

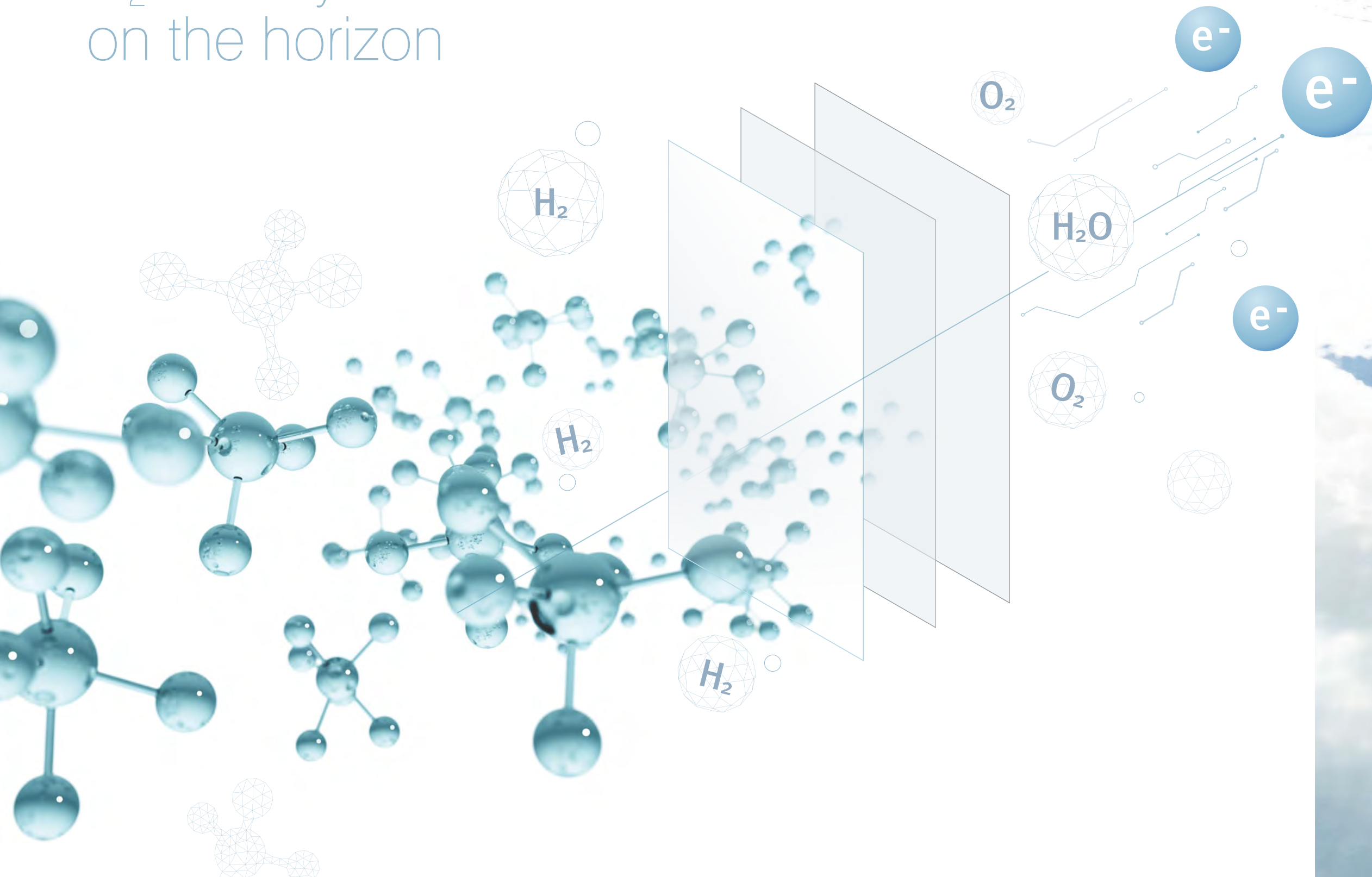
# Doosan Fuel Cell Profile 2020



**DOOSAN**

We are leveraging eco-friendly technologies that can enhance the sustainability of humankind, thereby paving the way to a society that runs on hydrogen, a clean and infinite energy source.

# H<sub>2</sub> society on the horizon







Safe enough to be located in urban centers,  
truly eco-friendly energy that only emits pure water,  
a clean energy source that brings electricity, heat,  
and water to wherever needed...  
Hydrogen fuel cell is expanding its horizons.





**Ways for humankind to live in harmony with Nature –  
the answer Doosan Fuel Cell is pursuing in hydrogen.**

With proven track records, including the world's largest byproduct hydrogen power plant, driven by the relentless pursuit of innovation that puts customer value first, and committed to a better tomorrow for our future generations and the natural environment, Doosan Fuel Cell is taking the lead in ushering in the hydrogen society.





Reliable



Stable

For the blue planet we live on,  
for the generations behind us,  
for a brighter future for all of us,  
Doosan Fuel Cell is leading  
the hydrogen economy and  
hydrogen society.

Doosan  
Fuel Cell



Safer



Smarter



Cleaner

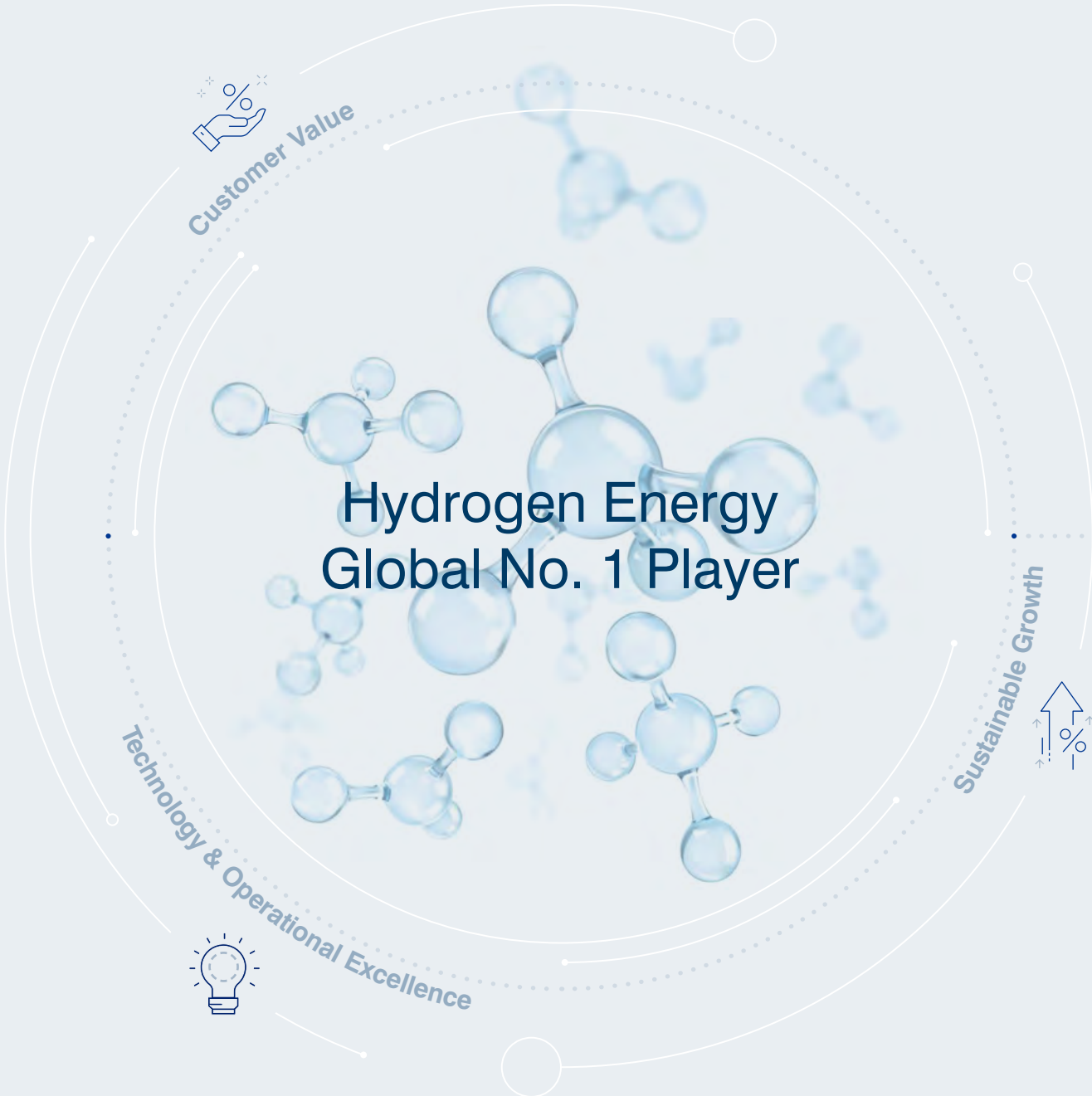


Greener



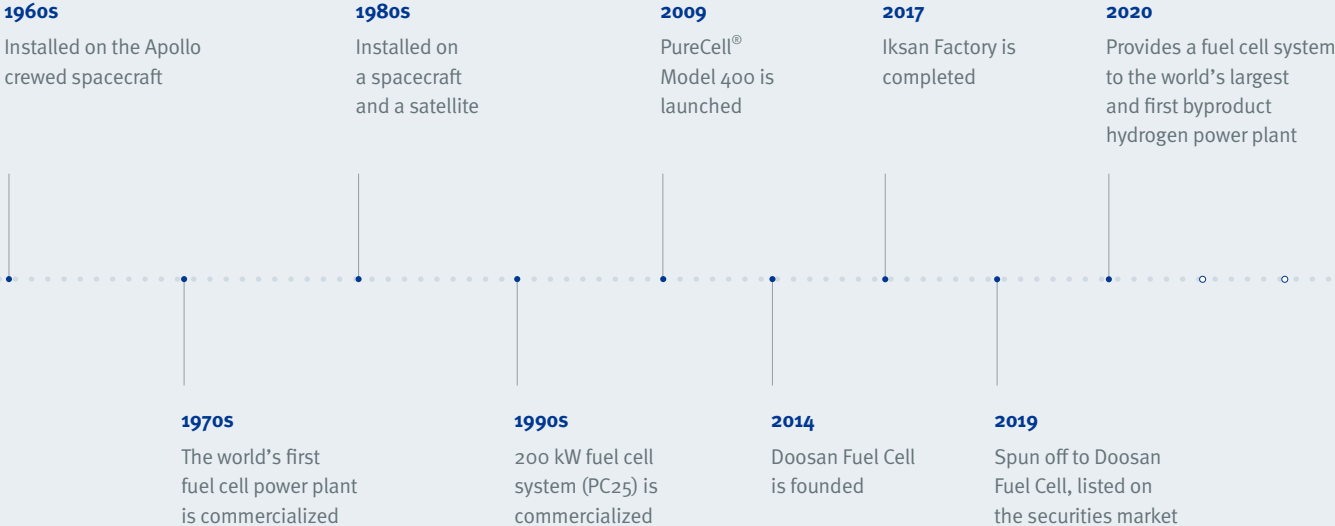
# Doosan Fuel Cell At a Glance

VISION



Armed with the technological prowess that has been proved in the global market, we provide clean and safe energy solutions to wherever needed, thereby leading the shift toward an eco-friendly hydrogen society.

MILESTONES



Doosan Fuel Cell, spun off from Doosan Fuel Cell BG in October 2019, has been leading the distributed energy market with tried-and-tested technologies of US-based UTC that were proven by being installed on the crewed spacecraft in the 1960s. Our flagship product, the M400 model, can generate heat in addition to 440 kW of electricity and be installed on a wide range of facilities including distributed power generation, data centers, cold storage warehouses, large buildings, smart farms, and national security complexes. The model is also designed to use not only hydrogen but also natural gas and LPG, and can be built in dual layers in the city center, allowing flexible response to field conditions of customers.



BUSINESS



Develop its own source technology for fuel cell systems

Own source technology for a phosphoric acid fuel cell (PAFC) that uses liquid phosphoric acid as an electrolyte

Established an R&D organization in the U.S. and Korea to develop new products and improve quality

Directly conduct research on materials, basic design and detailed design in order to better meet customers' new requirements

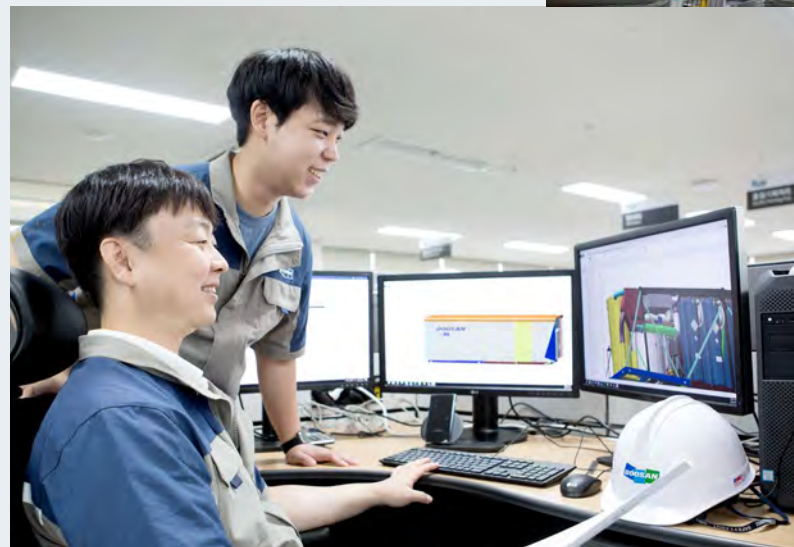
Manufacture and supply fuel cell systems

Have the annual production capacity of 90 MW in Korea and 60 MW in the U.S.

Automized the manufacturing facility for cell stacks

Strictly comply with international quality standards by conducting peak load test for all products

Own a stable parts supply chain that boasts a localization rate of 98%



Offer long-term maintenance service for fuel cell systems

Manage all products around the world 24/7 through a remotely controlled system

Hire and foster skilled engineers to quickly solve problems in the field

Maintain the highest level of capacity factor through systematic, preventive maintenance and lifecycle management by module

R&D CENTER

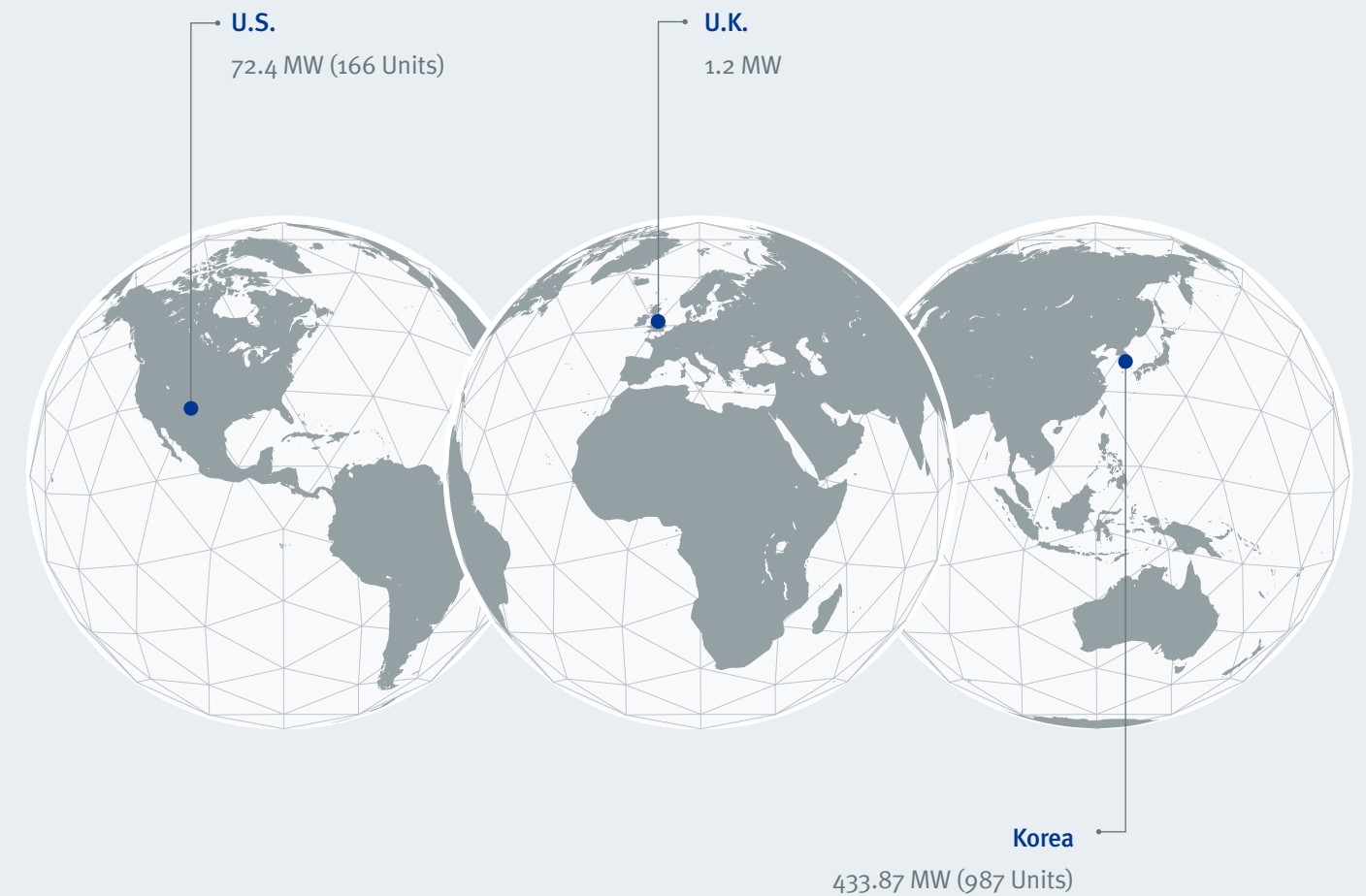
R&D Center in Korea



R&D Center in the U.S.



GLOBAL TRACK RECORD



\* As of August 2020



# Our Products

Doosan Fuel Cell leads the hydrogen fuel cell market through products and services that are widely respected in the global market for their superior quality.



## How fuel cells work

Doosan Fuel Cell's fuel cell system produces electricity and heat through the electrochemical reaction of hydrogen and oxygen by using hydrogen, natural gas, and LPG.

### CATHODE

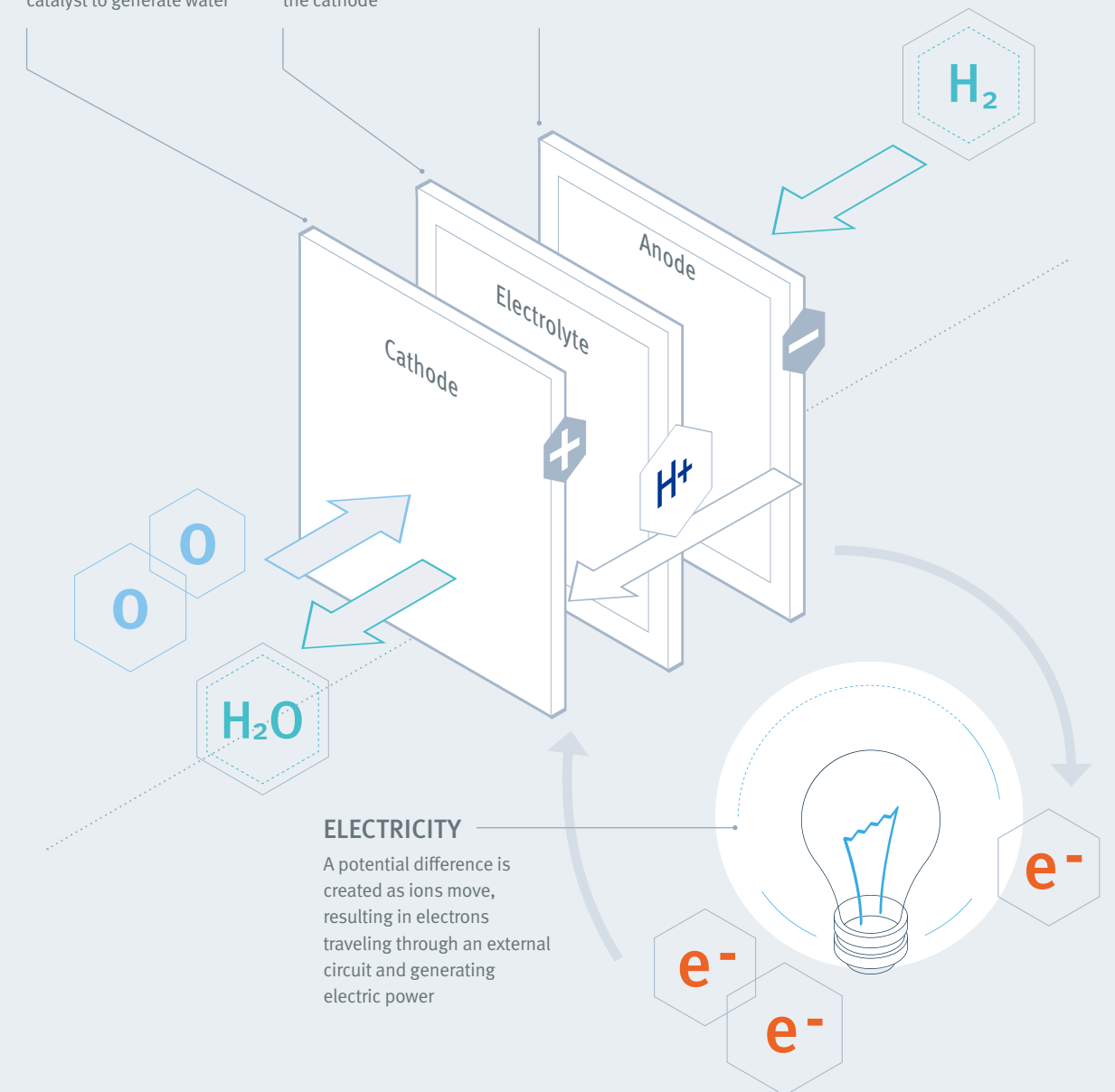
The protons that passed through the electrolyte and oxygen that was injected into the cathode are combined together by the catalyst to generate water

### ELECTROLYTE

This substance allows only ions to pass through. Hydrogen ions pass through the electrolyte to move from the anode to the cathode

### ANODE

Hydrogen is injected in anode and split into protons and electrons by a catalyst





## Competitive advantages of Doosan Fuel Cell



### Fuel flexibility

Our fuel cell systems can be used in more diverse environments and customer requirements as they operate on hydrogen, natural gas, and LPG.



### High durability

Our fuel cell systems last longer owing to their 200°C-and-below operating temperatures and stabilized stack technology.



### Quick response

Our fuel cell systems respond to load fluctuations in real time as their output can be scaled to as high as 10 kW/Sec (2.27%) ramp-up and as low as 20 kW/Sec (5%) ramp-down of rated output per second.



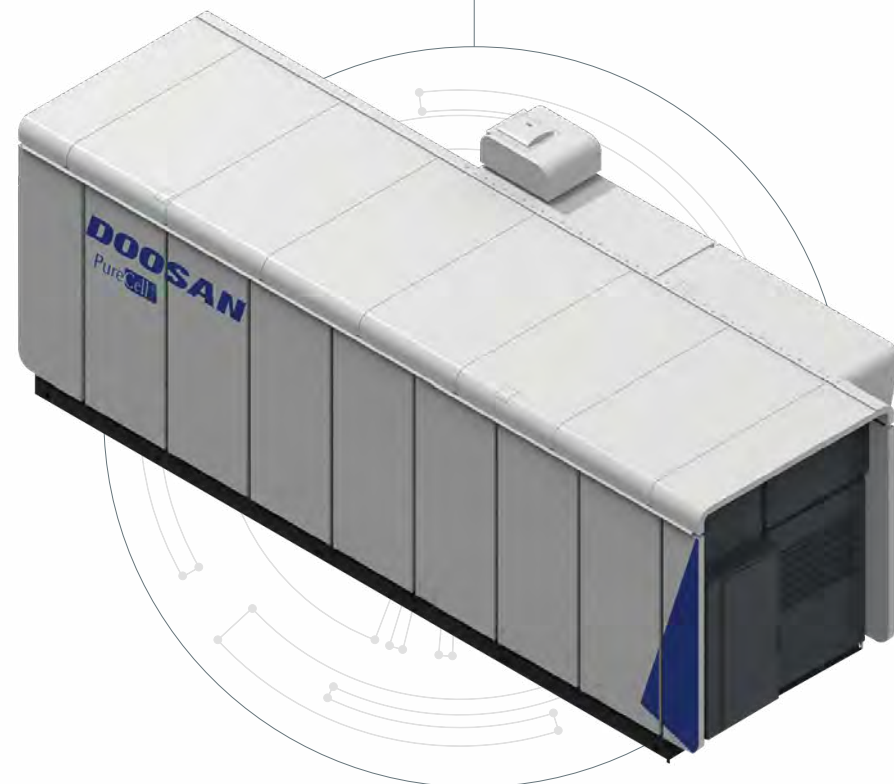
### Eco-friendly

Our fuel cell systems generate significantly less emissions of hazardous materials compared to the conventional combustion power generation system, and they also make less noise, quiet enough to be installed in residential areas.



### Combined heat and power

Our fuel cell systems are highly efficient in that they supply not only electricity but also local heating and cooling as well as heat for industrial facilities with a maximum overall efficiency of 90%.



## PureCell® Model 400 Hydrogen

This pollution-free clean energy solution, which uses hydrogen to generate electricity and heat, boasts high energy conversion efficiency and also produces clean water as a byproduct.

Hydrogen 8.3 x 2.5 x 3.0m 440kW

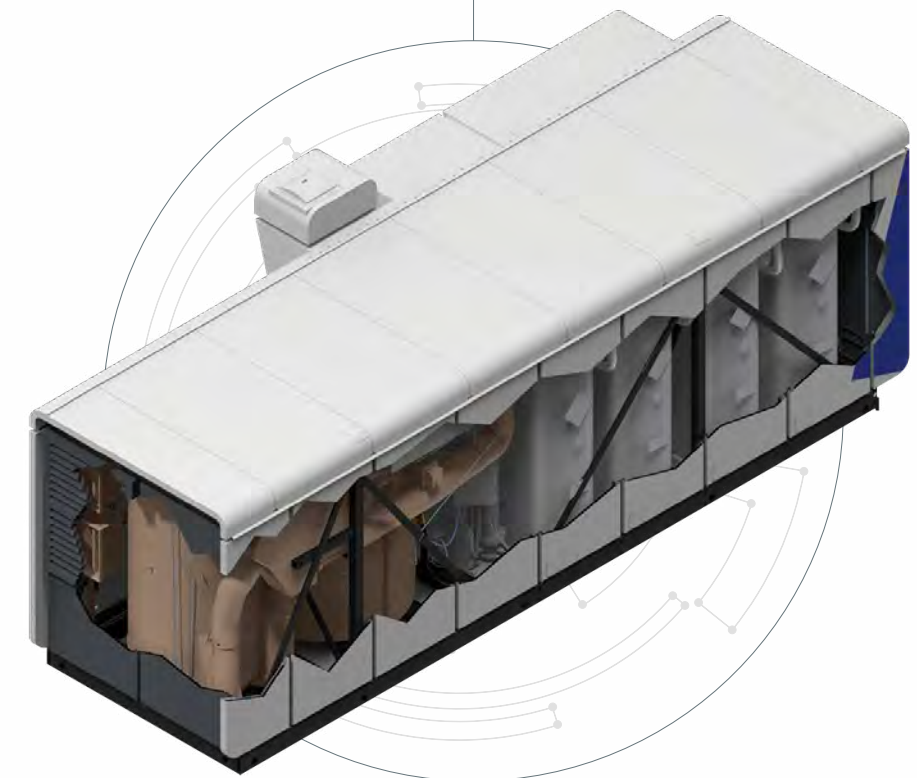
HG (120°C) 30-130L/hr Total 85%, Electricity 49%, Heat 36%

## PureCell® Model 400

This is ideal for urban areas as highly efficient, eco-friendly technologies that produce clean electricity and heat any time, any place where natural gas is available.

NG 8.3 x 2.5 x 3.0m 440kW

HG (120°C) Total 90%, Electricity 43%, Heat 47%



Fuel Size Rated Output Heat Supply  
Water Production Hydrogen Production Efficiency



## PureCell® Model 400 LPG/NG Dual

This model produces electricity and heat at places without natural gas pipes by using LPG that is easy to store and transport. In particular, it is designed to be applied to isolated regions and national infrastructure facilities.

LPG/NG 9.8 x 2.5 x 3.0m 440kW

HG (120°C) Total 90%, Electricity 41% 43%, Heat 49% 47%



## Tri-gen

This model produces three types of energy – hydrogen, electricity, and heat – through a reformer inside the module, and simultaneously goes through the stack to generate electricity and heat. In particular, it is directly installed on a hydrogen station, leading to a considerable reduction in high-pressure hydrogen shipping costs.

NG 8.3 x 2.5 x 3.0m 350-440kW

HG (120°C) 0-220kg/day



# Installation Cases of Doosan's Fuel Cell Systems

Utilize cold energy generated from cold storage warehouses to produce energy



Korea Superfreeze Cold Storage (9.6 MW)

World's first and largest dual-layer fuel cell system



Busan Green Energy (30 MW)

Provide electricity and heat for the large building



Lotte World Tower (0.8 MW)

World's first and largest byproduct hydrogen power generation



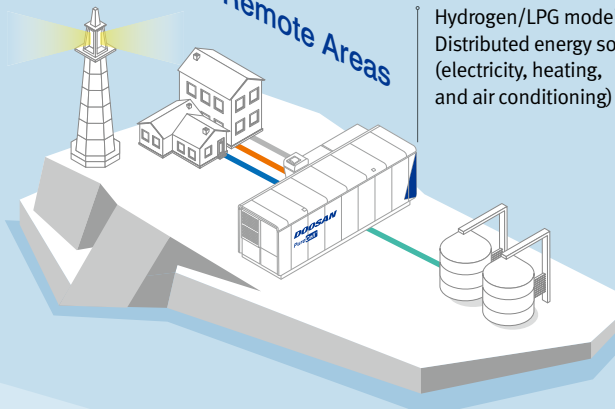
Hanwha Daesan (50 MW)

Fast load following for industrial application

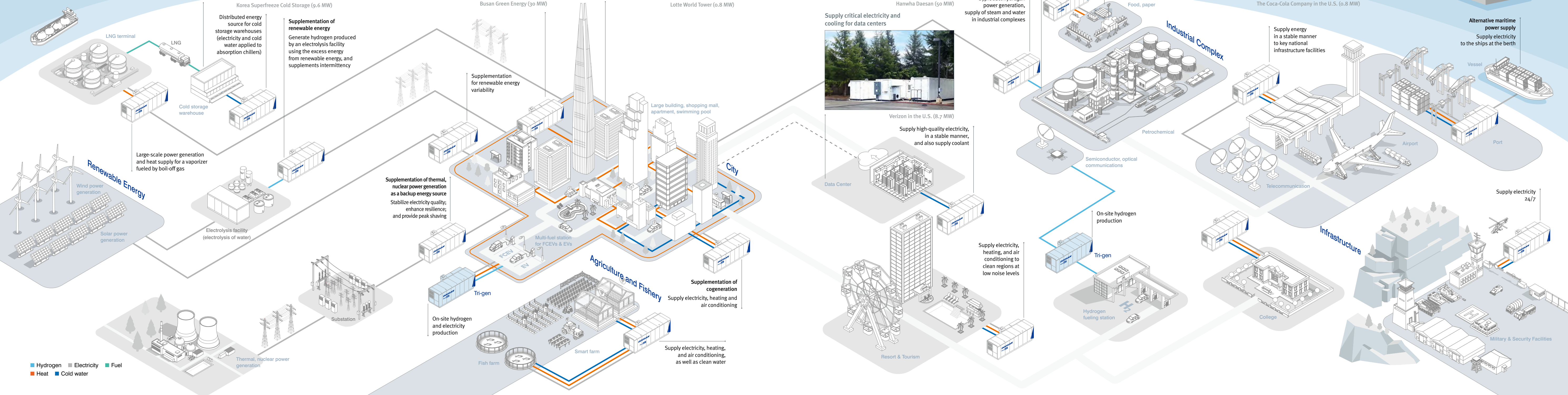


The Coca-Cola Company in the U.S. (0.8 MW)

Island and Remote Areas



Hydrogen/LPG model  
Distributed energy source  
(electricity, heating,  
and air conditioning)





# Our Value

Doosan Fuel Cell places top priority on customer value and produces clean, safe, and high-efficient energy solutions, in our efforts to realize customer value, leading to the happiness of humankind.



There is increasing concern over economic and environmental costs that are inevitably accompanied by traditional energy production technologies, going beyond national boundaries to become a new international order. Fuel cells are the only solution, in order to achieve sustainable growth where we can grow with local communities and co-exist with the natural environment, because it is a flexible distributed energy source that can complement intermittency and volatility in addition to the expansion of renewable energy.

We generate a set of distinctive value – “substitution value” that eliminates the use of water, costs associated with power transmission, energy loss, and blackout risks; “improvement value” that improves air quality and reduces greenhouse gas emissions and community health costs; and “new value” that fosters technology development and industry.

## KRW 159,442

Social value generated when producing 1 MW of electricity using a fuel cell system

ELIMINATE Substitution Value KRW 35,969			IMPROVE Improvement Value KRW 11,628			CREATE New Value KRW 111,845		
Zero water consumption	Zero investment in and losses in power transmission and distribution	Zero blackout	Improvement to air pollution	Reduction of greenhouse gas	Reduction of community health costs	Removal of fine dust	Heat production	Development of the fuel cell industry
1,820	33,800	349	7,585	4,043	87,535	278	54,484	57,082

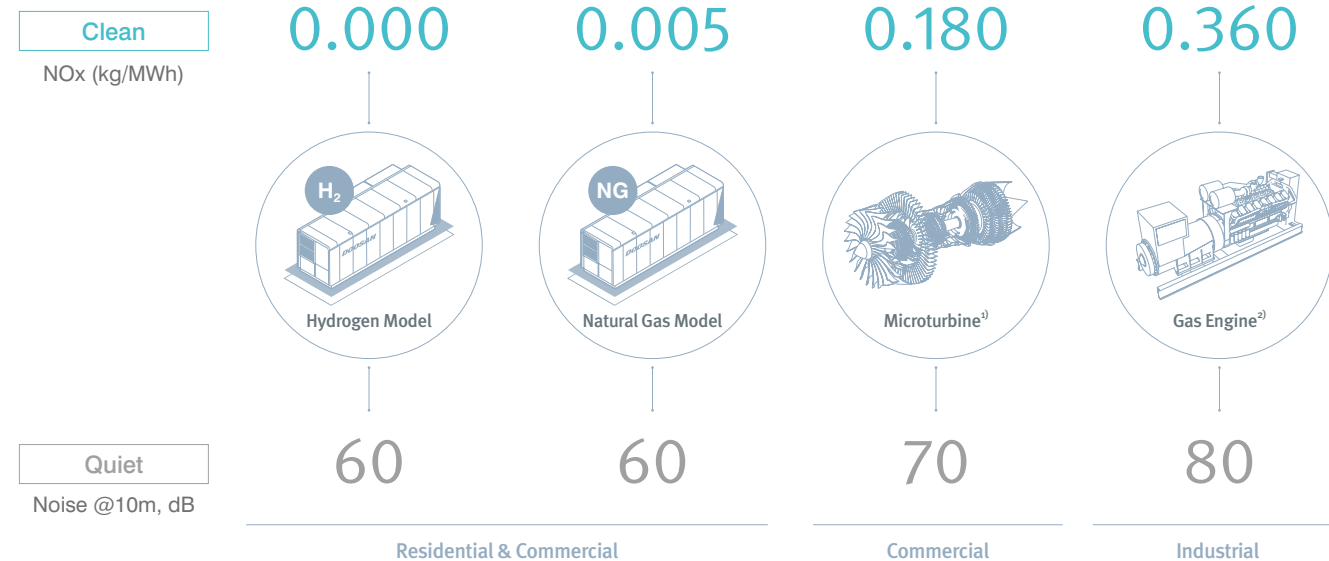
\* Source: 2019 Korea Management Association Consultants





Our fuel cell system boasts its advanced eco-friendly energy conversion technology in reducing exhaust gas emissions and noise to levels far lower than those associated with conventional power generation. We are also taking the lead in the shift toward the hydrogen society by offering a hydrogen-based solution to zero-emissions power generation.

Fuel cell system is a pollution-free power generation method that does not emit NOx since energy conversion takes place through an electrochemical reaction. It also maintains a low noise level that enables it to be installed in residential areas.



<sup>1)</sup> 333 kW (Source: DOE)  
<sup>2)</sup> 633 kW (Source: DOE)



Fuel cell system does not require high pressure and combustion reaction during the fuel cell stack's internal power generation process, making it a safe technology that has no risk of an explosion or fire. Through design standards that exceed international standards as well as inspection and certification, we have achieved the highest level of safety that has been proven by commercial operation over decades.

We preemptively respond to accidental fuel leaks by adding three-tier safety measures, and provide safe and clean energy in strict compliance with domestic and international safety standards.

# Zero

Fuel cell technology converts fuels into electricity through the combustion free electrochemical reaction, reducing the risk of fire

Fuels are supplied and processed at normal pressure and there is no high pressure storage, removing the risk of explosion

# 3 Steps

STEP 1  
Gas leakage is fundamentally blocked

STEP 2  
Gas concentration is monitored in real time

STEP 3  
Town gas is shut off and an automatic fuel cell stoppage system is activated in case of gas leakage

# 100%

**Meet safety standards in Korea**  
Process Management Safety (PSM) Inspection by the Korea Electrical Safety Corporation and the Korea Occupational Safety and Health Agency

**Meet safety standards in the U.S. and Canada**  
American National Standards Institute (ANSI), Canadian Standards Association (CSA), Institute of Electrical and Electronics Engineers (IEEE), International Standards Organization (ISO)

**Receive environmental certification of the U.S.**  
California Air Resources Board (CARB)

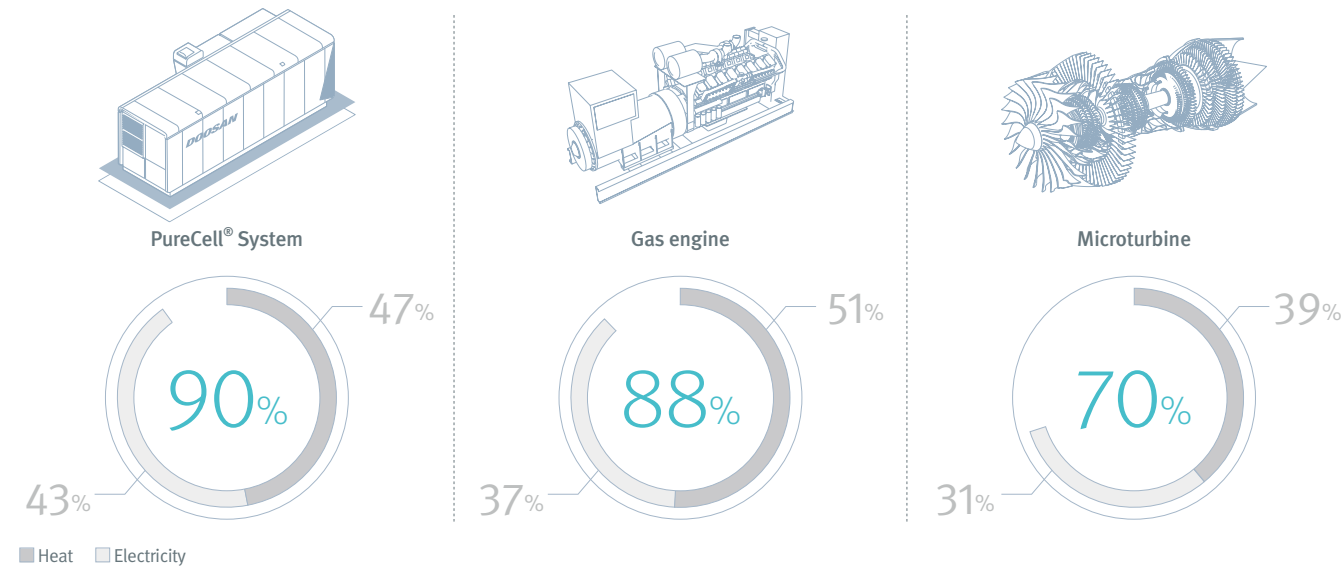


We offer additional customer value compared to previous distributed energy production facilities by realizing the industry's top-level efficiency through our unique, creative process and thermal design. In particular, our fuel cell systems help minimize initial investment costs as they can be installed in a dual layer that requires a smaller space.

We have realized the only commercialized technology that can produce electricity and heat by using hydrogen only, without any auxiliary fuel. It also boasts exceptionally high efficiency compared to previous generators even when natural gas is used.

### High energy efficiency

Highly efficient, combined heat and power generator, producing heat and electricity at the same time



Fuel cell system is an optimal distributed energy facility for making up for the shortcomings of renewable energy since it can deliver quick responsiveness and the highest level of capacity factor among existing power generation facilities. In particular, we guarantee stable performance of the facility up to its end of life by offering remote monitoring and maintenance services that leverage our operation data which was accumulated over decades.

We maintain safety and performance excellence by monitoring all our fuel cell systems across the globe 24/7 in our monitoring rooms located in Korea and the U.S. We also create customer value by offering preemptive maintenance services.

### Reliable energy production under all circumstances

Outstanding capacity factor, quick responsiveness, and durability that allows rated output 365 days a year

### Unique grid resilience

Even in such crisis situations as an external blackout

Capacity factor



95%

Responsive speed (In case of 440 kW of rated output)



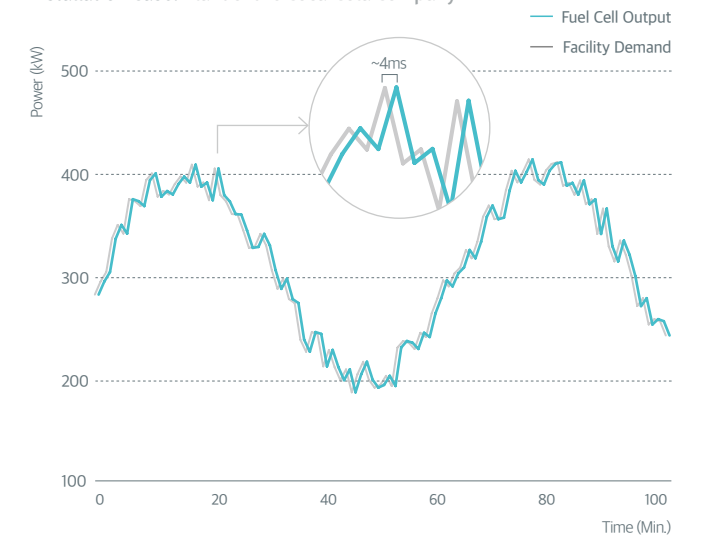
10-20 kW/Sec

Durability that ensures rated output 365 days a year



24/7

Installation Case: Plant of the Coca-Cola Company

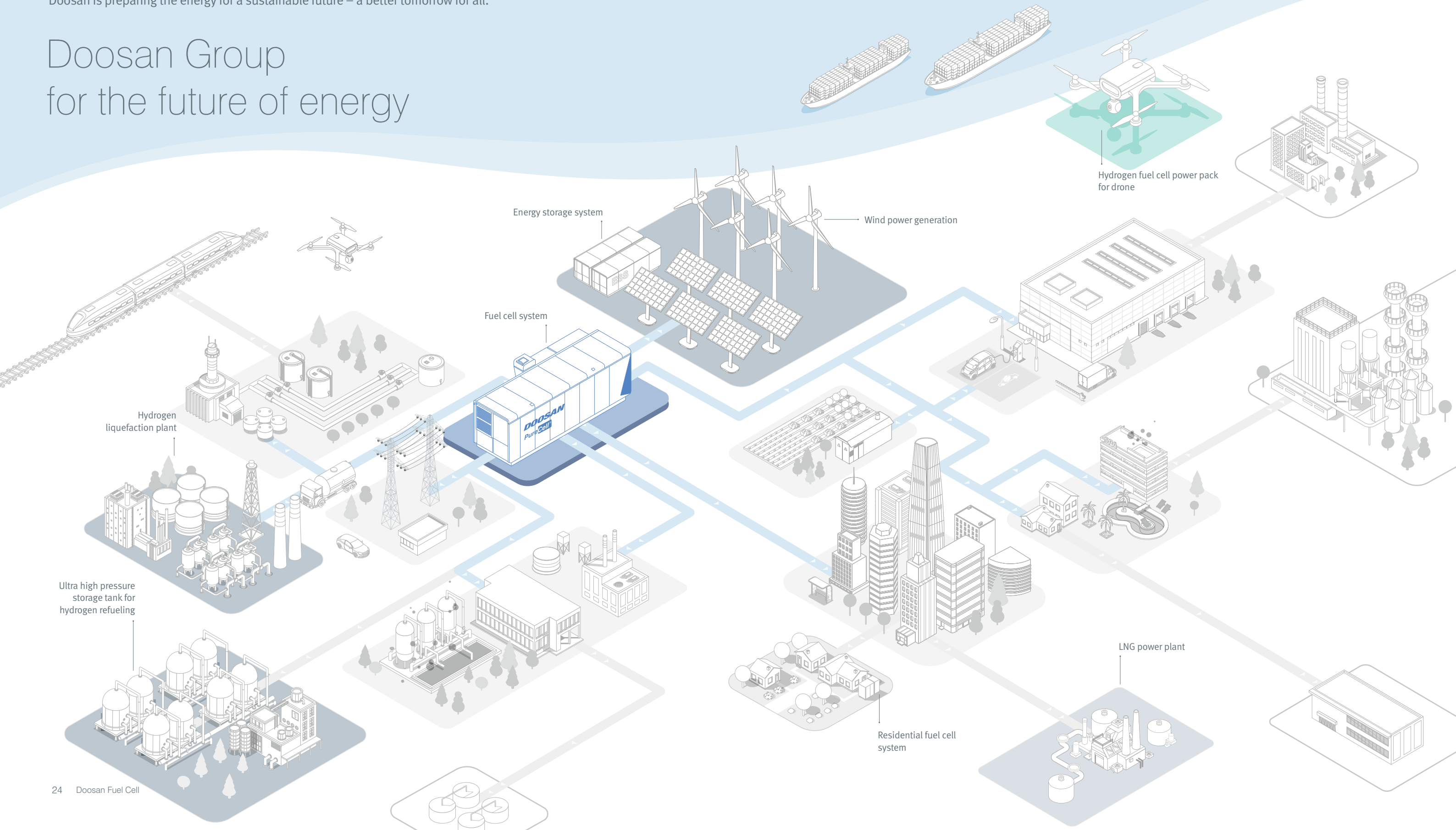




Doosan Group is preparing for the future across the globe to improve the lives of all people. With a 124 year-long history behind, Doosan is shaping its future as a global company. In particular, drawing on its experience and expertise in thermal, nuclear, water, and wind, as well as other energy fields, Doosan is building new growth momentum. Doosan is preparing the energy for a sustainable future – a better tomorrow for all.

- Doosan Fuel Cell
- Doosan Heavy Industries & Construction
- Doosan Mobility Innovation
- Doosan Corporation Fuel Cell Power

# Doosan Group for the future of energy







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## **Location**

### **Headquarters**

100, Seogam-ro 7-gil, Iksan-si,  
Jeollabuk-do

### **Seoul Office**

17F, Doosan Tower, 275,  
Jangchungdan-ro, Jung-gu, Seoul

### **R&D Center**

Suite 310, Gwanggyo Central Biz Tower,  
260, Changnyong-daero, Yeongtong-gu,  
Suwon-si, Gyeonggi-do

[www.doosanfuelcell.com](http://www.doosanfuelcell.com)

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