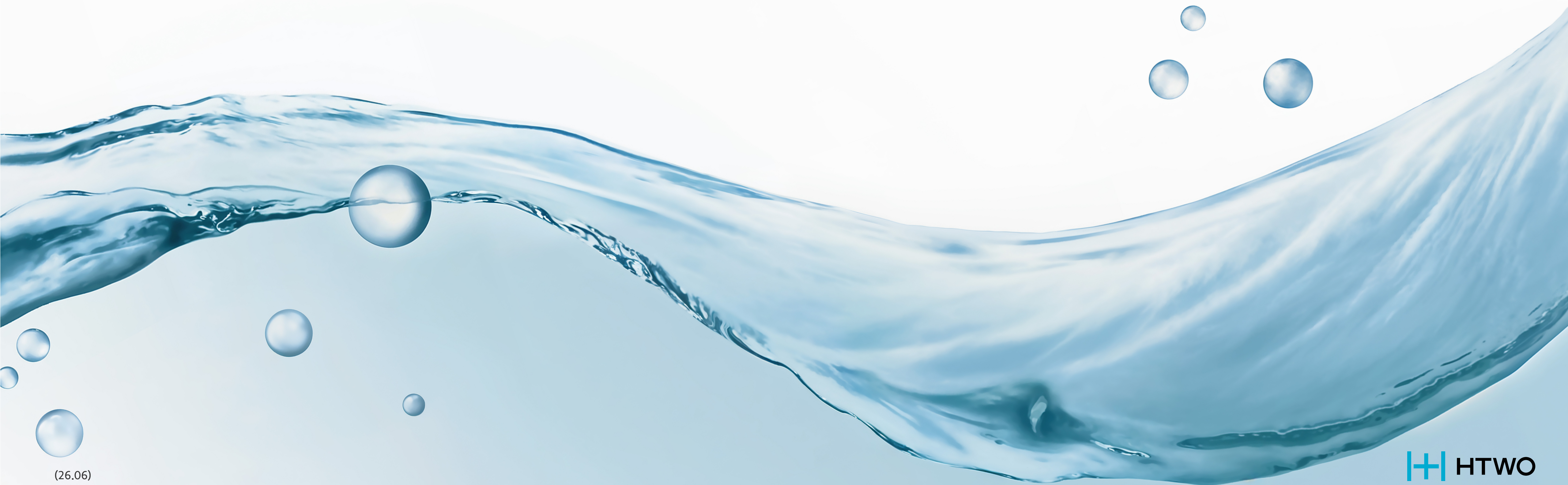


Hydrogen. Born of Everyday, Powering Everyday

Hydrogen Essentials

Why hydrogen



Born of everyday, powering everyday

- Hydrogen, the energy carrier for a sustainable future.

Fossil fuels, which have sustained human civilization for 200 years since the Industrial Revolution, now face limits due to the climate crisis and resource inequality. The era-defining task of achieving carbon neutrality for a sustainable future now lies before us.

The question is no longer "Should we change?" but "How should we transition?" And we find the answer in 'hydrogen'.

Hydrogen is not merely an alternative. It is the key that secures humanity's sustainability.

1. An energy carrier for a sustainable earth

With the right technology, hydrogen can be produced anywhere using everyday resources. It is an energy carrier for the sustainable future, offering advantages such as high energy density, diverse storing methods, and eco-friendliness—emitting water as the only byproduct.

2. A catalyst for accelerating the energy transition

As an energy carrier capable of large-scale storage and long-distance transport, hydrogen complements intermittent renewables and enhances their efficiency and utilization. Hydrogen offers a viable pathway to reduce carbon emissions in hard-to-abate sectors such as steelmaking, ports, and aviation, where direct electrification is difficult. By opening up options for eco-friendly mobility, enabling the decarbonization of logistics, and linking the power, industrial, and mobility sectors, hydrogen plays a pivotal role in accelerating the transition to a sustainable energy system.

3. A solution for energy security

Hydrogen can be produced through a wide range of pathways, allowing countries with high energy import dependence to diversify their energy mix and strengthen energy self-reliance. Its versatility in storage also enhances power system flexibility, enabling a more stable and resilient energy supply. Amid growing global supply-chain uncertainties driven by geopolitical shifts, hydrogen is emerging as a strategic resource that reinforces both energy security and industrial competitiveness.

4. Towards a hydrogen society

We are at a big turning point of the energy paradigm. The world is looking at hydrogen to create a cleaner, more sustainable future. We're already on our way to a hydrogen society, and Hyundai Motor Group is leading the way. Our interest and investment in hydrogen will be the foundation for a cleaner, brighter tomorrow.

Contents

Chapter 1 About Hydrogen	PG 04	Chapter 3 Global Energy Transition Leader, Hyundai Motor Group	PG 25
The Story of Hydrogen We Didn't Know			
01. The simplest and most abundant element in the universe	05	01. The sustainable hydrogen ecosystem created by Hyundai Motor Group	26
02. Lightweight yet powerful energy carrier		02. 30 Years of leading the hydrogen industry	27
03. Attainable from everyday resources	06	03. HTWO - Hyundai Motor Group's hydrogen business brand	28
04. Various methods of hydrogen storage	07	04. From production to utilization. HTWO's hydrogen value chain	29
05. Hydrogen for a sustainable future	08	05. HTWO business platform	30
Summary	09	06. Key business solutions	31
		① Hydrogen production	
		② Eco-friendly logistics business	
		③ Port/Airport decarbonization	
		④ Hydrogen mobility	
		⑤ Expansion of hydrogen fuel cell system lineup	
		⑥ Hydrogen industry application - Hydrogen burners	
		⑦ Hydrogen refueling solutions	
		Summary	40
Chapter 2 Why Hydrogen	PG 10		
Why Hydrogen Now?			
01. Fairer - The cornerstone of energy independence and security	11		
① Key to reducing geopolitical energy imbalances			
② A shortcut to carbon neutrality, clean hydrogen based water electrolysis			
③ Expanding the industrial ecosystem with hydrogen			
Appendix. Global hydrogen market outlook			
02. Cleaner - The choice for a sustainable future	16		
① When wasted renewable energy meets hydrogen			
② Eco-friendly mobility transition with hydrogen			
③ What only hydrogen can do			
03. Faster, Further - The partner for future mobility	20		
① Hydrogen fuel cell vehicles - Passenger vehicles			
② Hydrogen fuel cell vehicles - Commercial vehicles			
Summary	24		
		Appendix Q&A	PG 41
		Questions about Hydrogen	



Chapter 1

About Hydrogen: The Story of Hydrogen We Didn't Know

- 01 | The simplest and most abundant element in the universe
- 02 | Lightweight yet powerful energy carrier
- 03 | Attainable from everyday resources
- 04 | Various methods of storing hydrogen
- 05 | Hydrogen for a sustainable future

01 The simplest and most abundant element in the universe

Hydrogen makes up 75% of the mass of the universe.
Hydrogen is the most abundant and simultaneously the lightest element in the universe.

Composed of just one proton and one electron, hydrogen occupies the first position on the periodic table thanks to this simple structure.
In addition, thanks to its light nature, it disperses quickly in the air, making the risk of explosion extremely low.

Hydrogen is highly reactive and rarely exists alone in nature.
Instead, it bonds with other atoms to form compounds like water (H₂O), ammonia (NH₃), and methane (CH₄). Therefore, we must extract hydrogen from these compounds to utilize it.

Hydrogen, the first element in the periodic table*

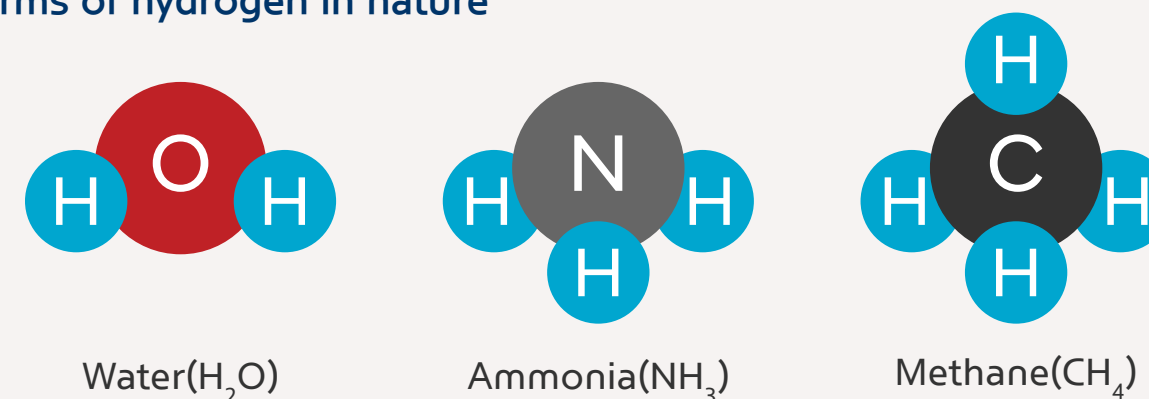
1 Hydrogen 1.008 g/mol
Atomic Mass

*Periodic Table: A table that arranges elements for easy classification based on their properties. Generally, elements positioned earlier in the table have smaller atoms and are more solid.

The simplicity of hydrogen's structure

Element	Hydrogen(H)	Oxygen(O)	Neon(Ne)	Magnesium(Mg)
Atomic Model				
Number of Protons	1	8	10	12
Number of Electrons	1	8	10	12

Forms of hydrogen in nature

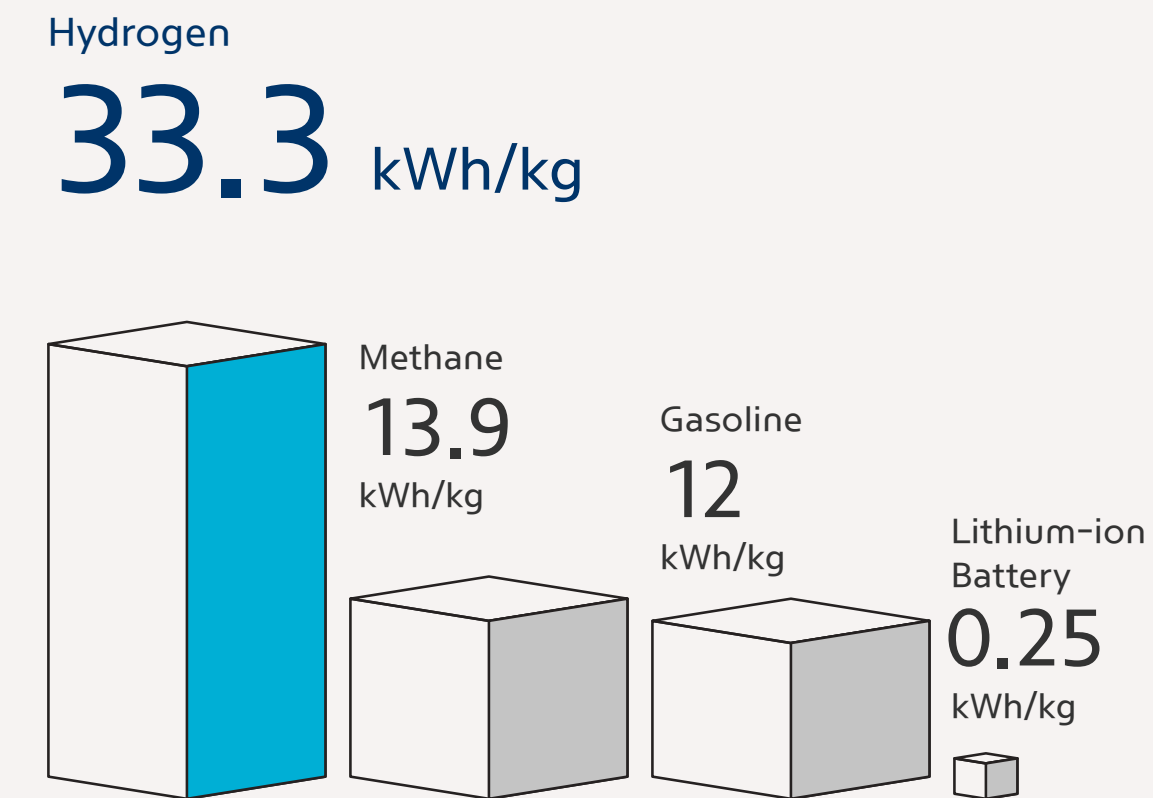


02 Lightweight yet powerful energy carrier

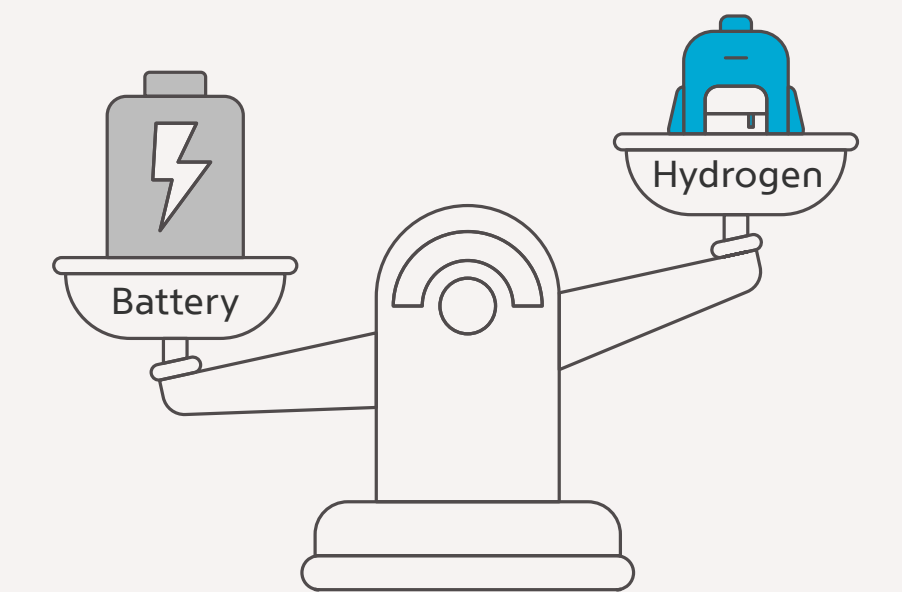
One kilogram of hydrogen can store approximately 33.3 kWh of energy.
To store the same energy in a battery (0.25 kWh/kg), a heavy battery weighing a whopping 130 kg would be required. Thus, hydrogen is advantageous for use in weight-sensitive industries like aircraft and spacecraft because it can store a large amount of energy within a light weight.

However, gaseous hydrogen at standard temperature and pressure has a low density (0.0899 kg/m³), requiring large storage volumes. Therefore, to store hydrogen efficiently, it must be compressed to high pressure (700 bar or higher) or cooled to extremely low temperatures (-253° C) to liquefy it.

Energy per unit mass comparison



Weight/volume comparison of hydrogen and batteries for storing the same amount of energy (Based on 33.3 kWh)



*1 kg H₂ in 700 bar

	Hydrogen	Battery
Weight	1 kg	130 kg
Volume	24 L	56 L

03

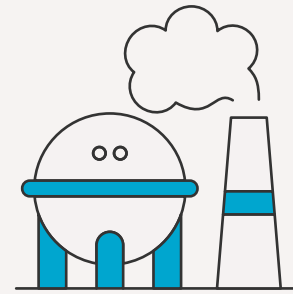
Attainable from everyday resources

Hydrogen can be produced in far more diverse ways than we might imagine. It can be extracted from fossil fuels like coal, oil, and natural gas, or produced through water electrolysis. Hydrogen can also be obtained from various organic

wastes such as food waste, sewage sludge, and livestock manure. Hydrogen can be obtained from various sources in our daily lives, and with the right technology, it can be produced anywhere. The various methods we can use to produce hydrogen are as follows.

Various methods for producing hydrogen

Fossil fuel-based



Natural Gas Reforming

The most widely used hydrogen production technology today, which extracts hydrogen by reacting methane—the main component of natural gas—with steam at high temperatures and pressures.

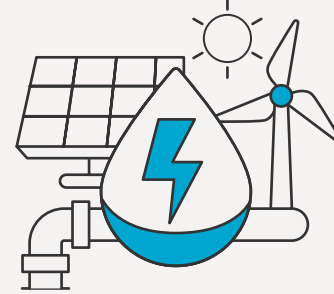
Byproduct Hydrogen

Capture and utilize hydrogen naturally generated as a byproduct during crude oil refining, petrochemical processes, and steelmaking.

Coal Gasification

A method that produces hydrogen by refining the hydrogen created when coal is gasified under high temperature and high pressure.

Electrolysis-based(water electrolysis)



PEM* Electrolysis

A method that uses a polymer electrolyte membrane to electrolyze water, producing hydrogen and oxygen. Advantages include higher current density, smaller footprint, and faster response compared to alkaline water electrolysis.

Alkaline Water Electrolysis

A method that uses an alkaline electrolyte** to electrolytically decompose water; it has lower efficiency compared to PEM.

Solid Oxide Electrolyzer

A method that uses a solid oxide electrolyte to electrolyze high-temperature steam above 800° C.

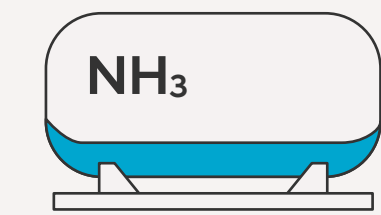
Biomass-based



Utilizing Organic Waste

Refining biogas obtained from organic waste such as food waste, livestock manure, and sewage sludge to extract hydrogen. Simultaneously enables waste treatment and hydrogen production.

Chemical carrier-based



Ammonia Cracking

A method of extracting hydrogen by decomposing ammonia, which contains hydrogen molecules, using a catalyst in a high-temperature environment.

Methanol Reforming

A method that reacts methanol with steam to obtain a hydrogen-rich gas.

Extraction from Liquid Organic Hydrogen Carrier (LOHC***)

A technology that chemically bonds hydrogen to specific organic compounds for liquid storage and transportation, then extracts hydrogen again when needed.

*PEM: Polymer Electrolyte Membrane

**Electrolyte: A liquid that facilitates ion movement during electrochemical reactions

***LOHC: Liquid Organic Hydrogen Carrier, liquid organic compounds such as toluene

Next-generation technologies

Photocatalytic Hydrogen Production

A technology where a light-absorbing catalyst chemically decomposes water to produce hydrogen and oxygen, similar to the principle of artificial photosynthesis.

Water Pyrolysis

A thermochemical technology that decomposes water at extremely high temperatures to obtain hydrogen and oxygen, primarily utilizing solar thermal collectors or nuclear reactor heat.

Plasma-Based Methane Pyrolysis

A technology that uses plasma energy to decompose methane gas into hydrogen and solid carbon. It can minimize carbon emissions, and the solid carbon can be recycled as an industrial material.

Photobiological Hydrogen Production

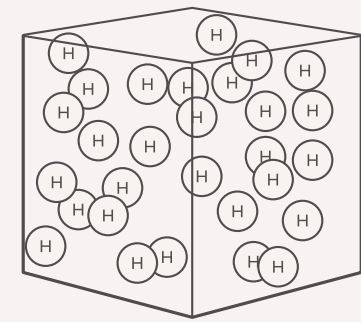
A technology that induces specific microorganisms to produce hydrogen during photosynthesis, enabling environmentally friendly hydrogen production at low temperatures.

04 Various methods of storing hydrogen

Although light and powerful, hydrogen occupies a large volume in its gaseous state. Technology leaders around the world are developing various methods and technologies to overcome hydrogen's low density and enable more efficient storage.

Hydrogen is gaining traction in terms of energy independence and security in many countries around the world today. This is due to its ability to be transported over long distances and in large volumes by a variety of storage methods.

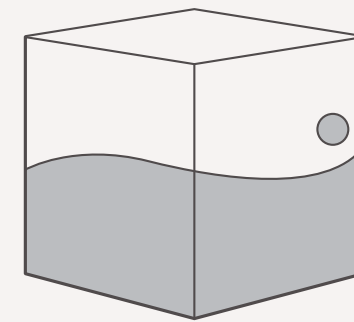
Various storage technologies that increase hydrogen density per unit volume



Compressed in gaseous state

Compressed at 700 times atmospheric pressure. Currently used in hydrogen fuel cell vehicles like NEXO.

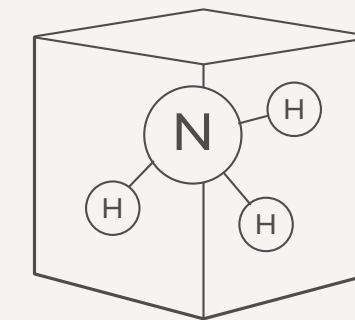
42 kg/m³



Liquefaction

Cooled to -253° C to convert to liquid. High energy consumption during liquefaction, but facilitates long-distance/large-volume transport.

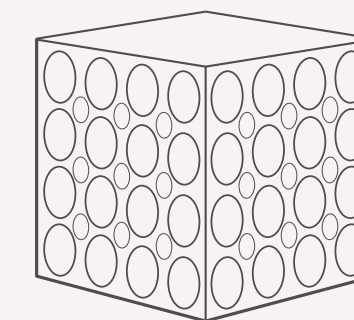
71 kg/m³



Conversion

Synthesized into liquid compounds like ammonia or LOHC. Can utilize existing transportation infrastructure and is advantageous for long-distance/large-volume transport.

121 kg/m³



Solid

A method of storing hydrogen by adsorbing it onto solid materials or chemically bonding it. It offers one of the highest energy densities per unit volume and excellent storage stability, making it suitable for construction machinery and submarines.

Up to 150 kg/m³

Hydrogen storage technology utilizing natural terrain

① Salt Caverns

Stores hydrogen in the empty spaces of underground rock salt layers

② Depleted Gas/Oil Fields

Storing hydrogen in the empty spaces of depleted gas fields or oil fields

③ Aquifers

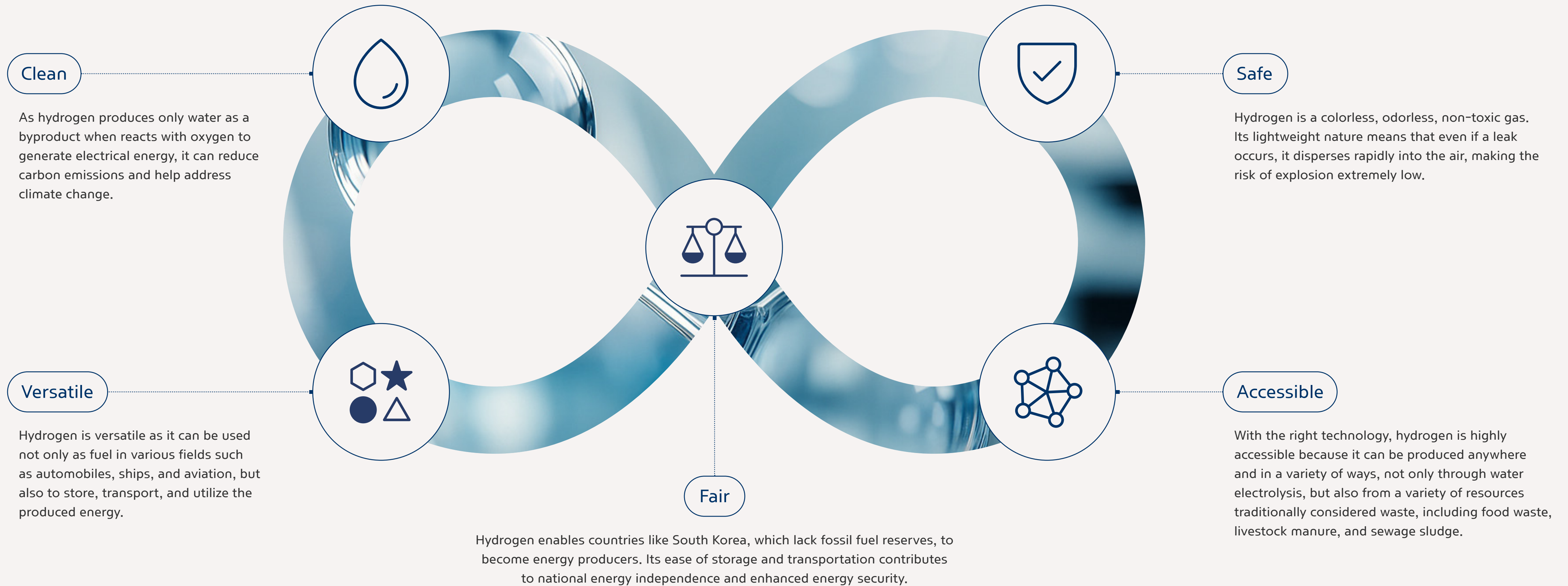
Storing hydrogen in porous strata containing water

④ Rock Caverns

Artificially excavating solid rock layers to store in man-made caverns

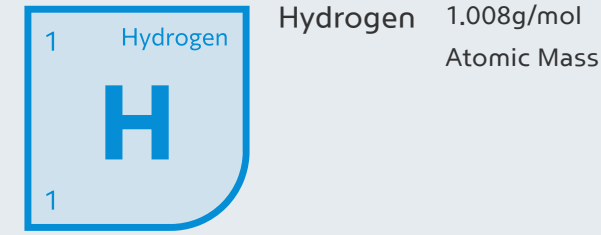
05 Hydrogen for a sustainable future

The characteristics of hydrogen as an energy carrier for building a sustainable future can be summarized as follows.



Summary - What is hydrogen?

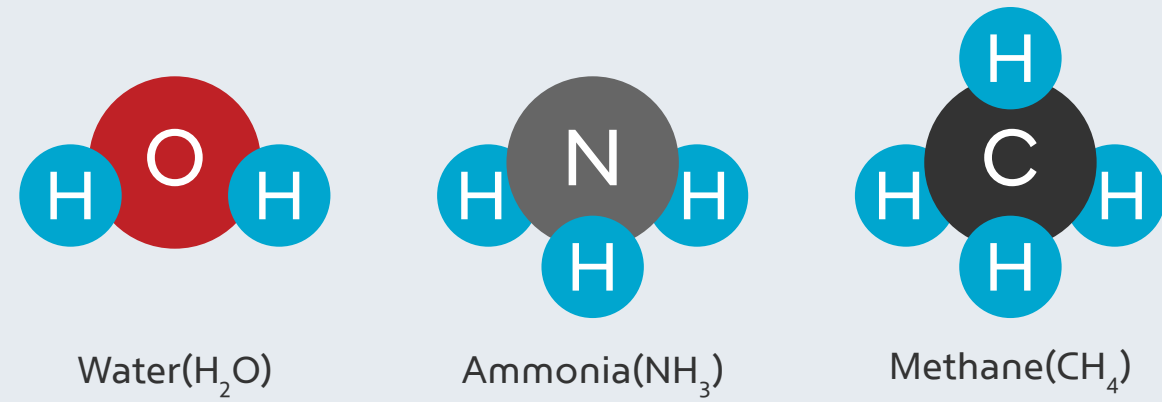
① The first element in the periodic table



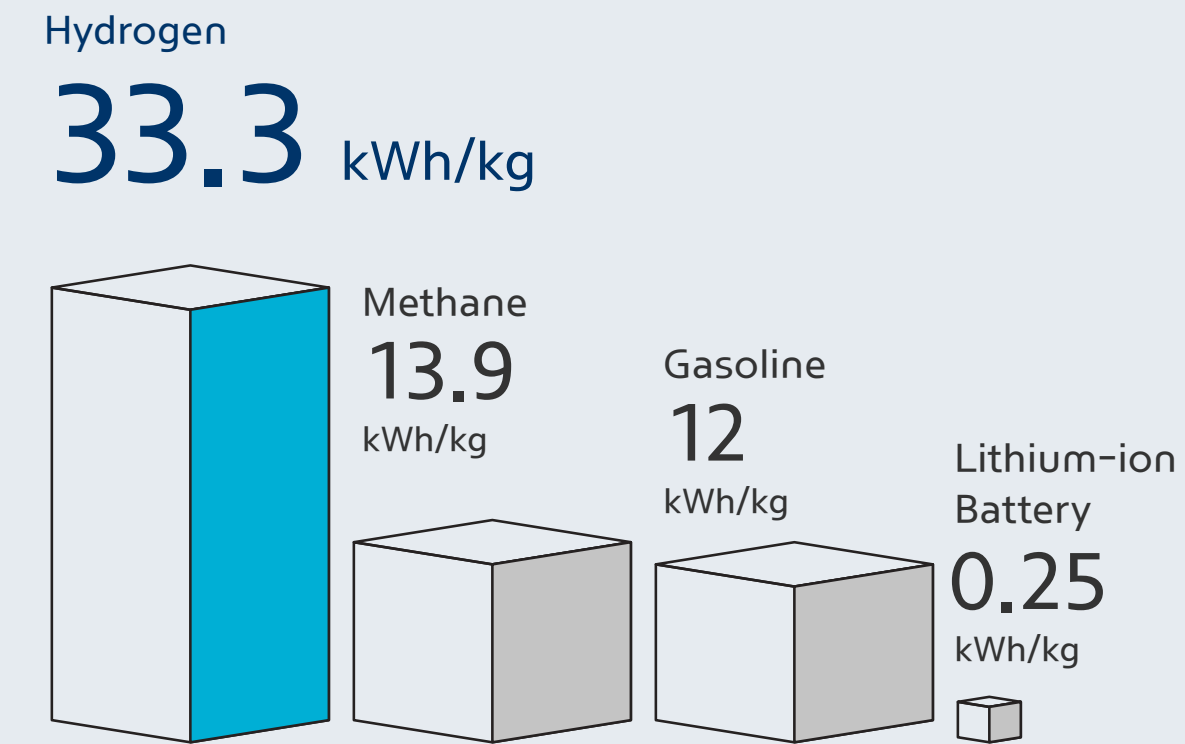
② The simplest element in the universe



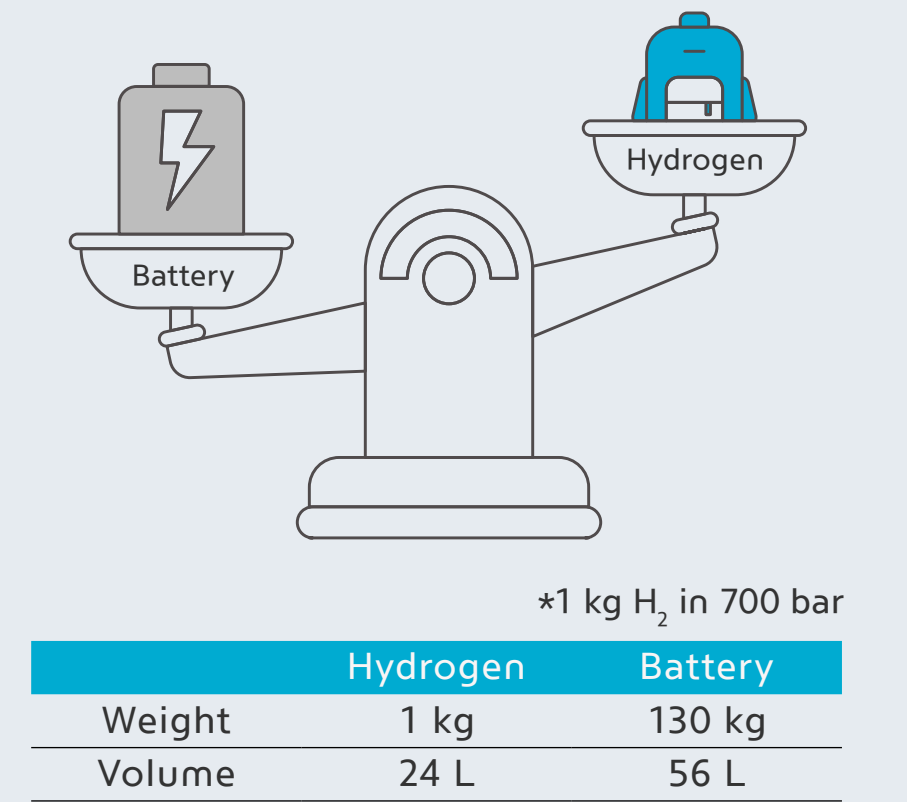
③ Generally exists in a bonded state with other atoms



④ High energy density
Energy stored in 1 kg of hydrogen = Energy stored in 130 kg of battery



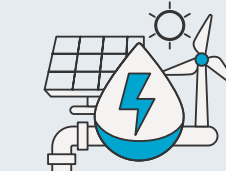
⑤ Low volumetric energy density



Hydrogen production - Can be produced using various everyday resources



① Fossil fuel-based:
Natural gas reforming, byproduct hydrogen, coal gasification, etc.



② Electrolysis-based(water electrolysis):
PEM electrolysis, alkaline water electrolysis, solid oxide electrolysis, etc.



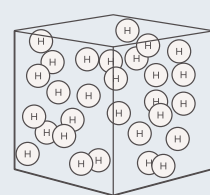
③ Biomass-based:
Utilization of organic waste



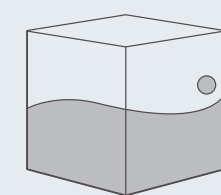
④ Chemical carrier-based:
Ammonia cracking, methanol reforming, extraction from liquid organic hydrogen carriers (LOHC), etc.

*Next-generation technologies: Photocatalytic hydrogen production, water pyrolysis, plasma-based methane pyrolysis, photobiological hydrogen production, etc.

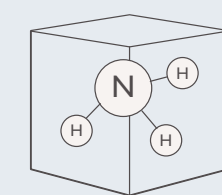
Hydrogen storage - Various storage methods facilitate long-term, long-distance, and large-volume transportation



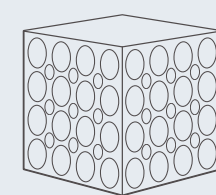
① Compressed in gaseous state



② Liquefaction



③ Conversion



④ Solid

*Methods utilizing natural terrain also exist

Characteristics of hydrogen - The universal energy carrier for a sustainable future

① Clean



② Safe



③ Versatile



④ Accessible



⑤ Fair





Chapter 2

Why Hydrogen: Why Hydrogen Now?

- 01 | Fairer - The cornerstone of energy independence and security
- 02 | Cleaner - The choice for a sustainable future
- 03 | Faster, Further - The partner for future mobility

01

Fairer – The cornerstone of energy independence and security

Today's society revolves around energy. Nearly every system—power, industry, transportation, defense, communications—operates on energy. As society becomes more advanced, the role and importance of energy grow, yet it has often been far from fair for many. Because most energy has relied on fossil fuels, geopolitical disparities in energy access have emerged based on resource distribution. Moreover, factors such as exchange rates, political conflicts, and global uncertainties have occasionally turned energy into a matter of security. Carbon emissions and the resulting climate change have also emerged as new threats to energy security.

It is precisely in this era that hydrogen is gaining attention as a new alternative to achieve energy independence and security. Hydrogen—produced anywhere and easily stored and transported—can serve as a cornerstone for a fair and equitable energy future. It can help overcome geopolitical limitations and produce new energy for a sustainable future.

The development of the hydrogen industry and new technologies that occurs in this process will serve as a new growth opportunity for national economies, contributing to the expansion and advancement of their industrial sectors.

01

① Key to reducing geopolitical energy imbalances

In the fossil fuel era, global energy hegemony was determined by geopolitical location. Unlike the Middle East, North America, and Russia, which possess large reserves of oil and natural gas, South Korea, with an energy import dependency rate of 93.7% (Korea Energy Economics Institute, 2024), was easily affected by global crude oil prices and exchange rates, requiring constant efforts to secure stable supply chains. Hydrogen is different. With the right technology, it can be produced from a variety of resources across locations, enabling a more diversified energy supply, while its versatility in storage and transport allows for a stable and reliable supply. This is why hydrogen can become a strategic resource for national energy independence and security.

1. Diverse Production Methods

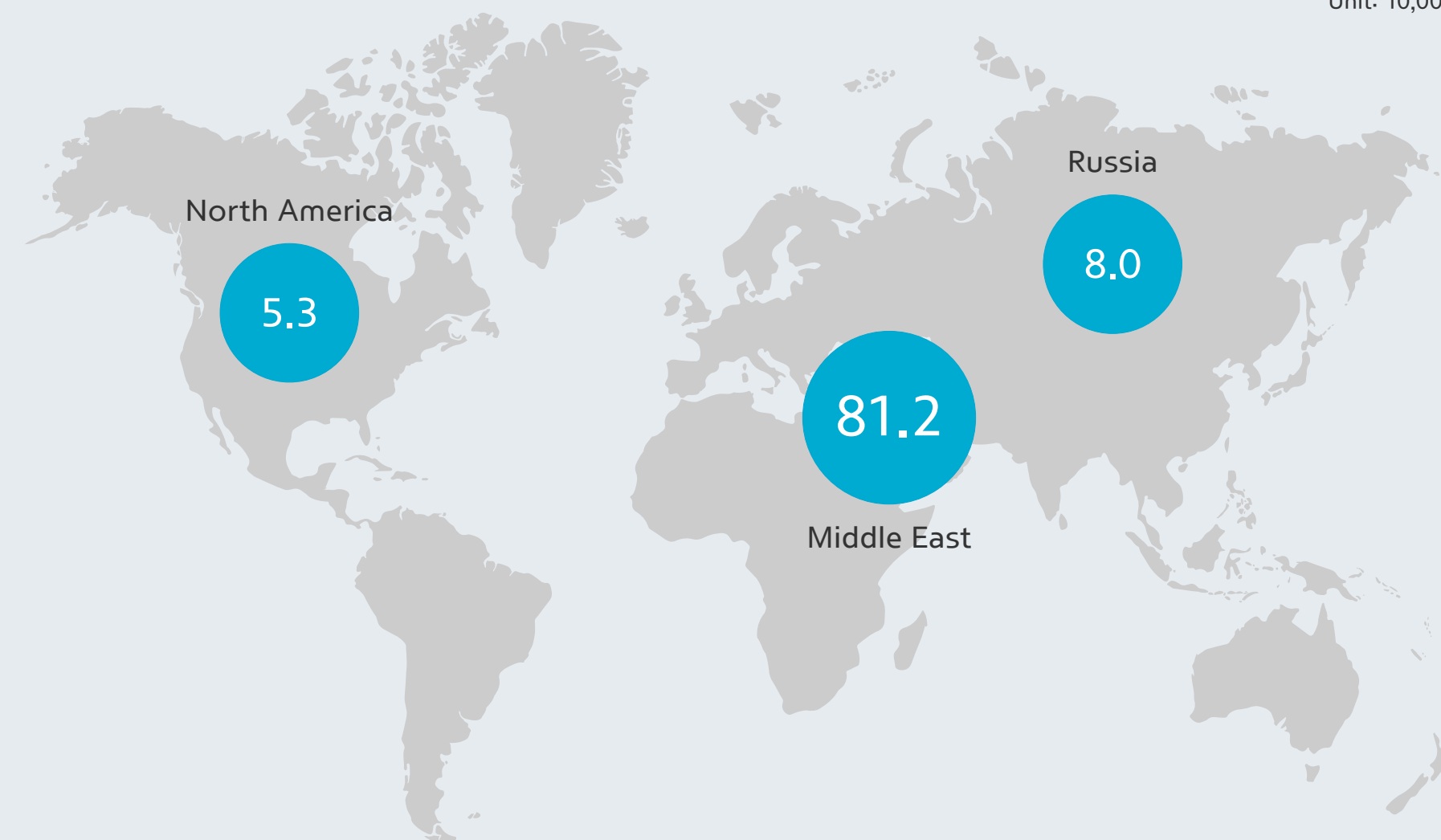
Hydrogen can be produced through diverse resources and methods. In regions with abundant sunlight, solar energy can be used to electrolyze water and produce hydrogen. In areas with limited sunlight, hydrogen can be produced using resources previously considered waste, such as food waste or sewage sludge. Hydrogen can be produced through region-optimized methods, strengthening energy self-sufficiency and reducing dependence on specific foreign suppliers, which helps secure a stable energy supply chain.

2. Diverse Transportation and Storage Methods

Hydrogen can be stored in various physical states, including gas, liquid, and solid. Depending on the storage form, it can be transported via pipelines, ships, trucks, and other means, making it relatively free from potential risks associated with the global energy logistics network.

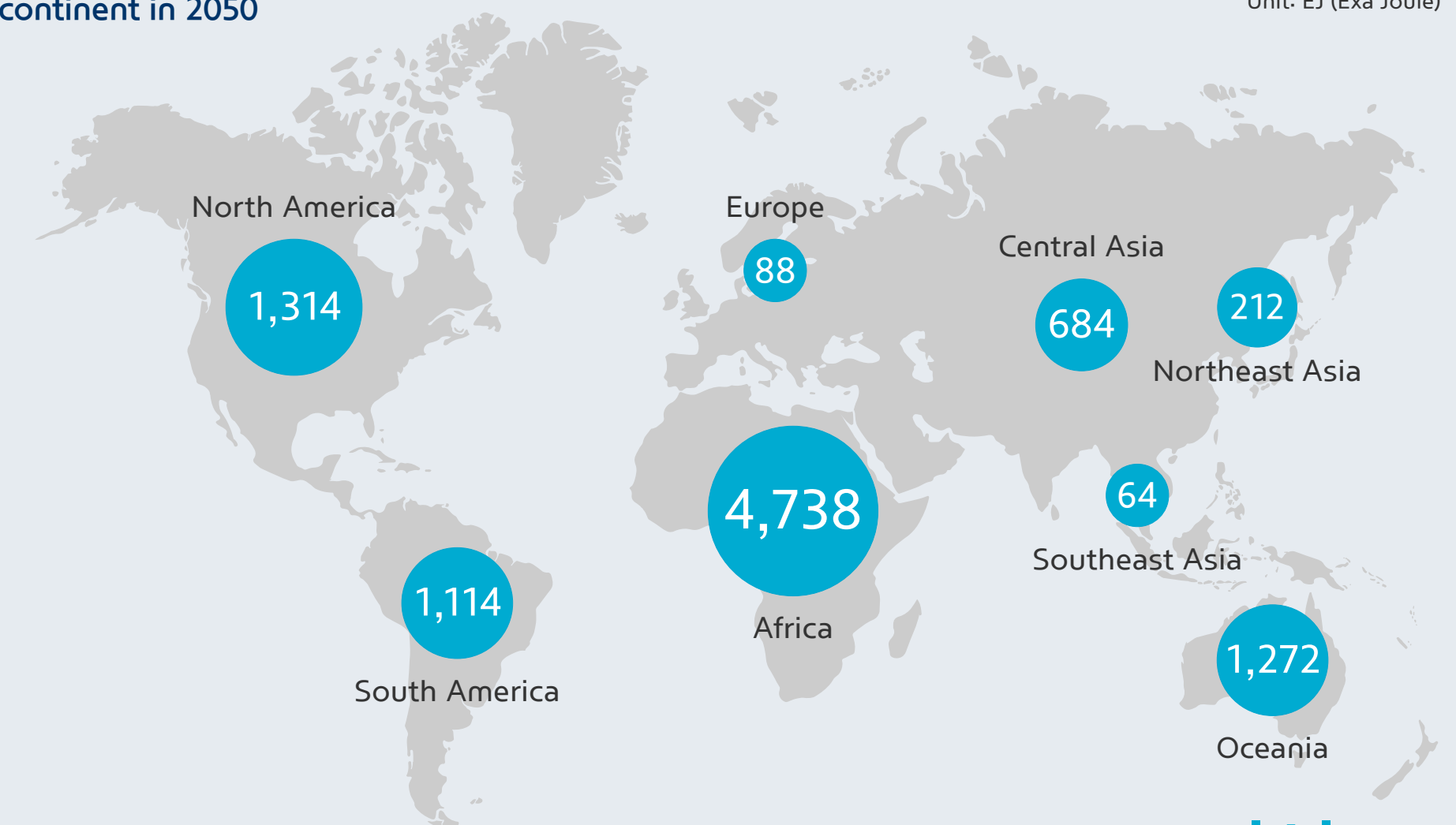
Global oil reserves distribution

Source: OPEC Annual Statistical Bulletin 2020
Unit: 10,000 barrels



Green hydrogen production potential by continent in 2050

Source: IRENA (International Renewable Energy Agency)
Unit: EJ (Exa Joule)



01

② A shortcut to carbon neutrality, clean hydrogen based water electrolysis

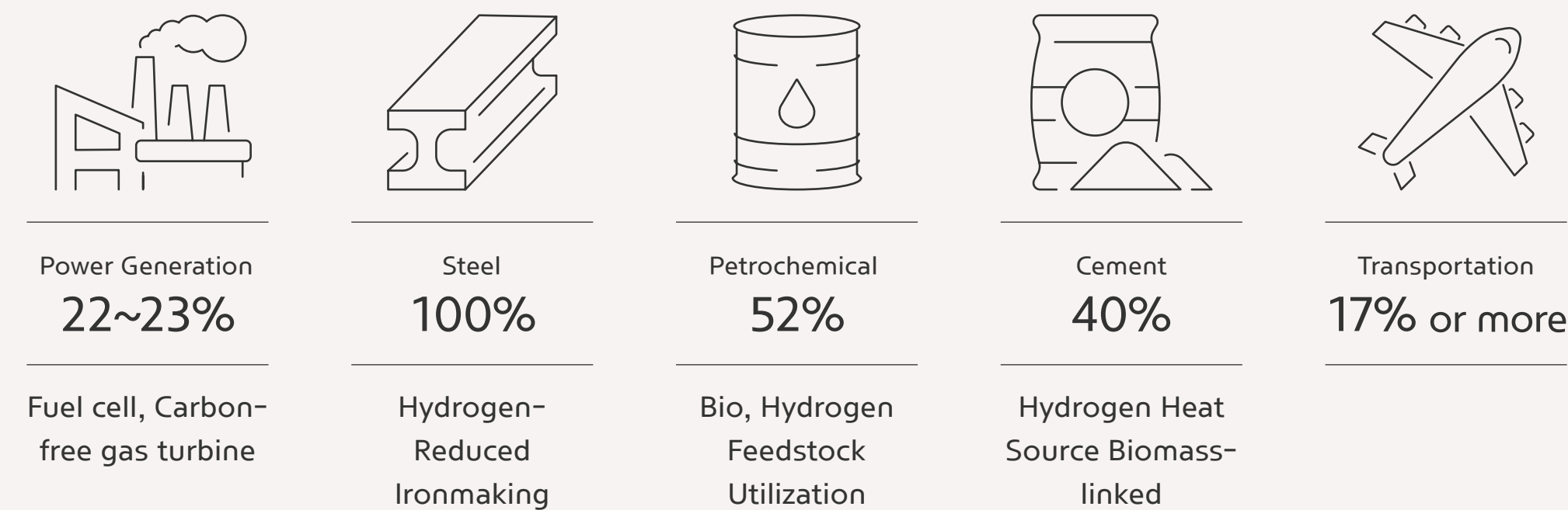
Energy security refers to the ability of a country or region to reliably and continuously secure the energy it requires. This concept goes beyond supply stability to include price stability, diversification of supply sources, and environmental and social sustainability. Today, achieving carbon neutrality and responding to the climate crisis have become central challenges for national industrial competitiveness and energy security—far surpassing the scope of environmental protection alone. Clean hydrogen production through water electrolysis, in particular, is emerging as a key pathway for Korea to realize its carbon-neutrality goals.

1. 2050 Carbon Neutrality Scenario

The Korean government's '2050 Carbon Neutrality Scenario' identifies hydrogen as a core enabler of economy-wide decarbonization, spanning power generation, steel, petrochemicals, cement, and transportation. Under this plan, Korea's annual hydrogen demand is projected to reach approximately 27.4 to 27.9 million tons by 2050.

Sector-specific hydrogen transition plans

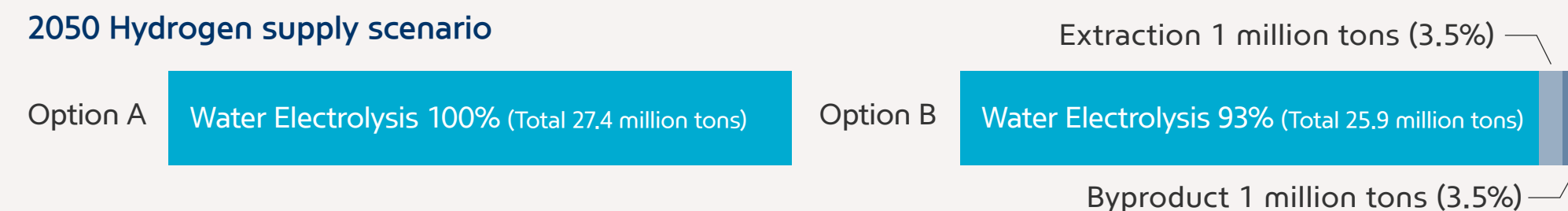
〈Source: 2050 Carbon Neutrality Scenario (2021)〉



2. Water Electrolysis Based Clean Hydrogen

Water electrolysis is the most crucial technology in hydrogen supply strategies for carbon neutrality. Water electrolysis produces hydrogen by decomposing water using electricity. When powered by renewable energy, it creates clean hydrogen with zero pollutant emissions during production. The Korean government's '2050 Carbon Neutrality Scenario' outlines plans to supply at least 93% and up to 100% of the required hydrogen through electrolysis-based clean hydrogen. In other words, water electrolysis technology is a core technology for achieving Korea's carbon neutrality.

2050 Hydrogen supply scenario

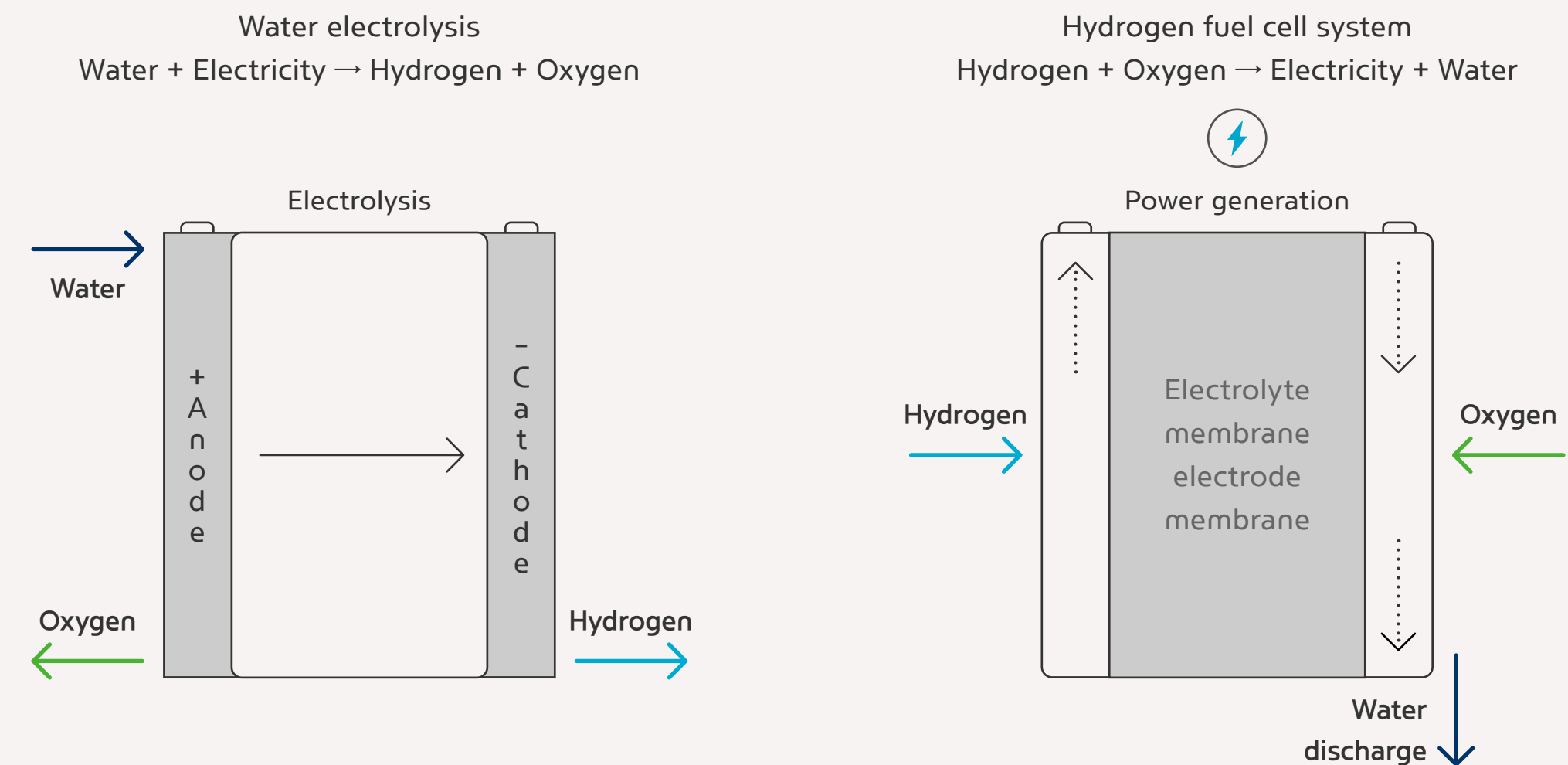


3. Water Electrolysis and Hydrogen Fuel Cell Systems

Water electrolysis produces hydrogen and oxygen by electrolytically decomposing water. This process is essentially the reverse of a hydrogen fuel cell, which combines hydrogen and oxygen to generate electricity and water. In other words, water electrolysis enables hydrogen production, while fuel cells enable hydrogen use. Together, these technologies form a complementary, end-to-end structure within the hydrogen ecosystem. Hyundai Motor Company's PEM electrolyzer further reinforces this link, sharing roughly 85% of its core components with the fuel cell systems used in vehicles such as the NEXO and XCIENT Fuel Cell trucks.

As hydrogen-powered vehicles scale, the resulting increase in fuel cell demand directly supports cost competitiveness in Korea's water electrolysis industry. This mutually reinforcing cycle is expected to become a central driver of industrial competitiveness and long-term sustainability across Korea's hydrogen value chain.

Structure of water electrolysis and hydrogen fuel cell systems with a reciprocal relationship



01

③ Expanding the industrial ecosystem with hydrogen

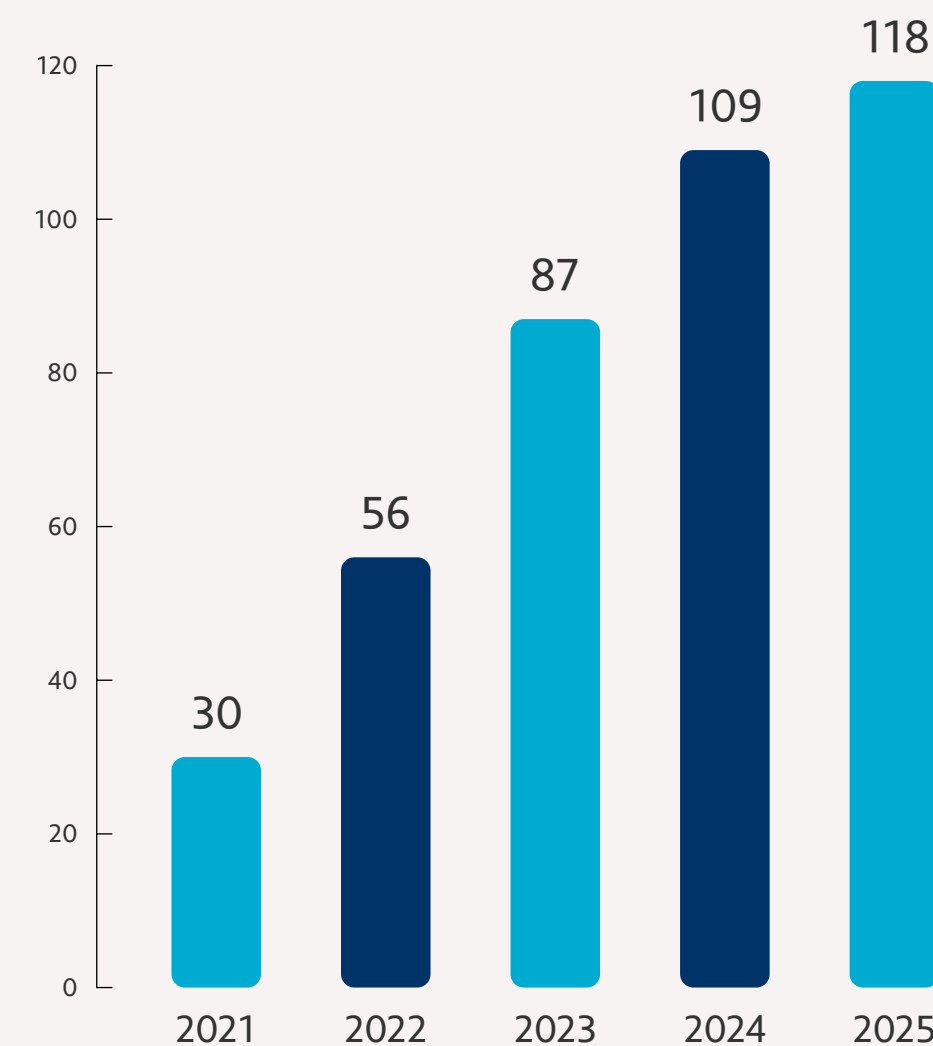
The development of new industries and the establishment of industrial ecosystems play a pivotal role in strengthening national competitiveness and ensuring energy security. By localizing more than 90% of the components in its hydrogen fuel cell systems and working with dozens of partners and over a hundred hydrogen-related companies nationwide, Hyundai Motor Group is strengthening Korea's industrial competitiveness. Thus, the growth of the hydrogen industry leads to mutual growth with partners and job creation, positively impacting Korea's overall economy.

Hyundai Motor Group and Korean hydrogen component manufacturers have already secured world-class technological competitiveness. Linking this technological capability with Korea's key industries, such as automotive, shipbuilding, and petrochemicals, will not only create synergies within the industry but also enable leadership in the global hydrogen market. Furthermore, Hyundai Motor Group's electrolyzers utilize the PEM (Proton Exchange Membrane) method, preferred in Europe and the U.S., providing favorable conditions for export industrialization.

Growth Trend of Korea's Hydrogen Industry

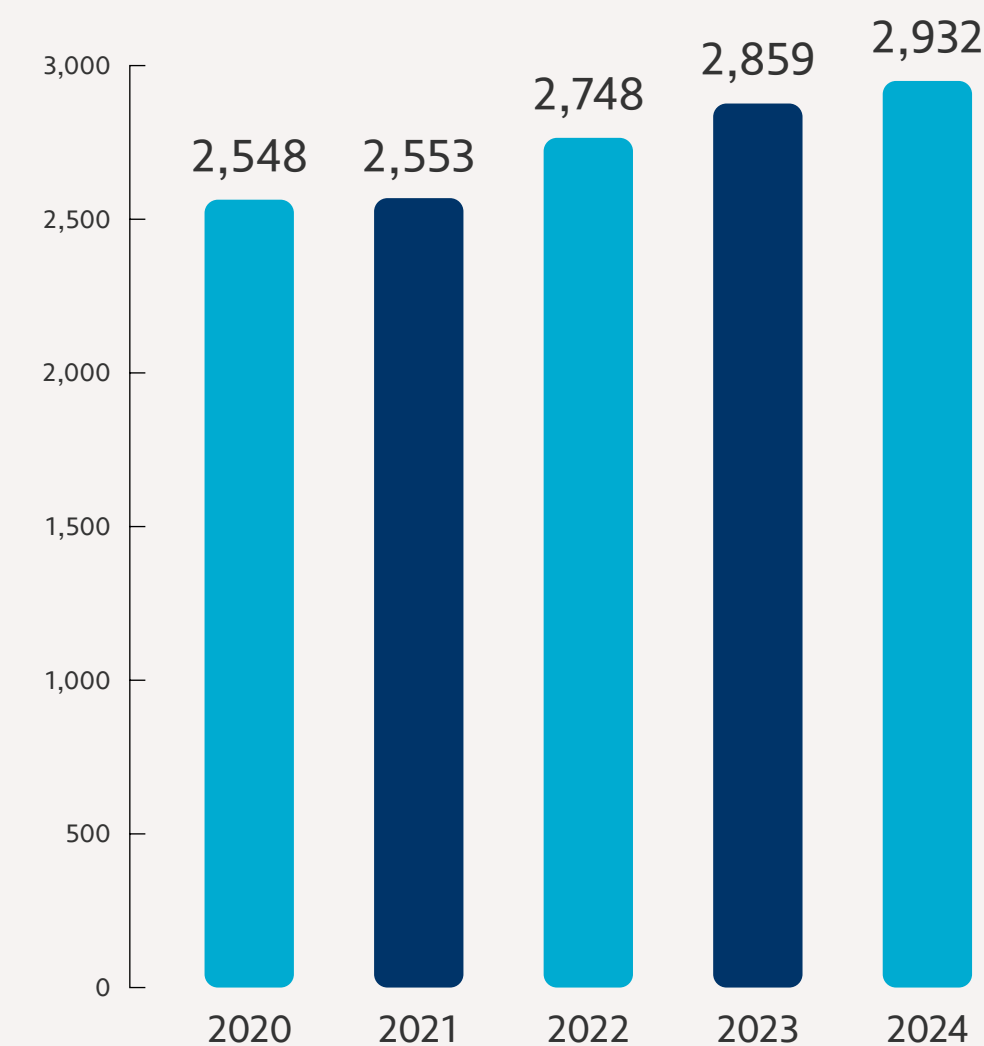
Number of Hydrogen-Specialized Companies in Korea (from 2021 to 2025)

(Unit: Number of companies)



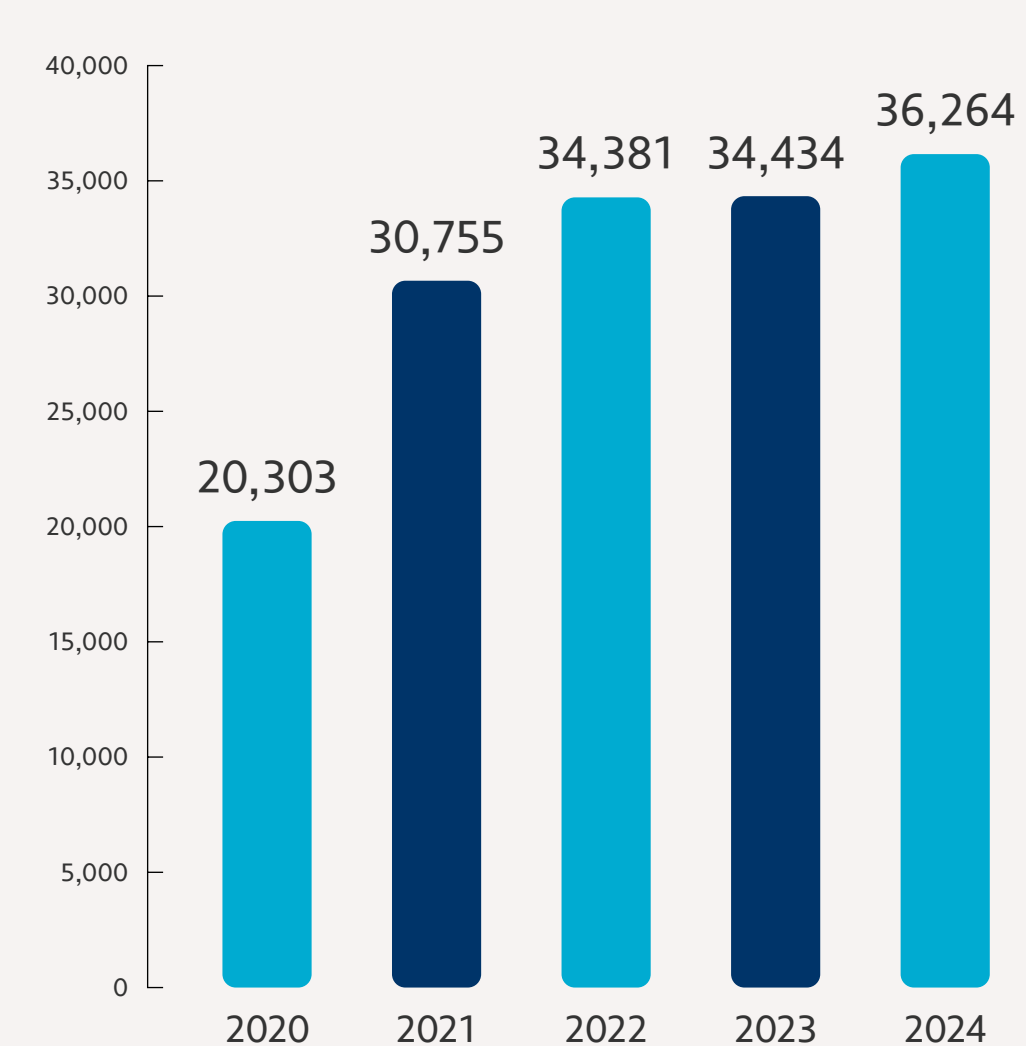
Number of Hydrogen-Related Businesses in Korea (from 2020 to 2024)

(Unit: Number of businesses)



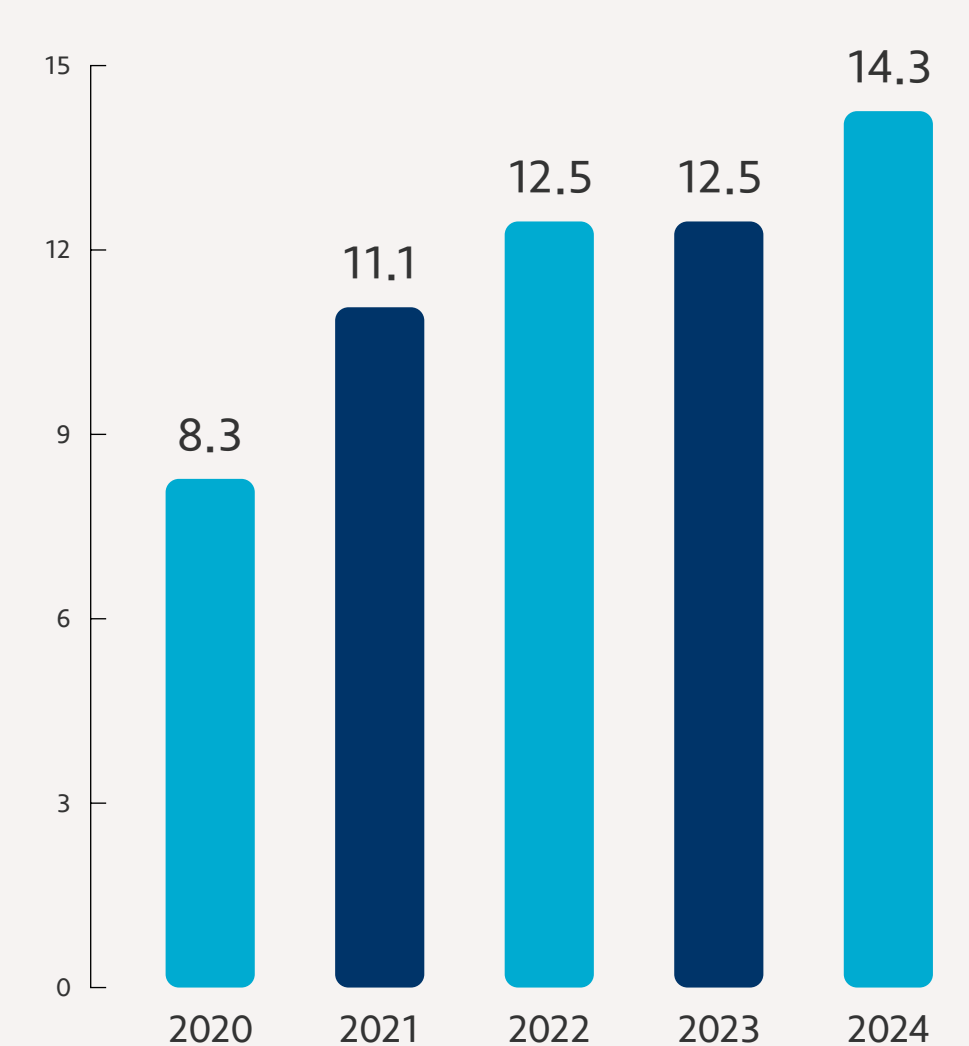
Number of Employees in Korea's Hydrogen-Related Businesses (from 2020 to 2024)

(Unit: Number of employees)



Sales Revenue of Korea's Hydrogen Industry (from 2020 to 2024)

(Unit: Trillion KRW)



<Source: Hydrogen Industry Status Survey, Korea Hydrogen Alliance (H2KOREA)>

Appendix. Global hydrogen market outlook

The hydrogen market is steadily growing amid global interest. According to global consulting firm PwC, the global hydrogen market is projected to expand to approximately \$420 billion by 2050, passing about \$250 billion in 2030.

The EU and China view hydrogen as a key resource for future energy and are sparing no effort in large-scale investment and policy support. The EU plans to produce 10 million tons of renewable hydrogen and invest over 40 billion euros by 2030, while building hydrogen pipelines across Europe. China has also designated hydrogen as a next-generation growth engine, operating approximately 572 hydrogen refueling stations (as of 2025).

In step with this global trend, it is time for Korea to accelerate the growth of its hydrogen industry through policy support and strategic investment. Leveraging the current opportunity created by the global hydrogen market outlook will be the key to enabling sustainable growth in the future energy market.

Hydrogen business status in major countries

EU

- Plans to produce 10 million tons of renewable hydrogen and invest over 40 billion euros by 2030
- Mandatory RFNBO* usage targets: 1% in the transportation sector and 42% in the industrial sector by 2030

China

- Approximately 572 hydrogen refueling stations built and operational as of 2025
- Performance-based differential subsidies totaling approximately 434.5 billion KRW allocated to 10 regions (2025)

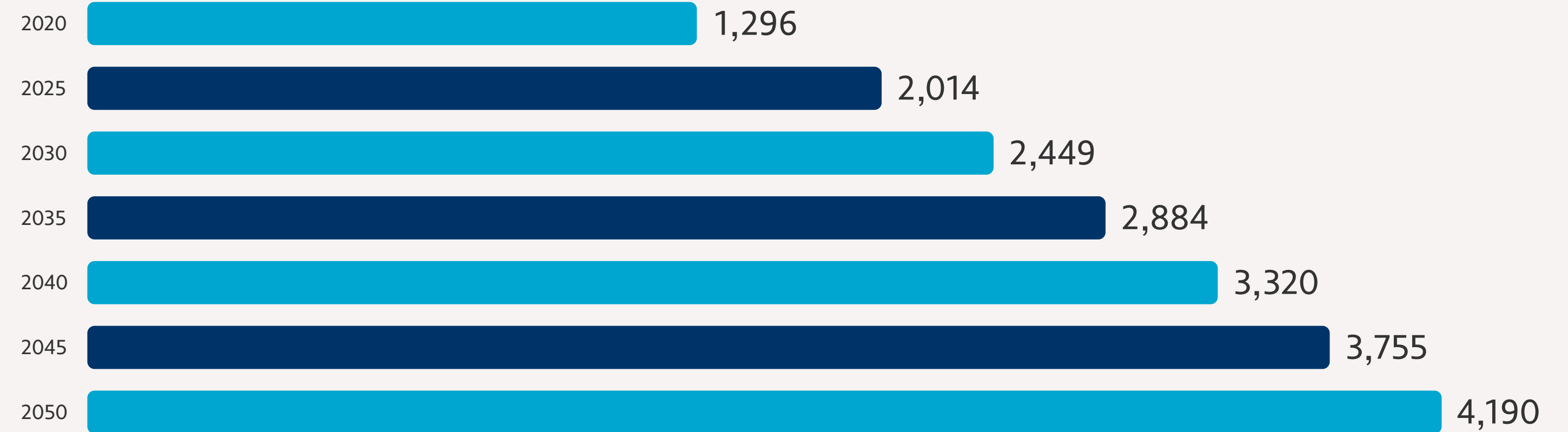
India

- Operating incentive programs for green hydrogen (up to \$0.6/kg) and green ammonia (up to \$0.11/kg) production

*RFNBO: Renewable Fuels of Non-Biological Origin. Fuels such as hydrogen and ammonia produced from sources other than biomass.

Global hydrogen market outlook

(Unit: Billion USD)



<Source : PwC(2023)>

02

Cleaner – The choice for a sustainable future

The energy transition is no longer an option, but a necessity. While renewable energy sources such as solar and wind power are gaining attention for a sustainable future, challenges remain—particularly the variability of power generation depending on weather and time, and the difficulty of storing surplus electricity. As electric vehicles become widely adopted, the lack of supporting power infrastructure is also emerging as a practical constraint we must confront.

In this context, hydrogen presents a key solution for building a sustainable future.

Hydrogen can complement the time- and season-dependent variability of renewable energy, enhancing its overall usability.

Together with electric vehicles, it will help lead the era of eco-friendly mobility and accelerate the transition to a sustainable future.

Let's explore hydrogen in detail—the cleaner path to our future.

02

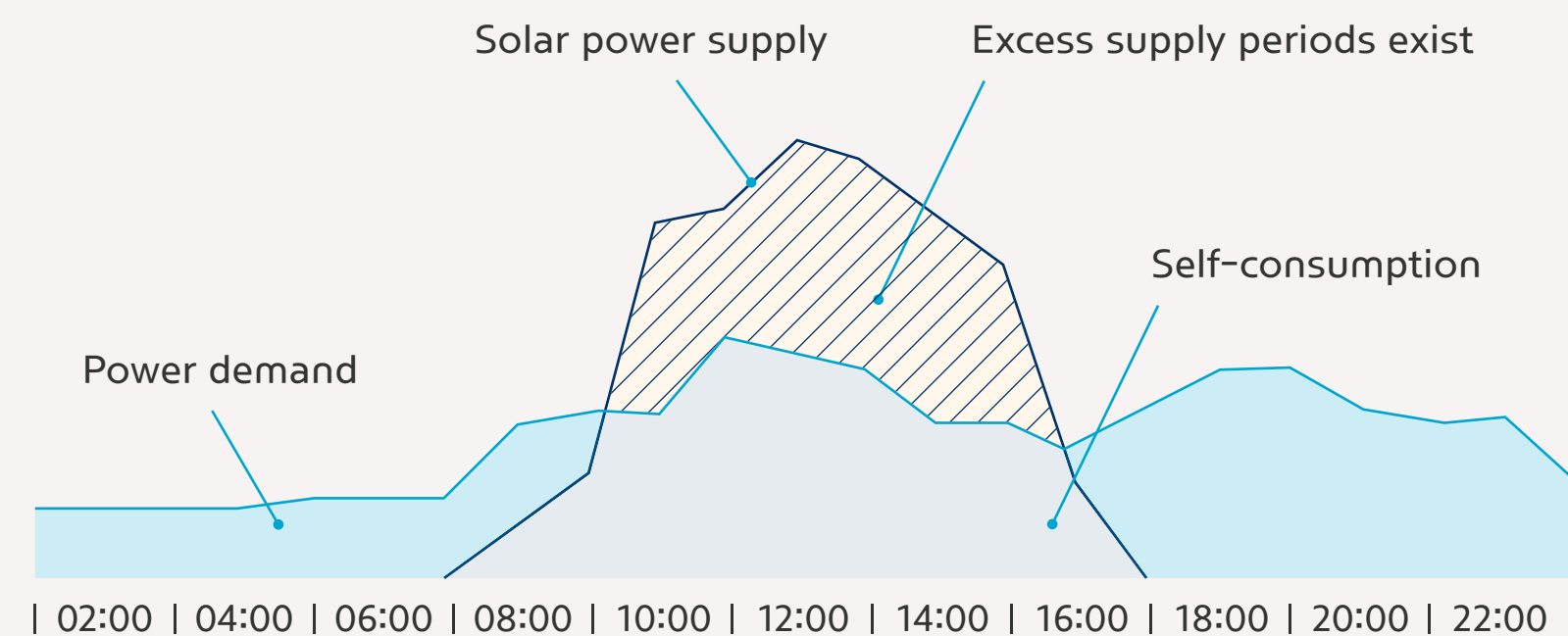
① When renewable energy meets hydrogen

Solar power generation, a leading renewable energy source, sees a sharp surge in electricity production during daylight hours, especially around noon when sunlight is abundant. However, due to insufficient transmission grids and limitations in electrical energy storage technology, a significant portion remains unused. **The amount of unused renewable energy power is estimated at approximately 3 GW. This scale is equivalent to the generating capacity of three nuclear power plants and represents enough electricity to power about 1.15 million households for a month.** What if this power were used to produce hydrogen?

3 GW of power is sufficient to produce approximately 65,000 tons of hydrogen annually through water electrolysis. This amount is also enough to power approximately 540,000 units of NEXO for one year.

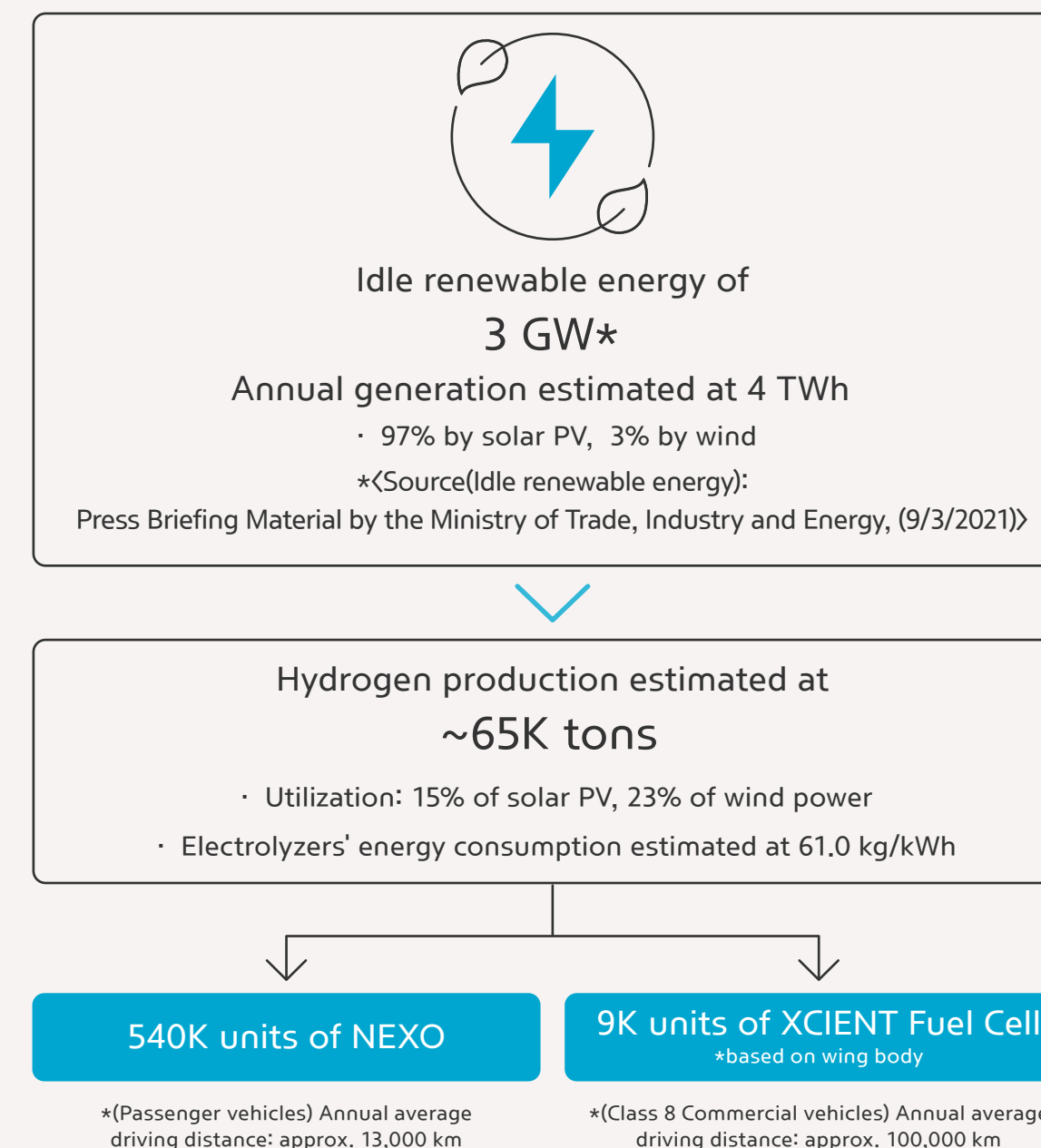
Converting renewable energy into hydrogen—a storable and transportable resource—could dramatically increase the utilization rate of Korea's renewable energy. In fact, Germany is actively pursuing plans to build 10GW of Power-to-Hydrogen facilities by 2030 to efficiently utilize renewable energy. Moreover, storing renewable energy as hydrogen rather than batteries allows for the stable storage of significantly more energy in a much smaller space for weeks to months. In this way, hydrogen can play a crucial role as an energy carrier in achieving carbon neutrality by enabling the use of more renewable energy for longer periods.

Imbalance in solar energy supply and demand



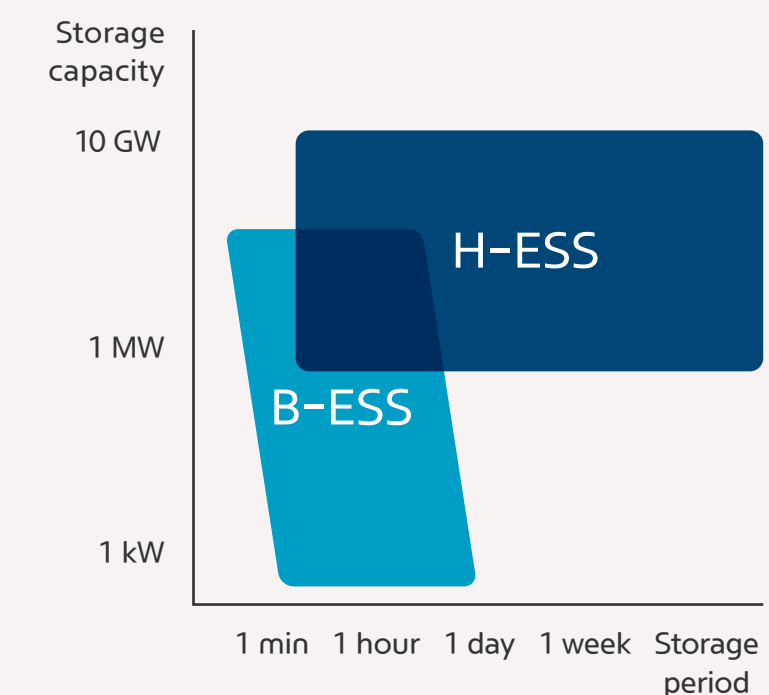
<Source: IRENA, Shinhan financial investment>

Example of converting renewable energy to hydrogen



Comparison of B-ESS* and H-ESS**

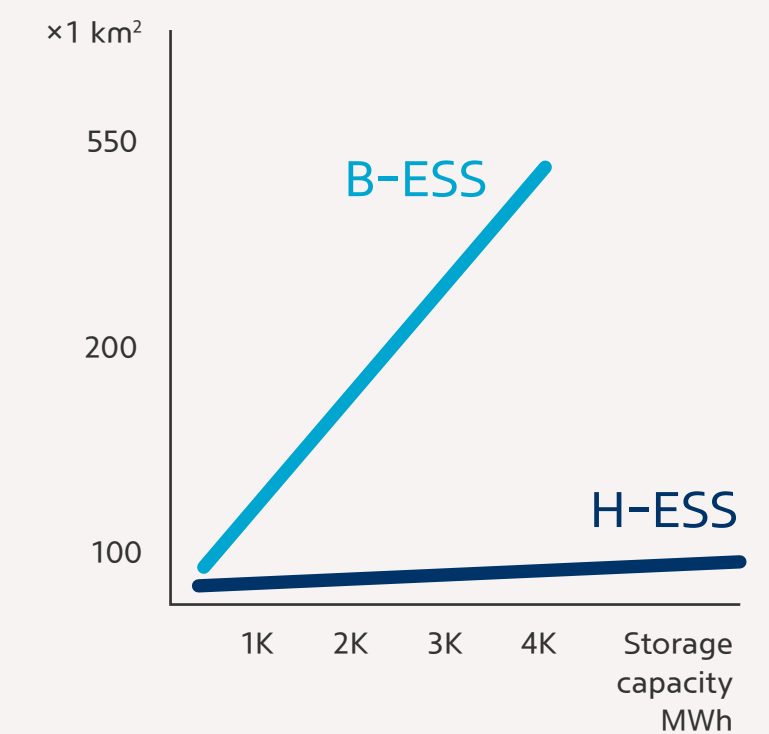
Comparison of storage duration and capacity



*B-ESS: Battery Energy Storage System
**H-ESS: Hydrogen Energy Storage System

<Source: M.F.Ruth et. Al., NREL(2020)>

Comparison of storage capacity against area



<Source: M. McKellar et. Al., U.S. DoE(2023.9)>

02

② Eco-friendly mobility transition with hydrogen

As countries worldwide set goals for eco-friendly mobility adoption to achieve carbon neutrality, South Korea has also announced plans to deploy 4.2 million electric vehicles by 2030. However, operating 4.2 million EVs as planned would require approximately 24,760 GWh of electricity. This is six times the electricity currently consumed by the roughly 750,000 EVs in operation (as of the first half of 2025).

Realistically, it is difficult to expand such a large amount of electricity and the supporting infrastructure within a short period of time.*

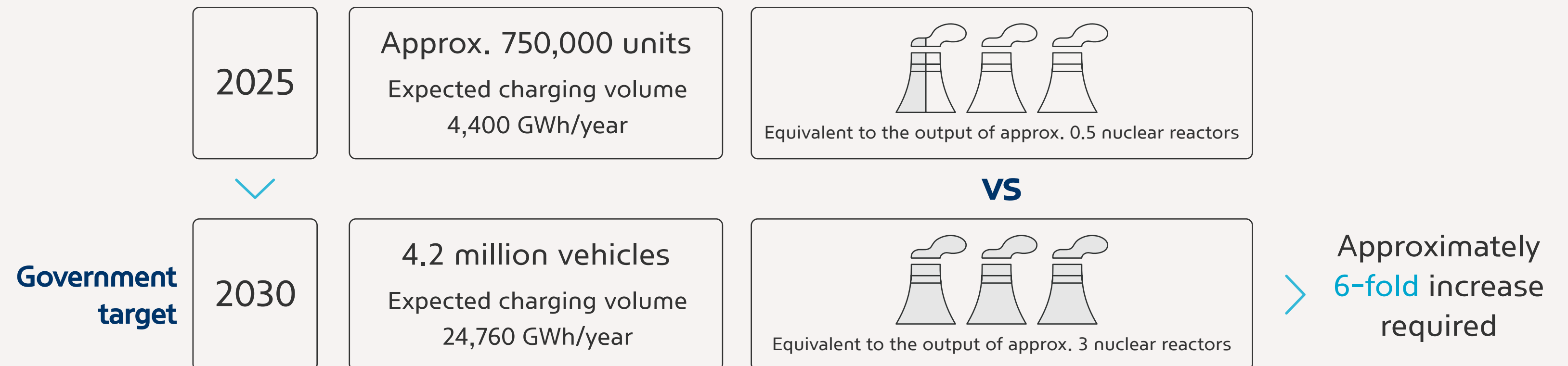
We can resolve the conflicting issue of insufficient power infrastructure with hydrogen vehicles.

Since hydrogen vehicles do not require electric charging, they can prevent sudden surges in electricity demand and alleviate energy burdens.

In other words, a balanced adoption of both electric and hydrogen vehicles will offer consumers broader choices, usher in an era of stable eco-friendly mobility for the nation, and deliver a cleaner future for us all.

*Building two nuclear reactors requires a 7 trillion KRW budget and over five years of construction time

Korea's EV adoption outlook and required power supply



<Source: Zero-emission vehicle integrated portal statistics>

Calculated based on annual charging volume per EV: 3,000 kWh (passenger car), 122,755 kWh (bus)

02

③ What only hydrogen can do

On the path to a carbon-neutral society, there are sectors where electricity alone cannot fully replace existing energy sources. The iron and steel, chemical, and cement industries, which utilize hydrogen as a feedstock, and the aviation and shipping sectors, where heavy batteries are difficult to apply, are prime examples. However, the greenhouse gases emitted from these sectors account for a staggering 28% (10.4 billion tons/year as of 2023) of global carbon emissions. Let's explore the decarbonization areas that can be addressed through hydrogen.

1. Hydrogen-based Industries

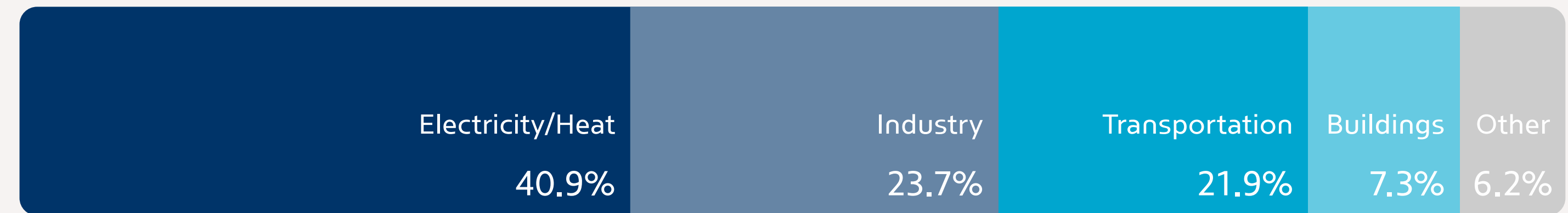
Traditional steelmaking processes emit massive amounts of carbon dioxide when coal is burned to separate oxygen from iron ore. However, if the hydrogen reduction method is applied—using hydrogen to remove oxygen from iron ore and produce iron—South Korea's steel sector alone could reduce carbon emissions by approximately 100 million tons, cutting national emissions by about 17%.

2. Industries that Use Hydrogen as Fuel

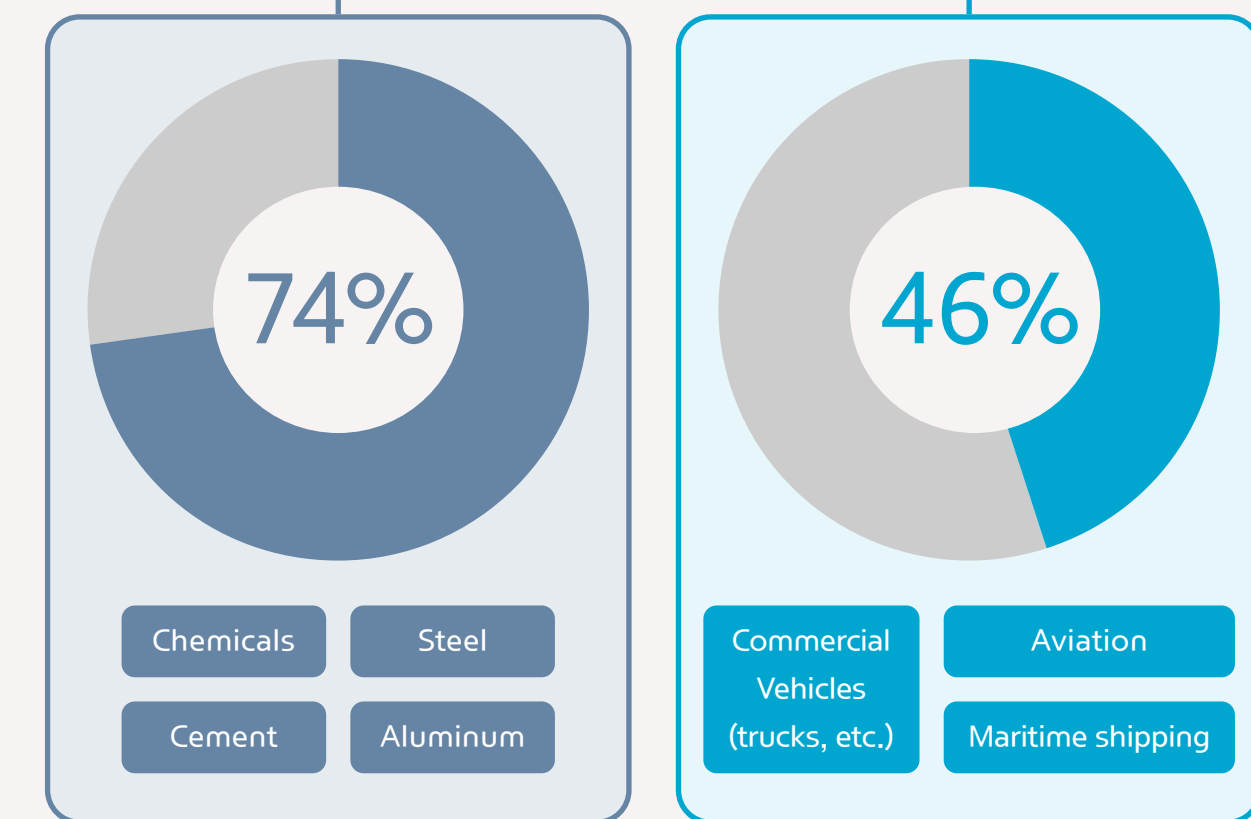
Aviation and shipping require long-distance operations, but batteries have low energy storage capacity relative to their weight, making it difficult to carry sufficient batteries for such journeys. Even if carried, operational range and efficiency would be significantly reduced. Therefore, hydrogen, with its high energy density and fast charging capability, is gaining attention as the next-generation eco-friendly fuel in aviation and shipping.

Carbon emissions by sector

Total emissions: 38.15 billion tCO₂ (as of 2024)



<Source: IEA (World Energy Outlook 2025)>



03

Faster, Further – The partner for future mobility

The mobility industry is likely the sector where we can experience hydrogen most tangibly in our daily lives.

Today, the mobility industry is evolving faster than ever before, and consumers' criteria for choosing vehicles are also becoming increasingly demanding and complex.

At the heart of this change lies the energy transition. As environmental concerns grow, hybrid electric vehicles (HEVs) and battery electric vehicles (BEVs, hereafter electric vehicles) which utilize electricity as a power source to overcome the limitations of conventional internal combustion engine vehicles, have emerged. Hydrogen fuel cell electric vehicles (FCEVs, hereafter hydrogen vehicles), which use hydrogen as fuel, are also gaining attention as a viable option.

Hydrogen vehicles compensate for the limitations of hybrid and electric vehicles with features like fast charging times and long driving ranges, presenting drivers with more diverse eco-friendly options and new possibilities.

Why are hydrogen vehicles necessary for the future mobility era, and what unique strengths do they possess?

Furthermore, how will hydrogen vehicles transform our daily lives?

Let's explore the characteristics of hydrogen fuel cell vehicles that will help us usher in the future mobility era.

03

① Hydrogen fuel cell vehicles - Passenger vehicles

Hydrogen vehicles are considered one of the leading eco-friendly vehicles alongside hybrids and electric vehicles. Hydrogen vehicles are an ideal option for those who want to avoid frequent charging and make the most of their time.

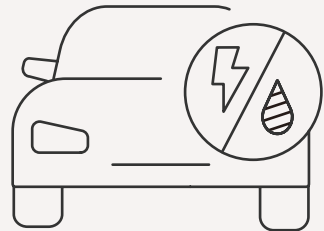
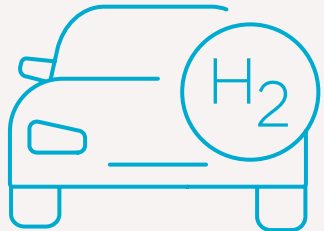
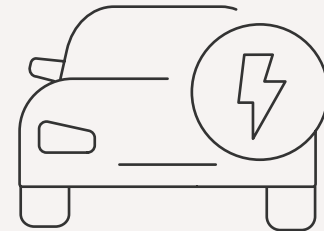
The NEXO, a leading hydrogen vehicle, only takes 5 minutes to charge. With a refueling time comparable to conventional internal combustion engine vehicles, it can travel up to 720 km. This distance is sufficient for a round trip between Seoul and Mokpo (344 km one way) with fuel to spare.

While electric vehicles may be more economical than hydrogen vehicles based on fuel cost per unit distance(km), electric vehicles require charging times that are at least 10 times longer and up to several dozen times longer than hydrogen vehicles.

When charging time is factored in, hydrogen vehicles emerge as an attractive eco-friendly option for economical long-distance travel—taking us faster and farther.

From hydrogen vehicles that deliver outstanding eco-efficiency with fast refueling, to electric vehicles with strong advantages in charging infrastructure, and hybrids that retain the familiar refueling method while adding economic benefits— You can choose from various eco-friendly vehicle options based on your driving patterns and preferences.

Comparison of characteristics by fuel type

	 Hybrid	 Hydrogen vehicle	 Electric vehicle
Charging Time	Approx. 5 min	Approx. 5 min	Approx. 50 min to 10 hours
Range (Fully Charged)	Approx. 1,039 km	Approx. 720 km	Approx. 485 km
Fuel Cost per km	107.0 KRW	92.9 KRW	Slow charging 49 KRW / Fast charging 74 KRW

*Assumed fuel/charging costs: hydrogen 10,000 KRW/kg, slow charging (7 kW) 255 KRW/kWh, fast charging (100 kW) 385 KRW/kWh, gasoline 1,660 KRW/L.

03

② Hydrogen fuel cell vehicles - Commercial vehicles

The strengths of hydrogen vehicles are even more pronounced in the commercial vehicle sector. The advantages of hydrogen vehicles - short refueling time + long driving range - truly stand out in the commercial vehicles sector, where utilization rates and economic efficiency are key.

1. Short Refueling Time & Long Driving Range

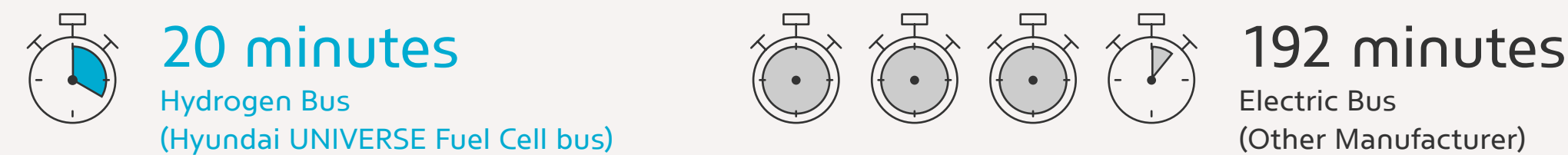
The hydrogen tank of a hydrogen fuel cell truck (hereafter hydrogen truck) can store over twice the energy compared to the battery of an electric truck of the same class.*

Based on this energy capacity, hydrogen trucks can travel up to 720 km on a single refuel. This is much longer compare to the electric commercial vehicles, which can travel up to 442 km. (Based on comparison with the Hyundai XCIENT Fuel Cell truck and comparable electric truck)

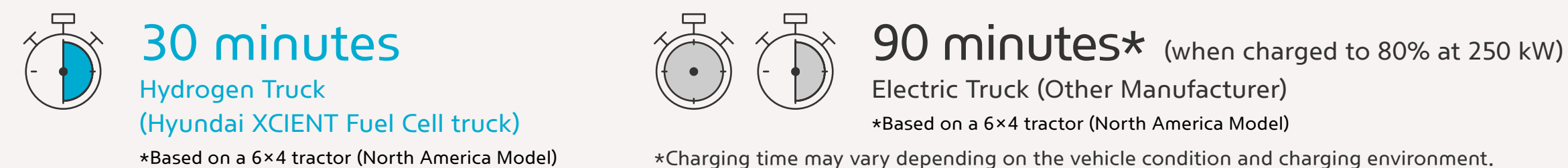
Similarly, while an electric bus requires a full charge time of 192 minutes, a hydrogen bus can be refueled in just 20 minutes. When an electric bus can only travel about 502 km, a hydrogen bus can travel nearly twice that distance, up to 960 km (Based on comparison with the Hyundai UNIVERSE Fuel Cell bus and comparable electric bus). In other words, hydrogen buses save over 9 times the refueling time compared to electric buses and secure nearly twice the driving range, dramatically improving bus operational efficiency.

*Based on 1 kg H₂ = 7.6 kWh. Actual 1 kg H₂ = 33.3 kWh, but this is a conservative figure accounting for potential thermal energy loss during the fuel cell's electricity conversion process.

Comparison of charging times between hydrogen buses and electric buses



Comparison of charging times between hydrogen trucks and electric trucks

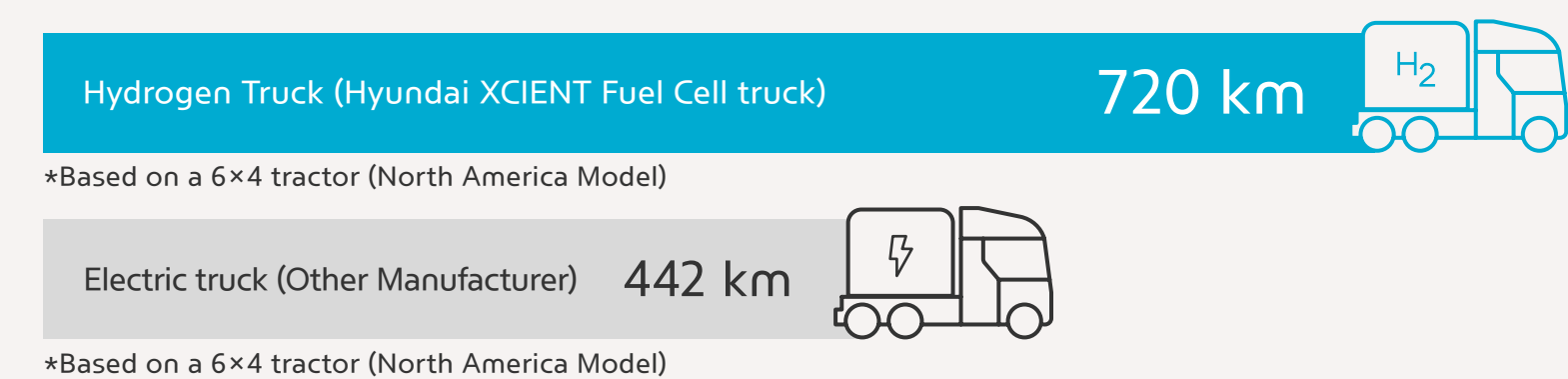


Comparison of driving range per full charge between hydrogen and electric buses

*Based on Korea's certification (unloaded + constant speed driving)



Comparison of driving range per full charge between hydrogen trucks and electric trucks



03

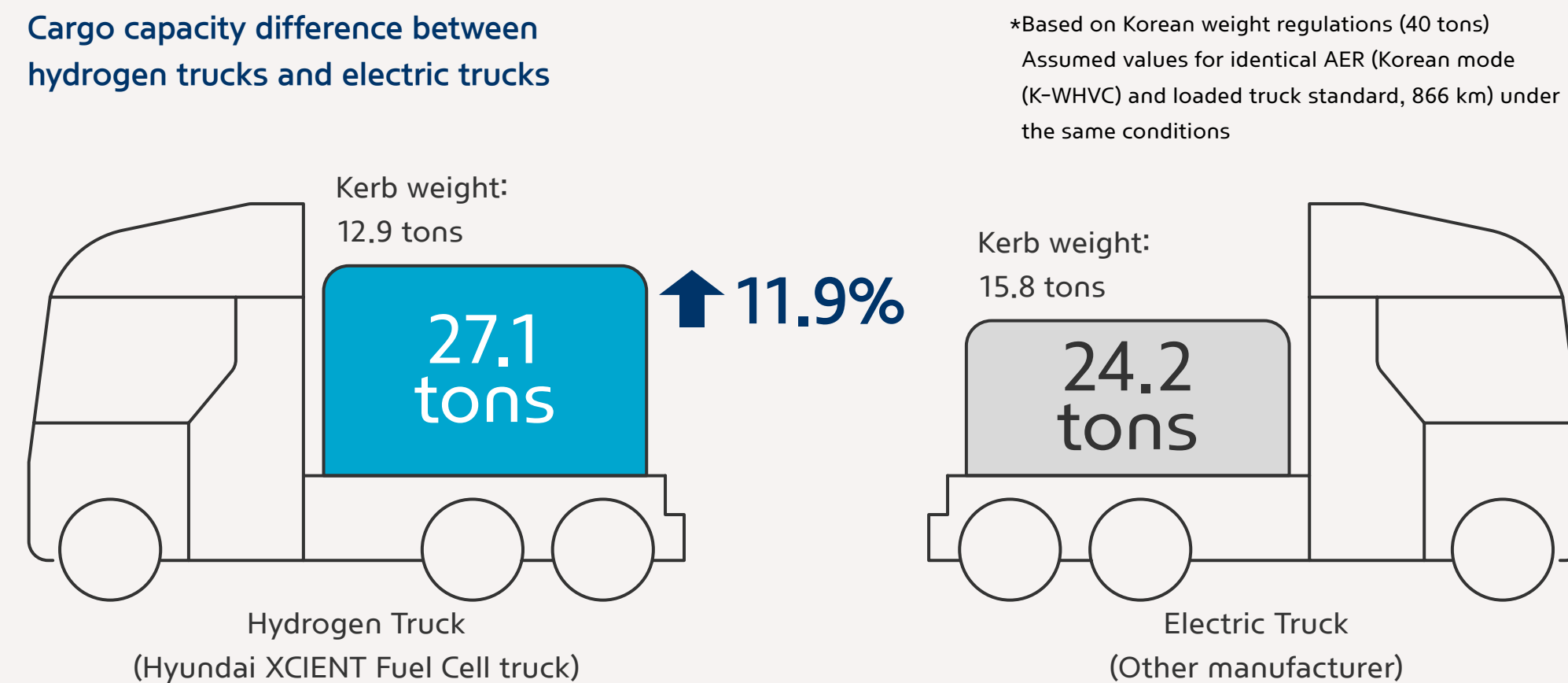
② Hydrogen fuel cell vehicles - Commercial vehicles

2. High Payload Efficiency

Operating large trucks requires significantly more energy than regular vehicles. Therefore, when building electric trucks, larger, heavier batteries must be installed, which in turn increases the vehicle's weight accordingly.

In contrast, hydrogen trucks have relatively lightweight energy storage systems, allowing them to carry more cargo than electric trucks under various weight regulations.

Cargo capacity difference between hydrogen trucks and electric trucks



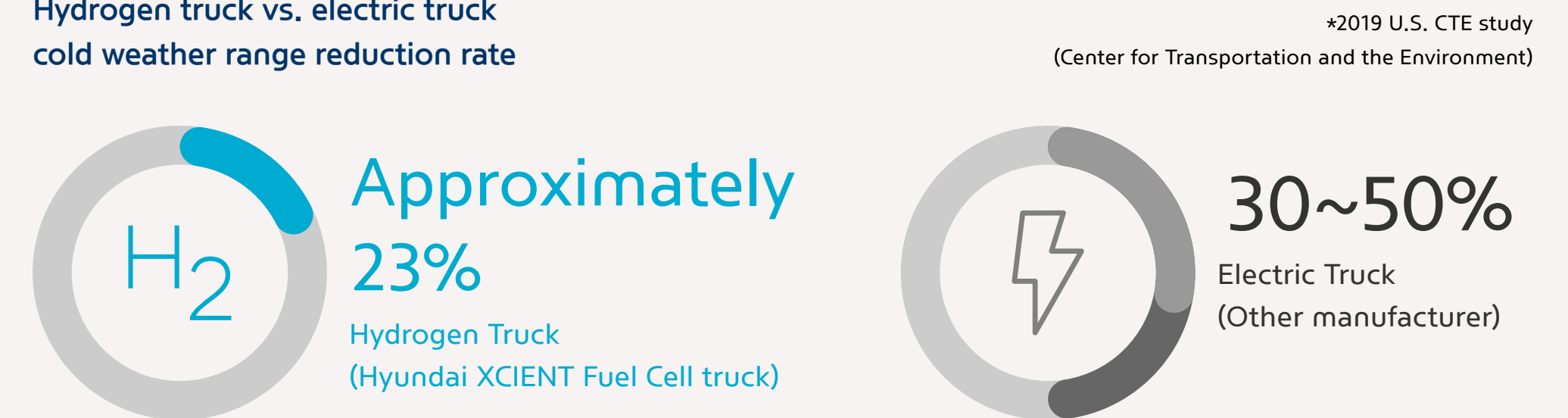
Ideal for weight-restricted routes

3. Ensuring Range in Extreme Cold

In extreme cold weather between -10° C and -20° C, most electric vehicles experience a 30-40% reduction in driving range compared to operation at normal temperatures due to battery performance degradation.

Hydrogen does not store electricity in a battery. Instead, it reacts with oxygen when needed to power the motor using hydrogen stored in tanks. This results in significantly less energy loss at low temperatures, ensuring operational stability during winter or in extreme regions. Hydrogen vehicles retain the quiet operation and stability advantages of electric vehicles, reducing fatigue during long-distance driving while maintaining excellent driving responsiveness.

Hydrogen truck vs. electric truck cold weather range reduction rate



Ideal for winter operation and extreme overseas regions

Summary

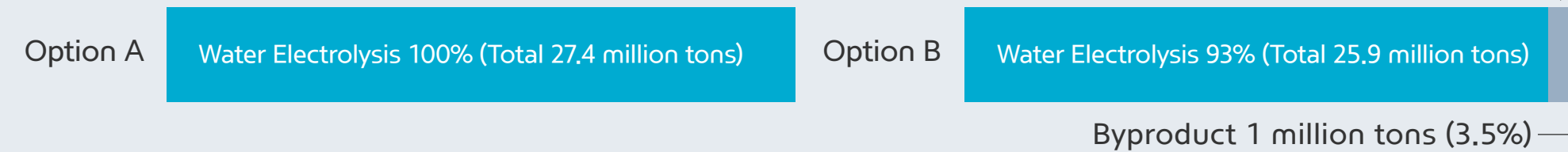
1. Fairer

- The cornerstone of energy independence and security

With the right technology, it can be produced anywhere, and stored and transported in various ways. Hydrogen is a strategic resource for enhancing energy independence and security

- ① Bridging the geopolitical energy divide
 - Moving beyond the fossil fuel era where energy hegemony was determined by geopolitical location, hydrogen can be produced, stored, and transported anywhere with the right technology
- ② Water electrolysis-based clean hydrogen
 - Clean hydrogen based on water electrolysis utilizing renewable energy is the key to the Korean government's 2050 carbon neutrality scenario

2050 Hydrogen Supply Scenario



- Water electrolysis technology, in particular, can form a virtuous cycle structure due to its reciprocal relationship with hydrogen fuel cell systems for hydrogen vehicles

③ Hydrogen industry ecosystem

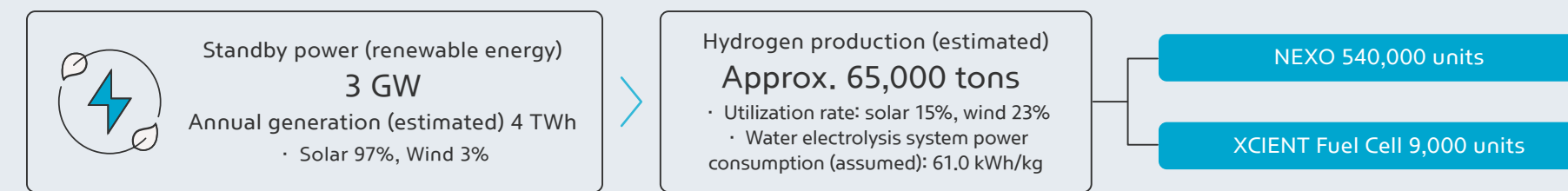
- Hyundai Motor Group's hydrogen fuel cell system, localizing most of the components, contributes to fostering Korea's future industries through collaboration and shared growth with various partners

2. Cleaner

- The choice for a sustainable future

It enhances the usability of renewable energy and presents solutions for industrial sectors where electric batteries are difficult to utilize. Hydrogen is essential for a sustainable future

- ① Expanding renewable energy efficiency
 - Storing approximately 3 GW of renewable energy that cannot be utilized due to power infrastructure issues as hydrogen could power about 540,000 units of NEXO for one year



- An energy carrier that facilitates long-term, large-volume storage, enhancing the utilization and efficiency of renewable energy

② Transition to eco-friendly mobility without power concerns

- As electric mobility expands and electricity demand grows, hydrogen vehicles offer an alternative refueling approach that does not rely on grid-based refueling. This can help mitigate sudden spikes in electricity consumption and contribute to a more resilient overall energy system.

③ Tasks only hydrogen can achieve

- Hydrogen is indispensable for decarbonizing hard-to-abate sectors that use hydrogen as a feedstock, such as steel, chemicals, and cement. It also provides one of the most practical low-carbon options for aviation and maritime transport, where battery energy density constraints limit electrification.

3. Faster, farther

- The partner for future mobility

In the eco-friendly mobility era, hydrogen vehicles offer an attractive option complementing electric vehicles

① Passenger vehicles - An attractive eco-friendly mobility option offering fast charging experiences and ample driving range



- ② Commercial vehicles - Fast refueling times, long driving range, high cargo efficiency, and extreme-weather driving capability are unique strengths of hydrogen vehicles compared to electric vehicles



Chapter 3

Global Energy Transition Leader, Hyundai Motor Group

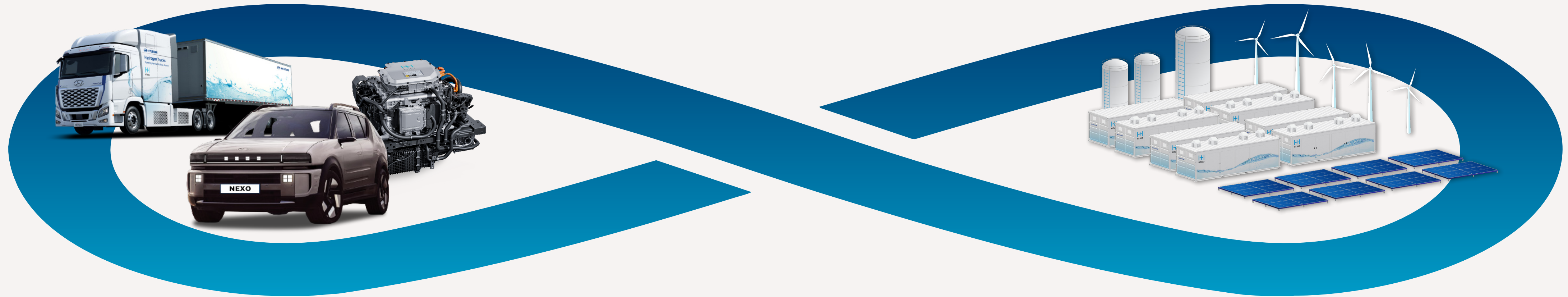
- 01 | The sustainable hydrogen ecosystem created by Hyundai Motor Group
- 02 | 30 Years of leading the hydrogen industry
- 03 | HTWO - Hyundai Motor Group's hydrogen business brand
- 04 | From production to utilization. HTWO's hydrogen value chain
- 05 | HTWO's business platform
- 06 | Key business solutions

Hydrogen Production | Eco-friendly Logistics Business | Port/Airport Decarbonization |
Hydrogen Mobility | Expansion of Hydrogen Fuel Cell System Lineup |
Hydrogen Industry Application - Hydrogen Burners | Hydrogen Refueling Solutions

01

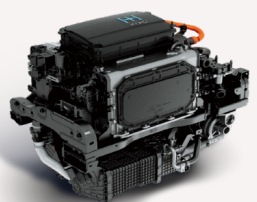













The sustainable hydrogen ecosystem created by Hyundai Motor Group

Hydrogen is essential on the path to a carbon-neutral society. For the sustainable growth of the hydrogen industry, balancing supply and demand is paramount. Hyundai Motor Group's hydrogen journey, which began in mobility—creating hydrogen demand—is expanding into production and transportation, building a hydrogen ecosystem across the entire industry. Leveraging its strengths in mobility, Hyundai Motor Group is creating a balanced virtuous cycle of demand and supply, leading the transition to a sustainable hydrogen society.



02 30 Years of leading the hydrogen industry

Hyundai Motor Group has maintained its position at the forefront of hydrogen technology innovation for over 30 years. Starting with hydrogen fuel cell research and development in 1998, it has set numerous milestones, including being the first in the world to mass-produce hydrogen fuel cell passenger cars and heavy commercial vehicles. The NEXO, launched in 2018, has sold over 40,000 units globally, setting the world's highest sales record in the hydrogen electric passenger vehicle segment. Building on its vision for the hydrogen industry, the Group continues to deliver steady achievements, including the start of hydrogen refueling station operations in 2022 and the production of Korea's first hydrogen-powered tram in 2023.

<p>1998</p>  <p>Fuel Cell System Development Initiation</p> <p>Hyundai Motor Company</p>	<p>2000</p>  <p>FCEV Prototype Development</p> <p>Hyundai Motor Company</p>	<p>2013</p>  <p>World's First Mass-Produced Hydrogen Electric Vehicle ix35 Fuel Cell Launch</p> <p>Hyundai Motor Company</p>	<p>2018</p>  <p>Hyundai's First Dedicated Hydrogen Fuel Cell Electric Vehicle Model NEXO Launch</p> <p>Hyundai Motor Company</p>	<p>2019</p>  <p>World's First Hydrogen Fuel Cell City Bus ELEC CITY Fuel Cell Launch</p> <p>Hyundai Motor Company</p>	<p>2020</p>  <p>World's First Hydrogen Fuel Cell Truck XCIENT Fuel Cell</p> <p>Hyundai Motor Company</p>	<p>2021</p>  <p>Hydrogen Delivery Center Tubular Trailer Operation Commences</p> <p>Hyundai Glovis</p>
<p>2022</p>  <p>High-Performance FCE Concept Car N Vision 74</p> <p>Hyundai Motor Company</p>	<p>2023</p>  <p>XCIENT Fuel Cell Tractor Launch (U.S.)</p> <p>Hyundai Motor Company</p>	<p>2023</p>  <p>World's First Hydrogen-Powered Electric Bus UNIVERSE Fuel Cell Launch (Korea)</p> <p>Hyundai Motor Company</p>	<p>2023</p>  <p>Korea's First Hydrogen-Powered Tram Manufactured</p> <p>Hyundai Rotem</p>	<p>2024</p>  <p>FCEV Concept Car INITIUM Unveiled</p> <p>Hyundai Motor Company</p>	<p>2025</p>  <p>Second-Generation Hydrogen Fuel Cell Electric Vehicle Dedicated Model The all-new NEXO Launch</p> <p>Hyundai Motor Company</p>	<p>2025</p>  <p>The New XCIENT Fuel Cell Product Enhancement Model Launch (Tractor/U.S.)</p> <p>Hyundai Motor Company</p>

03

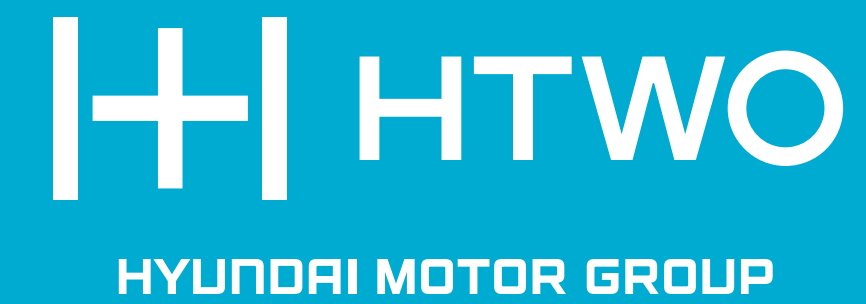
HTWO – Hyundai Motor Group's hydrogen business brand

Hyundai Motor Group has proactively invested in hydrogen technology development for over 30 years, contemplating a sustainable future amidst the era's challenges of addressing the climate crisis and energy transition.

As a result, it has achieved unparalleled accomplishments in hydrogen mobility, including the world's first commercialization of hydrogen fuel cell vehicles. Now, it is building a comprehensive hydrogen value chain encompassing the entire process—from production and storage to transportation and utilization—beyond mere transportation, laying the groundwork to accelerate decarbonization across the industry.

HTWO is the hydrogen brand and business platform that embodies the combined capabilities of the Hyundai Motor Group. Starting with hydrogen mobility, it produces hydrogen through diverse methods, achieves carbon neutrality across various sectors such as eco-friendly logistics and the decarbonization of ports and airports, and provides integrated solutions covering the entire hydrogen value chain.

As an open platform for collaboration, partnership, and investment, HTWO continuously evolves and grows, playing a pivotal role in accelerating the transition to a hydrogen society.



04 From production to utilization. HTWO's hydrogen value chain

HTWO provides solutions that meet diverse customer needs across all stages of hydrogen production, storage, transportation, and utilization. By bringing together the capabilities of its affiliates across the entire hydrogen business value chain, Hyundai Motor Group is making its mark as a global energy transition leader beyond just a mobility company.

UPSTREAM



Production

- Organic Waste Decomposition (Waste-to-Hydrogen)
- Water Electrolysis
- Hydrogen Extractor

MIDSTREAM



Storage, Transportation, Refueling

- Tube Trailers
- Stationary Hydrogen Refueling Station
- Ammonia (Storage/Transportation)
- Mobile Hydrogen Refueling Station
- Liquid Hydrogen (Storage/Transportation)
- Packaged Hydrogen Refueling Station
- Solid Hydrogen (Storage)
- L2G Charging (Liquid to Gas)

DOWNSTREAM



Utilization

- Fuel Cell System
- Commercial Vehicles (Trucks, Buses, Car Carriers, etc.)
- Power Generator
- Passenger Vehicles (NEXO)
- Power Pack
- Rail Vehicles (Trams, Trains)
- Low-Carbon Steel Plate
- Heavy Equipment (Forklifts, Construction equipment, etc.)
- Hydrogen Burners
- Military Vehicles (All-terrain Vehicle)
- Aviation
- Ships, Port Equipment

05 HTWO business platform

HTWO is an open business platform that drives partnerships, investments, and collaborations based on synergies among group affiliates, expanding the scope of the hydrogen ecosystem.

Eco-friendly Logistics Business



HYUNDAI MOTOR GROUP

HTWO Logistics: Eco-friendly Logistics Operations at Hyundai Motor Group Metaplant America(HMGMA) in Georgia, USA



Hydrogen Energy Business



HYUNDAI MOTOR GROUP

HTWO Energy Savannah: Integrated Hydrogen Production and Refueling Hub in Georgia, USA



Hydrogen Research and Collaboration



HYUNDAI MOTOR GROUP

Hyundai HTWO Innovation Centre at IIT Madras (Funding): Sponsorship of Hydrogen Research Facility at Indian Institute of Technology



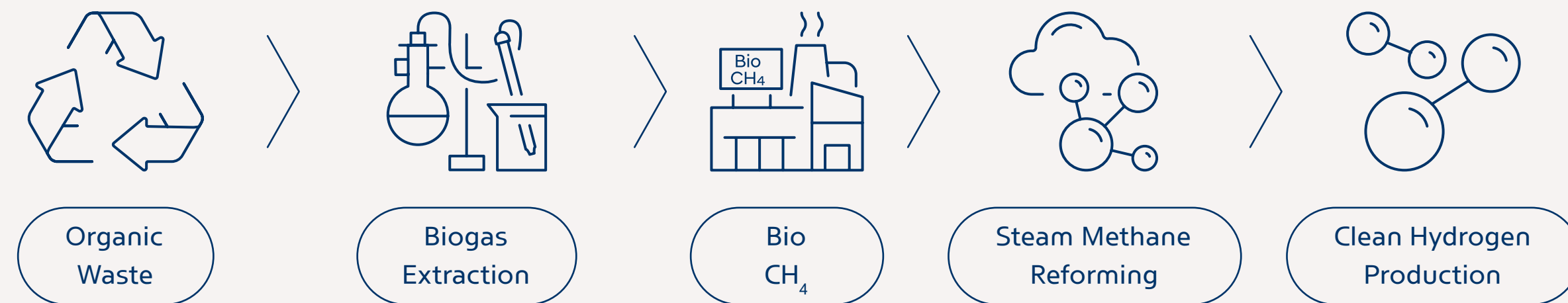
06

Key business solutions ① Hydrogen Production

We are building a carbon-neutral society based on diverse hydrogen production technologies, including W2H technology that converts organic waste into hydrogen and PEM electrolysis powered by renewable energy.

Waste to Hydrogen (W2H)

A method to produce hydrogen by utilizing biogas generated from organic waste, such as food waste, sewage sludge, and livestock manure. By converting everyday waste back into a valuable resource, it enables resource circularity and supports the realization of community-based energy self-sufficiency.



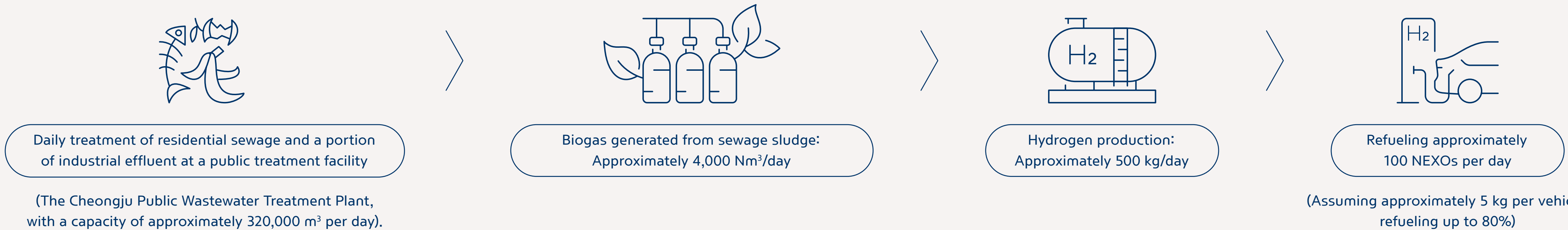
- South Korea**
- Chungju W2H
 - Cheongju W2H
 - Paju W2H



- Indonesia**
- West Java W2H



Effects of Waste to Hydrogen(W2H): The Case of Cheongju City, South Korea



(The Cheongju Public Wastewater Treatment Plant, with a capacity of approximately 320,000 m³ per day).

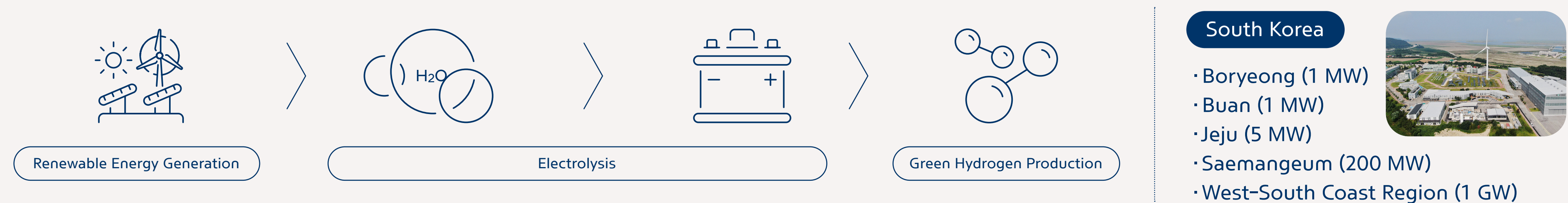
(Assuming approximately 5 kg per vehicle, refueling up to 80%)

06

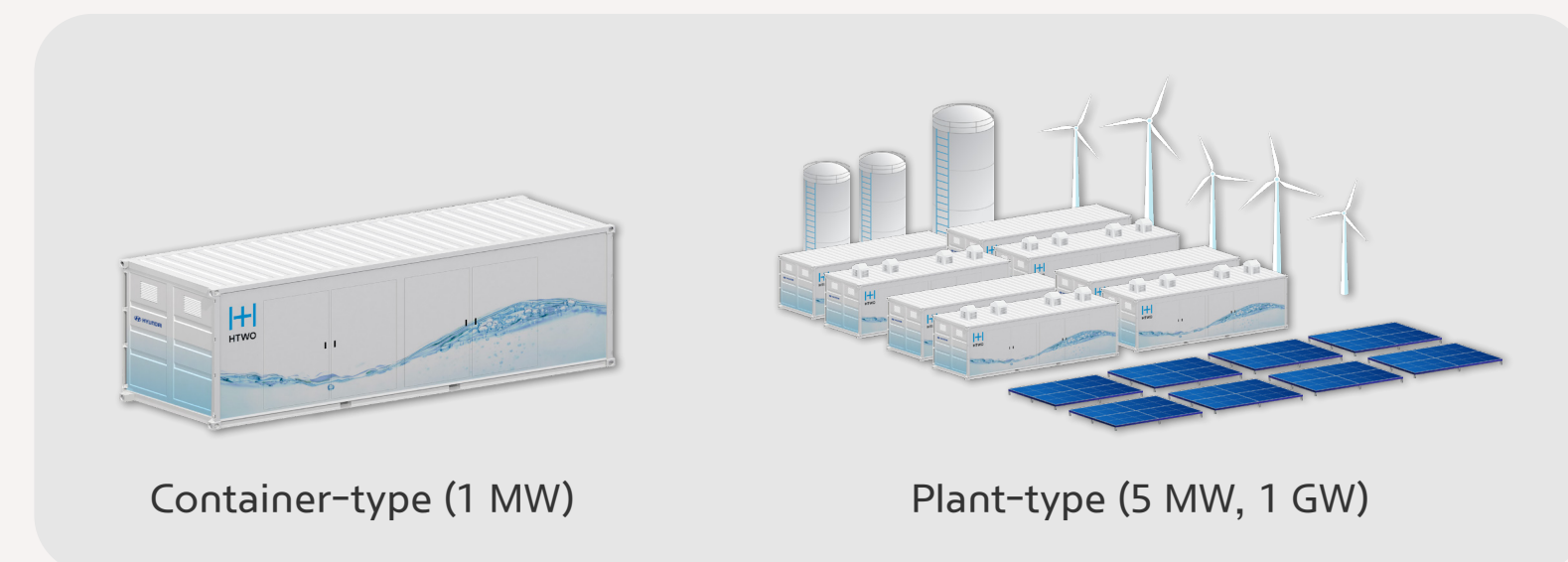
Key business solutions ① Hydrogen Production

Water Electrolysis

Water electrolysis produces high-purity hydrogen by electrolytically decomposing water. Using electricity generated from renewable energy enables the production of clean hydrogen with zero carbon dioxide emissions. In particular, PEM(Polymer Electrolyte Membrane) water electrolysis utilizes the reverse reaction of hydrogen fuel cells. Hyundai Motor Company has achieved technology and component commonality based on its fuel cell development expertise accumulated over approximately 30 years. Localization rate of over 90%, the company has secured a stable supply chain. It plans to produce South Korea's first PEM water electrolysis system at its new hydrogen fuel cell production plant in Ulsan, scheduled for completion in 2027.



Hyundai Motor Group's PEM Water Electrolyzer



- Expanding its PEM water electrolyzer portfolio: A 1 MW container-type solution and a scalable 5 MW and 1 GW plant-type solution
- Hydrogen purity: 99.99%
- (1 MW basis) Hydrogen production capacity: 300 kg/day or more (enough to charge 44 NEXOs)
- (1 MW basis) Energy consumption: 52.1 kWh/kg H₂, hydrogen pressure at atmospheric level
- Higher current density compared to alkaline electrolysis, smaller installation footprint, and faster response time

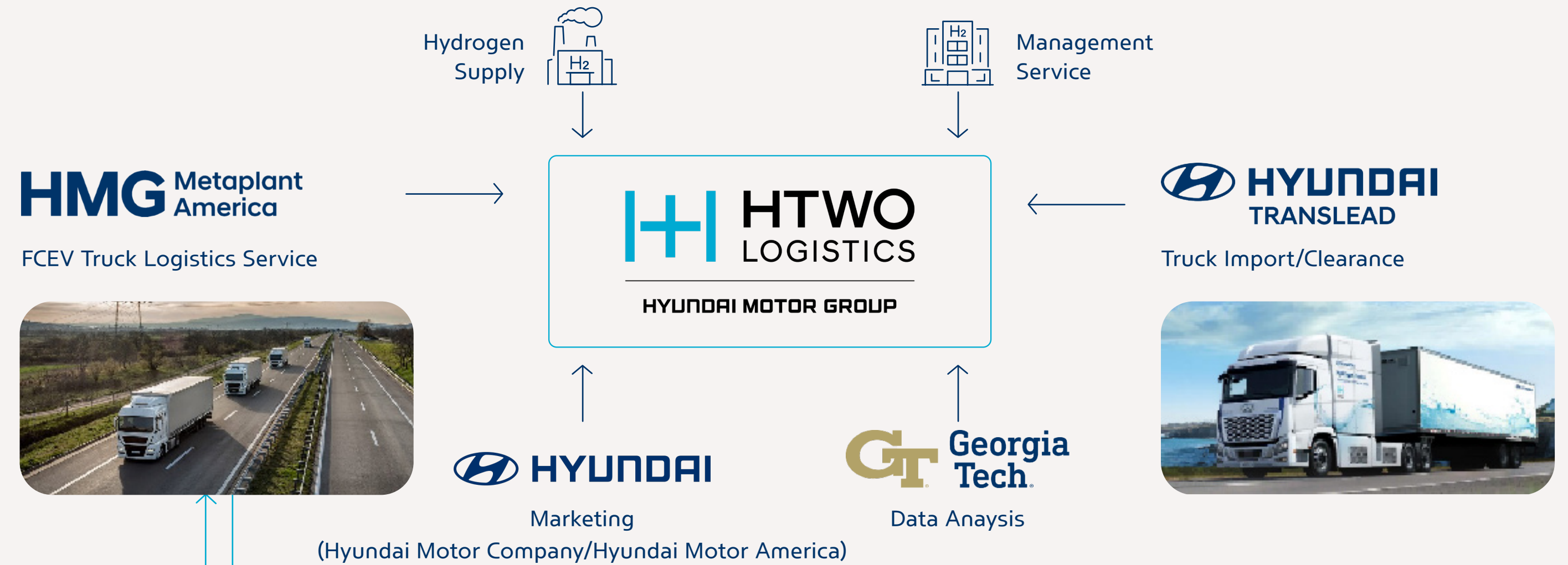
06

Key business solutions ② Eco-friendly Logistics Business

Leveraging Hyundai Motor Company's hydrogen fuel cell truck technology and Hyundai Glovis' logistics expertise, we are building a carbon-free, eco-friendly logistics system. Starting with the Hyundai Motor Group Meta Plant America (HMGMA) facility in Georgia, USA, we plan to expand the eco-friendly logistics business and lead the decarbonization of the logistics industry.

HTWO Logistics Joint Venture

Deployment of 21 XCIENT Fuel Cell trucks to support Hyundai Motor Group Metaplant America logistics



HTWO Energy Savannah

Installation of hydrogen production and refueling stations for seamless hydrogen truck operations



*Current hydrogen production: 1,200 kg per day (Plans to expand to a maximum of 4,200 kg per day to meet future demand)

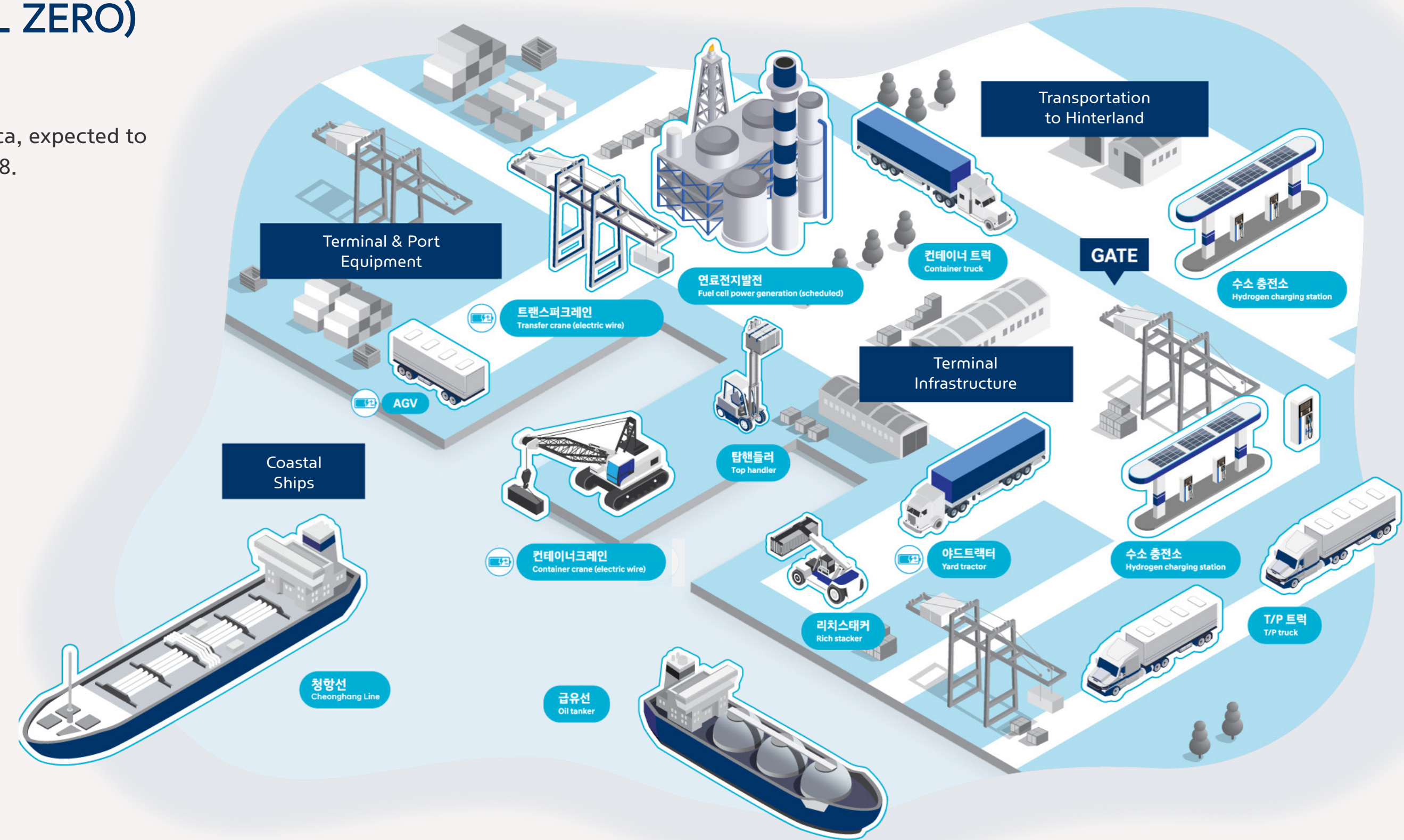
06

Key business solutions ③ Port/Airport Decarbonization

We are providing hydrogen-based business solutions to ports and airports that have traditionally relied on fossil fuels. Hyundai Motor Company was selected as the official supplier for the NorCAL ZERO project to introduce eco-friendly trucks at ports in California, USA, supplying 30 XCIENT Fuel Cell trucks. It has also signed an MOU with Incheon International Airport Corporation to expand hydrogen infrastructure within the airport and accelerate the transition to hydrogen mobility.

California Ports Eco-Friendly Truck Introduction Project (NorCAL ZERO)

North American port decarbonization project.
The supply of 30 XCIENT Fuel Cell trucks is the largest single deployment in North America, expected to reduce carbon emissions by approximately 24,000 tons compared to diesel trucks by 2028.



06

Key business solutions ④ Hydrogen Mobility

Hyundai Motor Company's hydrogen vehicles are already on roads around the world. The NEXO, embodying Hyundai's conviction toward a hydrogen society, has sold over 40,000 units globally since its 2018 launch, maintaining its position as the world's top-selling hydrogen vehicle. The XCIENT Fuel Cell, the world's first commercialized hydrogen-powered heavy-duty truck launched in 2020, is pioneering the hydrogen truck market worldwide, including in Korea, the United States, Europe, Asia, and the Middle East.

The all-new NEXO

CO ₂ emissions while driving	0 kg CO ₂
Global cumulative sales of hydrogen fuel cell vehicles	No.1
Global cumulative sales of NEXO	Over 47,000 units (as of March 2026)
Time to full charge	5 minutes
Maximum range per full charge	720 km



XCIENT Fuel Cell

Maximum range per full charge **570 km** (6x4 wing body) / **720 km** (6x4 tractor *North America model)

Since its launch in 2020, it has been sold in major global markets including Korea, the US, Switzerland, and Germany
Cumulative driving distance exceeds **23 million km** (as of March 2026)

Approximately **6,500 tons*** of CO₂ emissions saved over 10 million km of operation

*Based on the IPCC (Intergovernmental Panel on Climate Change) Guidelines / CO₂ emissions from a 10 million km of diesel truck operation.



06

Key business solutions ④ Hydrogen Mobility

Hyundai Motor Company introduced the world's first hydrogen-powered city bus, the ELEC CITY Fuel Cell Bus, in 2019, followed by the launch of the UNIVERSE Fuel Cell Bus in 2023, further accelerating the adoption of hydrogen buses on the road.

Hydrogen mobility is also expanding into urban rail systems. Hydrogen fuel cell trams—requiring no overhead wires and thus preserving city skylines—are set to be deployed on Ulsan's Jangsaengpo Line and Daejeon Line 2 in South Korea, which will become the world's longest wire-free hydrogen tram route. These advancements establish a new benchmark for hydrogen-powered public transportation.

Hydrogen Fuel Cell Buses (ELEC CITY Fuel Cell & UNIVERSE Fuel Cell)

Cumulative Units Sold: Over **3,000** units (as of March 2026)

Annual CO₂ Reduction: Approximately **200,000** tons*

*Equivalent to the CO₂ absorbed by approximately 21 million pine trees

Intercity route vehicles in the Seoul metropolitan area by 2030

Planned conversion to approximately **300** hydrogen electric buses

Hyundai Motor Group commuter buses at business sites (**1,201** units)

Planned conversion to hydrogen electric buses by 2030



ELEC CITY Fuel Cell bus

World's first hydrogen electric city bus
Maximum range of 550 km on a full charge



UNIVERSE Fuel Cell bus

World's first hydrogen electric express bus
Maximum range of 960.4 km on a full charge

Hydrogen Fuel Cell Tram

Refueling time within **20** minutes

Range of over **200** km per charge

Maximum speed **70** km/h

Hydrogen storage capacity **84** kg

Scheduled introduction of hydrogen electric trams in South Korea on Ulsan Jangsaengpo Line in 2027 and the Daejeon Line 2 (Daejeon city circular line and 2 branches)*by 2028

*The world's longest overhead wire-free hydrogen tram route (38.8 km, 45 stops)



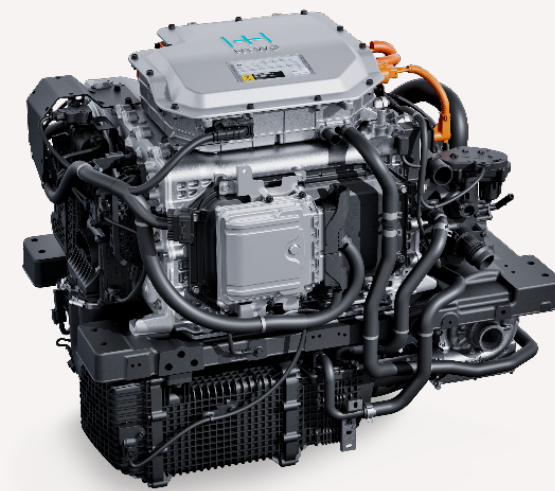
06

Key business solutions ⑤ Expanding of Hydrogen Fuel Cell System Lineup

At the heart of Hyundai Motor Group's journey to lead the hydrogen industry and establish global leadership lies its hydrogen fuel cell systems. Based on reliable, high-quality hydrogen fuel cell technology, we are developing a diverse lineup of hydrogen fuel cell systems—from mobility to power generation equipment, construction machinery, aviation and marine transportation—expanding the scope of solutions for a hydrogen society.

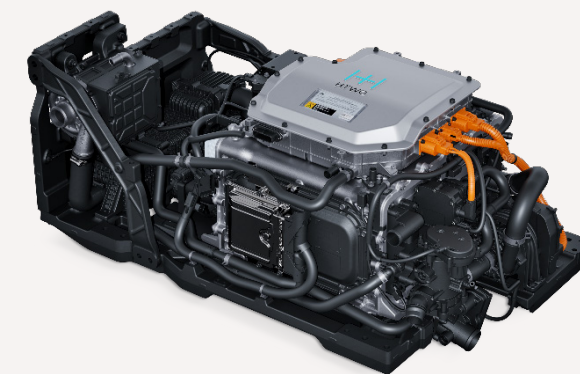
Engine-Type Fuel Cell System

- Output 94 kW / Energy Efficiency up to 61.7%
- Operates in environments from -30 to 50° C
- Used in commercial vehicles, passenger cars, medium/heavy-duty trucks, special-purpose vehicles, city/intercity buses, generators, etc.



Flat-Type Fuel Cell System

- Output 94 kW / Maximum energy efficiency 61.7%
- Operates in environments from -30 to 50° C
- Used in trams, trains, buses, etc.



Hydrogen Fuel Cell Power Pack

- Rated output 20 kW / Peak output 60 kW (5 seconds)
- All-in-One package integrating essential water-based components like fuel cells, batteries, and hydrogen tanks
- Designed for application in industrial vehicles such as forklifts



Hydrogen Fuel Cell Power Generator

- Rated output 70 kW / Peak output 100 kW
- Based on Seoul's average household power consumption, capable of supplying power to 250+ households*
- Complements the intermittency/variability of renewable energy by linking with building self-generation, small-scale distributed generation, and H-ESS

〈Source: Seoul Metropolitan Government Energy Information (2024 Seoul Metropolitan Government Household Electricity Consumption)〉



Mobile Power Generator (Equipped with Swappable Hydrogen Storage System)

- Rated Power 35 kW AC 380 V / AC 220 V
- Peak Power 50 kW AC 380 V / AC 220 V
- Low noise, low vibration, and eco-friendly operation compared to diesel generators
- Its high portability and easy installation make it suitable for construction sites, outdoor broadcasting and events, and military field operations



Hydrogen Fuel Cell System Application Fields



MW-class hydrogen fuel cell power generators



Excavators



Forklifts



Agricultural tractors



Military vehicles



AGVs (Automated Guided Vehicle)

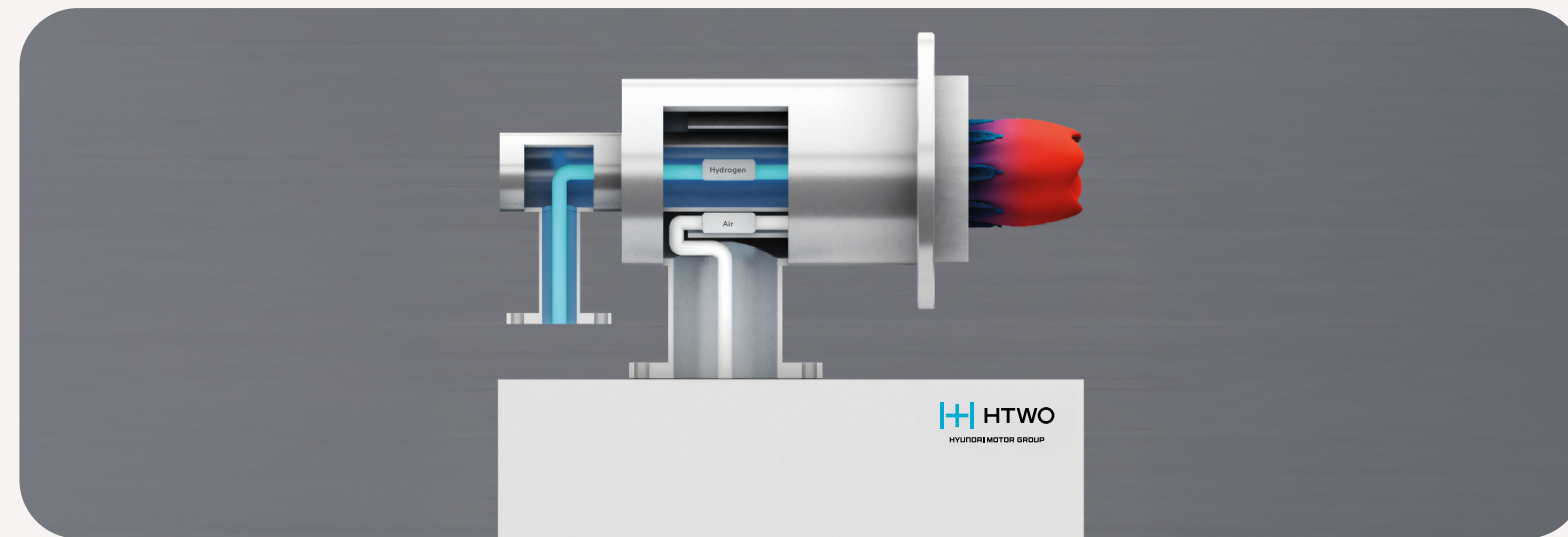


Ships

06

Key Business Solutions ⑥ Hydrogen Industry Application - Hydrogen Burners

Hydrogen burners are eco-friendly equipment that utilize heat generated by mixing hydrogen with air and combusting the mixture. Starting with the painting ovens at Hyundai Motor Company's Ulsan plant, the plant is expanding to high-temperature equipment, such as regenerative thermal oxidizers, air conditioners, and boilers. Hyundai Motor Group plans to gradually convert approximately 5,000 LNG burners across Korea's production plants to hydrogen burners.



- Eco-friendly facilities generating heat through hydrogen-air mixed combustion
- Currently utilized in Hyundai Motor Company's Ulsan plant for paint ovens, regenerative thermal oxidizers, air conditioning units, boilers, etc.
- Hyundai Motor Company plans phased conversion of approximately 5,000 LNG burners across Korea's production plants

Hydrogen Burners in Automotive Manufacturing Processes



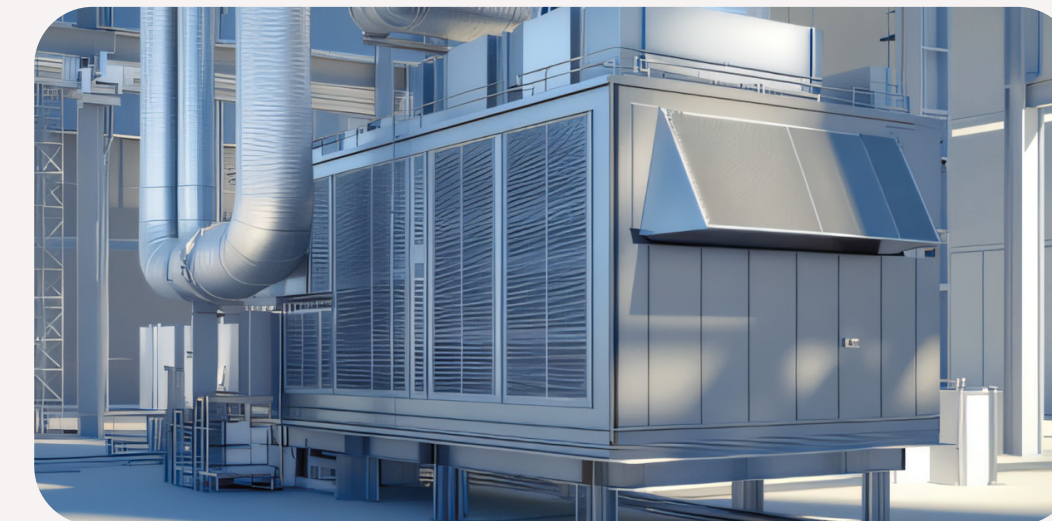
Paint Oven

Hydrogen burners directly or indirectly heat air to the target temperature, quickly and evenly drying and curing automotive coatings.



Regenerative Thermal Oxidizer

The heat generated by the hydrogen burner is utilized to heat exhaust gases to 800-850° C in the RTO process, completely combusting harmful substances (VOCs) and contributing to improved thermal energy efficiency at the facility.



Air Handling Unit

An air handling unit is an air processing device that regulates indoor temperature and humidity. When equipped with a hydrogen burner, it can rapidly heat outdoor air and supply it indoors.



Boiler

The high-temperature exhaust gases generated by the hydrogen burner heats water in the pipes, producing hot water and steam for use across the facility.

06

Key Business Solutions

⑦ Hydrogen Refueling Solutions

HTWO connects the global energy ecosystem through innovative refueling technologies that expand hydrogen infrastructure and enhance operational efficiency. It delivers safety, efficiency, and sustainability through diverse solutions including stationary, mobile, and packaged hydrogen stations, as well as automated hydrogen electric vehicle refueling robots.



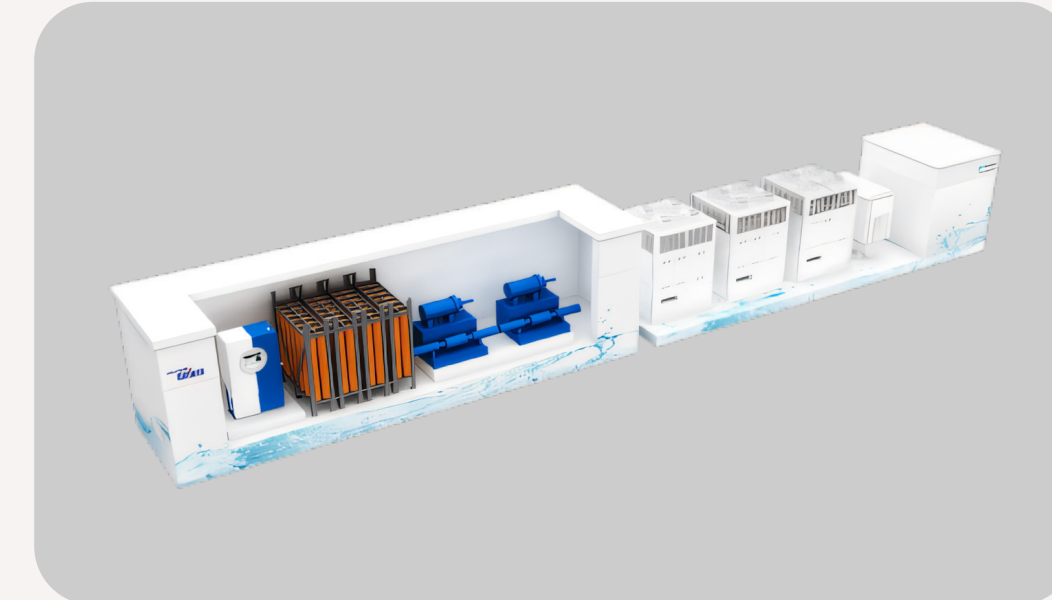
Stationary Hydrogen Refueling Station

- Compressed and cooled hydrogen is supplied through dispensers to various hydrogen mobility solutions, including passenger cars, trucks, buses, and trams.
- Hyundai Motor Group and its partners directly operate/ supply refueling equipment for approximately 30% of the nationwide network of about 230 stations in South Korea (as of December 2025)
- Hyundai Rotem's stationary hydrogen dispenser flow rate: 60g/s; jointly developing technology with Hyundai Motor Company for high-speed refueling up to 300g/s



Mobile Hydrogen Refueling Station

- Functions as a complete hydrogen refueling station by mounting core equipment—hydrogen compressor, storage tank, cooler, and charger—onto a truck or large trailer
- Contributes to alleviating refueling wait times during peak hours in major cities
- Overcomes space constraints by utilizing small areas and idle land



Packaged Hydrogen Refueling Station

- A refueling solution where core equipment is modularized into containers and assembled
- Reduced civil/construction costs through container modularization (33%↓ for 50kg/h-class stations)
- Reduced facility footprint (approx. 40%↓ in pure equipment area)
- Shortened installation time (3.5 months → 1.0 month)
- Enhanced space utilization through equipment integration and size standardization
- Enables rapid package replacement/relocation within a short timeframe

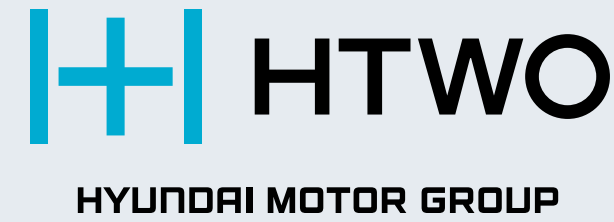


Automatic Charging Robot-Hydrogen

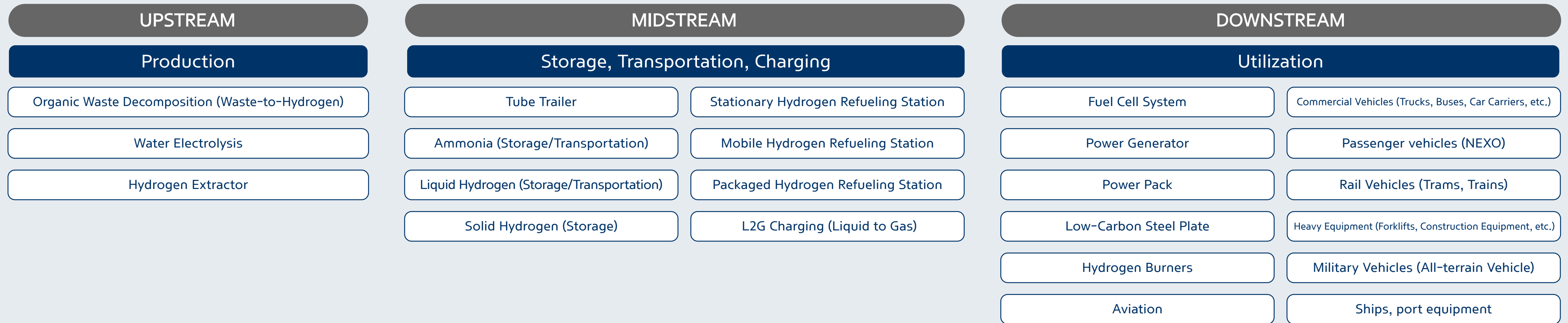
- A refueling robot that provides a convenient refueling experience through an automated charging process
- Utilizes advanced vision AI technology to identify vehicle type, license plate, and parking location, enabling precise recognition of the refueling port's position and angle
- Supports stable connection between the refueling connector attached to the robotic arm and the vehicle's refueling port using force and torque measurement sensors for secure positioning and control technology
- Ensures safety and stability by applying international standard safety design technology

Summary

HTWO: Hyundai Motor Group's hydrogen brand and business platform, encompassing the entire hydrogen value chain from production to utilization, built on over 30 years of expertise leading the hydrogen industry.



HTWO's Hydrogen Value Chain



HTWO Business Platform



Eco-friendly Logistics Business



Hydrogen Energy Business



Hydrogen Research and Collaboration

HTWO Key Business Solutions

- ① Hydrogen Production
- W2H
 - PEM Electrolysis, etc.

- ③ Port/Airport Decarbonization
- California Port NorCAL ZERO
 - Incheon International Airport Corporation MOU, etc.

- ④ Hydrogen Mobility
- Global No. 1 in cumulative hydrogen vehicle sales - NEXO
 - World's first commercialized hydrogen-electric heavy-duty truck - XCIENT Fuel Cell
 - World's first hydrogen electric bus - ELEC CITY Fuel Cell & UNIVERSE Fuel Cell
 - Hydrogen-electric tram, etc.

- ⑤ Expanding of Hydrogen Fuel Cell System Lineup
- Engine-type fuel cell system
 - Flat-type fuel cell system
 - Hydrogen fuel cell power pack
 - Hydrogen fuel cell generator

- ⑦ Hydrogen Refueling Solutions
- Stationary hydrogen refueling station
 - Mobile hydrogen refueling station
 - Packaged hydrogen refueling station
 - Automatic charging robot-hydrogen

- ② Eco-friendly Logistics Business
- Joint venture HTWO Logistics, etc.

- ⑥ Hydrogen Industry Application
- Hydrogen Burners



Appendix

Q&A: Questions About Hydrogen

Question 01. If hydrogen is everywhere, why is 'production' necessary?

Related Content

- ▶ 1-3. Hydrogen attainable from everyday resources

Hydrogen is highly reactive and exists in nature not as a free element but bound to other atoms in compounds like water (H₂O), ammonia (NH₃), and methane (CH₄). Therefore, a process to separate and extract hydrogen from these compounds is necessary. Hydrogen can be produced primarily through the electrolysis of water. It can also be produced from various resources, including fossil fuels like coal, oil, and natural gas, as well as organic waste such as food waste, sewage sludge, and livestock manure. Unlike resources like petroleum or natural gas, which are confined to specific regions, hydrogen can be produced anywhere provided the technology is available.

Question 02. Isn't hydrogen difficult to store and transport?

Related Content

- ▶ 1-4. Hydrogen can be stored in various ways

In its gaseous state, hydrogen has a low density per unit volume, requiring extremely large storage tanks to store it as a gas. Therefore, processes to reduce its volume are necessary for storing large quantities of hydrogen, such as compressing it to high pressure or cooling it to convert it into a liquid state. Hydrogen can be stored in various ways as follows, enabling easy storage and long-distance/large-volume energy transport.

- Compressed in gaseous state: Hydrogen gas is compressed to pressures exceeding 700 times atmospheric pressure. This is the most common storage method currently used for hydrogen vehicles and industrial hydrogen. Compared to other storage methods like liquefaction or solid storage, it has a lower density per unit volume and requires significant energy consumption for compression.
- Liquefaction: Hydrogen is cooled to an ultra-low temperature of -253° C to store it as a liquid. This allows direct use of hydrogen without chemical conversion. Although energy is consumed during the liquefaction process, it is advantageous for long-distance/large-volume transportation.
- Conversion: Hydrogen can also be stored by combining it with other substances. Representative methods include synthesizing it into liquid chemicals like ammonia (NH₃) or liquid organic hydrogen carriers (LOHC). This method leverages existing transportation infrastructure and offers advantages for large-scale maritime and land transport.
- Solid: This method stores hydrogen by adsorbing it onto solid materials or chemically binding it. It possesses a higher volumetric density than gas compression or liquefaction methods, and despite its small volume, it is heavy, making it suitable for use in submarines or drilling rigs.
- Natural terrain utilization storage: This method utilizes natural cavities like salt domes or depleted gas fields. Developed to address seasonal and temporary spikes in energy demand and enhance energy security, it is recognized as the most economical approach for storing large volumes of hydrogen within existing natural environments.

Question 03. Isn't hydrogen dangerous?

Related Content

- ▶ 1-1. The simplest and most abundant element in the universe

The perception that hydrogen is dangerous is a misconception. Hydrogen's self-ignition temperature (585° C) is more than twice that of gasoline (247° C), making the possibility of spontaneous explosion extremely low. Furthermore, as the lightest element in the universe (four times lighter than air), it disperses rapidly into the air upon leakage. Being a non-toxic gas, it poses almost no risk of suffocation or poisoning. The misconception that hydrogen is dangerous likely stems from hydrogen bombs. However, the hydrogen used in hydrogen bombs has been artificially altered in structure and is completely different from the natural hydrogen used in common fuels.

Question 04. I heard hydrogen is also categorized by color. What are the different types?

Related Content

- ▶ 1-3. Hydrogen attainable from everyday resources

Hydrogen is categorized as gray hydrogen, blue hydrogen, green hydrogen, or pink hydrogen based on the energy source used in its production process and whether carbon emissions occur.

- Gray Hydrogen: Hydrogen produced with carbon emissions during production. Primarily refers to hydrogen obtained from fossil fuels like natural gas or oil. Carbon emissions are unavoidable during production, but it is the cheapest method and remains the most widely used today.
- Blue Hydrogen: Hydrogen produced using carbon capture, utilization and storage (CCUS) technology, which collects carbon emitted during gray hydrogen production instead of releasing it into the atmosphere. Efforts to minimize carbon emissions during production involve storing and utilizing the captured carbon separately. It is also called 'transitional hydrogen' during the shift to carbon neutrality.
- Green Hydrogen: Refers to clean hydrogen produced without any carbon emissions during production. Hydrogen produced by electrolysis of water using renewable energy is a prime example. It is also the ultimate eco-friendly hydrogen, with zero carbon dioxide emissions during production.
- Pink Hydrogen: Hydrogen obtained by electrolysis of water using electricity and steam produced at nuclear power plants. It is environmentally friendly with minimal carbon emissions during production and is gaining attention as nuclear power provides a stable supply source that can compensate for the variability issues of renewable energy.

While hydrogen is categorized by these colors, what matters most is its practical utilization rather than its color.

Using hydrogen produced through diverse methods together expands the market. This process drives continuous advancement in production technology and reduces costs. Gradually growing the market in this way can accelerate the transition to clean hydrogen.

Question 05. Is hydrogen truly eco-friendly?

Hydrogen fuel cells emit only water during the process of converting hydrogen into energy. Hydrogen vehicles, which generate electricity through the reaction of hydrogen and oxygen, also emit only water as a byproduct, emitting no carbon dioxide, fine dust, nitrogen oxides, or other pollutants. They also act as air purifiers on the road, filtering fine dust through their intake systems during operation.

Question 06. Is hydrogen an energy source or a fuel?

Hydrogen can be used as a fuel in mobility applications like automobiles and various industrial sectors, while simultaneously serving as a medium for storing and preserving energy. We can convert energy into hydrogen for storage, and then convert the stored hydrogen back into energy for use where needed. Therefore, we refer to hydrogen as both an energy storage medium and an energy carrier. Specifically, hydrogen enables long-term, large-volume storage depending on the storage method and facilitates long-distance transportation, helping reduce geopolitical energy disparities among nations worldwide.

Question 07. Is there no risk of explosion in hydrogen fuel tanks during collisions or fires?

As the lightest element in the universe, hydrogen rapidly dissipates into the air in the event of a leak. Even so, hydrogen vehicles like the NEXO incorporate a variety of advanced safety systems to further reinforce hydrogen safety. The NEXO's hydrogen storage system is designed to maintain structural integrity even in collision accidents or external fires. And it proactively prevents accidents caused by hydrogen leaks by continuously monitoring hydrogen detection sensors, fuel level changes, and pressure variations in real time. Furthermore, it is equipped with a safety valve that rapidly releases hydrogen into the atmosphere if the temperature around the hydrogen tank becomes excessively high.

Question 08.

What is the biggest difference between hydrogen fuel cell vehicles and electric vehicles?

Related Content

▶ 2-1. Faster, Further

- The partner for future mobility

To be precise, hydrogen vehicles are officially called “fuel cell electric vehicles”, and they ultimately run on electricity.

While both hydrogen and electric vehicles operate on electricity, they differ in how that electricity is produced.

Electric vehicles store externally generated electrical energy in their internal batteries for use, whereas hydrogen vehicles utilize hydrogen stored in fuel tanks to generate electricity internally and drive. The hydrogen fuel cell system installed in hydrogen vehicles combines hydrogen and oxygen to produce electrical energy, which then powers the vehicle.

In other words, electric vehicles receive electricity from an external source to charge their batteries, while hydrogen vehicles receive high-pressure gaseous hydrogen at refueling stations to generate their own electrical energy for driving.

This difference gives hydrogen and electric vehicles distinct characteristics.

Electric vehicles are equipped with large, heavy high-voltage batteries to store as much electrical energy as possible, which increases the vehicle's overall weight.

While battery charging takes a long time, electric vehicles can be more economical today thanks to their relatively well-established charging infrastructure compared with hydrogen. Conversely, hydrogen vehicles run on lightweight, high-energy-density hydrogen fuel. Notably, hydrogen has a mass-based energy density roughly 133 times higher than that of lithium-ion batteries, enabling longer driving ranges per charge than electric vehicles. Their lighter weight also allows for greater cargo capacity or passenger seating.

Hydrogen vehicles are an eco-friendly option suitable for those who find frequent charging inconvenient or wish to save time spent charging.

Those who value the highest eco-friendliness and fast charging may prefer hydrogen vehicles, while those prioritizing widespread charging infrastructure and affordability may opt for electric vehicles. Ultimately, the choice depends on individual values and preferences.

Question 09.

What are the fuel costs and refueling times for hydrogen vehicles?

The NEXO can travel 720 km on a 5 minute charge. Fuel costs per km vary based on charging prices, with hydrogen prices ranging from 8,000 to 11,000 KRW/kg depending on the region. Based on The all-new NEXO's hydrogen storage capacity of 6.69 kg, a full charge costs approximately 60,000 to 70,000 KRW. Trucks can travel over 720 km with about 30 minute charge, while buses can travel 960 km with a 20 minute charge. (Based on Hyundai Motor Company's product)

Question 10.

In what areas are hydrogen vehicles more competitive than electric vehicles?

Related Content

▶ 2-1. Faster, Further

- The partner for future mobility

Both electric and hydrogen vehicles are eco-friendly options with low carbon emissions during operation. They are not mutually exclusive alternatives but rather complementary choices that broaden options in the carbon-neutral era.

Hydrogen vehicles demonstrate distinct advantages in the commercial vehicle sector. Compared to electric vehicles, hydrogen vehicles offer shorter charging times, enabling higher operational uptime for buses and trucks. They also offer higher energy efficiency than batteries, allowing longer driving ranges on a single refueling. Furthermore, hydrogen vehicles feature lighter energy storage systems than electric vehicles, allowing them to carry more cargo and transport more passengers.

A balanced adoption of both electric and hydrogen vehicles can help stabilize the national power grid.

According to the the Korean government's eco-friendly vehicle deployment plan, if 4.2 million electric vehicles are on the road by 2030, approximately 24,000 GWh of electricity will be required to keep them running. This is about six times the power needed for the 750,000 EVs currently in operation (as of end-October 2025), and expanding the power infrastructure to this extent within five years is highly challenging in reality. On the other hand, if hydrogen vehicles—which do not require electric charging—are adopted alongside EVs, the burden of sudden surges in power consumption can be alleviated. Hydrogen vehicles, an attractive and practical alternative in the eco-friendly vehicle era, will expand consumer choice, usher in a stable era of eco-friendly mobility for the nation, and ultimately provide humanity with a cleaner future.

Question 11. Do hydrogen vehicles operate well in winter?

Hydrogen vehicles are designed to operate reliably even in the harshest winter conditions.

Hyundai Motor Company's hydrogen fuel cell system features a wide operating temperature range from -30° C to 50° C, maintaining start-up and driving performance not only in typical winter weather but also in extreme cold environments.

To prevent potential fuel cell stack icing during prolonged stops in extremely cold weather or when power generation is minimal, the Hyundai NEXO incorporates a 'Wake Up' function. This function raises the stack temperature and removes internal moisture as needed, preventing icing and improving cold-start performance—the ability to start reliably in low temperatures. Simply put, the NEXO is designed to start reliably even in sub-zero temperatures.

Hydrogen vehicles also hold advantages over electric vehicles in the commercial vehicle sector.

During severe cold spells of -10 to -20° C, electric vehicles experience a reduction in driving range to 60-70% of normal levels due to reduced battery efficiency. In contrast, hydrogen vehicles produce electrical energy by directly reacting hydrogen in the fuel tank with oxygen, resulting in far less efficiency loss at low temperatures. This makes them highly advantageous for winter driving or operation in extreme regions.

Question 12. Why are hydrogen vehicles so expensive?

Unlike internal combustion engine vehicles or electric vehicles, which have already entered the market maturity stage, hydrogen vehicles are still in the early market stage. Although constraints exist, such as the high cost of hydrogen fuel cell systems and the lack of full-scale mass production, subsidies from the Korean government and local governments are currently being provided to promote the adoption of hydrogen vehicles. Furthermore, technological development to popularize hydrogen vehicles is steadily progressing.

Question 13. What is the current status of hydrogen refueling stations, and are there plans for expansion?

Alongside the adoption of hydrogen vehicles, the hydrogen refueling station infrastructure is also steadily expanding. In Korea, since the first hydrogen refueling station was established in 2019, the number nationwide grew to 78 by 2023. As of August 2025, there are approximately 230 stations—about a threefold increase over the past two years. The Korean government also plans to further expand hydrogen infrastructure, aiming to build more than 660 stations by 2030 and over 1,200 by 2040.

Question 14. What advanced technologies does Korea possess in the hydrogen sector?

Related Content

- ▶ 2-2. Fairer
 - The cornerstone of energy independence and security
- ▶ 3-2. 30 Years of Leading the Hydrogen Industry

Korea possesses world-class competitiveness in hydrogen electric vehicles and hydrogen fuel cell systems.

Hyundai Motor Group has been at the forefront of hydrogen technology innovation for over 30 years, starting with hydrogen fuel cell research and development in 1998. In 2013, it launched the world's first mass-produced hydrogen vehicle. The NEXO, a dedicated hydrogen model launched in 2018, has sold over 40,000 units cumulatively, maintaining its position as the global leader in hydrogen vehicle sales.

With the launch of Korea's first hydrogen fuel cell tram in 2023, The all-new NEXO in 2025, and the new XCIENT Fuel Cell, Hyundai Motor Group is continuously expanding its mobility lineup utilizing hydrogen fuel cell systems. Hyundai Motor Group is building a comprehensive hydrogen ecosystem across the entire industry, expanding beyond mobility to encompass hydrogen production, storage, transportation, and utilization.

South Korea's production rate for hydrogen fuel cell components has already reached approximately 90%. Through collaborative growth with dozens of nationwide partners and over 100 hydrogen-related companies, Hyundai is strengthening national industrial competitiveness. Furthermore, the PEM water electrolyzer developed by Hyundai shares approximately 85% of its key components and systems with the proven hydrogen fuel cell systems used in the NEXO and XCIENT Fuel Cell. The expansion of hydrogen vehicle adoption will directly lead to securing competitiveness for the Korea's water electrolysis industry.

Question 15. If a hydrogen society is realized, how will our daily lives change?

Hydrogen, which accounts for 75% of the universe's mass, can be produced from various resources we encounter daily. If a society utilizing this hydrogen becomes fully realized, our world will become cleaner, safer, more sustainable, and fairer.

Renewable energy will be stored as hydrogen, then used to heat household water and supply electricity to offices.

On the way to work, cars, buses, and trucks will be running on the roads, emitting clean water vapor instead of carbon dioxide or nitrogen oxides.

Port cranes and ships will also quietly run on hydrogen, and factories will produce steel using hydrogen instead of coal.

But that's not all. Energy, once solely dependent on imports, will shift to clean energy produced on our own soil, gradually narrowing the global energy wealth gap.

The emerging hydrogen industry will expand the ecosystem, becoming the driving force of a new cycle that fuels national economic growth and job creation.

In this great energy transition, hydrogen—recognized as a key to a sustainable future—will transform not just our daily lives, but industry and the world itself.

Every time the wind blows,
and every moment the sun shines,
hydrogen gets to work.

Hydrogen stores the power of the sun and the wind, storing it longer, carrying it further. Hydrogen connects energies, and can be created anywhere, making energy fair for everyone.

Hydrogen can be made from water and even from the waste of our daily lives.

Born from what we leave behind, hydrogen returns to power every moment of our days. Waking up the morning, lighting up our cities, enabling AI, and carrying us on our daily commute.

Hydrogen takes us on long journeys, powers factories, carries heavy materials, and makes long distance logistics possible.

At the heart of hydrogen's entire journey lies Hyundai Motor Group. Through our hydrogen brand HTWO, we are building a cleaner, fairer, and sustainable hydrogen society.

