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Jeju Special Self-Governing Province's Energy Transition: A Sustainable Model for Green Growth

Climate and Energy Policy Division, Jeju Special Self-Governing Province

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Foreword



In 2012, Jeju Special Self-Governing Province launched its renewable energy transition with the “Carbon Free Island 2030” vision. Over the past 14 years, Jeju has raised its renewable energy share to the highest level in Korea, while navigating structural power grid limitations, including integration constraints and curtailment. These experiences have become a valuable asset in driving a transformation centered on flexibility resources, going beyond renewable energy expansion alone.

The climate crisis is no longer a future challenge but a present reality reshaping our lives and economy—and an opportunity for new growth. Accordingly, Jeju has set out “Jeju, the Climate Economic Capital” as a core provincial vision, aiming to build a virtuous cycle where renewable energy fosters new industries, creates jobs, and improves residents’ energy welfare. To realize this, Jeju is accelerating its transformation by positioning sector-coupling technologies—including green hydrogen and heat pumps—as key flexibility resources.

This report shares Jeju’s energy transition experience with the international community, particularly with developing countries and island regions facing similar conditions. We hope Jeju’s experience—including its Wind Power Resource Profit Sharing Fund, sector-coupling demonstrations, electricity market reform, and designation as a Distributed Energy Specialized District—will serve as a practical reference worldwide.

In March 2026, the Korean government designated Jeju as “an island pioneering a green civilization through carbon neutrality and energy transformation,” positioning it as a leading national model.

I sincerely thank those involved in the Korea Green Growth Trust Fund (KGGTF), along with hydrogen and energy experts across the World Bank Group, for their cooperation and valuable insights. Jeju will strengthen its partnership with the World Bank Group and share its experience and knowledge internationally as we address the climate crisis and energy transition together.

August 2026

A handwritten signature in black ink that reads "WI Seong Gon". The signature is written in a cursive, flowing style.

WI Seong Gon
Governor
Jeju Special Self-Governing Province

Executive Summary

This report analyzes the trajectory of Jeju's energy transition over the fourteen years since the launch of the 'Carbon Free Island JEJU by 2030' initiative in 2012, focusing on the province's strategic efforts to address structural constraints by establishing a green hydrogen ecosystem. Confronted with geographic and grid limitations, Jeju serves as an empirical reference model for island regions and developing nations facing similar constraints.

Key Messages

The Structural Paradox of Energy Transition: Jeju highlights South Korea's primary energy transition dilemma, where rapid renewable expansion has triggered severe curtailment and an urgent need for flexibility resources. This is underscored by wind power curtailment reaching 26.2 GWh in 2023.

The Reality of the 2030 Target: The original Carbon Free Island policy is projected to fall short of its 100% renewable energy target. As of 2025, Jeju's renewable share stands at 24.3%—which, while more than double the national average of 10.6%, still leaves a significant gap toward full self-sufficiency.

The 2035 Pivot to Green Hydrogen: Through the 2035 carbon neutrality scenario for the energy great transformation based on renewable energy and green hydrogen (2035 Scenario) announced in 2024, Jeju has repositioned green hydrogen as a core flexibility resource, effectively moving the national 2050 carbon neutrality target forward by fifteen years.

A Cohesive Policy Framework: This regional milestone aligns with a consistent national hydrogen roadmap, spanning from the 2019 Hydrogen Economy Roadmap and the world's first Hydrogen Act (2020) to the Clean Hydrogen Certification System (CHCS) enacted in 2024.

Key Implications for Developing Countries

Renewable energy deployment should be designed from the outset as an integrated package that includes robust flexibility resources. Simultaneously, public acceptance can be secured through institutional redistribution mechanisms, such as Jeju's Wind Power Resource Profit Sharing Fund. Operationally, a phased approach to green hydrogen offers the most realistic pathway—moving from early pilots (260 kW in 2017) to commercial operation (3.3 MW in 2024) and toward large-scale commercialization (10.9 MW planned for 2028). Ultimately, building institutional foundations like the CHCS and the Distributed Energy Specialized District is just as critical as funding physical infrastructure.

Scope and Considerations for Readers

Several core policies—including the 2035 Scenario, the Seven Innovation Demonstration Projects, and the Distributed Energy Specialized District—remain in their early implementation or announcement stages, meaning their long-term performance is yet to be fully verified. This report should therefore be read as a set of interim lessons from an ongoing experiment rather than a definitive, proven model. Due to the limited operational data currently available, key economic indicators such as the Levelized Cost of Hydrogen (LCOH) are presented in qualitative and directional terms.

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Abbreviations and Acronyms

Acronym	Full Term	Acronym	Full Term
AEC	Alkaline Electrolysis Cell	LCOH	Levelized Cost of Hydrogen
AEM	Anion Exchange Membrane	LEDS	Long-term Low-carbon Dev. Strategy
AI	Artificial Intelligence	LFG	Landfill Gas
AMI	Advanced Metering Infrastructure	MDB	Multilateral Development Bank
BESS	Battery Energy Storage System	MCEE	Ministry of Climate, Energy and Environment
BEV	Battery Electric Vehicle	MOLIT	Min. of Land, Infra. & Transport
BOP	Balance of Plant	MOTIE	Min. of Trade, Industry & Energy
BTM	Behind-the-Meter	Mt	Million Tonnes
CAPEX	Capital Expenditure	NO_x	Nitrogen Oxides
CCS	Carbon Capture and Storage	NWA	Non-Wire Alternative
CFI	Carbon Free Island	OECD	Org. for Econ. Co-op. & Development
CHCS	Clean Hydrogen Certification System	OPEX	Operating Expenditure
CHPS	Clean Hydrogen Portfolio Standard	P2G	Power-to-Gas
CO_{2eq}	Carbon Dioxide Equivalent	P2H	Power-to-Heat
DFI	Development Finance Institution	P2X	Power-to-X
DOE	Department of Energy (U.S.)	PCS	Power Conversion System
DR	Demand Response	PEM	Proton Exchange Membrane
ECA	Export Credit Agency	PM	Particulate Matter
EPC	Engineering, Procurement and Construction	PMS	Power Management System
ESS	Energy Storage System	PPA	Power Purchase Agreement
E-STATCOM	Energy-storage Static Synchronous Compensator	PV	Photovoltaic
EV	Electric Vehicle	RE	Renewable Energy
FCEV	Fuel Cell Electric Vehicle	RE100	Renewable Electricity 100%
GGGI	Global Green Growth Institute	SFOC	Solutions for Our Climate
GHG	Greenhouse Gas	SIDS	Small Island Developing States
HRS	Hydrogen Refueling Station	SMP	System Marginal Price
HVDC	High-Voltage Direct Current	SOEC	Solid Oxide Electrolysis Cell
ICCT	Int'l Council on Clean Transportation	SO_x	Sulfur Oxides
ICJ	International Court of Justice	STLF	Short-Term Load Forecasting
ICT	Information & Communication Technology	TRL	Technology Readiness Level
IEA	International Energy Agency	V2G	Vehicle-to-Grid
IRA	Inflation Reduction Act	VPP	Virtual Power Plant
KPX	Korea Power Exchange	VRE	Variable Renewable Energy

Jeju Special Self-Governing Province's Energy Transition: A Sustainable Model for Green Growth

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1 Global Energy Transition Trends and the Emergence of the Hydrogen Economy

1.1 Climate Crisis and the Shift in Energy Paradigms

The climate crisis demands a fundamental restructuring of economic and industrial frameworks. In its July 2025 advisory opinion, the International Court of Justice affirmed that climate action is no longer discretionary but a binding obligation under international law, with potential liability for transboundary harm.¹ As the fossil fuel paradigm reaches its limits, the renewable transition becomes imperative—yet the intermittency of solar and wind gives rise to curtailment, the forced disposal of surplus power, once renewables surpass a critical threshold.

Jeju stands at the forefront of this challenge. Following the aggressive renewable expansion under its Carbon Free Island initiative, it has become the first region in the Republic of Korea to embody both the success of renewable deployment and the acute reality of the 'curtailment paradox.' This report analyzes Jeju's strategic pivot to transform these constraints into a catalyst for a green hydrogen ecosystem, and distills the resulting lessons for emerging and developing economies.

1.2 Global Hydrogen Market Trends

According to the Global Hydrogen Review 2026 published by the International Energy Agency (IEA), global hydrogen demand grew by almost 3% in 2025, surpassing 100 million tonnes (Mt) for the first time. Low-emissions hydrogen production also grew by roughly 20% in 2025, approaching 1 Mt—yet a significant qualitative gap persists, as global hydrogen production remains dominated by unabated fossil fuel-based grey hydrogen, with low-emissions hydrogen still accounting for less than 1% of total production, though this share is expected to exceed 1% for the first time in 2026.

Efforts to bridge this gap are accelerating. According to the report, global installed electrolysis capacity doubled in 2025 to exceed 4 GW, driven largely by the commissioning of several large-scale projects in China, which accounted for nearly three-quarters of new installations. China is expected to retain over 60% of the world's committed electrolysis capacity by 2026, while Europe—accounting for under 20% of capacity but 45% of investment—is projected to see its installed capacity quadruple in 2026. However, rising capital costs and a wave of project cancellations, concentrated in the electrolysis segment, indicate that the market's transition beyond the pilot phase remains uneven across regions.²

1 *Obligations of States in Respect of Climate Change*, Advisory Opinion, 2025 I.C.J. 1, paras. 158–164 (July 23)

2 International Energy Agency. (2026). Global hydrogen review 2026

For developing countries, this trend represents both an opportunity and a challenge. Despite their abundant renewable energy potential, there is a risk of being marginalized from the benefits of the energy transition due to high initial investment costs and technological barriers.

In this context, the case of Jeju Island holds special significance. Jeju approaches hydrogen not merely as a futuristic technology, but as a practical tool to resolve grid instability caused by renewable energy. By focusing on securing local energy flexibility and domestic applications such as mobility, Jeju's approach serves as a more realistic reference model for developing countries or island regions that lack extensive infrastructure.

1.3 Background and Structure of the Report

This report analyzes how Jeju Special Self-Governing Province has addressed grid instability—a critical byproduct of rapid renewable expansion—by establishing a pioneering green hydrogen ecosystem. While Jeju successfully increased its renewable energy share under the 'Carbon Free Island 2030 (CFI 2030)' policy, this rapid growth triggered structural challenges like curtailment. In response, the province is now pursuing systemic innovation through an updated energy transformation roadmap.

In September 2022, the Ministry of Trade, Industry and Energy (MOTIE) and Jeju jointly unveiled the 'Green Hydrogen Global Hub Construction Plan.' Launched alongside South Korea's first large-scale (10 MW+) green hydrogen demonstration project, this plan aligns tightly with the national Hydrogen Economy Roadmap. It positions Jeju as a vital testbed not only for regional energy self-sufficiency but also for localizing and exporting Korean water electrolysis technologies. Building on this momentum, the '2035 Scenario' (May 2024) established a comprehensive framework powered by renewable energy and clean hydrogen. This updated roadmap targets full carbon neutrality by 2035 while driving regional economic growth and job creation.

Ultimately, Jeju's journey is far more than a localized success story; it serves as a highly replicable 'sustainable green growth model' for developing countries facing comparable geographic and economic conditions.

To provide a comprehensive analysis, the report is structured into six key chapters:

- Chapters 1 and 2 set the broader context by examining the climate crisis, global hydrogen market trends, and South Korea's national carbon neutrality strategy alongside its institutional drive for a hydrogen economy.
- Chapter 3 evaluates the concrete achievements and ongoing systemic challenges of Jeju's energy transition.
- Chapter 4 outlines actionable strategies to overcome curtailment through a robust green hydrogen ecosystem.
- Chapter 5 addresses the economic feasibility of green hydrogen, the Clean Hydrogen Certification System (CHCS), and the Distributed Energy Specialized District.
- Chapter 6 concludes with key policy implications and transferable lessons tailored for developing nations.

2 The Korean Government's Carbon Neutrality Strategy and the Promotion of the Hydrogen Economy

To contextualize Jeju's initiatives, it is essential to first examine the broader policy landscape of the Korean government. According to the 2024 Yearbook of Energy Statistics, the Republic of Korea is a highly industrialized nation with an energy import dependency of 93.9%.³ In response, the government has committed to a 2050 carbon neutrality goal, positioning the hydrogen economy as a core pillar of national competitiveness to address the climate crisis and secure future growth engines. The strategic foundation was laid in 2019 with the announcement of the Hydrogen Economy Roadmap, the first comprehensive national plan of its kind. This was further solidified in 2020 by the enactment of the Hydrogen Act—the world's first legislation dedicated to hydrogen—which established a robust institutional framework. In 2021, the government accelerated the transition toward a 'clean hydrogen-centric' paradigm through the 1st Basic Plan for the Implementation of the Hydrogen Economy. Most recently, in April 2023, the government finalized the National Strategy for Carbon Neutrality and Green Growth and its associated 1st Basic Plan, representing the highest-level statutory framework for the nation's transition to a carbon-neutral society.

2.1 Republic of Korea's 2050 Carbon Neutrality Declaration

The Republic of Korea's official commitment to achieving carbon neutrality by 2050 was formalized during former President Moon Jae-in's policy speech to the National Assembly on October 28, 2020. This declaration served as a catalyst for a nationwide policy overhaul. In December 2020, the government unveiled the '2050 Carbon Neutral Strategy,' a joint ministerial initiative pledging bold investment and support for climate technology innovation. Aligned with the Long-term Low-carbon Development Strategy (LEDS) submitted to the United Nations, the framework is built upon five fundamental pillars:

- Expanding the utilization of electricity and hydrogen;
- Fostering innovation in energy efficiency;
- Accelerating the commercialization of future technologies;
- Scaling the circular economy; and
- Enhancing carbon sinks and sequestration.⁴

2.2 The 1st Basic Plan for the Implementation of the Hydrogen Economy

The '1st Basic Plan for the Implementation of the Hydrogen Economy,' announced by the Korean government in November 2021, represents the national plan for the hydrogen sector established following the enactment of the Hydrogen Act. This plan provides a comprehensive blueprint for the nation to ascend as a world-leading hydrogen powerhouse by 2050. Central to this vision is the ambitious target of supplying 27.9 million tons of hydrogen annually by 2050, with 100% of the supply sourced from clean hydrogen. This objective signifies a resolute policy commitment to move beyond being a technology adopter and to proactively secure a dominant position in the burgeoning global clean hydrogen market.⁵

3 Korea Energy Economics Institute. (2024). *2024 Yearbook of Energy Statistics*.

4 Government of the Republic of Korea. (2020). *Strategy for 2050 Carbon Neutrality. Jointly issued by relevant ministries*.

5 Ministry of Trade, Industry and Energy (2021). *The 1st Basic Plan for the Implementation of the Hydrogen Economy*.

The Republic of Korea's hydrogen-centric carbon neutrality strategy is a calculated maneuver to enhance energy resilience and capitalize on decarbonization as a primary driver for industrial innovation. By institutionalizing the Hydrogen Act and the CHCS, the government has provided a clear regulatory trajectory, thereby reducing market volatility for the private sector. This framework, which outlines incremental decarbonization milestones, positions Korea as a pivotal reference point in international climate policy. The strategy's emphasis on a comprehensive ecosystem shift—spanning the full life cycle from upstream production to downstream utilization—underpins the Republic of Korea's ambition to secure a dominant position in the future decarbonized global economy.

2.3 National Strategy for Carbon Neutrality and Green Growth and the 1st National Basic Plan

In April 2023, the Korean government finalized the 'National Strategy for Carbon Neutrality and Green Growth and the 1st Basic Plan (2023–2042),' the nation's highest-level statutory framework for the transition to a carbon-neutral society. This plan explicitly delineates, for the first time, sectoral and annual reduction pathways to achieve the 2030 target of a 40% reduction in greenhouse gas emissions relative to 2018 levels. It designates the hydrogen industry as a critical instrument for carbon neutrality, energy security, and the creation of new industrial drivers. The cultivation strategy is built upon four strategic pillars.⁶

- **Production:** Expanding electrolysis-based green hydrogen, establishing blue hydrogen production systems, and securing overseas clean hydrogen supply chains.
- **Infrastructure:** Developing hydrogen-dedicated ports and pipeline networks, with a nationwide deployment target of 660 refueling stations by 2030 and over 1,200 by 2040.
- **Utilization:** Scaling hydrogen adoption across all sectors, including 100% hydrogen and co-firing power generation, mobility, and hydrogen reduction steelmaking.
- **Ecosystem:** Reinforcing the foundation through the localization of core components, talent cultivation, and the establishment of regional hydrogen clusters to foster a bottom-up, region-led implementation framework.

2.4 Jeju: A Vanguard for National Energy Sovereignty

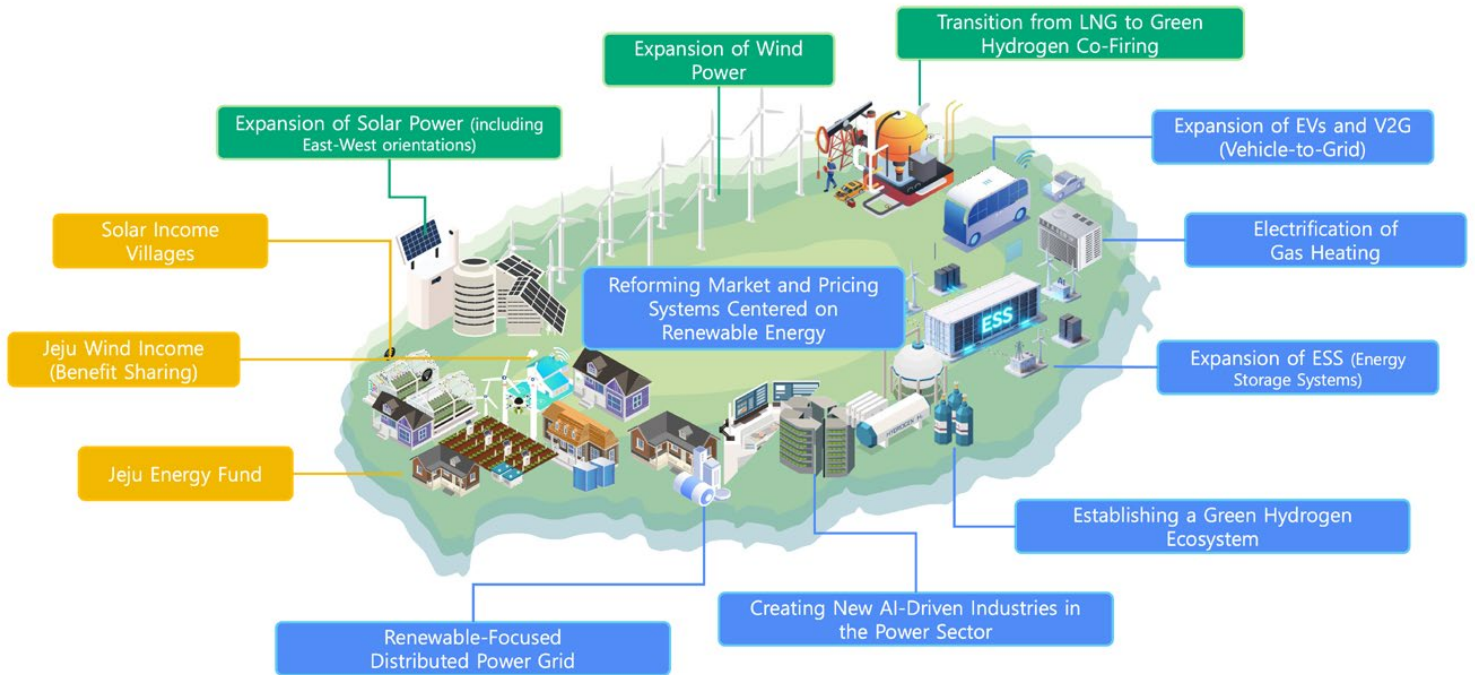
On March 30, 2026, a town hall meeting was held in Jeju Special Self-Governing Province under the theme 'Energy Great Transformation: Jeju's Future Is the Future of the Republic of Korea.' The event was attended by President Lee Jae-myung, the Minister of Climate, Energy and Environment, the Minister of Science and ICT, the Governor of Jeju Special Self-Governing Province, and local residents. The gathering was convened to elevate Jeju's '2035 Scenario' vision to a core national strategic priority and to formalize the government's support measures for its substantive implementation.

At the meeting, President Lee Jae-myung emphasized that Jeju is not merely a tourist destination, but rather the most critical strategic outpost leading the Republic of Korea's energy sovereignty in an era of climate crisis. The Minister of Climate, Energy and Environment subsequently announced the 'Seven Innovation Demonstration Projects' designed to advance Jeju's energy self-sufficiency and foster new industries. This initiative constitutes a comprehensive strategy aimed at overcoming the structural limitations of renewable energy and positioning Jeju as both a living testbed for the Republic of Korea's energy transition and a global benchmark model. The principal components of the seven projects are as follows:

6 Presidential Commission on 2050 Carbon Neutrality and Green Growth. (2023). *National Strategy for Carbon Neutrality and Green Growth and the 1st National Basic Plan (2023–2042)*.

- **Expansion of Electric Vehicles and Vehicle-to-Grid (V2G):** Increasing EV penetration to 50% of new vehicle sales by 2030 and 100% by 2035. The V2G system will be scaled from a demonstration of 55 vehicles during 2025–2027 to 10,000 vehicles by 2030 (equivalent to 1 GWh of mobile ESS capacity). The plan further entails the expansion of dedicated bidirectional chargers, the development of a circular system for repurposing used batteries—deployed in applications such as streetlights and logistics robots—and the establishment of an integrated management center.
- **Electrification of Gas-based Heating:** Transitioning fossil fuel-based heating systems to electrified solutions centered on heat pumps. In 2026, heat pumps will be prioritized for installation in 1,563 residential households, with phased expansion to social welfare facilities and childcare centers thereafter.
- **Energy Storage Systems (ESS) Expansion:** Substantially scaling ESS from 68 MW in 2026 to 1 GW by 2030. Distribution-grid-level ESS will be deployed to minimize grid reinforcement requirements, while a Virtual Power Plant (VPP) demonstration integrating solar PV, ESS, and heat pumps will be conducted (2026–2027), targeting hotels, resorts, farms, and households.
- **Establishment of a Green Hydrogen Ecosystem:** Building a green hydrogen production foundation through a 10.9 MW electrolysis demonstration (through 2028), with hydrogen refueling stations expanding from 2 in 2026 to 6 by 2030. The hydrogen vehicle fleet will be increased from 94 units in 2026 to 1,336 units by 2030, thereby cultivating a comprehensive hydrogen mobility ecosystem.
- **Creation of New AI-driven Industries in the Power Sector:** Advancing a microgrid demonstration that integrates Advanced Metering Infrastructure (AMI) with AI (2026–2027), and implementing energy efficiency optimization models for households equipped with solar PV, heat pumps, and ESS. In parallel, a public-led 40 MW-class AI data center will be established to lay the foundation for new industries in the power sector.
- **Demonstration of a Renewable-Centric Distributed Power Grid:** In response to the expansion of renewable energy, state-of-the-art grid stabilization technologies will be deployed sequentially, including 40 MW of grid-forming ESS (2027), 50 Mvar of E-STATCOM (2027–2029), and 50 Mvar of high-inertia synchronous condensers (2027).
- **Comprehensive Introduction of a Renewable-Centric Market and Tariff Framework:** Diversifying market participation by 2028 to enable demand-side resources—including electric vehicles, electrolyzers, and industrial and commercial facilities—to engage in supply-side bidding through a VPP or to participate independently in demand-side bidding. In addition, an ‘Electricity Forecast System’ will be introduced, allowing residents to monitor periods of renewable energy oversupply in real time and to access electricity at reduced rates, thereby establishing a price-signal-based grid and market operation framework.

Figure 1. Seven Innovation Demonstration Projects



Source: Presentation materials from the Jeju Town Hall Meeting, Ministry of Climate, Energy and Environment (March 2026).



3 Milestones and Challenges of Jeju Island's Energy Transition

In 2012, Jeju Special Self-Governing Province announced the 'Carbon Free Island 2030 (CFI 2030)' vision, commencing one of the world's most ambitious experiments in energy transition. This initiative represented the first global attempt to achieve a complete phase-out of fossil fuels in a region with a population exceeding 500,000.⁷

3.1 The Carbon Free Island (CFI) Policy

The conceptual inception of the 'Carbon Free Island' (CFI) initiative in Jeju dates back to May 2008. Initially, the term emerged as a strategic response to the era of high oil prices—when crude oil surpassed \$100 per barrel—with a primary focus on transitioning toward a low-energy usage structure. This evolved into a more comprehensive framework in 2012, when the province officially promulgated the 'Carbon Free Island Jeju by 2030' (CFI 2030) plan. As a tailor-made low-carbon green growth model aimed at climate mitigation and energy self-sufficiency, this policy stands as the most enduring and comprehensive regional renewable energy initiative in the Republic of Korea. Its implementation has been consistently underpinned by structural and institutional support from the central government.⁸

The core of the policy is to realize three fundamental values—Clean, Stable, and Growth—by meeting 100% of the province's electricity demand through renewable energy and transitioning 377,000 registered vehicles to electric vehicles (EVs). 'Clean' refers to the establishment of an emission-free energy system that harmonizes with the natural environment. 'Stable' signifies the implementation of a resilient energy supply-demand structure through self-sufficiency, optimized trading, and minimized consumption. 'Growth' denotes the creation of a resident-led ecosystem for the innovative energy industry.⁹

Following the policy's announcement, wind and solar power facilities expanded rapidly. As of 2025, the renewable energy generation share reached approximately 24.3%, significantly surpassing the national average of 10.6%. Additionally, as of May 2026, 48,305 EVs were registered in the province—representing an 11.65% penetration rate, nearly three times the national average of 3.95%—and Jeju ranks first in the nation for EV adoption, successfully establishing its brand as the "Island of Electric Vehicles."

Furthermore, to realize energy justice and foster social consensus, Jeju has operated the 'Wind Power Resource Profit Sharing Fund' since 2017. This fund aims to contribute to regional energy independence and the activation of energy welfare programs by utilizing development profits from wind resources, which are treated as public goods. Beyond its fiscal role, the fund serves as a critical policy instrument for resolving social conflicts that may arise during the energy transition and for establishing the public nature of resources. These funds are reinvested in renewable energy education, public relations, and infrastructure expansion. This mechanism ensures the momentum for a self-sustained energy transition without relying solely on external funding and serves as a tool for energy justice by supporting energy welfare projects for vulnerable populations.

7 Han, H. J., & Min, S. O. (2022). Achievements and challenges in Jeju's pursuit of Carbon Free Island: Implications for carbon neutrality of Korea. *Asian Studies*, 25(1), 347–374.

8 Jeju Special Self-Governing Province. (2012). *Carbon Free Island Jeju (CFI) 2030 Plan*.

9 Jeju Special Self-Governing Province. (2019). *Revision and Supplementation of the CFI 2030 Plan*.

Table 1. Current Operational Status of the Wind Power Resource Profit Sharing Fund

(Unit: Million KRW)

Category	2017	2018	2019	2020	2021	2022	2023	2024	Total (USD 1 = KRW 1,500)
Fund Raised	4,658	3,505	7,157	3,744	3,106	5,208	6,734	2,487	36,599 (Approx. USD 24.4 million)
Expenditure	3,044	3,862	4,249	3,704	3,995	2,829	3,265	2,947	27,895 (Approx. USD 18.6 million)

Source: Status Data of Energy Industry Division, Jeju Special Self-Governing Province

However, when measured against the targets set forth by CFI 2030 in 2012, the figure of 24.3% as of 2025 represents an unmistakable shortfall. Achieving the original 2030 target from the current vantage point is, in practical terms, virtually unattainable. The '2035 Scenario' announced in 2024 is the product of this candid recognition: it postpones the target year by five years while diversifying the policy instruments to encompass green hydrogen and distributed energy.

The causes of this shortfall are not attributable to any single factor. A confluence of elements has been at play, including the rigidity of the electricity market system, the economics of renewable energy, the complexity of permitting procedures, delays in securing community acceptance, and—above all—the economic constraints on further deployment arising from the curtailment phenomenon to be discussed in the following section. Yet this shortfall does not, in itself, diminish the value of the Jeju case. On the contrary, a record that accurately documents the limits encountered along the way constitutes an invaluable lesson for follower regions seeking to walk a similar path.

3.2 Structural Limitations and the Occurrence of Power Curtailment

The rapid proliferation of renewable energy has precipitated unintended side effects that exceed the hosting capacity of the power grid. Electricity systems require a rigorous real-time equilibrium between generation and consumption; however, the inherent intermittency of solar and wind power frequently leads to instances of oversupply during favorable weather conditions. Consequently, the very success of renewable expansion policies has introduced a paradoxical vulnerability, where excessive generation threatens grid stability and could trigger widespread blackouts.

3.2.1 Current Status of Power Curtailment and Economic Losses

In an effort to safeguard the power system from potential blackouts caused by overcapacity, authorities have implemented mandatory curtailment on renewable generators. The trajectory of this issue is stark: instances that were nearly nonexistent in 2015 surged to 117 occurrences for wind power by 2023, representing a curtailment volume of 26.2 GWh. The crisis intensified in 2021 as curtailment mandates began to encompass solar power as well. This trend underscores the widening gap between renewable deployment and the grid's adaptive capacity, necessitating urgent structural solutions like green hydrogen integration.¹⁰

10 Korea Power Exchange (KPX). (2026). *2025 Annual Operational Performance of the Jeju Power System*.

Table 2. Current Status of Power Curtailment in Jeju

Category	Wind Power Curtailment (Times)	Wind Power Curtailment Amount (MWh)	Solar Power Curtailment (Times)	Waste-to-Energy Curtailment (Times)
2017	14	1,300	-	-
2018	15	1,366	-	-
2019	46	9,223	-	-
2020	77	19,449	-	3
2021	64	12,016	1	12
2022	104	25,633	28	66
2023	117	26,201	64	70
2024	51	9,370	32	30

Source: Korea Power Exchange (KPX), February 2025

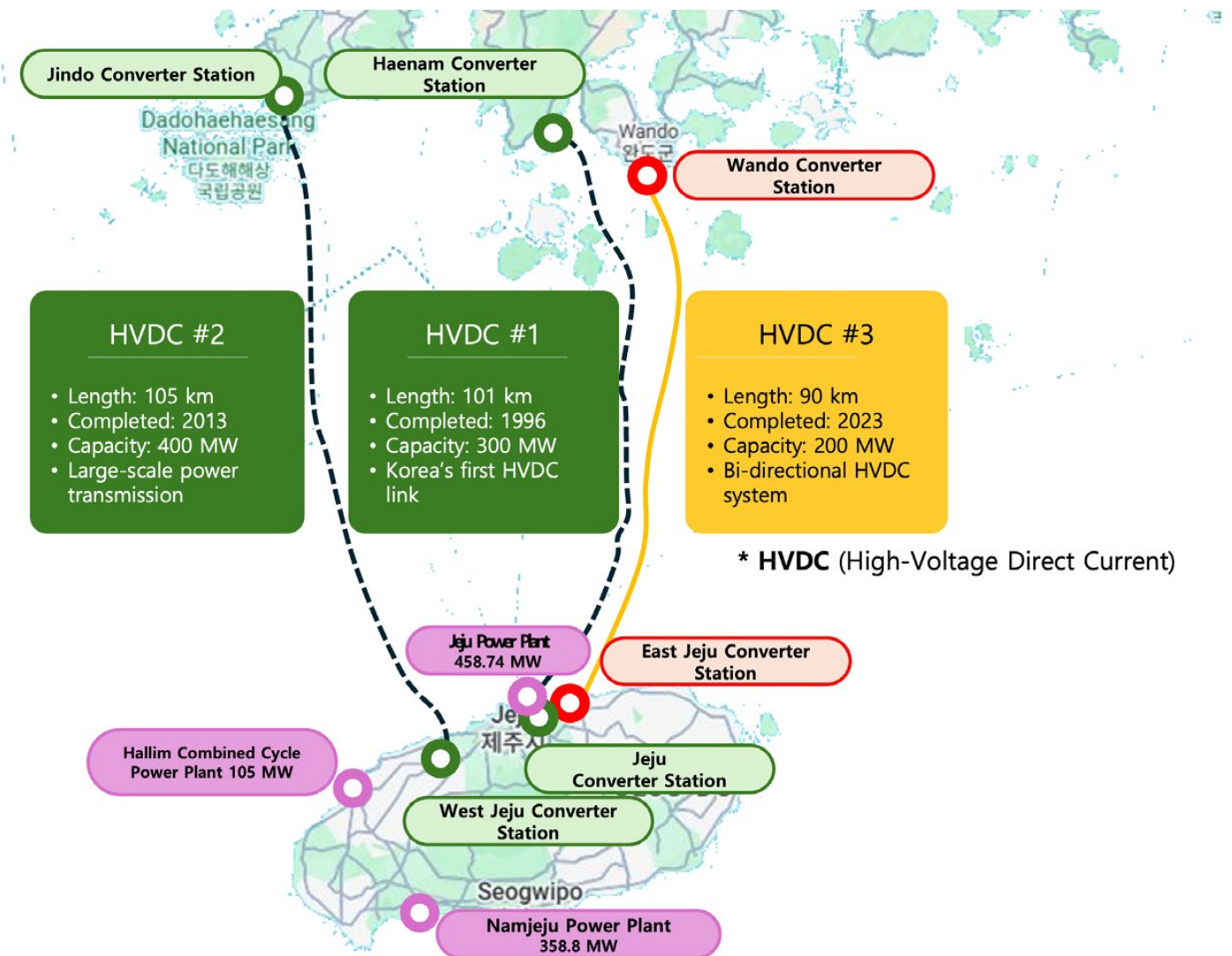
The persistent rise in power curtailment was significantly reversed in June 2024 following the implementation of the 'Renewable Energy Real-time Power Market Bidding System.' By integrating renewable sources into the competitive bidding process, generation can now be synchronized with real-time demand, effectively mitigating and reducing forced curtailments. This improvement in grid hosting capacity was further bolstered by the expansion of ESS as flexibility resources, the scaling of 'Plus DR' (surplus-driven Demand Response) to incentivize consumption during peak production, and technical adjustments to lower the minimum stable generation levels of thermal power plants.

3.2.2 Technical Cause Analysis

While Jeju has prioritized renewable integration, the province's grid stability continues to depend on three HVDC subsea cables and local thermal assets. The primary technical bottleneck is the absence of rotational inertia in renewable energy, which compromises frequency regulation. While conventional thermal turbines act as a buffer against frequency drops through their kinetic energy, inverter-based renewables lack this stabilizing mechanism. Given Jeju's status as a small, isolated power system, maintaining 'Must-Run' thermal units is an essential prerequisite for grid reliability. This requirement often results in involuntary surplus power, forcing authorities to curtail renewables despite their availability. The operational challenge is further compounded by forecasting inaccuracies in Short-Term Load Forecasting (STLF) and the unpredictable nature of Behind-The-Meter (BTM) solar power, which remains invisible to standard utility meters.¹¹

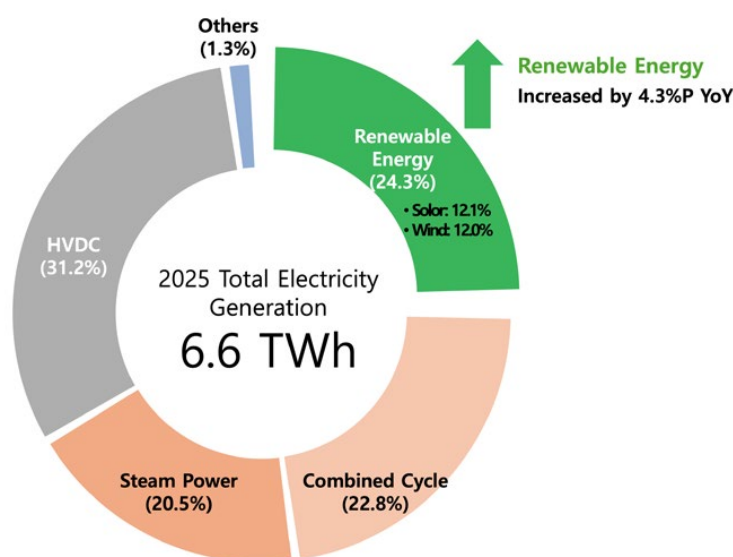
11 Kim, H. G., et al. (2025). Short-term Load Forecasting of Jeju Island Considering the Behind-the-Meter Solar Power. *New & Renewable Energy*, 21(2), 52–59.

Figure 2. Power System of Jeju Island



The 2025 operational data for the Jeju power grid, published by the Korea Power Exchange (KPX), indicates a total power production of 6.6 TWh. The regional energy portfolio was distributed among HVDC links (31.2%), renewables (24.3%), combined cycle plants (22.8%), and steam-based thermal generation (20.5%). These figures underscore the significant role of both external interconnections and variable renewable energy within Jeju's energy landscape.

Figure 3. Total Electricity Generation of Jeju Island, 2025



Source: Korea Power Exchange (KPX), February 2026. * Figures may not sum to 100% due to rounding (100.1%).

According to KPX data, Jeju is undergoing a profound transition in its power generation profile, moving away from conventional fossil fuel-based centralized dispatch toward a sustainable, low-carbon framework. Despite a 0.18% uptick in total generation, conventional sectors experienced significant contractions—most notably internal combustion at -71.9%. In contrast, HVDC and renewables have consolidated their positions, with renewables now representing 24.3% of the total generation after an increase of 4.3 percentage points year over year. Driven by the robust growth of solar and wind energy, this trend underscores a systemic shift toward a decentralized power system that prioritizes non-centralized flexibility assets.

Table 3. 2025 Power Generation by Source in Jeju

Category		Performance (MWh)		Growth (%)	Share (%)	
		2024	2025			
HVDC		1,953,740	2,062,234	5.6	31.2	
Centralized Dispatch	Steam	1,454,897	1,352,646	-7.0	20.5	
	Internal Combustion	41,427	11,622	-71.9	0.2	
	Combined Cycle	1,752,739	1,506,578	-14.0	22.8	
Non-Centralized	Renewable	Wind	793,897	19.6	12.0	24.3
		Solar	799,566	25.2	12.1	
		Others*	10,057	-27.9	0.2	
	Waste		71,231	-6.5	1.1	
Total		6,595,744	6,607,830	0.18	100	

* Others includes Bioenergy, Small Hydro, Landfill Gas (LFG), and Wave Energy.

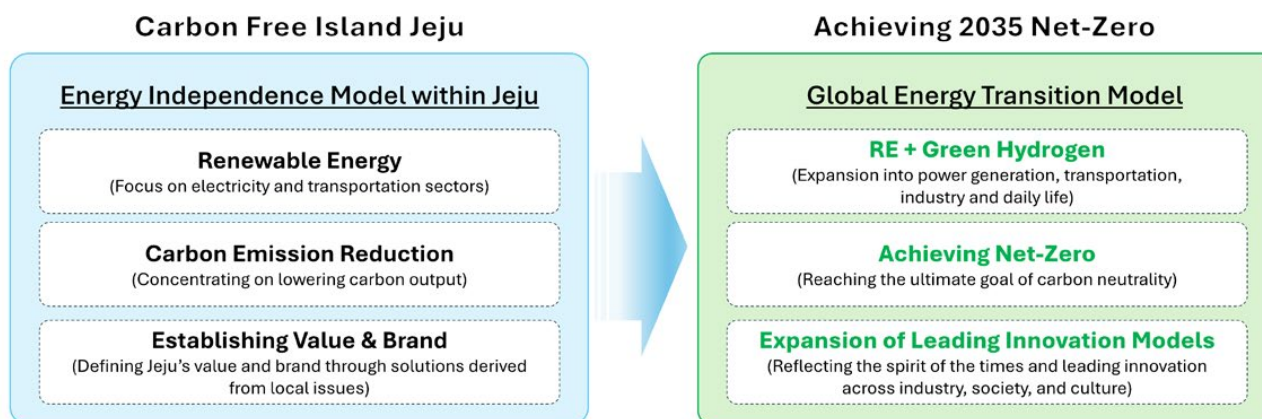
Source: Korea Power Exchange (KPX), February 2026.

4 From Crisis to Opportunity: Strategies for Establishing a Jeju-style Green Hydrogen Ecosystem

As the share of renewable energy intensifies, curtailment emerges as an inevitable systemic challenge; without its resolution, the attainment of carbon neutrality remains fundamentally unattainable. Jeju is transforming this predicament into a strategic opportunity by prioritizing 'Green Hydrogen' as a critical, large-scale flexibility resource for surplus power storage. This initiative is aligned with the national Basic Plan for the Implementation of the Hydrogen Economy and the Clean Hydrogen Ecosystem Strategy. By spearheading large-scale demonstration projects and infrastructure development, Jeju is firmly established as the vanguard of the Republic of Korea's journey toward carbon neutrality.

Seeking to transcend the constraints of the initial CFI 2030 policy, Jeju Special Self-Governing Province announced the 'Renewable Energy and Green Hydrogen-based Energy Great Transformation Scenario' in May 2024. This proactive vision pledges to reach carbon neutrality by 2035, effectively advancing the national 2050 Net Zero timeline by fifteen years. This highly challenging trajectory positions green hydrogen as the primary linchpin for restructuring the regional energy system and ensuring a sustainable, zero-emission future.¹²

Figure 4. Strategic Directions for the Energy Transformation

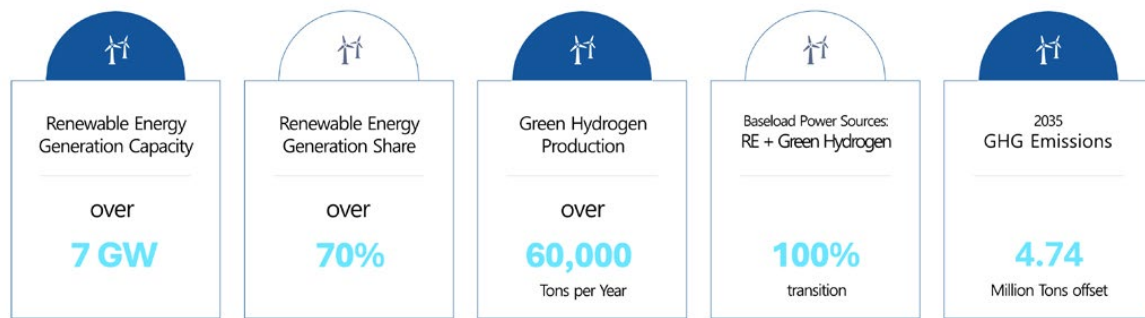


4.1 2035 Carbon Neutrality Vision and Energy Transformation

The cornerstone of this new vision is the expansion of renewable energy installed capacity to 7 GW, thereby increasing the renewable generation share to over 70%. By producing more than 60,000 tons of green hydrogen annually, the province aims to achieve carbon neutrality through a total transition of its baseload power. This involves replacing conventional thermal sources with a 100% carbon-free mix of renewables and green hydrogen mono-firing power generation.

¹² Jeju Special Self-Governing Province. (2024). 2035 carbon neutrality scenario for the energy great transformation based on renewable energy and green hydrogen.

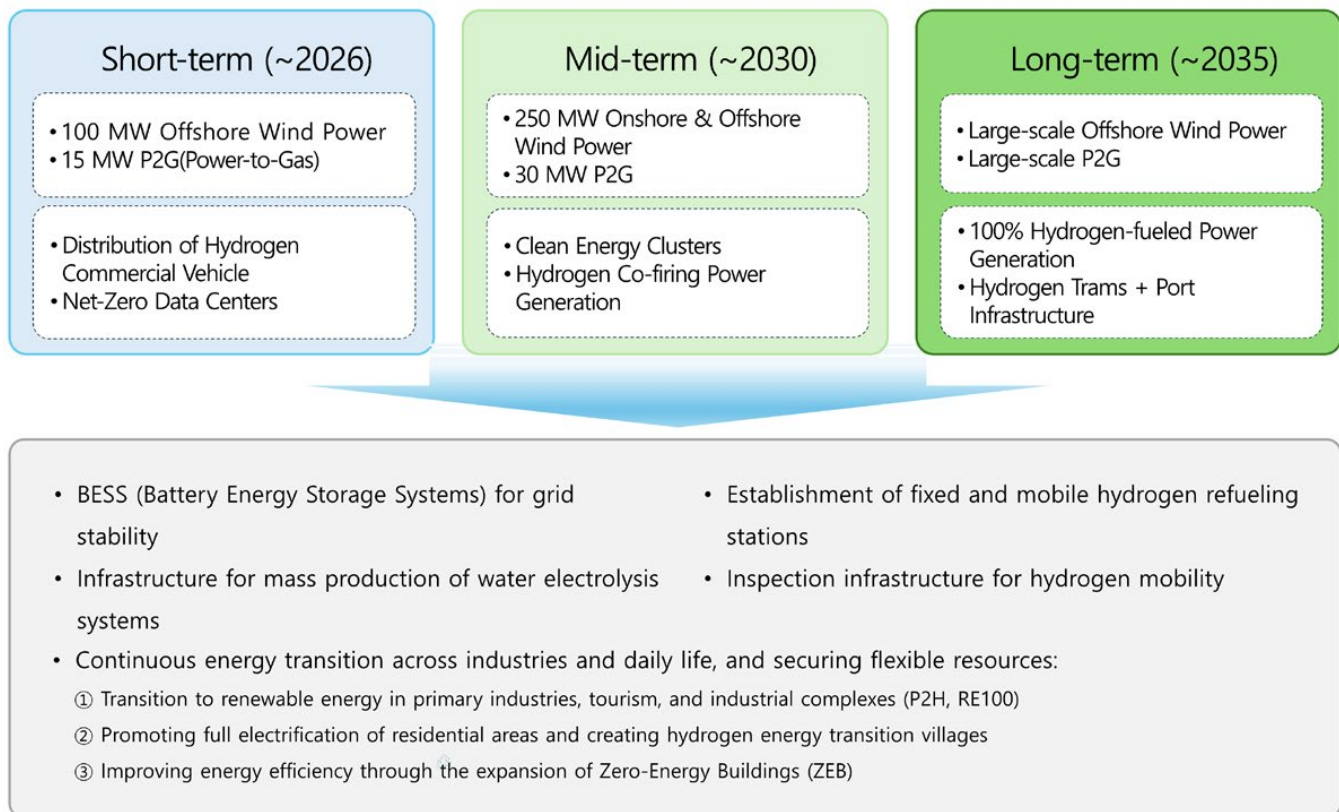
Figure 5. Targets of Energy Great Transformation Scenario



Source: Jeju Special Self-Governing Province, Energy Transition Scenario, 2024.

Targeting 2035, Jeju's energy transition strategy outlines sequential innovation tasks focused on scaling offshore wind and institutionalizing a hydrogen economy. The initial phase in 2026 focuses on the commercialization of hydrogen mobility, underpinned by a 100 MW offshore wind milestone and Power to Gas (P2G) empirical studies. The 2030 horizon involves expanding wind capacity by an additional 150 MW and cultivating clean energy hubs via hydrogen co-firing technologies. The roadmap culminates in 2035 with the realization of a full-scale P2G framework and dedicated hydrogen power generation, complemented by a sustainable mobility network connecting hydrogen-powered trams and maritime logistics.

Figure 6. Renewable Energy and Green Hydrogen-based Energy Great Transformation Projects



4.2 Progress in Establishing the Green Hydrogen Ecosystem

Jeju is pursuing a phased strategy that transitions from small-scale pilots to large-scale commercialization. This staged approach is an essential process for managing technical risks and enhancing the localization rate of core technologies.

4.2.1 Electrolysis-based Green Hydrogen Production Technology and Demonstration

In 2017, the '260 kW-class Electrolysis Technology Development and Demonstration Project' was initiated. This project validated the feasibility of producing green hydrogen by connecting renewable energy from the Sangmyeong Wind Farm in Hallim to electrolysis systems developed by domestic SMEs specializing in hydrogen. As the first initiative of its kind to produce green hydrogen in the Republic of Korea, the demonstration was successfully concluded in 2021.

Subsequently, in 2020, the '3.3 MW-class Renewable Energy-linked Green Hydrogen Production and Storage System Technology Development' project was launched in Haengwon-ri, Gujwa-eup, Jeju City. The scope involved designing and constructing a 3.3 MW electrolysis system—integrating domestic Alkaline (AEC, 2 MW) and PEM (0.3 MW) technologies with an international PEM (1 MW) unit—to produce 600 kg of green hydrogen daily for use in refueling stations and mobility. In 2025, following equipment upgrades including new compressors, the daily output was increased to 900 kg. The facility has since transitioned into a full-scale commercial operation.

Table 4. 3.3 MW Green Hydrogen Production and Storage System

Category	Details
Project Period	October 2020 – September 2024 <i>* Commercial operation commenced in October 2024, following the conclusion of the R&D phase</i>
Total Cost	Approx. USD 14.8 million (National: USD 9.0M / Provincial: USD 1.1M / Private: USD 4.7M) *1USD=1,500KRW
Project Scope	Construction and demonstration of a 3.3 MW electrolysis system (2 MW AEC, 0.3 MW PEM, 1 MW overseas PEM) Construction and demonstration of a green hydrogen storage system (600 kg) and battery storage system (2 MWh)
Participating Institutions & Roles	Electrolysis System Construction 1. Susoenergen (Domestic AEC 1 MW×2) 2. Korea Gas Corporation (Overseas PEM 1 MW) 3. Doosan Enerbility (Domestic PEM 0.3 MW, system integration design, integrated management system) Regulatory & Institutional Support 4. Jeju Energy Corporation (site development permit, high-pressure gas permit, site development construction) 5. Korea Midland Power (safety management plan) 6. Jeju Special Self-Governing Province (charging station, bus introduction, permit support) Infrastructure Construction & Operation 7. GTC (compression and dispensing equipment) 8. Korea Research Institute of Ships & Ocean Engineering (ESS) 9. G-Philos (power conversion system (PCS), integrated control system (PMS)) Economic Analysis & Foundational Research 10. Jeju National University (curtailed power analysis and utilization assessment) 11. Korean Register (economic feasibility analysis)

This project has moved beyond mere technical validation of renewable-linked electrolysis; it has demonstrated the viability of commercial-scale application. Today, it serves as a central hub for Jeju's green hydrogen ecosystem and a practical catalyst driving the province's energy transition.

Figure 7. 3.3 MW Green Hydrogen Production and Storage System Site



In 2022, Jeju was selected for the “10.9 MW Large-scale Renewable Energy Green Hydrogen Demonstration” project, spearheaded by the Ministry of Trade, Industry and Energy (MOTIE). This major initiative seeks to achieve a daily green hydrogen output of 2.9 tonnes through the validation of all four major electrolysis technologies: PEM, AEC, AEM, and SOEC. Serving as a critical stepping stone toward GW-scale production, the project focuses on securing operational expertise for high-capacity electrolysis while verifying economic viability. Completion is targeted for the first half of 2028.

In the same year, the province secured the “Maritime Renewable Energy-linked Green Hydrogen Production” project under the Ministry of Oceans and Fisheries (MOF). This project entails the construction of a fixed offshore platform designed to produce hydrogen by harnessing wave and offshore wind energy. By integrating desalination, offshore structural engineering, and remote-control systems, the project validates the feasibility of hydrogen-based energy storage in remote offshore environments. The demonstration is scheduled to conclude in December 2026.

In 2024, Jeju launched the “RE100-based Hydrogen Pilot Cluster Infrastructure Development” project under the Ministry of Land, Infrastructure and Transport (MOLIT). This site will feature 1 MW of electrolysis, 800 kg of hydrogen storage, a 3 MW (8 MWh) ESS, and 0.7 MW of fuel cells. As Korea's first dedicated RE100 demonstration site, the project tests a 100% self-sufficient energy model without external power supply, in direct response to global RE100 demands. Completion is slated for the second half of 2026.

Most recently, in 2025, Jeju was awarded the “5 MW Plant-type PEM Electrolysis System Development” project by MOTIE. Moving beyond pilot-scale testing, this project constitutes Korea's most ambitious domestic localization initiative for PEM technology. By developing plant-scale systems applicable to massive clean hydrogen hubs, it aims to establish a verifiable track record to support entry into the global electrolysis market. This initiative is anticipated to significantly strengthen national industrial competitiveness, with a target completion in the second half of 2029.

4.2.2 Expansion of Hydrogen Mobility Deployment

To achieve carbon neutrality in the transportation sector, Jeju is leading the large-scale deployment of Fuel Cell Electric Vehicles (FCEVs) powered by locally produced green hydrogen. This strategy is designed to reduce greenhouse gas (GHG) emissions and foster an energy-circulating, low-carbon society. FCEVs generate power through the electrochemical reaction between stored hydrogen and atmospheric oxygen, emitting only pure water as a byproduct. Notably, FCEVs overcome the inherent limitations of Battery Electric Vehicles (BEVs), including reduced driving range in cold weather conditions and considerable battery weight.

These characteristics position hydrogen as the preferred energy carrier for heavy-duty transport, where battery weight and extended charging times present substantial operational constraints. By 2035, Jeju plans to deploy 300 hydrogen buses and 50 hydrogen-powered refuse trucks in the public sector. In 2026, the province began promoting private-sector adoption of hydrogen passenger vehicles. The 2026 allocation of 79 vehicles drew 174 applications, with final recipients selected through an electronic lottery in July, demonstrating strong public interest. Together with its existing EV deployment policy, Jeju's eco-friendly vehicle promotion policy is set to expand further.

4.2.3 Expansion of Hydrogen Refueling Infrastructure

In alignment with the hydrogen vehicle deployment roadmap, Jeju is systematically expanding its hydrogen refueling station infrastructure through a carefully phased approach. Currently, two facilities—the Hamdeok Green Hydrogen Refueling Station and the Dodu-dong Mobile Refueling Station—are operational, providing fuel for 94 hydrogen vehicles in the province (comprising 22 buses, 1 refuse collection truck, and 71 passenger cars).

In the Seogwipo area, a public-sector-led hydrogen refueling station is currently in the design phase, with completion targeted for the first half of 2027, and an additional mobile refueling station is planned to be built by the end of 2026. In addition, private companies also plan to pursue hydrogen refueling station development projects within Jeju City, indicating that the expansion of hydrogen refueling infrastructure is set to gain momentum across both the public and private sectors.

Figure 8. Green Hydrogen Refueling Infrastructure



[Hamdeok Green Hydrogen Refueling Station]



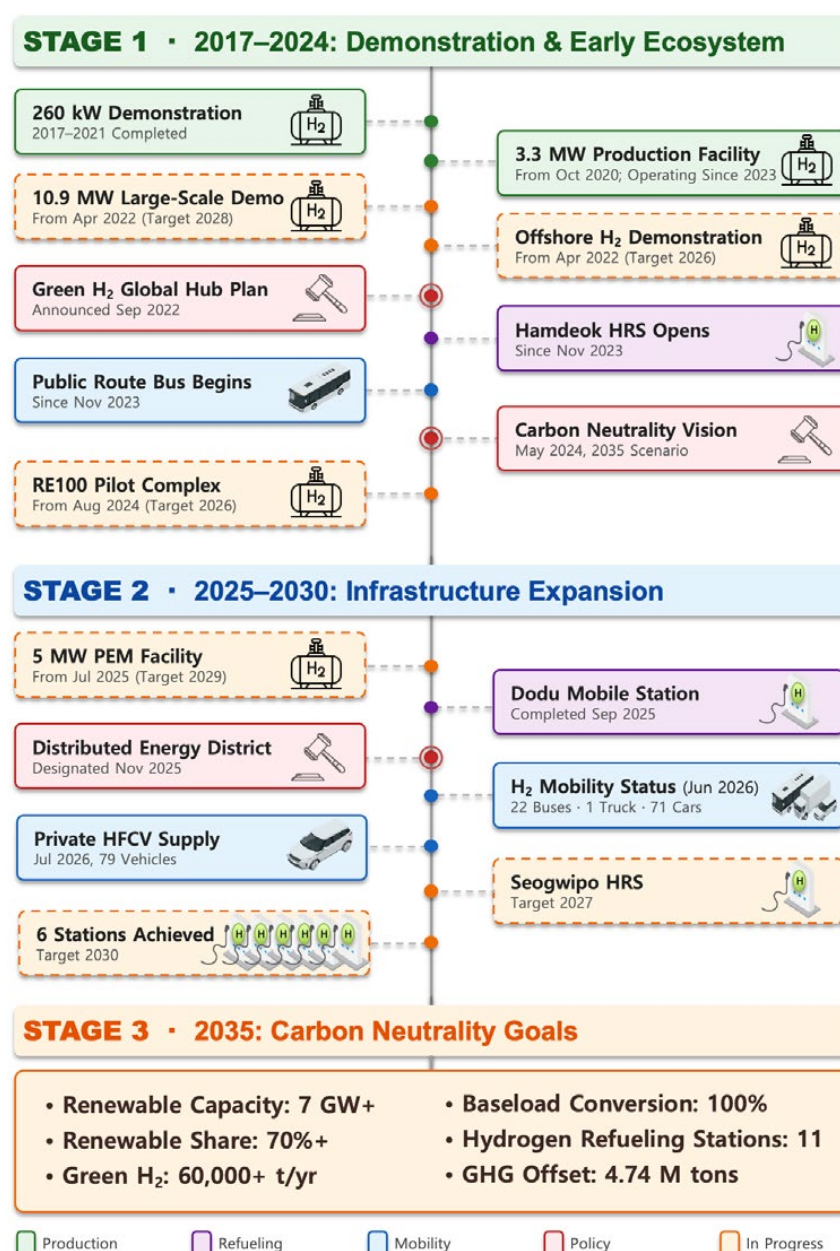
[Dodu Mobile Refueling Station]

4.2.4 Summary of Achievements in Establishing Jeju's Green Hydrogen Ecosystem

The inauguration of the Hamdeok Hydrogen Refueling Station and the deployment of hydrogen buses on Route 312 in November 2023 served as a pivotal milestone, announcing the realization of the Republic of Korea's first-ever green hydrogen ecosystem. By demonstrating a seamless organic synergy with the 3.3 MW electrolysis facility, Jeju has successfully validated a stable supply-demand framework for clean energy.

Building on this success, the province is broadening the horizons of its hydrogen economy through continuous participation in national demonstration projects and the expansion of infrastructure and mobility assets. Today, green hydrogen stands as a central axis of Jeju's 'Energy Great Transformation,' driving the journey toward a 2035 Carbon Neutral Society. The current progress and future roadmap are outlined below.

Figure 9. Progress and Framework for Establishing the Green Hydrogen Ecosystem



Leveraging the successful pilot operations of the 3.3 MW production facility and hydrogen buses, Jeju became the first jurisdiction in Korea to commercialize green hydrogen, launching retail sales at KRW 15,000/kg in November 2024. This price reflects an initial market-entry level incorporating subsidies from the central and provincial governments, rather than a price reflecting the actual Levelized Cost of Hydrogen (LCOH).

In 2024, approximately 29 tons were supplied across 3,670 refueling events (2,090 for buses, 1,580 for passenger cars). This volume grew to approximately 71 tons in 2025, across 7,178 refueling events (5,526 for buses, 1,652 for passenger cars), reflecting the continued expansion of the green hydrogen mobility ecosystem. As of the end of June 2026, 94 hydrogen vehicles were registered in Jeju, comprising 22 buses, 1 refuse collection truck, and 71 passenger cars in operation.

Table 5. Hamdeok Green Hydrogen Refueling Station: Sales Summary

Category	Subtotal	2023	2024	2025
Total (kg)	102,403	1,899	29,182	71,322
Public Buses (kg)	89,793	1,133	23,678	64,982
Passenger Cars (kg)	12,610	766	5,504	6,340

4.2.5 Green Hydrogen Global Forum

Established to build international partnerships, the Green Hydrogen Global Forum is dedicated to translating the vision of energy transition into concrete and actionable decarbonization strategies. By cultivating a high-level network of global policymakers and industry leaders, the forum facilitates the cross-border exchange of cutting-edge hydrogen technologies and best practices.

Although the 2023 forum took place just before the Hamdeok station and hydrogen buses officially launched in November, it served as a key opportunity to share Jeju's operational plans and technical preparations for Jeju's green hydrogen transit system. This event showed that hydrogen infrastructure can be practically integrated into a real urban environment. Today, the forum works closely with international organizations like the IEA and GGGI to build reliable global hydrogen supply chains and support energy transitions in both developed and developing countries.



Table 6. Overview of the Green Hydrogen Global Forum

Category	(1st) 2023	(2nd) 2024	(3rd) 2025
Theme	Leading the Clean Hydrogen Nation, Towards Sustainable International Cooperation	Moving Forward with Innovation for Sustainable Clean Hydrogen	K-Carbon Neutrality Initiative: Advancing with Green Hydrogen and Distributed Energy
Date	Oct. 23 (Mon) – Oct. 25 (Wed)	Jun. 17 (Mon) – Jun. 19 (Wed)	Sep. 24 (Wed) – Sep. 26 (Fri)
Program Day 1	Student Academy, Cooperation Session with Developing Nations (Nepal, Namibia, etc.), Opening Ceremony	Global Roundtable (Ambassadors), Student Academy, Opening Ceremony and Leadership Dialogue	Hydrogen New Industry Roadmap; Storage, Transportation and Global Standardization Session
Program Day 2	Global Policy Exploration (U.S. DOE, etc.), Jeju Net-Zero City Strategy, Global Enterprise (Doosan, SK, Linde, etc.) Technology & Investment Session	Distributed Energy Activation Strategy (Local Government Cooperation), Green Energy City Development, Hydrogen Value Chain and V2G Smart Strategy	Renewable Energy Power Mix (V2G), Student Academy, Opening Ceremony and Jeju Future Vision Declaration, Global Roundtable
Program Day 3	Youth Academy, 3.3 MW Site Tour	Renewable Energy Sector Coupling, Future Mobility Transition Strategy, 3.3 MW Site Tour	Carbon-Free Power Transition, Thermal Management Cooperation (Denmark), Hydrogen Mobility and Carbon-Neutral City Session, 3.3 MW Site Tour
Exhibition & Experience	Indoor/Outdoor Corporate Exhibition (including Safety Pavilion), Hydrogen Production Demonstration Facility Tour	Hydrogen Bus Test Ride (ICC ⇄ Yeomiji), Hydrogen Drone and Hydrogen Vehicle Outdoor Exhibition	Hydrogen Refuse Truck, Mobile Charging Station and Other Daily-Use Mobility Exhibition, 44 Corporate Booths
Key Outcomes	Hydrogen Economy Master Plan Implementation and Global Networking Launch	2035 Carbon Neutrality Vision Sharing and Linkage with Distributed Energy Special Act	K-Carbon Neutrality Initiative Declaration and Proposal of System Integration Standards

5 Economic Viability and Institutional Support for Green Hydrogen

Securing economic viability is the fundamental prerequisite for ensuring the sustainability of the green hydrogen ecosystem. Currently, the production cost of green hydrogen is approximately 1.5 to 6 times higher than that of fossil fuel-based hydrogen; consequently, the transition necessitates sophisticated economic models and robust policy support to bridge this price gap.¹³

5.1 Economic Feasibility of Green Hydrogen

The Levelized Cost of Hydrogen (LCOH) represents the total lifecycle expenditure required to produce one kilogram of hydrogen. In the context of Jeju, the most significant variables influencing LCOH are the System Marginal Price (SMP) of electricity procurement and the capacity utilization rate of the electrolysis system. The 3.3 MW Haengwon Green Hydrogen Production Facility was operated as a national demonstration project from 2020 to 2024, with a total investment of KRW 22.2 billion (approximately USD 14.8 million), consisting of KRW 13.5 billion from the central government, KRW 1.7 billion from local government, and KRW 7.0 billion from the private sector. Since October 2024, following the project's conclusion, the Jeju Energy Corporation has been systematically optimizing key operational parameters — including utilization rates, electricity procurement strategies, workforce allocation, and equipment maintenance — with the aim of establishing a stable and cost-competitive green hydrogen supply chain for the region.

This report is constrained by its inability to present a precise LCOH figure for Jeju's green hydrogen. This limitation arises from the fact that commercial-scale operations commenced only recently, and a sufficient body of reliable operational data has yet to be accumulated. The retail price of KRW 15,000/kg in effect since November 2024 represents a market-entry price that incorporates partial subsidies, rather than a price reflecting the actual LCOH. From a global comparative perspective, the International Energy Agency (IEA) has estimated that renewable hydrogen produced in China is approximately 40–45% less expensive than its European or American counterparts. Accordingly, in order for Jeju's green hydrogen to secure competitiveness, sustained efforts toward further cost reduction will be essential.

Utilizing standard industrial electricity severely undermines the economic feasibility of green hydrogen. However, production costs can be drastically reduced by leveraging surplus power that would otherwise be lost during curtailment or by securing incentives through the Plus DR (Demand Response) system. Relying solely on surplus power minimizes electricity procurement costs but increases the Capital Expenditure (CAPEX) burden per unit due to reduced electrolysis operating hours. Conversely, increasing the utilization rate necessitates the use of expensive grid electricity. Therefore, identifying the optimal 'sweet spot' between ensuring adequate utilization and securing low-cost power is essential.¹⁴

Achieving economic viability for green hydrogen exceeds the capabilities of single-technology or single-operator models. An 'Integrated Operation Model' that synergizes renewable energy, hydrogen production, storage, and load management is required, underpinned by both specialized

13 Christensen, A. (2020). *Assessment of Hydrogen Production Costs from Electrolysis: United States and Europe*. International Council on Clean Transportation (ICCT).

14 Glenk, G., and S. Reichelstein. (2019). Economics of Converting Renewable Power to Hydrogen. *Nature Energy*, 4, 216–222.

software and hardware. In this regard, Jeju's designation as a Distributed Energy Specialized District will serve as a catalyst to expand the energy transition paradigm from mere hardware deployment to sophisticated software integration and institutional design.

5.2 The Republic of Korea's Clean Hydrogen Certification System (CHCS)

In its initial phase, the Republic of Korea's hydrogen policy concentrated on the quantitative expansion of downstream applications, including the deployment of hydrogen vehicles and fuel cell power generation. More recently, however, the policy orientation has shifted toward securing 'cleanness' through stringent management of carbon emissions arising from the hydrogen production process. At the heart of this transition lies the CHCS, which serves as the institutional backbone for objectively measuring greenhouse gas emissions across the entire production and import lifecycle of hydrogen, classifying hydrogen into tiers on this basis, and providing differentiated administrative and financial support accordingly. Following the system's entry into force on March 4, 2024, the Clean Hydrogen Portfolio Standard (CHPS) competitive bidding market—the first of its kind in the world—was launched. Under this scheme, the electricity authority is mandated to procure a prescribed annual minimum volume of electricity generated from clean hydrogen, reflecting the government's resolve to establish a robust clean hydrogen ecosystem.

The greenhouse gas emissions threshold for clean hydrogen certification has been set at no more than 4 kg of CO₂-equivalent per kilogram of hydrogen produced (kgCO₂eq/kgH₂). This benchmark is comparable to the eligibility standards under the U.S. Inflation Reduction Act (IRA). While somewhat more lenient than the corresponding criteria in the European Union and Japan, the threshold was determined through a comprehensive consideration of the Republic of Korea's domestic energy infrastructure and the prevailing level of technological maturity.¹⁵

Table 7. Tier criteria for the CHCS

Tier	Emissions Threshold (kgCO ₂ eq/kgH ₂)	Expected Technological Pathways and Characteristics
Tier 1	0.00 – 0.10	Top-tier carbon abatement technologies, including high-efficiency electrolysis (green hydrogen) and systems linked to zero-carbon power sources
Tier 2	0.11 – 1.00	Blue hydrogen with advanced Carbon Capture and Storage (CCS), and electrolysis powered by a renewable energy mix
Tier 3	1.01 – 2.00	Blue hydrogen with conventional-level CCS, and hydrogen extracted from low-carbon energy sources
Tier 4	2.01 – 4.00	Transitional blue hydrogen with relatively low carbon capture efficiency, or low-carbon extraction pathways

The CHCS is expected to exert a substantial influence on the development of Jeju's green hydrogen ecosystem.

First, the system enhances quality assurance and market credibility for green hydrogen. Green hydrogen produced in Jeju—generated through electrolysis powered by renewable sources such as wind and solar—is expected to qualify for the lowest emissions tier. Through official state-level certification and objective verification, consumers and enterprises will be provided with a clear basis to distinguish Jeju-produced green hydrogen from blue or grey hydrogen produced in other regions, thereby enabling trust-based purchasing decisions. Jeju is currently actively pursuing the procedures necessary to obtain the Republic of Korea's first-ever Clean Hydrogen Certification.

15 Ministry of Trade, Industry and Energy (MOTIE). (2024). *Notification No. 2024-34: Operation of the Clean Hydrogen Certification System*, enacted and effective March 4, 2024.

Second, the system is expected to generate stable demand through the CHPS. Lower greenhouse gas emissions correspond to higher tier classifications and incentives, with certified clean hydrogen receiving preferential treatment under CHPS. Within a regulatory framework that obligates power generators to fulfill a designated proportion of their generation from clean hydrogen, Jeju's green hydrogen—qualifying for the highest tier—stands to secure stable institutional demand. This will function as a critical mechanism in providing market access for Jeju's green hydrogen industry, which currently remains in the early stages of commercialization.

Third, once the certification system becomes firmly established, private investors will be able to project business profitability with greater clarity, potentially accelerating large-scale investment decisions in production facilities. Furthermore, if the premium accorded to green hydrogen under the certification system is calibrated to offset the price competitiveness gap with conventional fossil fuels and other forms of hydrogen, it will contribute decisively to the sustainable growth of Jeju's green hydrogen industry.

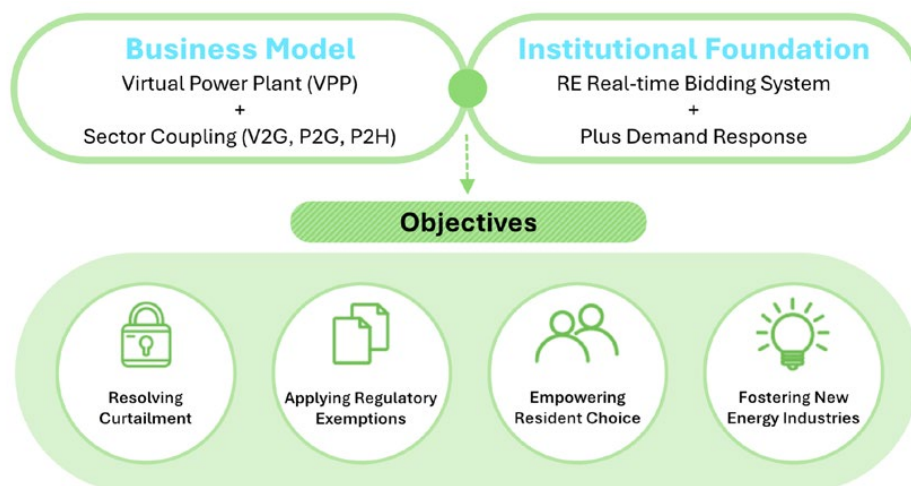
In summary, the Republic of Korea's CHCS carries significance that extends well beyond its regulatory function for Jeju's green hydrogen ecosystem. Jeju's strategy of converting surplus renewable electricity into green hydrogen will be endowed with national-level credibility and market value through the certification system. In this regard, the system is poised to function as a foundational institutional pillar supporting the leap forward of Jeju's green hydrogen industry across three dimensions: catalyzing investment, securing stable demand, and aligning with national carbon neutrality policy.

5.3 Implications of the Designation as a Distributed Energy Specialized District

In November 2025, Jeju was officially designated as a Distributed Energy Specialized District by the central government. This designation signifies a definitive departure from the legacy energy architecture—characterized by centralized systems, fossil fuel dependency, and public utility monopolies—toward a future-oriented paradigm centered on distributed energy, renewable resources, and active prosumer participation. Through this initiative, Jeju aims to transcend the structural constraints of centralized grid regulation by introducing flexible market mechanisms. Beyond grid stabilization, the province seeks to foster a novel industrial ecosystem predicated on power data analytics.

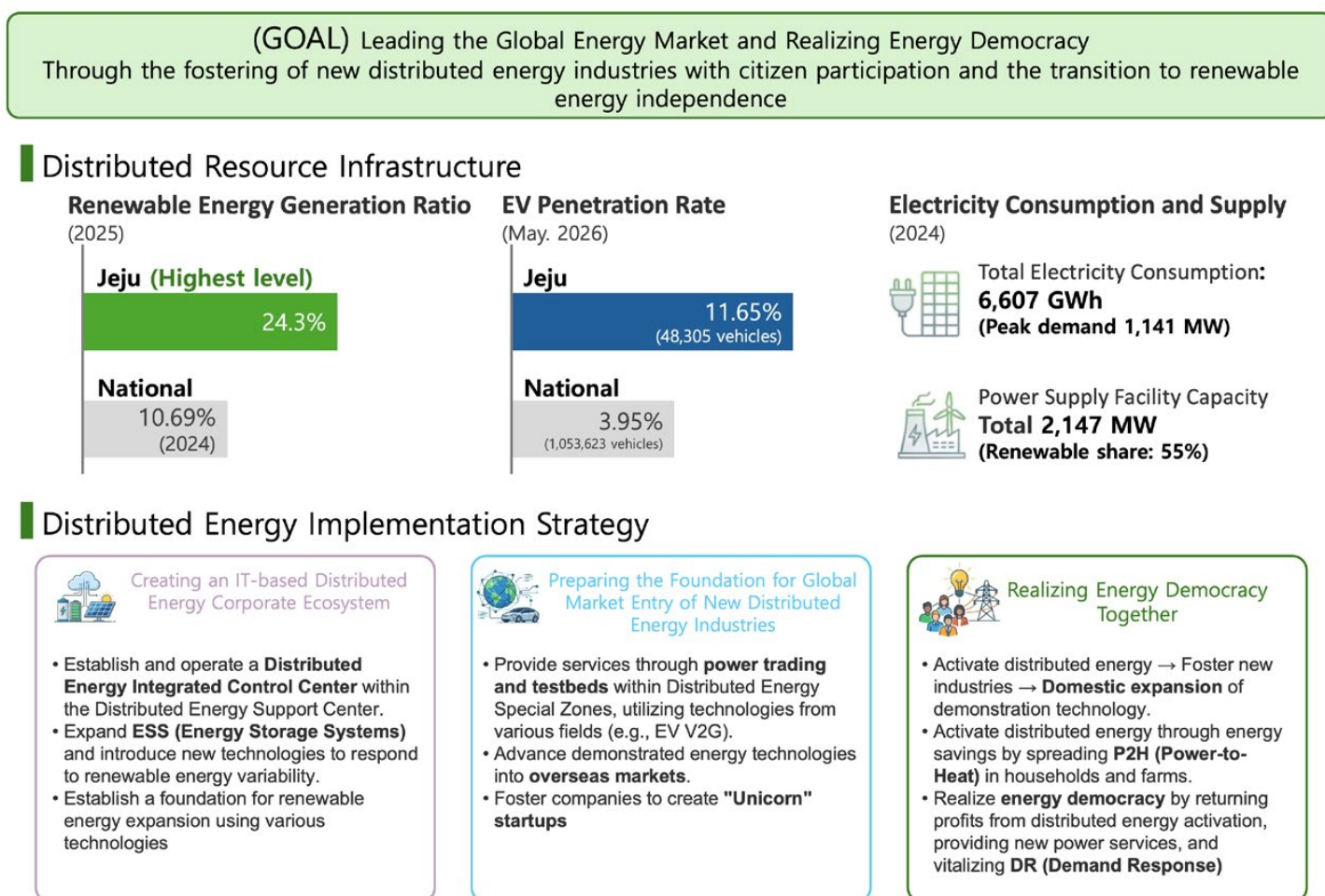
Jeju's specialized district is categorized under the “New Industrial Revitalization” type, encompassing three primary technical models: VPP-based V2G systems, ESS, and innovative Power-to-X (P2X) demand-side technologies.

Figure 10. Specialized District for Renewable-Compatible Distributed Energy



With its designation as a Distributed Energy Specialized District, Jeju has moved a step closer to its 2035 Carbon Neutrality goal. By 2032, the province plans to secure 153 MW of flexibility resources—comprising 36 MW of VPP-based V2G, 60 MW of VPP-based ESS, and 57 MW of VPP-based P2X models—to enhance grid stability and accelerate renewable deployment. Furthermore, Jeju is establishing a pioneering compensation framework within the district. By introducing Non-Wire Alternatives (NWAs), specialized Power-to-Heat (P2H) rates, and advanced Demand Response (DR) pricing, the province will create an environment where residents can actively participate and discover new revenue streams. Utilizing platforms managed by emerging VPP operators, citizens will transition into 'Prosumers' who both produce and consume energy, thereby realizing 'Energy Democracy.' For instance, EV owners can charge during the day and discharge power back to the grid (V2G) during peak hours for profit. This ICT and AI-driven smart energy system will not only reduce costs for residents but also attract corporate investment, create jobs, and position Jeju as a global bridgehead for the new energy industry.¹⁶

Figure 11. Strategic Framework and Objectives for Distributed Energy



16 Jeju Special Self-Governing Province (2025). *Jeju-type Distributed Energy Specialized District Plan*.

6 A 'Green Growth Energy Transition Model' for Developing Countries

Jeju Island's energy transformation journey extends well beyond a regional success story; it stands as a vital reference point for the global community. By openly sharing not only its achievements but also the iterative processes through which it has navigated and overcome challenges, Jeju offers a realistic and scalable model for developing economies and Small Island Developing States (SIDS). The 'Jeju Model' offers invaluable insights for nations and regions seeking to strengthen climate resilience and leapfrog conventional energy infrastructure constraints on the path toward a sustainable, net-zero future.

6.1 Applicability of the Jeju Model to Developing Nations

Developing countries and island regions share characteristics similar to Jeju's energy environment, in that—even when interconnected with mainland power grids—structural limitations such as grid instability, transmission losses, and supply imbalances necessitate the establishment of localized energy production and consumption systems. In particular, in regions with a high dependence on fossil fuel-based generation, microgrids combining renewable energy with sector coupling are gaining attention as an effective policy model for achieving energy self-sufficiency and securing economic viability.

Moreover, for Pacific Island nations confronting existential threats from rising sea levels, the vision of a 'Carbon-Free Island' is not simply an environmental objective but a core agenda directly tied to national survival. Against this backdrop, the Jeju green hydrogen ecosystem model can be concretely applied to developing countries across three dimensions—energy, environment, and industry.¹⁷

First, a fundamental reduction in social costs. The transition to green hydrogen can structurally reduce the various social costs associated with fossil fuel-based power generation systems. Fossil fuel-based power generation entails substantial external costs, including exposure to rising carbon prices and public health costs stemming from environmental pollution. Green hydrogen, by contrast, can substantially reduce lifecycle greenhouse gas emissions compared with fossil-based hydrogen. In particular, fuel cells generate electricity while producing only water and heat at the point of use, with no direct air pollutant emissions. However, hydrogen combustion may still produce nitrogen oxides (NO_x), which need to be appropriately controlled. In this respect, green hydrogen holds the potential to deliver social benefits—including reduced costs for purchasing carbon credits, as well as improved public health and environmental restoration.

Second, the restoration of energy sovereignty and the strengthening of macroeconomic resilience. Island nations that rely on imported fuels for most of their energy consumption are acutely exposed to international oil price volatility. Establishing a hydrogen production system based on local renewable energy—as exemplified by the Jeju Model—can curb the foreign-currency outflows associated with fuel imports and secure energy at stable prices, thereby reinforcing both the nation's overall economic resilience and its sovereignty over domestic energy supply.

Third, the advancement of industrial structure through multi-sector decarbonization. Green hydrogen extends decarbonization beyond the power sector into transport and industry more broadly. Jeju is demonstrating such a pathway by introducing hydrogen mobility for heavy-duty commercial vehicles and vessels, offering a useful reference for island nations with relatively simple industrial structures that seek to build energy systems resilient to climate variability. For developing countries where agriculture accounts for a large share of the economy, green hydrogen offers further benefits—such as greater fertilizer self-sufficiency through green ammonia production and stronger food security—opening a strategic path to upgrade their economies from a primary-industry orientation toward clean chemical industries.

6.2 Implications for Developing Countries

During the implementation of its Carbon Free Island (CFI) policy, Jeju encountered frequent issues with renewable energy intermittency and power curtailment. This prompted a paradigm shift: moving beyond merely greening power production to ‘securing flexibility across the entire energy system.’ Recognizing that scaling renewable infrastructure alone cannot achieve true energy independence, Jeju now prioritizes the acquisition of ‘Flexibility Resources’—critical assets capable of storing and converting surplus power.

Table 8. Shifts in Jeju’s Energy Transformation Policy

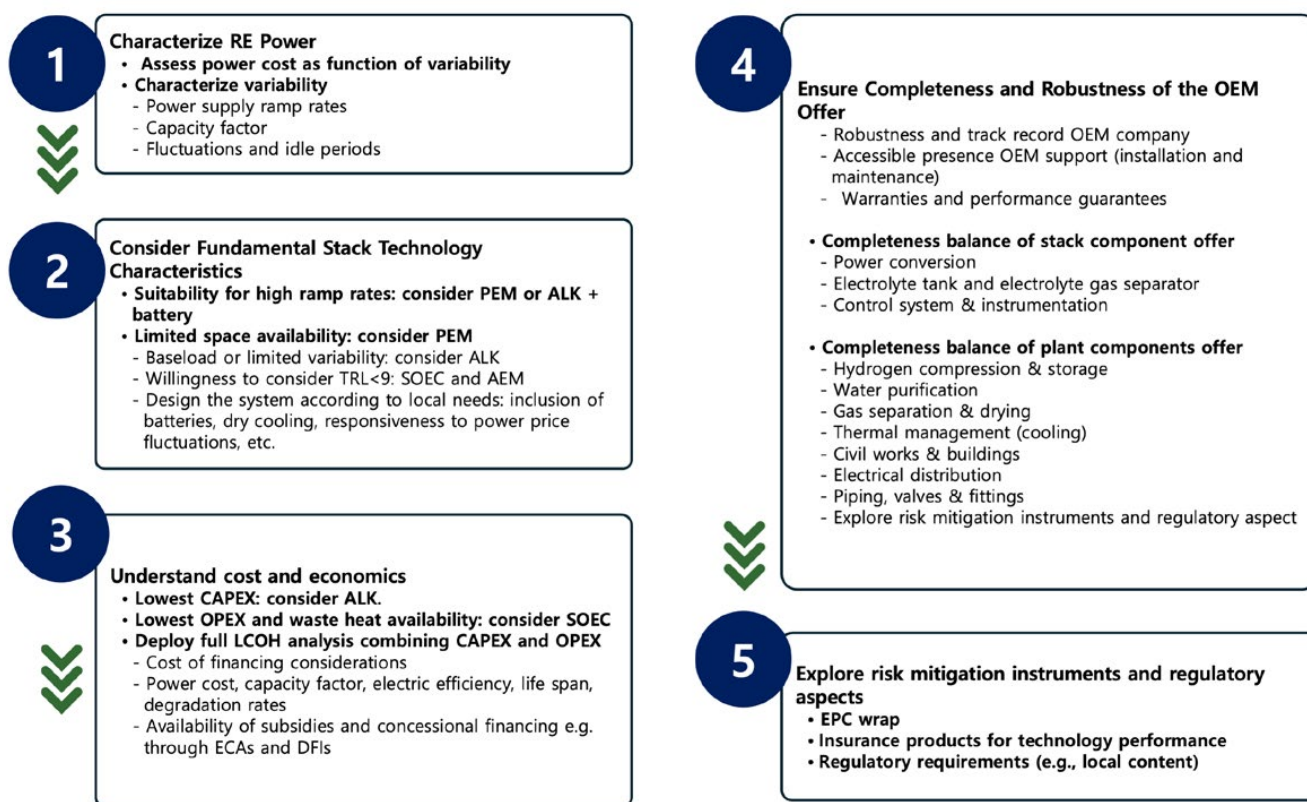
Category	CFI 2030	Energy Great Transformation Scenario	Implications
Core Goal	100% Power Self-Sufficiency	Achieving Net-zero by 2035	Need for decarbonization in non-electric sectors such as heating and transportation, in addition to electricity
Main Energy Source	Onshore/Offshore Wind, Solar Power	RE + Green Hydrogen(P2G)	Need for long-term storage(hydrogen) to complement the intermittency of renewable energy
Power Grid Strategy	Smart Grid Demonstration	Distributed Energy Specialized District Sector Coupling	Transition from centralized control to flexible linkage between distributed resources
Storage Method	Mainly ESS	ESS + Hydrogen + Thermal Energy	Need for a diversified storage mix that goes beyond the limitations of batteries

Jeju’s energy transition policy is currently a work in progress; therefore, it is premature to pass a final judgment on its success at this stage. Instead, focus should be directed toward the tangible and intangible assets accumulated throughout the implementation process and the journey of overcoming various structural hurdles.

The World Bank’s report, *Green Hydrogen in Developing Countries*, points out that Variable Renewable Energy (VRE) alone cannot guarantee a stable energy supply. It emphasizes the strategic value of green hydrogen as a critical medium for seasonal and daily energy storage to mitigate the volatility of solar and wind power. The report provides a phased energy transition roadmap, offering vital insights into technical requirements and economic feasibility. To successfully implement water electrolysis systems, the following five prerequisites must be addressed:

1. **Analyze Power Supply Patterns:** A meticulous analysis of VRE supply patterns is essential. Since solar and wind outputs are intermittent, evaluating how this volatility impacts overall operational costs is a crucial first step.
2. **Select Appropriate Technology:** Electrolysis methods must align with site-specific conditions. Fast-response technologies are suited for volatile power environments, while cost-effective models may be preferred where space is limited or power supply is stable. High-risk, immature technologies should be approached with caution.
3. **Conduct a Comprehensive LCOH Assessment:** Beyond initial CAPEX, LCOH must factor in Operating Expenditure (OPEX), equipment lifespan, and efficiency degradation. Availability of government subsidies and international financing programs should also be explored.
4. **Evaluate Suppliers and Balance of Plant (BOP):** Suppliers should be vetted for their track record, after-sales support, and performance guarantees. The scope of supply must also include BOP components, such as hydrogen compression, storage, and purification systems.
5. **Mitigate Project Risks:** To counter potential risks, EPC (Engineering, Procurement, and Construction) contracts with integrated warranties and performance insurance are highly recommended. Furthermore, compliance with local regulations, including local content requirements, must be clearly established and documented.¹⁸

Figure 12. Roadmap for the Implementation of Electrolysis



Source: World Bank (2026). Electrolyzers for Hydrogen Production

18 World Bank. (2020). *Green Hydrogen in Developing Countries*.

As emphasized in the World Bank's technical report on electrolysis, there is no single optimal technology. Rather, it requires a phased and context-specific approach, ensuring that technology selection is meticulously aligned with local power supply profiles and final end-use applications.¹⁹

The following roadmap, derived from Jeju's empirical experience, outlines a phased approach to energy transition. It encompasses institutional foundation and governance, appropriate technology-based infrastructure, flexibility resources and market reform, green hydrogen ecosystems, and capacity building. Given that local conditions vary, this roadmap is designed to be flexible and non-linear, allowing regions to adapt specific phases to their unique contexts for a more effective transition.

Table 9. Energy Transition Roadmap for Developing Countries

Stage	Policy Objectives	Application Details
Phase 1 (Institutional Foundation & Governance)	Establishing systems for public ownership of energy resources	- Establishing a legal basis to define wind and solar power as 'public goods' (Jeju) Introducing the public wind resource fund model. Power producers are required to donate 7% of revenue or 17.5% of net profit, which is used to support energy-vulnerable groups and invest in renewable energy infrastructure
	Clear roadmap and control tower establishment	- Establishing a master plan that includes sectoral execution plans and specific figures, rather than just declaring goals (Jeju) Established the CFI 2030 policy plan in 2012 and a revised plan in 2019. In May 2024, the Energy Transition Scenario was announced aiming for 2035 Net-Zero due to curtailment issues
	Financing	Establishing a green finance procurement framework through cooperation with international organizations (MDBs)
Phase 2 (Infrastructure Construction based on Appropriate Technology)	Localized microgrid demonstration	- Fossil Fuel Hybrid: Ensuring stability through hybrid systems where renewable energy works in harmony with fossil fuels rather than excluding them entirely - Resource Mapping: Securing precise data on wind conditions and solar radiation - Appropriate Technology: Introducing versatile equipment that can withstand the local climate and is easy to repair locally - Capacity Building: Creating conditions for sustainable operation by training local technical personnel (Jeju) Conducted small-scale pilot tests for CFI. Faced difficulties with high-cost microgrid equipment due to lack of maintenance capacity and frequent breakdowns. Transitioning to equipment at the 'Appropriate Technology' level that allows for local alternatives
	Distributed power sources and resident participation	- Expanding renewable energy distribution at the village level, rather than focusing on large-scale power plants - Increasing social acceptance by introducing the Prosumer model where residents directly produce and consume electricity (Jeju) Expanding 'Public-led Renewable Energy Development' to prevent overdevelopment and promote coexistence with residents

¹⁹ World Bank. (2026). *Electrolyzers for Hydrogen Production*.

Stage	Policy Objectives	Application Details
Phase 3 (Securing Flexibility Resources & Market Reform)	Expansion of ESS & Flexibility Resources	• Introduction of BESS (Battery Energy Storage Systems) to absorb renewable energy variability. • (Jeju) Curtailment has occurred since 2015. To address this, BESS installation and green hydrogen demonstration projects are underway, alongside institutional frameworks to expand flexibility resources.
	Regulatory Sandbox & Power Trading Liberalization	• Easing regulations to enable Power Purchase Agreement (PPA) power trading and VPP to overcome the limitations of existing power market structures. • (Jeju) Promoting power trading liberalization through the designation of Distributed Energy Specialized District.
Phase 4 (Advancement & Sector Coupling)	Creation of Green Hydrogen (P2G) Ecosystem	• Producing green hydrogen using surplus power (otherwise lost to curtailment) for use across all decarbonized industrial sectors. • (Jeju) Establishing an initial green hydrogen ecosystem with a focus on mobility, with plans to expand its application to all industrial sectors in the future.
	Utilization of Bidirectional EV Charging (V2G)	• Building a business model that uses EV batteries as 'Mobile ESS' to supply power back to the grid and generate revenue. • (Jeju) Installing bidirectional chargers and promoting V2G demonstration projects starting from 2026.
Phase 5 (Capacity Building & Cooperation)	Local Maintenance Talent Nurturing & Partnerships	• Developing local maintenance personnel to ensure sustainable and continuous system operation. • (Jeju) Jeju Energy Corporation is pursuing P2G and V2G projects through partnerships with specialized companies and is focusing on securing core technological capabilities.

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