

Aachen Colloquium 2026

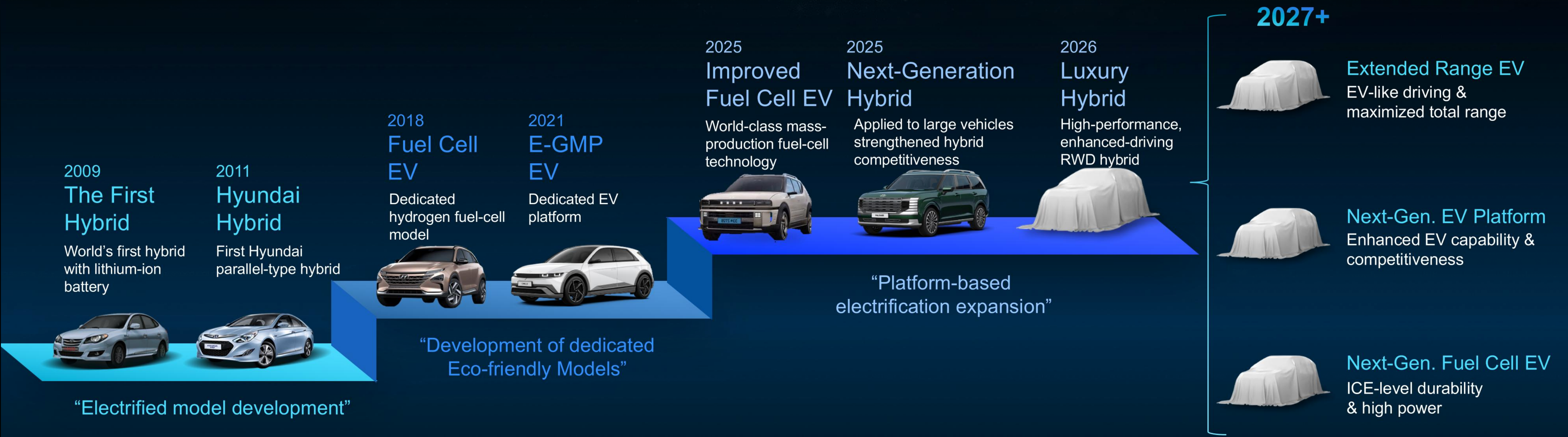
Challenges and Opportunities in Hydrogen Fuel Cell Technology : Insights from Real-World Data

Duckwhan Kim

Vice President / Hydrogen and Fuel Cell Engineering Design Group 1
Hyundai Motor Group
dwkim77@hyundai.com

Heritage and strategy of Electrification

World-class electrification energy solutions enabling top-level safety and performance in eco-friendly vehicles
Customer-centric electrification solutions across all vehicle segments

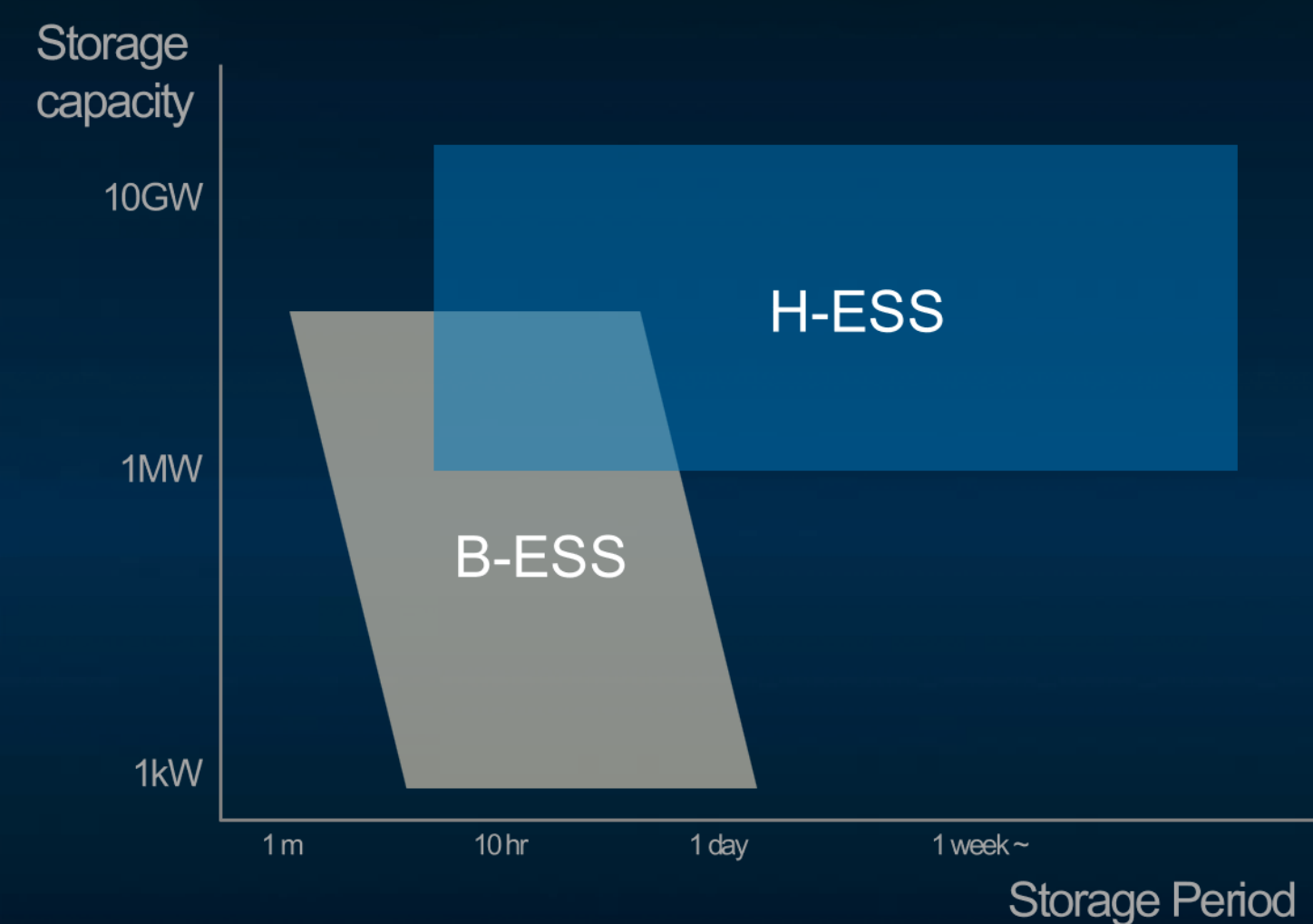


Why Hydrogen?

Hydrogen serves as a robust energy carrier that stabilizes supply by enabling large-scale, long-term storage to compensate for the intermittency and production discrepancies of renewable energy

H2 : Energy Carrier

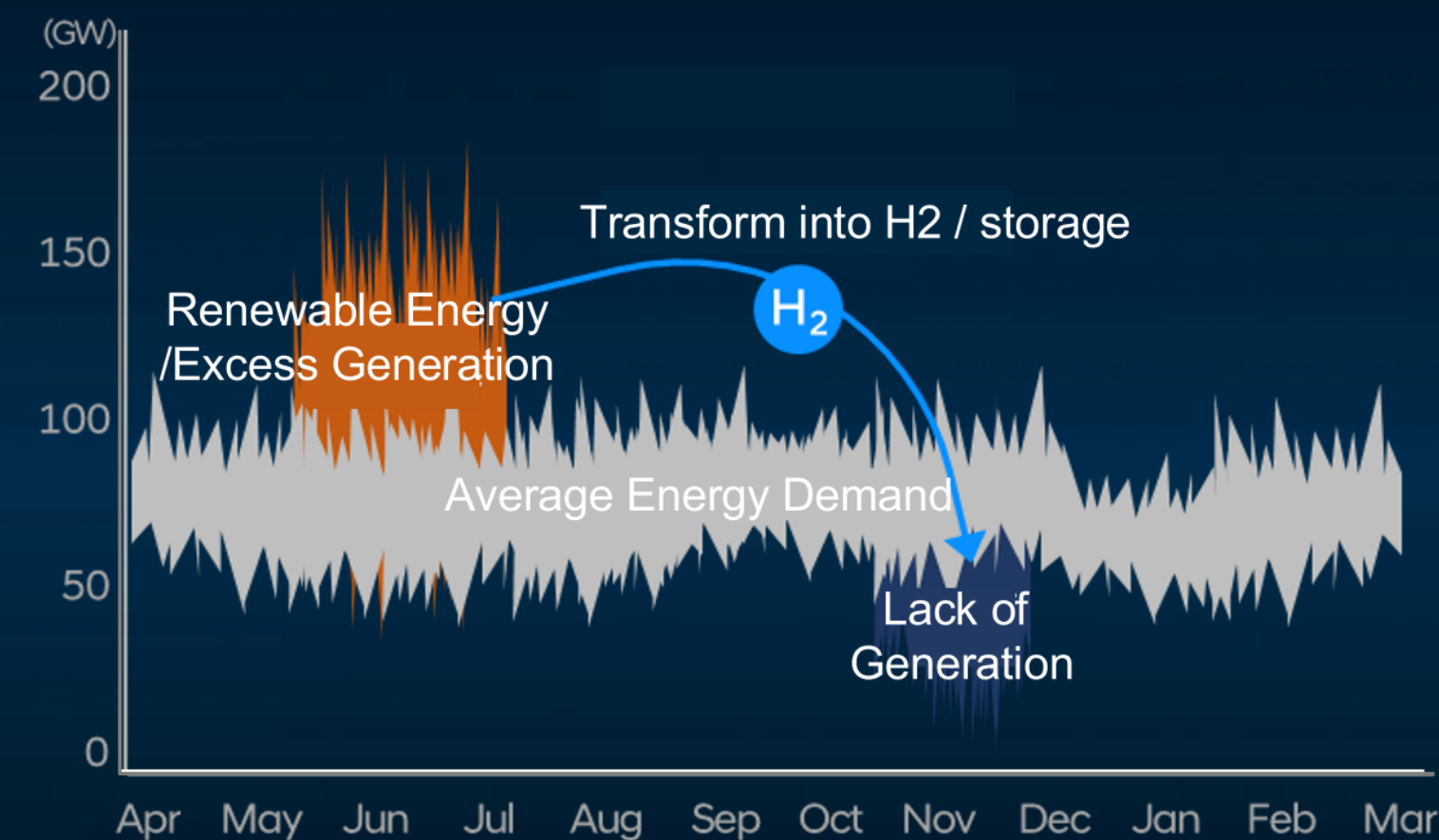
Large Capacity & Long term Energy Storage



※ M.F.Ruth et. Al., NREL(2020)

< Suitability by energy storage type >

Supplementing Intermittency of Renewable Energy



< Energy Demand Scenario, Germany, 2050 >

Complementing Discrepancies Renewable Energy Production

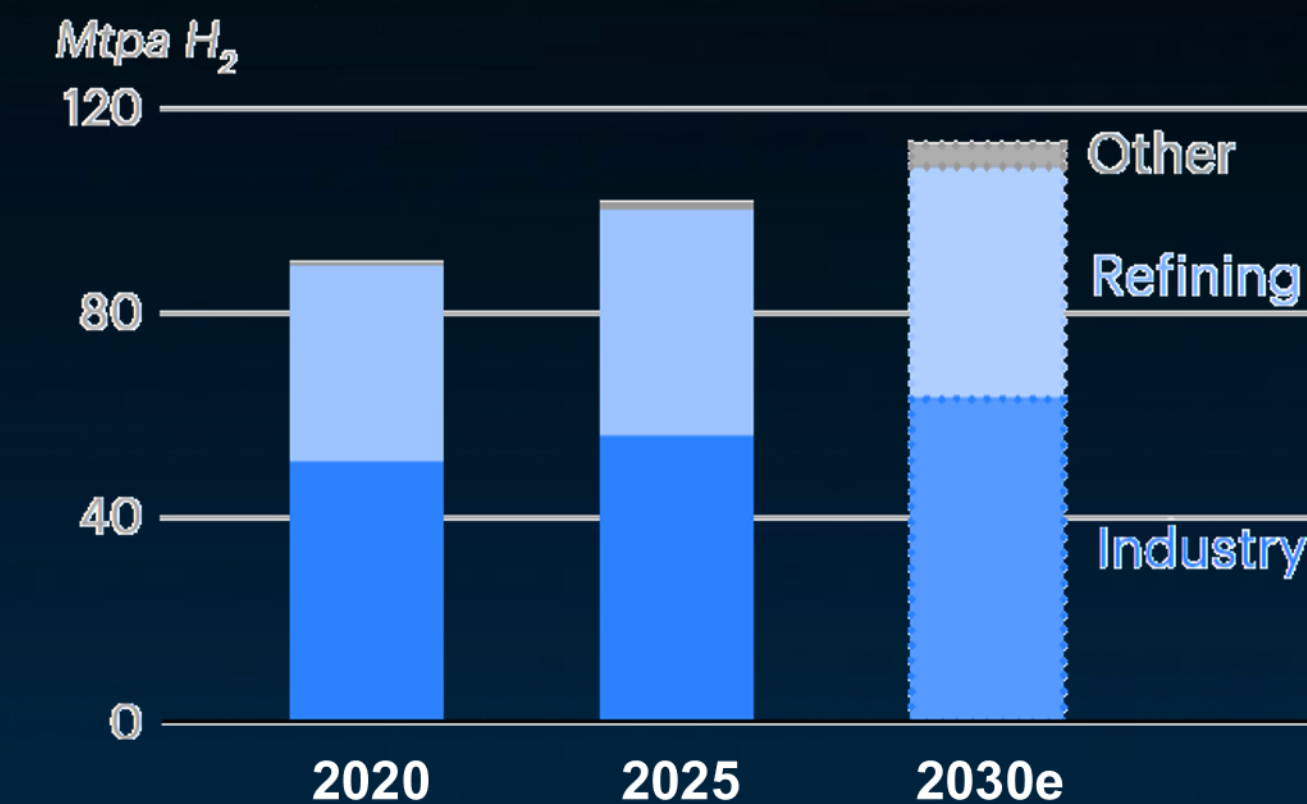
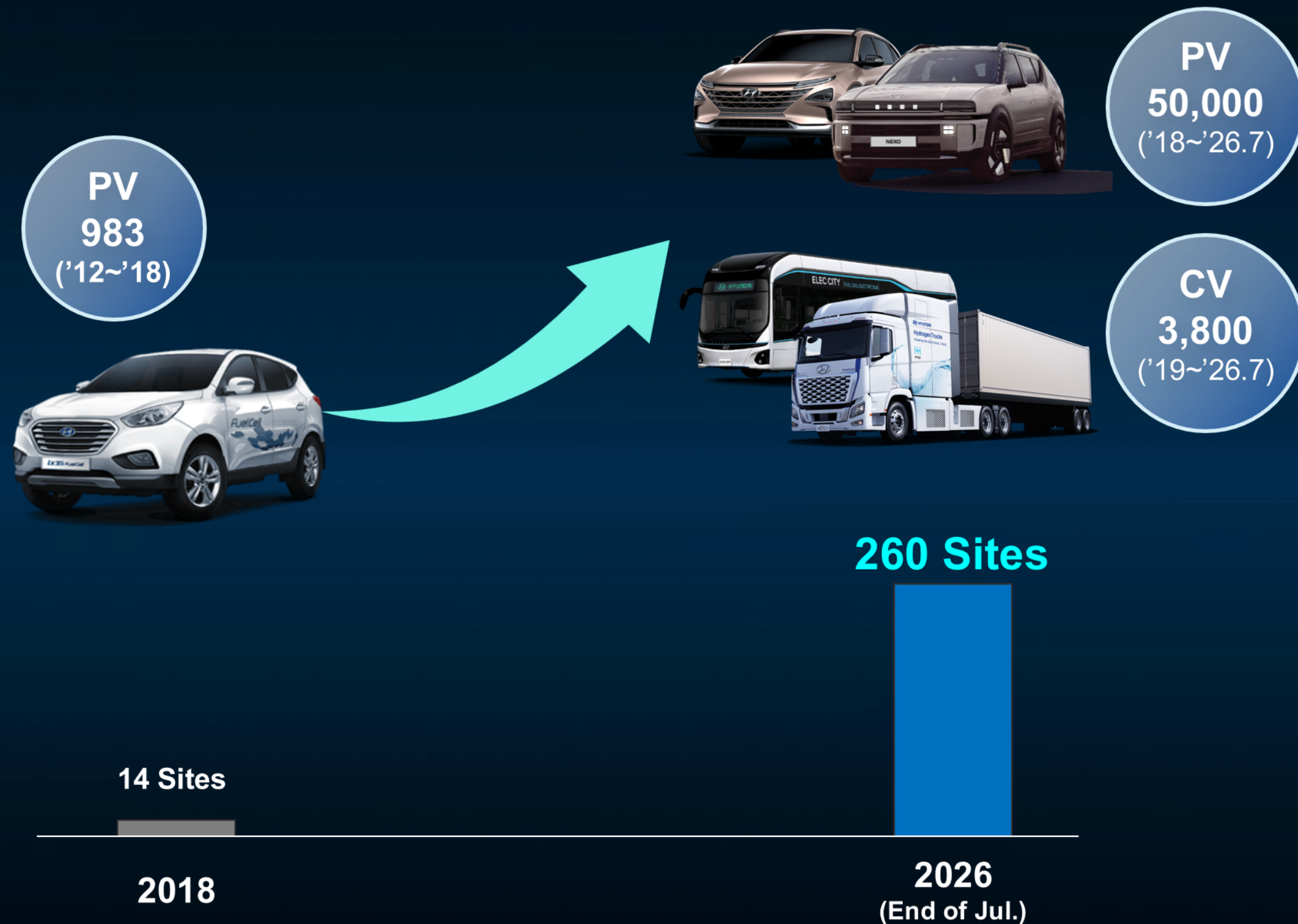


< Forms of Regional H₂ Energy Transportation >

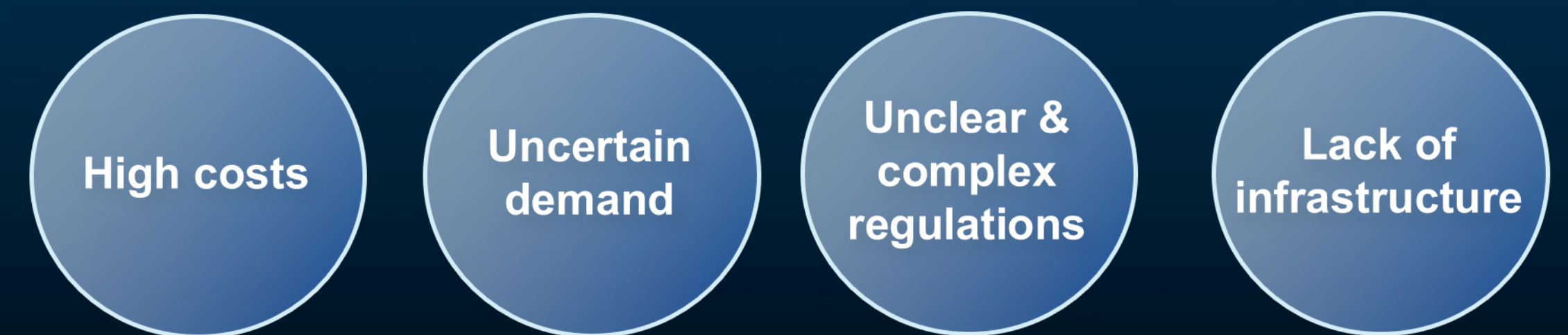
Hydrogen Market Landscape

Supported by Korea's infrastructure of 260 stations, HMC's cumulative sales surpassed about 50,000 units
Global Hydrogen demand supposed 100Mt for the first time in 2025
It is necessary to overcome major barriers for faster uptake

HRS in Korea and FCEV Sales



Global hydrogen demand



Main barriers

Hydrogen Market Landscape

Europe, Japan, China, and Korea are committed to accelerating the transition to a hydrogen society through policy supports, infrastructure investment, and technological innovation



Trans-European Transport Network

Alternative Fuels Infrastructure
(’24), AFIR, EU



Hydrogen Backbone
(1,300km, ’26), Japan, JH2A



Hydrogen Transport Corridor(’23),
One of six key future industries(’26),
China

FC System/FCEV Development status & Achievements

Dedicated to hydrogen R&D with proven milestones, securing continuous leadership through next-gen fuel cell system development and a new dedicated production plant

2018



NEXO Mass Production

2020 ~ 23



Hydrogen CV Mass Production
(ELEC City / Universe / XCIENT)

2025



Launch of The All New NEXO /
The New XCIENT

2028 ~



Improving FCEV Competitiveness
& Expanding into New Vehicles & Applications



In-house MEA Production /
Dual MEA Strategy for Commercial Vehicles



Power / Marketability /
Quality Improvement



High Power / High Durability / Low Cost
Next-Generation FC System

“The No.1 in the accumulated
global sales of FCEV”



* Based on accumulated sales volume of FCEVs

“2.3 billion km of
actual driving data”



* Based on HMC's cumulative data

“Building a Dedicated Next-Gen FC Plant”

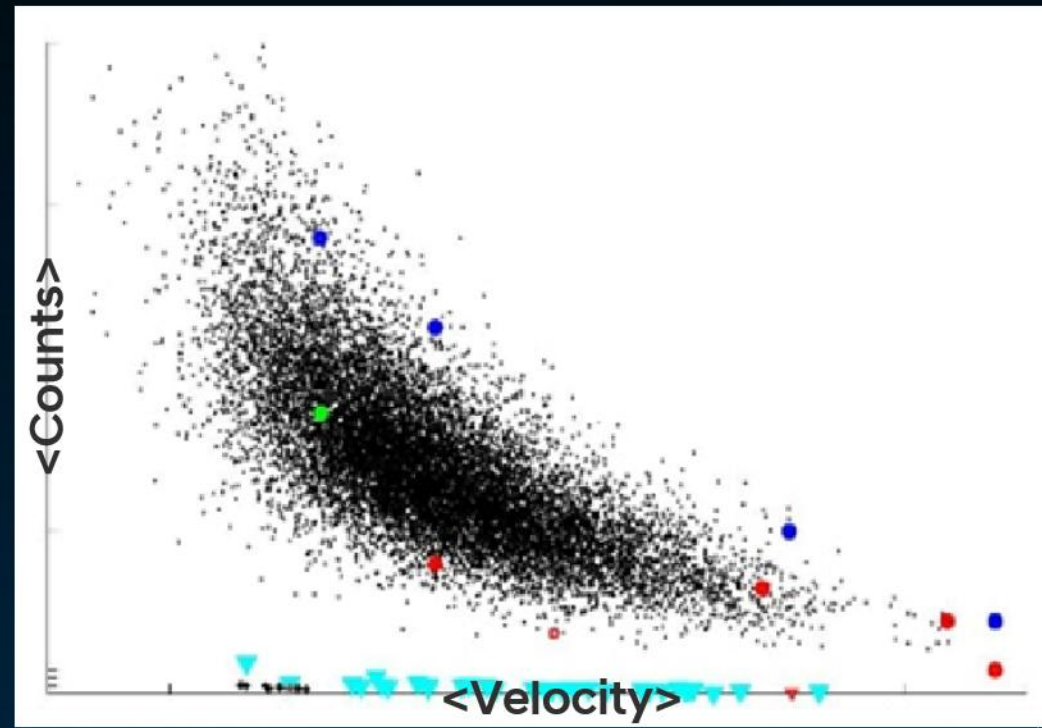
One Factory
Integrated Hub Leading the Global FCEV Market
(New Ulsan Plant, Carrying Hyundai's Heritage)



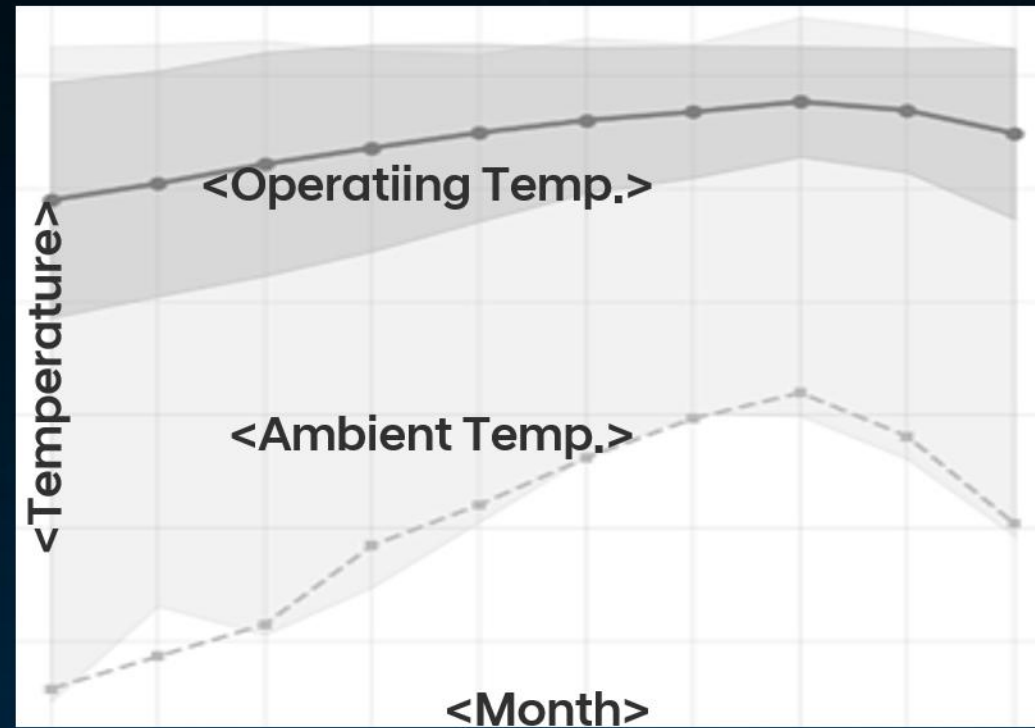
Key Improvements in 'The All New NEXO' FC System

Real-world field data analytics drive key technological advancements in system performance, thermal management, and long-term durability for 'The All New NEXO'

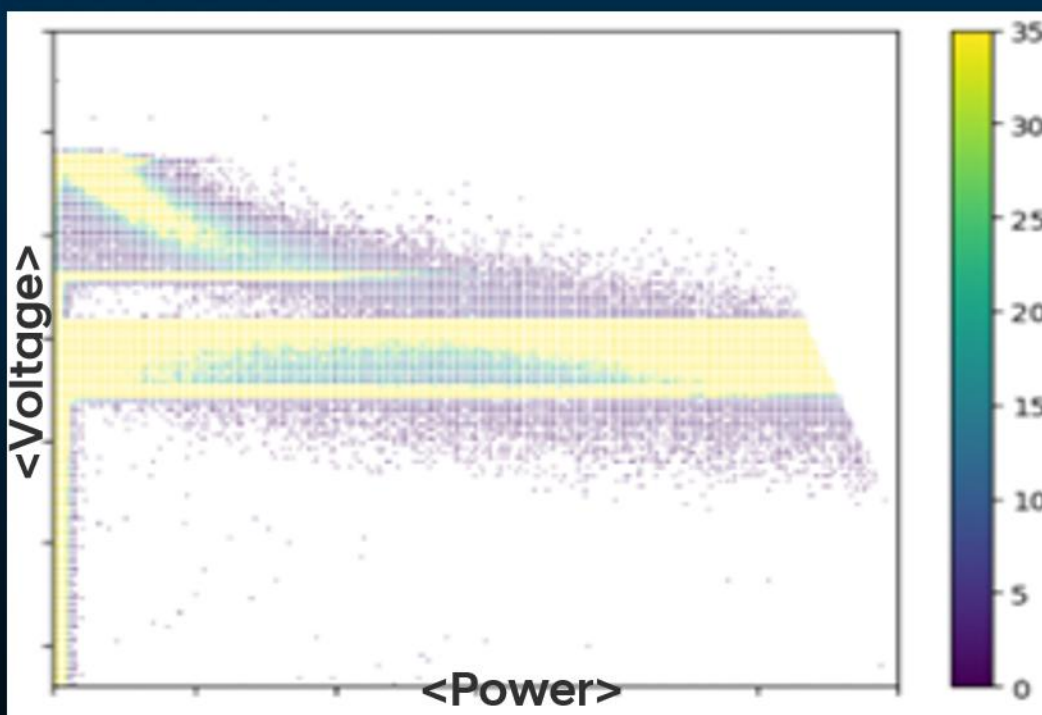
Field data analysis example



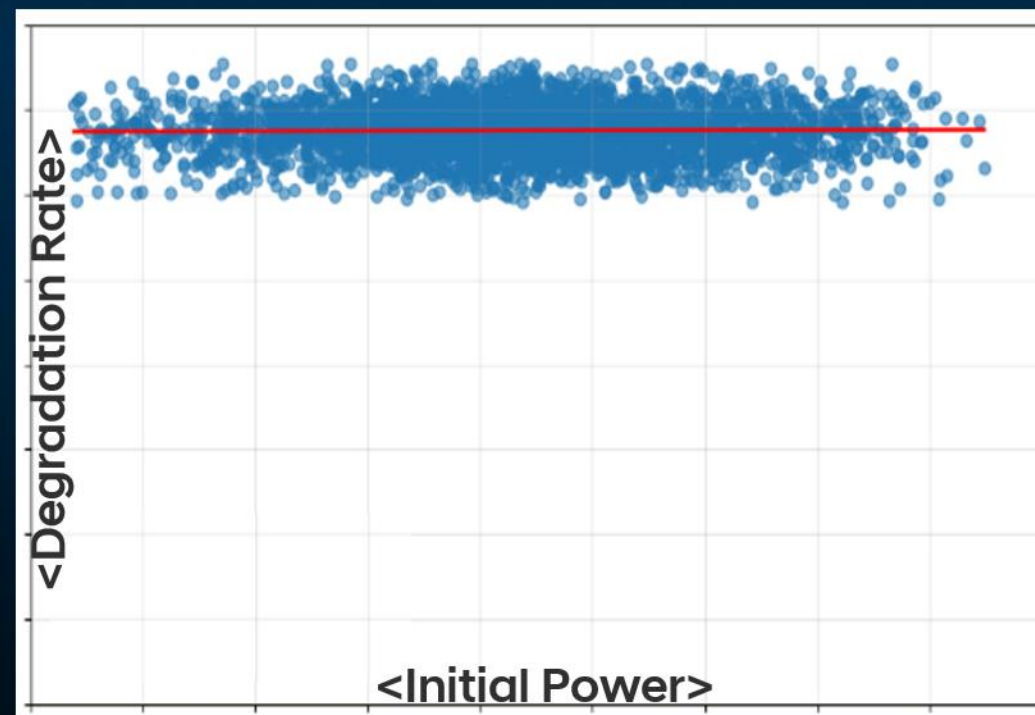
Number of on/off vs. Average velocity



Operating Temperature



High potential exposure ratio



Degradation rate vs. Initial power
(@50,000km)

Performance improvement items

- High-performance air compressor with integrated controller
- Rapid warm-up function
- Optimized FC/PE power distribution

Durability improvement items

- Improved chemical stability of Membrane
- End-cell degradation mitigation structure
- Wake-up function
- Effective water extraction technology in flow channels

Fuel Cell System Comparison (NEXO vs. The All-new NEXO)

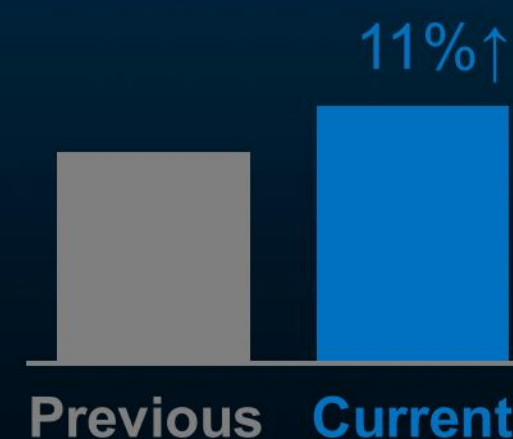
Achieved world-class FC system efficiency; currently optimizing performance and durability for specific applications while driving continuous cost improvements

Key indicators

Performance

“Higher power
in same volume”

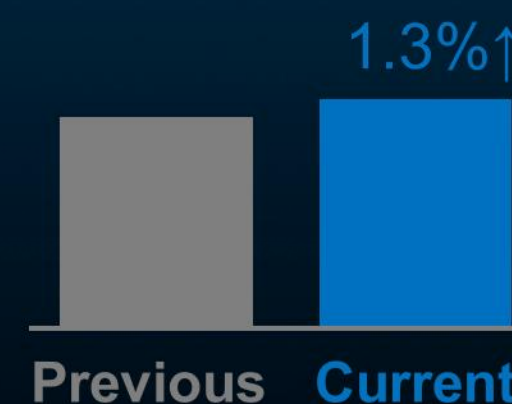
Power



Efficiency

“Longer range
with same fuel”

Efficiency

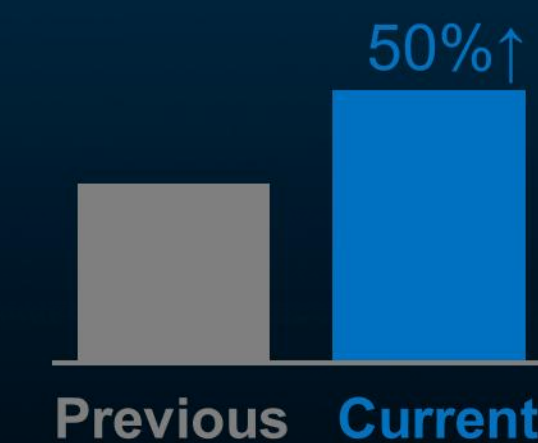


Cost

Durability

“Lower degradation
at same distance”

Durability



Hyundai FCEV – Passenger Vehicle (PV)

The all-new NEXO has been launched with an advanced FC/Storage Sys. offering enhanced output & mileage
Achieved cumulative global sales of over 50,000 units, including NEXO (2018)

NEXO FCEV (2018)

The all-new NEXO (2025)



< NEXO FC System >



< The all-new NEXO FC System >

- 1. In-house development of core technologies such as MEA and Bipolar plate
- 2. Marketability & Convenience equivalent to internal combustion engines

Max Speed	177 kph
0 → 100 kph	9.2 sec
Output (FC)	85 kW
Mileage	666 km*

* Europe WLTP mode

- 1. Enhanced power train performance and mileage
- 2. Improved cold-start performance in low-temperature conditions
- 3. Provided unique value for FCEV reflecting customer’s voices

→ It has the value of the car itself.

Max Speed	179 kph
0 → 100 kph	7.8 sec
Output (FC)	94 kW
Mileage	826 km*

* Europe WLTP mode

Hyundai FCEV – Commercial Vehicle (CV)

Fuel cells have advantages in the field of commercial vehicles that require high energy
Commercial vehicle durability achieved through membrane electrode assembly (MEA) optimization
Various CV's such as HDT, city bus, and coach bus are being developed

FC City Bus – ELEC City(2020) Universe(2021)



- 1. About 3,000 FC buses are operating in Korea ('26.2)
- 2. Test run in Munich, Germany ('21.6)

	ELEC City	Universe
FC Power	160 kW (80kW x 2ea)	160 kW (80kW x 2ea)
Motor Power	300 kW	350 kW
Hydrogen Storage	34.3 kg	34.3 kg
Mileage	751 km*	960 km*

* Korean certification

FC HDT – The new XCIENT Fuel Cell (XCIENT Fuel Cell, NA Tractor 2025)



- 1. Start of mass production of new FC HDT in NA
- 2. Increased mileage through improved fuel cell system power and durability, as well as the addition of hydrogen tanks

	XCIENT FC	The new XCIENT FC
FC Power	160 kW (80kW x 2ea)	160 kW (80kW x 2ea)
Motor Power	350 kW	350 kW
Hydrogen Storage	41.2 kg	68.6 kg
Mileage	570 km*	724 km**

* Korean certification ** NA EPA mode

XCIENT Fuel Cell Operation status

Since October 2020, Hyundai’s Class 8 hydrogen-powered trucks have been operating from the Alps of Switzerland. Expanding into the North American market, 21 units are now deployed to support HMGMA logistics, delivering a practical pathway for energy transition in port operations



	Europe Business Status	Port Logistics - NorCAL ZERO Project	NA HTWO Logistics
Business Start	'20.10	'24.5	'24.12
Fleet	186 units	30 Units	21 Units of The Ne XCIENT Fuel Cell
Cumulative Mileage	20,450,286 km ('26.1)	919,513 km ('26.1)	590,174 km ('26.1)
Remarks	Deployed to 5 European countries since 2020 (Swiss, Germany, France, the Netherlands, Austria)	Total H2 consumption : 500 tons	Using Mobile HRS(280kg x 4unit) Total H2 consumption : 35 tons

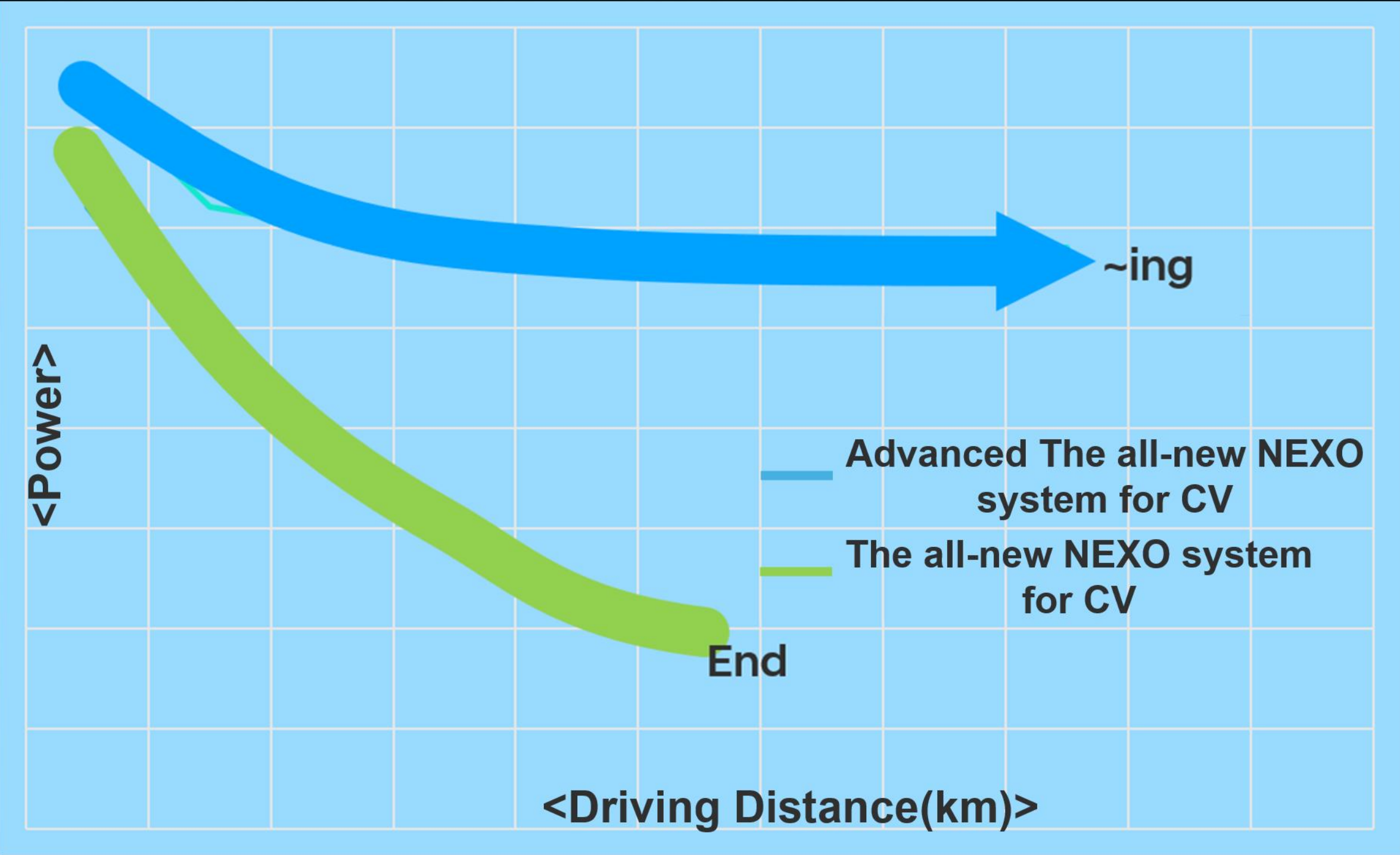
Advanced The All new NEXO system for CV (2026)

Development of new cell structure for enhanced durability
: Mambrane, catalyst, flow channels, and bipolar plate/GDL modifications
Maintains stack and FC system compatibility except cell structure



< Advanced the all-new NEXO FC System for CV >

Power	94 kW ↑
Efficiency (peak)	60 % ↑
Cold start (@-30°C)	40 sec ↓
Responsibility (10 → 90%)	1 sec ↓



Durability Test (@ FC system, HMC truck mode)

Competitiveness of Next-Gen FC System

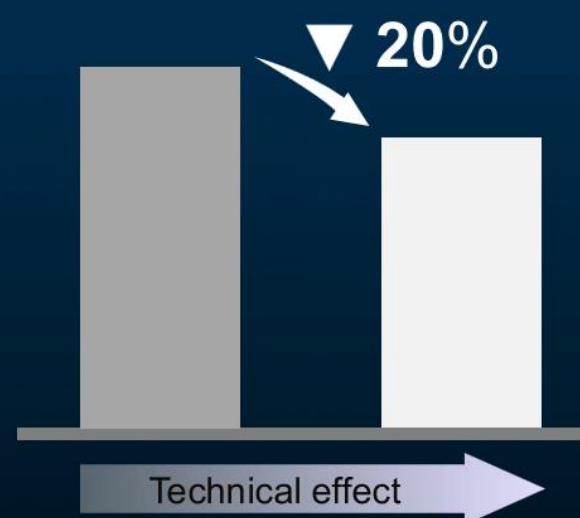
Securing Next-Gen FC competitiveness by driving phased cost reduction through technological innovation, while continuously enhancing core performance to achieve TCO parity with electric trucks

Secure Cost Competitiveness of FC

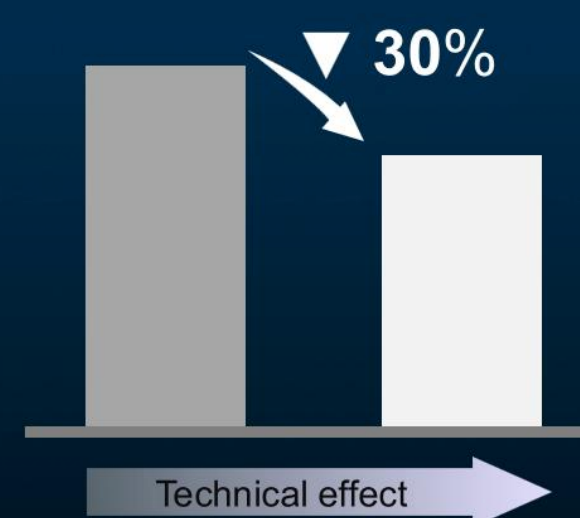
- Phased cost reduction via tech innovation
- Component integration & lineup expansion



[PV FC System Cost]



[CV FC System Cost]



● Current ● Next Gen

Secure Product Competitiveness of FC

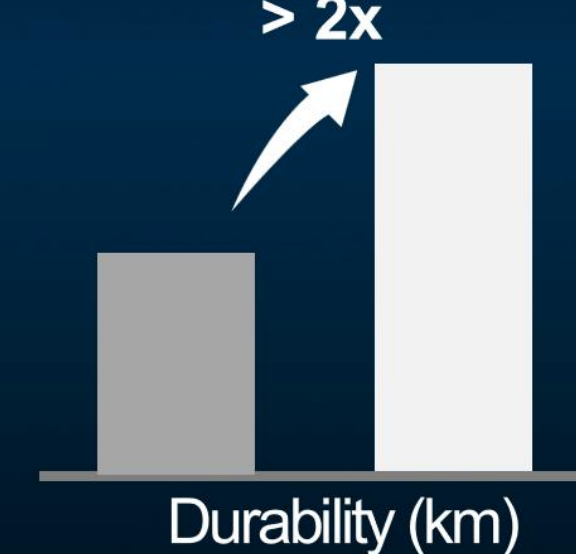
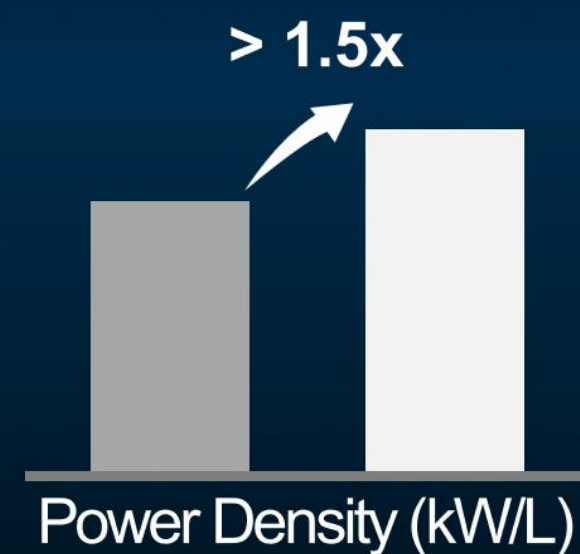
- Continuous upgrade of efficiency, performance & durability
- Optimized system lifespan & driving range



Performance
"High Power Density"



Durability
"Long Life / Low deg."



● Current (CV) ● Next Gen (CV)

Achieve Cost Parity with Electric Trucks

- Reduce material costs of core PE modules
- Target EV parity by '29 & Diesel parity post-'35

Near-term Target

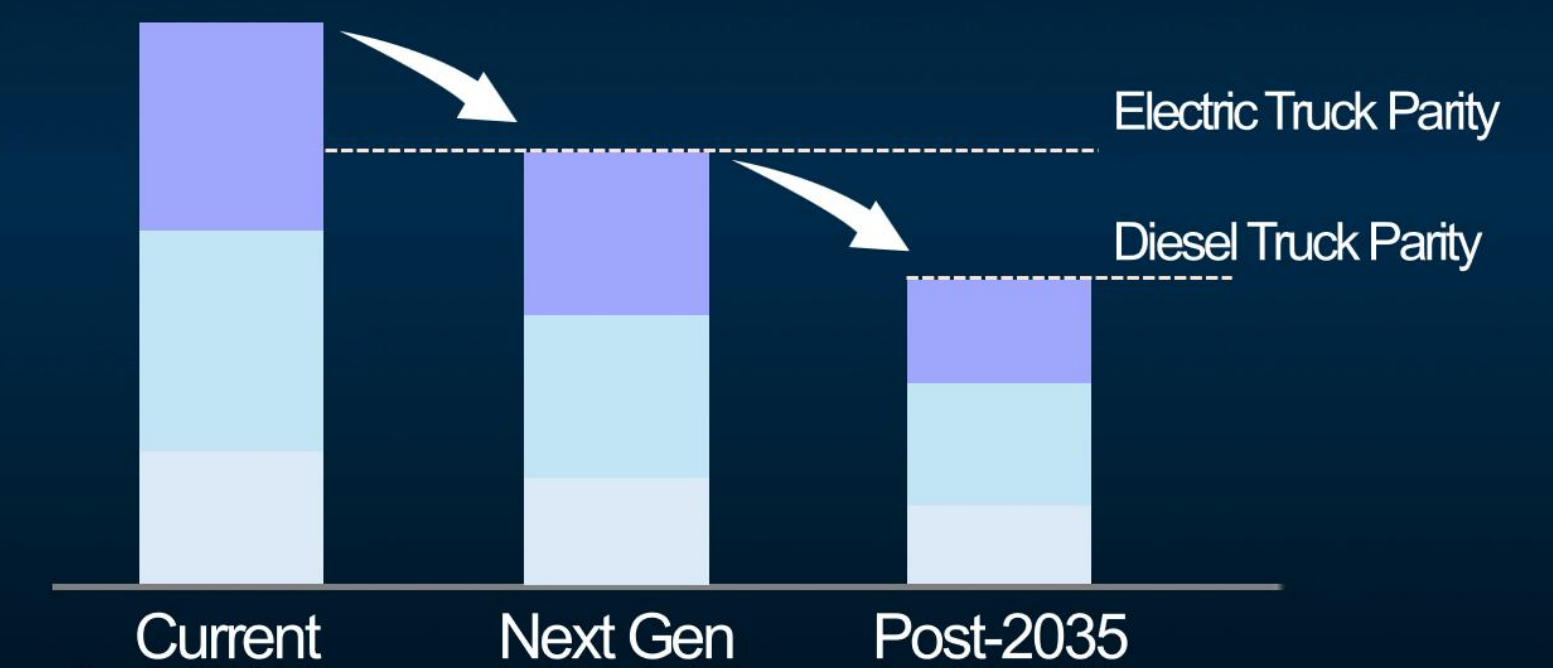


EV Truck
Cost Parity

Ultimate Target



Diesel Truck
Cost Parity



● FC System ● H2 Storage System ● Battery

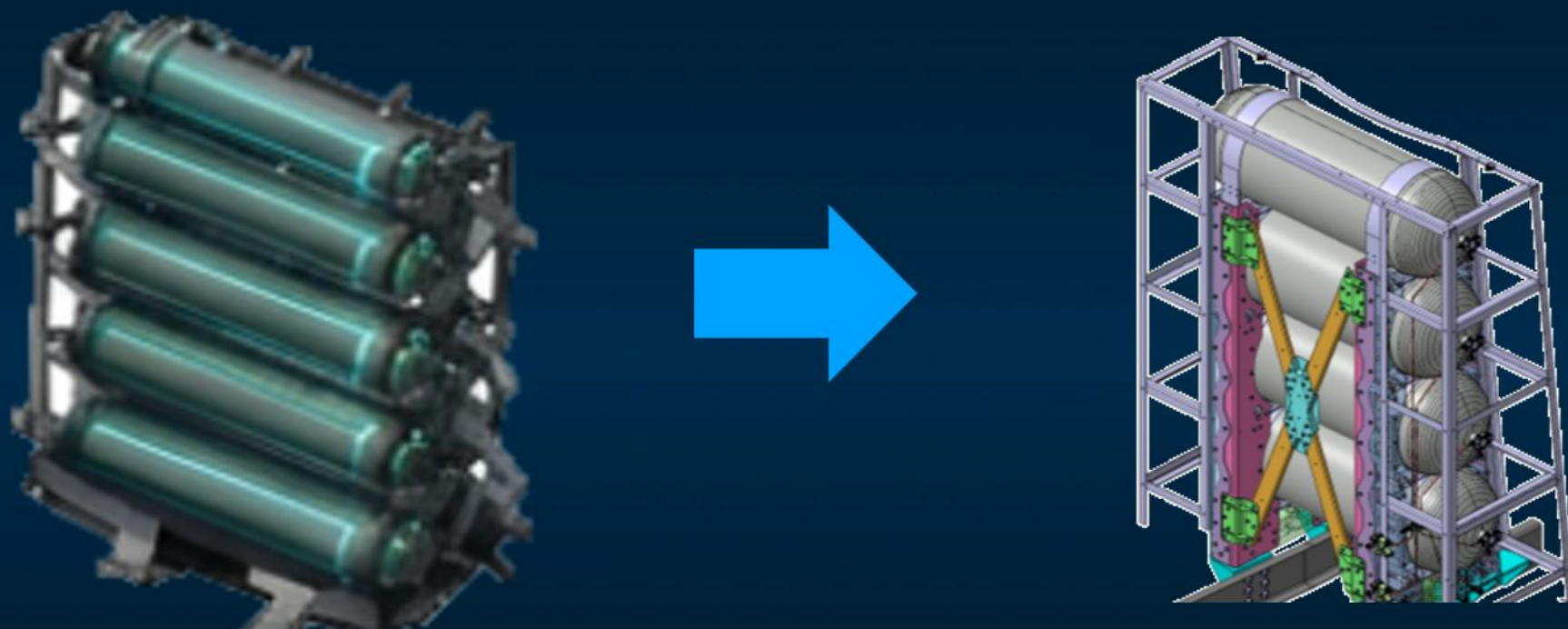
Hydrogen Storage System Development Strategy (CV)

Simultaneous development of gaseous and liquid H₂ storage systems (HSS) for application-specific deployment

- Gaseous HSS suited for short and mid-size vehicles (PV, BUS, small/mid-size truck)
- Liquid HSS suited for long-range and scheduled-operation vehicles (Heavy duty truck, TRAM, Airplane)

Gaseous hydrogen storage system

- Large diameter hydrogen tank development for truck
: Cost, weight, and volumetric storage density improvement through tank number reduction (10ea → 4ea)



- Development of high-speed refueling technology
to reduce hydrogen refueling time (40min → 10min↓ for 60kg)

Liquid hydrogen storage system

	XCIENT (NA, G-HSS)	XCIENT (NA, L-HSS)
		
Hydrogen storage (kgH ₂)	68.6 (ref.)	Ref. ↑
Tank numbers (EA)	10	2
Weight (kg)	Ref.	50%
AER (km)	724	1,000 ↑
Refueling time (min for 60 kg)	About 40min	About 9 min

Hydrogen Value Chain

HTWO, HMG's hydrogen brand and business platform, delivers end-to-end solutions across the entire hydrogen value chain – from production, transport and utilization

Upstream



Production

Waste-to-Hydrogen

PEM Electrolysis

Ammonia Cracker

Hydrogen Reformer

▪
▪
▪

Midstream



Storage, Transportation & Refueling

Tube Trailer

Stationary HRS

Ammonia
(Storage/Transportation)

Mobile HRS

Liquid Hydrogen
(Storage/Transportation)

Packaged HRS

Solid Hydrogen
(Storage)

L2G Charging
(Liquid to Gas)

▪
▪
▪

Downstream



Utilization

Fuel Cell System

Commercial Vehicle
(Truck, Bus, Car Carrier, etc.)

Hydrogen Power
Generator

Passenger Vehicle
(NEXO)

Powerpack

Rail Mobility
(Tram/Train/Locomotive)

Low-carbon
Emissions Steel

Heavy Equipment
(Forklift, Port AGV etc.)

Burner, Turbine

All Terrain Vehicle
(ATV)

Aeronautics

Boat, Maritime

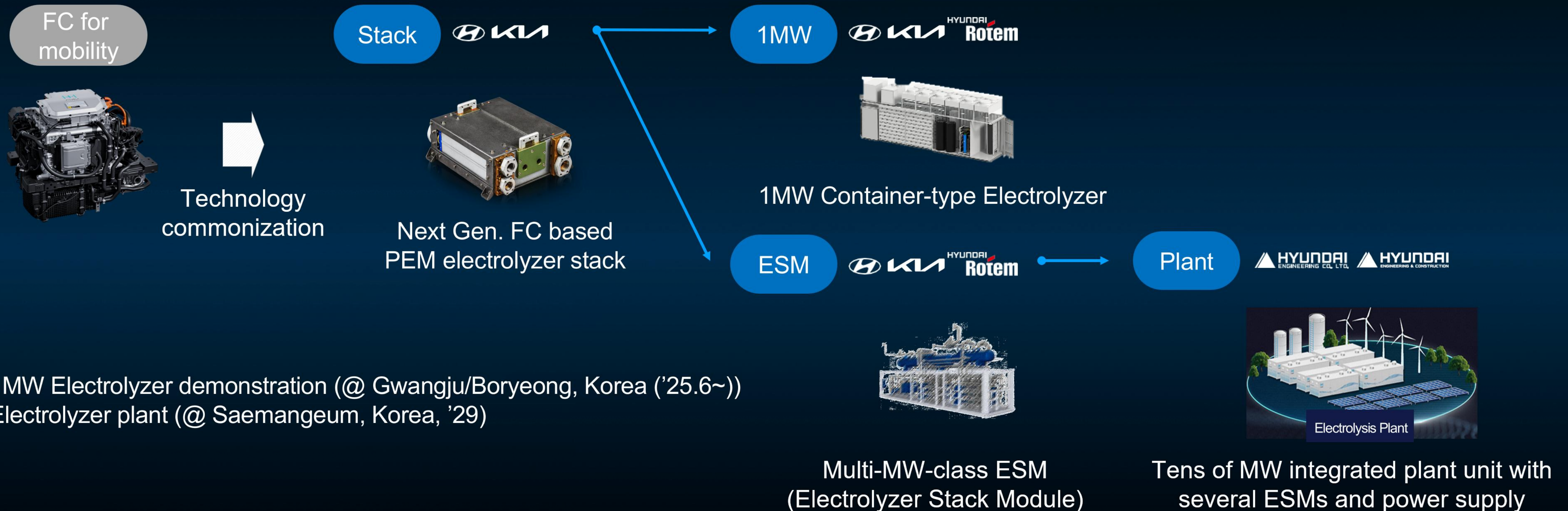
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Hydrogen Value Chain R&D Status – PEM Electrolyzer

Implementing competitive LCOH (Levelized Cost of Hydrogen) through phased plant expansion based on fuel cell technology

Development strategy

: Scaling electrolyzer stack technology from MW modules to multi-hundred MW plants utilizing fuel cell design and manufacturing technology



Expanding Fuel Cell Applications

Developing customized systems for railways, power generation, and construction machinery based on automotive fuel cell models to broaden applications and drive hydrogen market growth

[Base Model]



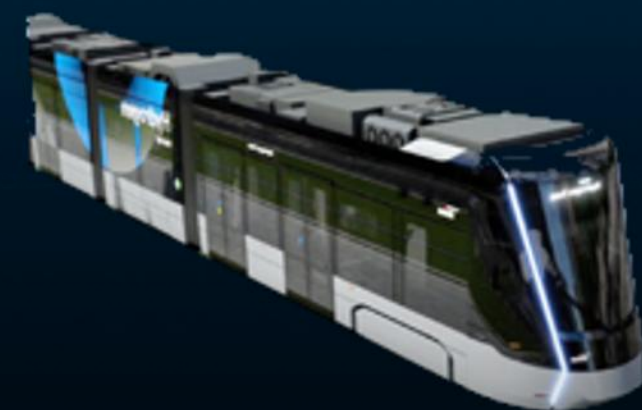
[Multi-Application Fields]



Flat-Type System



- Reduced system height via repackaging
- Roof-mounted structure for railway vehicles



Power Generation System



- Flexible power scalability through modular configuration
- Power supply for AI data centers and large buildings



Power Pack



- Integrated packaging of fuel cell & H₂ storage system
- Application to forklifts, excavators & industrial equipment





Born of Everyday, Powering Everyday

Duckwhan Kim, dwkim77@hyundai.com