

Smart Grid in Korea: Overview and Policy

Seung-II Moon
Distinguished Professor, KENTECH

Biography of Seung-Ill Moon

> Education

- 1981~1985 : Seoul National University, School of EECE (B.S.)
- 1986~1993 : The Ohio State University EE (Ph.D.)

> Work Experiences & Academic Activities

- 2022~ : Distinguished Professor, KENTECH
- 1997~2021 : Professor, School of EECE, SNU
- 1993~1997 : Assistant Professor, Department of EE, JBNU
- 2019~2021 : Director, SEPRI(SNU Electric Power Research Institute)
- 2015~2016 : President, Korea Electrical Engineering & Science Research Institute
- 2014~2016 : Member, National Energy Committee of Korea
- 2015~2018: Member, The National Academy of Engineering of Korea
- 2018~ : Fellow, The National Academy of Engineering of Korea
- 2009~2013: Member, Green Growth Committee of Korea(GGCK)
- 2013~2015 Division Chairman, Industrial Technology Division, GGCK
- 2018~2021: Division Chairman, Energy Conversion Division, GGCK
- 2010~2014: Member, Electric Power Policy Committee of Korea
- 2014~2016: Chairman, Electric Power Policy Committee of Korea



1

Power System in Korea

Structure of Korean Power Industry

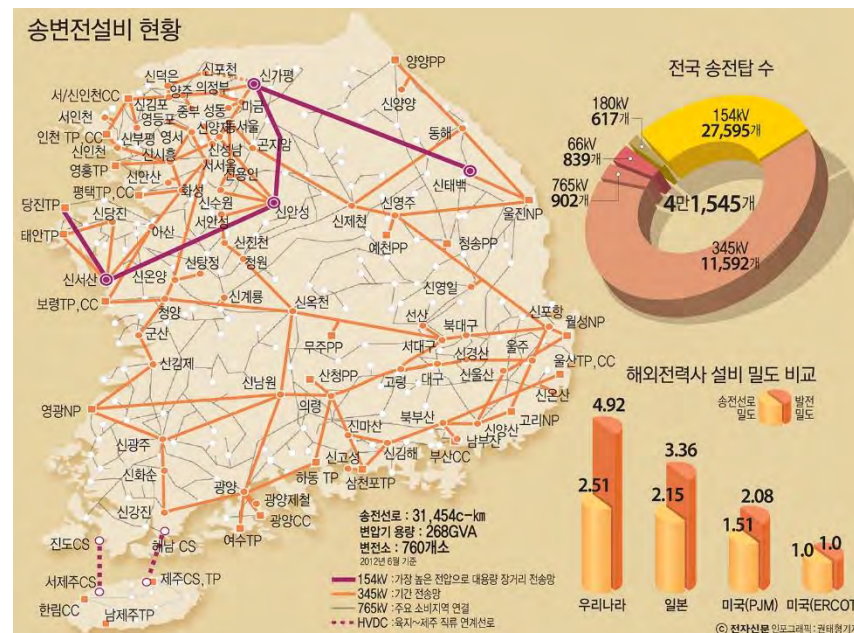
➤ History of KEPCO

- In 1887, Asia's First Electric Lights Up
 - at Geoncheon Palace in Korea
- In 1898, Hansung Electric Co. Founded
- In 1915, Gyeongseong Electric Co. Founded
 - In 1904, Korea-America Electric Co. Founded
 - In 1909, Ilhanwasa(日韓瓦斯) Co. take over Korea-America Electric
 - In 1915, Ilhawasw Co. changes its name to Gyeongseong Elec. Co.
- In 1927, Namseon Electric Co. Founded
- In 1943, Joseon Electric Co. Founded
- In 1961, Korea Electric Power Co. was established
 - through the merger of the three companies
 - Gyeongseong Electric, Namseon Electric, Joseon Electric
- In 1981, KEPCO was converted into a public enterprise
- In 2001, the KPX was founded
 - separating power generation from KEPCO



Power System of Korea

- **The beginning of Electricity**
 - In 1887, The first lights were lit at Geoncheonggung
- **The establishment of KEPCO**
 - In 1961, Korea Electric Power Corporation(KEPCO) was established
- **Nowadays**
 - Power grid facility growth slows down (at saturation)
 - Demands for the accommodation of renewable energy

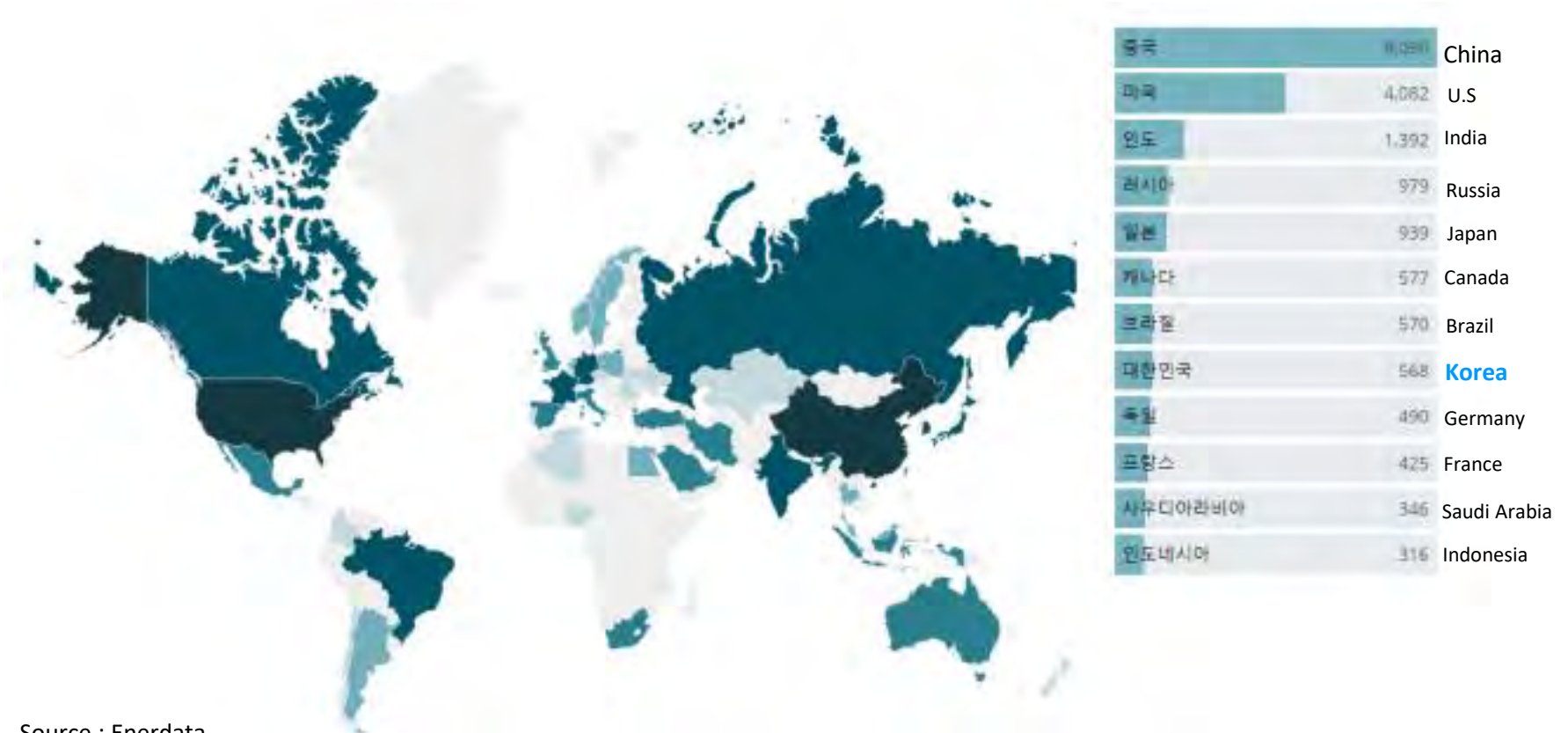


[Statistics and Map of Korea Electric Power grid]

Overview of Power Systems in Korea

- **Korea's electricity consumption**
 - Korea is the world's 8th largest electricity consumer (as of year 2022)

< Worldwide electricity consumption ranking (unit: TWh) >



Source : Enerdata

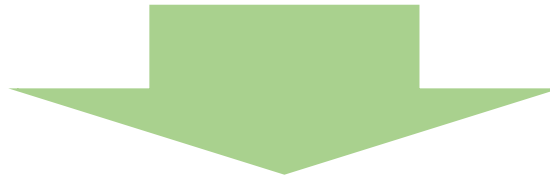
Overview of Power Systems in Korea

➤ Energy mix forecast

• Quick glance at Korea's energy mix and its forecast for 2030

< Status of power generation by source in Korea, as of 2022 >

구분	Coal	Nuclear	LNG	Renewables	District E	Others	Total
Generation (GWh)	186,748	176,054	125,062	47,266	49,159	10,112	594,401
Proportion(%)	31.4%	29.6%	21.0%	8.0%	8.3%	1.7%	100.0%



Category	Nuclear	Coal	LNG	Renewables	H2/NH3	Others	Total
2030년	204.2 (31.8%)	111.9 (17.4%)	160.8 (25.1%)	138.4 (21.6%)	15.5 (2.4%)	10.6 (1.7%)	641.4 (100%)
2038년	249.7 (35.6%)	72.0 (10.3%)	78.1 (11.1%)	230.8 (32.9%)	38.5 (5.5%)	32.5 (4.6%)	701.7 (100%)

Source : 11th Basic Plan for Electricity Supply and Demand

Expect to respond to carbon neutrality through harmonious **expansion of renewable energy and nuclear energy**

Overview of Power Systems in Korea

➤ Power imbalance of Korea

- Discrepancies between power plant locations and areas with high electricity demand (approx. 40% in urban cities, such as Seoul)
 - Strongly requires additional large-scale transmission facilities



<Coal Power Plants>

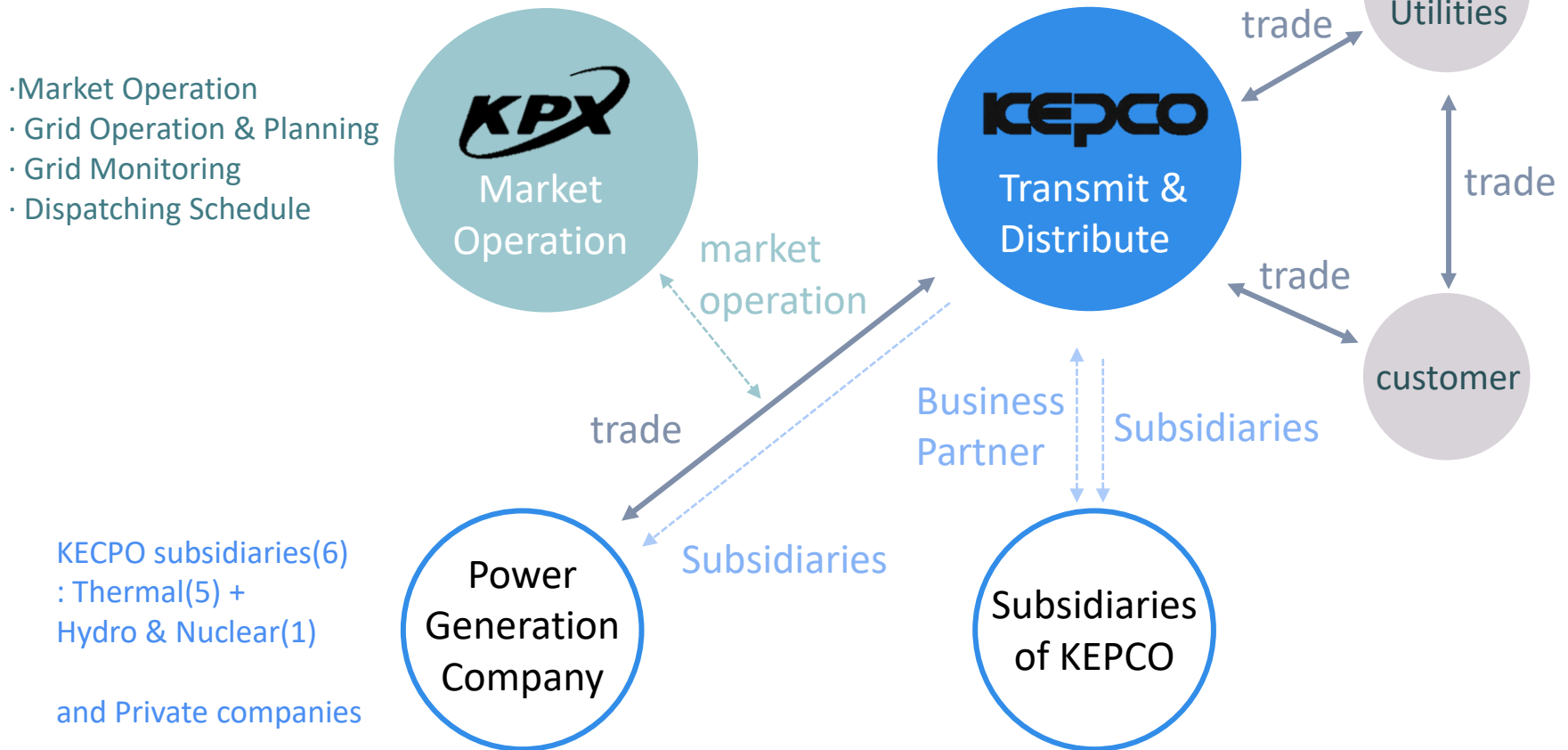


<Nuclear Power Plants>

- More than 60% of total power generation is produced from coal and nuclear power plants.
- Most of the power plants are located along the coast.

Structure of Korean Power Industry

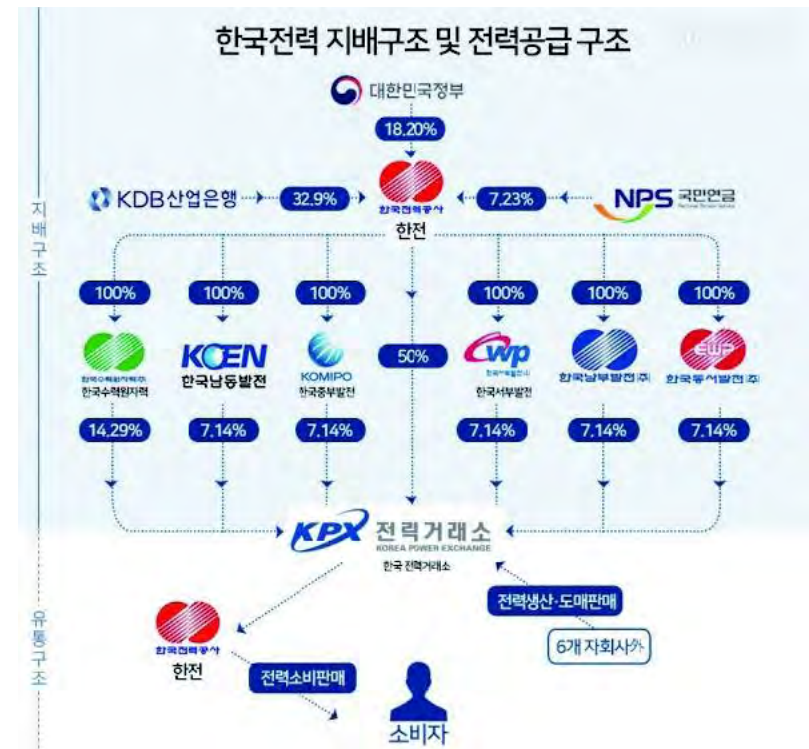
➤ Structure of Korean Power Industry



Structure of Korean Power Industry

➤ Role of KEPCO

- KEPCO, Korea Electric Power Corporation (founded in 1961)
- A monopoly responsible for Korea's electricity supply
- Transmission + Distribution + Public sales
- Doesn't generate electricity
- 6 Power Generation Subsidiaries
 - Korea South-East Power Co.
 - Korea Midland Power Co.
 - Korea Western Power Co.
 - Korea Southern Power Co.
 - Korea East-West Power Co.
 - Korea Hydro & Nuclear Power Co.

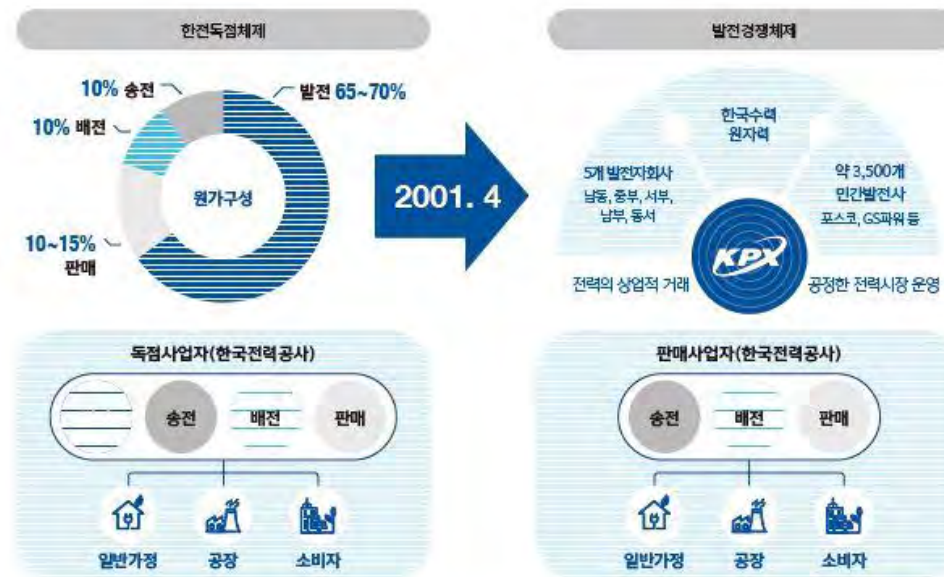


[KEPCO's Corporate Governance]

Structure of Korean Power Industry

➤ Role of KPX

- KPX, Korea Power Exchange (founded in 2001)
- Operation of the power market of Korea
- Operation of a power system
- Real-time power supply operation
- The Basic Plan of Long-Term Electricity Supply and Demand
- Founded to reorganize the generation sector



전력원가의 65~70%를 점유하는 발전부문에 경쟁을 도입하여 전력산업의 효율성 향상 도모

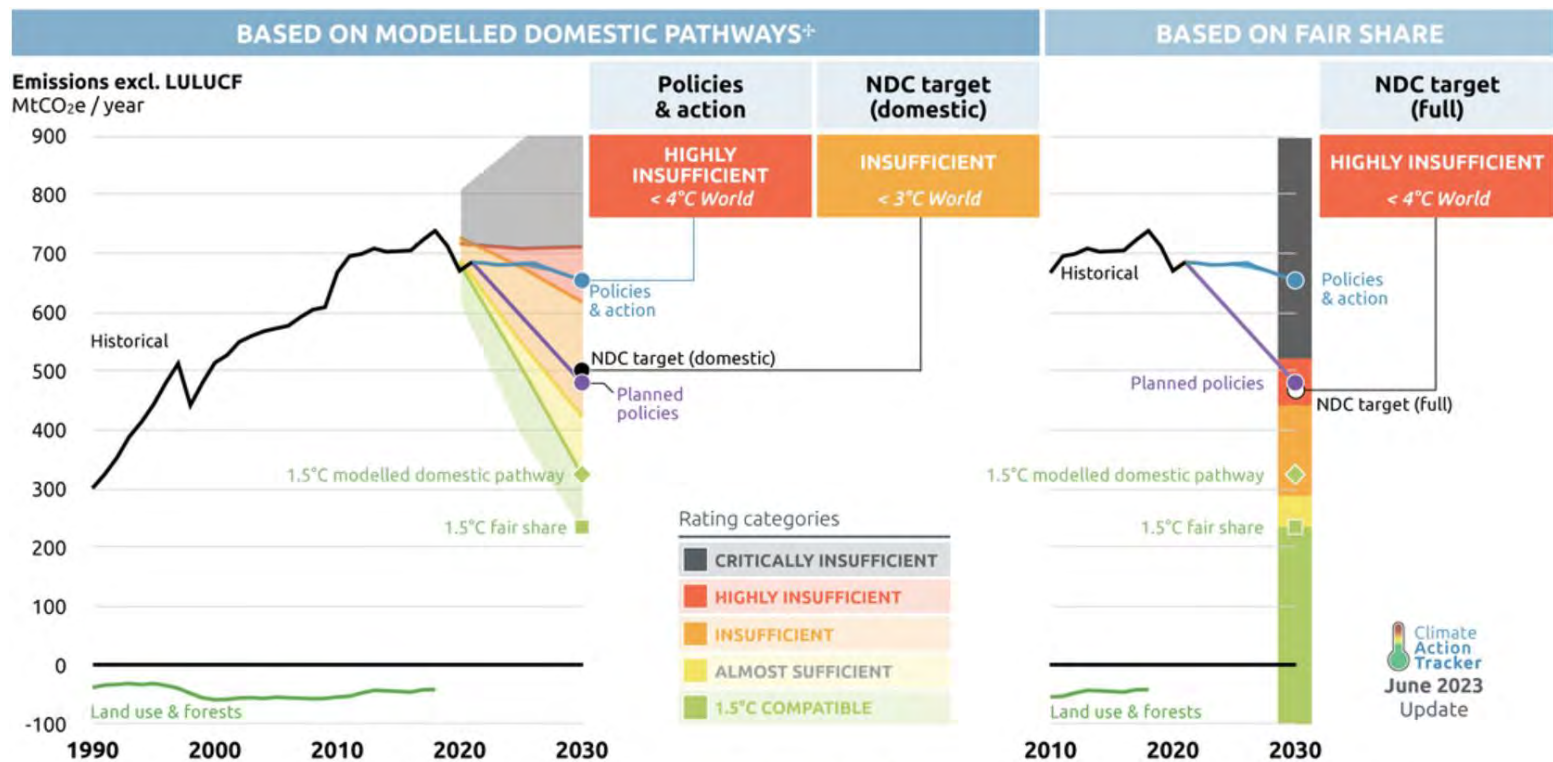
[Reorganization after the foundation of KPX]

2

Smart Grid Policy in Korea

Carbon Neutral 2050 in Korea

- 2050 Carbon Neutral Strategy of the Republic of Korea is announced
- 2030 NDC* have been set to reduce GHG** emissions by 40%



⁺ Modelled domestic pathways reflects a global economic efficiency perspective with pathways for different temperature ranges derived from global least-cost models

Climate Action Tracker Summary of Korea

Smart Grid Promotion Act in Korea

- **Smart Grid Construction and Utilization Promotion Act**
 - First enacted in 2011, revised in 2013, 2014, 2016 and 2017
- **Purpose of Promotion Act(article 1)**
 - The purpose of this Act is to create smart grids and facilitate the use thereof to develop related industries, cope proactively with global climate changes, lay foundations for future industries oriented to low carbon and green growth, and ultimately contribute to the innovation of the environment for the use of energy and the growth of the national economy
- **Definition of Promotion Act(article 2)**
 - "Smart power grid" refers to a power grid that maximizes energy efficiency by supplying electricity through methods such as applying information and communication technology to the power grid and allowing suppliers and users of electricity to exchange information in real time

Definition of Smart Grid in Korea

➤ Definition of Smart grid

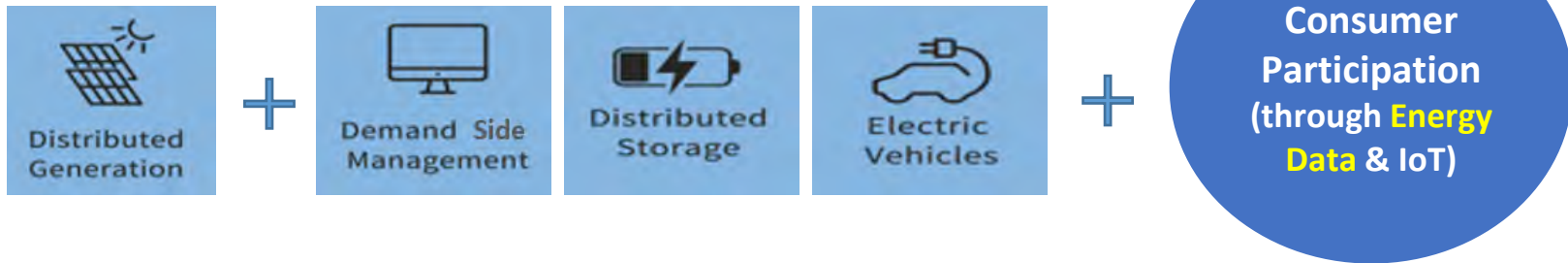
- A power grid that optimizes power demand and supply through two-way operation such as real-time data collection, communication, and control using ICT technology



Smart Grid Policies in Korea

> Overview of smart Grid-related Services Drivers in Korea

Next DER Wave: Energy Storage, EVs, IoT & Energy Data



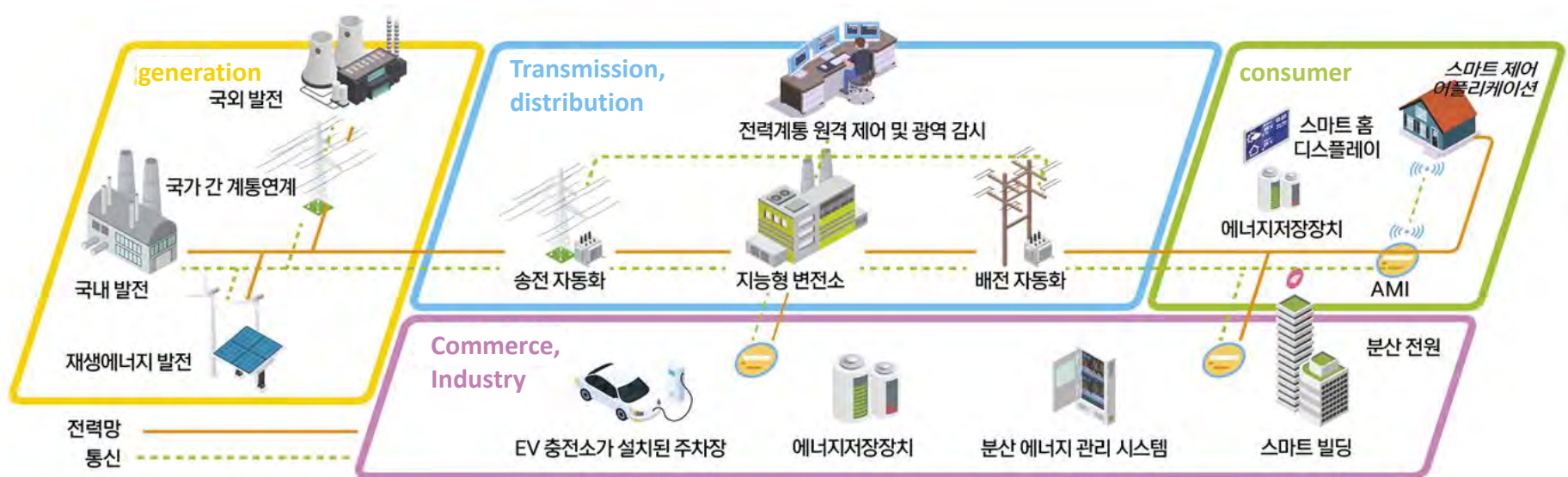
Smart Grid Technology and Policy Trends

Energy Access	Energy Transition	Sustainability	Technology evolution	Digitalization
<ul style="list-style-type: none"> The goal of 100% access to electricity Consumption growth in the transport sector Globalization of the electricity market by grid connection 	<ul style="list-style-type: none"> Expansion of clean energy supply Changes in power patterns according to EV increase Government regulations and licensing schemes 	<ul style="list-style-type: none"> Carbon reduction or carbon neutrality Circular economy and waste minimization Diversification of energy resources 	<ul style="list-style-type: none"> Battery, V2G solution Renewables, Solar & Wind Hydrogen fuel, regional shifts in supply and demand 	<ul style="list-style-type: none"> Battery, V2G solution Affordable Renewables, Solar & Wind Hydrogen fuel, regional shifts in supply and demand

Structure of Smart Grid in Korea

➤ Structure of Smart Grid

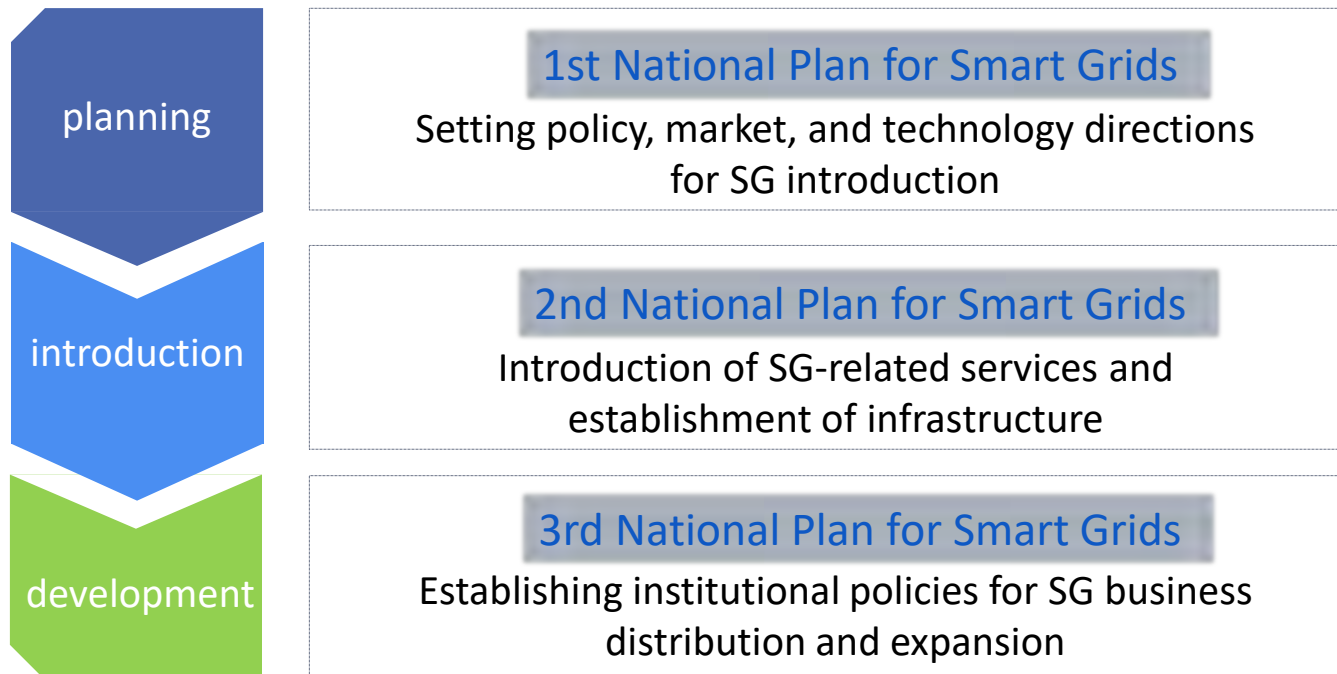
- Power generation, transmission, distribution, and consumers, which were previously connected only through the power grid, are operated organically by interacting through two-way communication



The 3rd National Plan for Smart Grids

➤ National Plan for Smart Grids

- Based on “Smart Grid Construction and Utilization Promotion Act”
- Establishment and implementation of plans unite 5 years
- 1st National Plan for Smart Grids(12~16) establishment · announcement
- 2nd National Plan for Smart Grids(18~22) establishment · announcement
- 3rd National Plan for Smart Grids (23~) establishment · announcement



The 3rd National Plan for Smart Grids

➤ Vision

- Building a smart and flexible power system to activate distributed energy

➤ Goals

- Achieving 18.6% share of distributed power generation in '27

➤ Basic directions

- Power grid intelligence for maximizing energy efficiency
- Market system flexibility to increase capacity of distributed energy
- Strengthening the industrial base to activate the smart power grid

The 3rd National Plan for Smart Grid

➤ Propulsion Strategy

- **Continuous expansion of distributed energy supply**
 - Securing flexibility in power supply
 - Advancing the power exchange market
 - Supporting core technologies for distributed energy
- **Advancement of power grid operation system**
 - Smart power grid based on ICT
 - Establishment of wide-area power grid management system
 - Establishment of distributed energy operation system
- **Establishment of smart power consumption system**
 - Expanding the operation of the demand resource market
 - Establishing a smart electricity metering system
 - Expanding seasonal, hourly rate system
- **Expansion of intelligent power grid at the local level**
 - Establishing a distribution network management system
 - Activating microgrids
 - Creating a foundation for the growth of energy prosumers
- **Strengthening competitiveness of intelligent power grid industry**
 - Establishing a power data utilization system
 - Activating certification of smart grid standards
 - Establishing a foundation for activating the smart grid industry

The 3rd National Plan for Smart Grids

➤ Key goals and strategies for the 3rd Plan ('23 ~ '27)



*LV AMI: 11.7M('22) → 22.5M('24)

The Special Act on Activation of Distributed Energy

➤ Background and Purpose



- Limits of large-scale power plants and long-distance transmission networks
- Conflicts of low consumer acceptance and economic costs

- Needs to revitalize the distributed energy system that produces and consumes locally

- Achieving carbon neutrality by converting the energy supply system to a distributed energy system



The Special Act on Activation of Distributed Energy (the 'Distributed Energy Act') enacted on June 13, 2023, and **came into force on 14 June 2024** together with the Enforcement Decree and the Enforcement Rules

< Status of power generation by source in Korea, as of 2022 >

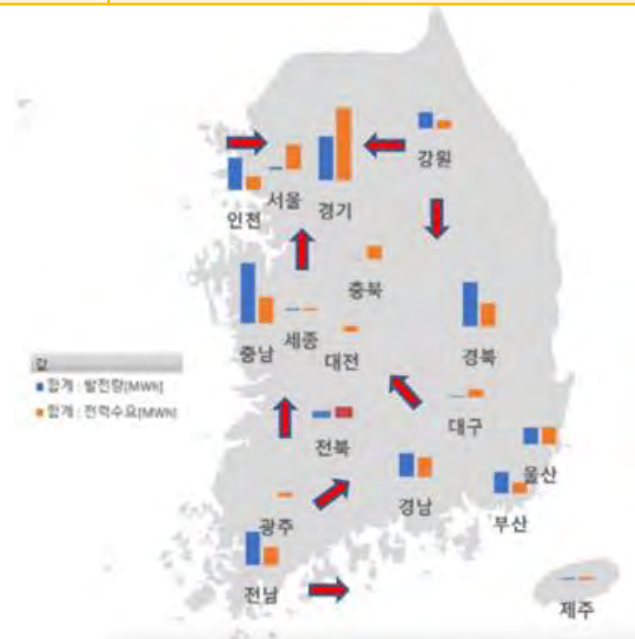
구분	Coal	Nuclear	LNG	Renewables	District E	Others	Total
Generation (GWh)	186,748	176,054	125,062	47,266	49,159	10,112	594,401
Proportion(%)	31.4%	29.6%	21.0%	8.0%	8.3%	1.7%	100.0%

출처 : KEPCO(2023.5)

The Special Act on Activation of Distributed Energy

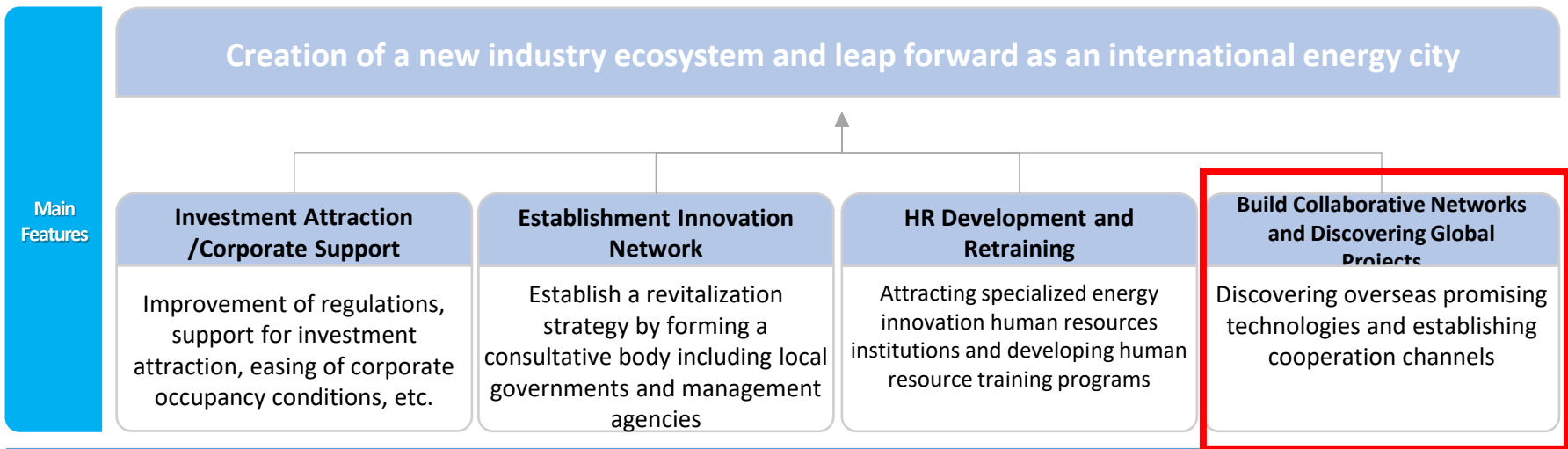
➤ Main contents

Key Highlights	<u>Obligation to install distributed energy</u> → Imposition of obligations to install new housing land and large-scale distributed energy for electricity consumers
	<u>Distribution network management and supervision</u> → Distribution network output monitoring and forecasting
	<u>Conduct Power System Impact Assessment</u> → Evaluation of the ripple effect on the power system when a certain size or more of a power consumer moves in
	<u>Designate a 'Distributed Energy Specialized Area' (regulatory sandbox)</u> → Regulation-free application such as direct power trading
	<u>Distributed Energy Support Project</u> → Promote differential pricing by region and designation of distributed energy support centers



Electricity self-sufficiency rate by local governments ('22)	
Seoul	9%
Gwangju	8%
Daejeon	3%
Busan	217%
Incheon	213%
Jeonnam	171
Jeju	80%

Establishment of an International Energy Cluster (Jeonnam)

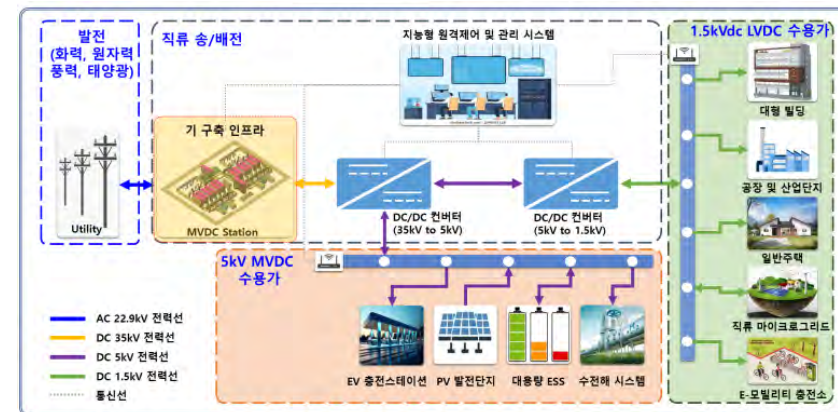
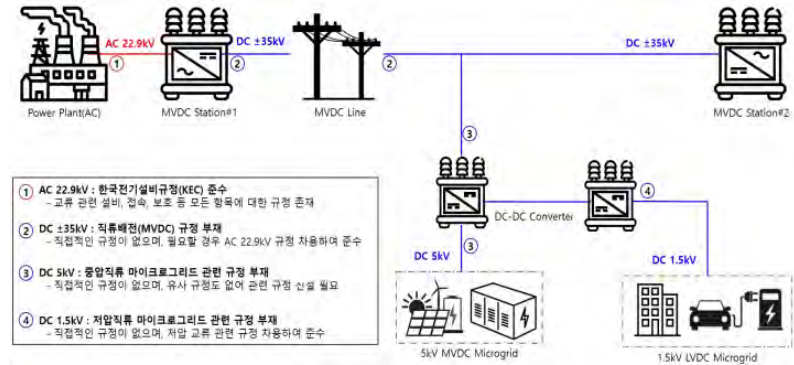


Target		2024	2025	2026	2027
	Number of innovative companies	278	308	348	388
	Number of innovative personnel	190	220	260	300
	Area	8.64km2 /11 Hub Cities	10km2 8.64km2 / 12 Hub Cities	15km2	28.64km2 / 15 Hub Cities



Establishment of an International Energy Cluster (Jeonnam)

Project Name	New Energy Industry Global Innovation Special Zone Project (Commercialization of future DC-based power grid platform)
Project Objectives	Utilizing the existing verified MVDC Station ($\pm 35\text{kV}$ direct current), reconvert it to 5kV MVDC and 1.5kV LVDC as a demonstrate model
Project Period	2024. 01 ~ 2029. 12 (6 years)
Location	Five districts Naju Bitgaram Innovation City, Yeonggwang-gun Daema Industrial Complex, Haenam-gun Solaseado (corporate city), Shinan-gun offshore wind farm, etc.
Total Project Cost	KRW 100.2 billion (national budget 250, local budget 415, private 337), equivalent to EUR 70 million
Key Business Details	Establish a DC power grid platform to demonstrate power equipment and operation technology and establish global technology standards
Main Items	MVDC station, power conversion device, integrated operating system, DC cable, DC breaker, LVDC power conversion device, central base control, V2G, electric vehicle charger, etc.
Project Organizations	A local government-led project with a total of 18 organizations participating, including KEPCO , KPX , local universities and institutes



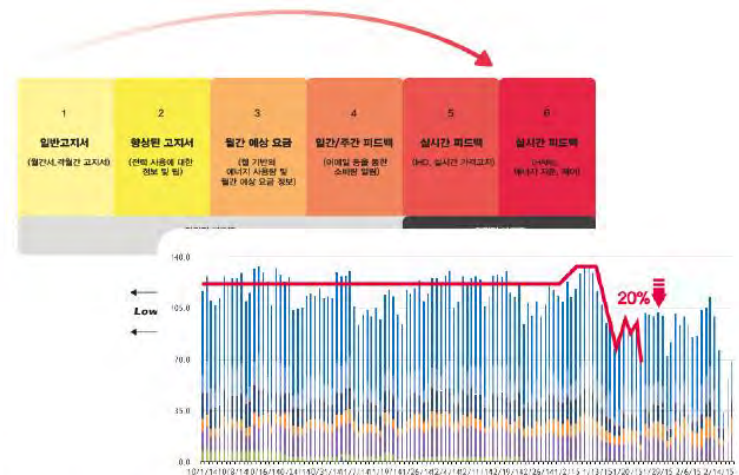
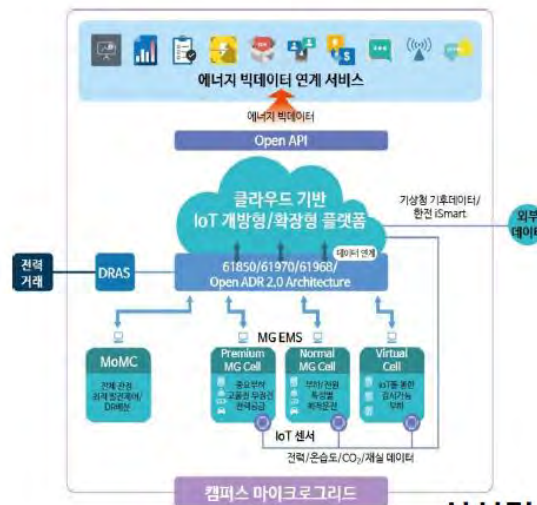
3

Smart Grid Implementation in Korea

Campus Microgrid on Seoul National University

➤ SNU campus microgrid project

- Establishment of Korea's first microgrid on Seoul National University campus('15 July)
- Demonstration of IoT-based campus microgrid



실시간 피드백 제공에 따른 사용자 행동 변화로 인한 수요감소 ↑ 27

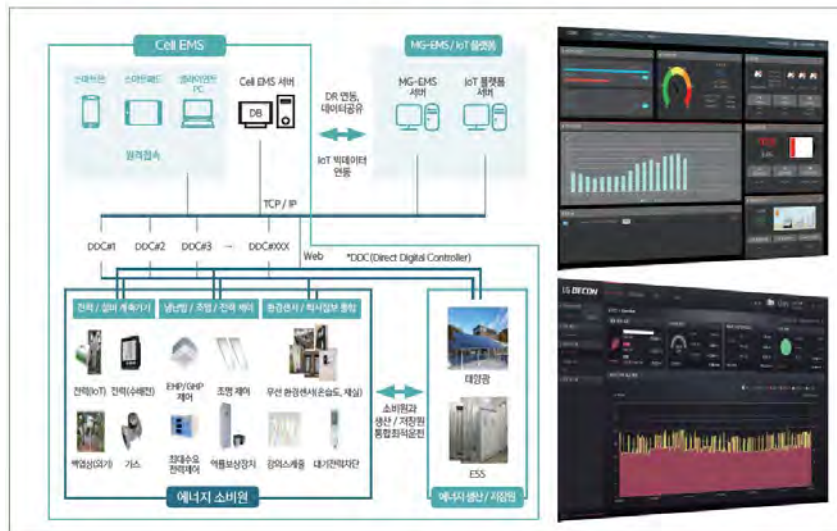
Campus Microgrid on Seoul National University

➤ Research and development details

- Energy and peak load saving operation with EMS that reflects the campus environment
- C-EMS development and grid connection for V2G application of EVs

캠퍼스 고유 모델 운영을 통한 에너지/Peak부하 절감운전

에너지 피크 20%, 에너지 비용 20% 절감 실험 및 사업화



IoT 기반 환경센서, EV-EMS, 마이크로그리드 교육 생태계 구축

에너지 모니터링 시스템 구축 및 사용자 행동 변화로 10% 소비 절감



Island Area Microgrid

- Gapa-do Island and Gasa-do island microgrid
 - Construction of a carbon-free island led by KEPCO
 - Demonstration of smart grid-based technology



[Gapa-do island microgrid]



[Gasa-do island microgrid]

Microgrid Technology in Korea

- **World class technology in microgrid construction & operation**
 - Accumulative experiences on the microgrids
 - Global competitive in key technologies such as ESS
- **Development and operation experiences**
 - Energy independent Gasa-island project, 2014
 - Seoul National University (SNU) campus microgrid, 2015



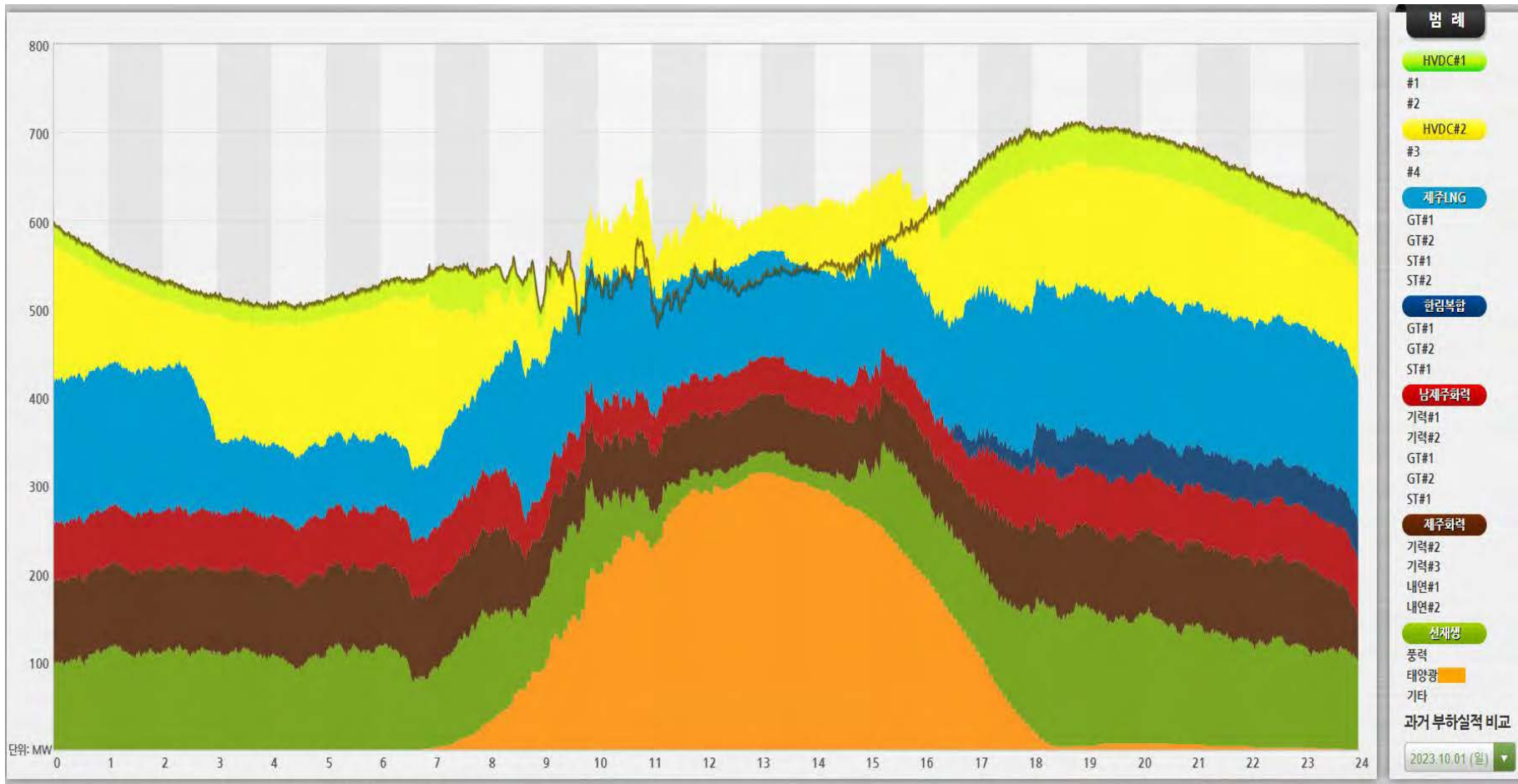
Gasa-island Microgrid
(Source: Korea Electric Power Association)



Microgrid Integrated operations office at SNU
(Source: The Korea Times)

Challenge in Jeju Island

➤ Duck curve due to excessive Renewable Energy Generation



Demand and Supply Curves in Jeju Island, October 1, 2023

Thank you!