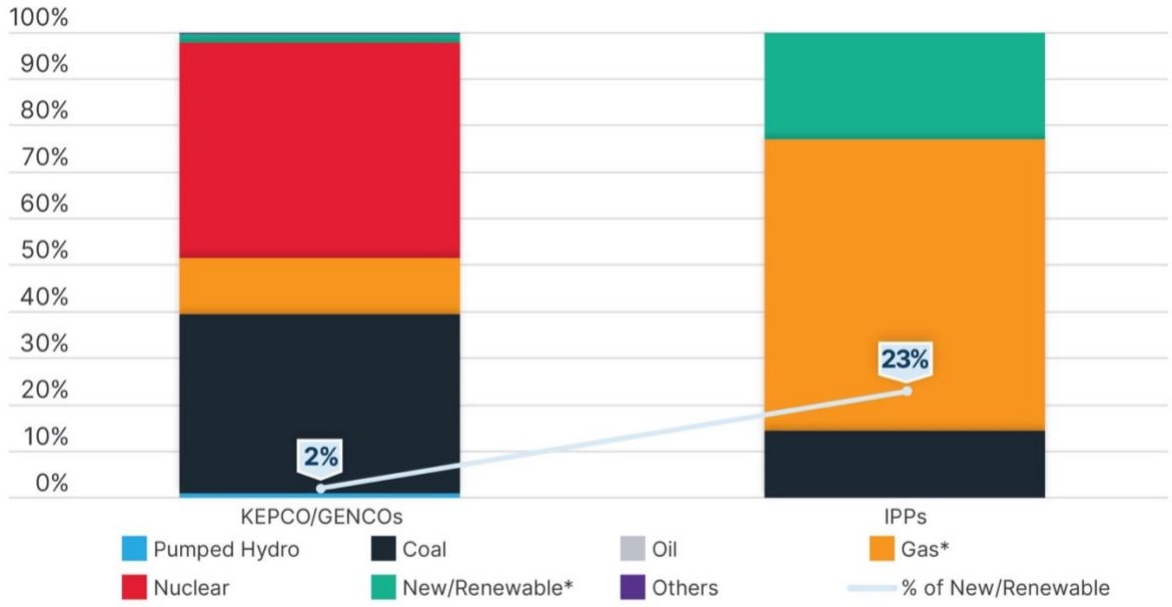
[34] Korean Law Information Center. Website.
[35] Except for renewable energy power generators.
[36] Korea Energy Agency. Website.
[37] Korea Energy Agency. Website.

This difference has resulted from loopholes in the RPS, which allow power generators to fulfill their obligations by directly increasing their renewable energy generation or purchasing RECs in the Korea Power Exchange (KPX).

RECs are tradable instruments that certify renewable electricity generation. Many GENCOs and KEPCO's power generators have primarily relied on purchasing RECs to meet their RPS obligations. This approach has resulted in a low share of renewable energy capacity in the national power mix.

Despite the mandated proportion of generation increasing to 13.5% in 2024, KEPCO and GENCOs' captive renewable energy production lagged at a 2% share in the national power generation in 2023, while IPPs contributed 23% (Figure 24).

Figure 24: Share of Renewable Power Generation – GENCOs and KEPCO vs IPPs (kWh, %)



Source: KEPCO.
Note: Gas includes gas and heat combined cycle power generation and group power generation. New/Renewable includes conventional hydro power but excludes pumped hydro.

The overreliance on purchasing RECs to fulfill RPS obligations has also resulted in rising costs. In 2023, KEPCO's provision for RPS and greenhouse gas (GHG) emission liabilities reached KRW36 billion and KRW19 billion, respectively.[38] This has significantly increased financial costs associated with RPS compliance, which could lead to suppressed investments and limited direct renewable power generation, especially for public entities.

Furthermore, South Korea's sluggish renewable energy deployment has tightened the supply of RECs in the spot market, pushing prices higher (Figure 22). Conversely, fluctuating and declining

[38] KEPCO. Annual Financial Statement Disclosure for 2024. 18 March 2025. Page 317.

REC prices discourage new investment in renewable energy projects due to lower profit margins and growing uncertainties.

The current RPS structure is not aligned with the PPA system, which connects consumers and renewable power generators, since it does not promote direct renewable power generation. It also does not address the shortcomings in grid expansion and modernization, failing to achieve the additionality of renewable power.

Consequently, the RPS fails to promote renewable energy investments and generation, deferring qualitative growth in the country's renewable energy adoption.

Debottlenecking Renewable Energy Integration

Clearing Transmission and Distribution Obstacles

The Power Grid Act was passed in South Korea's National Assembly plenary session in late February 2025 with bipartisan support. It aims to maximize renewable energy integration in the country.[39]

This Act aims to enhance compensation measures to improve public acceptance of power grid expansion, which is considered the most significant construction challenge. It also includes procedures to accelerate various permitting processes through government intervention, especially for emerging AI data centers.[40] The law is expected to be promulgated within six months.

Additionally, local governments are required to gather and respond to residents' opinions within 60 days when planning power grid projects, with the automatic completion of consultation after this period to prevent delays. Key provisions include establishing a Power Expansion Network Committee under the Prime Minister, extending permit agenda items from 18 to 35, and reimbursing residents and local governments near transmission and transformation facilities. This law will help ensure the timely construction of the national core power grid (345 kilovolts [kV] or higher).[41]

This Special Act could alleviate the delays caused by resistance from local communities, mainly due to the separation between power generation and consumption locations.

However, implementing the law should involve proactive investment to streamline and modernize South Korea's transmission and distribution system. This investment is critical for renewable energy integration and electricity distribution in an era of soaring power demand, driven by AI and mega-scale semiconductor clusters. According to the International Energy Agency (IEA), global grid

[39] Yonhap News. The 'Energy 3 Bills,' including the Power Grid Expansion Act, passed the National Assembly plenary session. 27 February 2025.
[40] Newspim. The Power Grid Special Act has missed its golden opportunity, putting transmission expansion at risk. 29 January2025.
[41] Chosun Biz. Korea passes energy laws after nine years, paving way for nuclear waste disposal. 27 February 2025.

investments must almost double by 2030, reaching over USD600 billion annually, to achieve national climate targets.[42]

To secure the currently lacking financial resources, resulting from KEPCO's transmission and distribution sector monopoly and economic difficulty, South Korea could consider:

1. Enhancing public-private partnerships to generate funding
2. Reforming the power sector to improve KEPCO's financial status and efficiency through competition
3. Rationalizing the electricity tariff system to allocate grid investment funds
4. Introducing government subsidies and tax incentives to promote grid investments

Accurately planned renewable energy connected to distribution networks can benefit the public through reduced network losses, increased electricity reliability, and decreased GHG emissions. It is crucial to address South Korea's inadequate transmission and distribution infrastructure along with increasing renewable energy capacity.[43]

Addressing PPA Restrictions

PPAs in South Korea are considered ineffective due to restrictive and complex rules and regulations, high prices, and inadequate renewable energy supplies. Despite the rising corporate demand for PPAs in the country, challenging conditions and implementation have hampered their widespread adoption. According to the Ministry of Trade, Industry, and Energy (MOTIE), merely 1.3 gigawatts (GW) of PPA contracts are estimated in the pipeline from various corporations[44], accounting for around 0.8%[45] of the annual renewable energy supply in the country. Given that over 160 corporations are committed to sourcing 100% renewable energy under frameworks like RE100, this small amount demonstrates the ineffectiveness of the current policy design and incentive framework.

To address these issues, MOTIE rolled out a plan in mid-2024 to increase renewable energy adoption and supply chain expansion.[46] The plan highlights deregulation of PPA participants for various companies[47], provides financial incentives to promote renewable energy investment, and creates a private-led voluntary renewable energy trading market.

[42] IEA. Electricity Grids and Secure Energy Transitions. October 2023.
[43] Joule. Grid connection barriers to renewable energy deployment in the United States. 19 February 2025.
[44] MOTIE. Master plan for increasing renewable energy adoption and supply chain expansion. 16 May 2024. Page 2.
[45] This was calculated based on the formula that the 1.3GW of PPA demand divided by the annual renewable energy capacity of 34.69GW in 2024, multiplied by the annual average operation rates of 21% in 2024. $1.3\ GW \div 34.69\ GW \times 21\%$.
[46] MOTIE. Master plan for increasing renewable energy adoption and supply chain expansion. 16 May 2024.
[47] Deregulation measures such as relaxing the minimum capacity requirement (1MW) for PPA participants to promote PPA uptake. (MOTIE. Master plan for increasing renewable energy adoption and supply chain expansion. 16 May 2024. Page 9.)

Table 2: PPAs Promotion Strategy by MOTIE

Category	Detail
PPAs Promotion	Improve PPA adoption
	Relax regulations (e.g. more than 1MW capacity renewable energy generators)
	Certification for unused self-RE supply facilities
	Resolve demand competition via RPS reform
Government Support	Strengthening support for private renewable energy investment
	Financing: Low-interest loans, renewable energy fund investments
	Incentives: Risk mitigation for PPA contract failure
Market Creation	Initial: Public-private collaboration for PPA brokerage market
	Long-term: Private-driven renewable energy market development

Source: MOTIE.

The MOTIE plan was expected to promote South Korea's inactive PPA market while relaxing regulations and facilitating renewable energy supply expansion. In March 2025, a new system was established through the amendment of the Electric Utility Act, allowing on-site electricity produced from renewable energy generators to be stored in energy storage systems (ESS) and sold directly to consumers, bypassing the power market.[48, 49]

In April 2025, MOTIE announced an enforcement amendment to the Electric Utility Act, in which previously, participation in direct PPAs required renewable energy facilities to have a capacity exceeding 1MW. However, this requirement will not be applied if the PPA is conducted on-site without using transmission and distribution infrastructure.[50]

Ultimately, a proper PPA system that enables direct transactions between renewable energy producers and consumers must be established. Bifurcated PPA systems, including direct PPAs and third-party PPAs, could be consolidated and streamlined to reduce unnecessary rigidity and complexity. Current PPA rules add avoidable additional costs, undermining renewable energy efficiency. Moreover, the prices of PPAs are exacerbated by limited renewable energy supply, which is reflected in the increasing costs of RECs, whose availability is also constrained.

PPAs are one of the key solutions for accelerating renewable energy adoption, and demand from corporate consumers is expected to grow amid increasing global pressure for decarbonization. This trend is driven by improved ESG performance among companies, voluntary net zero commitments

[48] Korea Energy Agency. KEA Energy Issue Briefing 265. 07 May 2025.
[49] While this differs from the PPA scheme, it is meaningful in that it enables renewable energy producers to engage in direct electricity sales to consumers.
[50] Statutes of the Republic of Korea. Website.

by more than 160 RE100 members operating in South Korea, and tightening carbon regulations (such as the Carbon Border Adjustment Mechanism in Europe and Scope 1, 2, and 3 financial reporting requirements) which would apply to South Korean exports.[51, 52]

Against this backdrop, and in light of KEPCO's financial constraints, it is essential to facilitate private sector participation in renewable energy development and provide incentives to developers and buyers while removing barriers. The PPA market could promote a buyer's market, activating the self-sustaining, virtuous cycle by increasing corporate demand for PPAs, expanding renewable energy investments, achieving economies of scale, increasing renewable energy supply, and lowering prices.

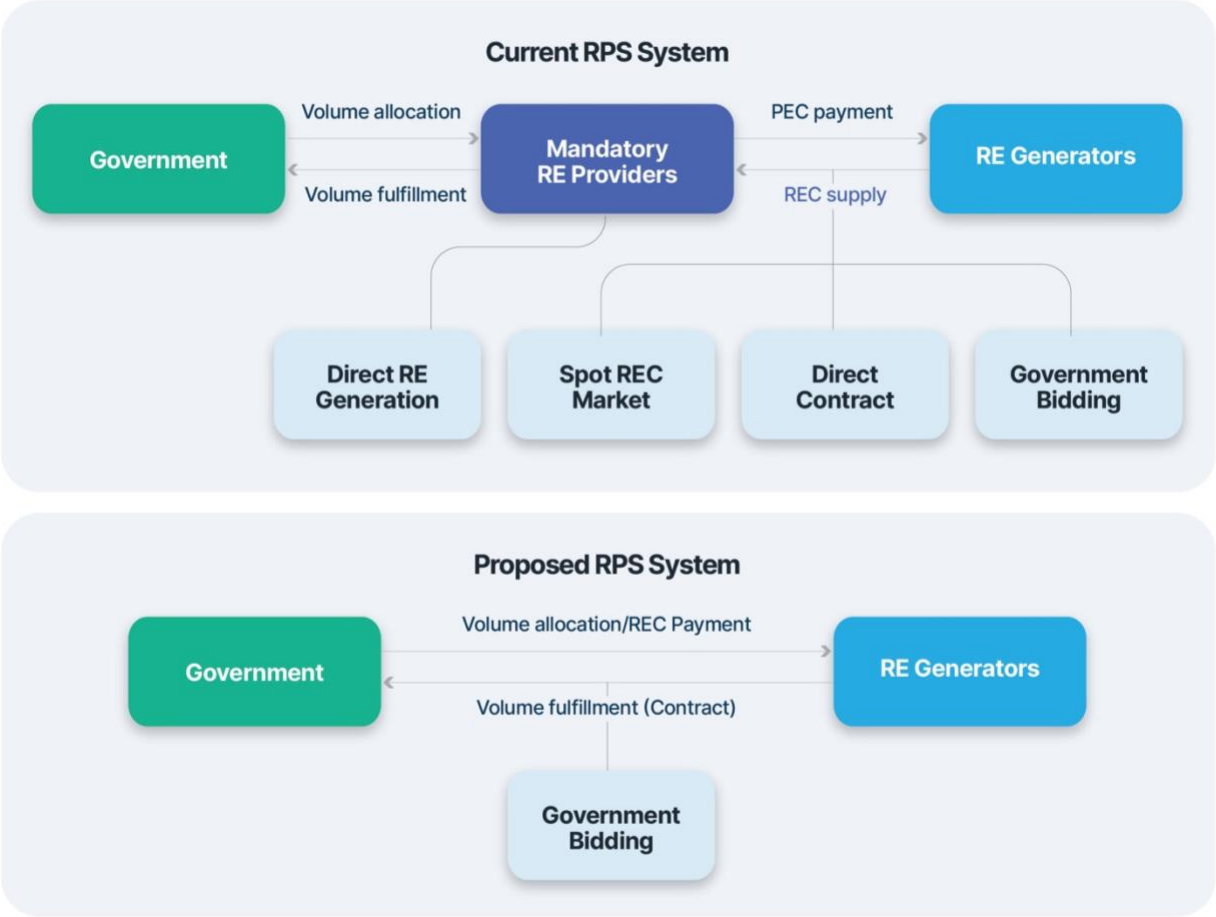
Enhancing the Inefficient RPS System

The current RPS system has failed to encourage the sufficient development of renewable power generation and grid expansion due to overreliance on REC purchases and complicated PPA requirements. To resolve these issues, the South Korean government has released a plan for streamlining RPS.[53]

The plan aims to reform the current mechanism by transitioning to a government-led system where renewable power generators and the government cooperate to meet mandatory renewable energy supply targets through direct bidding. This revised RPS is expected to provide clearer market signals, ensure steady development goals, and enhance efficient grid operation. It would also strengthen domestic renewable energy supply chains, promote stable investment returns, and supply renewable power at cheaper costs to corporations and the public.[54]

[51] IEEFA. South Korea needs to accelerate renewable energy adoption to fuel Artificial Intelligence (AI) and semiconductor sectors. 10 October 2024.
[52] IEEFA. South Korea's economy risks missing out on global transition to renewables. 14 August 2024.
[53] MOTIE. Master plan for increasing renewable energy adoption and supply chain expansion. 16 May 2024.
[54] MOTIE. Master plan for increasing renewable energy adoption and supply chain expansion. 16 May 2024.

Figure 25: Comparison of Current and Proposed RPS



Source: MOTIE.

However, for this RPS reform to succeed, it should be accompanied by grid expansion and modernization, as well as more effective PPA terms that are favorable to developers and buyers. These changes could accelerate renewable energy integration and adoption.

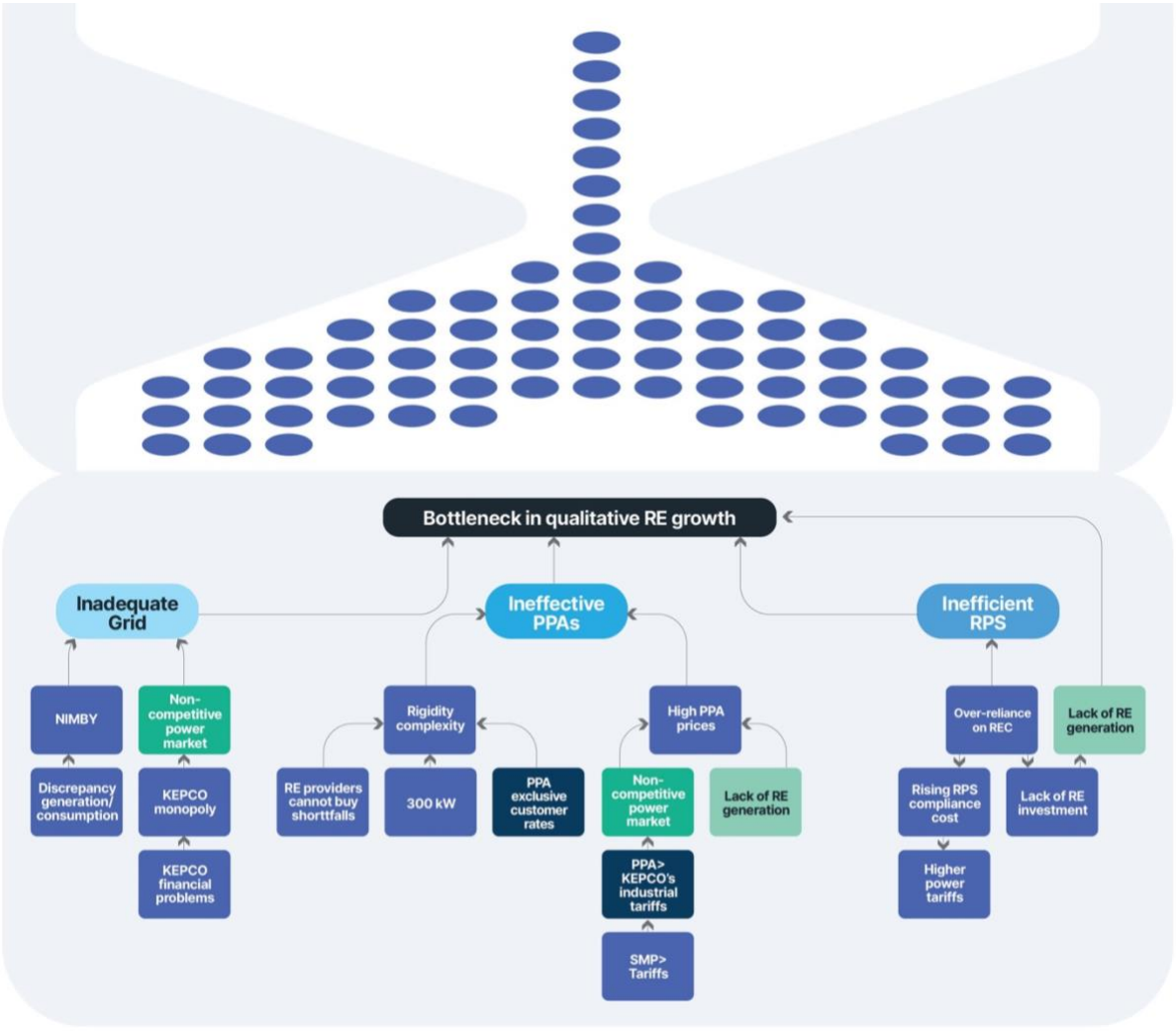
Conclusion

Despite South Korea's efforts to expand renewable energy capacity, the actual increment of renewable energy in the national grid has been lacking due to multiple bottlenecks, which include an inadequate grid, inefficient PPAs, and an ineffective RPS system.

Over the decade leading up to 2023, renewable energy capacity spiked more than sixfold, but the real generation delivered to consumers rose only around half that. This highlights that the quantitative increase in renewable energy capacity is insufficient to achieve actual renewable energy growth in the national grid.

South Korea has issued several reforms and amendments to address the three key bottlenecks, which is a positive sign. However, more coherent and holistic approaches are needed to accelerate the qualitative growth of renewable energy, as all policies are intertwined (Figure 26).

Figure 26: Bottlenecks in Qualitative Renewable Energy Growth



Source: IEEFA.

Amid increasing global pressure for decarbonization, South Korea should focus more on qualitative rather than just quantitative growth in the renewable energy sector. This would be imperative for the emerging industrial sectors, such as AI data centers and semiconductors, to be globally competitive.

About IEEFA

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

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