ESMAP
Energy Sector Management Assistance Program

South Korea Study Tour

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Smart Grid Strategy and Vision in Korea

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Introduction to KETEP

(Korea Institute of Energy Technology Evaluation & Planning)

A government agency under the Ministry of Trade, Industry and Energy (MOTIE) of the Republic of Korea. Established to promote technological advancements and innovation in the energy sector, KETEP plays a pivotal role in evaluating, funding, and managing various R&D projects related to energy technologies.

■ **Mission** (since 2009) : Create values for the future via energy technology innovation and related industry development

- Key Areas: Solar energy, Wind energy, Hydrogen, Fuel cell, Nuclear, Energy Efficiency, ESS, Smart Grids, CCS, etc
- Annual Funding budget : KRW ₩1,000 billion approximately (about USD 700~800 million)
- Location : 14, Teheran-ro 114-gil, Gangnam-gu, Seoul
- Home page : https://www.ketep.re.kr

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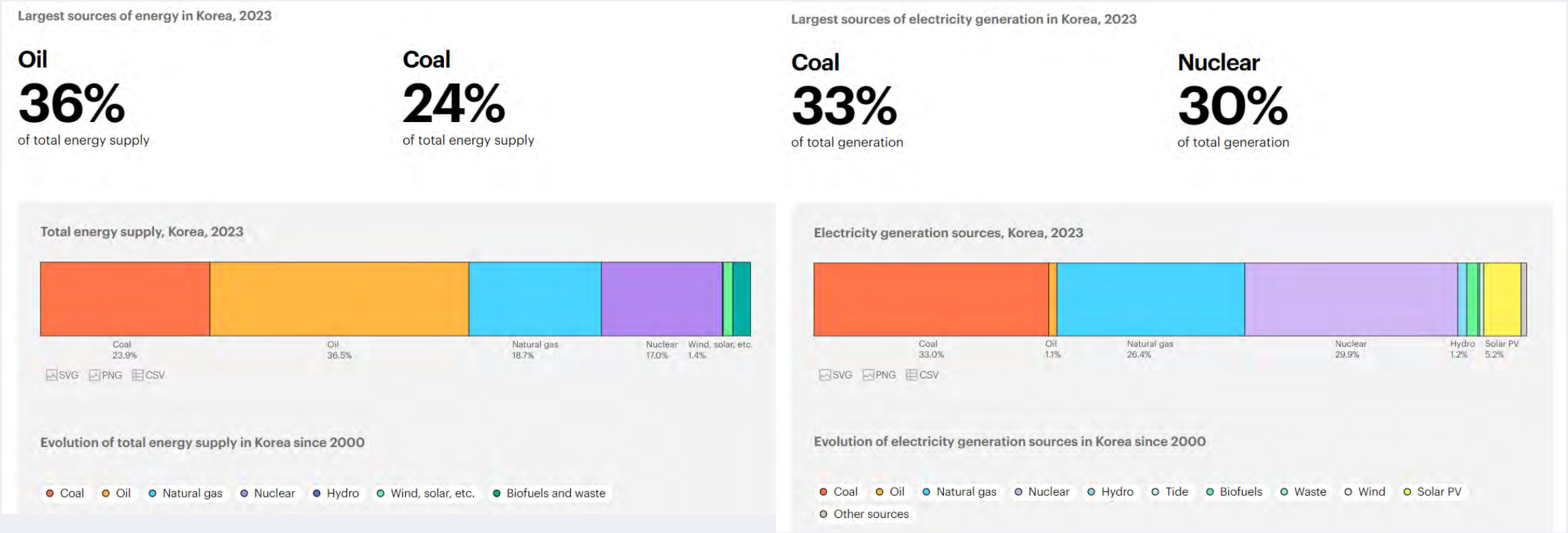
Energy Mix in Korea, 2023

The share of fossil fuels (oil, coal, and gas) in total energy consumption remains high. Electricity accounts for about 20% of the final energy consumption. When looking at the proportions by power generation source, the combined share of coal-fired, nuclear, and gas power generation is around 90%.



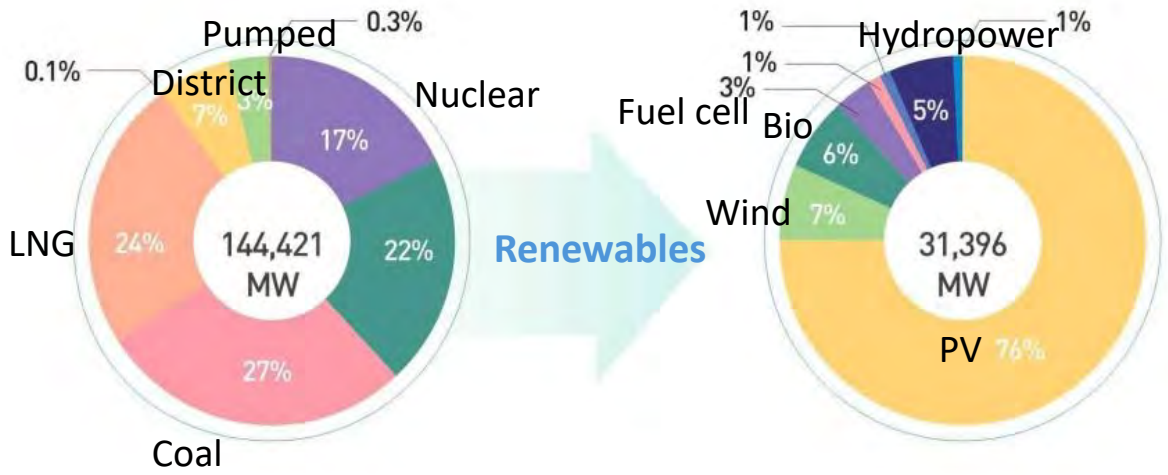
Power Generation Mix Plan, 2023-2036

As of 2023, renewable energy accounts for approximately 22% of the total rated capacity of power generation facilities, with a target of 45% by 2036. The effective utilization rate stands at around 10%, highlighting the need for continued investment expansion.

■ Power Generation Mix Plan for 2036 under the 10th Basic Plan for Electricity Supply & Demand

➢ Rated Generation Capacity : Renewables(45.3%), LNG(27.0%), Nuclear(13.2%), Coal(11.3%)

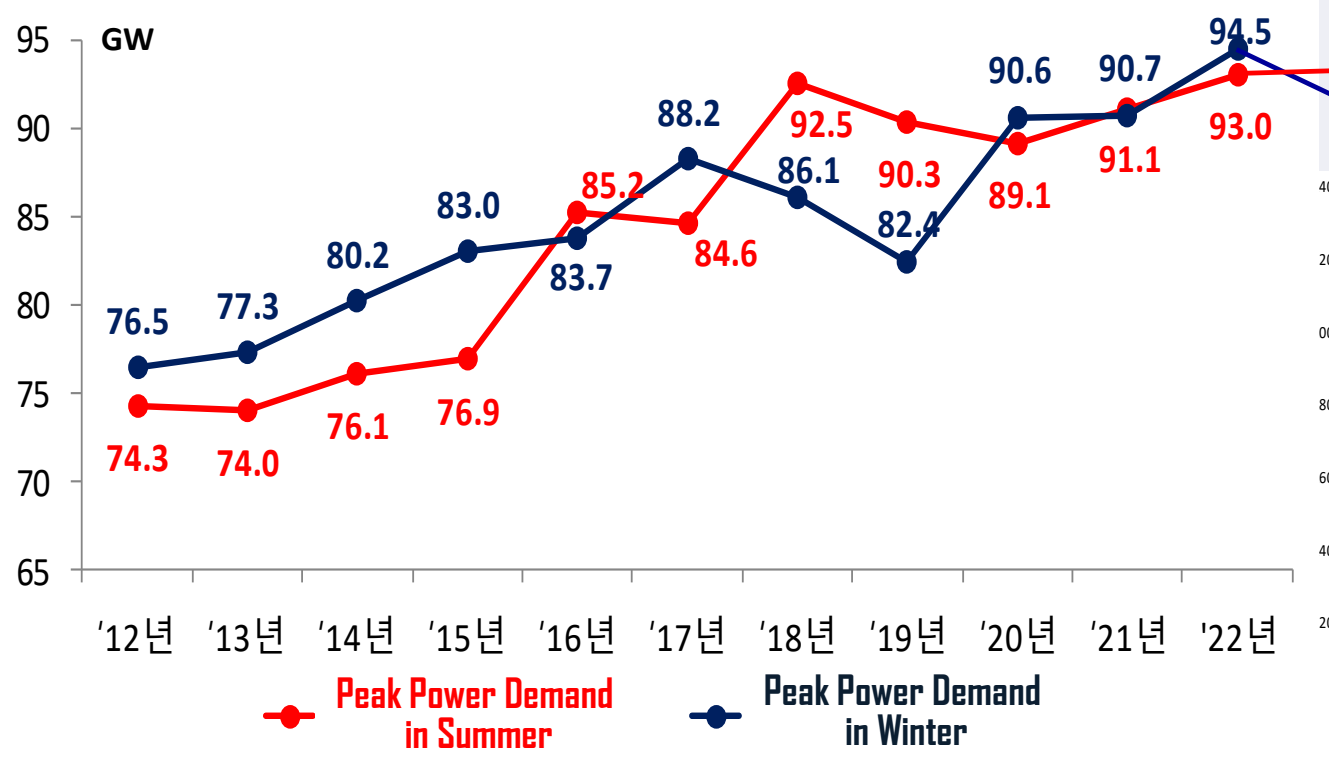
< Share of Renewable Power Generation in 2023 >



Year		Nuclear	Coal	LNG	Renewable	Pumped	etc	Total
2026	Capacity	28.9	37.6	52.4	44.8	4.7	0.7	169.1
	Share	17.1%	22.2%	31.0%	26.5%	2.8%	0.4%	100%
2030	Capacity	28.9	31.7	58.6	72.7	5.2	0.9	198.0
	Share	14.6%	16.0%	29.6%	36.7%	2.6%	0.5%	100%
2033	Capacity	31.7	29.7	62.0	91.5	5.8	0.9	221.6
	Share	14.3%	13.4%	28.0%	41.3%	2.6%	0.4%	100%
2036	Capacity	31.7	27.1	64.6	108.3	6.5	0.8	239.0
	Share	13.2%	11.3%	27.0%	45.3%	2.7%	0.5%	100%

Trends in Peak Power Consumption, 2012 - 2023

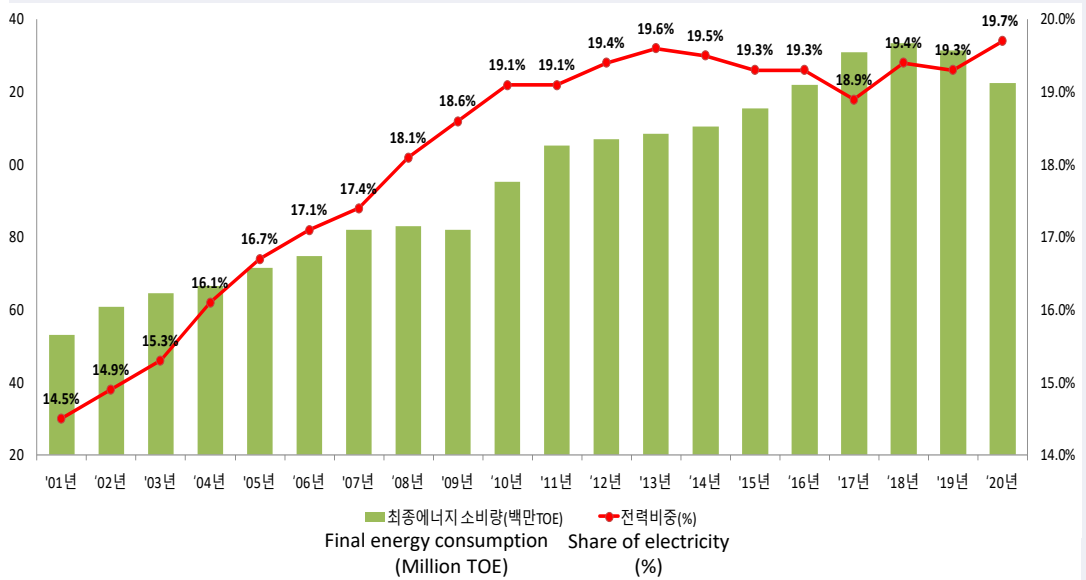
Electricity consumption has been continuously increasing, mainly due to the demand for cooling in summer and heating in winter. With the growing demand for clean electricity in the industrial sector to achieve carbon neutrality, and considering the cooling and heating needs due to climate conditions, the share of electricity in final energy consumption is expected to increase to around 50% by 2050.



93.6 ('23.8.7)

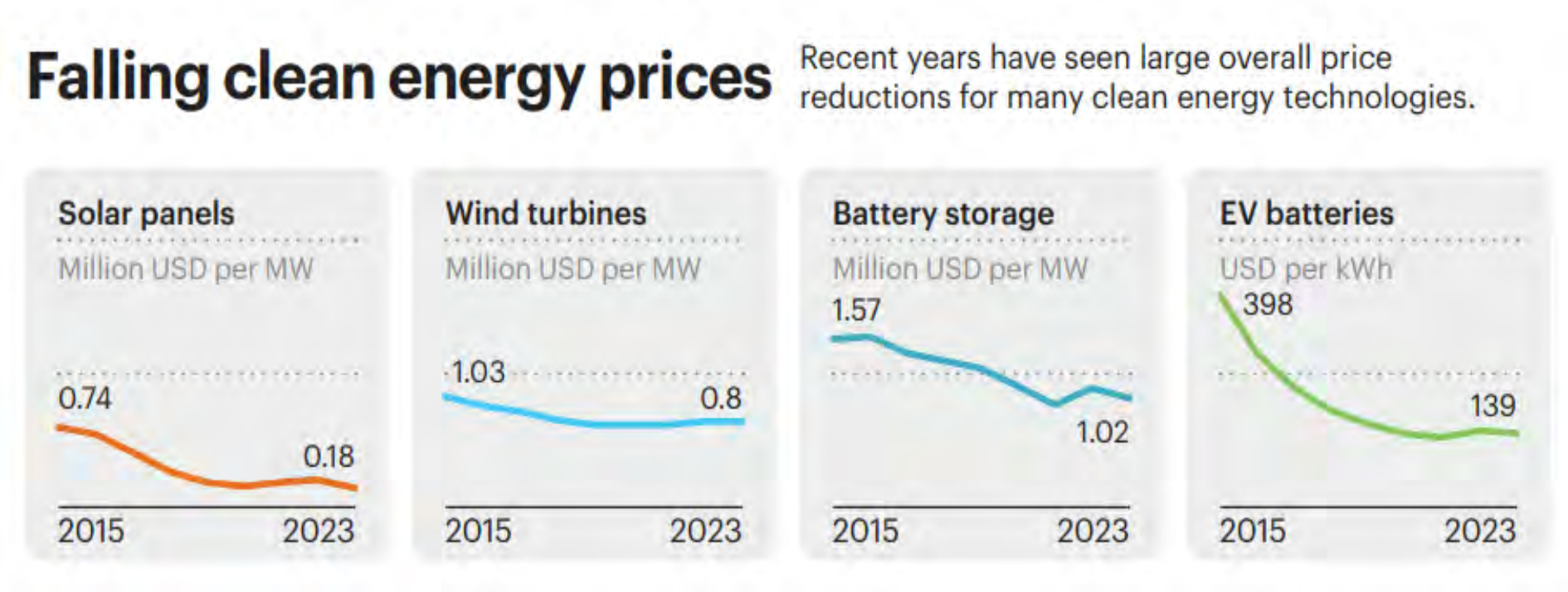
91.6 ('23.12.21)

< Share of Electricity in Final Energy Consumption (%) >



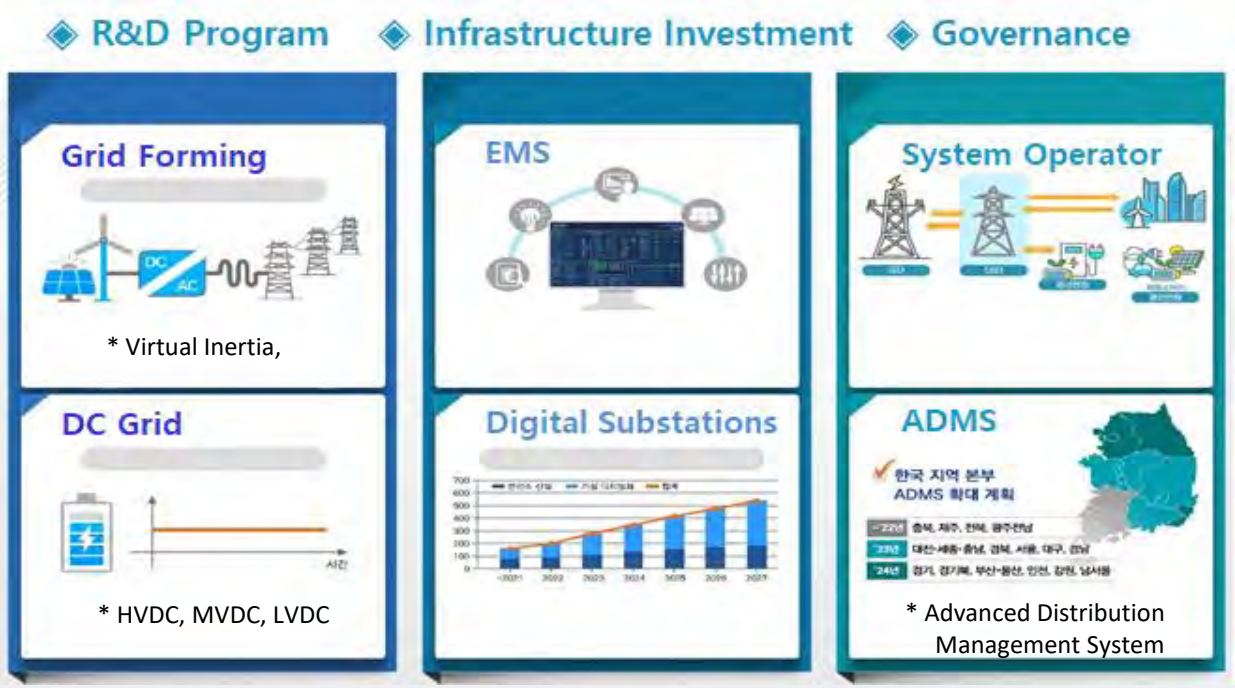
Outlook for Clean Energy Prices, 2015 - 2023

Clean energy prices are gradually declining due to increased production driven by technological advancements and rising demand, along with economies of scale and the learning curve effect. With policy support and enhanced economic viability, significant growth is anticipated in the installation and deployment of renewable energy sources, battery-based energy storage systems, and electric vehicles.



Direction of National Plan for Smart Grid

The primary purpose and direction are to create a stable power supply environment through market flexibility, strengthen power system management capabilities to respond to real-time variability, and establish an industrial foundation to support the expansion of intelligent power grids.



- **R&D Programs**: Grid forming inverters, Grid Inertia, DC grid (HVDC/MVDC/LVDC)
- **Infrastructure Investment**: National grid EMS, Digital Substations (154kV)
- **Governance of Grid Operator & Market**: ISO/DSO, ADMS(Advanced Distribution Management System)

- To achieve a successful transition of the energy mix in the smart grid sector, it is necessary to improve governance for operating the power market and grid, establish digital infrastructure for Distributed Energy Resources

Vision and Strategies for Smart Grid

The 3rd Basic Plan for Smart Grid is aiming to expand Distributed Energy Resources(DER) through **Smart & Flexible Power Systems**

■ Objectives (2023~2027)

- DER generation share ('22) 13.2% → ('27) 18.6%
- Demand Response(DR) participants ('22) 11,000 → ('27) 20,000 households
- Plus DR size ('22) 175MW → ('27) 1,000MW

Vision :

a Smart and Flexible Power System

Strategies

- Enhancing flexibility on the power supply side
- Establishing a smart power consumption system
- Advancing digitalization of power grid system
- Facilitating deployment of Microgrids
- Building a high value-added supply chain

Review of The 1st and 2nd Basic Plans for Smart Grid

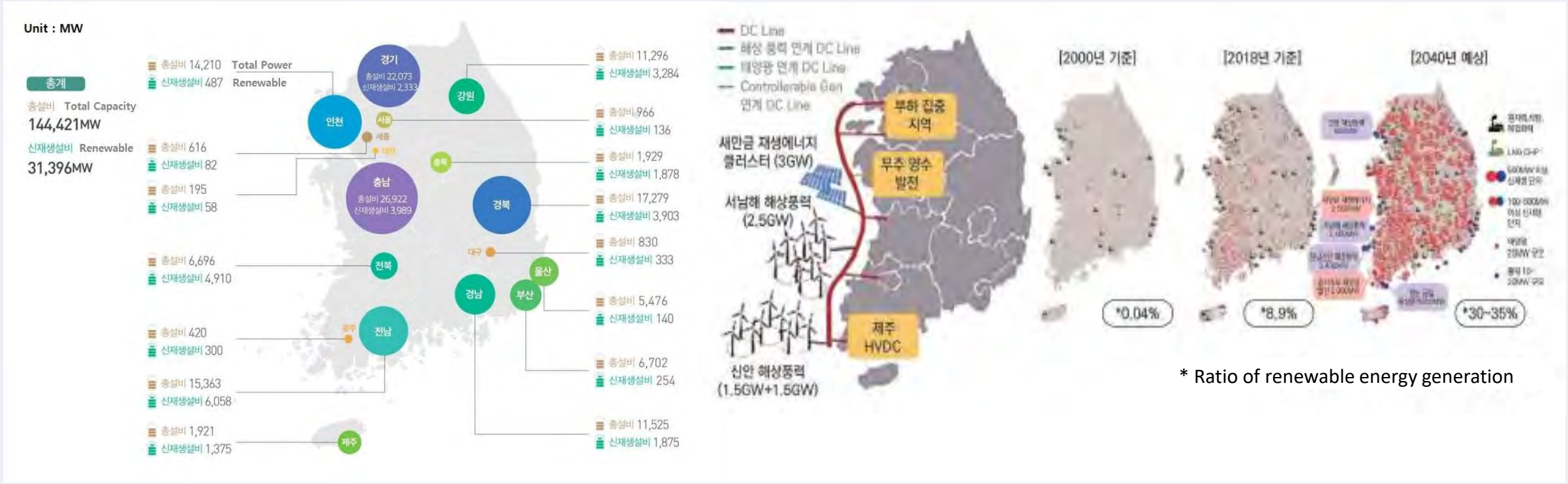
Based on the importance and necessity of smart grids, legislation was enacted in 2011, and the 1st Basic Plan for Smart Grids was established to enable systematic implementation. The 2nd Basic Plan subsequently focused on expanding infrastructure, such as AMI and digital substations, and promoted policy initiatives and demonstrations to facilitate consumer participation in various pricing plans and services.

The 1st Basic Plan for Smart Grid (2012-2016)	The 2nd Basic Plan for Smart Grid (2018-2022)
▪ Initiation of AMI and ESS Installation, alongside the development of Smart Grid technologies ▪ Promotion of large-scale Smart Grid demonstration projects such as K-MEG in Jeju ▪ Microgrid demonstration projects in island areas (high electricity price) and University Campuses (large-scale consumers)	▪ Introduction of various new electricity services to expand consumer participation * Power Brokerage Market, Demand Response (DR), and Time-of-Use Pricing for residential housing in Jeju ▪ Establishing a service pilot complex in urban apartment buildings to demonstrate new technologies & services * Power Purchase Agreements, renewable energy sharing services ▪ Expanding AMI infrastructure for consumers and building ICT Infrastructure for the power grid

Power Supply and Grid Issues by Regional Zone

Due to the concentration of power demand in the metropolitan area versus the concentration of generation capacity in other regions, long-distance transmission line construction is required.

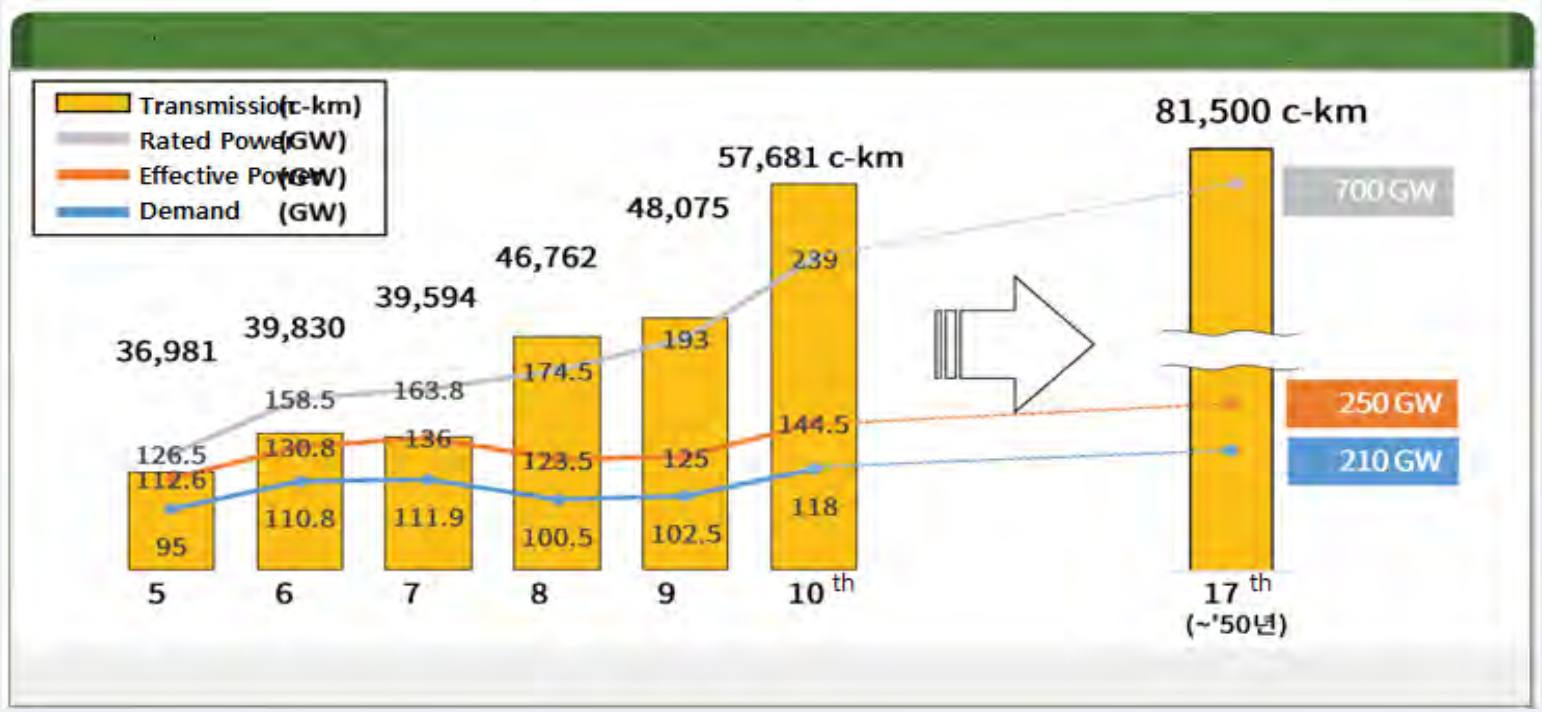
- (South & West Coast) Address grid connection delays and excess power supply from renewable energy generation
- (Seoul Metropolitan) Power supply imbalance due to semiconductor clusters and new data centers



* Ratio of renewable energy generation

T&D Investment Plan

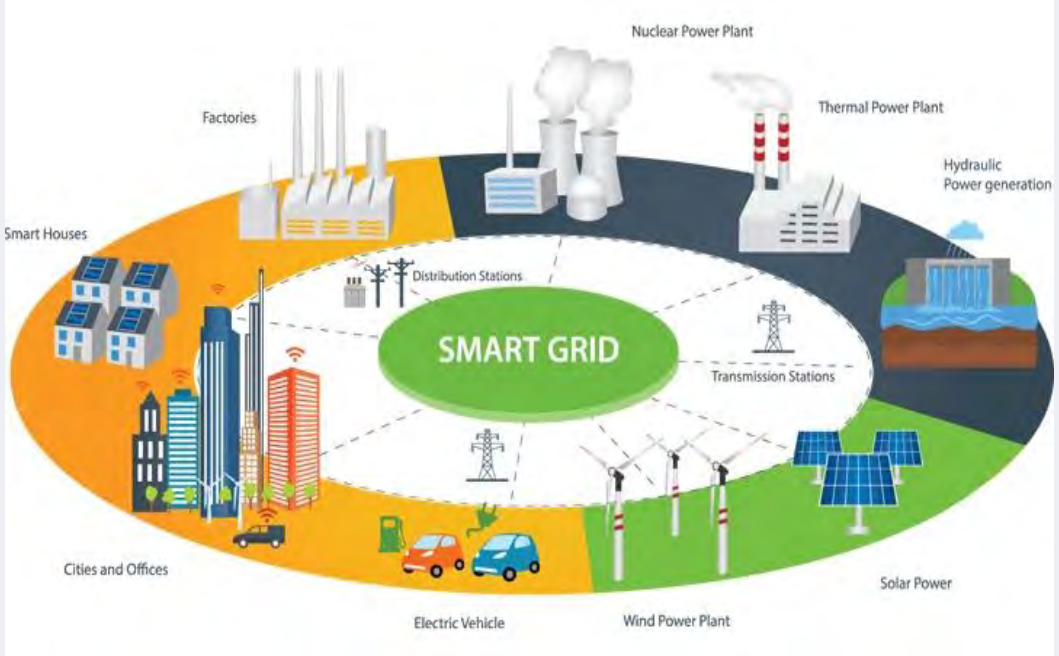
Investment plans for transmission & distribution networks are being established based on long-term forecasts of power supply and demand. The growth in power generation and consumption, along with geographical imbalances, necessitate large-scale expansions of the power grid. It is crucial to enhance resilience through improved forecasting, preparedness, and recovery capabilities.



➢ A Simulation Case estimating the required Transmission Line
according to the "10th Basic Plan for electricity supply & demand"

Technology Development Roadmap

DER is typically generated on a small scale and connected to distribution networks near demand centers. This enables localized energy production and consumption, helping to balance variations in generation and demand at the regional level. A technology development roadmap has been created to address these challenges and offer potential solutions



2030 Carbon Neutrality Target in the Energy Sector

- Nuclear Power Generation
- Renewable Energy Generation
- Zero-Emission Vehicle Registrations

('21) **27.4%** → ('30) **32.4%**

('21) **7.5%** → ('30) **21.6%+α***

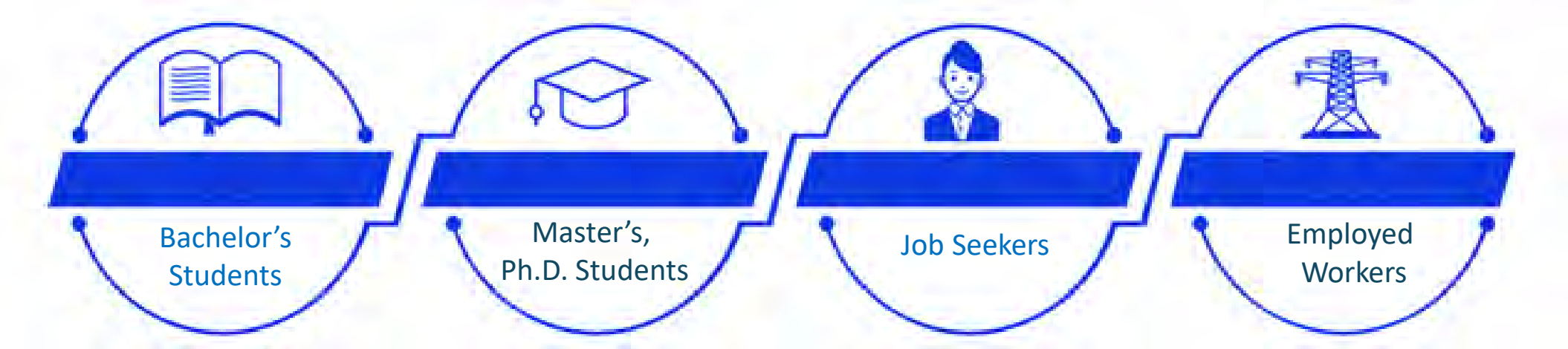
('22) **1.7%** → ('30) **16.7%**

430,000 units → 4,500,000 units

➢ Strategy for Carbon Neutrality and Green Growth and the 1st National Basic Plan in 2023

Workforce Development Roadmap

A plan has been established for long-term workforce development in the smart grid sector, including the expansion of job training to enhance expertise, and the introduction of new educational programs focused on future promising industries such as energy big data, V2G, power brokerage, and VPP.



Bachelor's Students	Master's, Ph.D. Students	Job Seekers	Employed Workers
Interdisciplinary Majors Including Electrical Engineering, Computer Engineering (AI, Big Data), and Communications	Investment in Equipment for Research on New Technologies and R&D Projects	Educational programs linked with industry sites to develop practical skills and facilitate employment opportunities	Train digital talent in areas such as AI and big data, and provide maintenance training for registered technical personnel

◈ **KETEP support programs :** education and training support of R&D personnel

To help transform the energy industry into a new growth engine, expand the workforce related to energy technology, and foster R&D specialists

International Cooperation Programs and Joint Research

To address rapidly changing international energy issues, there is an initiative to strengthen international cooperation networks. This includes expanding multilateral cooperation through various programs such as Official Development Assistance (ODA), ISGAN and joint research projects.

* International Smart Grid Action Network

International Energy Agency (IEA)

ISGAN is Technology Collaboration Program (TCP) of the IEA. We work closely with the IEA and other TCPs on Power System related research. Our Partnership includes the collaboration on Power System related research within the IEA, interaction with the End Use Working Party (EUWP) and other Technology Collaboration Programs.

Clean Energy Ministerial (CEM)

As one of CEM's initiatives, ISGAN delivers policy support and briefs at various CEM events and meetings. Further collaboration includes coordination within other CEM initiatives and external communication.

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

ISGAN and Mission Innovation MI IC#1 Smart Grids

IC#1 aims to accelerate development and demonstration of smart grids technologies in a variety of grid applications, including demonstrating the robust, efficient and reliable operation of regional and distribution grids as well as microgrids in diverse geographic conditions, in order to facilitate the cost-effective uptake of renewable energy. Within MI future innovations are developed. (detailed information about Mission Innovation you will find under http://www.mission-innovation.net/)

ISGAN acts at a later phase of the development chain and focuses on policy support and deployment of research results and best practices

- Korea participates in 29 out of the 38 Technology Collaboration Programs (TCPs) under the IEA Committee on Energy Research and Technology (CERT), with KETEP supporting 14 of these TCPs
- As a member country in Mission Innovation (MI), KETEP funds international collaborative research projects based on MI and engages in various activities, including workshops, research, and visits to demonstration plants

◈ **KETEP support programs :** global technology exchange and cooperation projects

Explore joint research topics through Government-to-Government (G2G) joint planning meetings and energy technology Joint workshops

New Technologies for Distributed Energy Resource

As the share of DER such as PV, wind power, ESS, EV, and CHP increases, the development and demonstration of new technologies like sector coupling, VPP, and V2G systems to match demand and supply while considering the fluctuations in electricity demand and production.

- **Sector coupling** :

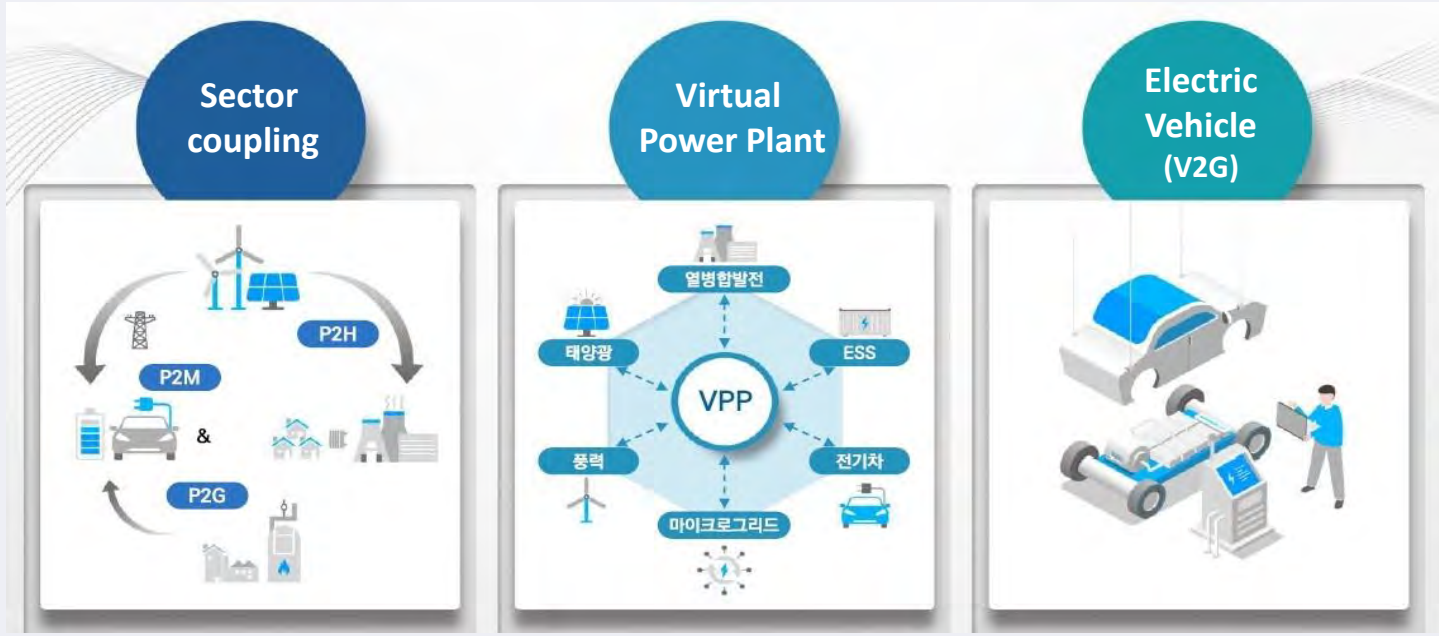
  MW scale R&D demonstration

- **Virtual Power Plant** :

  New Business Model demonstration

- **EV charging system** :

  Introducing new standards & grid code



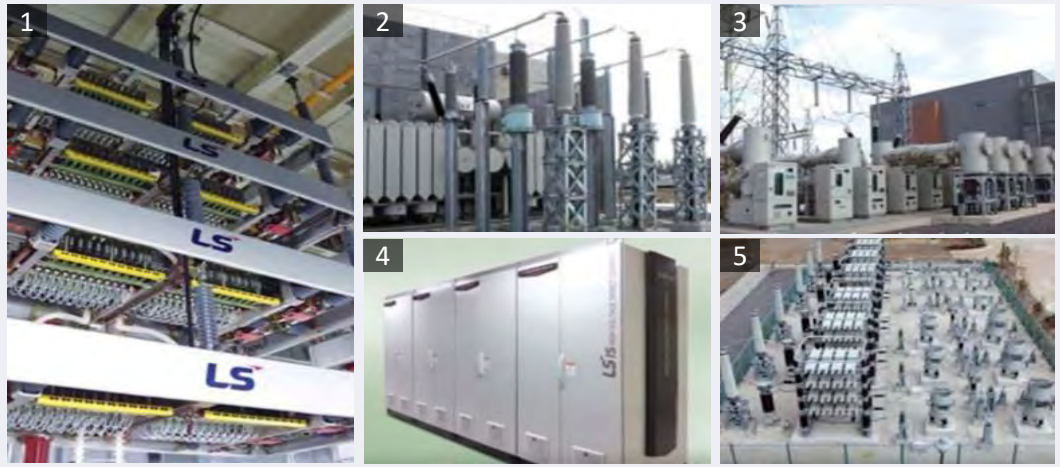
- P2M: Power to Mobility
- P2H: Power to Heat
- P2G: Power to Gas

- Renewables
- Microgrids
- ESS: Energy Storage System
- CHP: Combined Heat & Power

- V2G: Vehicle to Grid

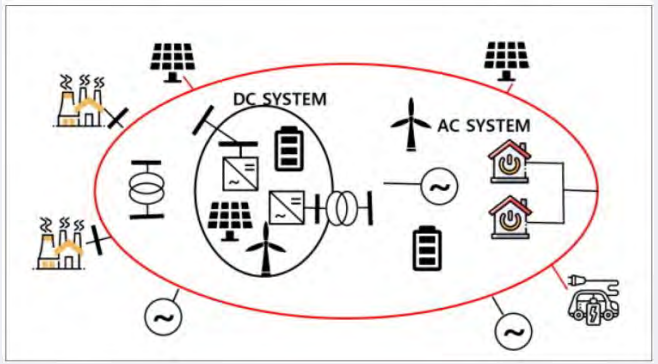
DC Grid : High Voltage DC, Medium Voltage DC, Low Voltage DC

By configuring a hybrid power grid that combines alternating current (AC) and direct current (DC), it is possible to enhance the stability of the power grid under high variability and uncertainty. This approach enables effective control of power flow, minimizes power losses, and improves overall efficiency.



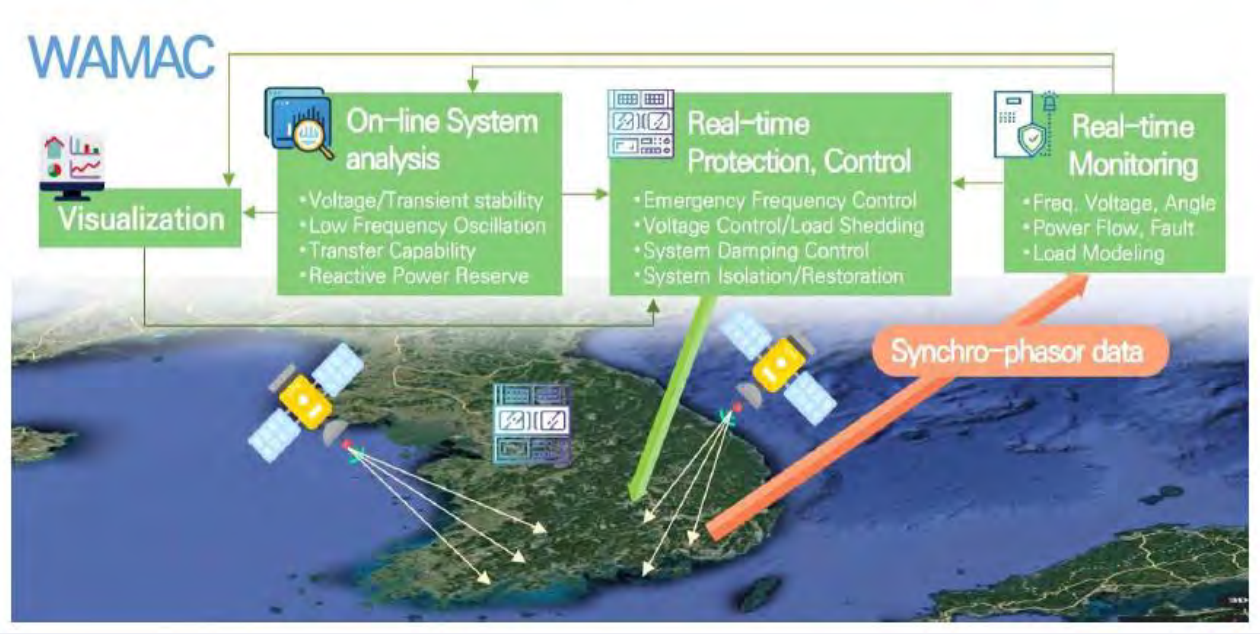
1. HVDC Valve 2. Converter Transformer 3. Gas Insulated Switchgear
3. HVDC Control & Protection System 5. Harmonic Filter

- LVDC Grid for Island 'Seogeochado'



WAMAC based on Communication, IoT, Big Data, and AI

In the context of monitoring and controlling highly volatile power grids, a PMU-based Wide-Area Monitoring and Control System is essential for monitoring the status of the power grid over a wide area and enabling rapid decision-making. Utilization of AI and Digital Twin technology in power grid operations and emergency situations



➢ Concept Diagram of the PMU(Phasor Measurement Unit))-Based Wide-Area Monitoring and Control System (WAMAC)

- ➢ Preparation for rapid power restoration in disaster and emergency situations
- ➢ Analyzing cybersecurity threats to smart grids and developing solutions

Smart Grid Demonstration Projects in Jeju

Jeju Island has favorable natural conditions for solar and wind power generation; however, it has a limited connection capacity in power grid. Due to the imbalance between electricity demand and supply, the island is actively conducting demonstration projects to introduce new technologies necessary for stable power grid operations and achieving carbon neutrality.

Site Name (PV, wind)	Capacity (MW)	Sector coupling
Dongbok· Bukchon wind farm	30	P2H Station(2MW)
Gasiri wind farm	15	P2G Station(3MW)
Haengwon wind farm	9.38	
Gyorae PV	496kW	EV Charging Station
Sports Complex PV	496kW	
Susan PV	999kW	BESS (8MWh)
Total	**56.371**	

- 10 MW Renewable energy-linked Green Hydrogen Demonstration (2022–2026)
- Power-to-Heat conversion and storage technology for electric boilers linked to District Energy (2022–2026)

Microgrid for Industrial Complexes, Data Centers & Communities

Technological development and demonstrations are underway to establish optimal balancing of energy production and consumption, as well as self-sufficiency systems within microgrids targeting industrial complexes, data centers, communities, and military bases.

< Plan to Construct Smart and Green Industrial Complexes >

ESS Capacity	Industrial Complex
1.0 MWh	Cheongju
0.5 MWh	Gunsan
0.23 MWh	Gwangju
1.6 MWh	Yeosu

ESS Capacity	Industrial Complex
1.8 MWh	Gumi
1.04 MWh	Seongseo
1.0 MWh	Noksan
3.0 MWh	Changwon

- The goal is to activate microgrid business models tailored to various scales and the specific characteristics of different demand sources
- The expansion of microgrids is expected to reduce peak power demand, optimize new power grid investments, and enhance grid stability

Smart Grid Projects in Korea and Abroad

Large-scale smart grid projects in the range of tens of MW (MWh) based on PV, wind power, and energy storage systems (ESS) have been initiated by Korean companies both domestically and internationally.

Yeongam in Korea (PV 93MW, ESS 242MWh)

➢ LS Electric

San Diego, California in US (PV 50MW, ESS 200MWh)

➢ Hanwha Qcells

Chitose, Hokkaido in Japan (PV 39MW, ESS 14MWh)

➢ LS Electric

Downing Nursling in England (ESS 50MW, 53MWh)

➢ Hyosung Heavy Industries

Leading Companies in the Smart Grid Sector (1)

Korean companies are demonstrating strong performance in various projects related to renewable energy, ESS, power grids, EV charging station, and EMS both domestically and internationally.

Korea Electric Power Corporation(KEPCO)

a pivotal role in the nation's smart grid initiatives. The company has been actively developing smart grid technologies

LS Electric

a provider of power solutions and automation technologies. The company has been expanding its smart grid offerings, including energy management systems (EMS), smart meters, and grid automation solutions.

Hyosung Heavy Industries

specialized in industrial solutions, including smart grid technologies. The company provides transformers, switchgear, and energy management solutions

LG Energy Solution

a key player in the global energy storage and battery industry, contributing significantly to the smart grid sector including EVs, ESS, and grid-supporting solutions.

Leading Companies in the Smart Grid Sector (2)

Korean companies are demonstrating strong performance in various projects related to renewable energy, ESS, power grids, EV charging station, and EMS both domestically and internationally.

Samsung SDI

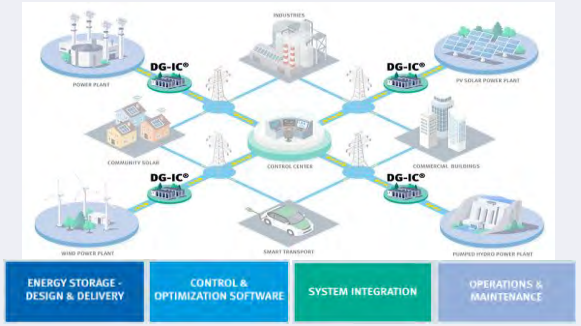
contributing to the smart grid ecosystem by offering ESS that are essential for renewable energy integration

Daeyoung Chaevi

EV charging infrastructure solutions, which are a critical component of the smart grid ecosystem

Doosan GridTech

focusing on technology solutions for the emerging digital distributed electric grid.



Encored Technologies

focuses on energy management solutions, particularly in microgrids, using AI and IoT to optimize energy systems and support regional energy self-sufficiency through renewable energy integration.

Lessons Learned …

The transition of the energy mix to achieve carbon neutrality is a highly challenging task. Due to differences in the existing infrastructure and available resources across countries, it is difficult to simply benchmark other cases.

- Power mix and grid investment plans should be established by forecasting seasonal and time-based demand fluctuations and considering the distribution of available resources by region
- Among policy instruments, the use of subsidies or incentives to expand the adoption of renewable energy, ESS, and electric vehicles has a short validity period. A phased reduction plan for subsidies or incentives should be presented to prepare in advance and provide guidelines
- Given the increased complexity of the power grid compared to existing systems, it is crucial to secure smart grid specialists who have a high understanding of the national infrastructure
- It is necessary to establish standards and criteria to ensure the reliability and safety of newly introduced technologies and infrastructure, and investment in digital monitoring systems is also essential to prepare for natural disasters and emergency situations
- It would be beneficial to reduce trial & error and build internal capabilities by collaborating and exchanging knowledge with research institutions or companies with advanced experience

THANK YOU

Link to Agenda and Materials