Strategy of Technology Innovation for Carbon Neutralization

July 7th, 2021

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I Korea's Current Status and Implications

01 Emission Status

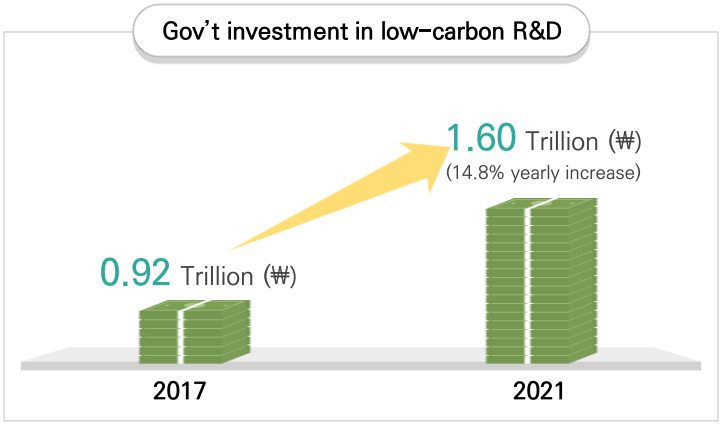
- **GHG emissions rised in key sectors until 2018**
  - [Emissions] ('17) 797 mln tons ➡ ('18) 727.6 mln tons
- **High percentage of coal power generation compared to developed countries**
  - [Coal power generation] ('17) 10TWh ➡ ('19) 225TWh
- **Energy-intensive industrial structure**
  - Manufacturing sector / energy-intensive sectors' (%, '19)
  - 28.4 / 8.4

Implications

Innovative technologies required to build GHG reduction capacities by efficiently supporting the expansion of carbon-free power generation sources and low-carbon transition of carbon intensive industries

02 R&D

- (Commercialization) New technology commercialization 30% (2018), limiting spread of outcomes



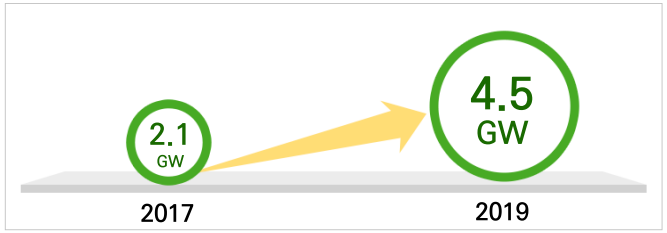
Implications

Despite continued growth of technical capacity due to mid-long term support, limitations in commercialization still exist

➡ Must create tangible outcomes For field application

03 Industries

- Government-led market is in formation, however competitiveness is limited due to small scale
  - Expanding RE dissemination through RPS, etc.



- Low-carbon industrial innovation is underway, but requires private sector's active participation and cooperation

Implications

Must create competitive new industries and accelerate the transition of carbon-intensive industries

➡ Need to create an ecosystem that encourages private sector participation

Technological Innovation to drive Korea's 2050 Carbon Neutrality

Establishing a technological innovation ecosystem that provides innovative carbon reduction measures

Policy Goals

Acquiring global leading technology	Carbon neutral Technology proliferation	New low-carbon industry
95% of advanced countries by 2040	Net-zero emissions from Industries by 2050	New low carbon Industry ecosystem

Strengthened support for
commercialization of new technologies through collaboration between ministries

Technology Development

01	Core Technology	Carbon neutral technology innovation (10 Core Technology Development Strategy)
02	R&D	Pan-governmental carbon neutral R&D project planning and launching

Ecosystem Creation

03	New Industries	Intensive support of core technology commercialization
04	Private-led Transition	Encouraging environment for active participation from the private sector
05	Strengthening R&D Foundation	Human resources development and strengthening of the legal and institutional foundation

5 Strategies: Detailed Implementation Plans

① Strategy to develop 10 core technologies for carbon neutral technology innovation

- Identification of 10 Core Technologies based on 1) LEDS, 2) sector analysis, 3) contribution level of GHG emission reduction, 4) relevance to major sectors, and 5) policy environment

Linkage With National Planning	Contribution Level of GHG Emission Reduction	Analysis of key Industry linkage
Green New Deal, LEDS	Percentage of GHG emissions by sector	Technological advancement and ICT technology convergence in line with key industries
Establishing key areas to achieve carbon neutral targets	Deriving key areas with high levels of contribution to GHG reduction	Developing key industrial areas and consideration of base technologies

Sector	Energy Transition	De-carbonization of Industries	Transport	Buildings
GHG Emission Percentage (2018)	37.0%	36.0%	13.5%	7.2%

10 Core Technologies

- Solar·Wind
- Hydrogen
- Bioenergy
- Steel·Cement
- Petro-chemical
- Industrial Process Enhancement
- CCUS
- Transport Efficiency
- Building Efficiency

Digitalization

5 Strategies: Detailed Implementation Plans

① Strategy to develop 10 core technologies for carbon neutral technology innovation

Solar/Wind Power

Securing solar energy super-gap leading technology

Key Indicators

- **Solar Cell Efficiency**

(present) 27% ➡ ('30) 35% ➡ ('50) 40%

Commercialized (2020)

Technology Development

01 Next generation energy efficient technologies (high-efficiency tandem), to replace existing tech in timely manner

02 Streamline installation & operation of water and sea systems (secure economic feasibility)

03 Development of urban solar energy technology (ultra-light photovoltaic cells, etc.)

Securing leading technology for larger wind turbines

Key Indicators

- **Wind Turbine Capacity**

(present) 5.5MW ➡ ('30) 15MW ➡ ('40) 20MW

Technology Development

01 Increase self-sufficiency of core component technologies such as large blades

02 Commercialization of large-scale floating wind farms

03 Ensure system stability and operational reliability

Hydrogen

Securing hydrogen life-cycle technology

Key Indicators

- **Hydrogen charging station supply price** (₩/kg)

(present) 7,000 ➡ ('30) 4,000 ➡ ('40) 3,000

- **Hydrogen unit generation cost**(₩/kWh)

(present) 250 ➡ ('30) 141 ➡ ('40) 131

Technology Development

01 Low-cost and mass production of hydrogen technology

02 Development of long-range and large-capacity hydrogen storage and transportation technologies

03 Development of high efficiency and long-life fuel-cell power system

Bioenergy

Securing leading Bioenergy technology

Key Indicators

- **Biofuel price competitiveness** (compared to fossil fuels)

(present) 120~150% ➡ ('30) 100% ➡ ('45) 85%

Technology Development

01 Development of low-cost, high-efficiency, high-quality and mass production technologies

02 Development of electric cycle technology for the utilization of unused biomass and expansion of application sites

5 Strategies: Detailed Implementation Plans

Technology Development

1 Strategy to develop 10 core technologies for carbon neutral technology innovation

Steel · Cement

Securing low-carbon conversion technology for steel and cement industries

Key Indicators

- Fuel & raw materials rate of substitution (hydrogen) for hydrogen-powered steel technology
  (present) 0% ➡('40) 100%
- Cement limestone substitutability rate
  (present) 0% ➡('40) 8%
- Cement fuel circulation substitutability rate
  (present) 24% ➡('40) 65%

Technology Development

01 (short-medium term)Low carbon furnace dev' ➡(long-term) hydrogen powered steel tech for the steel industry

02 Development of low-carbon fuel and raw material substitute technology for the cement industry

Petrochemical

Implementation of low-carbon, next-generation petrochemical technology

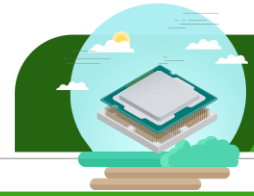
Key Indicators

- Price competitiveness of carbon-neutral raw materials
  (compared to petrochemical equivalent)
  (present) 150% ➡('40) 100%

Technology Development

01 Biomass, petrochemical raw materials utilizing resource circulation, value-added product manufacturing technology

02 Development of manufacturing process electrification (renewable linkage) and low energy technology



Industrial Process Enhancement

Maximize efficiency of industrial process

Key Indicators

- Efficiency of emission reduction technology for semiconductor and display manufacturing
  (present) 80% ➡('40) 95%
- Error in energy efficiency design for industrial processes
  (present) 30% ➡('30) 5% level

Technology Development

01 Improve efficiency of gas emission reduction for manufacturing processes and development of low GWP substitute gas

02 Development of technology for smart devices, manufacturing process optimization, and factory upgrading

5 Strategies: Detailed Implementation Plans

① Strategy to develop 10 core technologies for carbon neutral technology innovation

Transport Efficiency

Secure carbon-free, next-generation mobility

Key Indicators

- Next-generation battery density
  - (present) 250Wh/kg ➡('45) 600Wh/kg(commercialized)
- High-speed hydrogen charging technology
  - (present) 1.6kg/min ➡('30) 7.2Kg/min

Technology Development

01 Early commercialization of next-generation battery and charging technologies

02 Development of high-durability and high-output technologies for mobility fuel cells

Building Efficiency

Establishment of a foundation for carbon-neutral building implementation

Key Indicators

- Building Energy Efficiency
  - ('30) Secure technology for 30% enhancement
- Zero energy building costs (compared to remodeling)
  - (present) 130% ➡('45) 105%

Technology Development

01 Improvement of building envelope performance to secure economic feasibility of zero-energy buildings

02 Maximize efficiency of unit technologies such as next-generation HVAC systems

03 Development of building ICT convergence technology

Digitalization

Digital-based energy efficiency optimization

Key Indicators

- Data center power consumption
  - ('30) Reduce over 20%
- Application of management system
  - ('40) Application of AI-based next-generation management

Technology Development

01 Maximize efficiency of ICT devices and infrastructure

02 Energy data aggregation and utilization technology

03 Next-generation power grids and high-capacity energy storage technologies

CCUS

Securing CCUS Commercialization Technology

Key Indicators

- Price competitiveness of commercial-grade CO_2 capture
  - (present) 60$/ton ➡('30) 30$/ton ➡('50) 20$/ton
- Price competitiveness of CO_2 conversion products (compared to current market price)
  - (present) under research ➡('40) 100%

Technology Development

01 Reduction of acquisition costs by developing innovative introduction, improving efficiency, and transitioning to larger-scale.

02 Domestic environment-based empirical study to verify technology and secure safety

5 Strategies: Detailed Implementation Plans

Photovoltaics

Current Status and Issues

01 China's aggressive price reduction and the limitations of commercial technology
02 Increase in demand for location diversification (water, buildings, etc.)
03 Increase in need for applied sector expansion in cities, etc.

※ Expansion of large-scale facilities in China's Longi, Jinko and Trina have led to a drop in module prices
※ The marginal efficiency of silicon solar cells, which currently account for more than 95% of the solar market, is 30%
※ Applied markets for water, sea, building (BIPV) are expected to rapidly expand in response to the global drive to carbon neutrality

Technology Development

01 Swift commercialization of next-generation high-efficiency technologies (high-performance tandem) to replace commercial technologies
02 Streamline the installation and operation of water and sea systems (secure economic feasibility)
03 Promotion of urban solar energy (ultra-light photovoltaic cells, etc.) technology development

※ Achieve maximum efficiency through the diversification of materials and methods, promote commercialization by inducing the joint development of industry, academia, and research, and promote the verification of water and marine systems safety and reliability

Policies and Institutions

✓ Establishing a foundation that promotes commercialization and market-entry mechanisms such as the installation of demonstration infrastructure, establishment of a new technology certification standard, and creation of public demand

* Expansion of Renewable Portfolio Standards(RPS), targets, ratios, etc. under review

Expected Results

✓ Increase solar power generation by reducing the required area (60% of current standard) and expanding applications (sea, building walls, etc.) by maximizing efficiency

※ Example) Area required for 1GW facilities: Present(module efficiency 21%) 14.2㎢ ➡'40 (module efficiency 35%) 8.5㎢

Strategy for Solar Technology Development

※ Period that requires intensive govt support

Division	Current Level	Short term (~'25)	Medium term(~'30)	Long term (~'50)	Goals
High Efficient Solar Cell	Battery efficiency ~26.7% Module efficiency ~21%	Tandem gap maximization, ultra-high efficiency Secure long-term stability / high durability		Commercialization	• ('30) Tandem cell eff. 35%, Module 30% • ('50) Multi-junction cell efficiency over 40%
Photovoltaic System	Unit cost of installing floating PV system : 13.5 tln ₩/MW	Water/Marine PV system Dev. of convergence system	Securing durability and affordability Demonstration of convergence systems		• ('30) Floating PV energy installation unit price (400 mln ₩ /MW) • ('50) (Floating PV energy installation unit price (270 mln ₩ /MW)
Carbon-neutral Urban PV Energy	Flexible solar cell efficiency ~20%	Increase efficiency of lightweight/flexible/translucent/high-sensitivity solar cells(inorganic thin film, organic/inorganic perovskite, organic, etc.) Development/commercialization of high-intensity functional modules		Commercialization	• ('30) Ultra-light flexible tandem cell efficiency 30% • ('50) High intensity and durability module

5 Strategies: Detailed Implementation Plans

② Planning and launching of pan-governmental carbon-neutral technology innovation R&D project

Promoting **"Running the Life-Cycle Together"** for two tracks:
1) Field-specific R&D based on urgent industrial demand and 2) forward-looking R&D for mid to long-term innovative resources

01. Acceleration of commercialization of field-specific low carbonization core technologies

Field-specification

① Stabilizing expansion and systemization of RE generation
② Transition of carbon-intensive industries (Steel, cement, etc.)
③ Carbon-free transport
④ Commercialization of sector-based core technologies, such as improving building efficiency

※ Development of GHG reduction tech for industries such as steel, cement, semiconductor, display, petro-chemical, oil refining

※ Development of hydrogen locomotive and vehicle technology, hydrogen-powered fishing boats and ships, recycling technology for metal-containing waste resources such as solar waste panels

02. Stage-by-stage acquisition of mid to long-term carbon-neutral basic and original technologies

Pan-governmental Collaboration

- Multi-department joint development of hydrogen supply, CCUS and plastic technology ('22~)

Overcoming Limits

- Promoting the top 10 technological innovation projects with the most significant impacts ('21.Preliminary feasibility study, MISTI)

– Form 10 large research groups composed of top private experts, mid to long-term support

※ Promote 2-track R&D for top 10 high-efficiency core technologies ('30),

03. Energy efficiency innovation through digitalization in all sectors

Utilization of ICT

- Technology development to increase intelligence-based efficiency for all stages of the energy cycle (production, distribution, consumption) ➡Promoting its demonstration with a "Carbon Neutral City"

※ (power generation) Predicting and controlling renewable power generation (MOTIE), (consumption) Development of customized EMS/Digital Twin (MOTIE, MOLIT, MISTI) ('21~)

ICT

- Maximize efficiency of data centers, wired and wireless networks, and ICT devices

※ Optimization of intelligent server heating and cooling, operation of a dynamic usage-linking network and PIM semiconductors (MISTI, '22~)

5 Strategies: Detailed Implementation Plans

3 Establishment of an intensive support system leading to the creation of new industries

01 Promote early commercialization of new carbon-neutral technologies

- **Expanding regulatory sandboxes for carbon neutral technologies and strengthening support for demonstration and commercialization by establishing regulation-free special zones and R&D zones**
  - Expansion of regulation-free zones for carbon neutrality sector (2020 11 zones ➡ 2025 Total 20 zones)
  - Establishment of special demonstration test beds and initial access to special demonstration cases (2021~)
- **Promotion of region and industry linking technology industrialization by fostering 100 technologies with commercialization potential and utilizing the influence of R&D zones and universities**
  - Utilizing government-funded (research centers) convergence research and infrastructure to promote early field application (~'2024)

02 Support creating a carbon-neutral new technology industry

- **Start-up support ➡ Linkage to public demand ➡ Expand support for the full-cycle growth of carbon neutral technology companies, such as green ventures and guarantees**
  - Expand support for technological start-ups such as the 'Green Start-Up 2000' and university start-up laboratories
  - Designation of carbon neutral technology innovation products and continued expansion of pilot purchasing projects
  - Selection of leading companies in the sectors of green venture investments, green guarantees, carbon neutrality and the provision of incentives

4 Promote low-carbon innovation in which the private sector is the key player

01 Enhanced institutional support for the spread of new technologies and products

- **Preparation of an incentive roadmap ('22) and preemptive establishment of standards and certification systems for commercialization of new technologies and promotion of market entry**
  - Establishing national measurement standard systems, such as those for emissions measurement and reduction technology reliability evaluation to enhance reliability of data related to carbon neutral tech & industries ('21.3~)
- **Completing the technological regulations and standards necessary for commercialization using the entire process of productization ➡ market-entry ➡ on-site dissemination ➡ carbon reduction**
  - (e.g.) Establishment of safety regulations for the transportation, storage, and processing of liquefied hydrogen, etc.

02 Promotion of private investment in innovation

- **Reviewing the expansion of carbon neutral R&D tax credits and easing corporate matching investments and technology fees**
  - Additional review of carbon neutral core technologies subject to new growth resource and technology R&D cost tax credits and the prioritization of investment in new growth technology facilities

5 Strategies: Detailed Implementation Plans

5 Reinforcement of research capabilities and foundations that continue to innovate technologies

01 Fostering innovative talent

- **Promoting cultural expansion by fostering human resources customized for low-carbon industries through education, exhibitions, etc.**
  - Developing professionals for seven industries including steel, cement, etc. (₩201 billion in 2021)
  - Expansion of carbon neutral domestic science classrooms (2 new), special climate crisis exhibition at the Science Museum ('22~) and the campaign for CCBK(Carbon neutral, Carbon zero, By Korean science and technology) Campaign ('21.4.~)

02 Strengthening the foundation for international cooperation

- **Continuous discovery of cooperation agenda items related to major countries, such as the Korea-U.S. summit, and expansion of joint research**
  - Organize and operate a planning committee centered on industry, academia, and researchers to actively discover agenda items ('21) and promote preferential support for international joint research projects
- **Reinforcement of overseas demonstration and commercialization of carbon-neutral new technologies through CTCN**
  - Strengthening the NDE's role and supporting full-cycle technological innovation by discovering demand through CTCN, large-scale commercialization utilizing GCF resources, etc.
  - Designate the Climate Technology Global Cooperation Center under the MSIT
  - Establish CTCN Partnership & Liaison Office opening in Incheon City in 2021 with cooperation with the CTCN/UNEP

03 Innovation foundation to secure long-term sustainability

- **Provision of a stable promotion platform for climate technology development, climate response funding, etc.**
  - Enactment of the 『Promotion Mechanism for the Development of Climate Change Mitigation Technologies』 for the safe promotion of climate technology development, international cooperation, and etc.

THANK YOU