



POWER UP ENERGY EXPO

Oct. 22-23, 2024
Tyndall Air Force Base, Florida

Brian Chakulski
Senior Director, Engineering

Installation of the Future



History of HyAxiom



In 2014, two industry powerhouses came together for a greater purpose:

UTC Power's hydrogen fuel cell experience



Doosan Group's extensive global manufacturing and energy sector expertise



60+ years

128 years

An Industry Pioneer with Long History in Hydrogen Technologies



Apollo space missions relied on UTC's fuel cell technology

1960s

Pioneer of Fuel Cell Technology



Space shuttle orbiters utilized UTC's fuel cells for all missions



Industry-leading 200KW stationary fuel cell is commercialized (1991), with over 300 units sold in 19 countries

1990s

World-First Commercialization



Developed PEMFC (PureMotion Model 120) for transit buses in CT/CA



Completed world's largest direct hydrogen-fueled power plant and first utility-scale fuel cell plant

2000s / 2010s

Global Expansion At Scale



Purecell® Model 400 in the market with expected max. 10-year stack life



Doosan's acquisition ensured installations of more than cumulative 1,300 units

Hydrogen and HyAxiom are a Core Business of Doosan Group



HyAxiom is a subsidiary of Doosan Group, Korea's oldest conglomerate with over 128 years of history specializing in infrastructure, energy, machinery and a wide range of innovative technologies.

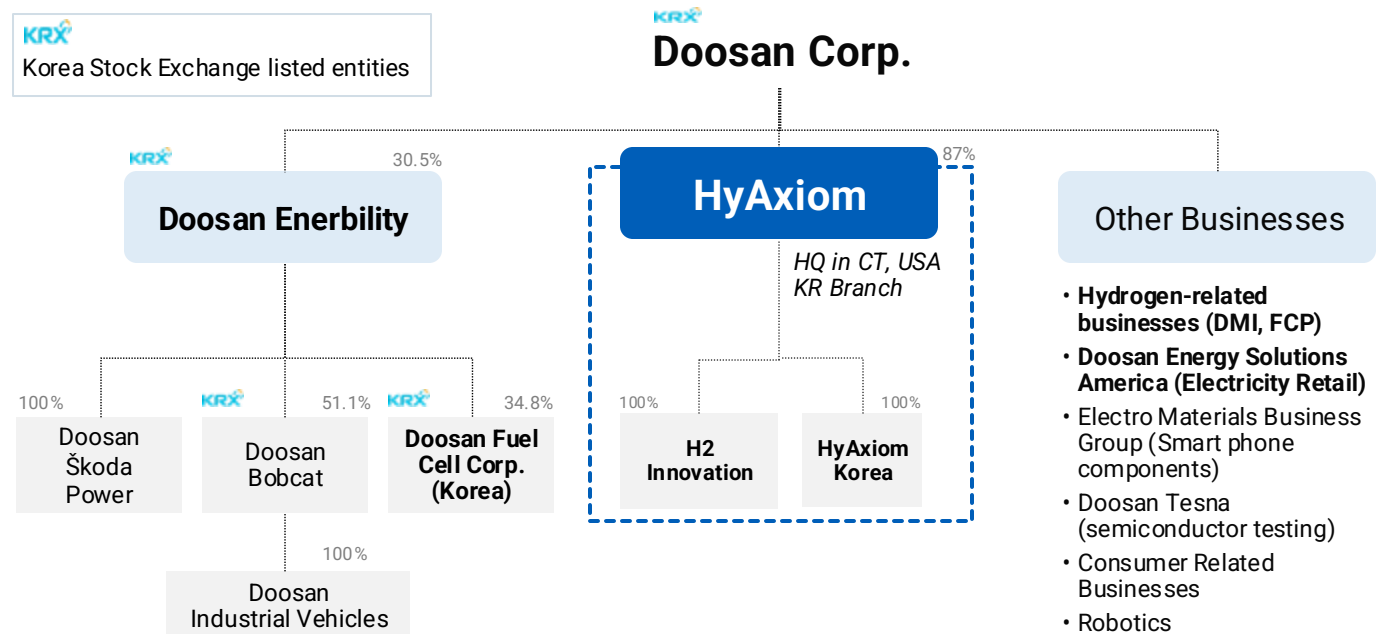
Heavy focus on Hydrogen

Doosan has been **investing in the hydrogen ecosystem for close to a decade** and views it as a **key strategic pillar** for decades to come.

Entities involved across the hydrogen value chain:

- **HyAxiom**
 - H2 Innovation (H2I)
 - HyAxiom Motors
 - Doosan Fuel Cell Corp (DFCC)
- Doosan Enerbility
- Doosan Mobility Innovation (DMI)
- Fuel Cell Power
- Doosan Energy Solutions America

- \$15B** Revenue
- 40K** Employees
- 38** Countries across all continents
- 24** Businesses/ Subsidiaries

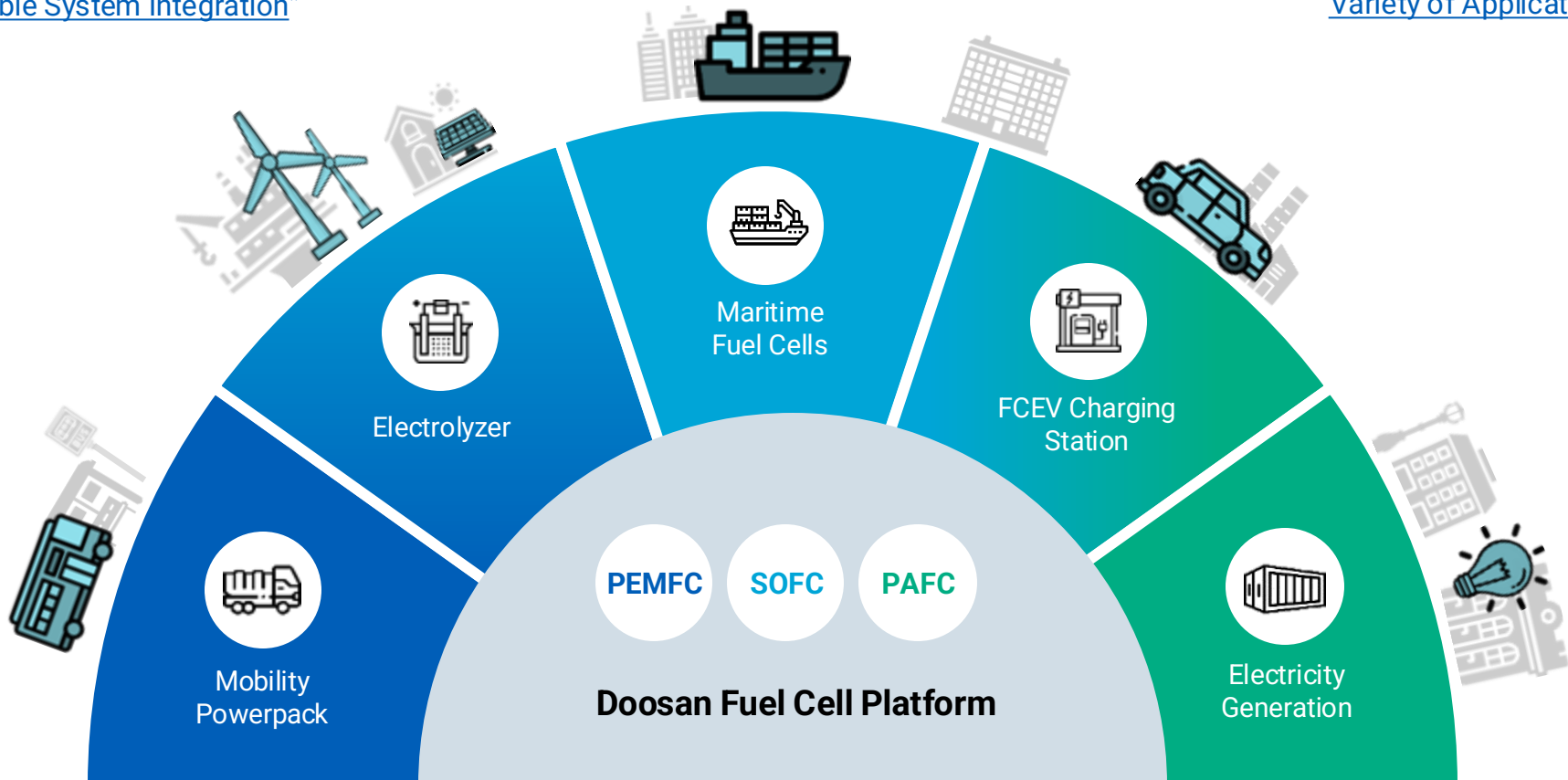


Doosan Fuel Cell Business Portfolio

Based on PAFC capabilities, we are expanding our business applications to hydrogen production and mobility.

“Flexible System Integration”

“Variety of Applications”



Global Experience (PureCell[®] M400)



■ In operation	609.70 MW	1,385 Unit
■ Under construction	231.30 MW	525 Unit



Doosan Fuel Cell Locations



Factory and Assembly/Quality System



Automated cell stack
Fabrication and assembly



State-of-the-art factory
Performance test



Long term
strategic suppliers



ISO 9001 & 14001
Certified

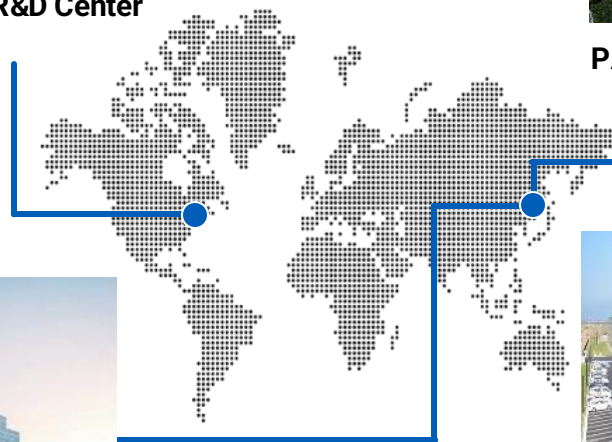


PAFC Factory & R&D Center
Connecticut, US

DOOSAN Fuel Cell



PAFC Factory – Iksan, Korea



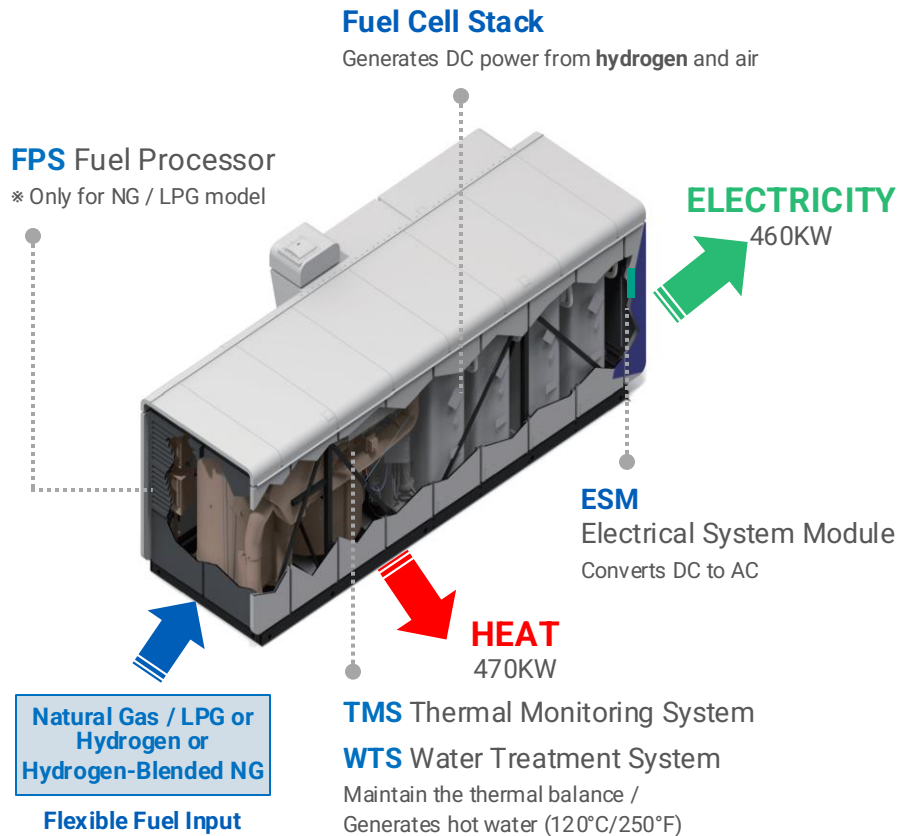
SOFC R&D Center
Gwangkyo, Korea



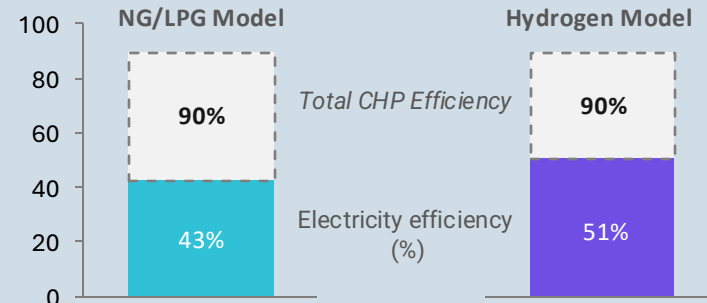
SOFC Factory – Gunsan, Korea

How the Natural Gas PAFC technology works

(PAFC= Phosphoric Acid Fuel Cell)



Capacity (Electric/Heat)	460 kW / 470 kW (404Mcal/hr.)
Efficiency, LHV (Electric / Total)	43.8% / 90% (BOL)
Emissions (CO, NOx, VOC)	Negligible (CARB Certified)
Durability (Lifetime)	10 yr. stack/20 yr. system
Installed Footprint (1 unit)	1200 sq. ft. (30' x 40')
Noise	60 dBA @33 ft. 43

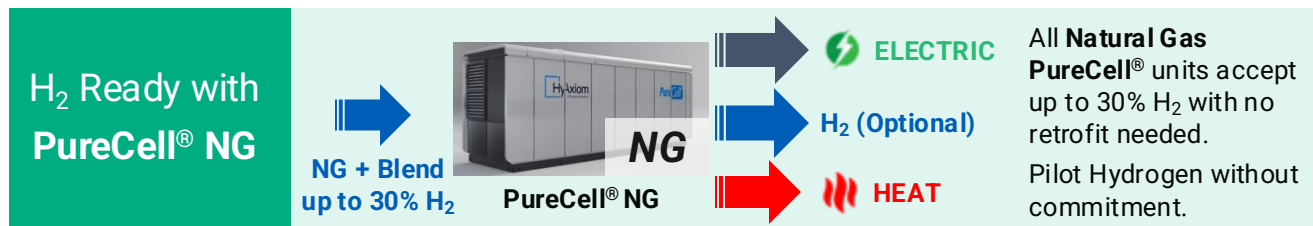


Source: EIA, Company Data

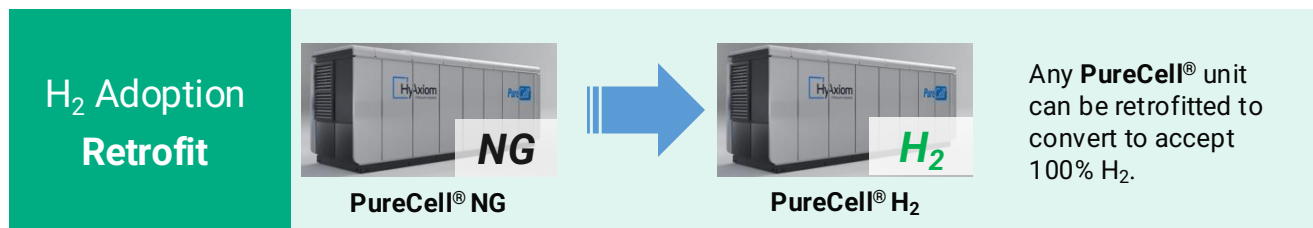
Transition to Hydrogen, Flexibly

Options for any step of the journey

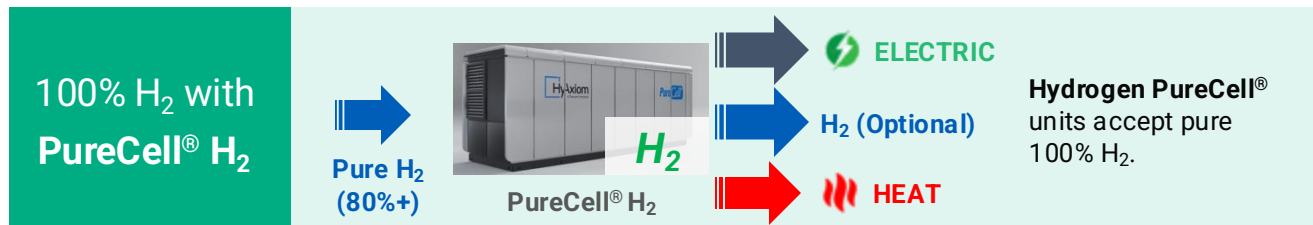
More Power Than H₂ Available



Increasing H₂ Availability



Full H₂ Availability

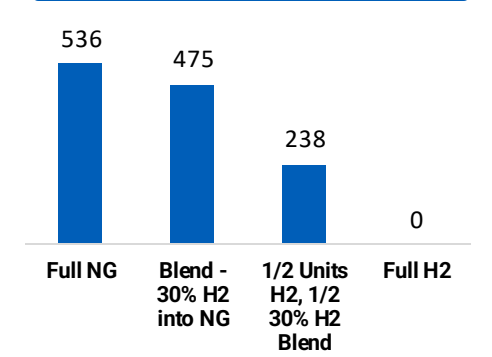


Adopt when you're ready.

PureCell® fuel cells fit any hydrogen transition roadmap, whether you are switching to Hydrogen now or want to be prepared for the future.

NG PureCell® provides continued fuel-flexibility into the future, with the option to continuously adjust NG / H₂ balance.

CO₂ Emissions^{1 2} (lbs/MWh)



1 Includes CO₂ emissions savings due to reduced on-site boiler gas consumption.
 2 Actual emissions from NG units based on multiple factors; shown values are estimates.

Source: EIA, Company Data

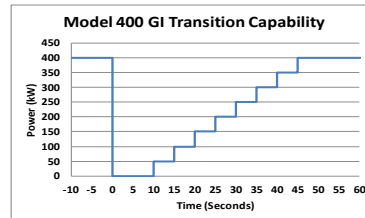
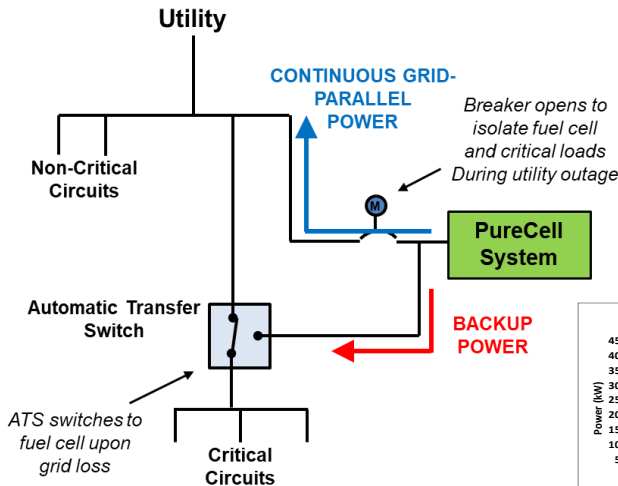
Key Features of PureCell® that differentiate HyAxiom from Others



Grid Independent Capability

PureCell®'s Grid Independent capability helps customers reduce dependence on the grid and increase reliability and energy security.

- Continuous operation – system running when backup power needed
- Critical asset used continuously for energy savings
- Highly reliable natural gas - no diesel tanks or refueling
- Heat available during grid outage
- Low GHG footprint

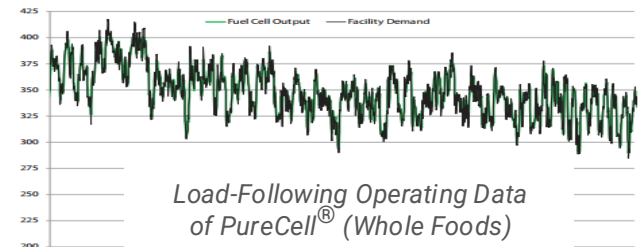
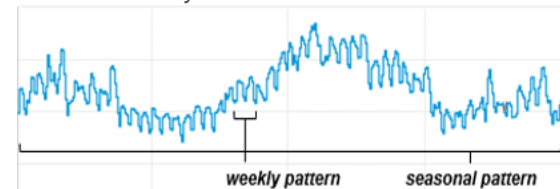


Load-Following Capability

Demand for electricity fluctuates hourly, weekly and seasonally.

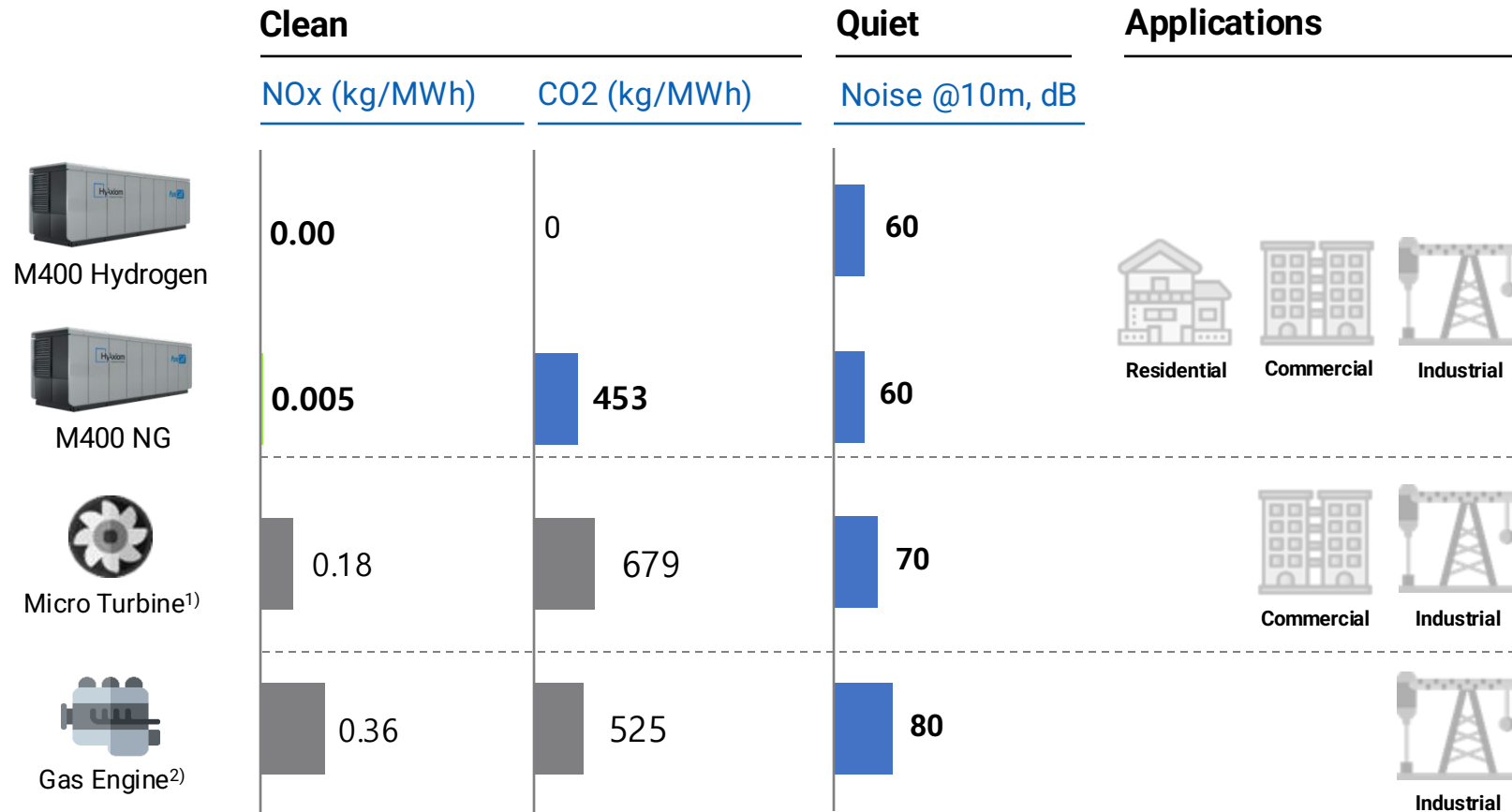
- Unlike other fuel cells and intermittent renewable sources, users of the PureCell® experience higher efficiency and lower life-cycle costs while generating only the electricity that they require.

U.S. Electricity Demand



Benefits of PureCell[®] M400

1. Clean & Quiet



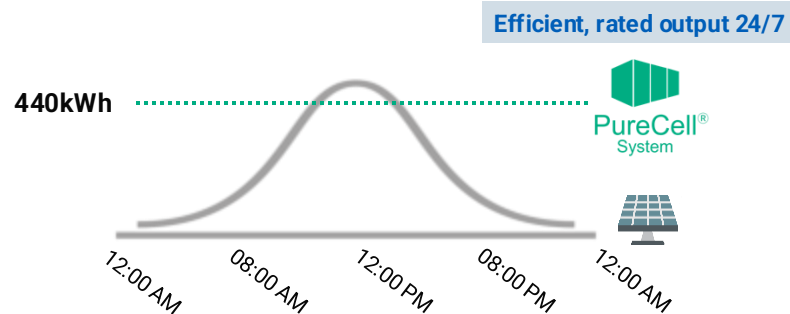
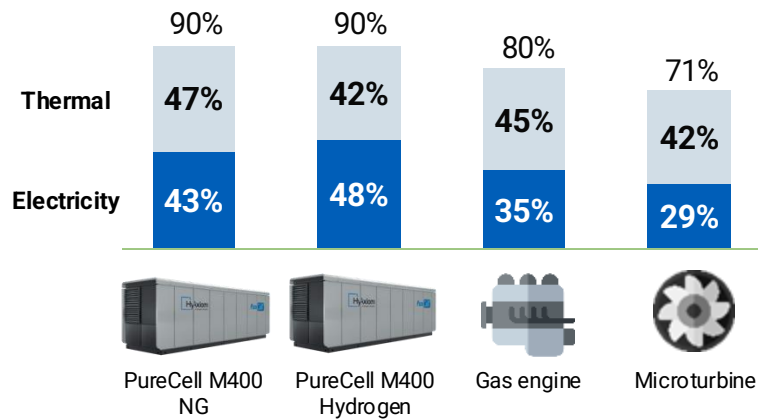
1) 333kW (Source: DOE)

2) 633kW (Source: DOE)

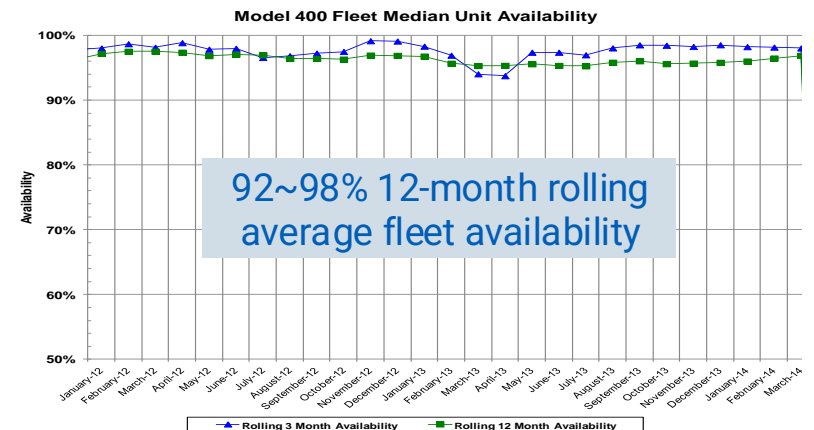
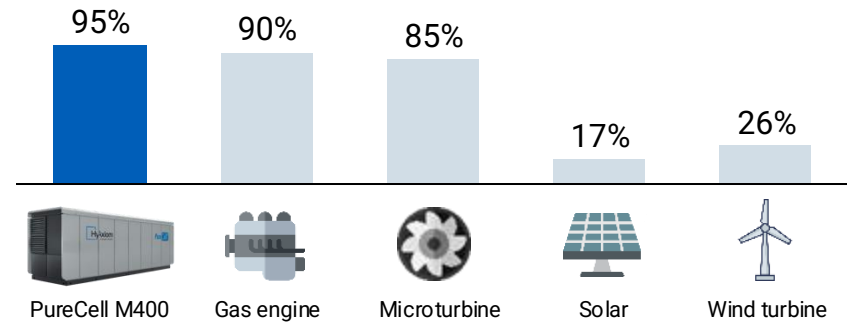
Benefits of PureCell[®] M400

2. High Efficiency & Capacity Factors

Electrical efficiency by sources

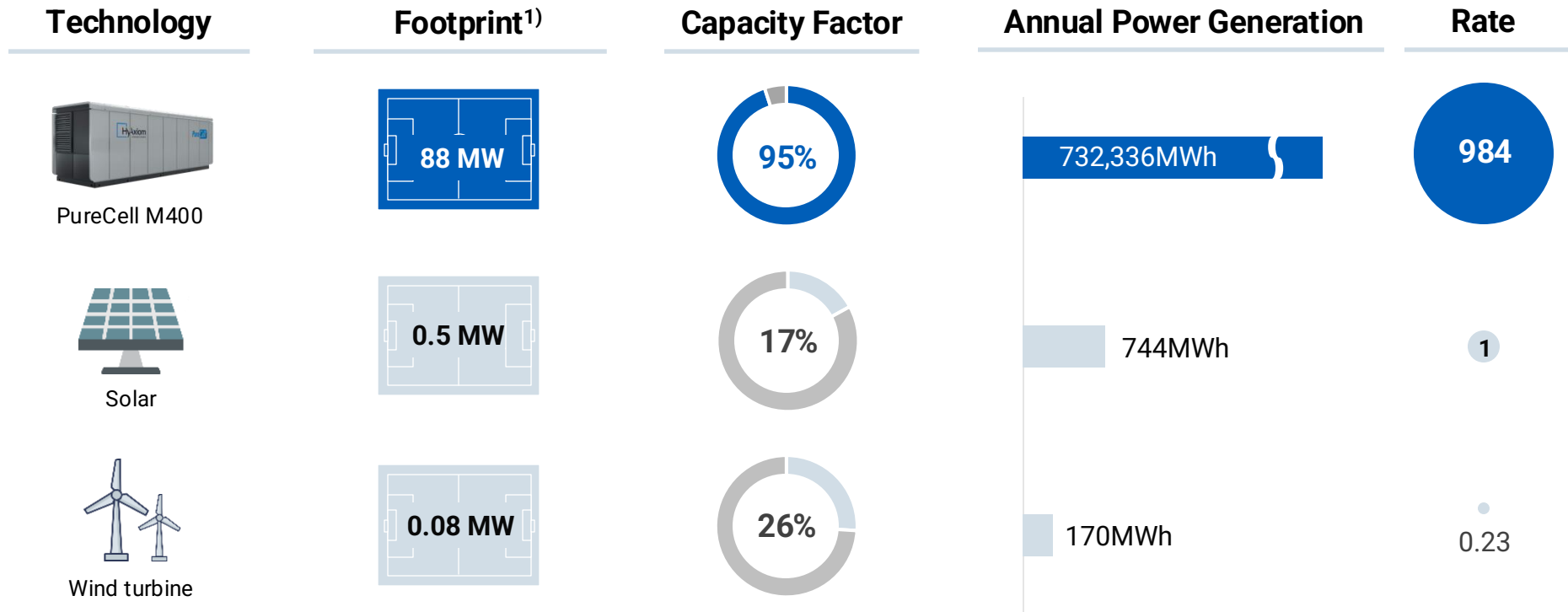


Capacity Factors



Benefits of PureCell[®] M400

3. Footprint



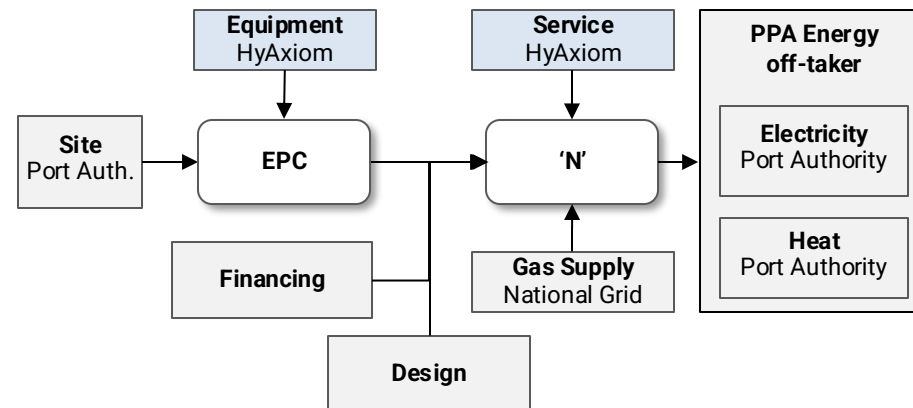
Smaller footprint than other renewables

- Container box sized module (8.3m x 2.5m x 3.0m)
- Multistory installation available depending on conditions, providing superior space efficiency
- No environment and climate prevents installing our fuel cells

1.) Soccer field area : 7,140m²

Project Reference: Microgrid Solutions

International Airport Project



First resilient airport transit hub that can function independently of the power grid to maintain 100 percent of airport operations during power disruptions.

Project Overview

- Name: 'N' Microgrid Solutions Project
- Total Power: 11.34 MW
 - 7.66 MW of rooftop solar
 - 3.68 MW of fuel cells (8 units)

HyAxiom's Work Scope

- Exclusive equipment supplier and service provider of fuel cells as a microgrid solution
- Design, Manufacture and Delivery of 8 units, with each unit producing 460kW of power
- 40-year long term servicing (LTSA) by HyAxiom
- Heat to generate chilled water and heating hot water

Project Reference: Waste Water Treatment Plant



4 Million Gallons of Water



The PureCell units will conserve approximately 4 million gallons of water annually where they were installed at the Waterbury facility – compared to the consumption of water by utility generation.

3 Million Pounds of Carbon Dioxide



The three PureCell units will annually reduce the plant's carbon footprint by 3 Million Pounds.

Achieving sustainability objectives with clean, affordable onsite energy

Project Overview

- Name: Wastewater Treatment Fuel Cells Project
- Total Power: 1.32 MW (3 units)
- Installation: 2017

HyAxiom's Work Scope

- Exclusive equipment supplier and service provider
- Design, Manufacture and Installation of 3 units
- 20-year long term servicing (LTSA) by HyAxiom
- HyAxiom arranged PPA (Power Purchase Agreement) deal
- The Yearly Environmental Benefits (compared to traditional energy sources) are;
 - amount of CO₂ saved is 3 million lbs., the amount of NO_x saved is 9,900 lbs.
 - amount of H₂O saved is 4 million gallons.

Project Reference:

Utility-Scale Hydrogen-fueled Power Solutions



Daesan Hydrogen Fuel Cell Power Plant*



1st

World's 1st Utility-scale hydrogen fuel cell power plant

50MW

World's Largest by-product hydrogen power plant

Only

The only commercialized and fully operational stationary fuel cell using hydrogen

Project Overview

- Name: Daesan by-product Hydrogen Fuel Cell Project
- Customer: Daesan Green Energy
- Location: Seosan, South Korea
- Total Power: 50.16 MW (114 units)
- In operation since July 2020 with capacity factor of 98% and electrical efficiency of 50%



HyAxiom's Work Scope

- Exclusive equipment supplier and service provider
- Design, Manufacture and Installation of 114 units
- 20-year long term servicing (LTSA)
- Generates up to 400,000 MWh of electricity annually, enough to power 160,000 South Korean homes.

* Actual images of the Daesan plant

Solid Oxide Fuel Cell S300 Introduction



STACK TECHNOLOGY	 SOFC (Ceramic Support)	 SOFC (Metal Support)
Efficiency	●	●
Fuel	NG Liquid Fuels Bio Fuels Hydrogen	NG Liquid Fuels Bio Fuels Hydrogen
Cost		●
Robust		●
Applications	Stationary	Stationary



SOFC Cell/Stack
license agreement



Pure Cell S300 (Preliminary)

Key Features

Capacity	300kW (60kW per Module)
Efficiency (Avg.)	57%
Capacity Factor	95%
Operating Temp.	< 620°C
Life Time	Stack: 7 years System: 20 years
Footprint (Module)	W 1.8m, D 2.3m, H 2.7m
Ramp Rate	0.25kW/s (5%/min)

Stationary

KHNP¹⁾ Demo. in 2024

Commercial Project Delivery
for 9MW in 2025



Maritime

*600kW APU system test on
voyage with Shell, KSOE, and DNV*

Commercialization in 2026



[Flexible Arrangement]

1) Korea Hydro & Nuclear Power Co.

All-in-one Containerized Solution (1MW-1.25MW)



HyAxiom PEM Electrolyzer - key characteristics

Flexible H₂ Production

- Balance of plant and electrical architecture capable of output up to 500 kg H₂/day

Optimized H₂ Production Cost from Any Power Source

- High system efficiency allows for low LCOH
- Flexible operations for optimized connection to all power sources, including renewables

Hydrogen Suitable for All Applications

- System includes hydrogen purification system (HPS), allowing for highest purity output hydrogen suitable for all use cases

Long Life for Optimized O&M

- Industry leading stack and system lifetime allows for long, reliable operations and optimized maintenance costs

H₂ Production

450-500 kg H₂/day

System Efficiency

51.6-51.8 kWh/kg H₂

Flexible Operations

Start Time: < 5 min
Ramp Time: 10 sec
Turn down: 10%

H₂ Purity

99.995%+ H₂
(with HPS)

H₂ delivery Pressure

30 bar(g)

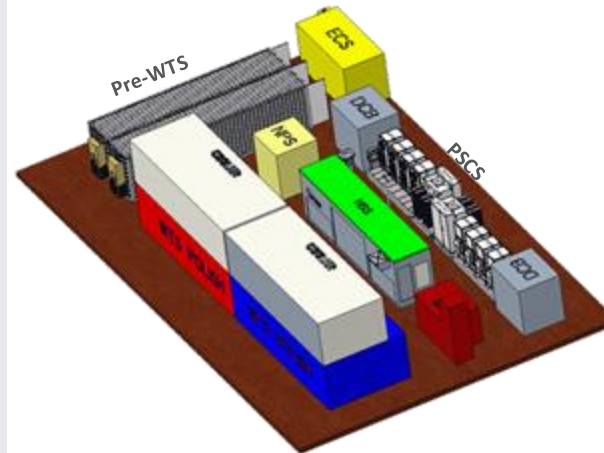
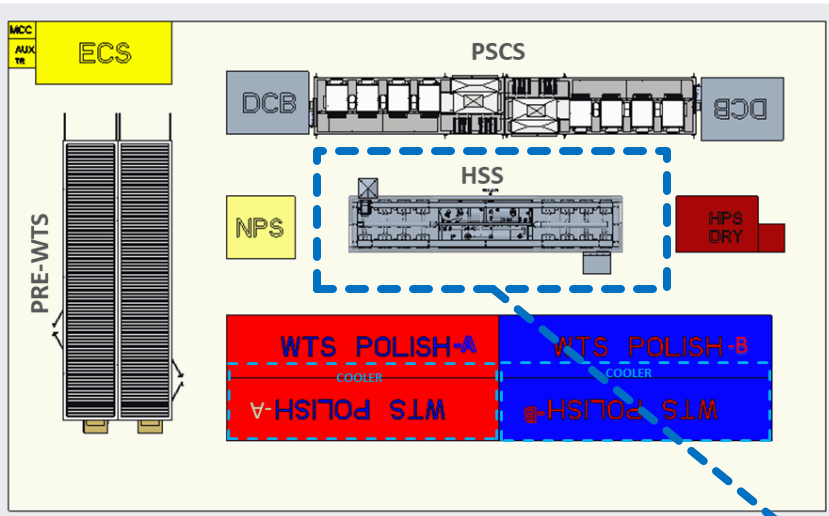
Product Life

20 years
Stack Life 80,000 hrs+
(~10 years full load)

HyAxiom's scalable Modular solution (Multi-MW)



H₂ Production 4,300 kg H₂/day/block @ 30 bar(g)



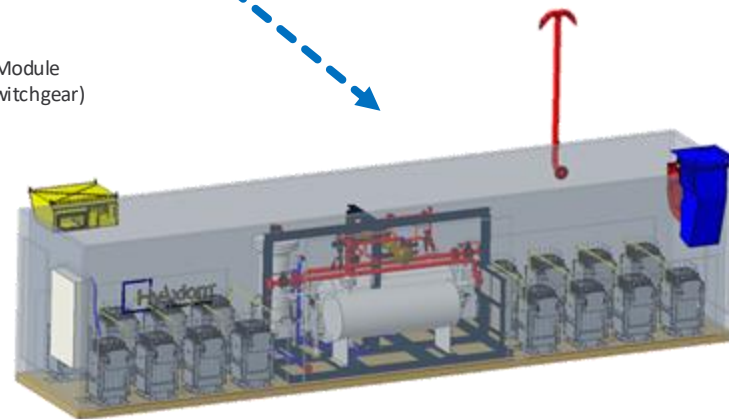
Modular hydrogen generation system allows for **ease in multi-MW scale-up**

Subassembly systems for water treatment, hydrogen processing, and electrical features **optimizes system cost and customer hydrogen production cost (LCOH)**

Flexible design allows for **HyAxiom scope optimization** with partners based on site supply requirements

End to end 20-year product life support with **site design, installation, monitoring, and service**

1. HSS – Hydrogen Supply System (contains CSAs)
2. HPS-SEP-CHL – Hydrogen Purification System Separator Stage
3. WTS Polish – Water Treatment System Water Quality Maintenance
4. TMS (Cooler/Glycol Pump) – Thermal Management System Cooling Module
5. PSCS – Power Supply Conditioning System (Transformer, Rectifier, Switchgear)
6. HPS-DRY-CHL – Hydrogen Purification System Dryer Stage
7. Pre-WTS/CIP – Water Treatment System City Water Interface
8. Master ECS – Electrolyzer control system





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