

Challenges of Decarbonization Policies and Technological Innovation toward Carbon Neutral Society in Korea

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1 Background of Carbon Neutrality

- UN IPCC (2021): 「Climate Change 2021: The Physical Science Basis」
- WWF (2020): The projected loss of GDP over the next 30 years due to the climate crisis **is more than \$83 billion (USA), \$80 billion (Japan) and \$10 billion (Korea).**
- What level should GHGs be reduced to maintain 1.5 degrees?
 - Net Zero Carbon by 2050
- **Carbon neutrality:** Achieving net-zero carbon dioxide emissions.
- Book “Six Degrees” say ;
 - Increase of 1°C: Extinction of polar bear
 - 2°C: Melting Greenland, Surging death for heatstroke
 - 3°C: Disappearing Amazon, 4°C: Flooding New York city
 - **5°C: Burning all jungle, intensifying flood and drought**
 - **6°C: Extinction 95% of creature (6 degrees)**

**Energy transition,
Industry restructuring,
Change of transport and
building**

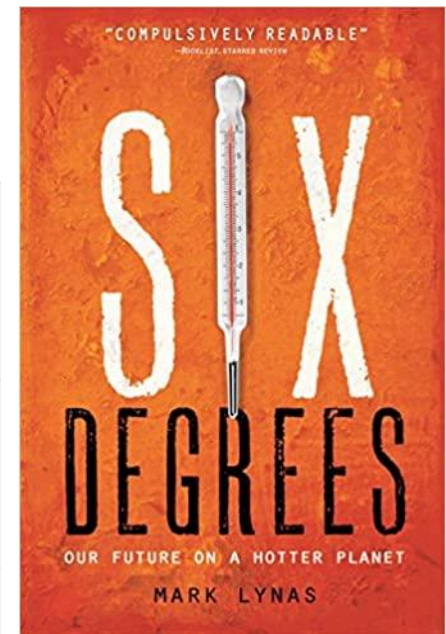
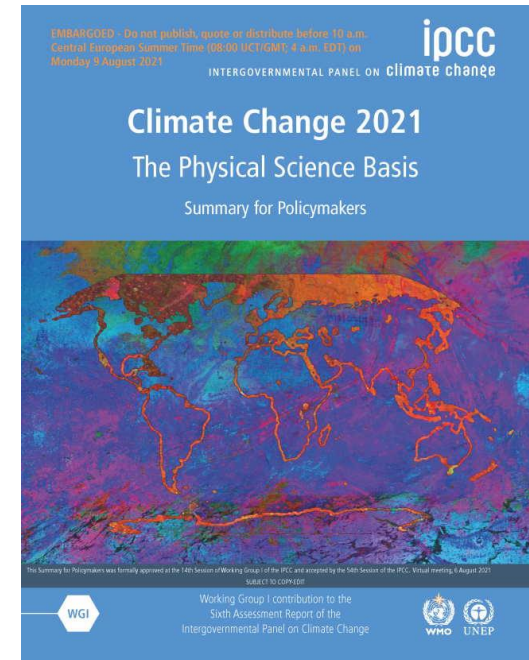
- Innovative transformation in energy source
- Innovative industry restructuring
- Accelerate 4th industrial revolution

**Drastic technical innovation,
Securing finance**

- Expansion of investment for SOC to respond to climate change, and increase technology R&D
- Increasing financial roles ; public and private

Civic education, co-operation

- Encouraging citizen participation and
- Strengthening community-based cooperation



2. Response of Countries and Companies for Carbon Neutrality

- **(EU)** After the announcement of the European Green Deal (2019),
 - Legalize 2030 reduction target to achieve carbon neutrality
 - Approved the “European Climate Law” (**55% reductions below 1990 levels by 2030**),
 - Announce Fit for 55 with CBAM(**Carbon Border Adjustment Mechanism**) as a means of implementation
 - **‘Fit for 55’ means the legislative package of 13 bills**
- **(USA)**
- **Invest** \$2 trillion for clean energy and low-carbon infrastructure,
- Reinforcement of automobile carbon emission regulations.
 - (**Targets**) Achieve 100% clean energy economy and net zero GHG emissions before ‘50
 - (**Power generation**) Carbon pollution free by 2035
 - (**Building**) Reducing carbon footprint by 50% by 2035
 - (**Transport**) Building 500,000 EV charging stations by 2030

“Fit for 55” legislative package (EU)

- Reduce emissions at least 55 percent by 2030 compared to 1990 levels.
- Comprised of thirteen proposals
 - : Eight are revisions to existing laws, five are new proposals.

[Fit for 55 – new proposals]

Forest Strategy ; to improve quality, quantity and resilience of EU forests,
- **ensure sustainable use of biomass, and plant three billion trees** by 2030.

Carbon Border Adjustment Mechanism(CBAM) ; to place a carbon price on imports and prevent EU companies being **undercut by energy-intensive competitors**;

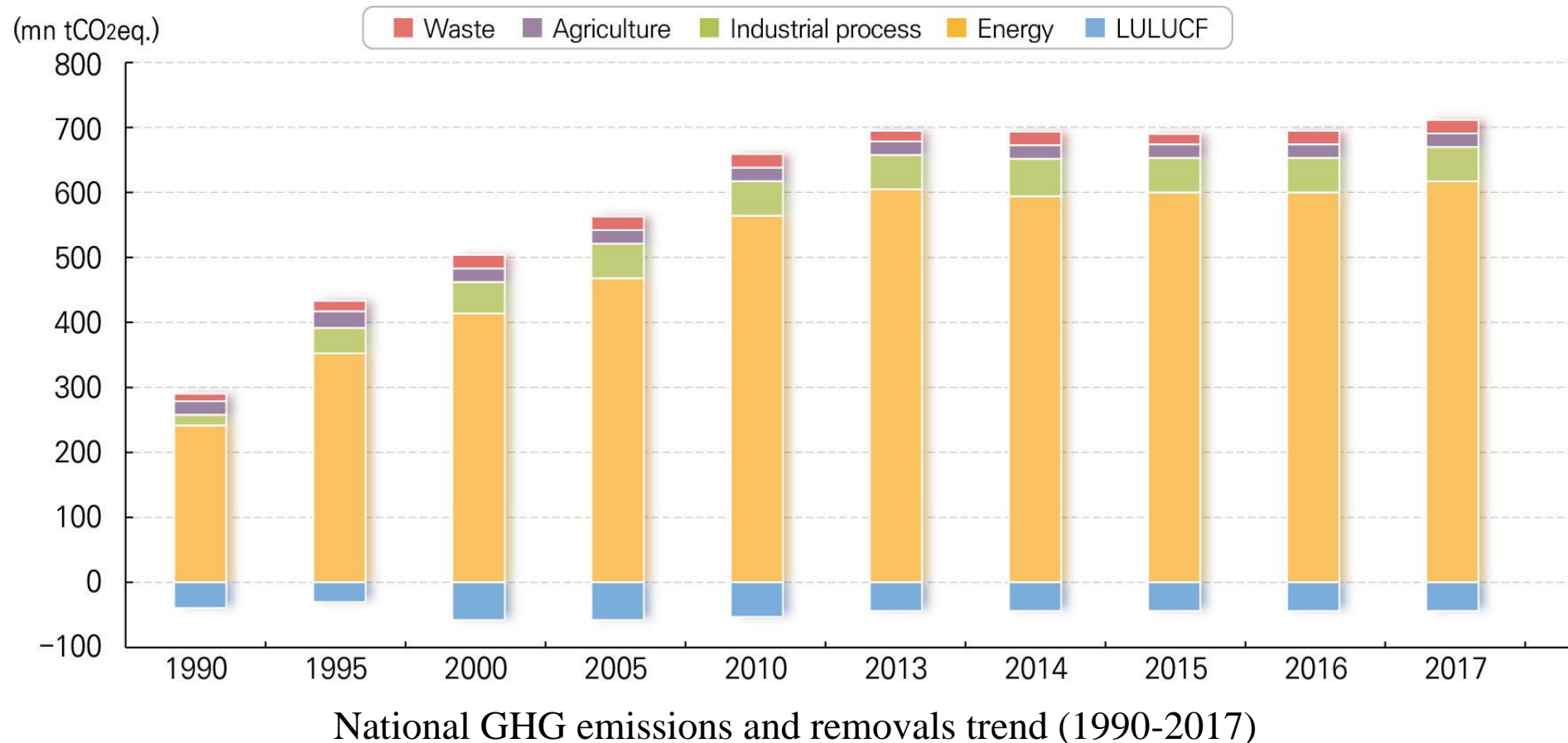
Social Climate Fund ; **to help citizens finance investment** in energy efficiency, clean mobility and renewable energy;

ReFuelEU Aviation Initiative ; to oblige fuel suppliers to **blend more sustainable aviation fuels in jet fuel, including e-fuels**;

Fuel EU Maritime Initiative ; to stimulate **uptake of sustainable maritime fuels** and zero-emission technologies.

3. Current Situation and Outlook for Carbon Neutrality in Korea

- In 2017, total GHG emissions in Korea were 709.1 million tCO₂eq of GHGs, which is 2.4% up from the previous year (727.6 million tCO₂eq as of 2018)



< Korea's GHG Emissions Status by Sectors (2015-2020)

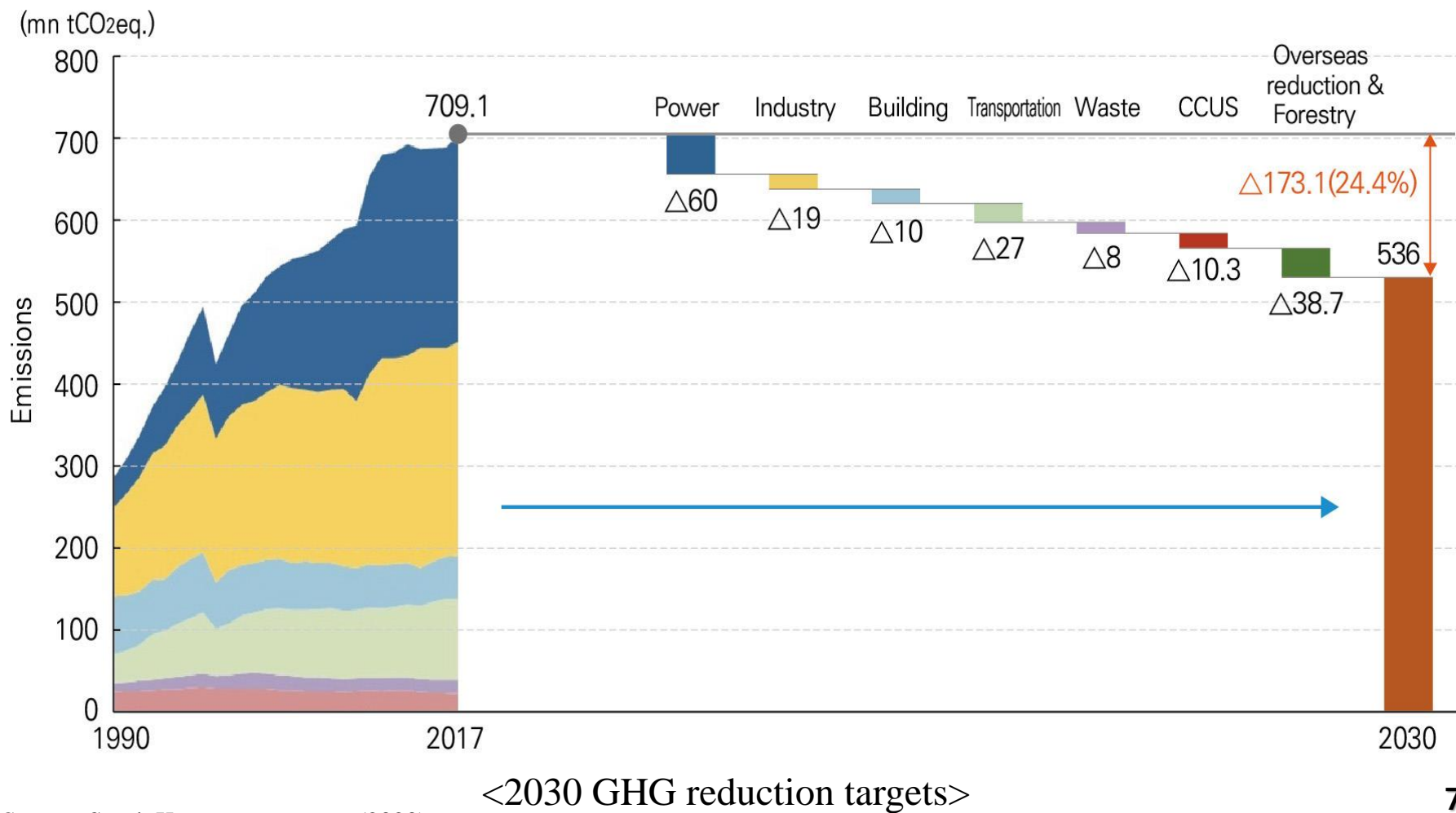
(unit : million CO₂eq.)

Sectors	Conformed				Estimated	
	'15	'16	'17	'18	'19	'20
Gross emissions (year-on-year rate)	692.5	693.5	709.7	727.6	699.5	648.6
		(0.1%)	(2.3%)	(2.5%)	(-3.9%)	(-7.3%)
Energy	600.7	602.7	615.7	632.4	611.2	563.7
		(0.3%)	(2.2%)	(2.7%)	(-3.3%)	(-7.8%)
Industry	54.3	53.2	55.9	57.0	51.0	47.4
		(-1.9%)	(5.1%)	(1.9%)	(-10.5%)	(-7.1%)
Agriculture	21.0	20.8	21.0	21.2	21.0	21.3
		(-0.8%)	(0.7%)	(1.1%)	(-0.8%)	(1.2%)
Waste	16.6	16.8	17.2	17.1	16.3	16.3
		(1.7%)	(2.2%)	(-0.7%)	(-4.5%)	(-0.1%)

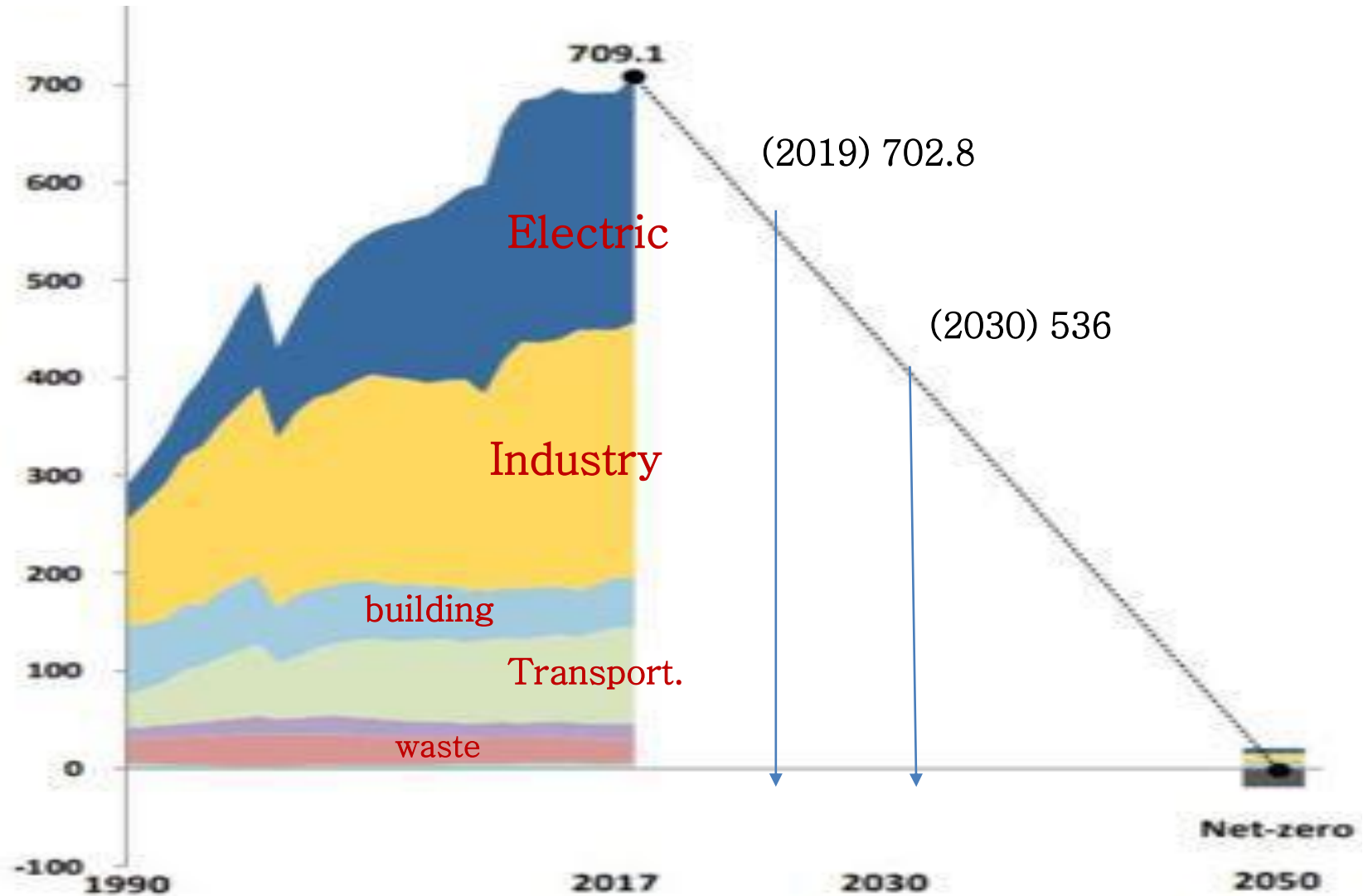
- Korea's Emission rank: 11th among UNFCCC, 5th among OECD (as of 2018)
- Korea's Emission proportion: 1.51% of global emission (as of 2018),

source: carbon Neutrality committee "Scenario Report ", 2021 8

- Korea's NDC target until 2030 is cut GHG emissions by 24.4% below 2017 level -2017
- However, **National Congress just pass the law (Carbon Neutral and Green Growth Basic Law, 2021.9) – More than 35% compared to 2018, even more than 40% recommended) .**



2030 – 2050 Net Zero Target



- **Net-Zero scenarios until 2050 (by Carbon Neutrality Committee, 21.8)**
 - 1st scenario (25.4 million ton), 2nd (18.7 million ton), 3rd (Net-zero)

Sectors	2018	2050 (unit: million CO ₂ eq)		
		1st(96.3%)	2 nd (97.3%)	3 rd (100 %)
Total	727.6 (686.3)	25.4	18.7	Net-Zero
Energy (Renewable Energ.)	269.6 10%	46.2 56.6%	31.2 58.8%	0.0 70.8%
Industry	260.5	53.1	53.1	53.1
Transport	98.1	11.2	11.2	2.8
Building	52.1	7.1	7.1	6.2
Agri.	24.7	17.1	15.4	15.4
Waste	17.1	4.4	4.4	4.4
Others	5.6	1.2	1.2	0.7
Sinks	-41.3	-24.1	-24.1	-24.7
CCUS	-	-95.0	-85.0	-57.9
Hydrogen	-	13.6	13.6	0.0

Net-Zero scenario of South Korea

Methods of Technologies and Energy Mix Proportion in 3 Net Zero Scenarios

Scenarios	Emissions (million ton)	Main Methods
1st	25.4	<ul style="list-style-type: none"> ■ Coal-fired plant: Maintenance (7 units) ■ Nuclear plant: 7.2% ■ Electric car and hydrogen car: 76%
2nd	18.7	<ul style="list-style-type: none"> ■ Coal-fired plant: Shut down ■ Nuclear plant: 7.2% ■ Electric car and hydrogen car: 76%
3rd	Net-Zero	<ul style="list-style-type: none"> ■ Coal-fired and LNG plant: Shut down ■ Nuclear plant: 6.1% ■ Electric car and hydrogen car: 97%

[Energy Mix Plan in the Net-Zero Scenario (in Detail)]

scenario		Nuclear	Coal	LNG	PV	Wind (land)	Wind (sea)	New power	Fuel -cell	Grid	Others	Total
①	Generation	89.9	19.1	101.1	530.7	38.5	141.4	177.2	121.4	33.1	3.9	1,256.4
	(%)	7.2	1.5	8.0	42.2	3.1	11.3	14.1	9.7	2.6	0.3	
	Capacity	11.4	7.26	32.9	413.2	14.6	42.6	57.8	17.2	5.6	1.2	603.8
	(%)	1.9	1.2	5.4	68.4	2.4	7.1	9.6	2.8	0.9	0.2	
②	Generation	86.9	0	92.2	530.7	38.5	141.5	159.6	121.4	33.1	3.9	1,207.7
	(%)	7.2	0	7.6	43.9	3.2	11.7	13.2	10.1	2.7	0.3	
	Capacity	11.4	0	30.1	413.2	14.6	42.6	52.1	17.2	5.6	1.2	593.7
	(%)	1.9	0	5.1	69.6	2.5	7.2	8.8	2.9	0.9	0.2	
③	Generation	76.9	0	0	445.8	178.3	267.4	270.0	17.1	0	3.9	1,259.4
	(%)	6.1	0	0	35.4	14.2	21.2	21.4	1.4	0	0.3	
	Capacity	11.4	0	0	347.0	67.7	80.5	88.1	4.1	0	1.2	600
	(%)	1.9	0	0	57.8	11.3	13.4	14.7	0.7	0	0.2	

Source: MOE (2021)

- There are three pillars for innovations of Korea to achieve 2050 carbon neutrality
: ① **Technological** ② **Social** ③ **Policy**

<Technological Innovation for Carbon Neutrality>

Technological innovation	Establishing policies for technological convergence	Driving R&D for technological integration and convergence
		Establishing R&D foundation for mitigation technologies
	Evaluating mitigation potentials	Evaluating mitigation potentials from technology development stage
		Assessing co-benefits of adaptation for carbon-neutral society
		Adopting Life Cycle Assessment approach in technology assessment
	Scaling up investment in technological breakthroughs	-

Source: South Korea government (2020)

Social innovation for carbon neutrality

Social innovation	Raising public awareness	Raising people's awareness of climate crisis
		Public outreach campaign for climate action
		Environmental education
		Higher education and research
	Governance and decision-making	Broader public engagement in policymaking
		Enhancing conflict management mechanism
		Laying groundwork for just transition
	Role of local governments	Greater role of local governments
		Emissions reduction projects at local level
	Green finance strategy	Green finance and climate change
		Mobilizing green finance
		Establishing taxonomy for green finance
		Better access to ESG information through TCFD
		Better access to ESG information through TCFD Scaling up green finance infrastructure

Policy innovation for carbon neutrality

Policy innovation	Assessing NDC implementation	Importance of implementation assessment
		Synthesis report for implementation assessment
	Institutional framework	Laying institutional framework for climate change response
		Linking mitigation policies with energy policies
		Considering climate change impact in policymaking
		Building foundation for energy transition
	Carbon pricing	Increase Role of ETS
		Introduce Carbon Taxation or charges
	Leadership by public sector	Public sector's leading role
	Korean Green New Deal	Pushing for Green New Deal as catalyst for carbon neutrality
		Key areas of Green New Deal

Source: South Korea government (2020)

Top 10 Korea's Low Carbon Technology Current and Future



Solar and wind

✓ Solar cell efficiency

(現) 27% **(20)** → ('30) 35% → ('50) 40%

✓ Wind power capacity

(現) 5.5MW → ('30) 15MW → ('40) 20MW



Hydrogen

✓ Supply price (won/kg)

21 7,000 → ('30) 4,000 → ('40) 3,000

✓ Generation cost (won/kg)

21 250 → ('30) 141 → ('40) 131



Bio-energy

✓ Generation cost (won/kg)

(Contrast with fossil fuel)

(現) 120~150% → ('30) 100% → ('45) 85%



Steel & Cement

✓ Hydrogen reduction

(現) 0% → ('40) 100%

✓ Limestone replacement in cement

(現) 0% → ('40) 8%

✓ Circulating fuel replacement in cement

(現) 24% → ('40) 65%



Petrochemistry

✓ Price competitiveness of carbon-neutral products

(現) 150% → ('40) 100%



Industrial process

✓ Emission reduction technology for semiconductor & display

(現) 80% → ('40) 95%

✓ Energy efficiency design error in industrial process

(現) 30% → ('30) 5%수준



Transport

Next generation battery

(現) 250Wh/kg → ('45) 600Wh/kg (Comm.)

Hydrogen fast charge

(現) 1.6kg/分 → ('30) 7.2kg/分



Building

Building energy efficiency

('30) 30% tech. improve.

Construction cost of zero-energy building

(現) 130% → ('45) 105%



Digitization

Power consumption of data center

('30) > 20%

System operation

('40) AI based grid connection system



CCUS

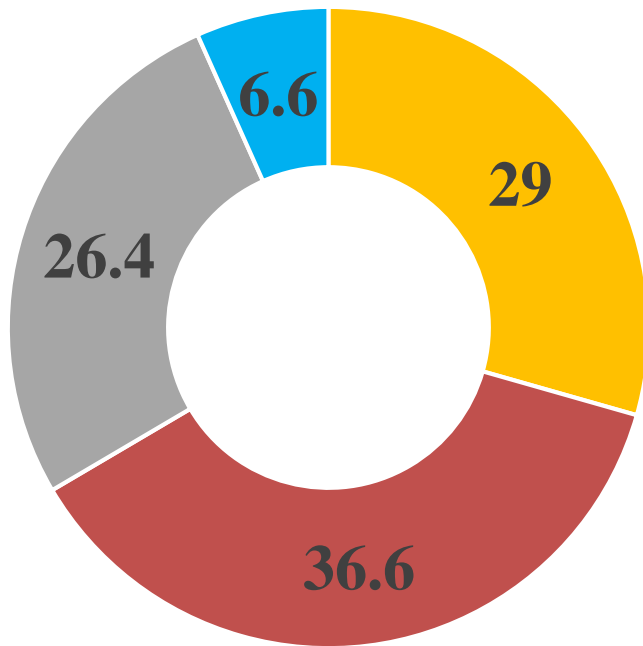
Cost competitiveness of CO₂ capture

(現) 60\$/ton ('30) 30\$/ton ('50) 20\$/ton

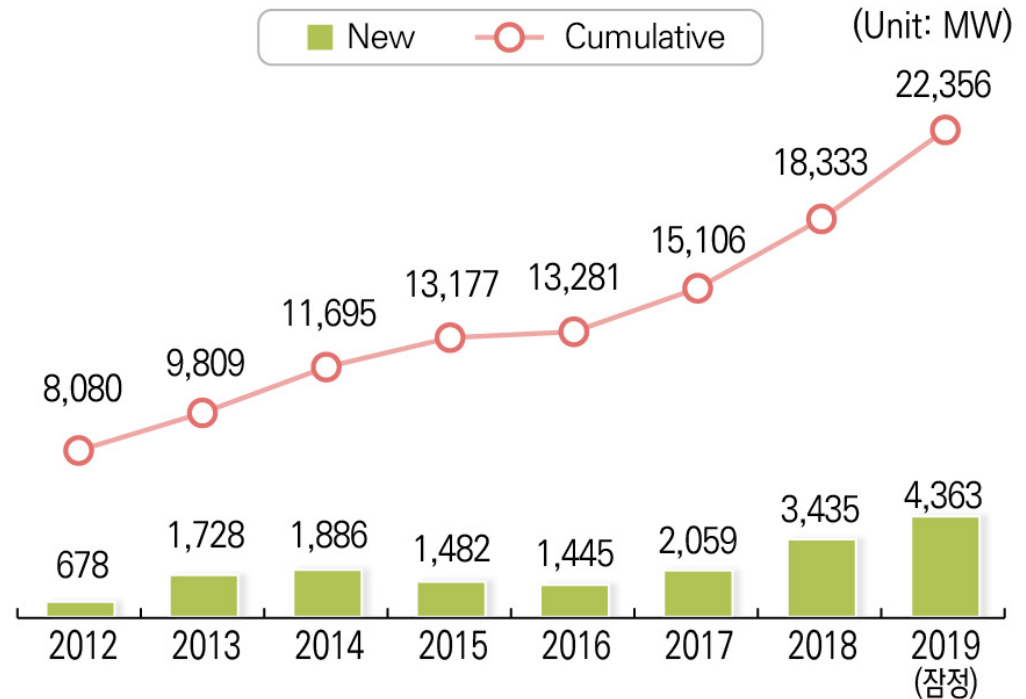
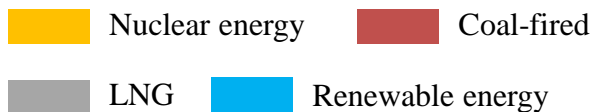
Cost competitiveness of low CO₂ products

Stat R & D → ('40) 100%

- The Renewable Energy 3020 Plan (RE 3020) envisions producing 20% of electricity from renewables by 2030, while the 3rd Basic Energy Plan aims at a 30-35% by 2040.



Energy mix in South Korea (2020)

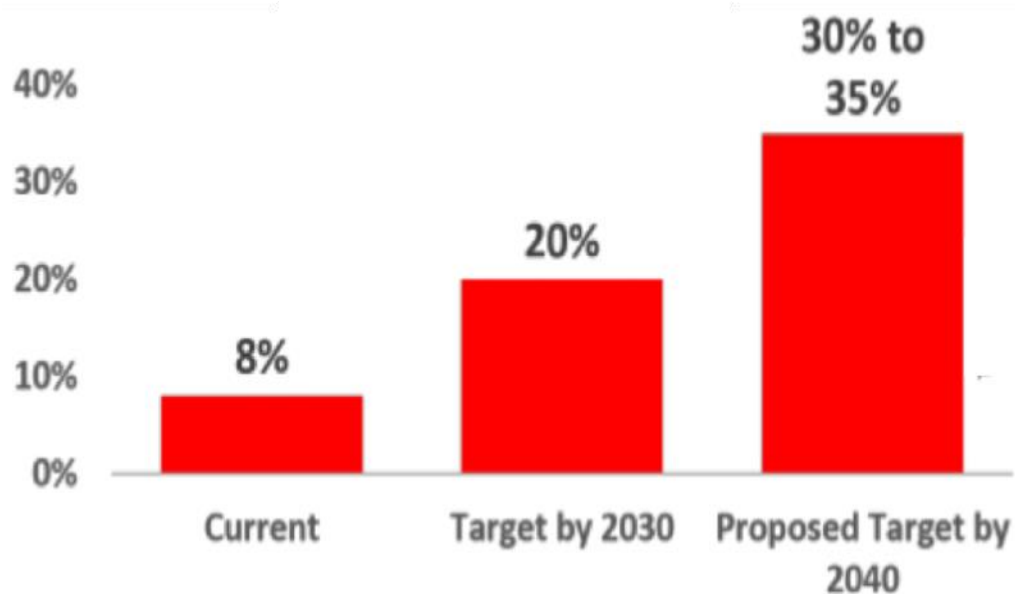


Installed capacity of renewables (MW)

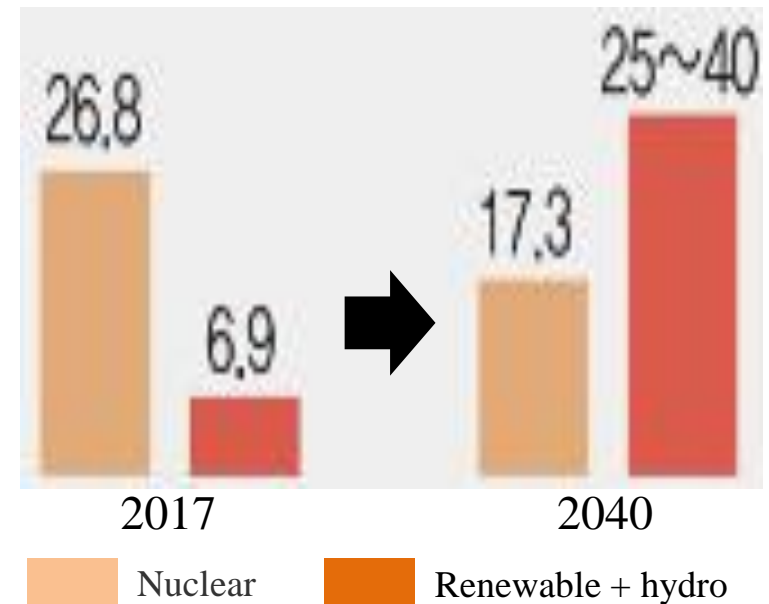
Source: South Korea government (2020)

- **Target for Energy Mix in Korea by 2040 (Renewable Energy)**

- Increase renewable energy share in total energy generation to between 30% to 35% through installation of 103 to 129 GW by 2040.
- Share of nuclear energy is filled by renewable energy
- 155 to 235 GW of solar and wind could be installed



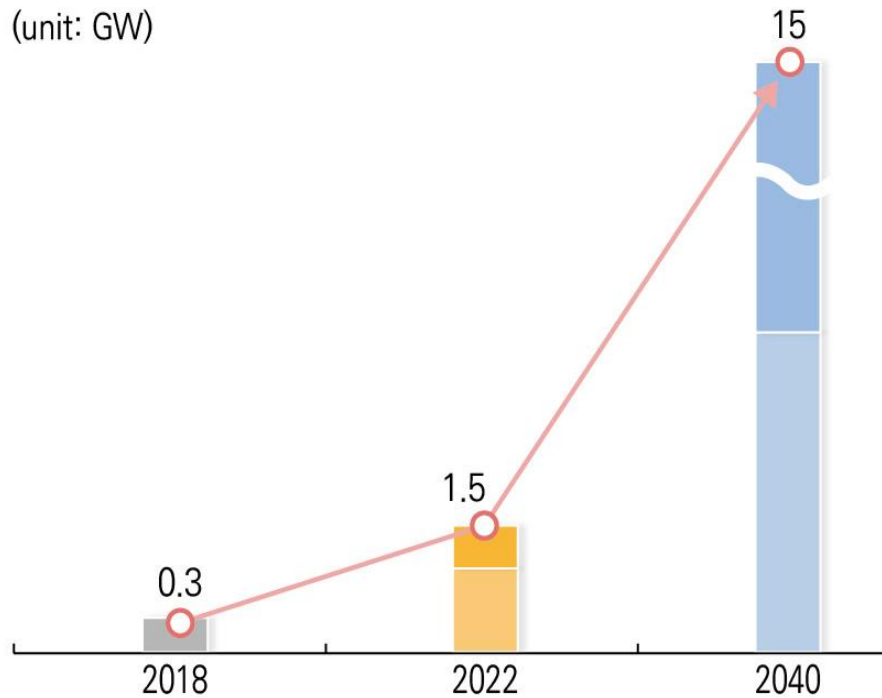
[2040 target for renewable energy]



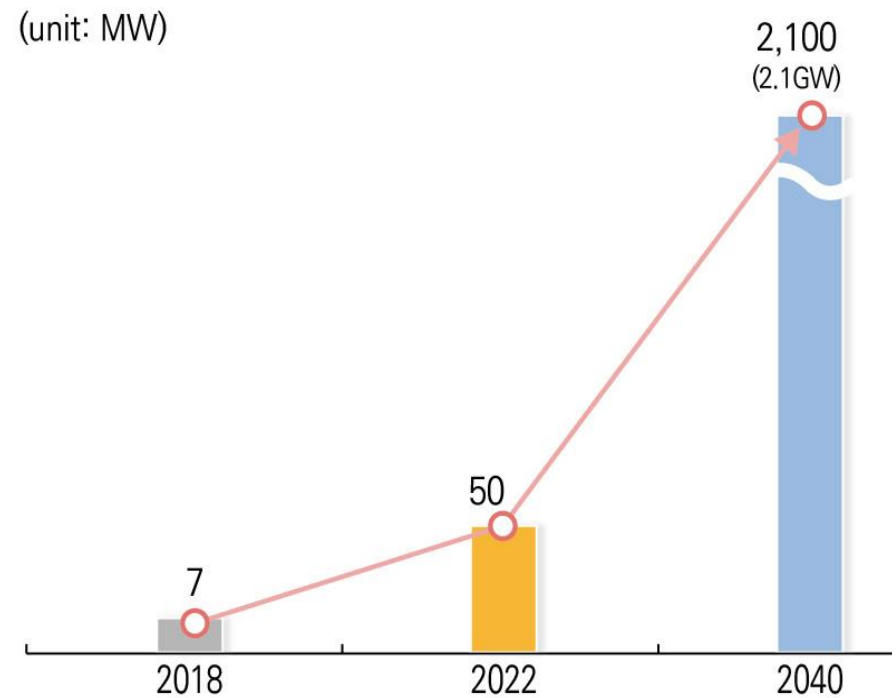
[2040 target for renewable energy mix]

- **Fuel cell and Green Hydrogen ; Status and the Future**

- Considers hydrogen as an important future power source in accelerating industrial innovation and reducing GHG emissions
- Developed a plan **to build up a fuel cell facility to generate 8GW of electricity by 2040** and will continue to scale up the production of fuel cells



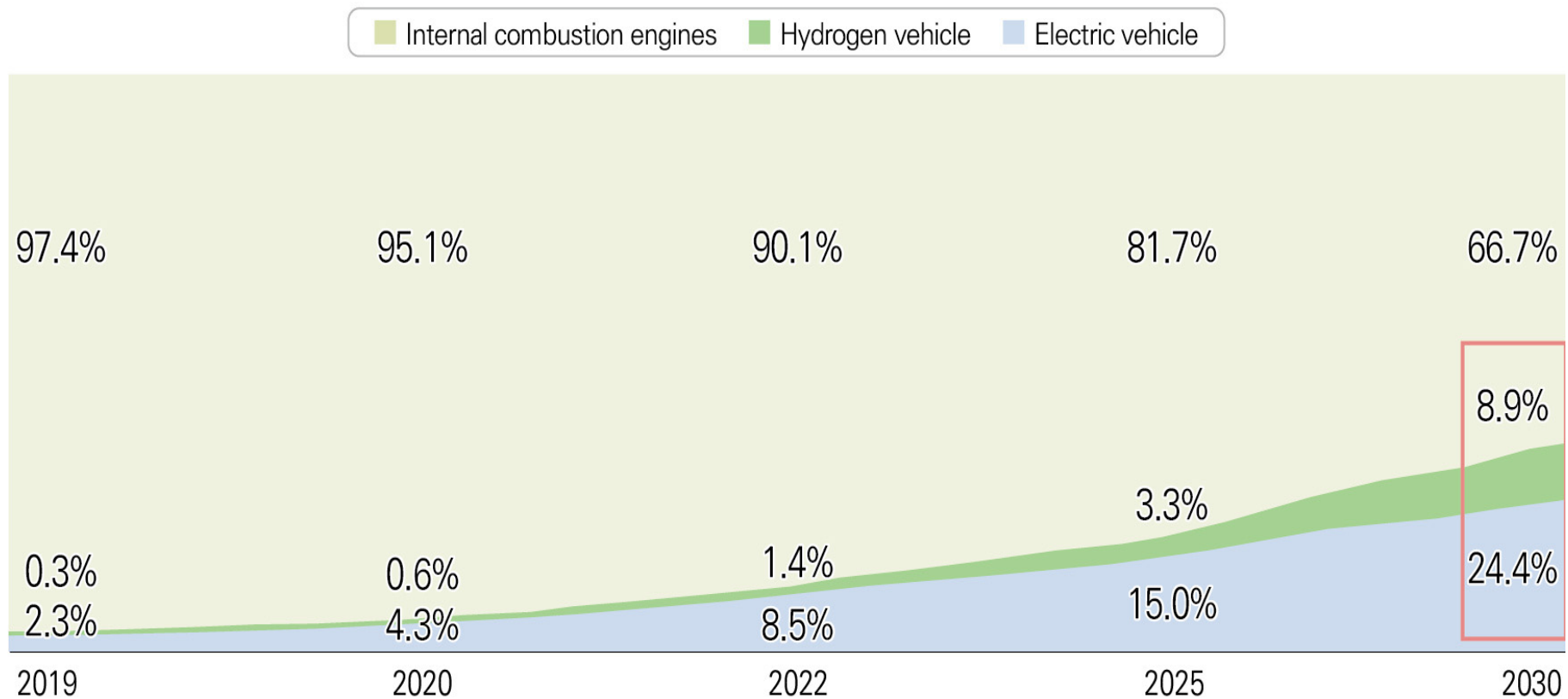
[Fuel cells for power generation]



[Fuel cells for homes and buildings]

- **Green Vehicles ; Status and the Future**

- Already set an ambitious target of deploying for clean vehicles, ;
- EVs and hydrogen vehicles will account for 1/3 of new vehicle sales in 2030.
 - Aim to deploy 3 million units of EV and 0.85 million units of hydrogen vehicle by 2030

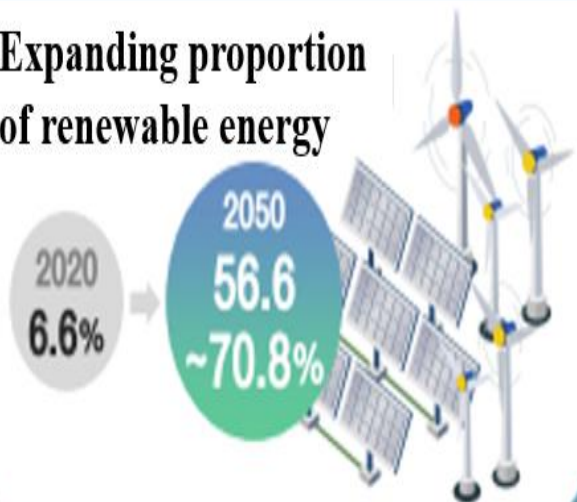


[2030 target for clean vehicle deployment road map]

<Summary of Net-Zero Plan by Sectors in Korea until 2050 (draft) >

Energy

Expanding proportion
of renewable energy



Transport

Significant expansion
of green car supply



Industry

Fuel replacement
and smartification
of industrial process



Building

New building
: Zero Energy building

Existing building
: Green remodeling



Agri

Using electricity
and hydrogen in
agri machine and
fishing vessel



Waste

Reducing waste by 25%
Enhancing recycling
rate by 90%
Bioplastic replacement



Involvement of Business Sector for Carbon Neutral Status

- **LG Electronics, LG Chem**, Steel companies (**POSCO, Hyundai Steel**, Dongkuk Steel, KG Dongbu Steel, Seah Steel, Simpac), Woori Financial Group, NAVER
- Joint statement of four companies (Samsung Electronics, SK hynix, Samsung display, LG display)
- LG Electronics: Reducing carbon generated in the production stage by 50% below 2017 levels by 2030. Reinforcing external carbon reduction activities to reduce net carbon emissions to zero
- LG Chem: Announcement of sustainability strategy based on 2050 carbon neutral growth. Declaring carbon neutrality for the first time in the Korean chemical industry
- The 1st carbon neutrality committee of shipbuilding companies was held
→ Declare 2050 Carbon Neutrality and
- Achieve RE100 by 2030

- The Korea Chamber of Commerce & Industry (2021)
 - Survey on **‘2050 Carbon Neutrality Response Status and Tasks’** ;
Targeting 403 companies participating in the Korean ETS
 - 57.3% of respondents ; 2050 carbon neutrality as ‘difficult but the way to go’
 - 42.7% of companies said ; ‘It is difficult to be carbon neutral from practical point
- **R&D projects required for carbon neutrality**
 - **Production technology using renewable energy**, 24.8%
 - **Process gas replacement/reduction technology**, 22.5%
 - **Energy efficiency improvement** technology, 22.2%
 - Resource circulation technology, 17.5%
 - CCUS technology, 13.0%
- **Urgent policy issues (surveyed as %)**
 - Increase **R & D investment**, 36.7%
 - Development of **innovative technology** for decarbonization, 31.0%
 - Establishment of **renewable and hydrogen energy supply** infrastructure, 15.1%
 - Rationalization of the legal system, 11.2%
 - Build a cooperative network, 5.0%

Strategy of Carbon Neutrality by Key Korean Industry Sectors

(Steel)

- Change from old furnace methods to hydrogen reduction method and electric arc by 2050 ;
 - 94% reduction possible (???)
- Enhance energy efficiency and increase electric arc furnace

(Petro-Chemical)

- Change fuel mix and raw material ; can reduce 31- 55% comparing to 2017
- (EX) CCUS 13.9 million ton , bio- Nafta, maximum Use for Plastic Wastes

(Petroleum)

- Change Energy Fuel mix to LNG and Bio-mass, CCUS ; can reduce 53-89 %

(Cement)

- Increase Waste, Increase hydrogen Use ;
 - Can reduce 44% (exclude CCUS), Can reduce 78% (include CCUS)

(Electric and Electronics)

- Substitute F gas and change products mix

Forest and Carbon Neutrality

(U.S.A)

- Make 2000 ha forestry, improve forest management, urban forestry, and wood product

(Canada)

- Improve forest management and biomass

(EU)

- Prevention of forestry related disasters

(France)

- Must use more than 50% of wood products for New Public building

(Japan)

- Must use more than 25% of wood products When New Public Building is low than 3rd floor.

• (Korea)

- Sink 27 million CO₂ until 2050 and plant 300 million trees
- Make more wood house and products

4. Future Direction for the Net Zero in South Korea

- Make Effective and Void R & D budget; Waste of Budget ??
(Ex) Green building, Green Car, Green technology, Start up
 - R & D compared to GDP is NO. 1 in OECD and in the World.
 - Is it really cost effective and efficient ???
- Make innovate waste treatment policy change ;
 - Too much regulation, Low valuation of WtE (Waste to Energy) (Petro., Steel , Cement and Chemical Industry can use)
- Make Economic Incentives and Include Strategic Future Technology Categories (SFTC) such as Low Carbon Tech.
(Ex) IT, Parts, Big Data, AI already included in the SFTC, more tech for low carbon tech.
- Establish “Climate Change Fund” or “Public or Private Green Bank”
 - Government try to make US \$ 2 billion Fund. But Not enough .
 - Increase role of Public Finance
- Make new Ministry ; Ministry of Climate and Environment
- Public and Private R & D Co-op from major industry.
 - Battery(ESS), Bio Plastic, Waste, Hydrogen etc

Future Policy Direction

- Make effective public communication to change civilian mind.
- Enhance capacity of Sink from Forestry and give Incentive
 - More than 70% of forestry is owned by private.
- **Support local government activities** and governance
- Study on the **feasibility of Hydrogen Supply, CCUS, CCS**
 - Still argument is going on.
- Change Education System ;
 - **Mandatory Environmental Education**
 - Lifetime education system for the climate change crisis
- **Revise and Make Feasible 2050 scenario and make Road Map**
 - Show timeline of 2030, 2040 and 2050
 - Increase 2030 NDC Targets from 24.4 % to More than 35% ??
 - Still working on the NDC Targets until Oct. 2021 – to be seen