Outline of the Mirai

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The Mirai is a fuel cell vehicle (FCV) which uses hydrogen as energy to generate electricity and power the vehicle.

■ Fuel cell system

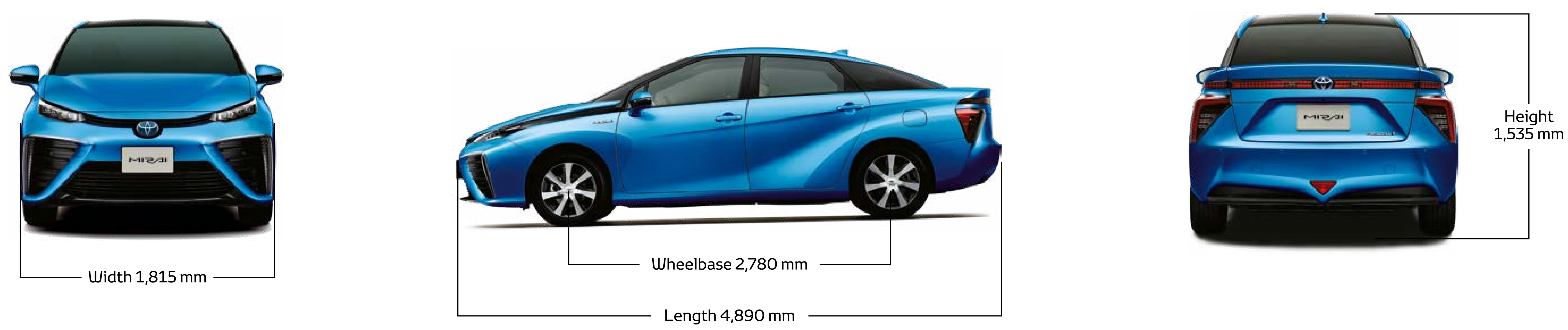
The hydrogen that powers the Mirai, hydrogen, can be produced from various types of primary sources, making it a promising alternative to current energy sources. The Toyota Fuel Cell System (TFCS) combines proprietary fuel cell technology that includes the Toyota FC Stack and high-pressure hydrogen tanks with the hybrid technology. The TFCS has high energy efficiency compared with conventional internal combustion engines, along with superior environmental performance highlighted by zero emissions of CO_2 and other pollutants during vehicle operation. The hydrogen tanks can be refuelled in approximately three minutes [*1], and with an ample cruising range, the system promises convenience on par with gasoline engine vehicles.

■ The Mirai's value

The Mirai offers the kind of exceptional value drivers would expect from a next-generation car: distinctive exterior design, excellent acceleration performance and unmatched quietness thanks to motor propulsion at all speeds, in addition to enhanced driving pleasure due to a low center of gravity bringing greater handling stability.

[*1] Toyota measurement under SAEJ2601 standards (ambient temperature: 20 °C; hydrogen tank pressure when fueled: 10 MPa). Fueling time varies with hydrogen fueling pressure and ambient temperature.

Key Specifications



Driving performance

Vehicle	Cruising range	Approx. 550 km Estimated, according to NEDC Cycle
	Maximum speed	178 km/h
Fuel cell stack	Volume power density	3.1 kW/L (world top level [*2])
	Maximum output	114 kW (155 DIN hp)
High-pressure hydrogen tank	Number of tanks	2
	Nominal working pressure	70 MPa (700 bar)
	Tank storage density [*3]	5.7 wt% (world top level [*2])
Motor	Maximum output	113 kW (154 DIN hp)
	Maximum torque	335 Nm

[*2] November 2014, Toyota data
[*3] Hydrogen storage mass per tank weight

Dimensions / seating capacity

Length		4,890 mm
Width		1,815 mm
Height		1,535 mm
Curb weight		1,850 kg
Wheelbase		2,780 mm
Track (front / rear)		1,535 mm / 1,545 mm
Minimum ground clearance		130 mm
Interior dimensions	Length	2,040 mm
	Width	1,465 mm
	Height	1,185 mm
Seating capacity		4

Main components of the Mirai

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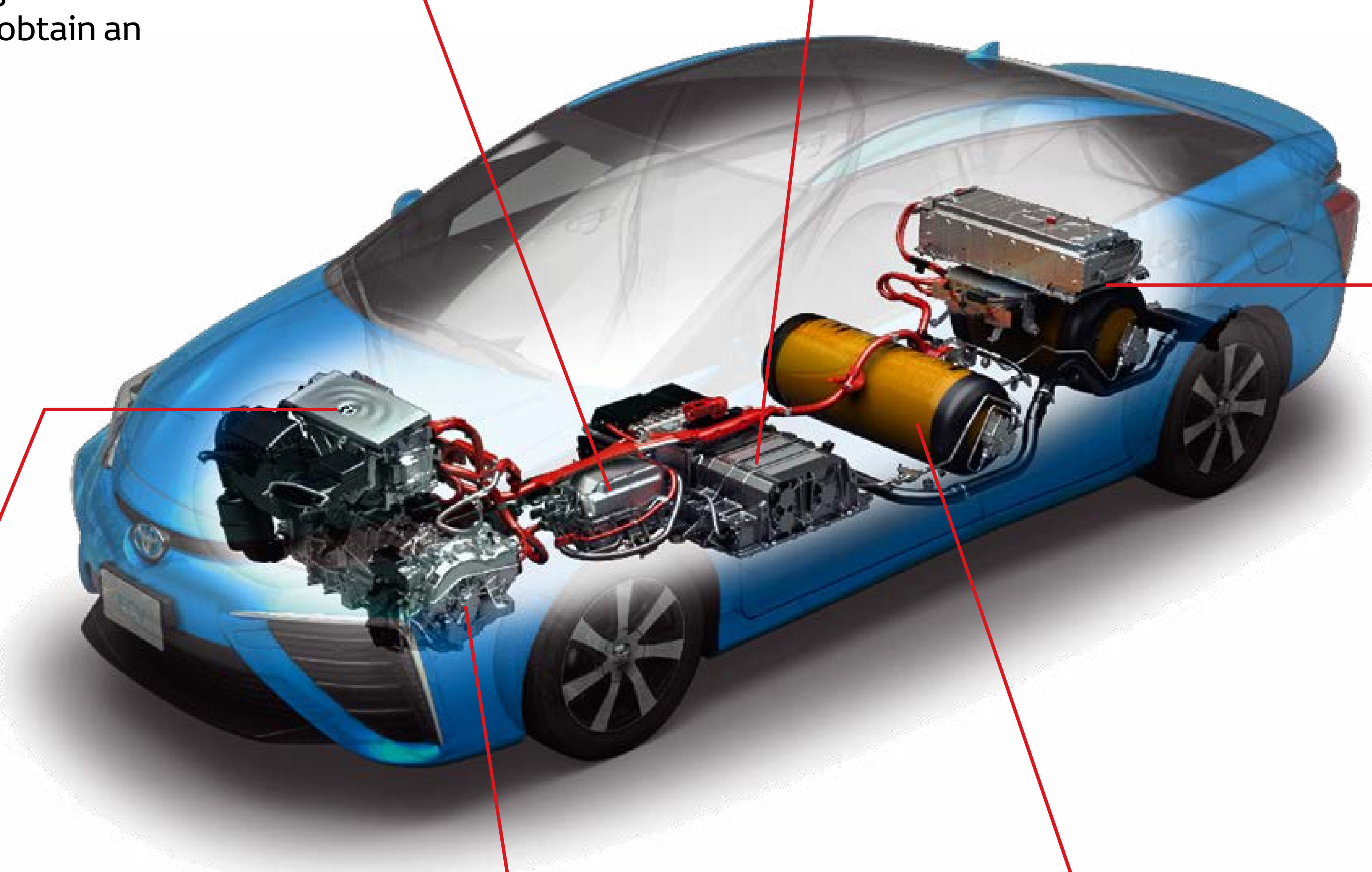
Main Components

Fuel cell boost converter

A compact, high-efficiency, high-capacity converter newly developed to boost fuel cell stack voltage to 650 V. A boost converter is used to obtain an output with a higher voltage than the input.

Fuel cell stack

Toyota's first mass-production fuel cell, featuring a compact size and world top level output density.
Volume power density: 3.1 kW/L
Maximum output: 114 kW (155 DIN hp)



Battery

A nickel-metal hydride battery which stores energy recovered from deceleration and assists fuel cell stack output during acceleration.

Power control unit

A mechanism to optimally control both fuel cell stack output under various operational conditions and drive battery charging and discharging.

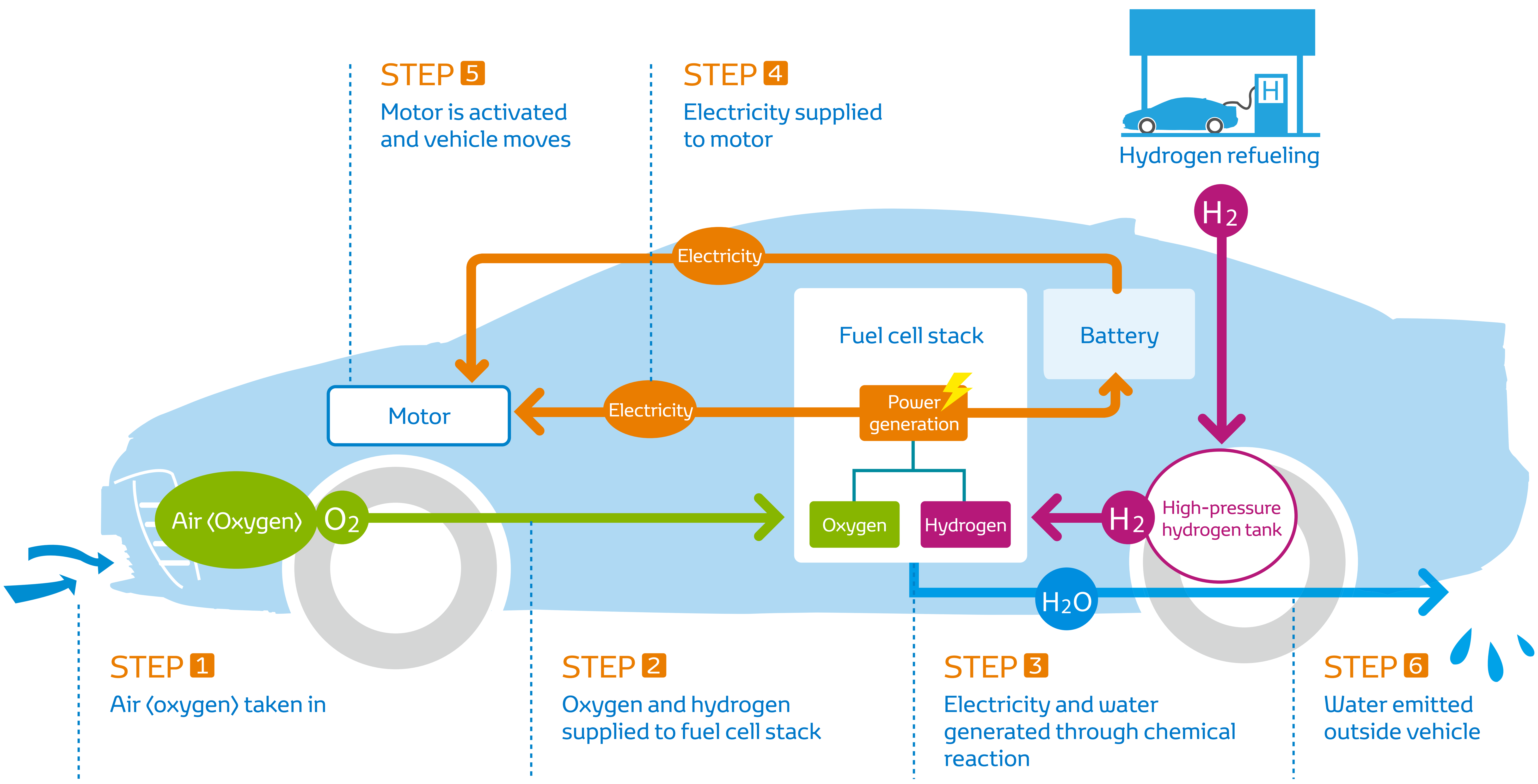
Motor

Motor driven by electricity generated by fuel cell stack and supplied by battery.
Maximum output: 113 kW (154 DIN hp)
Maximum torque: 335 N·m

High-pressure hydrogen tank

Tank storing hydrogen as fuel. The nominal working pressure is a high pressure level of 70 MPa (700 bar). The compact, lightweight tanks feature world's top level tank storage density.
Tank storage density: 5.7 wt%

Operating principals



Driving performance of the Mirai

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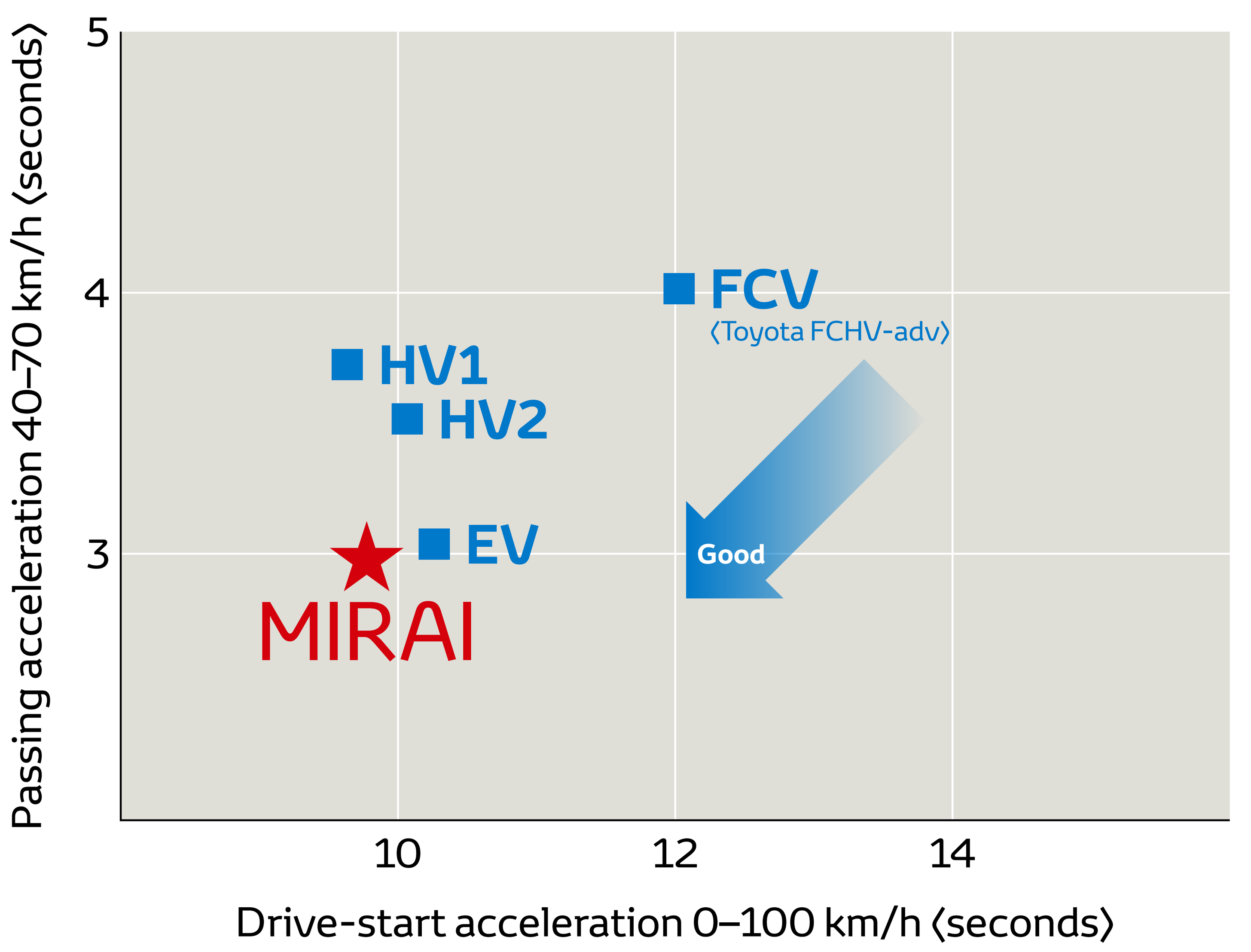
The Mirai offers far more than superior environmental performance. From the start of driving, the Mirai features a smooth and gliding feel, which promises exceptional driving pleasure, combining a high level of cornering performance through winding roads with superior acceleration and quiet operation.

An unprecedented drive feel born from motor-based driving

Superior drive-start acceleration performance

Superior acceleration offers drive-start acceleration 〈from 0 to 100 km/h〉 of 9.6 seconds and passing acceleration of 3.0 seconds 〈from 40 to 70 km/h〉

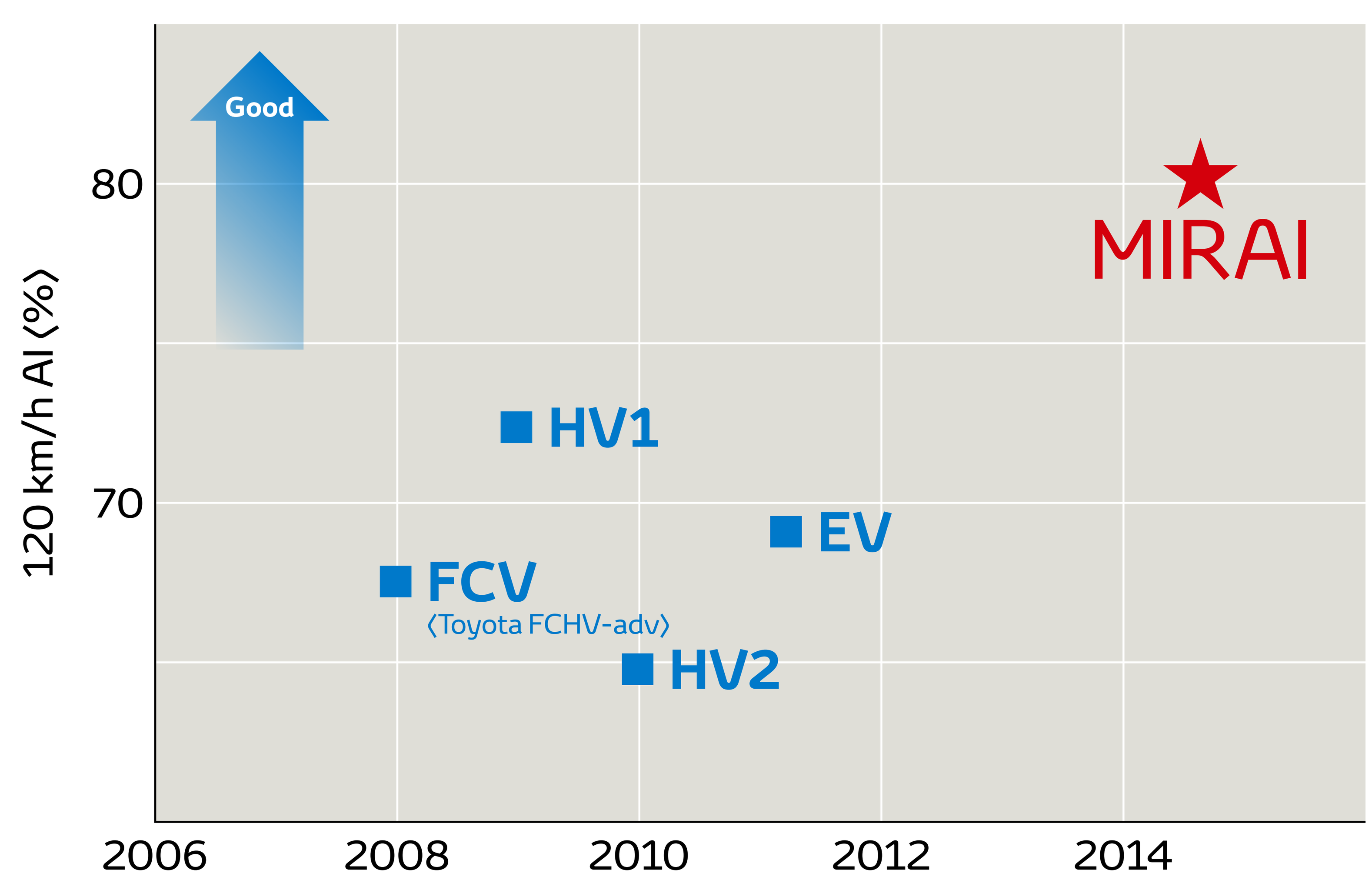
Acceleration performance comparison 〈Toyota measurements〉



Outstanding quiet drive

The highly sound-insulating body and motor propulsion at all speeds deliver outstanding quietness

Conversation articulation comparison 〈Toyota measurements〉



Toyota Fuel Cell System 〈TFCS〉 achieves driving pleasure

High-level cornering performance

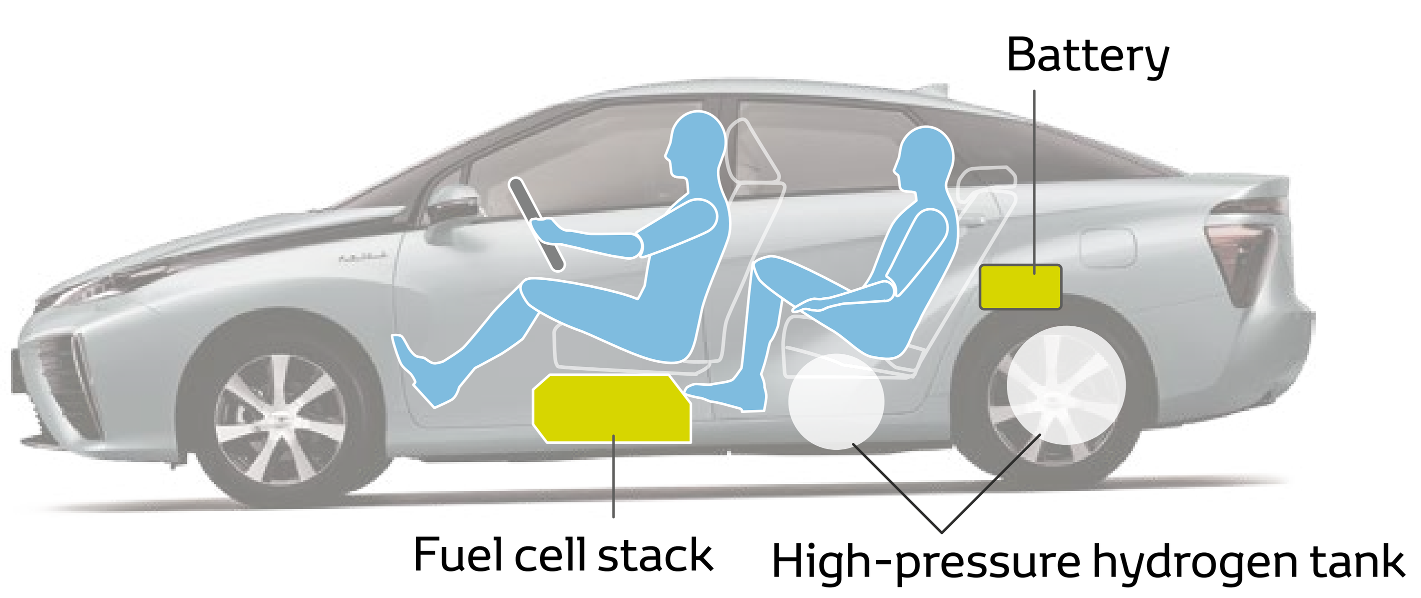
Low center of gravity

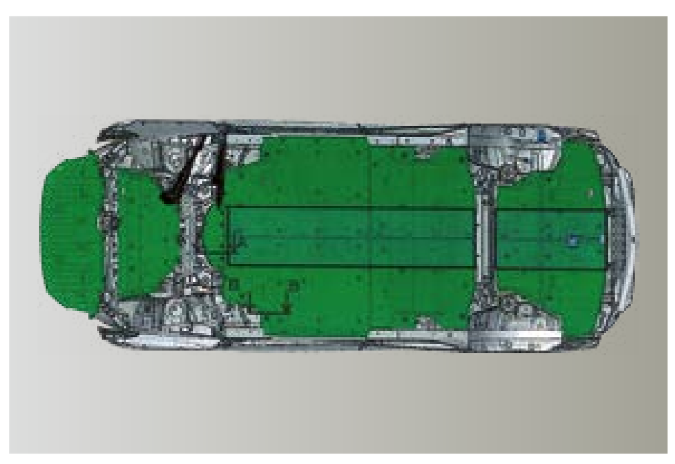
- Fuel cell stack, high-pressure hydrogen tanks and other power unit components are placed under vehicle floor.
- The lower center of gravity raises handling stability and produces a comfortable driving experience by reducing changes in vehicle position.
- The front-rear weight balance is adjusted to produce a midship feel despite the front wheel drive design.

Contributes to superior handling stability and quietness

Aerodynamics

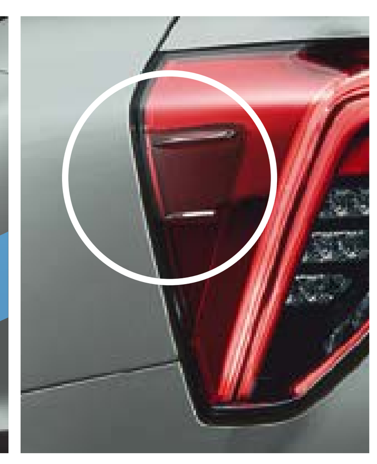
- Since the vehicle does not emit heated gases, the floor can be fully covered. Air resistance is reduced to boost fuel efficiency.
- The design of the clearance lamps contributes to the aerodynamics.
- Aero-stabilizing fins are positioned next to the rear combination lamps. This improves straight-driving stability.





Full underbody covering

Clearance lamps designed to streamline airflow



Aero-stabilizing fins

Power performance of cold start capability

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Issues concerning FCVs cold start capability

Maintaining good power generation from a fuel cell requires water. In environments below the freezing point, however, excess water freezes, impeding the supply of air (oxygen) and hydrogen and causing a decrease in power generation performance.

Improving cold start capability

We made it possible to start the vehicle at –30 °C and to achieve output at levels satisfactory for practical use immediately after starting.

■ Improved power generating performance immediately after starting below the freezing point

- Higher cell flow channel and electrode performance (exclusion of generated water and air (oxygen) diffusion were improved to achieve excellent power generating performance even below the freezing point)
- Establishment of intra-cell water volume control technology (the volume of water is measured and controlled at a volume suitable for power generating performance below the freezing point)

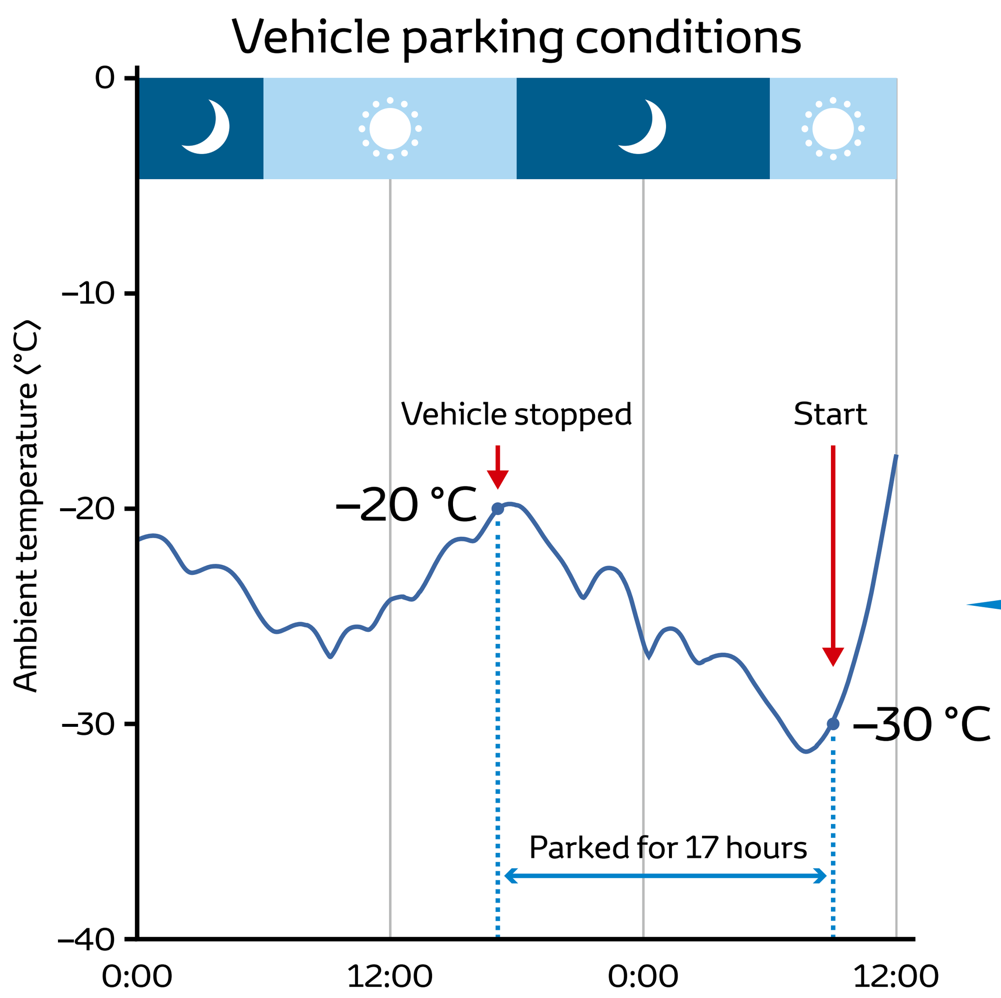
■ Improved warming-up performance

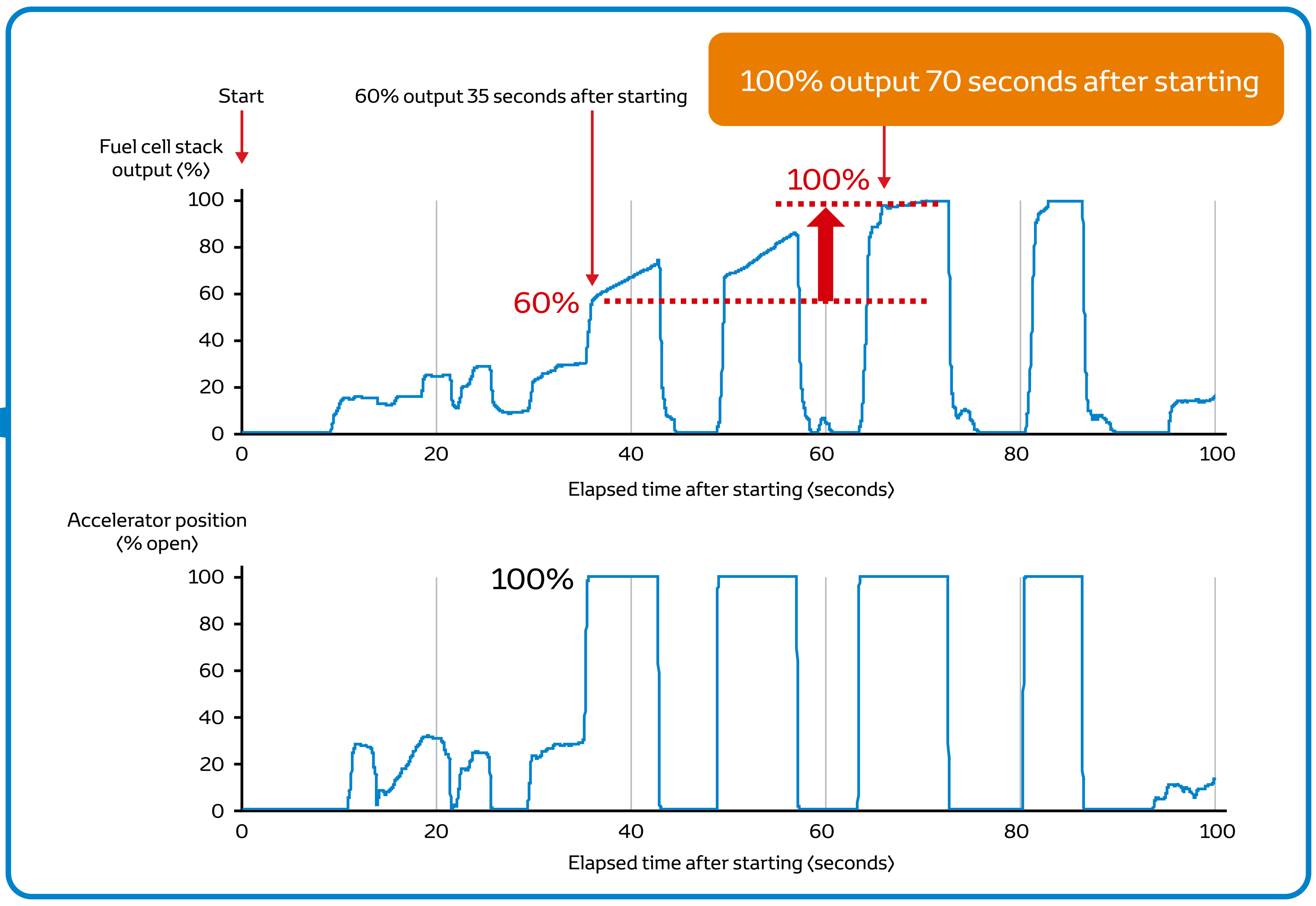
- Lower thermal capacity as a result of higher fuel cell stack output density
- Establishment of fuel cell rapid warm-up control technology (heat generated by the fuel cell is controlled to drastically reduce warm-up time)

Example of evaluation in an extremely cold region

Yellowknife, Canada evaluation (2014)

Evaluation of fuel cell stack output performance immediately after starting after parking the vehicle outdoors overnight (17 hours)



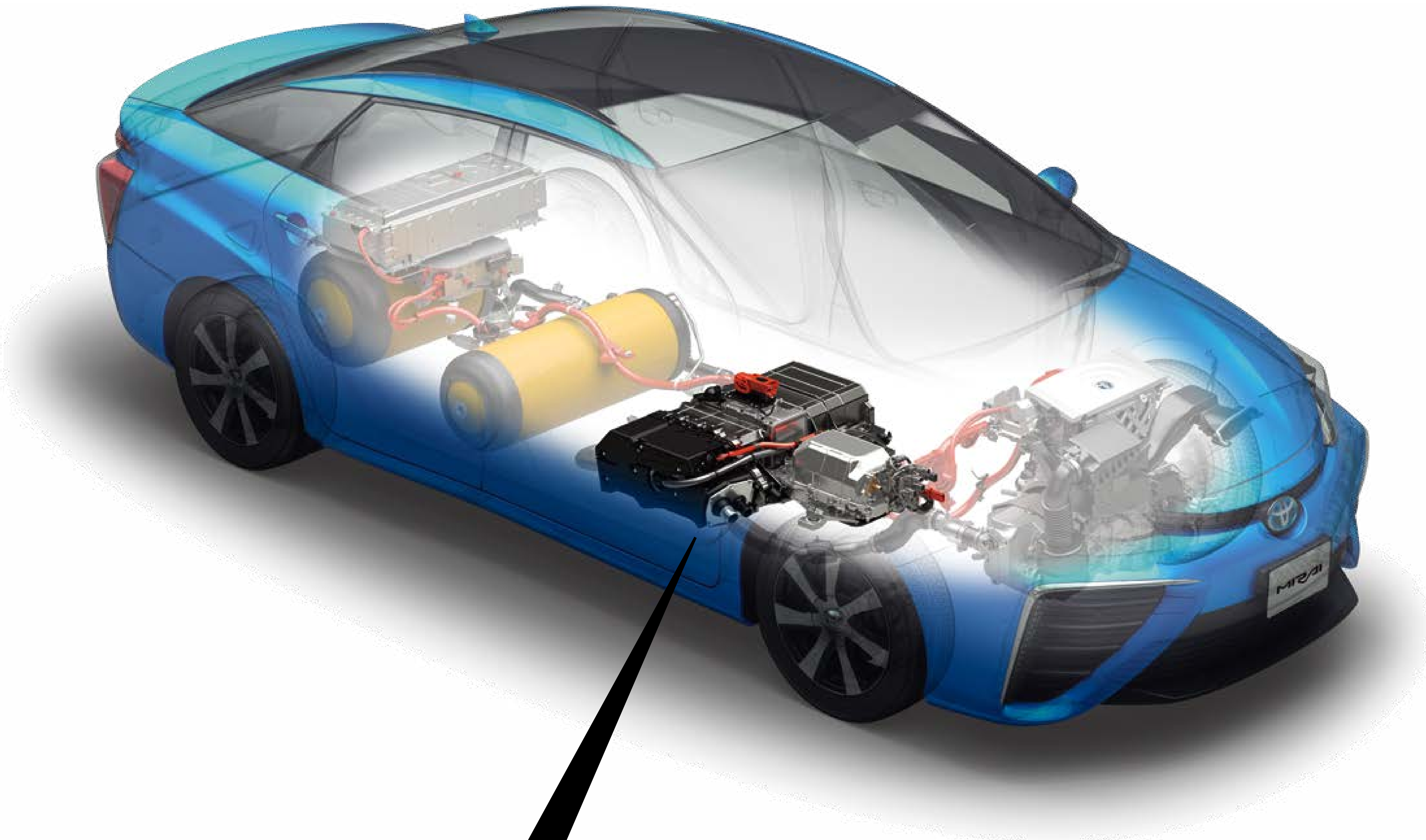


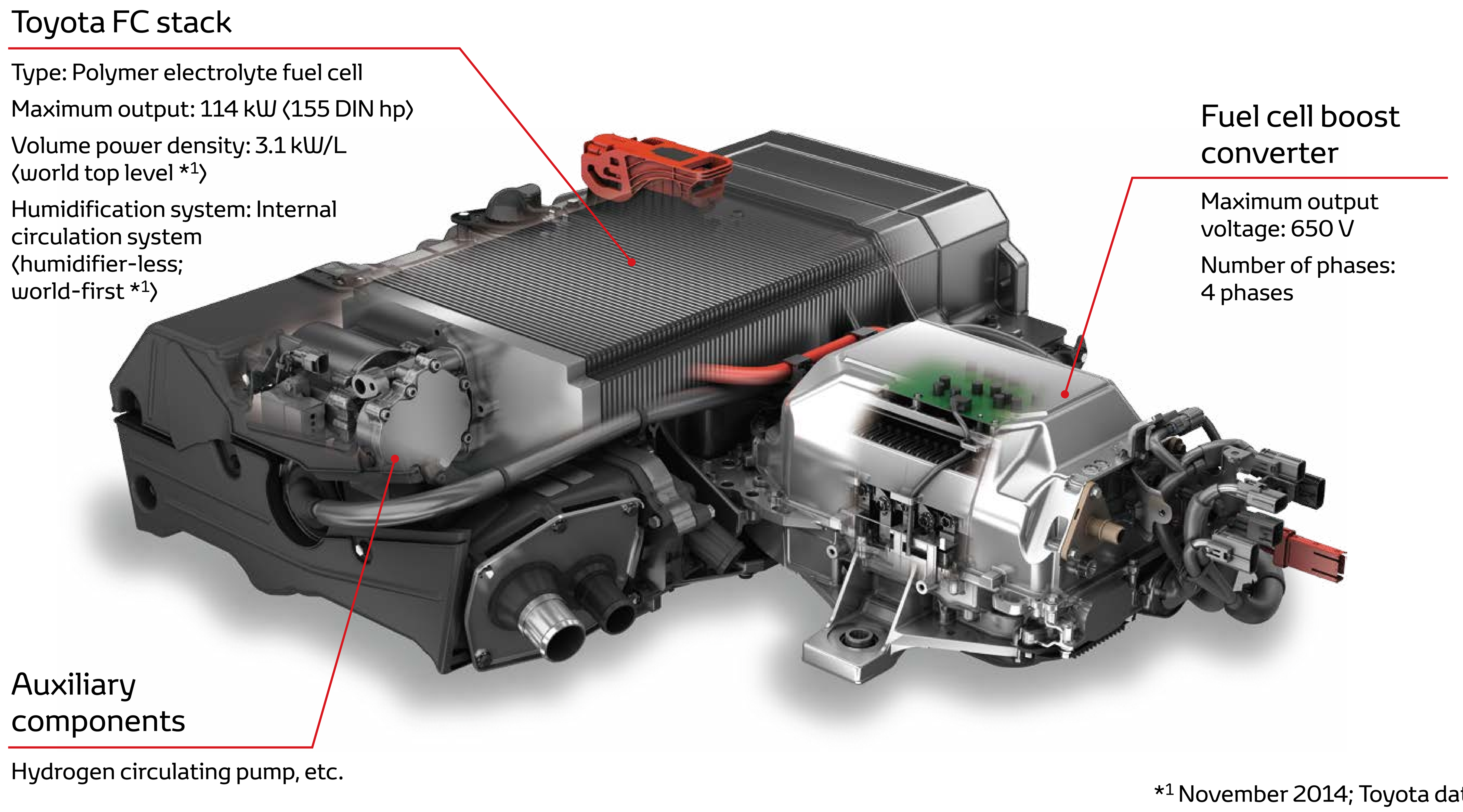
Evaluations were performed in extremely cold regions including Yellowknife, Canada; Rovaniemi, Finland; and Shibetsu, Japan, confirming suitability for these environments.

Fuel cell stack assembly

The fuel cell stack assembly comprises the fuel cell stack, auxiliary components (hydrogen circulating pump, etc.) and fuel cell boost converter. Integrating these components achieves a smaller, lighter, and less expensive fuel cell stack assembly.

Fuel cell stack assembly structure and main specifications



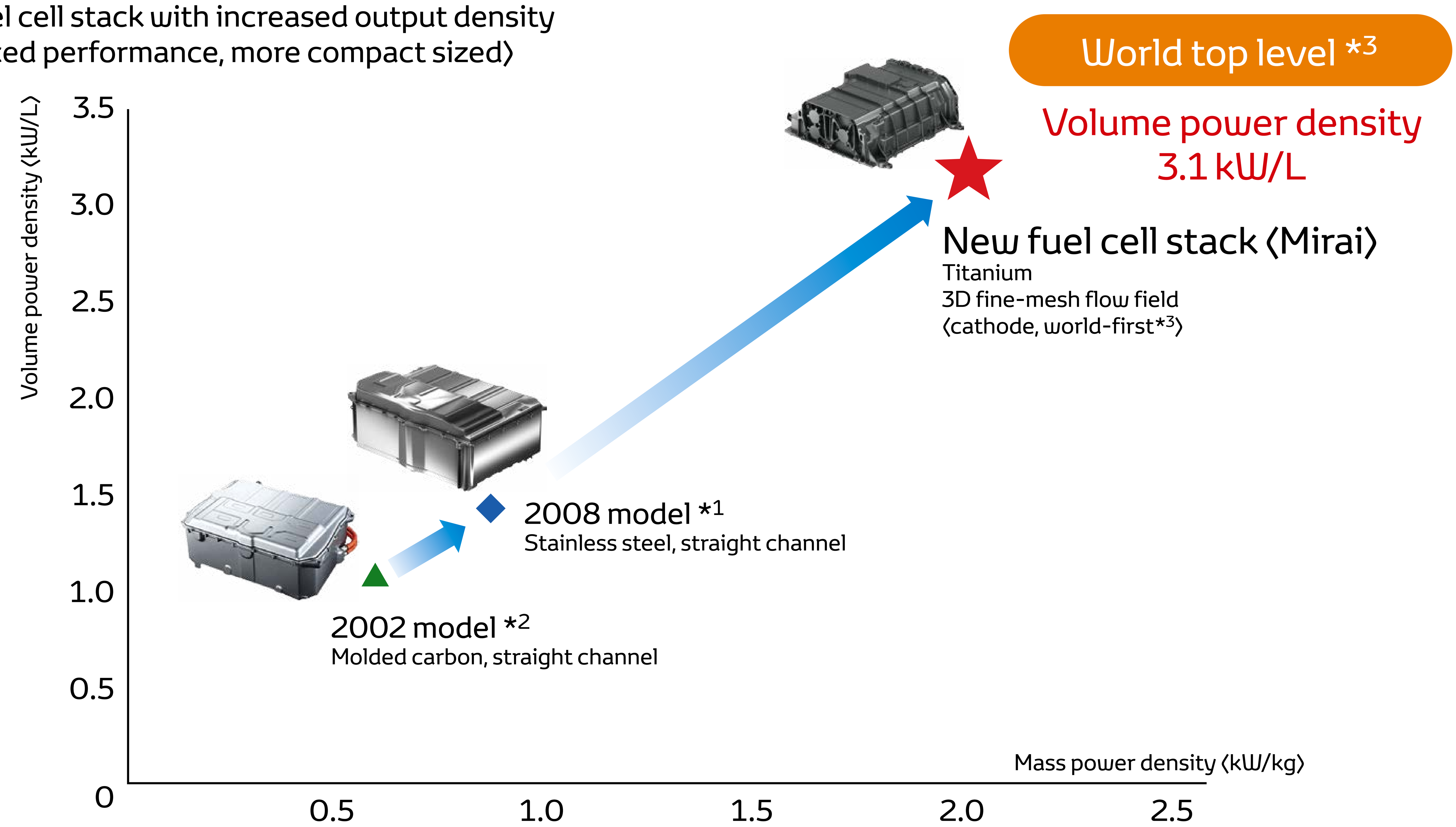


*[1] November 2014; Toyota data

Toyota FC Stack

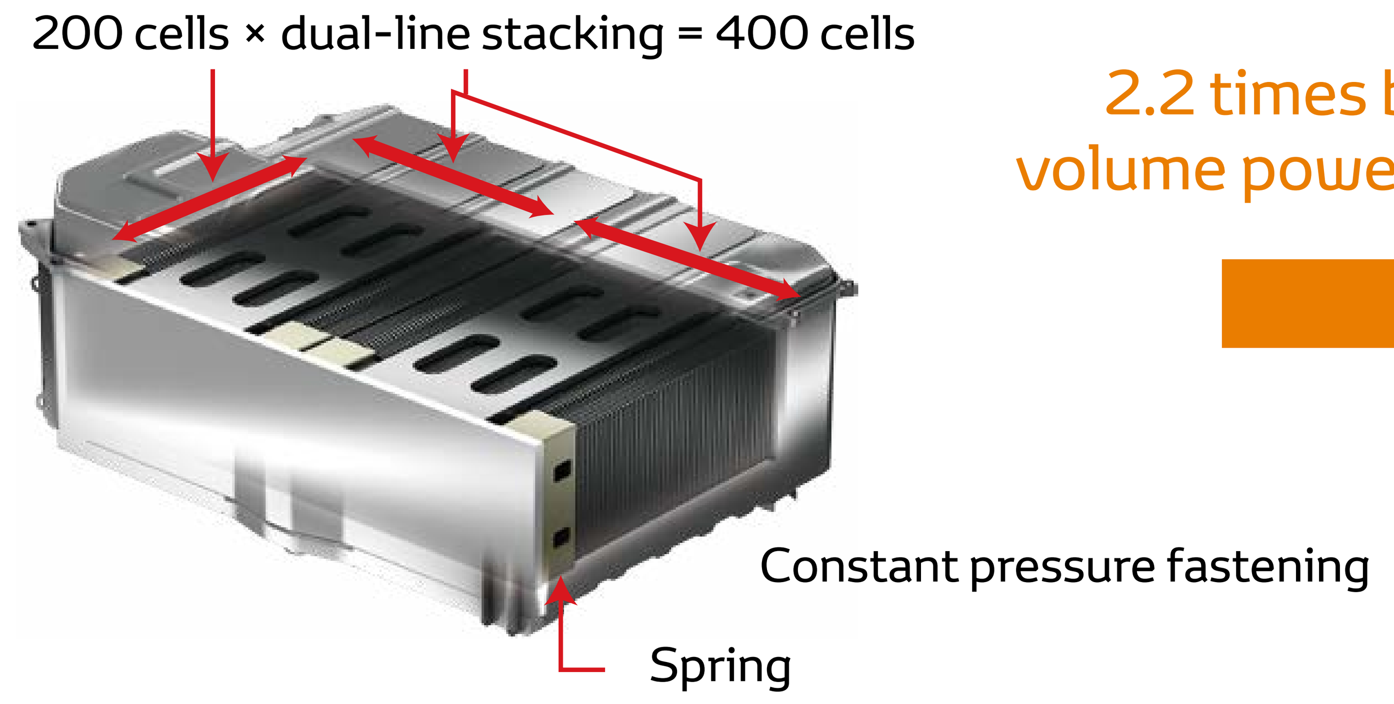
Breakthroughs in fuel cell technology have led to the creation of a smaller, lighter new fuel cell stack with enhanced performance.
The new stack has a volume power density of 3.1 kW/L – among the world top level *3 –, and can now be mounted underneath the floor of a sedan.

New fuel cell stack with increased output density
(enhanced performance, more compact sized)



2008 model *1 fuel cell stack

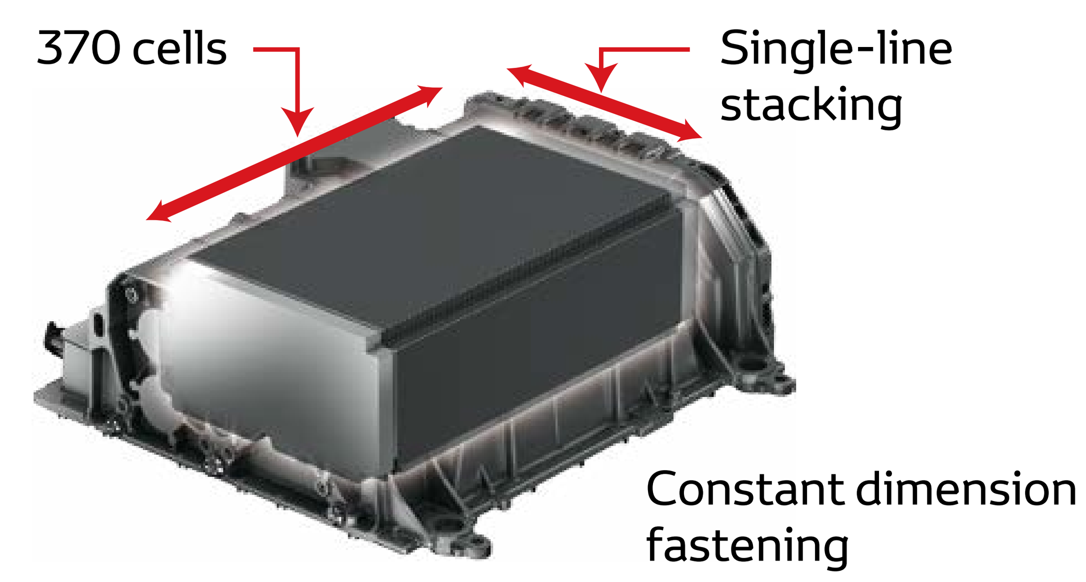
1.4 kW/L
(Maximum output: 90 kW / volume: 64 L; weight: 108 kg)



2.2 times better
volume power density

New fuel cell stack (Mirai)

3.1 kW/L
(Maximum output: 114 kW / volume: 37 L; weight: 56 kg)



		2008 model *1 fuel cell stack	New fuel cell stack (Mirai)
Maximum output		90 kW	114 kW (155 DIN hp)
Volume power density / Mass power density		1.4 kW/L / 0.83 kW/kg	3.1 kW/L (World top level *3) / 2.0 kW/kg
Volume / Weight		64 L / 108 kg	37 L / 56 kg (Cell + fastener)
Cell	Number of cells in one stack	400 cells (dual-line stacking)	370 cells (single-line stacking)
	Thickness	1.68 mm	1.34 mm
	Weight	166 g	102 g
	Flow channel	Straight channel	3D fine-mesh flow field (cathode, world-first *3)
Mounting position		Motor room (SUV)	Under floor (Sedan)

*1 2008 model: Toyota FCHV-adv *2 2002 model: Toyota FCHV *3 November 2014, Toyota data

Cell

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To increase the power generating performance of the cells, it is important to enhance the water exclusion of produced water and promote the diffusion of air (oxygen).
The new cells achieve a high current density by enhancing both the uniformity of generation in cell surfaces and electrode responsiveness with innovative flow channel structures and electrodes.

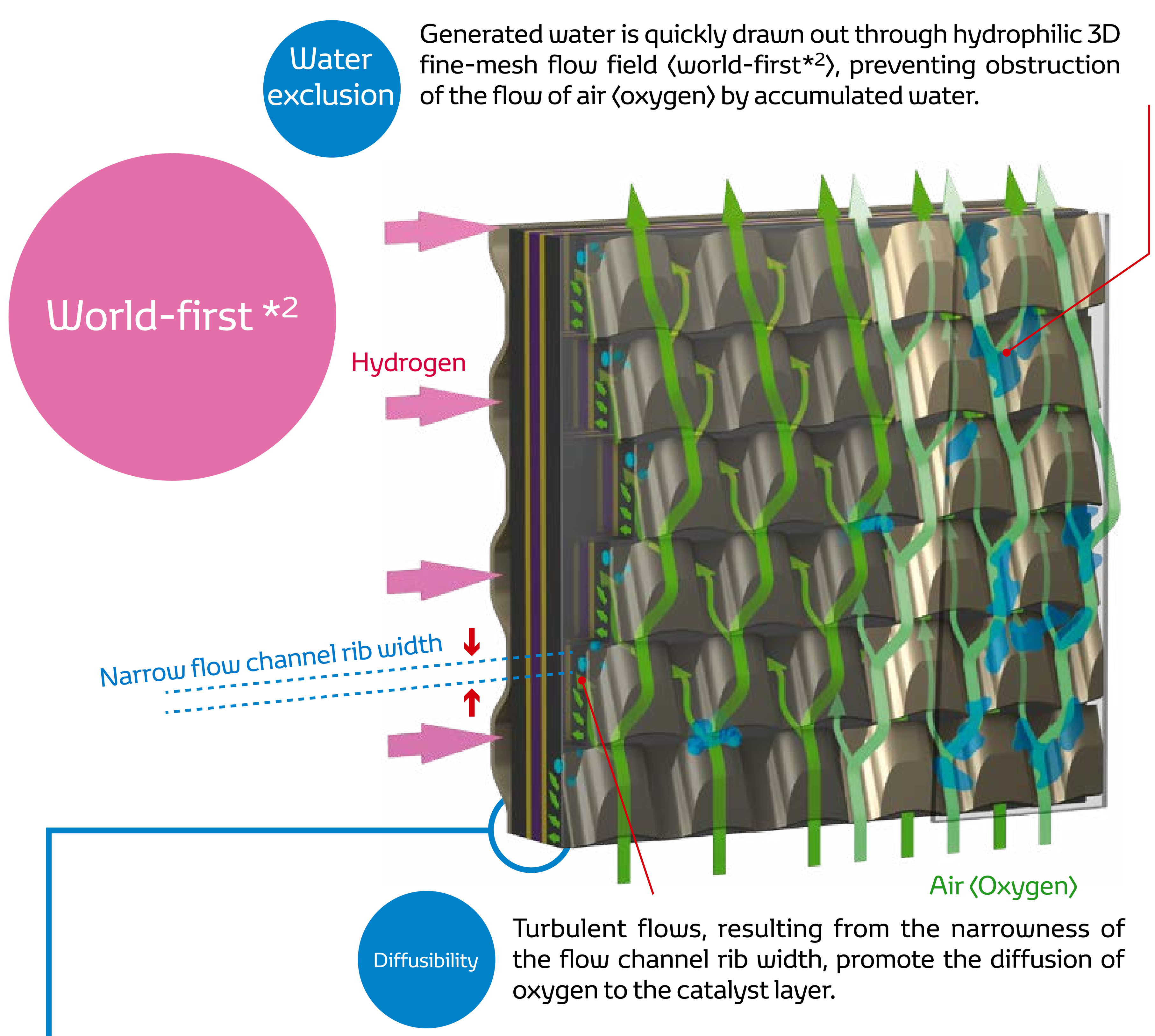
Higher performance of new cells

1 Innovations to cell flow channels (Cathode)

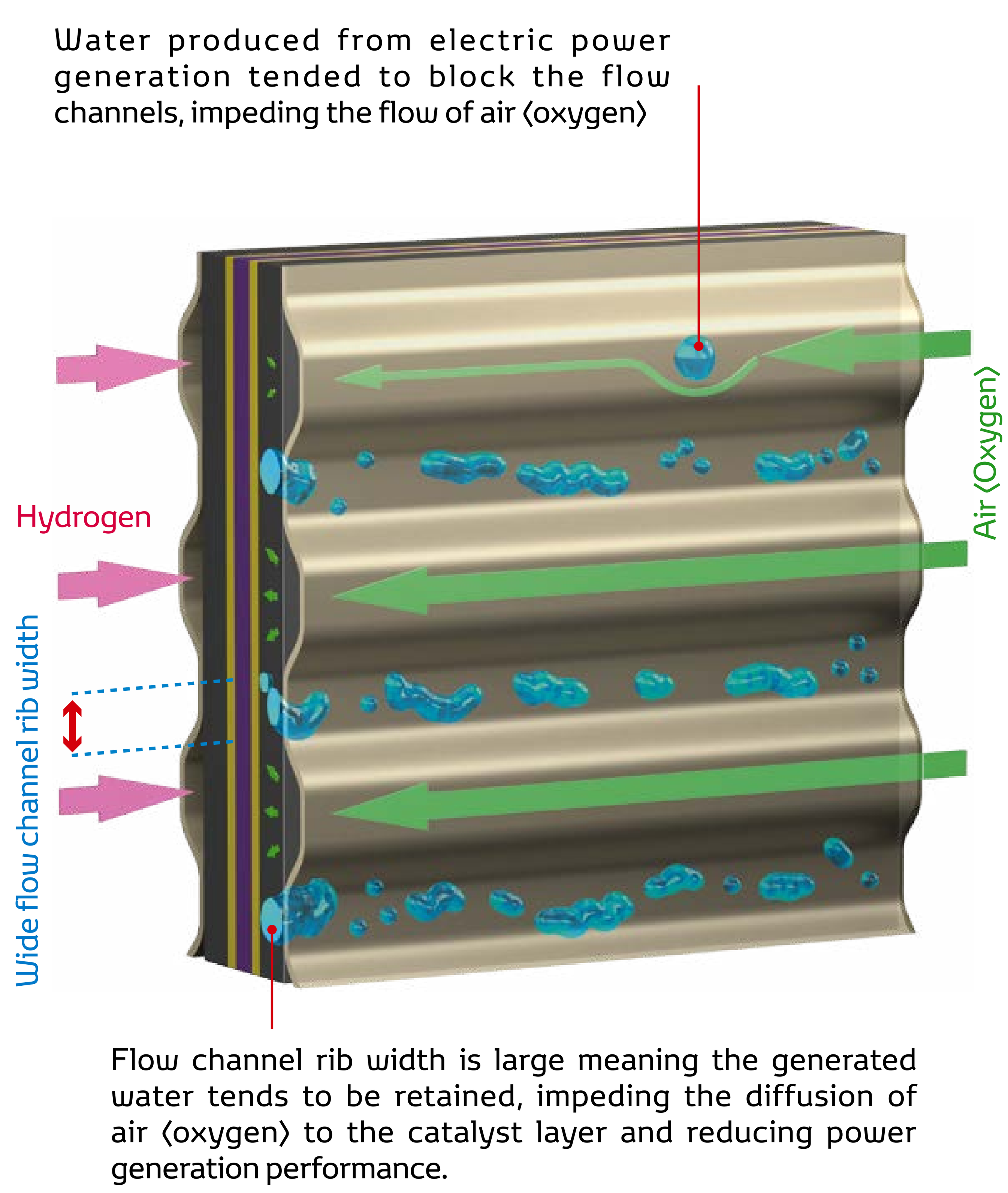
Flow channels: Using 3D fine-mesh flow field (world-first *2) simultaneously improves water exclusion and air (oxygen) diffusion, achieving uniform generation in cell surfaces.

3D fine-mesh flow field: A flow channel with a three-dimensional fine mesh structure

New cell (Mirai)

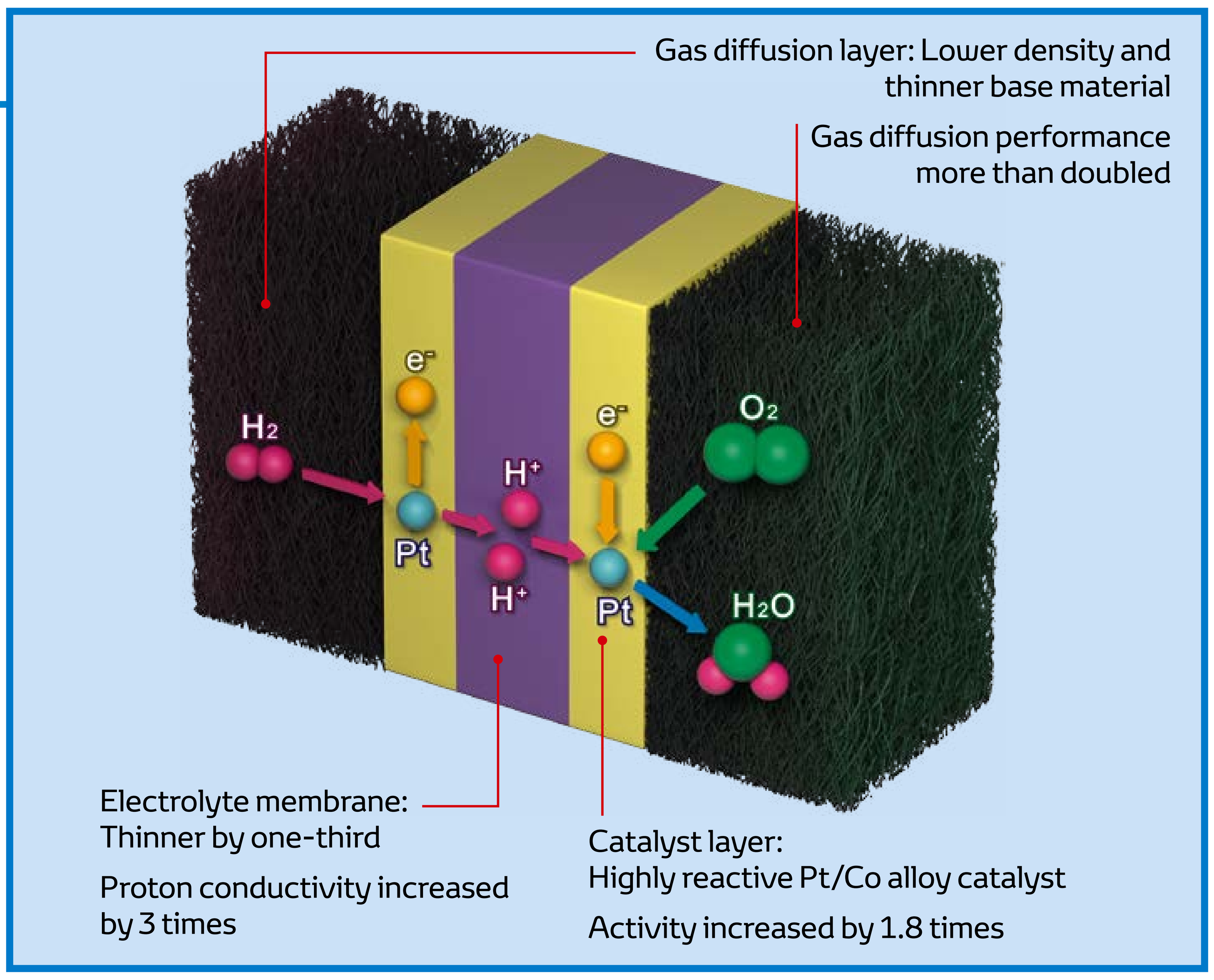


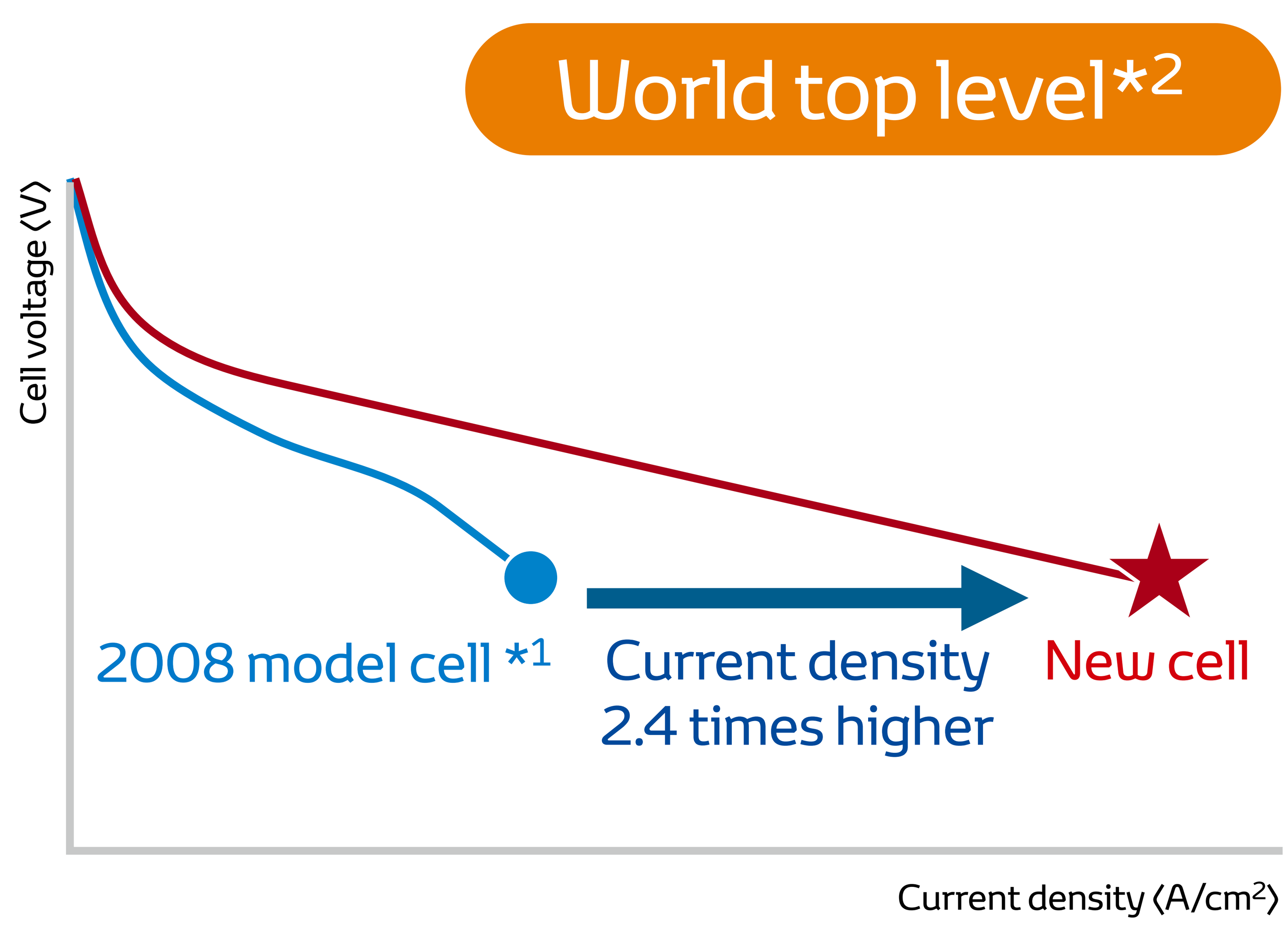
2008 model cell *1



2 Electrode innovations

The electrolyte membrane was made thinner, the diffusion performance of the gas diffusion layer was increased, and the catalyst was hyper-activated to greatly enhance electrode responsiveness.





*1 2008 model: Toyota FCHV-adv *2 November 2014, Toyota data

Internal circulation system – Humidifier-less

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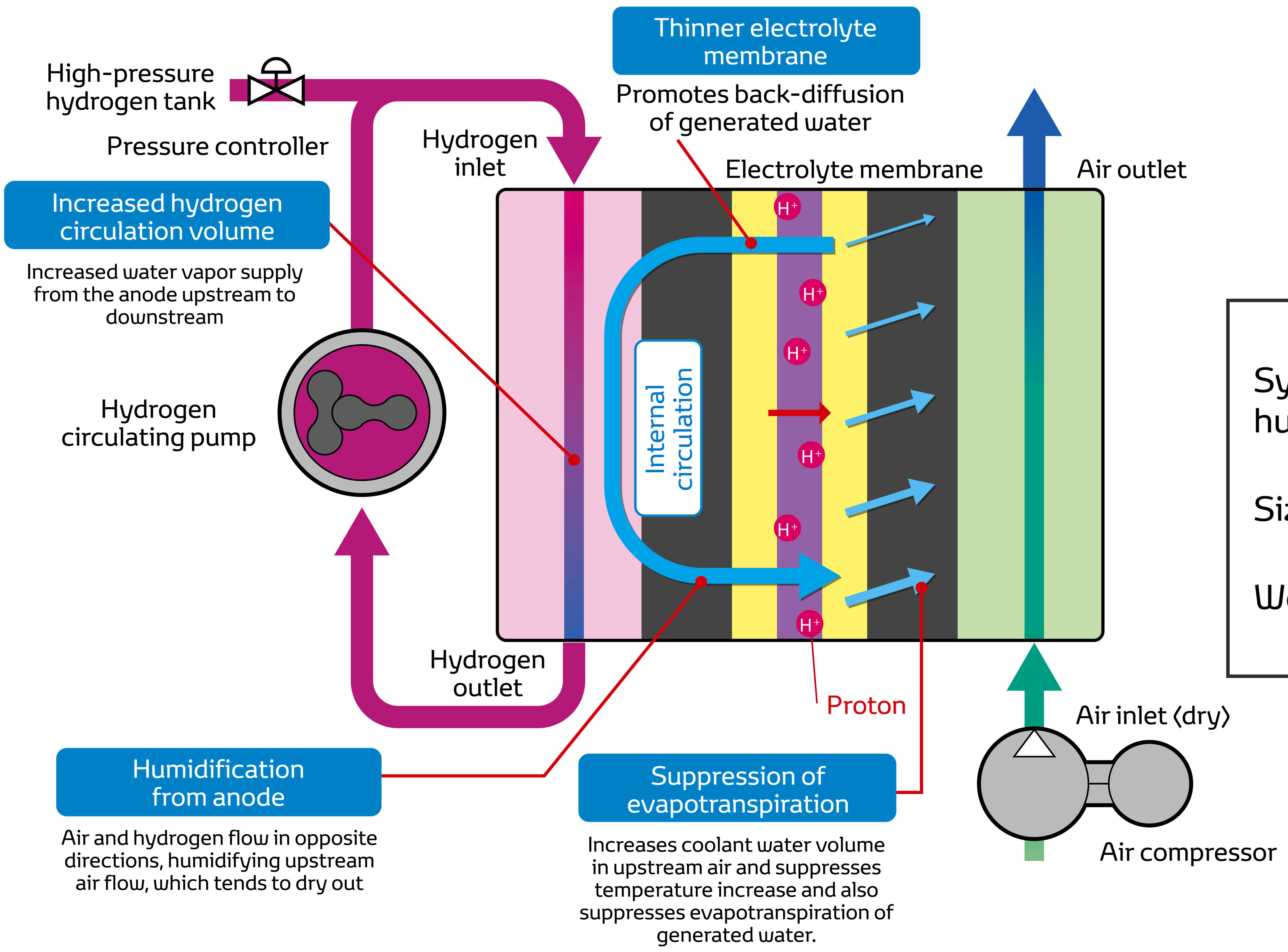
The new fuel cell stack performs self-humidification by circulating water produced from power generation within the cells, eliminating the need for external humidification. This makes it possible to eliminate the humidifier (world-first *1), making the system smaller and lighter.

Internal circulation system – Humidifier-less

The system self-humidifies by circulating water (water vapor) produced from power generation within the cells in order to maintain the proton conductivity performance of the electrolyte membrane.

World-first *1



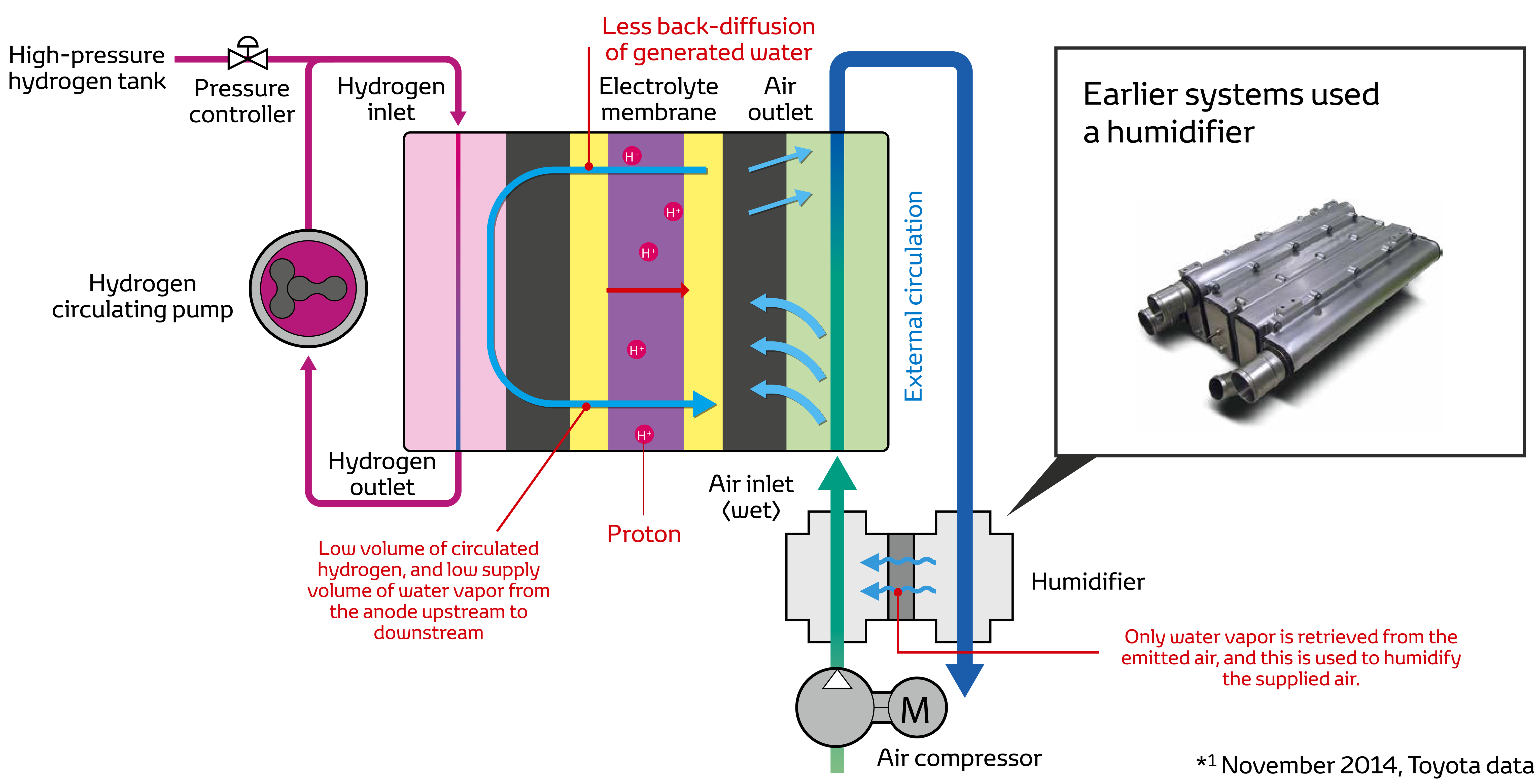
System simplified by eliminating humidifier

Size reduction: −15 L

Weight reduction: −13 kg

External circulating humidifier (previous system)

The system humidifies the supplied air (oxygen) using a humidifier to maintain the proton conductivity of the electrolyte membrane.



*1 November 2014, Toyota data

Fuel cell boost converter

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By developing a high-capacity fuel cell boost converter, it was possible to increase the voltage of the motor, reduce the number of fuel cell stack cells, and reduce the size and weight of the system.

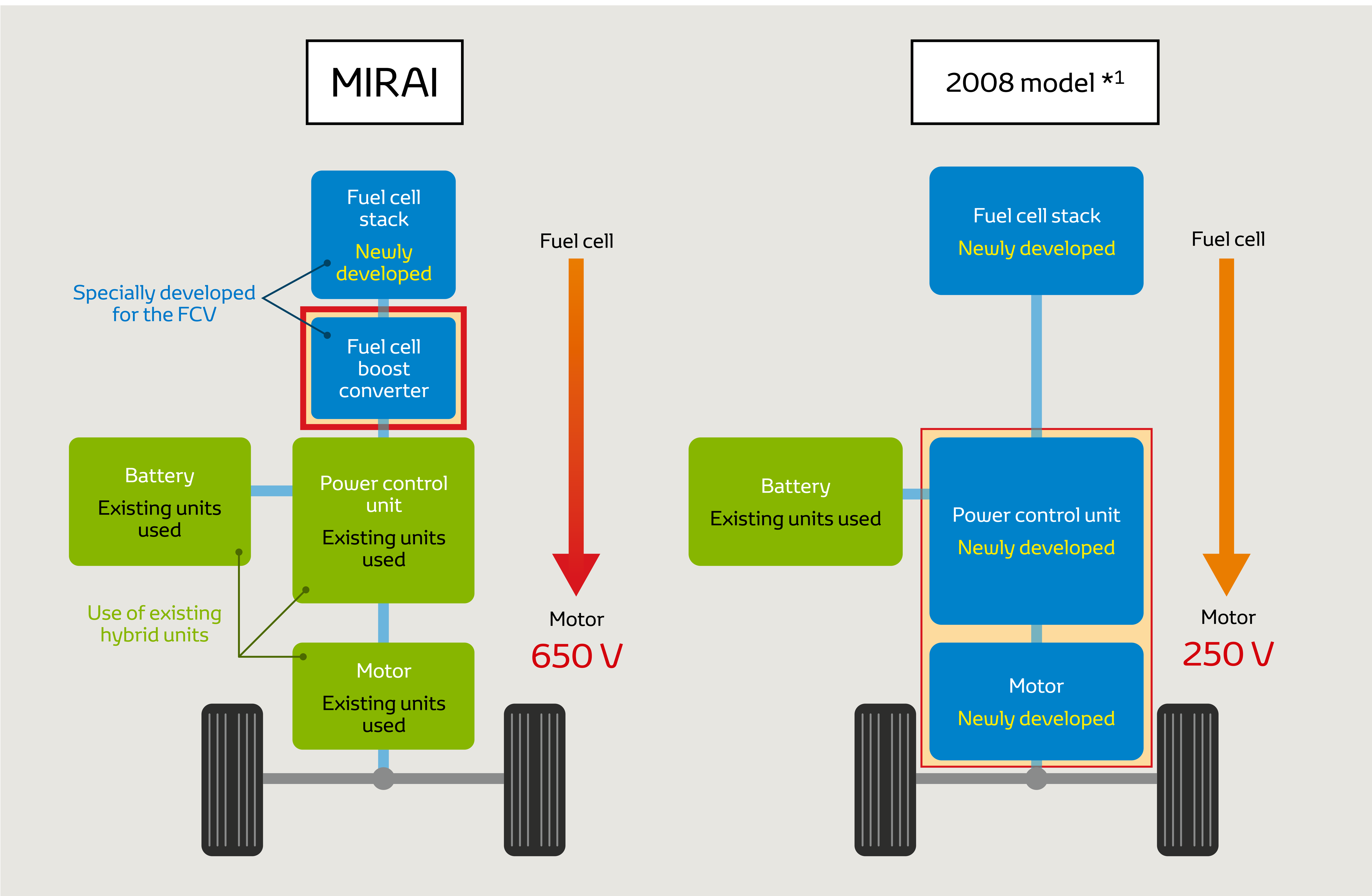
Also, innovations to the voltage-boost control and case structure provide exceptionally quiet operation.

In addition, the new system can be used with existing hybrid units, enhancing reliability and greatly reducing costs.

Main specifications of fuel cell boost converter

Maximum output voltage	650 V
Volume	13 L
Number of phases	4
Cooling method	Water-cooled

Fuel cell boost converter



*1 2008 model: Toyota FCHV-adv

High-pressure hydrogen tank

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In-house development of high-pressure hydrogen tank since 2000

Tank storage density *1

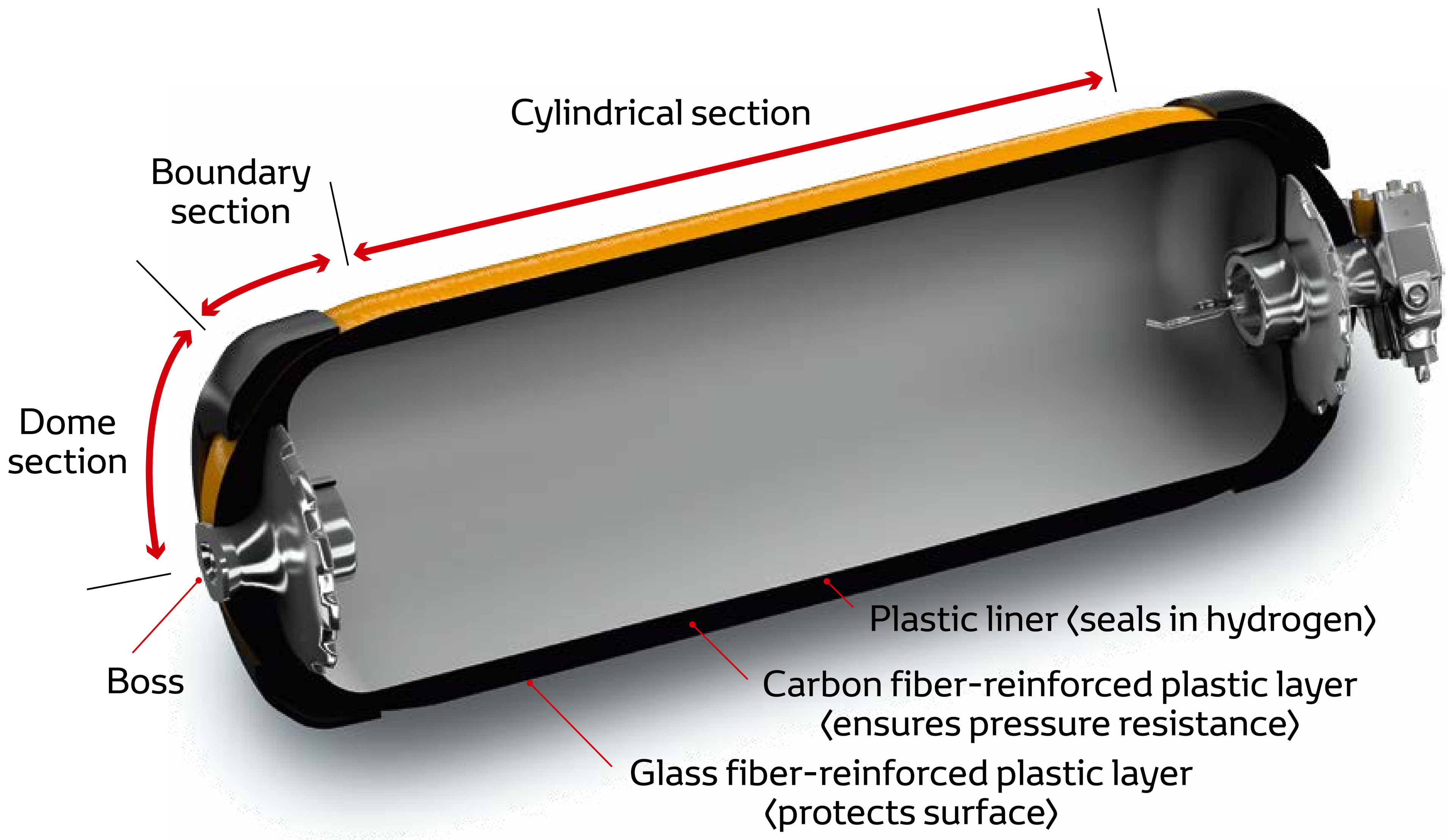
*1 Hydrogen storage mass per tank weight

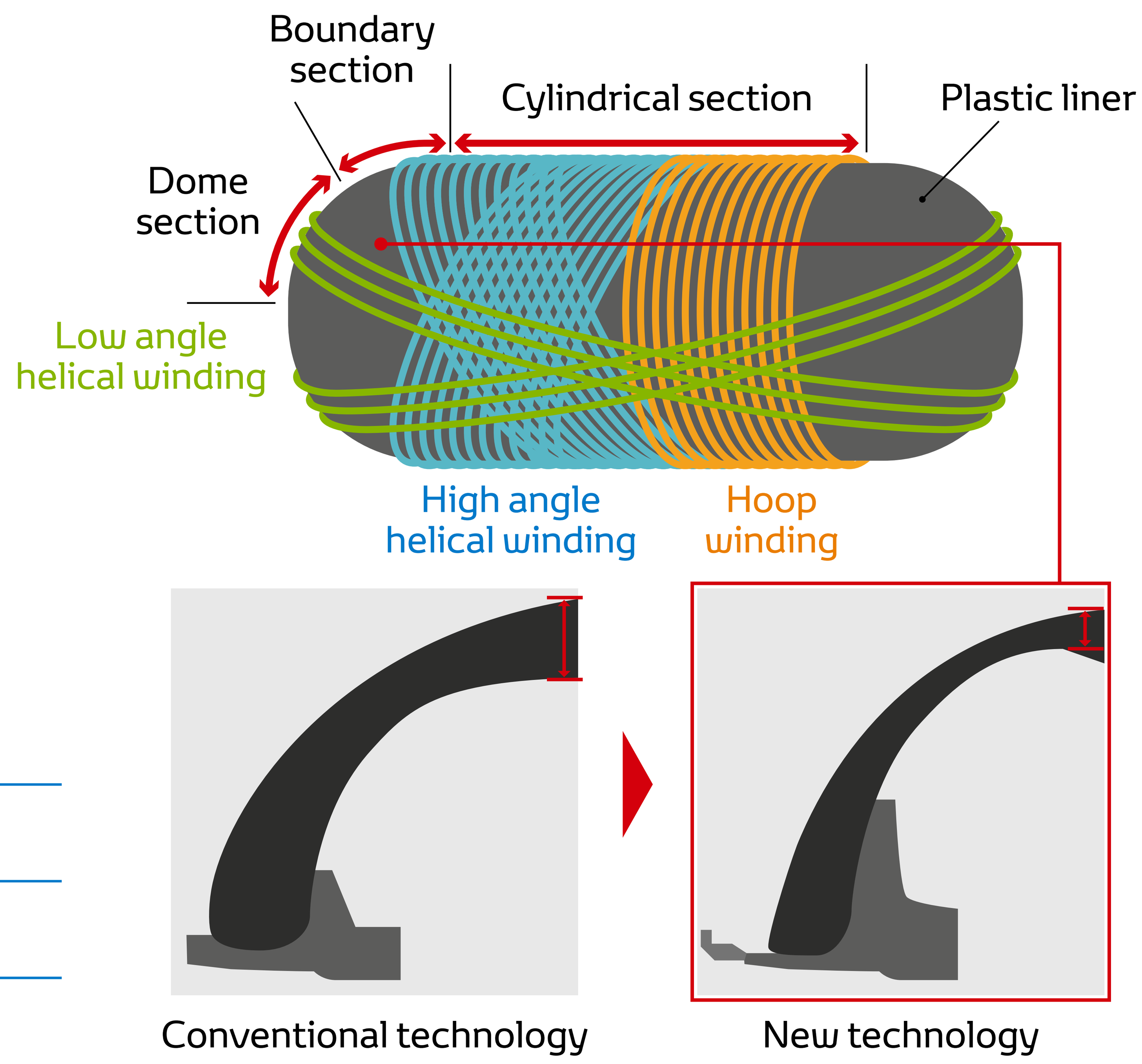
Lighter weight achieved through innovations of carbon fiber reinforced plastic layer structure

Tank storage density of 5.7 wt% achieved, a world top level *2

World top level *2

Innovations to the plastic liner configuration and efficient layering pattern resulted in a reduction of approximately 40% in the amount of carbon fiber used





High-pressure hydrogen tank

Nominal working pressure	70 MPa (700 bar)
Tank storage density	5.7 wt% (world top level *2)
Tank internal volume	122.4 L (front tank: 60.0 L, rear tank: 62.4 L)
Hydrogen storage mass	Approx. 5.0 kg

*2 November 2014, Toyota data

Hydrogen refueling

In response to new fueling standards *3 (the same in Japan, the US, and Europe), fueling time of approximately 3 minutes *4 has been achieved

*3 (Refueling devices) ISO 17268: Gaseous Hydrogen Land Vehicle Refueling Connection Devices
(Refueling methods) SAE J2601: Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles
(Communications fueling) SAE J2799: 70 MPa Compressed Hydrogen Surface Vehicle Fueling Connection Device and Optional Vehicle to Station Communications

*4 Toyota measurement under SAEJ2601 standards (ambient temperature: 20 °C; hydrogen tank pressure when fueled: 10 MPa).
Fueling time varies with hydrogen fueling pressure and ambient temperature.