

The Current Status of the Global Hydrogen Industry & Hyundai Motor Group's Vision

HYUNDAI MOTOR COMPANY
FUEL CELL CENTER

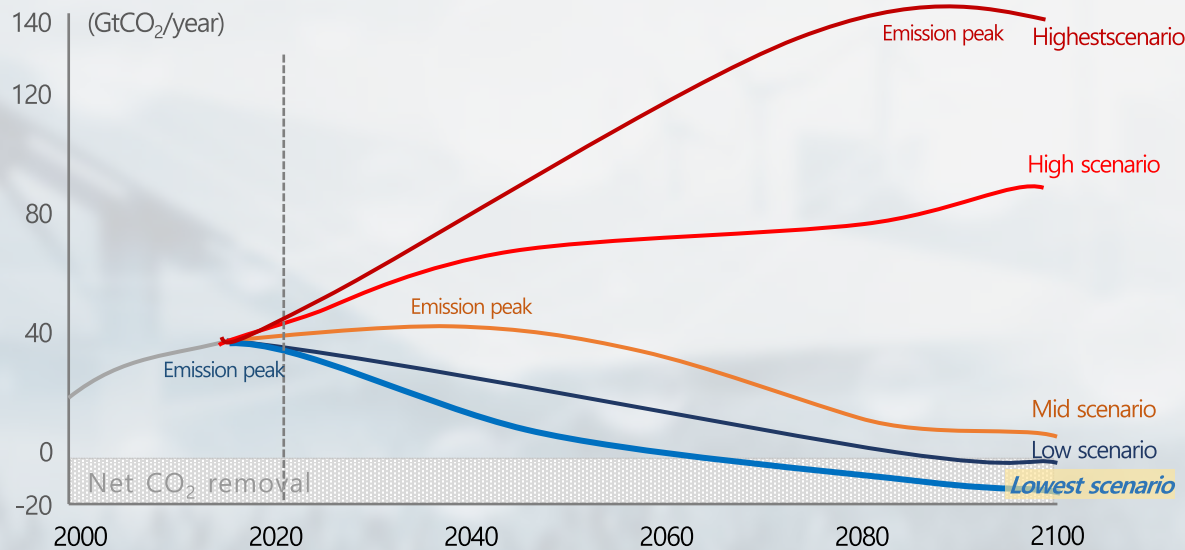


Paradigm Shift towards Renewable Energy

- Energy demand is increasing while the world is faced with the imperative to cut carbon emissions
- Global efforts are made to reduce energy demand, move away from fossil fuels & towards renewable energy

The Need for Carbon Neutrality

- IPCC report: only the lowest emission scenario can keep the global temperature rise below 1.5°C
- Lowest emission (SSP1-1.9): need to cut emissions with the current level as the peak (Scenario: half the carbon emissions cut by 2030 → Net Zero achieved by 2050)



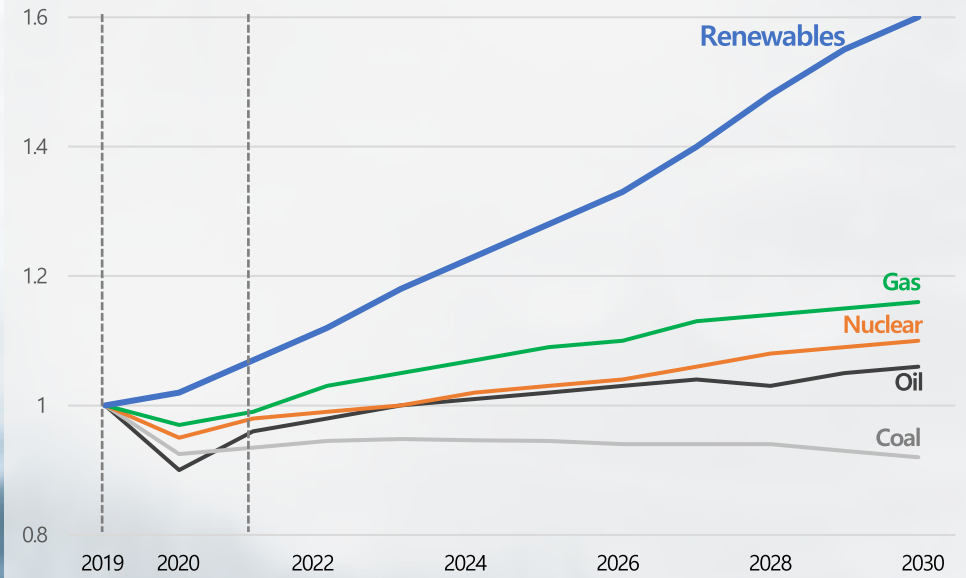
< Changes in global surface temperature by scenario >

* Source : IPCC 6th assessment report (2021. 8, IPCC)

The Transition towards Renewable Energy

- Along with efforts to reduce energy demand to achieve carbon neutrality, renewable energy will play a leading role in the energy industry of the future

Outlook of future energy demand (2019 energy demand = 1)



< Primary energy demand by fuel >






* Source : World Energy Outlook 2020 (2020. 10, IEA)

Global Net Zero Announcements

- Major countries and industries are announcing their Net Zero targets, budgets, and policies
- ESG management in particular is pushing businesses to be environmentally & socially more responsible




Worldwide commitment to Net Zero

- Major countries are committing themselves to go carbon-neutral by 2050
- Specific policy announcements & budget plans are made to reaching that objective

	EU 	US 	CN 	JP 	KR 
Net Zero target	2050	2050	2060	2050	2050
Budget	\$ 1.2 trillion ↑ (by 2030)	\$ 2 trillion ↑ (by 2030)	(TBD)	\$ 18 Billion (by 2030)	\$ 62 Billion (by 2025)
Keywords	► Fit for 55 Package - Raise emission target - Ban ICEs by 2035 - Expand EV/FCEV charging infrastructure	- Infrastructure investment - Eco-cars - CBAM	- Government leadership - New-energy vehicles - Quasi carbon-neutrality (~2050)	- Renewables - Hydrogen - Eco-cars	- Expand EV/FCEV and charging infra - CCUS - resource cycle cluster

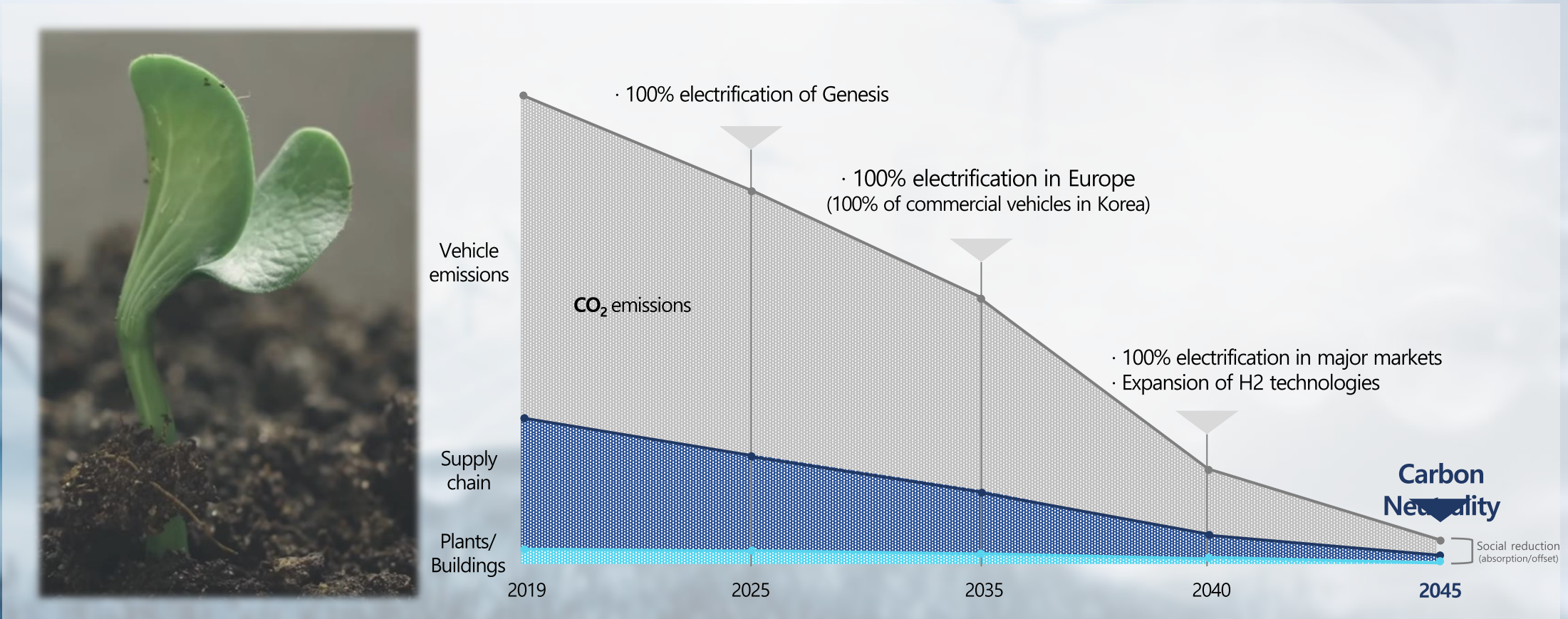
Net-zero announcement of industries

- A wide range of industries are devising their own strategies for carbon neutrality
- Such movements are accelerated as ESG (Environmental, Social and corporate Governance) is gaining traction

	IT	Automotive	Energy
Net Zero target	2030 ~ 2040	2040 ~ 2050	2050
Businesses			
Keywords	- Expand renewables - Renewables made mandatory (for partner companies)	- 50~100% electrification by 2030 - Recycle resources - Renewables made mandatory (for partner companies)	- Renewable power generation & green hydrogen production - Phasing out of petroleum & gas-based power generation

HMC's Net Zero Announcement: Generation One

- HMC announced its plan to achieve Net Zero by 2045 at the 'IAA Mobility' event (Sep. 2021 in Munich, Germany)
- Goal: carbon-neutral part procurement – production – operation through electrification & hydrogen



* Vehicle emissions: carbon emitted during the customer's operation of the vehicle (Tank-to-Wheel)

* Supply chain: carbon emitted by part suppliers; HMC's goal is to achieve carbon emission reduction/carbon neutrality through cooperation

HMC's Fuel Cell Technology

- HMC has become a leader in FC technology after accumulating 20 years worth of technological know-how
- With such leading technology, HMC is rapidly dominating the FC passenger car & commercial vehicle market



1998

New organization dedicated to Fuel Cell Development

2000

The 1st FCEV model developed by HMC (based on Santa Fe)

2004

Independent Development of Fuel Cell Stacks

2005

Independent Development of Fuel Cell Systems

2013

1st Generation FCEVs (Tucson ix)
"The world's 1st mass-produced FCEV"

2018

2nd Generation FCEVs (NEXO)
"Superior range and energy efficiency"

2020

Commercial FCEVs (XCient FC truck) (Elec City FC bus)
"The world 1st mass-produced FC truck"
"Mass-produced FC bus"

Leader of the FCEV market

- Over 16,000 NEXOs sold globally
- Nexo's performance on par with ICEVs



Stack output	95 kW
Motor output	113 kW
H2 Tank Capacity	6.33 Kg
AER	666 km

- 46 trucks exported to Switzerland (631 tons of CO₂ reduction/year)
- 1,600 trucks to be exported to Switzerland by 2025



Stack output	190 kW
Motor output	350 kW
H2 Tank Capacity	32 Kg
AER	400 km

- 115 buses in operation (target: 200 buses sold by '21)
- Successful test drive in Munich, Germany (25-Jun-2021)



Stack output	180 kW
Motor output	300 kW
H2 Tank Capacity	34 Kg
AER	474 km

Gen2A Fuel Cell Specification

Performance	
Power (Gross)	95kW
Max, Output Current	300 A
Output Voltage	250 ~ 450 V
Hydrogen specification	ISO 14687-2
Fuel supply pressure	- 17 Bar (abs)
Fuel efficiency	62%



Physical	
Operating ambient Temperature	-30°C ~ 45°C
Storage temperature	-30°C ~ 75°C
Dimensions(mm)	703 x 892 x 723
Dry/Wet Weight	175kg / 185kg
Volume	453L

✓ Fuel Cell Stack

The key part that generates electric energy through the electrochemical reaction between hydrogen and oxygen



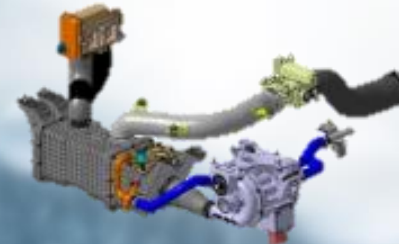
✓ Fuel Processing System

Supply/recirculate hydrogen from fuel cell, thereby improving the efficiency of the hydrogen supply



✓ Air Processing System

Supply air at the optimal pressure and flow rate



✓ Thermal Management System

Manage flow rate and direction of coolant to maintain the optimal stack temperature for chemical reactions



Fuel Cell System Business

1998~
R&D



2013~
Mass Production of FCEV



2019~
System Business



HMC's Fuel Cell System Business

- FCs can contribute to large hydrogen demand other than vehicles, as it can be used as a power generator
- HMC will maximize the expandability of fuel cells by developing Next-gen. & derivative systems

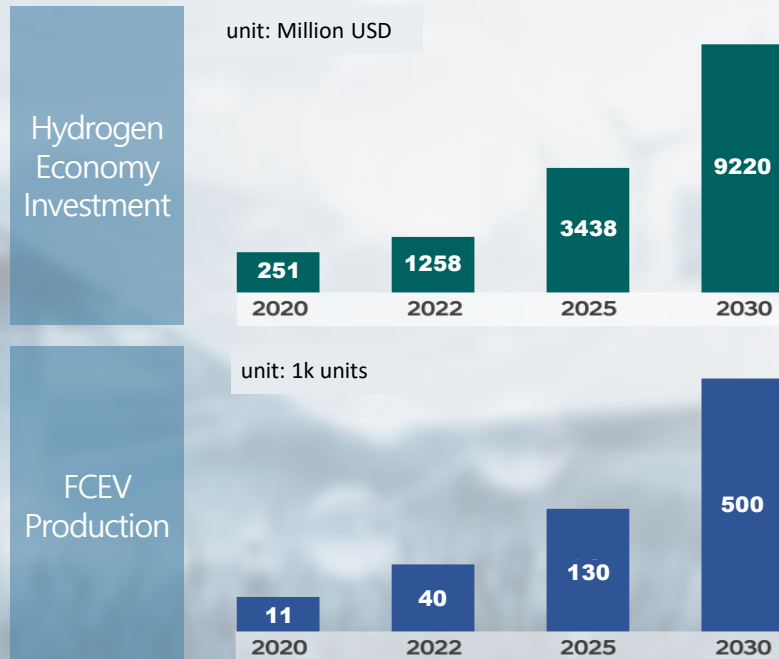


HMG's Hydrogen Vision

- HMG plans to invest KRW 11.1T in order to become a leading player in the hydrogen economy by 2030
- The ultimate goal is to build a society where H2 is available for 'Everyone, Everything, Everywhere' by 2040

Expand H2-related production & investment

- Invest KRW 11.1T, produce 500,000 FCEVs & 700,000 FC systems by 2030
- Invest in FC system production plants (Cheongna/Ulsan) for the realization of HMG's Hydrogen Vision 2030



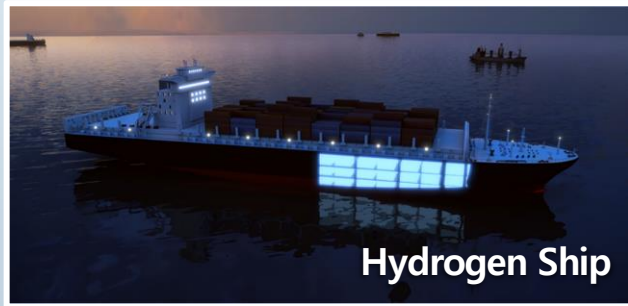
Popularize hydrogen energy by 2040

- Set 2040 as the first year of the popularization of hydrogen energy, introduce a wide range of hydrogen vehicles
- Announce gradual execution plan including the application of fuel cell systems to ALL commercial vehicle models by 2028 & expansion of FC passenger car line-up



Hyundai's Fuel Cell System Brand, HTWO

- Hyundai unveils HTWO → To materialize FCS business through various applications
- HTWO will strive to provide green energy with "Hydrogen" and "Humanity" in mind.



Hydrogen — Humanity

Together for a better future!

“HMG will lead the society that uses hydrogen as its main energy source as the first mover in the forthcoming hydrogen economy”.

Euisun Chung, Chairman of Hyundai Motor Group

