

Knowledge Exchange Sector Guidebook: Energy

**WORLD BANK GROUP
KOREA GREEN GROWTH TRUST FUND**



ABOUT THIS BOOKLET

This booklet serves as a companion to help you explore green growth in Korea's energy sector. It provides relevant information and a directory for reference, guidance and comprehension. Inside you will find details of past experiences that have shaped the sector, as well as recent green growth practices and the frameworks and government institutions that support Korea's advanced energy sector.

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PART 1



What is a Technical Knowledge Exchange

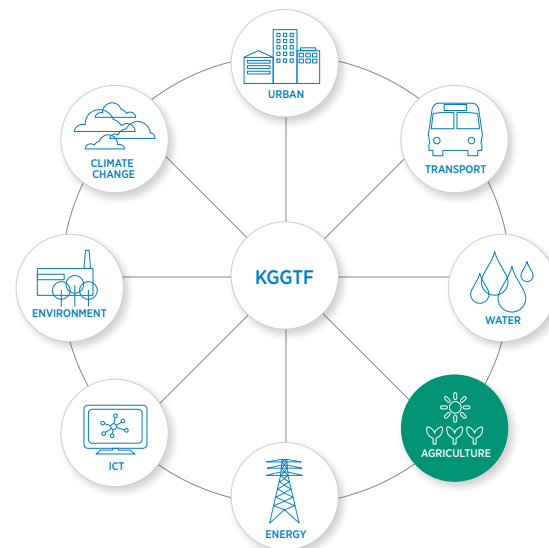
And What You Will Experience?

TECHNICAL KNOWLEDGE EXCHANGE

The KGGTF Technical Knowledge Exchange is where ideas, strategy and action come together. Facilitating the sharing of green growth best practice and technical expertise through on-site learning is part of what makes the Korea Green Growth Trust Fund unique.

This week brings together leading experts from the fields of: urban, transportation, environment and energy, agriculture, water and air. Their technical expertise includes everything from recent technological advances in smart grids, to monitoring and analysis, ICT integration, smart-card deployment to effective policy incentives and governance best practices and to facilitate wide-stakeholder engagement and support green economic growth policy and investment.

You will meet with key government ministries, institutes, multi-lateral organizations and companies relevant to your field. Site visits will provide a unique opportunity to see green growth in action first-hand, and to ask country specific and technical questions.



Sector Integration and Multiple Wins

KGGTF is passionate about tackling infrastructure challenges with integrated Green Growth approaches and methodologies. We seek to support countries in their sustainable growth strategies and investments by promoting collaboration across multiple sectors, and when appropriate, multiple scales, to create a multiplier effect that positively impacts quality of life.

“The exchange itself was very insightful and carefully planned and directly relevant to our work program. We learnt a lot from Korean experience and hope to bring good lessons learned from there to India.”

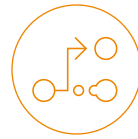
SURBHI GOYAL, WORLD BANK

During This Knowledge Exchange You Will Experience:



POLICY IDEAS

- In depth learning with policy makers and industry experts.
- Discussion on financial and policy incentives for innovative partnerships.
- Innovative governance structures that support transparency and interdepartmental collaboration.
- Policy development and coordination with municipal and central government, public institutions, private sector and local communities.



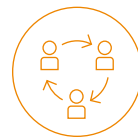
IMPLEMENTATION STRATEGIES

- Policy safeguards to ensure project funding withstands changes in political party and priority shifts.
- New frameworks for decision-making and problem solving.
- Strategy sessions on financial and technical solutions.
- Role of technical and policy think-tanks in policy setting and technical dissemination.



CAPACITY BUILDING

- Behind-the-scenes infrastructure site tours led by technical specialist.
- Learn how to avoid common and costly mistakes.
- Discover how synergies between the government, business and academia can speed the implementation of large projects.



GREEN GROWTH COMMUNITY

- Develop a network of key thought leaders working on innovative projects.
- A network of key thought leaders working on innovative green growth projects.

Be prepared to explore, ask questions and engage with leaders changing the world.



What We Do

The Korea Green Growth Trust Fund is a partnership between the World Bank Group and the Republic of Korea, established in 2011 to support client countries as they shift to green development path. Both partners share a common goal to reduce poverty and promote shared economic prosperity in an environmentally responsible and socially inclusive way.

KGGTF AT A GLANCE

\$138
MILLION FUND

144
GRANTS TO DATE

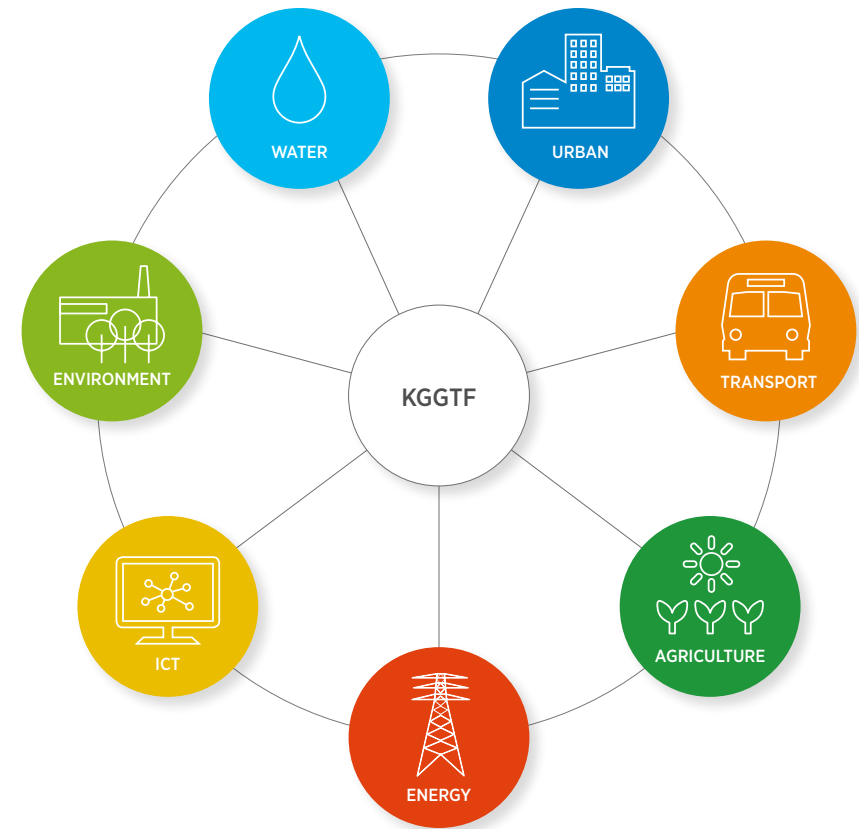
THROUGH 2026

SECTORS



The Trust Fund finances on-the-ground programs as well as knowledge exchange activities, and to date has approved 144 programs in the urban, transport, digital development, energy, environment, water, climate and agriculture

sectors. Based on strong performance, as well as increasing demand for collaborative development implementation programs, the fund has grown from US\$40 million to US\$138 million WBG programs through 2026.



The trust fund facilitates green growth programs across the urban, transport, digital development, energy, environment, water and agriculture sectors. Many of its programs are multi-sector, integrating two or more sectors at both the planning and implementation stages. This provides opportunities that allow for cost savings, data collection, citizen engagement and new forms of transparency and governance.

Knowledge sharing and network building are an integral part of green growth implementation. Facilitating the sharing of green growth best practice and technical expertise through on-site learning, and through the development of practical learning tools is part of what makes the Korea Green Growth Trust Fund unique.

Fund, manage, coordinate and monitor WBG KGGTF funded programs.

Aggregate, facilitate, and leverage Green Growth knowledge and learning.

Institutionalize global knowledge sharing to promote sustainable economic development.

PART 2

Why Korea?

Impact of War ¹

CIVILIAN CASUALTIES

Around 1 million people

DAMAGED INDUSTRIAL BUILDINGS

44%
of the total industrial buildings
(as of August 1951)

DAMAGED ELECTRICITY GENERATION CAPACITY

80% of the capacity

DEVASTATED SCHOOLS

4,800 schools

GROSS NATIONAL INCOME PER CAPITA (1953) ²

US \$67

GROSS DOMESTIC PRODUCT ²

US \$1.35 billion



South Korea's remarkable recovery from war and poverty provides case studies with specific solutions for economic advancement, creation of employment opportunities, and sustainable infrastructure development that is highly relevant for any country planning to transform or rebuild its economy.



Currently

RANKING ³

12th

largest economy
in the world

GROSS NATIONAL INCOME PER CAPITA (2018) ²

US \$33,564

GROSS DOMESTIC PRODUCT (2018) ²

US \$1.7 trillion

Source: Global Knowledge Exchange and Development Center (GKEDC), 2019

1953-1960

Post-war Korea faced varieties of hardships and challenges — a weak industrial base, dearth of natural resources, increasing population, and political instability. Foreign aid began to dwindle while poverty remained widespread.

1961-1979

The government embarked on an ambitious industrialization program as embodied in a series of Five-Year Economic Development Plans. The program relied on exchange rate reform, export subsidies, investment in economic infrastructure, expansion of schooling and training, and selective choice of strategic industries in later years.

1980-1996

Inflation and overcapacity created by the state-led industrialization in the 1970s were gradually resolved with stabilization policies in the early 1980s. The government pursued conservative fiscal and monetary policies to stabilize prices and rationalize the overly expanded industries. Economic liberalization gained speed in the 1990s.

1997-PRESENT

An extensive restructuring in the wake of the Asian financial crisis enabled Korea to avoid sovereign default, overhaul institutions and practices in its economy, and grow into one of the world's richest countries. Various efforts are now being made to meet the new challenges in the 21st century.

Seoul's Transformation Over The Last 50 Years (1970-2020) ⁴

Rising through the destruction and turmoil left by the Korean War, the city of Seoul has transformed to a global megalopolis in only 50 years. Seoul underwent several phases to overcome significant urban challenges and become a model smart city full of urban development best practices.



Photo: Seoul Photo Archives

1960S-1980s

To accommodate increasing population and address inadequate social infrastructure, the Seoul Metropolitan Government formulated urban development plans and implemented projects tailored to address the city's urban challenges.

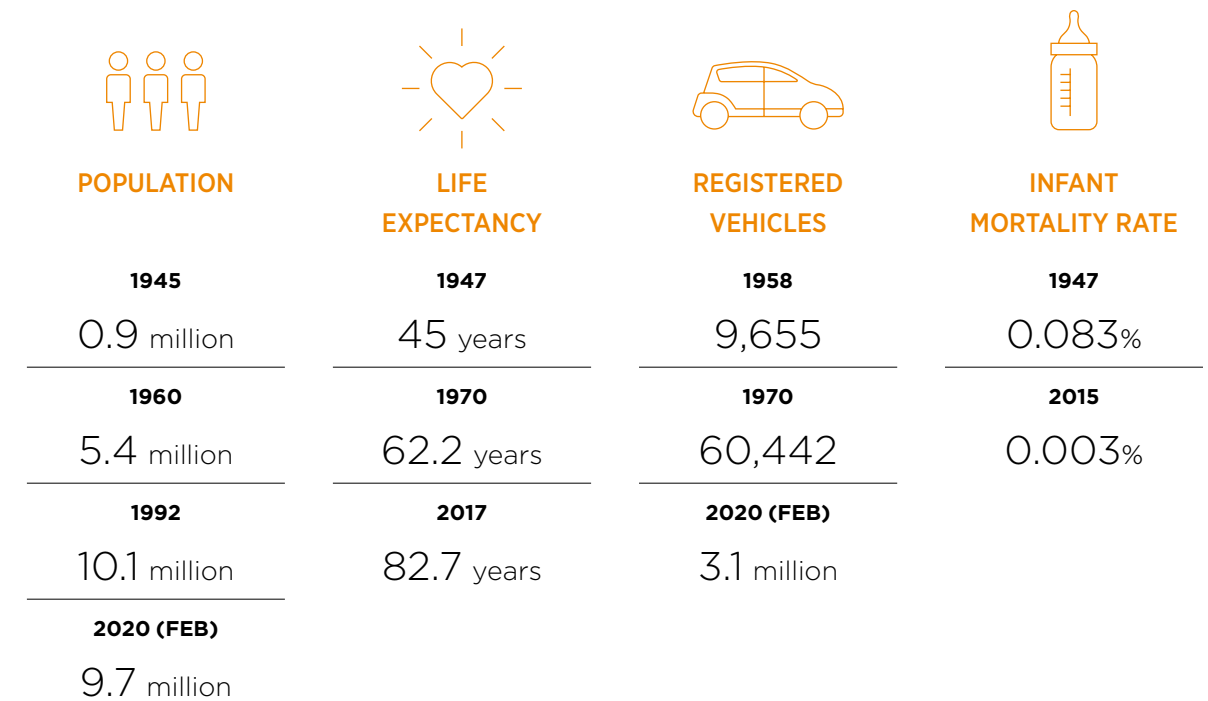
1980S-2000s

Extensive urban development planning continued, and policies were put in place to beautify the city. Subsequently, Seoul's infrastructure network flourished with quality transport, water and sewage systems.

2000-PRESENT

Seoul adapted a software-centered approach to its urban management policy. The use of advanced information technology helped Seoul facilitate a sustainable city and improve the well-being of its residents and visitors.

The implementation of extensive development projects spurred demographic change across the city of Seoul, providing a quality living environment for its nearly 10 million residents.



Cheonggye-cheon Restoration Project (CRP)

Cheonggye-stream was once a symbol of the culture of the people of Seoul, a place where traditional celebrations were held, where women did their washing and where children played. Over time the poor built settlements and shanty

towns and pollution became an issue and serious problem. In 1958 the decision was taken to cover the stream for public safety and from 1968 to 1978 an expressway was constructed over the covered stream.

The area became the most overcrowded part of the city with 60,000 businesses, 200,000 shopkeepers and over 1 million people per day passing through causing severe congestion and crime. The business district underneath the expressway became synonymous with Seoul's deterioration. For 40 years the covering of the Cheonggye-stream to ensure public safety led to additional problems. The Cheonggye-stream

Restoration was a visionary approach to remake downtown Seoul. After city leaders held over 1500 meetings with local stakeholders the expressway was removed and the river restored. Now the river and pedestrian paths are a popular greenspace providing residents with a peaceful reprieve from city life. The project represents a new model for cities and city dwellers and the start of new evolution.



Photo (Left and Center): Seoul Museum of History; University of Seoul

MAJOR OUTCOMES

- Environment—average daytime temperature in the area dropped
- Economic vitalization
- Traffic—discouraged driving cars in the center, eased traffic flow, \$1 public transport system

PROJECT SPANNED

5.8 km



IMPLEMENTED OVER

1 year

for planning and preparations

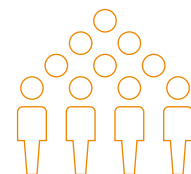
2 years &

3 months

for construction

TOTAL LABOR FORCE OF

700,000



TOTAL COST

\$305 USD million

Fully funded by Seoul Metropolitan Government (already owned most of the land used by the elevated highway redirected and earmarked funds for maintenance of deteriorated elevated highways).

DESIGN

\$1.7 USD million

CONSTRUCTION

\$294 USD million

LAND ACQUISITION

\$2.3 USD million

PROJECT MANAGEMENT

\$6.1 USD million

ADMINISTRATION

\$0.5 USD million

Overview of Korea's Green Growth Approach



Initiated by the necessity to adopt sustainable practices, Korea underwent a development paradigm shift from quantity to quality-oriented growth, and from fossil fuel-dependent to energy independent growth and sustainability. Korea's green growth was propelled by the establishment of key institutional arrangements that created an enabling environment and laid the foundation for advancement through legislative, institutional and strategic frameworks. In 2008, Low Carbon, Green Growth was declared as a new vision and Green New Deal for the nation for the next 60 years, and the green growth action plan was promoted thereafter.

Countries around the world are finding the Green Growth model highly relevant.

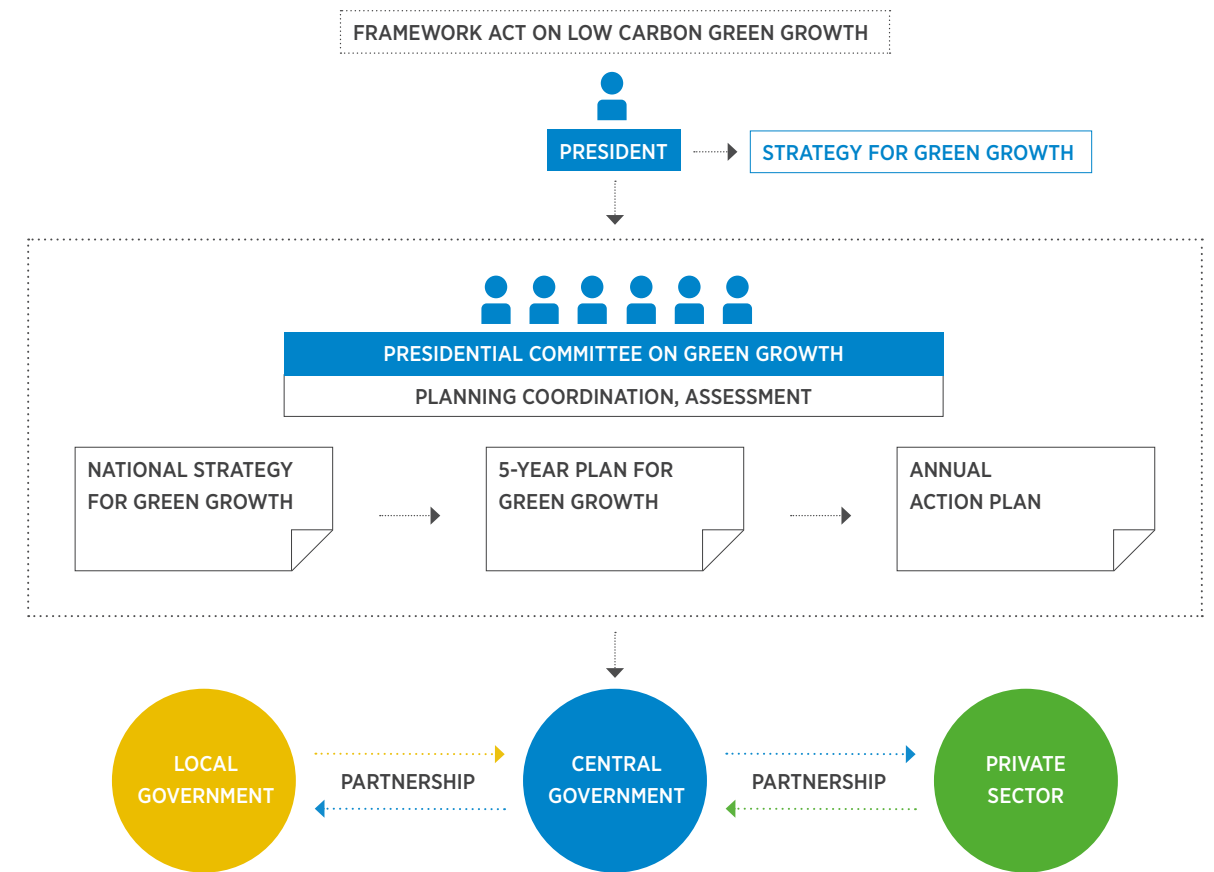
INSTITUTIONAL FRAMEWORK

The Presidential Committee on Green Growth (PCCG) was established in 2009 to spearhead Korea's Green Growth Transformation. Specifically, the PCCG developed and mandated the legal framework, strategic planning, and budget allocation for the National Strategy.

The Committee on Green Growth was instituted several years later in 2013 with the main function of deliberating matters concerning Green Growth. The Committee was comprised of 38 people: 21 Private Experts and 17 ministers, Co-chairs: Prime Minister and one Private Expert and 4 Sub-Committees focused on:

- Green Growth Strategy
- Climate Response
- Green Technology and Industry
- Energy

Figure 2 Institutional Framework for Green Growth



LEGISLATIVE FRAMEWORK

The Framework Act on Low Carbon Green Growth was enacted in 2010. It provided the legal basis for implementing measures to effectively address climate change and energy issues, promote sustainable development, build the implementation system for green growth (such as the establishment of the Committee on Green Growth), and revise a variety of institutional systems to promote low-carbon green growth in the region.

The major provisions in the Framework Act include:

- The realization of the green economic system, green technology and green industries.
- Policies on energy, sustainable development; the green life, the green homeland and the low-carbon traffic system.
- International negotiations and cooperation in relation to low carbon, green growth, including climate change.
- Procurement of financial resources, taxation, financing, training of human resources, education, and public relations activities necessary for low carbon, green growth.

STRATEGIC FRAMEWORK

The National Strategy for Green Growth (2009-2050), provides a comprehensive policy framework towards green growth. Launched in 2009, the strategy aims to promote eco-friendly new growth engines, enhance people's quality of life, and contribute to international efforts to fight climate change. To achieve the goals set in the National Strategy, South Korea rolled out a series of five-year plans with the following objectives:

Definition of Green Growth:

Growth that registers harmony between economy and environment that reduces climate change and environmental damage by saving and efficiently using energy and resources and creates jobs by exploiting new growth engines through R&D in clean energy and green technology.

*Article 2, Section 2 of Low Carbon Green Growth Framework Act (hereafter the Framework Act)

The government set a budget target to allocate 2% of GDP for Phase 1 (2009-2013)
Total: 107.4 trillion KRW (98.1 billion USD (1/1/2013))⁵

	Total	'09	'10-'11	'12-'13	Growth
Public Investment (trillion KRW)	107.4	17.5	48.3	41.5	10.2%
Adaptation to climate change	56.9	8.6	29.2	19.1	14.0%
New growth engine	28.6	4.8	10.8	13.1	9.4%
Better life quality	27.9	5.2	10.5	12.2	3.6%

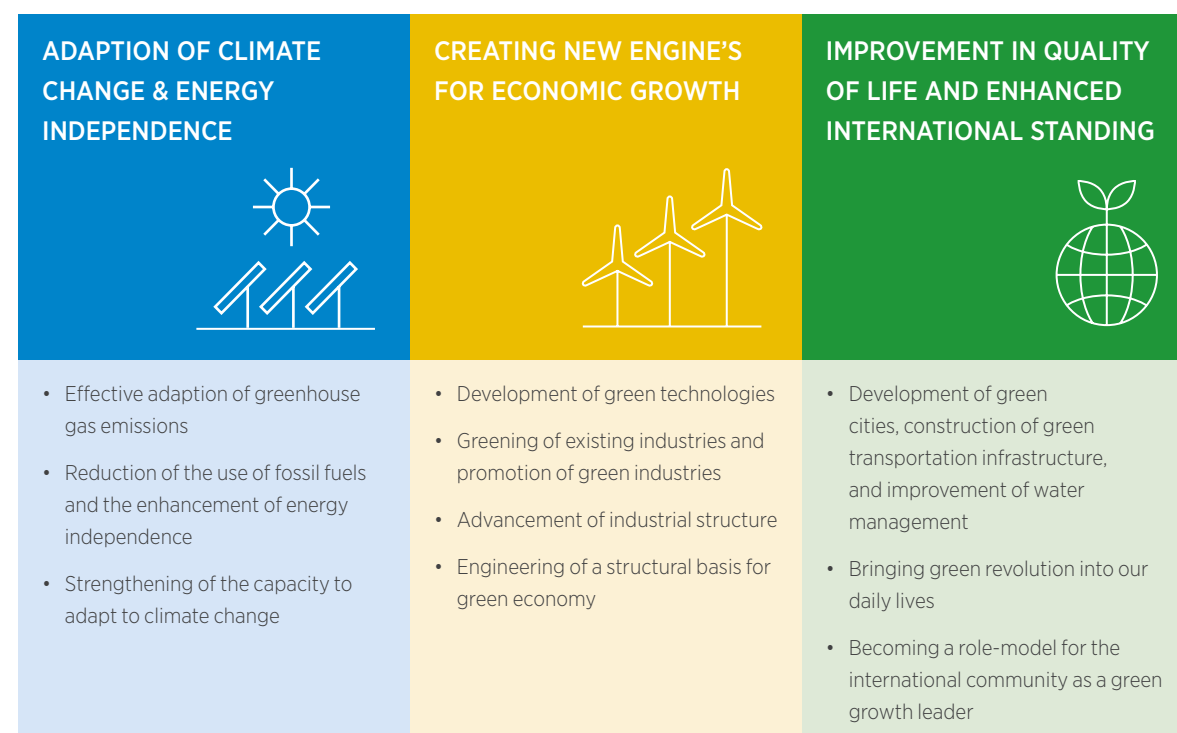
The 1st Five-Year Green Growth Plan 2009-2013

- Adaptation to climate change and energy independence
- Creating new engines for economic growth
- Improvement in quality of life and enhanced international standing

The 2nd Five-Year Green Growth Plan 2014-2018

- Establishing a low-carbon socio-economic infrastructure
- Achieving a creative economy through the convergence of green technology and ICT
- Building a pleasant living environment safe from the harms of climate change

Figure 1 Three Objectives and Ten Directions of Green Growth



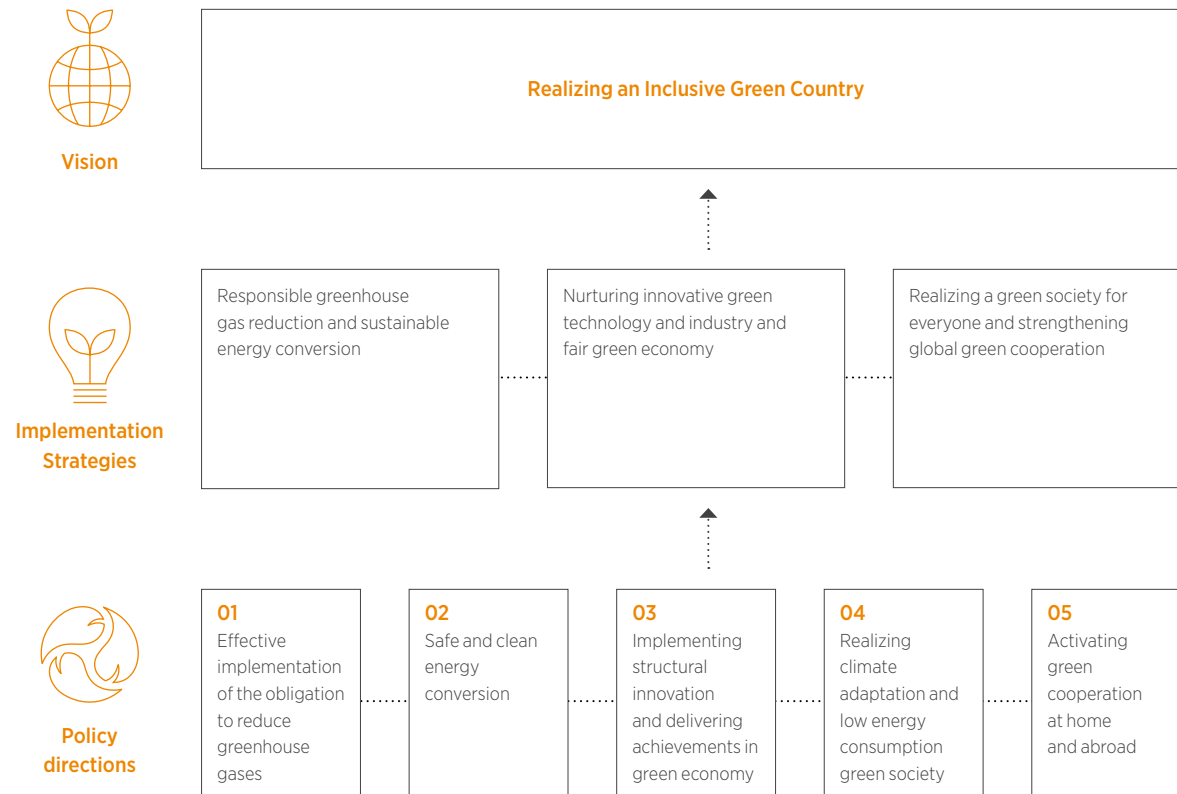
MAJOR ACHIEVEMENTS 2009-2019⁶

10 years of Green Growth Policy implementation has:

- Facilitated the adoption of Green Growth as an agenda for national development and the institutionalization of Green Growth promotion.
- Led to an increase in the supply of green products and efforts for actualizing green lifestyle.
- Aided in preparing the basis for preemptively setting the GHG reduction target and system.
- Enhanced national standing by setting green growth as a global agenda by establishing and engaging related internal organizations.
- Established the foundation for future growth engines through the development of green technology.

**The 3rd 5-Year
Green Growth Plan ⁷**
2019-2023

- Responsible greenhouse gas reductions and sustainable energy convergence
- Nurturing innovative green technology, industry and fair green economy
- Realizing a green society for everyone and strengthening global green growth cooperation

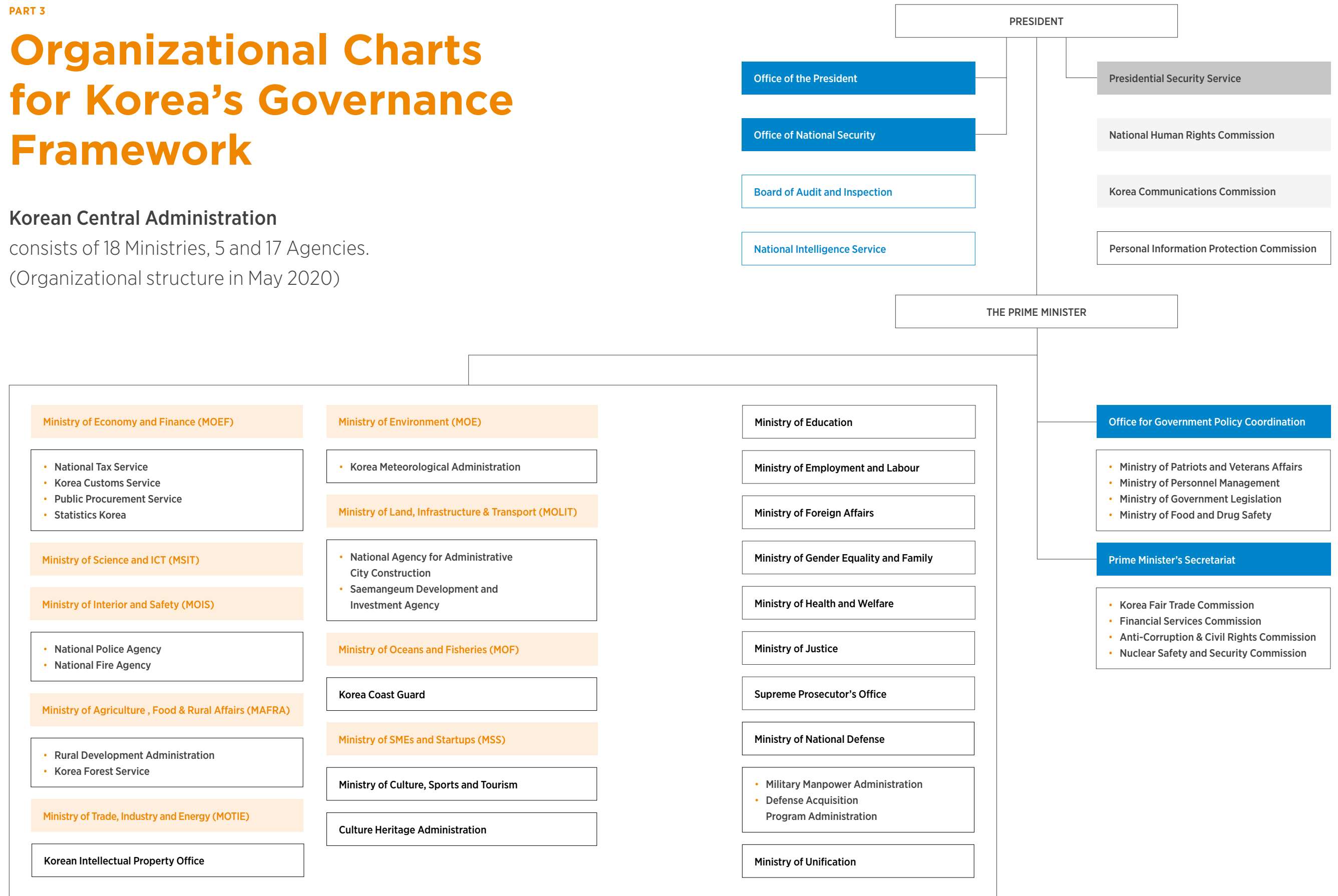


PART 3

Organizational Charts for Korea's Governance Framework

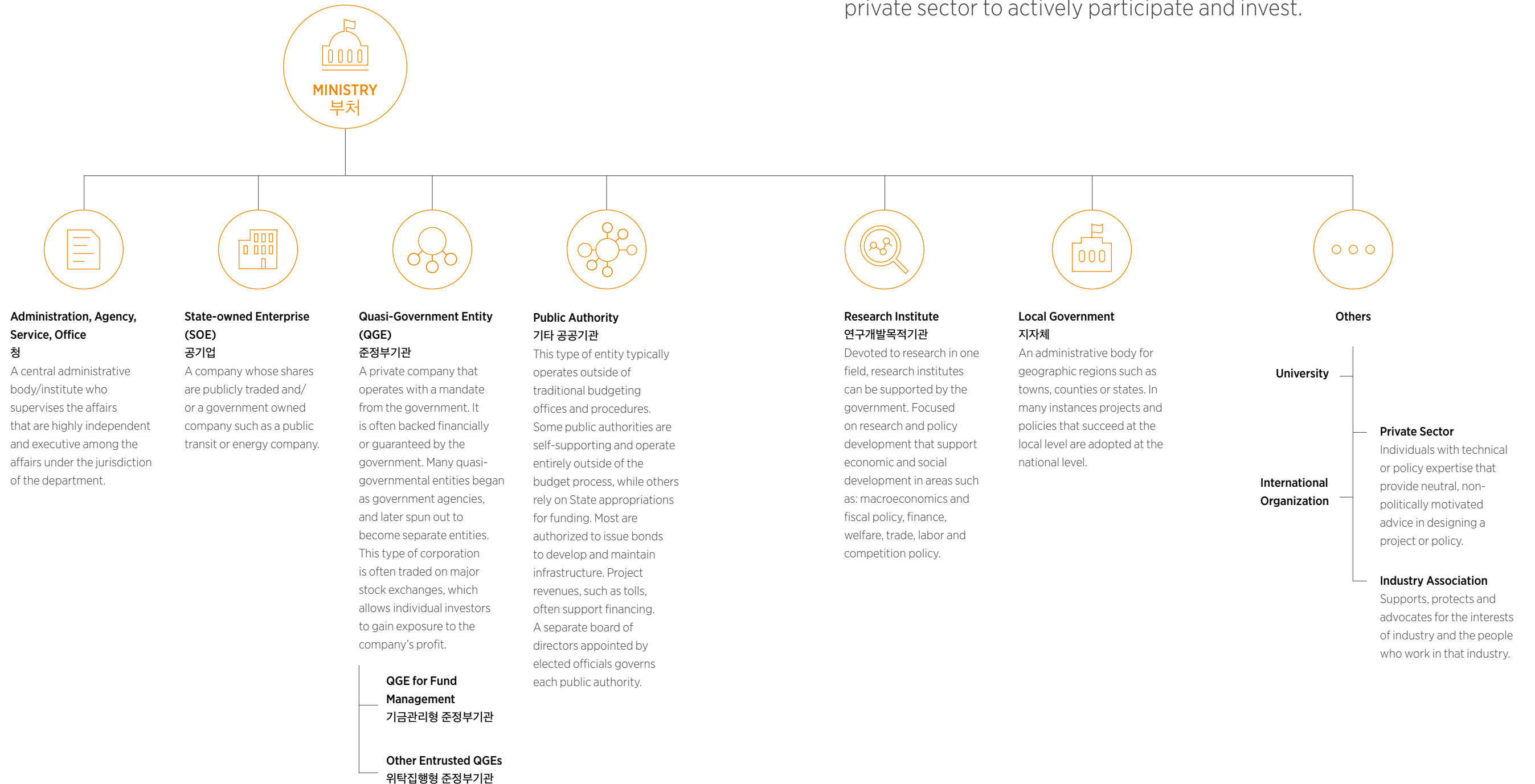
Korean Central Administration

consists of 18 Ministries, 5 and 17 Agencies.
(Organizational structure in May 2020)



Institutional Roles and Functions in Korean Governance

Much of Korea’s successful transformation from war-torn country to global leader is a direct result of institutional frameworks and strategically designed governing structures. Establishing effective institutional frameworks allows for long-term strategic planning and investments. When done correctly, such long-term planning can align citizens’ interests and nation building with clear opportunities for the private sector to actively participate and invest.



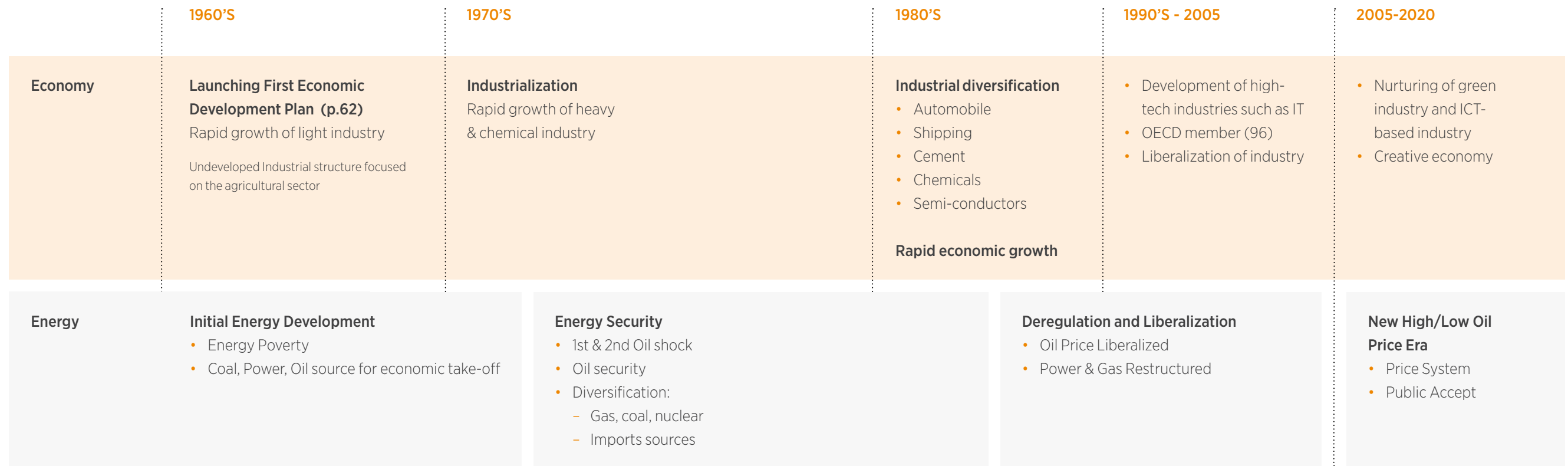
PART 4



Korea's Green Growth Approach to Energy: From Ashes and Coal to Hydropower and EV

Ministry of Trade, Industry and Energy (MOTIE) stems from a ministry established in 1948. It is concerned with regulating economic policy, especially regarding the industrial and energy sectors. Originally established as the Ministry of Trade and Industry (MTI) in 1948, it later merged with the Ministry of

Energy and Resources. MOTIE works to design policies that provide a strong foundation for economic growth across all areas of commerce, investment, industry and energy. Korea's transition to a knowledge-based economy over the past few decades was in large part because of policies designed by MOTIE.



Source: Ki hyun Park, Korea's Energy Landscape and Future Direction, Korea Energy Economics Institute

INDUSTRIALIZATION AND THE NEED FOR MORE ENERGY

Korea's energy experience provides a unique perspective. Rapid export driven, high energy intensive growth beginning in the 1960's was achieved by high levels of imported coal and oil.

Consumption grew at over 30% annually and resulted in economic instability during the oil shocks in the 1970s. Korea started its industrial development in the 1970s, focusing on energy-intensive heavy and chemical industries such as steel, chemicals, shipbuilding and cement.

The decision to pursue energy security and greater independence led to the development of the *Basic Energy Plan* which provides the primary guidance on all areas relevant to energy and defines the direction of the mid- to long-term energy policy.

The *Basic Energy Plan* is updated every five years, when the Ministry of Trade, Industry and

Energy (MOTIE) prepares a new draft, with consultation from the heads of topic-related central administrative bodies, followed by a public hearing. Confirmation is made through the consecutive deliberation processes of the Energy Commission (within the Ministry), the Committee on Green Growth and the Cabinet Council.

SITUATION AND POLICY INTERESTS

1970s

The oil shocks of the 1970s led to a significant structural change to the energy sector. The Korean government shifted towards adoption of energy security enhancement policies. Measures included diversification of energy sources and suppliers, conservation and oil stockpiling, construction of nuclear and bituminous coal-fired power plants, and the establishment of the energy conservation institute (currently Korea Energy Agency).

1990s

The first Basic Energy Plan was established in 1997 (1997–2006) as a requirement of the Energy Use Rationalization Act (article 4) and with a 10-year parameter.

2010s

Korea announces an emissions-trading plan in 2012, the first of its kind in Asia, with the aim of achieving its target of a 30% reduction in greenhouse gas emissions by 2020.

In January 2014 the government announced a long-term strategy which aims to reduce final energy consumption by 13% by 2035. A shift towards new and renewable energy such as photovoltaic energy, and wind power energy is also envisioned with increased targets from 3.9% in 2014 to 11% by 2035.

1960s

Following the war, Korea launched the 5-year economic development plan (1962–1966). To achieve its development plan, the energy policies shifted from the use of coal to oil as domestic coal production was not enough to fuel the economy. Oil refineries were built, which resulted in oil consumption growing annually to over 30% from 2%.

1980s

The 1980s were characterized as a period of rapid economic expansion & large population concentration in large cities. As a result, air pollution increased in urban areas. The government shifted its energy and imposed stringent control to improve air quality.

Environmental protection became a top priority in the national agenda. The following acts and regulation were established:

- Environmental Conservation Law in 1977
- Establishment of the Agency of Environment in 1980 (currently the Ministry of Environment).

2000s

The second Basic Energy Plan, for 2002–2011 was established in the Roh Moo-hyun government however in 2006 second Basic Energy Plan changed to the framework Act on Energy, which included a 20-year parameter for the Basic Energy Plan.

Following the 2008 financial crisis the government establishes a stimulus plan built around Green Growth that prioritizes economic development that is environmentally sustainable, simultaneously creates jobs and invests in industries that positions the country for the Fourth Industrial Revolution.

2020s

The coronavirus pandemic that struck the world in 2020 is causing economic upheaval. Korea has recently released plans known as the 'Green New Deal' which will focus stimulus funds on investing in green growth and accompanying technology and sustainability investments to prepare the country for a new energy future.



Green Growth Energy Approach

Korea was among the first countries to enshrine green growth in its national development strategy. During the global financial crisis in 2008, the country dedicated 80% of its fiscal stimulus plan to green growth projects, particularly infrastructure and transportation. In 2009, it announced plans to invest US\$85 billion in clean energy technologies and implementing its green growth plan, estimated to create more than one million new jobs and bolster a clean-tech export industry. That emphasis on environmental sustainability is partly credited for Korea's early recovery from the economic crisis.

As part of its Five-Year Plan, implemented in 2009, Korea committed 2% of its GDP through 2013 to create a knowledge and technological foundation to sustain a green growth economy for generations. The investment fueled ambitious goals, including:

- Developing the world's first nationwide "smart grid" system by 2030.
- Increasing the country's renewable energy to 20% of energy supplies by 2030.
- Reducing its greenhouse gas emissions 30% by 2020.
- Building 1 million green homes by 2020.

Sihwa Lake Tidal Power Station



Photo: Arne Mueseler / [arne-mueseler.com](https://creativecommons.org/licenses/by-sa/3.0/de/deed.de) / CC-BY-SA-3.0 / <https://creativecommons.org/licenses/by-sa/3.0/de/deed.de>

Originally constructed in 1994 the seawall and newly created Sihwa Lake, supported flood mitigation and agricultural development in the region. After more than a decade, increased population and industrial waste from nearby factories caused pollution to increase to such an extent, the water could no longer be used for agriculture.

In 2004, an innovative solution was devised to both bring fresh water into the lake and generate energy. The seawall became the backbone of a new power station and the installation of 10 large turbines reintroduced fresh seawater into the lake. Fresh seawater was introduced to the lake that flushed out contamination while simultaneously generating energy for the local area. While the initial cost of a tidal power plant is relatively high compared with other types of power plants, benefits include low operating and maintenance costs, and no emissions. Completed in 2011 it is now the largest tidal power station in the world.

Ten 25.4 MW turbines create power generated by tidal inflows.

Water Quality Improvement

COD 17.4 ->2.0ppm

Ecosystem Recovery

- Birds: 145 species 230,000 population
- Circulates 60 billion tons of seawater into the lake annually
- Clean energy production: 552GWh
- Annual crude oil substitution: 862,000 barrels
- Annual reduction of CO2 emissions: 315,000 tons
- Reduces oil imports by approximately 860, 000 barrels (\$43 million)

Operating Range

- Mean: 5.6 m
- Spring tidal range: 7.8 m
- Basin area: 30 km²

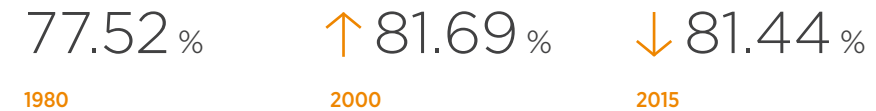
The power station and surrounding lake area are now home to a broad range of wildlife. The diverse wildlife is so abundant, 1.5 million tourists each year visit the area to view the wildlife.

Energy at a Glance

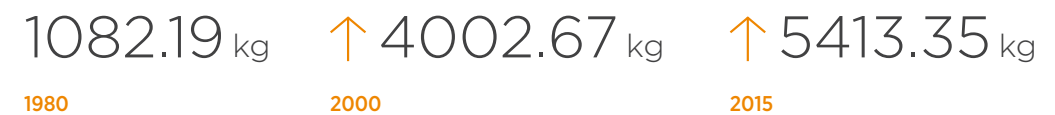
NATIONAL ECONOMY AND ENERGY CONSUMPTION

Over the last 40 years, energy imports have only increased slightly as the country as increased renewable energy and focused on demand side management.

Energy imports (net % of energy use)⁸



Energy use (kg of oil equivalent per capita)⁸



Renewable energy consumption (% of total final energy consumption)⁸



New and Renewable Energy Supply (thousand TOE)⁸



Solar PV Supply Status (TOE)⁸



Wind Supply Status (TOE)⁸

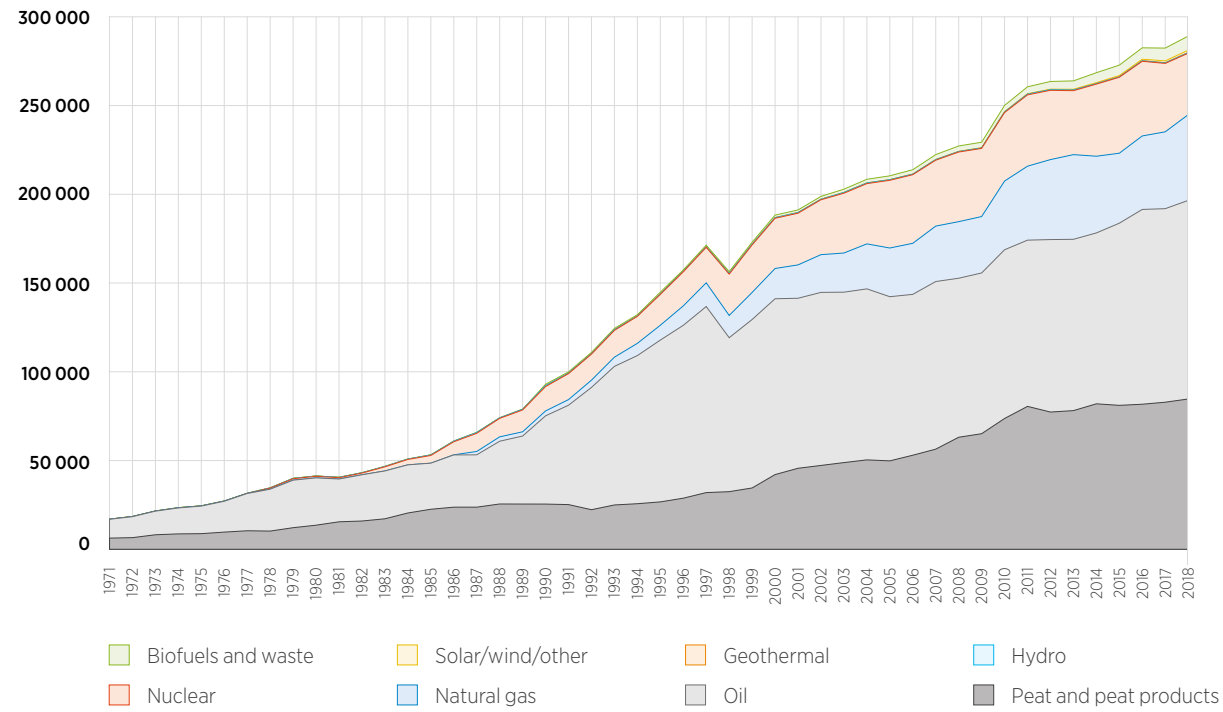


TOTAL ELECTRICITY CONSUMPTION	TOTAL CONSUMPTION/GDP	ENERGY INDEPENDENCE
507.60 bn (kWh)	88.5 (2015=100)	21.7 %
PER CAPITA ELECTRICITY CONSUMPTION	POWER GENERATION CAPACITY	TOTAL CONSUMPTION/GDP
9,836 kWh	97,648,761 kW (2015)	88.5 (2015=100)

Percent changes are calculated from the base year

KOREA ELECTRICITY PRODUCTION PERCENTAGE BY FUEL TYPES ⁹

Total Primary Energy Supply (TPES) in Korea (1971-2018)



PART 4

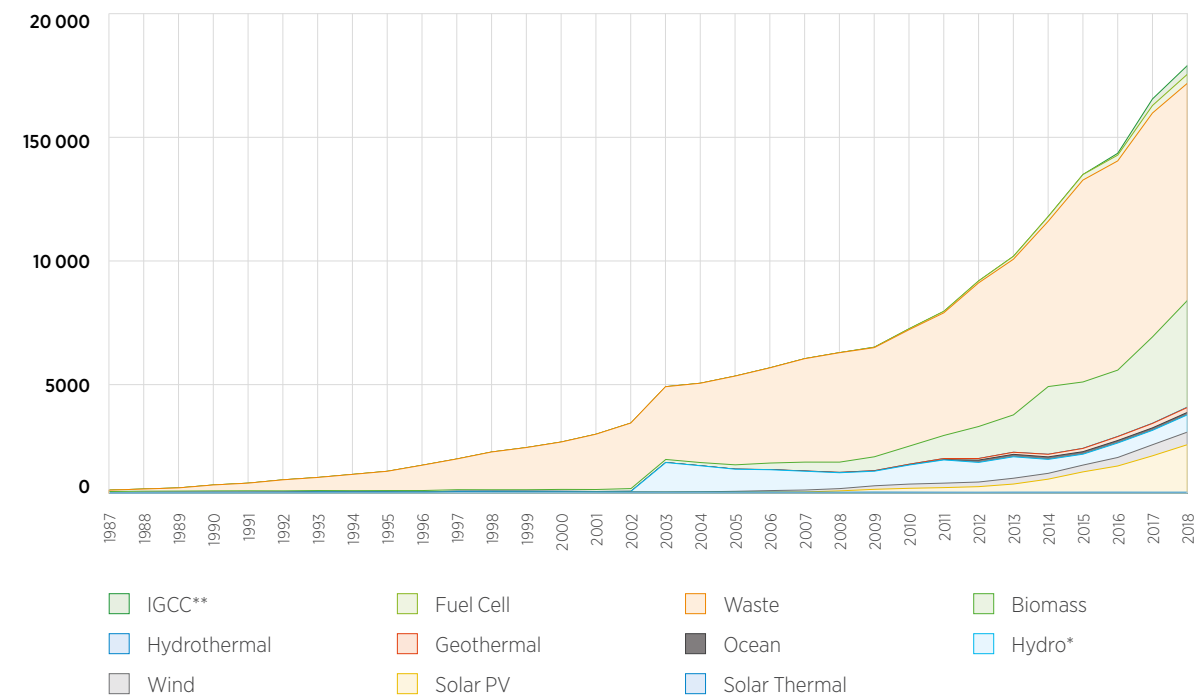
Energy Markets

Looking at Old Problems in a New Light

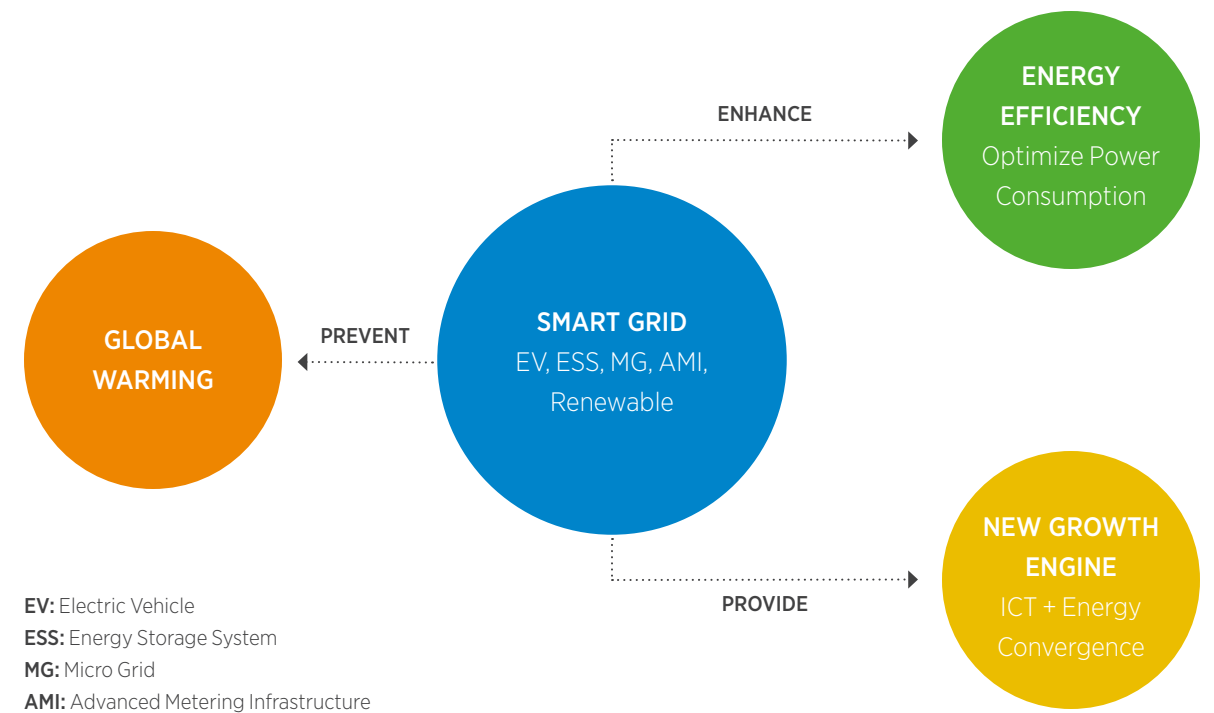
The energy sector is undergoing tremendous growth and new technologies have changed the price dynamics. Technological advances and the convergence of ICT creates energy efficiencies that optimize power consumption, and bring down energy costs, while simultaneously addressing global warming.

RENEWABLE ENERGY SUPPLY

Renewable Energy Supply in Korea (1987-2018)



*Hydro includes "Large Hydro" since 2003. In that, the values in Hydro column before 2003 indicate "small-Hydro". Also, Hydro as renewable energy excludes "pumped-storage hydroelectricity".



New Solutions to Old Problems

Ambitious Plan Generating Energy from an Open Landfill

Rapid urbanization and economic growth in Seoul inevitably increased waste volume from household and industrial sites, and due to lack of official waste disposal sites, municipal solid waste was disposed of at open landfill sites. A low-lying island located on the Han river was chosen as Seoul's official dump site in 1978 for its easy accessibility

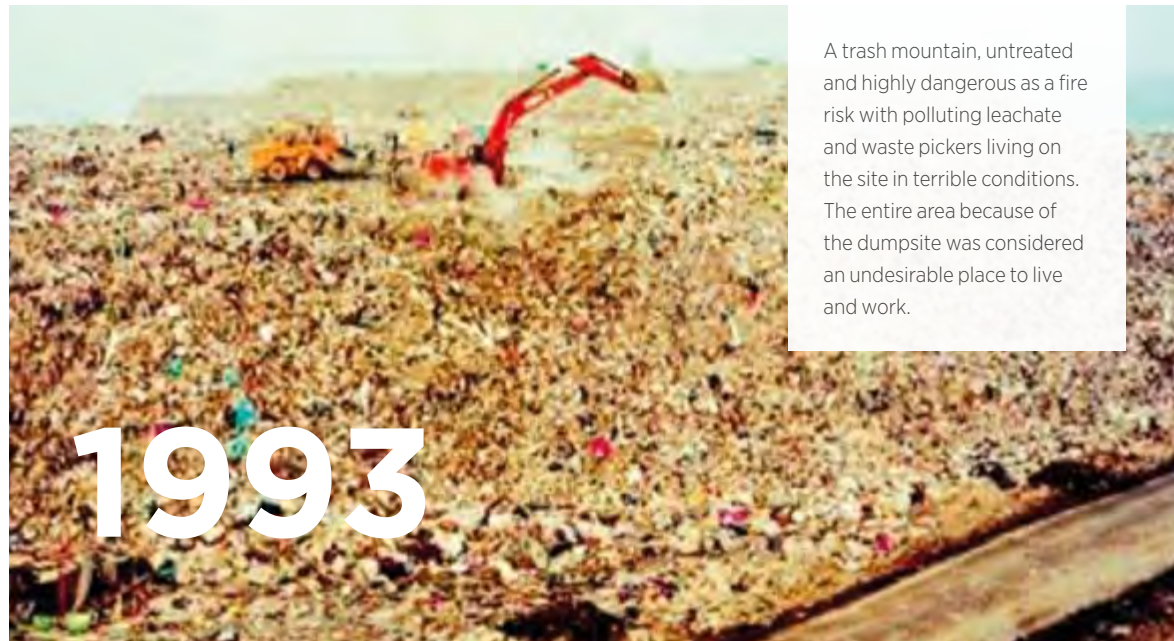
and close proximity to downtown. The beautiful island became a toxic trash mountain with 28,877 tons of garbage emptied into the landfill every day throughout the 1980s. In the span of two years, the site was transformed to include an eco-park with recreational areas and walking paths, a World Cup soccer stadium, a golf course and more. Building

over the dumpsite and deploying technology to capture methane turned an unsustainable health hazard that depressed property values in the surrounding area, into an energy asset and beautiful greenspace for residents and visitors.

held in October when the silver grass is in bloom. Once an eyesore on its skyline, Haneul Park and Seoul have become a model for energy and solid-waste management innovation.

Sector integration is a key element in green growth thinking, planning and implementation. In most countries, the ministries that handle solid waste management and those that handle energy infrequently work together, yet now with new technologies collaboration can bring about innovative solutions.

Completed in four years, Haneul Park is the most popular of the five parks situated in World Cup Park. Like its name Haneul, which means "sky" in Korean, the park is situated on the highest part of World Cup Park and offers breathtaking views of Seoul. Today it attracts 10 million visitors annually, is a popular location for weddings photos, and plays host to Seoul's annual Silver Grass Festival,



A trash mountain, untreated and highly dangerous as a fire risk with polluting leachate and waste pickers living on the site in terrible conditions. The entire area because of the dumpsite was considered an undesirable place to live and work.



The Park was completed on time for the World Cup in 2002, and has become the symbol of Seoul as a world leading Eco-City. The transformation of the trash mountain to a recreational park and generator of energy changed public perception on waste treatment

facilities and represents Seoul's paradigm shift in Ecological Management. Because of the transformation, the area now includes residential apartment buildings, schools and local businesses. A thriving and healthy community was built in the course of a few years.

Before 1970's

Before the 1970s the park was a small island, chosen as the first official landfill site for Seoul.

1970's to 1990's

The island was used for open dumping, it was an unsanitary landfill from 1970s—1990s and Seoul's main landfill from 1978 to 1993.

1992

Sangam development and new town plan was announced in 1992, as part of Seoul's Basic Redevelopment Plan.

1993

The landfill site was officially closed down in 1993.

1998

In 1998 Seoul selected the Sangam area to host the World Cup, which set a firm deadline for cleaning up the toxic landfill site.

Ambitious Plan

An ambitious vision transformed the country's largest landfill into an energy producing asset. The implementation committee was divided into two organizations that worked to engage local stakeholders and ensure a fast transition.

- New Millennium Preparation Committee
- Seoul Institute— focused on planning & design

TOTAL COST

\$203 USD million

ON STABILIZATION

63%

ON PARK DEVELOPMENT

33%

Energy Independence R&D, Innovation and Technology

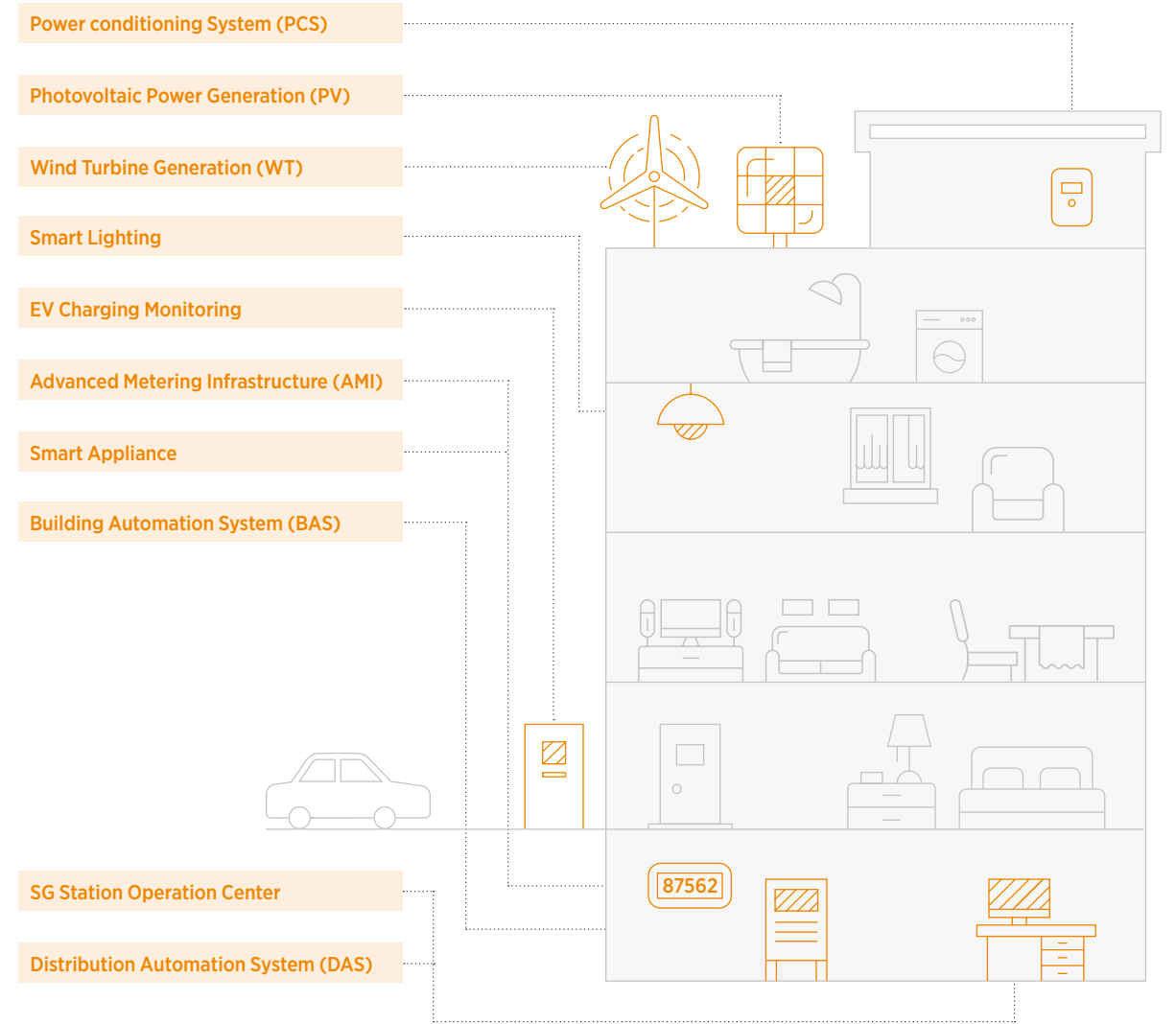
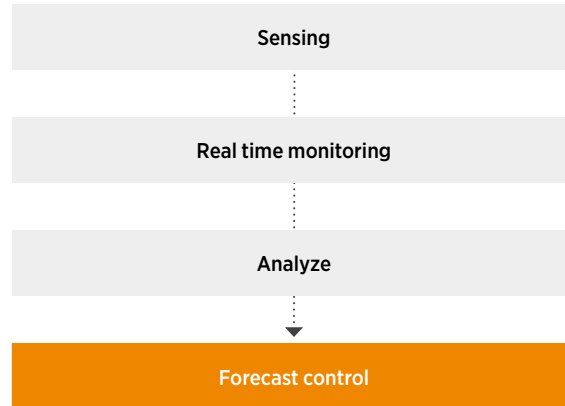
In the 1970s Korea recognized that reliance on importing energy was financially risky as fluctuating energy markets could impede economic development. The government invested heavily in research and development across a range of sectors and industries that laid the foundation for the country having some of the best high-speed internet access in the world. R&D investments have resulted in Korea's global leadership in fuel cells, the Internet of Things (IoT) and renewable energy.

SMART GRIDS

The next-generation electrical grid features a variety of ICT-based functions aimed at providing high-quality electricity while maximizing energy efficiency. Energy efficiency is gained by leveraging electric power and IT through real-time information exchanges between energy suppliers and consumers. Korea is developing diverse types of smart grids for a variety of applications including: microgrid, and sustainable city and environmentally friendly towns, smart grid stations, and energy-independent islands.

PROSUMER AND TWO-WAY EXCHANGE

The smart grid electricity network is a two-way exchange of information for power generation and consumption conducted in real time through the convergence of the existing electrical grid with ICT. This two-way exchange of electricity allows businesses and even consumers to add energy to the power network.

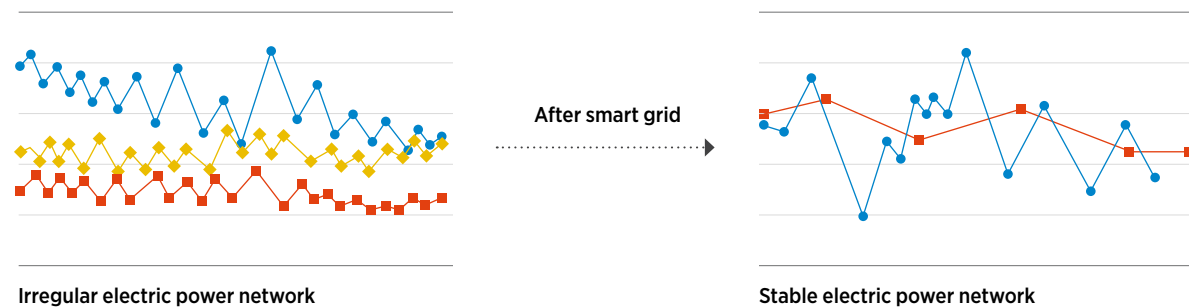
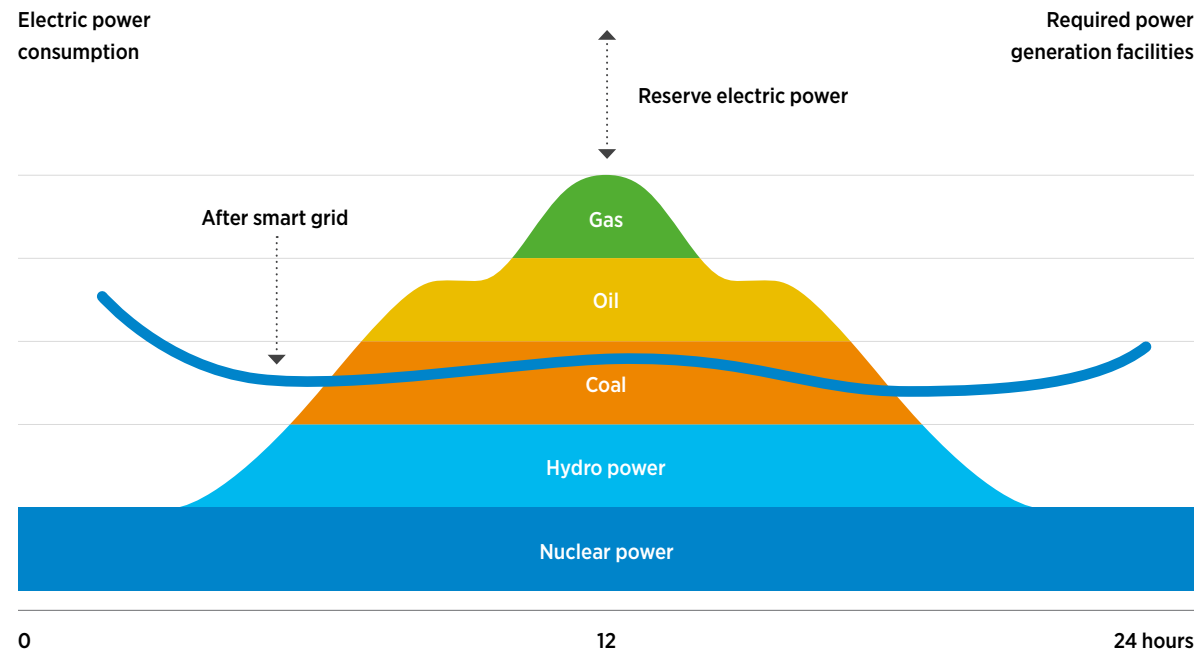


BENEFITS OF SMART GRIDS

- Update data in real time backed by smart sensors
- Remove system's risk elements with real-time monitoring and data analysis program
- Optimizes operation of electric power network with intelligent electric power appliances and artificial intelligence operating system
- Optimize energy efficiency unlike existing electric consumption which can be inefficient with heavy usage during the summer and winter afternoon hours
- Smart grids reduce energy waste and boost efficiency while promoting distributed resources based on new and renewable energy
- Seamlessly link new and renewable energy sources such as solar and wind
- Lowers facility investment costs because of the mitigation of peak load, investment costs are less intense.

VOLUNTARY ENERGY SAVINGS

Providing a clear rating system based on power supply and demand induces voluntary energy savings by citizens.



ENERGY STORAGE SYSTEM (ESS)

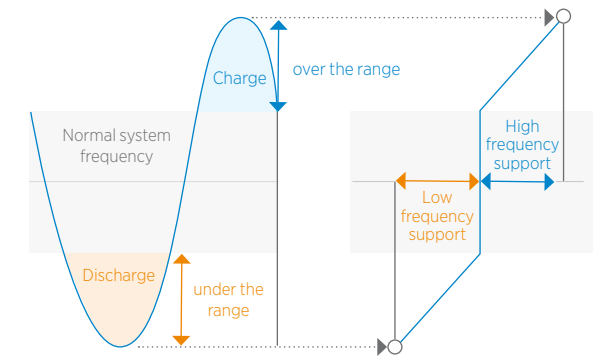
Storing energy from renewable sources has until recently been a concern. ESS has progressed and now provides a solution for both large- and small-scale needs. ESS currently plays an integral part of renewable energy production as its designed

for diverse applications such as wind power integration modules, frequency regulator modules, and conventional peak load reduction modules.

ESS can be used for the three purposes:

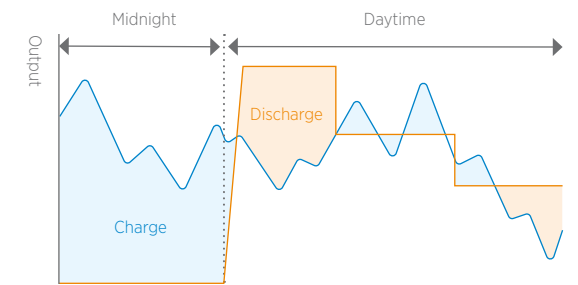
Frequency Regulation (FR)

The frequency of the power grid can be maintained in the norm of grid code by charging and discharging of electricity in the ESS. Fast response of the ESS (within less than 0.5 seconds) contributes to recovery from sudden low or high frequency.



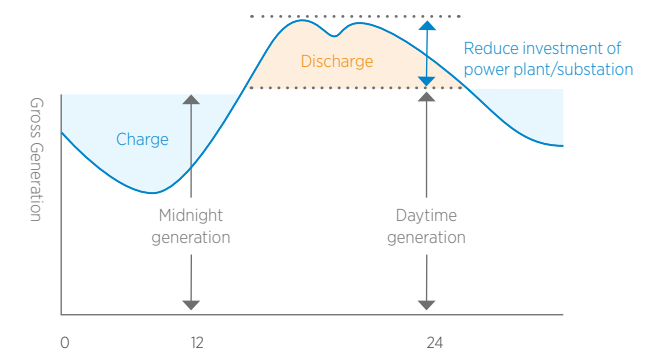
Renewable Smoothing

The fluctuations in the renewable energy output can be controlled using the ESS, improving power efficiency and the stability of grid operation.



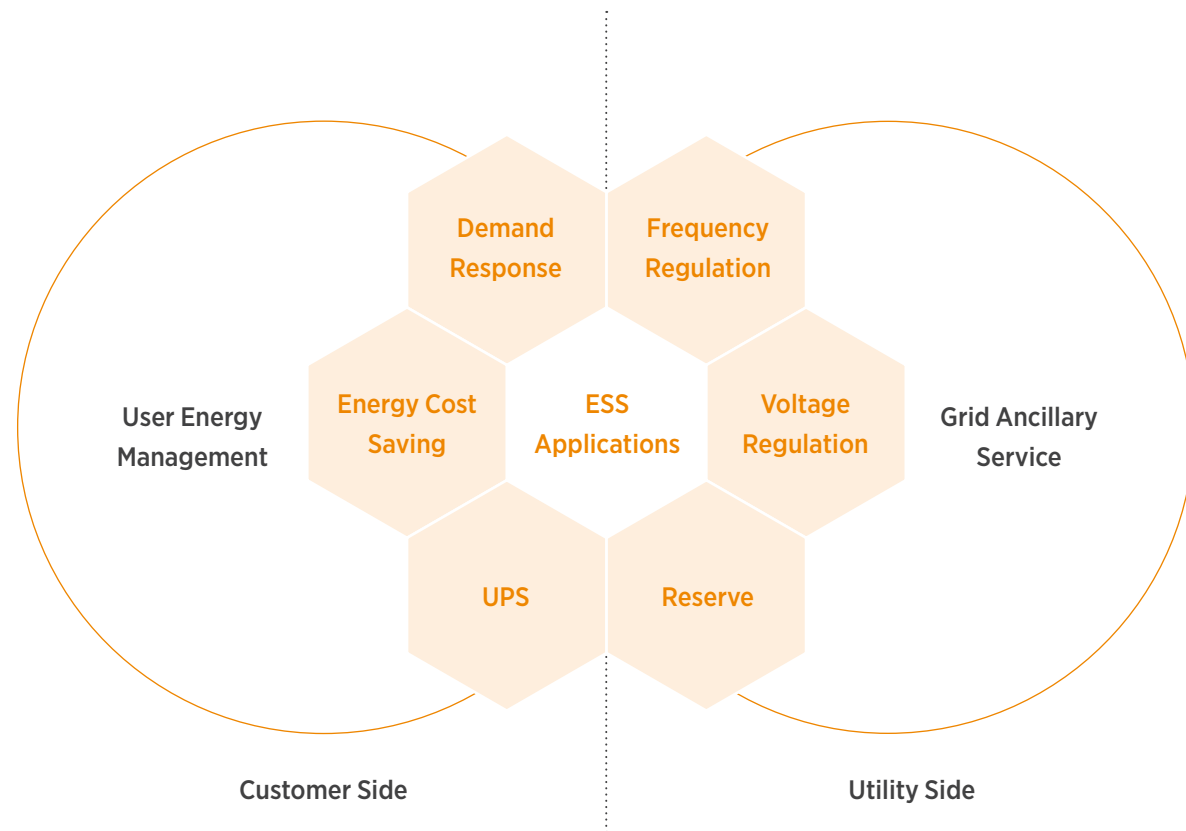
Peak Shaving

The peak load can be managed with the ESS. The discharging of ESS during peak period reduces peak loads and energy cost. The ESS charges its battery when electricity loads are low.



FR (Frequency Regulation) is to control power frequency level that fluctuates with changes in demand, to keep it within a certain range for reliable grid operation.

Energy Storage System Applications



Korea Electric Power Corporation (KEPCO) is the largest electric utility in South Korea and responsible for the generation, transmission and distribution of electricity and the development of electric power projects including those in nuclear power, wind power and coal. KEPCO is responsible for 66% of Korea's electricity generation. The Korean government owns a 51% share of KEPCO, and together with its affiliates and subsidiaries, KEPCO has an installed capacity of 65,383 MW. KEPCO is a state-owned Enterprise (SOE).

In 2013, KEPCO announced its plan for a FR ESS project following the government's electricity market policy. The plan included an investment of USD 242 million by 2017 for a total capacity of 376MW. Accordingly, a 52MW capacity were installed as a pilot project followed by 200MW, 124MW, every year until the end of 2017.

In 2014, KEPCO started a 52MW FR ESS pilot project in two substations. The ESS units (28MW, 24MW) were installed in Seo-Anseong substation governorfree and Shin-Yongin substation automatic generation control respectively, where the pilot project participants included KEPCO RI and companies of various sizes. The ESS has been in successful operation since 2015.

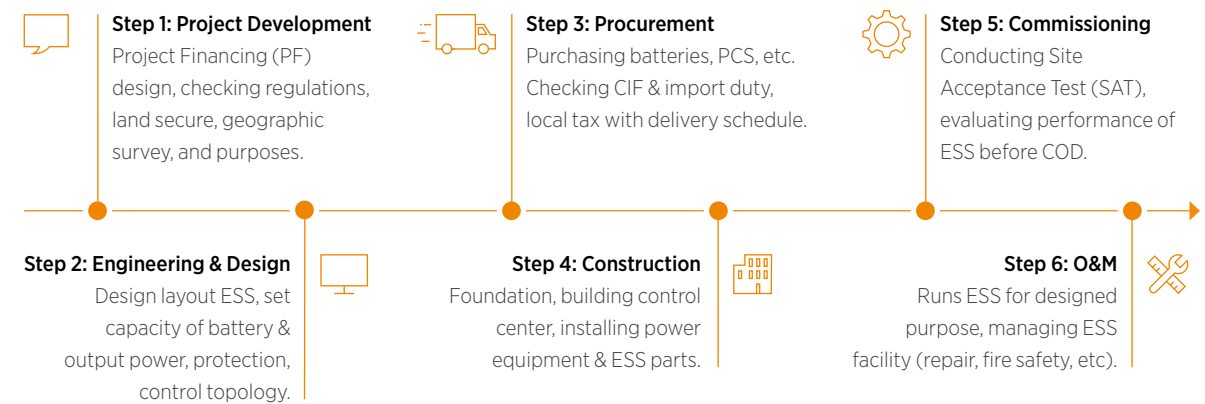
ESS APPLICATIONS FOR UTILITY + CUSTOMERS AND THE CHANGING DYNAMICS OF ENERGY

Bulk energy services	Ancillary services	Transmission infrastructure services	Distribution infrastructure services	Customer energy management services	Off-grid	Transport
Electric energy time shift (arbitrage)	Regulation	Transmission upgrade deferral	Distribution upgrade deferral	Power quality	Solar home systems	Electric 2/3 wheelers, buses, cars and commercial vehicles
Electric supply capacity	Spinning, non-spinning and supplemental reserves	Transmission congestion relief	Voltage support	Power reliability	Mini-grids: System stability services	
	Voltage support			Retail electric energy time shift	Mini-grids: Facilitating high share of VRE	
	Black start			Demand charge management		
				Increased self-consumption of solar PV		
Utility Scale					Customer (Demand Side)	

Energy storage services directly supporting the integration of variable renewable energy

LESSONS LEARNED

Six Steps: Building ESS Project



Battery Selection Considerations

- Efficiency
- Application
- Policy /Regulatory Treatment
- Grid/ Utility Requirements
- Depth/Length of Discharge Installation Infrastructure
- Space Limitations
 - Energy Density
- Ambient Condition / Temperature
- Safety
- Company Warranty / Performance Guarantee
- Performance Requirements
- Maintenance Requirements and Costs
- Battery Cell and Module Costs
- Power Component Availability and Costs

Green Growth In Action



CASE STUDY

Smart Grid, ESS and EV Jeju Island

Jeju Island located in the south is the largest island in Korea and has a mild climate and a thriving tourist industry. Back in 2014 the Jeju Special Self-Governing Province set the ambitious goals of installing a smart grid, ESS system to utilize the island's wind to power the island's transportation. The government was first to adopt EV, followed by the commercial sector and then consumers. In order to reduce anxiety over batteries going dead the island established a high-density network of chargers - 12,235 - roughly one charger every square kilometer. In the past six years the roughly 700,000 residents have become a living example of technology adoption at scale as the island is now a global leader in electric vehicle (EV) adoption.



Photo: Earth Observatory, NASA

ESS technology solved the problem of seasonal variation with wind as the energy source. The island generates 17 times MORE energy than currently consumed by EV.

ISLAND AT A GLANCE

- Carbon Free Island by 2030 - Gapa, Jeju Island
- Goal to replace diesel generated power with renewable energy and a smart grid
- Smart Grid Test Bed
- 18 months to build infrastructure December 2009-May 2013
- 24 months to test integrated operation of smart grid
- Solar PV system, two wind turbines, and an ESS. Island made completely energy independent through the establishment of an integrated system linking New & Renewable Energy sources with an ESS.
- Intelligent operation of power distribution
- Microgrid Operation Center
- Remote meter reading
- EV charging
- Automated diesel power generation facility

RESIDENTS*

700,000

* population in pilot area

BUDGET

\$200 million

(\$50 million public funds, \$150 million private investment)

SALT WATER DESALINATION FACILITIES

50 kW

SOLAR PV

174 kW

POWER STORAGE DEVICE

3.9 MWh

LOAD-SHIFTING DEVICE

2.4 MVA

WIND POWER

500 kW power, on-off control

HOW TO IMPLEMENT CHANGE

As countries look to deploy new technologies, key factors in Jeju's EV adoption provide an example of how to implement ambitious change.

EV SUBSIDY AND TAX BREAKS

Incentives include: free parking, admission, free charging.

Across Jeju island, EVs are an integral part of daily life. When first introduced in 2013 only four types of EV were deployed. Now, just a few years later 21 types of high-speed EVs are in use, along with three types of micro EVs and one type of freight EV, in addition to electric taxis and buses. More than 2,000 rental EVs provide visitors with the opportunity to experience the latest EV advancements.

Financial incentives and subsidies made the purchase price of EVs comparable to traditional internal combustion vehicles and created the initial demand.

Loans averaged only 1.52%.

PUBLIC SECTOR AND BUSINESS ADOPTION OF EV

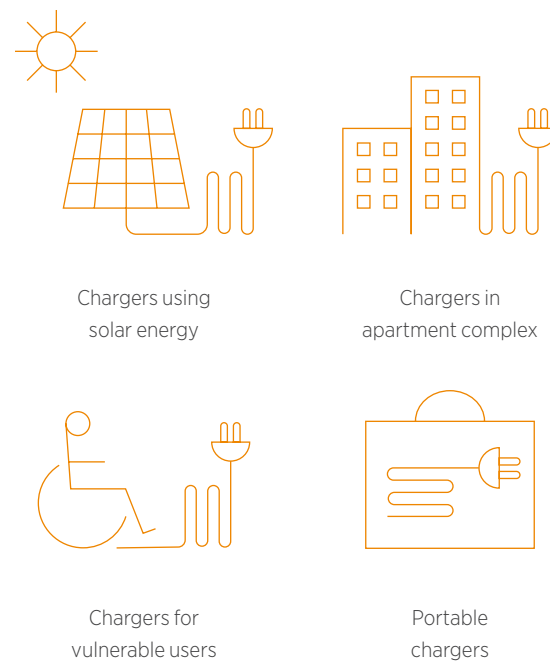
EV bus fleet, taxi and rental cars increased adoption and dissemination across the island.

CONTINUOUSLY EXPANDING ACCESS CHARGING INFRASTRUCTURE

The Ministry of the Environment established a variety of programs to increase charging stations. Including subsidizing units for resident areas, establishing high-speed charging units at multi-unit dwellings and public corporations and inducing private charging companies to expand locations.

2014	2018
REGULAR CHARGING STATIONS 992	REGULAR CHARGING UNITS 10,082
HIGH-SPEED CHARGING STATIONS 79	HIGH-SPEED CHARGING STATIONS 667

Various charging systems in Jeju



IMPROVE CONVENIENCE AND SUPPORT

Call centers for EV users were established to assist drivers and respond to requests and questions. Safety and educational programs were created to focus on EV education and include helping drivers understand:

- Advantages of EVs
- Efficient use of EVs
- How to respond to EV breakdowns
- Preparation for flooding and fires and other accidents

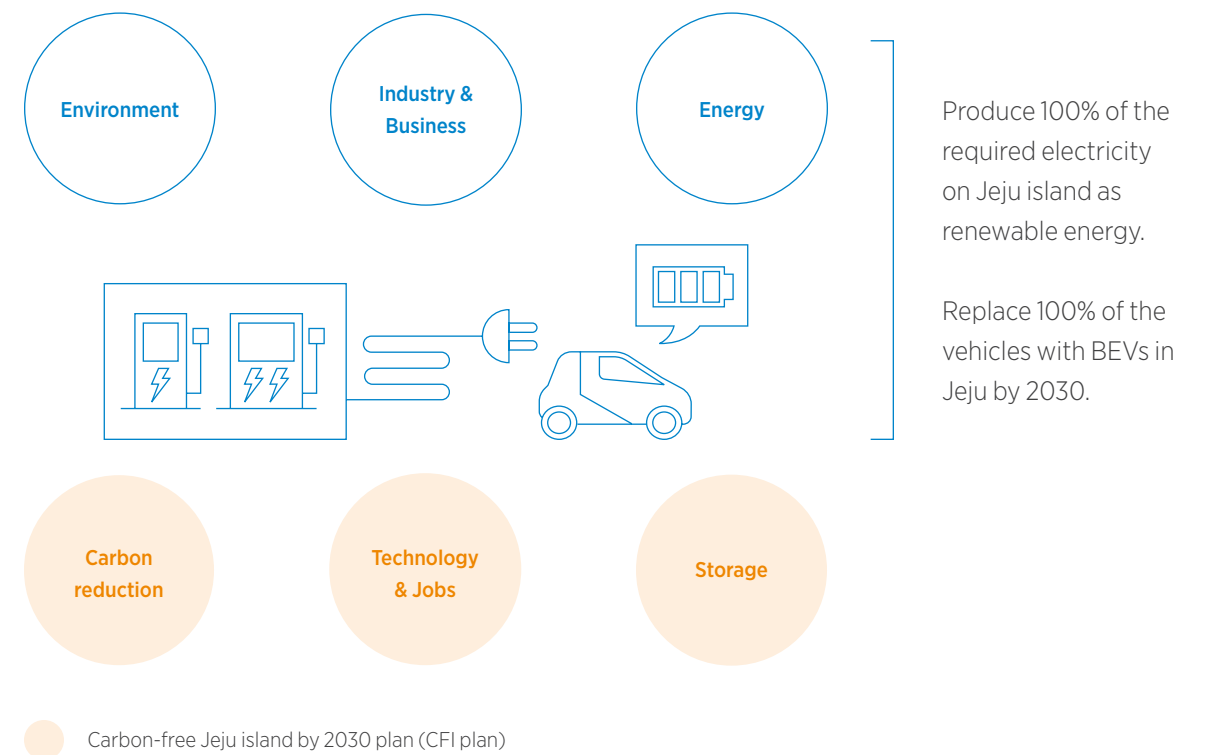
POLICY AND CULTURE: USER PARTICIPATION

Encouraging users to propose EV policies, establish EV etiquette and maintain public chargers.

PROVIDING DIVERSE OPPORTUNITIES TO EXPERIENCE EVS

- Eco rallies
- EV road parades
- Test driving and experience center temporarily operated each Friday
- EV expo partnerships

Linking EV Adoption to Larger Energy and Environment Plans



MID AND LONG-TERM STRATEGIC IMPLEMENTATION ¹⁰

BEV strategic initiatives were established in 2015. The initiatives are modified and upgraded every two years.

Implementation strategies	Strategic initiatives
Expanding BEV dissemination and charging infra	<ul style="list-style-type: none"> Transition of vehicles in operation in the province to BEVs Realize zero inconvenience in charging and using BEVs
Creating BEV industry ecosystem and nurturing related industries	<ul style="list-style-type: none"> Reinforce the establishment of the foundation for the BEV industry ecosystem Revitalize the local economy through the focused nurturing of BEV industries Create new industries linking with national strategic programs on BEVs Thorough preparation for changes to BEV-based future society
Creating BEV culture & refining institutions	<ul style="list-style-type: none"> Reinforce the roles and image of Jeju as a global center of BEV Expand BEV users' participation and lead BEV culture Refine BEV institutions/organizations and reinforce collaboration

SUCCESS FACTORS OF EV DEPLOYMENT IN JEJU

Effective local government leadership

- Long-term EV plan
- 2030 Carbon free island
- Local government ordinance on EV
- Additional EV incentives

→
Step-by step implementation

Natural conditions

- Within 2-hrs and 200km driving range
- Mild climate (stable battery performance)
- Flat road, tourist attraction (EV rentals)
- Single detached houses (suitable for charging)

→
Alleviate crucial EV limitations

EV infrastructure

- 12,000 EV chargers
- EV call center for EV beginners charging station information

→
Convenient usage of EV

Public Relation

- EV expo
- EV experience center
- Various EV operation (Rental, Taxis, Bus, urban delivery)

→
Overcome EV misconception

Jeju Island adoption has been a success. *EV 2.0* has recently been launched by the Self-Governing Province and they will shift EV policy to focus on infrastructure, ecosystem, culture and tourism.

CASE STUDY

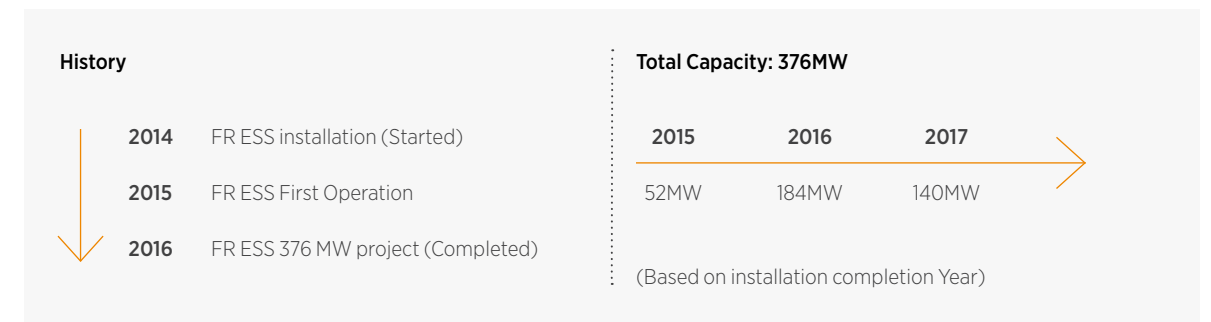
Seo-Ansung Smart Grid Test Site

In 2013, KEPCO announced plans for an ESS project following the government's electricity market policy. The \$242 million investment created a 376 MW by 2017.

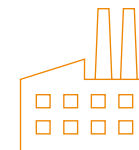
Currently in coal-fired generators, there exists a 5% reserve margin saved for frequency regulation. Replacing 500MW capacity with ESS, generators

can operate at maximum capacity. Resulting in savings of roughly \$271 million a year.

The Seo-Anseong project was designed so multiple companies could participate. This strategy allowed companies to accumulate development and operation experience and build appropriate track records for industry development.



EXPECTED RESULTS



Korea

- Improving thermal power plant's operation rate (100%)
- Minimizing future power facility investment costs



KEPCO

- Reducing power purchase costs up to KRW 320 billion/year
- Enhancing power quality and supply reliability



Growth Sharing

- Encouraging participation of major firms & SMEs
- Securing operation track record for technology export

Resulting in savings of roughly \$280 million a year.

Small Islands Microgrids

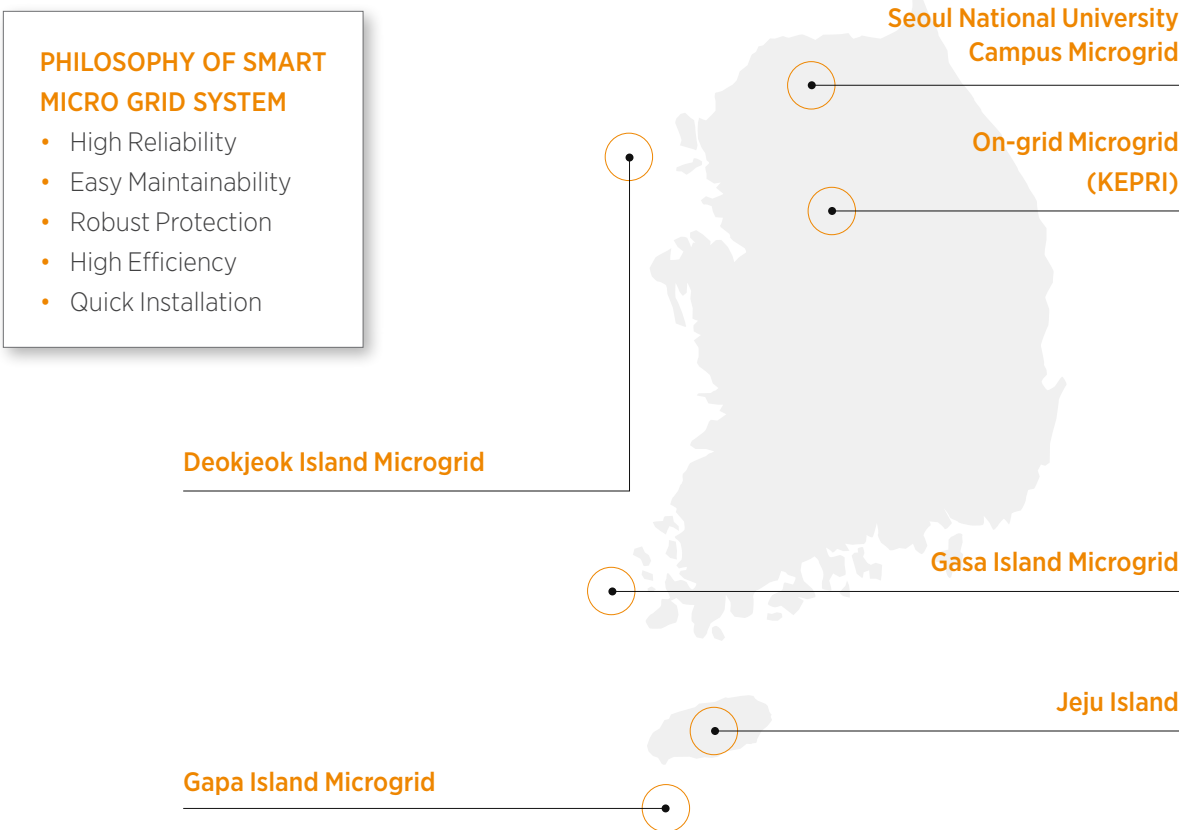
A new type of power supply system designed for the independent generation, storage, and consumption of power in a small area using New & Renewable Energy (NRE) and small, decentralized power sources. The technology can boost future economic growth of a country by providing a solution to the problem of global warming and reducing dependence on fossil fuels.

Microgrid refers to a system that helps effective generation and consumption of renewable energy. It refers to a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. It can connect and disconnect from such grid to enable it to operate in both On-grid and Off-grid mode.

Compared to a smart grid, a similar but larger scale project, *microgrids are set up in specific areas such as schools and industrial complexes to independently produce, consume and store energy.*

sustainable energy systems. A special feature of the Korean approach has been a focus on modular microgrids, with the development of an urban-based modular concept called the Smart Grid Station (SGS) and island-based microgrids. The objective behind energy self-sufficient island is to replace high cost diesel generators in islands with micro-grid with new/renewable energy converged with ESS.

In 2017 the Korean government set up a new energy business plan to promote the megawatt market, energy storage systems, energy self-sufficient islands, and other innovations in



Since 2013, several microgrid projects have been undertaken including in Deokjeok Island in Korea (Near Incheon International airport).

AREA	POWER CONSUMPTION
20.87 km ²	9,462 MWh in 2014
POPULATION	(Peak1, 770kW, Average 1,080kW)
1,669	
INDUSTRY	
Fishery and Tourism	

	Gapa Island	Gasa Island	Deokjeok Island
Area/Population	0.85km ² / 281	0.85km ² / 281	0.85km ² / 1,919
Customers	193	168	1,000
Configuration	WT + PV + ESS + AMI + EMS	WT + PV + ESS + EMS	WT + PV + ESS + EMS + Geotherm
Main Characteristics	Carbon Free Island (Korea's First)	Carbon Free Island	Ecology Energy Independent Island (Sterilization, Optimization)
Status	Operating	Operating	Project Started

SOLUTION FOR ENERGY SELF-SUFFICIENCY:	ESS	RENEWABLE ENERGY CONTROL	MG BENEFITS (DIESEL REDUCTION)
RENEWABLES	2 MW / 6 MWh (PCS/Batteries)	MG-EMS	933,494 (L) per year
PV 0.5 MW WT 1.5 MW	DIESEL GENERATORS FOR FREQUENCY REGULATION	ESS CONTROL	MG BENEFITS (CO2 REDUCTION)
	63 %	Smoothing/ Frequency Regulation Constant Power	2,408 (tCO2) per year

Implementing Change

Uniting Stakeholders Behind A Shared Vision



Instituting change across an industry requires a comprehensive approach. Typically, the largest environmental gains are achieved when heavy emitters and industry modify their behavior. Therefore, first improving and adjusting industry behavior BEFORE focusing on consumer behavior is most effective in creating change.

IMPROVE ENERGY INTENSIVE COMPANIES
In 2009 heavy emitters (25,000 tCO₂ or more) in Korea accounted for 67% of national GHG emissions. Green credits were created to help companies meet their targets. Emitters provided capital and technology to SMEs on energy efficiency projects. Then SMEs transferred their GHG reduction credits from the project to heavy emitters so they are able to meet their targets.

1. Planning and target setting

- GHG energy target management
- Cap and No Trade
- Energy intensive emitters (over 15,000 tCO₂) negotiates GHG reduction targets with the government
- Implement actions, then assess and fine if fail
- Identify energy saving factors: energy audit and green credits
- Energy Audits: Heat, Electricity, TVS
- Train energy auditors from the private sector
- Survey and analyze on-site energy management
- Identify energy loss factors and propose improvement measures.

2. Investments – Soft loans and Tax incentives, ESCO

- Soft loans provided to support energy efficiency investment (EE). Interest rate far lower than market rate (typically 1.5-1.75%)
- Tax credit of 10% given for EE investments
- Promote energy service company (ESCO) activities
- Soft loans to ESCOs have contributed significantly to their increase (from 4 in 1993 to 324 in 2015).
- Roughly \$2.13 billion invested between 1993-2014
- Average investment around \$1 million.

2,693 factories and buildings have been audited since 2014

Energy service companies (ESCOs)

develop, design, build, and arrange financing for projects that save energy, reduce energy costs, and decrease operations and maintenance costs at their customers' facilities. In general, ESCOs act as project developers for a comprehensive range of energy conservation measures (ECMs) and assume the technical and performance risks associated with a project.

ESCOs are distinguished from other firms that offer energy-efficiency improvements in that they use the performance-based contracting methodology. When an ESCO implements a project, the company's compensation is directly linked to the actual energy cost savings.

KOREA ENERGY AGENCY (KEA)

Since its establishment in 1980, Korea Energy Agency has been at the forefront of energy efficiency, renewable energy and rational energy use in Korea, and is a guardian of Korea's sound economic development and better quality of life. From energy audit services, identifying energy saving potential in energy intensive businesses, to systematic optimization of building and industrial energy consumption pattern using ICT, KEA has led the transformation into a low energy consumption culture.

KEA plays a pivotal role in shaping citizens understanding of energy use and behavior. The KEA mascot and penguin is now a popular character that can be found in citizen engagement campaigns.

DEFINITION

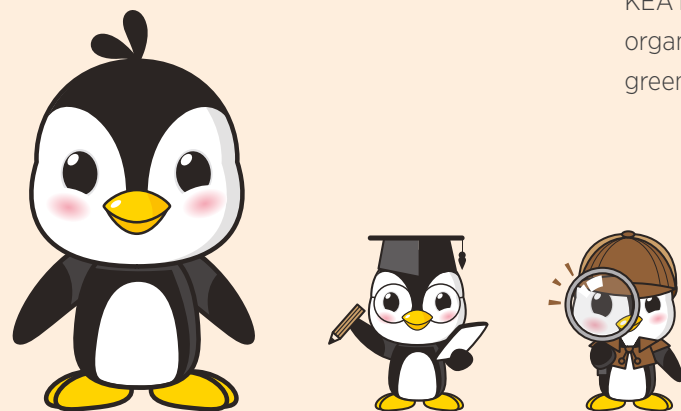
Program aims to encourage participation of the citizen

Energy conservation contest

KEA holds a contest of essays, posters and newspaper advertisement ideas for energy conservation, climate change and new and renewable energy.

Energy conservation social contribution campaign

Citizens, companies and other private organizations share ideas to save energy in the daily life to create social values.



Partnership programs with NGOs

- Partnership programs with private organizations
 - KEA implements partnership programs using networks of NGOs to promote energy saving and green lifestyle.
- Partnership programs with Korea NGOs' Energy Network
 - Korea NGOs' Energy Network is an association of 245 NGOs created in 2000. They include NGOs in the field of social issues including consumer, gender, and environment. KEA works with them to promote voluntary energy saving efforts of the citizen.

Electricity Conservation Portal page

KEA posts real-time electricity supply and demand status and other information on electricity conservation on its portal page to help address the recent power shortage issues.

Production and distribution promotional materials on energy conservation

- Produce printed promotional materials on energy conservation to raise awareness of the people and help mitigate power shortages
- The promotional materials include recommendations for power conservation, energy conservation posters and stickers for summer and winter season.

Award those who are active in energy conservation efforts

KEA identifies and awards individuals and organizations who contributed to low carbon green growth to spread energy saving culture.

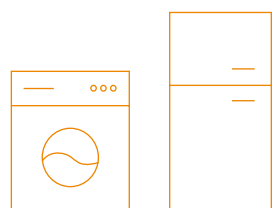


CHANGING CONSUMER HABITS

To achieve new energy targets consumer habits and behaviors often need to be modified. In many instances technological advances in appliances, building materials and transportation make upgrading an effective way to meet new efficiency targets.

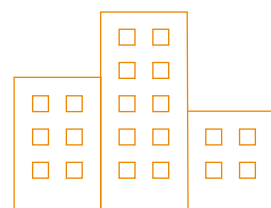
Appliances

- EE labeling: 27 most used items such as refrigerator, washing machines etc
- EE Certification: Certificate and rebates for efficient products of 47 high-use items, such as lighting, pumps etc
- E-Standby program for 21 items: PC, copier, set-top box etc: Automatic shift to low power standby mode
- Provide information for consumer choice
- Provide finance support for efficient appliance installation
- Require public organizations to use efficient appliances.



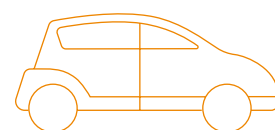
Promoting Energy Efficiency in Building & Transport

- Building energy codes: Induce low-energy buildings at construction stage
- Grade certificate is issued according to energy use per unit area, using simulation tool and on-site survey
- Target all types of buildings, new and old
- Energy Saving Plan submitted to local government when getting construction permit for large building (more than 500m2)
- Insulation standards continue to strengthen to achieve target of Zero Energy Buildings for new construction by 2025.



Transport Energy Efficiency

- Fuel Economy and Fuel Efficiency Labeling
- Require car producers and importers to meet average fuel economy standards
- Standard: 17 km/l or 140g/km
- First applied to passenger cars, then expanded to light trucks
- Require fuel efficiency labels on windows to raise EE awareness among consumers
- Tire Efficiency Labeling
- Promotes efficient tires and reduces fuel consumption.



NEW & RENEWABLE ENERGY (NRE) PROMOTION

Category	Sector	Tools	Programs
NRE Deployment Program	Private Sector	Subsidy	Household Subsidy Program (1 Mil. Green Homes)
			Building Subsidy (Non-Residential, Non-Public Bldg.)
			Feed-in-tariffs (FIT)
			Overseas Business Support
	Loan	Soft Loan	
	Regulation	Renewable Portfolio Standard (RPS)	
		Renewable Fuel Standard (RFS)	
Biz Promotion	PV Rental Program		
Public Sector	Subsidy	Local NRE Project by Local Govt.	
		Convergence Project (PV+Wind, Power+Heat, etc)	
		Establishment of NRE Test-bed	
Regulation	NRE Mandatory Use for Public Buildings		
Infrastructure-building Program	Private & Public Sector	-	Certification, Standardization, and International Cooperation
			R&D (Policy and Regulation)

Future Energy Plans Green New Deal 2020

The energy focus is on preparing for a paradigm shift towards future energy by actively investing in R&D facilities that promote the use of sustainable and renewable energy throughout the country. The country will invest roughly \$30 billion in the energy sector by 2025 to create 209,000 jobs.

Key investments include:

- Building a smart grid for more efficient energy management.
 - Advanced metering infrastructure (AMI), which is an integrated system of smart meters that enables two-way communication between suppliers and consumers, will be provided to 5 million apartments to help disperse energy needs and save energy.
 - An eco-friendly generation system will be established in 42 island regions to reduce emission from pollutants caused by diesel-powered generators.
 - Overhead cables providing electrical power or telecommunication will be replaced with underground cables in school zones and other areas in need (roughly \$1.7 billion by 2025).
- PROMOTE RENEWABLE ENERGY USE AND SUPPORT A FAIR TRANSITION:**
- Support will be provided to measure the wind conditions and conduct feasibility studies on up to 13 regions to find sites for large-scale offshore wind farms of either the floating or fixed-bottom types. Demonstration complexes will be established in phases.
 - Community benefit sharing for renewable energy projects will be introduced.
 - Higher support on loans for renewable energy will be provided to participating residents of farming areas and industrial complexes.
 - Support will be provided to 200,000 households for renewable energy facilities installed in residential or commercial buildings for private use.
 - A fair transition will be ensured for those regions that foresee difficulties coming from a reduced use of coal power and other traditional sources of energy by supporting their adjustment to the renewable energy sector (e.g. green mobility, digital management of renewable energy, platform for offshore wind farm, etc.).



The opening of the world's first byproduct hydrogen power plant which uses gas produced from processing petrochemicals was recently announced. Producing 50 megawatts, enough to supply 160,000 households the plant has a relatively small footprint and will produce no greenhouse gas. Korea now produces 40% of the world's hydrogen fuel cells and 'plans for exportation of the technology to become a key export industry' said Prime Minister Chung Sye-kyun.

Having deliberately invested wisely in green technologies has positioned the country to experience less costly energy, cleaner air for citizens and additionally established the technology to now be able to export to countries around the world. The impact of smart government leadership and strategic investments has a multiplier effect that ripples throughout the entire economy and benefits citizens for generations.

MULTIPLIER EFFECT

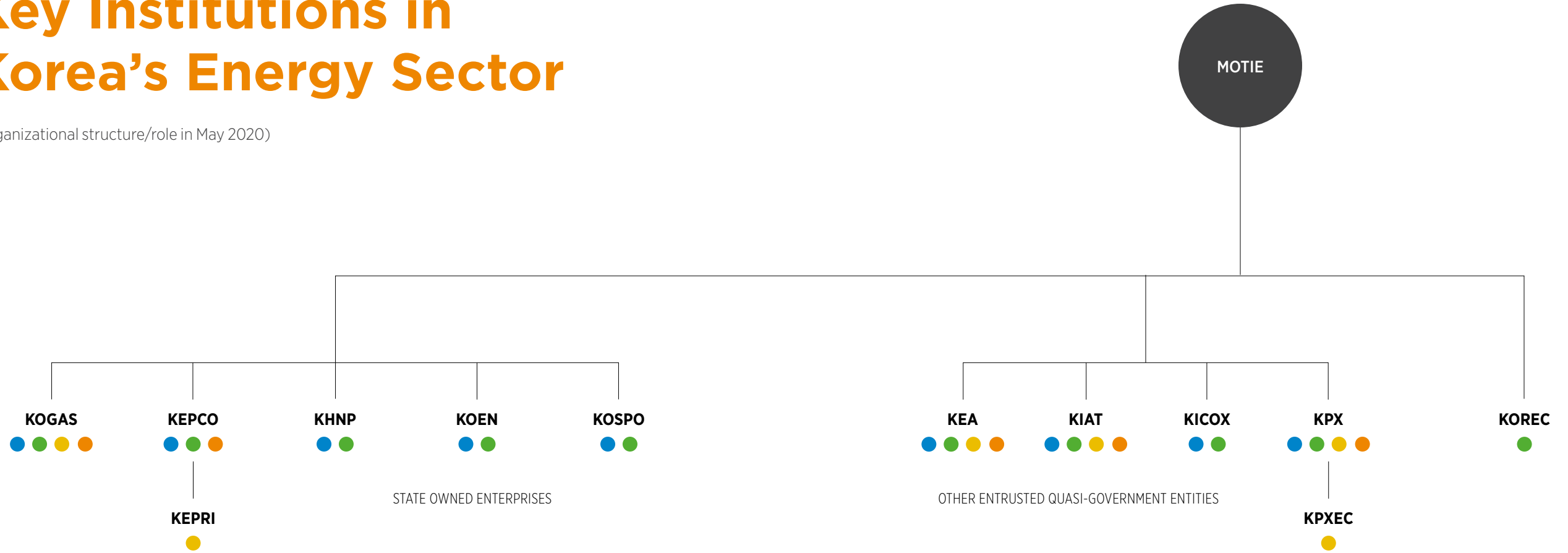
The multiplier effect of the green growth framework is what makes it such a successful strategy for countries to adopt. The greatest benefits are achieved when implemented across multiple sectors as sector integration (for example energy and ICT, transportation and ICT, solid waste management, transportation and ICT) creates the most dramatic improvements. But if investment across multiple sectors or an overall national plan is not feasible, taking the green growth approach in even one sector is a smart strategy as the emphasis on technology, sustainability, job creation and shared economic prosperity will position the sector for long-term success.

EXPANDING THE SUPPLY OF ELECTRIC AND HYDROGEN VEHICLES

- The provision of 1.13 million EVs including passenger cars, buses, and freight vehicles, will be supported along with the installation of 15,000 rapid chargers and 30,000 slow chargers.
- The provision of 200,000 hydrogen vehicles including passenger cars, buses and freight vehicles will be supported along with the installation of 450 charging facilities.
- Fuel cell plants and other infrastructure for the distribution of hydrogen will also be established.
- The scrapping of old diesel cars and the transition to liquefied petroleum gas (LPG) or electric vehicles will be supported.
 - Scrapping of 1,160,000 diesel cars and construction equipment, and 32,000 farming machines; and the transition of 135,000 freight and 88,000 school buses to LPG vehicles.

Key Institutions in Korea's Energy Sector

(Organizational structure/role in May 2020)



KOGAS
Korea Gas Corporation

KEPCO
Korea Electric Power Corporation

KEPRI
Korea Electric Power Research Institute (KEPCO-Affiliated Research Institute)

KHNP
Korea Hydro & Nuclear Power Corporation

KOEN
Korea South-East Power Co.Ltd.

KOSPO
Korea Southern Power Corporation

KEA
Korea Energy Agency

KIAT
Korea Institute for Advancement of Technology

KICOX
Korea Industrial Complex Corporation

KPX
Korea Power Exchange

KPXEC
Korea Power Exchange Education Center (KPX-Affiliated Training Institute)

KOREC
Electricity Regulatory Commission

● DOMESTIC AND OVERSEAS DEVELOPMENT IMPLEMENTOR
● RESEARCH + POLICY INSTITUTE

● IMPLEMENTING AGENCY/INSTITUTE
● CONDUCTING INSTITUTIONAL TRAINING & CAPACITY BUILDING



Ministry of Trade, Industry and Energy (MOTIE) stems from a ministry established in 1948. It is concerned with regulating economic policy, especially regarding the industrial and energy sectors. It was established as the Ministry of Trade and Industry (MTI) in 1948 and in 1993 was merged with the Ministry of Energy and Resources, an agency launched in 1977 to ensure stable energy supply, to create MOTIE. The ministry aims to become a knowledge-based economy by reinforcing traditional industrial strengths while developing new growth engines.



Electricity Regulatory Commission (KOREC) is an affiliate of the Ministry of Trade, Industry & Energy, and it plays a leading and essential role in the tasks of restructuring the electricity industry and creating markets based on fair competition. The major functions of KOREC can be categorized as follows; licensing electricity companies; facilitating competition and eliminating unfair practices; protecting the rights and interests of consumers; monitoring antitrust activities supervising the operation of electricity markets and power systems and restructuring the electricity industry.

Other Entrusted Quasi-Government Entities



Korea Energy Agency (KEA) established in 1980, is the government agency responsible for designing and implementing policies for energy efficiency, new and renewable energy, and climate change response. Its primary function is to manage nationwide energy use through technical and financial support, administrative services, and more while keeping environmental and socioeconomic sustainability in mind. The agency's scope of work includes rationalization of energy use, promotion of new and renewable energy, reduction of greenhouse gas emission as well as implement energy audit and technical assistance, among others. KEA implements cooperation projects with developing countries to build infrastructure for climate change adaptation and lay foundation of relative businesses. As a part of KEA's efforts of international cooperation, KEA develops GHG reduction and capacity building projects in developing countries. The goal is to help them adapt to climate change while giving new market opportunities to Korean companies. KEA runs networking agencies in 4 regions to support Korean companies to enter the new markets: 1) South-East Asia 2) Central Asia 3) South-West Asia 4) Central & South America.



Korea Institute for Advancement of Technology (KIAT) was recently established in May 2009 as a quasi-government institute (a public institute) under the Ministry of Knowledge Economy, according to the government's public institutes advancement plan. To promote Korea's industrial development and industrial technology innovation, KIAT plays a crucial role in suggesting R&D strategies for industrial technology through systemic technology planning and policy research. It will also strengthen the competitiveness of the industrial technology ecosystem in Korea by promoting various activities such as transferring and commercializing industrial technology, establishing an industrial technology infrastructure, supporting parts & materials industries, and regionally specialized industries. It also manages Korea's Industrial Technology Official Development Assistance's (ODA) budget and partners with developing countries around the world providing climate change related technology transfer.

State-Owned Enterprises (SOE)



Korea Electric Power Corporation (KEPCO) is the largest electric utility in South Korea and responsible for the generation, transmission and distribution of electricity and the development of electric power projects including those in nuclear power, wind power and coal. KEPCO is responsible for 66% of Korea's electricity generation. The Korean government owns a 51% share of KEPCO, and together with its affiliates and subsidiaries, KEPCO has an installed capacity of 65,383 MW.

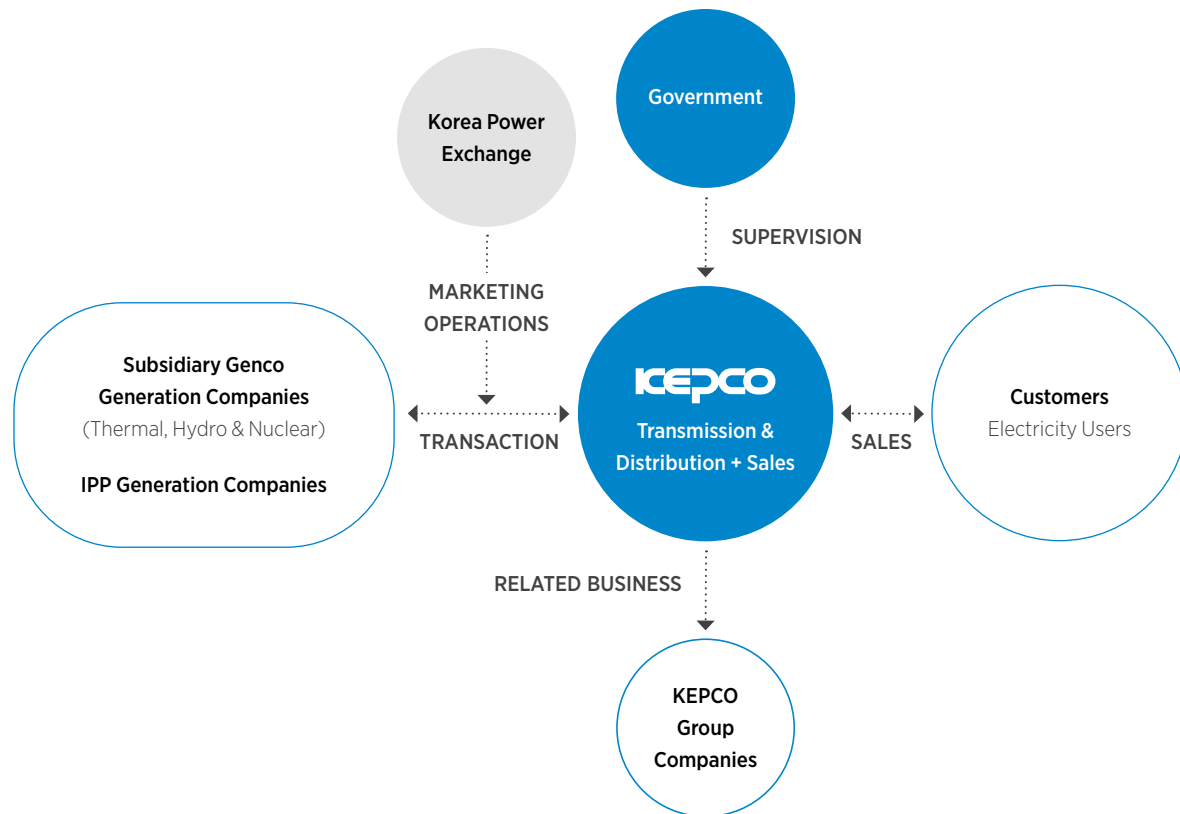


Korea Gas Corporation (KOGAS) is Korea's sole liquefied natural gas (LNG) provider and is principally engaged in the sale of natural gas. It was incorporated by the Korean government in 1983. The company operates its business through two segments. The Gas Introduction and Sale Business segment sells city gas and natural gas for power generation, among others. This segment introduces LNG from overseas natural gas production sites and supplies it to domestic power generation companies and city gas companies through national pipelines, tank lorry and others. The Other segment is engaged in the repair and maintenance of gas facilities, the construction and operation of LNG terminals, and the provision of engineering services. It currently operates four LNG terminals and a nationwide pipeline network spanning over 4,440km.



Korea South-East Power Co.Ltd. (KOEN) was established in 2001, after separating from the electricity generation department of Korea Electric Power Corporation (KEPCO). The company is headquartered in Jinju, South Korea. KOSEP produces and sells electricity in Korea and internationally. It develops electric power resources; and generates electricity through wind, water, thermal, fuel cell, and solar power resources. The company is also engaged in the operation and maintenance of utility plants, and the manufacture of fly ash industrial materials. It operates six power plants with a total capacity of over 8,156MW and supplies over 10% of the nation's energy. KOEN focuses on the development of combustion technology for environmental preservation and operates advanced environmental facilities with desulfurization and denitrification capabilities.

Korea Southern Power Corporation (KOSPO) a subsidiary of Korea Electric Power Corp. (KEPCO) specializes in the power generation industry, which was formed under the South Korean government's Power Industry Restructuring Act on April 2, 2001, when it was separated from Korea Electric Power Corporation ("KEPCO"). The company operates thermal power stations, wind power plants, and solar power plants in South Korea, using bituminous coal and LNG, electricity which it sells locally. KOSPO is currently running -9.6% (11,343 MW) of Korea's total installed capacity in seven core areas throughout the country including Shincheon, Busan, and Namjeju contributing to a



stable power supply in the domestic market. The company also offers power plant development, EPC management, operation and maintenance, commissioning and performance monitoring services, as well as engineering consulting services.



Korea Hydro & Nuclear Power Corporation (KHNP) is KEPCO's wholly owned subsidiary which owns and operates Korea's 21 nuclear power units (NPP) along with 27 hydro-electric power plants. Services provided by KHNP – ranked 3rd globally in NPP capacity – range from feasibility studies and technical assistance on plant design modification and improvement to overseas operation of Korean NPPs. KHNP employs roughly 7,600 employees. KHNP accounts for nearly 25% of Korea's generation facilities and supplies over 34% of the country's total power.



Korea Power Exchange (KPX) was founded in 2001 following reforms by the Korean Government to privatize the electricity market in 1999. It was founded for the purpose of undertaking wholesale electricity trading. It mediates the wholesale trading of power between generators and retailers. For example, KPX forecasts electricity demand for each trading day and receives bids from generation companies for available capacity, determines wholesale market price in accordance with a pricing mechanism under its Electricity Market Operation Rules (Market Rules). Utilities companies such as KEPCO then transport the electric power it purchased from KPX through the transmission and distribution network and sell it to general customers. It is independent from all electric utilities including KEPCO and operates the electricity market, the power system, and the real time dispatch.

Research Institutes



Korea Electric Power Institute (KEPRI) is a central research institute of KEPCO and its subsidiary companies. It was first established as the Electricity Test Facility for KEPCO in 1961 and for a half-century has been developing various technologies for stabilizing Korea's power supply, such as the real-time interpretation of the regional power grid, underground cable testing, and Korean distribution automation system. Technological focus areas include micro grid and frequency-control energy storage system, carbon dioxide capturing technology, and grid connection technology for the marine wind power complexes to power the 4th Industrial Revolution and its trend of energy conversion. Its Basic Power Research Center conducts joint research programs with other companies and universities to establish energy base university clusters to expand the technical cooperation network and make KEPRI the central research institution for the power industry in Korea.

Korea Institute of Energy Technology Evaluation and Planning (KETEP) is an energy technology R&D funding agency in the Republic of Korea that takes roles in planning, evaluating, and managing energy technology R&D projects in renewable energy, energy efficiency improvement technology, power, nuclear energy technologies, etc. KETEP also makes key energy technology policies including energy technology roadmaps, the national energy technology development plans etc., and supports commercialization of energy R&D projects carried out by enterprises, universities, and research institutes.



Korea Institute of Industrial Technology (KITECH) is a South Korean government research institute, established in 1989 to help develop technologies for the domestic industry, with focus on export competitiveness and SMEs. Its main research areas include manufacturing technologies, clean production system and integrated production technologies. Based on technical support infrastructures of local governments, universities and research centers, it undertakes for role of connecting industry and academia to technology research.

Korea National Clean Production Center (KNCPC) was established under the Korea Institute of Industrial Technology in 1999 to promote cleaner production technology infrastructures, develop industry environment policy, establish green management system, form resource circulation system and respond to international environmental agreements. It supports SMEs to adopt cleaner production practices through consulting, infrastructure development, and policy formulation.

Private Sector



LS Electric

Founded in 1974, LS Electric works to create an efficient convenient future through ICT convergence and the integration of sophisticated technologies while creating an abundant future by delivering safe, clean energy. LS Electric works with global markets to provide efficient and safe green solutions. LS Electric focuses on seizing new market opportunities in line with the increasing demand for intelligent power grids, new and renewable energy, manufacturing innovation, and efficient energy. LE Electric focuses on implementing strategies appropriate to different overseas regions. In the Asian markets, their focus is on power distribution and automation business, in the Middle East and African markets, their focus is on the power transmission and transformation EPC (Engineering, Procurement, and Construction) markets, in the American markets, their focus is on key strategic markets to further boost growth; and in the European/CIS markets, their focus is on a foundation on which to create opportunities to leap forward.



Hyosung Heavy Industry

HanYoung Industrial, founded in 1962, underwent a change of name in 1977 to become Hyosung Heavy Industries. Hyosung Heavy Industries exports its products to many corners of the world, including North America, the Middle East, and Europe while aiming to create environmentally

friendly infrastructure where humanity and nature can be sustained together. Hyosung Heavy Industries is deemed highly valuable not only in the area of electrical power equipment such as transformers and circuit breakers but also in electric motors and gears. The company possesses core technologies necessary for building the future such as electricity grids, including Energy Storage Systems (ESS), STATCOM, and Smart Grid etc. Hyosung Heavy Industries is engaged in various areas of construction, including the areas of housing, redevelopment and reconstruction, business and commercial facilities, civil engineering and environment, and SOC. Through constant research and investment, the company practices environmentally friendly management whereby humanity and nature can coexist and is determined to lead the era of low-carbon green life.



LG Electronics

LG Electronics is focused on developing new innovations across the globe and aims at improving customers' lives and businesses with leading products and world-class technology. LG Electronics has a strong global network with manufacturing and production plants, sales offices, and research and development facilities in 142 global operations. LG Electronic products include commercial display solutions, solar solutions, energy storage systems (ESS) and energy management solutions (EMS). LG's Solar

products offer the latest in solar technology that assist businesses to save money through unique energy efficient features. LG's ESS caters towards everything from design to integration, with electronics that have features that provide total solutions to customers. LG offers optimized HVAC solutions for all climate needs, providing fresh and crisp air for different business environments. LG Compressors and motors provide meaningful and differentiated values to customers sustainably by achieving world class eco-friendly energy saving technologies.



Hyundai Electric

Since 1977, Hyundai Electric has served as a partner to its customers on their growth path in the heavy electrical machinery sector by establishing, procuring, and building systems that enable efficient use of electric power through the integrated management of energy production, consumption, sales, and operation. Hyundai Electric pursues electric power efficiency and demand side management systems through business solutions linked with Factory Energy Management System (FEMS)- A system that provides an energy-efficient environment by integrating the analysis, operation, and management of energy consumption in plants, Building Energy Management System (BEMS) - A system that maximizes efficiency by integrating the analysis, operation, and management of energy used in buildings, Energy Storage System (ESS)- A customized system for energy production, efficiency or management, and Microgrid Solution (MG)- Next-generation power systems that support independent supply by building smart systems capable of self-sustaining power in small areas.



Hanwha Energy

As a Fortune 500 company, Hanwha's business spans across chemicals and materials, aerospace and mechatronics, solar energy, finance, leisure & lifestyle, and construction. From China, the Americas and Europe, to emerging markets in Southeast Asia and the Middle East, the company's goal is to support local operations, embrace the skills of new workforces and bring greater value and prosperity to the world. Hanwha's solar leadership is fundamentally transforming the way people produce, distribute, use and store energy, delivering alternative energy solutions that respond to several major problems facing the planet such as climate change, energy depletion, and energy poverty. Hanwha's petrochemical business is on the cutting edge with industry leading technology for petrochemical products, advanced materials, eco-friendly solar products and even nanotechnology. Hanwha has been a driving force behind innovation in aerospace, unmanned technology and machinery to make better future for lives and industries through precision in engineering and cutting-edge technology.



Samsung SDI

Since 1970, Samsung's SDI division has been creating innovative renewable energy and energy storage system with cutting-edge technology that is being experienced by homes, businesses and organizations worldwide. Samsung SDI's quality manufacturing and pioneering R&D sets the industry standards for everyone on the solar and energy storage technology market today. Samsung SDI is a manufacturer of the rechargeable batteries for IT industry, automobiles, and energy storage systems (ESS), as well as cutting-edge materials used to produce

semiconductors, displays, and solar panels. Samsung SDI's technology supplies eco-friendly energy solutions for the present and the future. The company provides safe, reliable and long-lasting performance with its Energy Storage solutions. ESS projects are deployed using Samsung SDI's battery solutions optimized for a range from residential to utility-scale projects.



LG Chemical

Since its establishment in 1947, LG Chem has continuously achieved growth through endless challenges and innovations as Korea's leading chemical company. LG Chem's globally competitive business portfolio includes Petrochemicals, Energy Solutions, Advanced Materials, etc. In the Petrochemicals business, the company has built a vertically integrated system from basic raw materials such as ethylene and propylene to the downstream products such as PE, ABS and synthetic rubber. The company has advanced its business structure by focusing on high-value added products such as nano-carbon tube. LG Chem has led the world lithium-ion battery market by leveraging its proprietary material technologies. As a global leader in the battery industry for EVs and Energy Storage Systems (ESS), the company has actively developed new products based on its proprietary technologies. LG Chem is rapidly developing distinguished materials for rechargeable batteries, the IT industry, and the automotive industry which are instrumental for e-Mobility and sustainability trends.



S-Fuelcell

S-Fuelcell, founded in 2014, focuses on business planning and technology development, sales, production, and A/S structured to cooperate

with outsourcing companies and the fuel cell market while minimizing the input of human/material resources. S-Fuelcell's business areas include: Fuel cell systems, hydrogen power generation systems, fuel conversion devices / fuel cell systems O&M (Operation & Maintenance), and follow-up management (A/S). S-Fuelcell has secured cutting-edge technologies both domestically and abroad based on many years of R&D and product sales experience in the field of fuel cells for buildings. The company is the first in Korea to acquire fuel cell facility certification for buildings from the Korea Energy Management Corporation (KEMCO) (Jul. 2014). The operating principles of fuel cell systems, fields of application, and S-Fuelcell's research history are on display at the Fuel Cell Experience Hall. Visitors can get hands-on experience of actual fuel cells and see how electricity and heat are generated during operation.



Doosan Fuel Cell

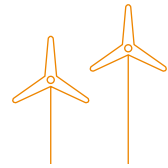
Founded in 2014, Doosan Fuel Cell provides green, reliable and robust energy solutions to promote eco-friendly hydrogen societies. Since UTC fuel cell supplied to NASA's Apollo missions, Doosan Fuel Cell has been delivering stationary fuel cells both home and abroad. The company leverages highly reliable decade-long CEP technology and has been a stationary fuel cell market leader. M400, the company's flagship model, is versatile and best suited for power plants, cold storages, large buildings or spas as it generates 440KW electricity and heat together. Furthermore, the model uses a wide range of fuels from natural gas, LPG to hydrogen. Doosan Fuel Cell is committed to developing and supplying efficient clean stationary fuel cells to satisfy the Korean Government's renewable energy plan while continuing to devote its practices to shaping the hydrogen future.



Doosan Heavy Industry (Doosan Heavy Industries & Construction)

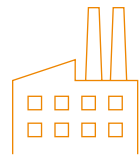
Founded in 1962 Doosan Heavy Industries & Construction owns core technologies and ongoing performance with the three core components of the power generation business - boilers, turbines and generators. Doosan is also making substantial inroads into the eco-friendly power generation business including wind power, ESS (Energy Storage System) and microgrid. The company is making efforts to clean the earth by concentrating on the development of technologies that maximize energy efficiency, such as power generation systems that use energy sources other than fossil fuels, i.e. wind and solar power, energy storage systems, and micro-grids. In addition to offering control system software, Doosan Heavy Industries & Construction delivers total solutions for microgrids. The company is expanding its business portfolio by constructing and operating ESS + solar power plants based on ESS technology. Wind Power Doosan has accumulated extensive know-how as a specialist in power generation facilities over the past 40 years, and has leveraged these competencies to develop the WinDS3000, 3300 and WinDS5500 and is developing an 8MW+ model especially for offshore wind farm projects.

Site Visits and Locations



Yeong-heung Wind Power Plant

Yeong-heung wind power plant is a wind power plant design with Korea renewable energy technology. It is located in Yeong-heung Island near the city of Incheon. It produces around 42 million kWh of electricity per year, supplying around 12,000 households' electricity demand.



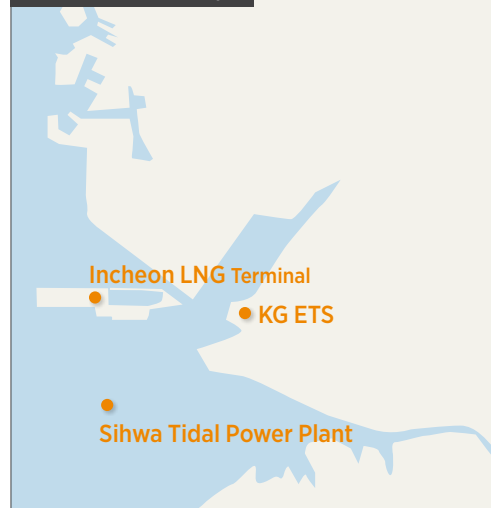
Yeong-heung Energy Park

Korea South East Power Co. (KOEN) is a power generating company separated from Korea Electric Power Corporation (KEPCO) in accordance with the Korean government's policy on Electric Power Sector Restructuring announced on April 2, 2001. KOEN has now operated six power sites: Samcheonpo Division, Bundang Division, Shin-Yeong-heung Division, Yeongdong Division, Yeosu Division and Yeong-heung Division.

Yeong-heung Division has six units in operation with a combined capacity of 5,080 MW, supplying approximately 25% of electricity consumption in the Seoul Metropolitan Area. It is Korea's largest thermal power site and the only coal fired power site located in the Seoul Metropolitan Area. With advanced environmental equipment in operation, they strive to protect the environment while expanding employment while finding ways to contribute to the local economy through activities that improve the quality of life for local residents. They operate new and renewable energy facilities such as 2 MW photovoltaic power plant, 12.6 MW small hydro plant, 46 MW wind power generation complex and 4 MW Energy Storage System which supports reduced carbon and green growth.

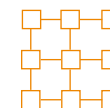


MAP B Seoul Vicinity



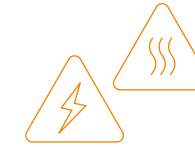
Soyang River Dam

Built in October 1973, Soyang Dam is Asia's largest and the world's fourth largest rock-fill dam. It stands 123m high and 530m long, and can generate 200,000kWh of electricity. It serves multiple purposes including flood control, hydroelectric power generation, irrigation, and fishing. It holds 29 million tons of water, which has become Soyangho Lake, Korea's largest man-made lake. Spanning a large area that borders the Gangwon-do cities and districts of Chuncheon, Hongcheon, Yanggu and Inje, the lake is often referred to as an "inland sea". Passenger ferries bound for Yanggu and Inje run along the 60km long water route that leads to Seoraksan Mountain.



Smart grid system (KEPCO)

Smart Grid Station of Korea Electric Power Corporation (KEPCO) is an integrated regional-based control center for best-managing independent energy systems converged with information and communication technologies. The project widely embraced diverse areas of smart grids and renewable energy encompassing heating/cooling, photovoltaic, wind turbine, energy storage system, advanced meter infrastructure, and electric vehicle charger. Each building is installed with an EMS that integrates various independent systems, such as renewable energy resources, energy storage, smart devices, heating and cooling devices, etc. The Smart Grid Station of KEPCO reduced indoor energy consumption by 10% of and reduced peak demand by 5%.



KG ETS

KG ETS has contributed to energy production and environmental conservation based on our abundant experience and expertise accumulated with world-class industrial waste incineration processing facility and energy production facility. It supplies high quality electricity and steam to 70 production factories in Shihwa Industrial Park.



LSIS - Smart building system (BEMS)

LSIS is the first domestic power and automation company based on 'quality assurance' and 'innovation'. In line with LS Industrial Systems' mission of 'Futuring Smart Energy', it is continuously maintaining the world's best quality and technology in power and automation business. The electric power sector is strengthening its position as the strongest power distributor in Korea and is increasing its global market share in China, the Middle East and Southeast Asia. The smart energy business such as smart grid, micro grid, ESS, and solar power has also become a representative company in Korea. It is also the first Korean company to enter the HVDC market and enter the global market.



Korea Hydro & Nuclear Power Corporation (KHNP) Hangang Hydropower site

Hangang Hydro Power Site is the headquarters of hydraulic power generation division supervising 10 hydraulic power plants (Hwacheon, Chuncheon, Euiam, Gangneung, Cheongpyeong, Paldang, Seomjingang, Boseonggang, Goesan and Anheung) scattered in 5 Dols (Gangwon, Gyeonggi, Chungbuk, Jeonnam and Jeonbuk) in a systematic manner.

The total capacity of the hydraulic power plants is 603MW. During the flood season, Hangang Water System Remote Supervisory Control Station focuses on prevention of flood damage to the residents in the downstream regions and in the capital region. Prevention is controlled through interconnected operations with seven dams in the Hangang water system and through close cooperation with Han River Flood Control Office. In the dry season, the control station distributes water to the dams in the Hangang water system, and the Paldang dam finally supplies water to 2,200 million people in the capital region.

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With sincere thanks to all of our knowledge partners for their collaboration, technical expertise and valuable contributions to the creation and production of this rich green growth resource:



KGTF is committed to sharing technical knowledge and first-hand experience of implementing integrated green growth solutions that contribute to sustainable development and shared economic prosperity.

To learn more about us visit www.wbgkgtf.org and for enquiries about grant applications please contact the Country Management Unit at your local World Bank office www.worldbank.org.



Korea
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