# WELCOME TO THE
# TOYOTA HYDROGEN EXPERIENCE

Enjoy exciting story on how TOYOTA aims to build the Hydrogen Society for a decarbonised future.

We will show you how our Multi-pathway strategy is translated into everyday use, in this case – how we envision building the Hydrogen Society towards a carbon neutral future.

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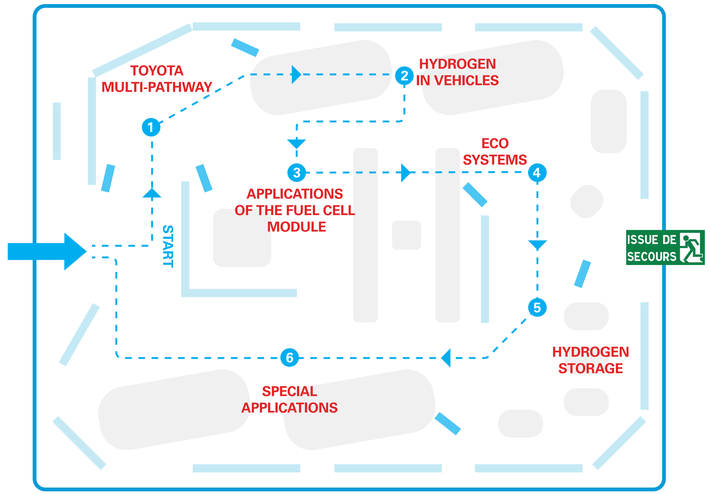
Starting from brief reminder on WHAT IS HYDROGEN, we will guide you through its production and storage, later showing how it can be used in transportation and other applications.

Last but not least, we want to assure you that it can be very exiting fuel for sports car applications.

Please refer to map on the right side to see the exhibition layout. **Blue signs** will guide you through. We advise to follow our story line, in order to get the comprehensive image.

DOWNLOAD PDF GUIDE



# TOYOTA FUEL CELL MODULE
## PROVIDING ELECTRICITY FROM HYDROGEN

### WHAT IS FUEL CELL MODULE & HOW DOES IT WORK?

A Fuel Cell Module is a source of electricity*. Thanks to a chemical reaction between hydrogen and oxygen, the fuel cell module generates electricity, heat and water.

To expand the potential of TOYOTA's Fuel Cell technology from cars to other uses, TOYOTA has created a compact Fuel Cell Module.

* For details on how a Fuel Cell works – see boards in TOYOTA Multi-pathway.

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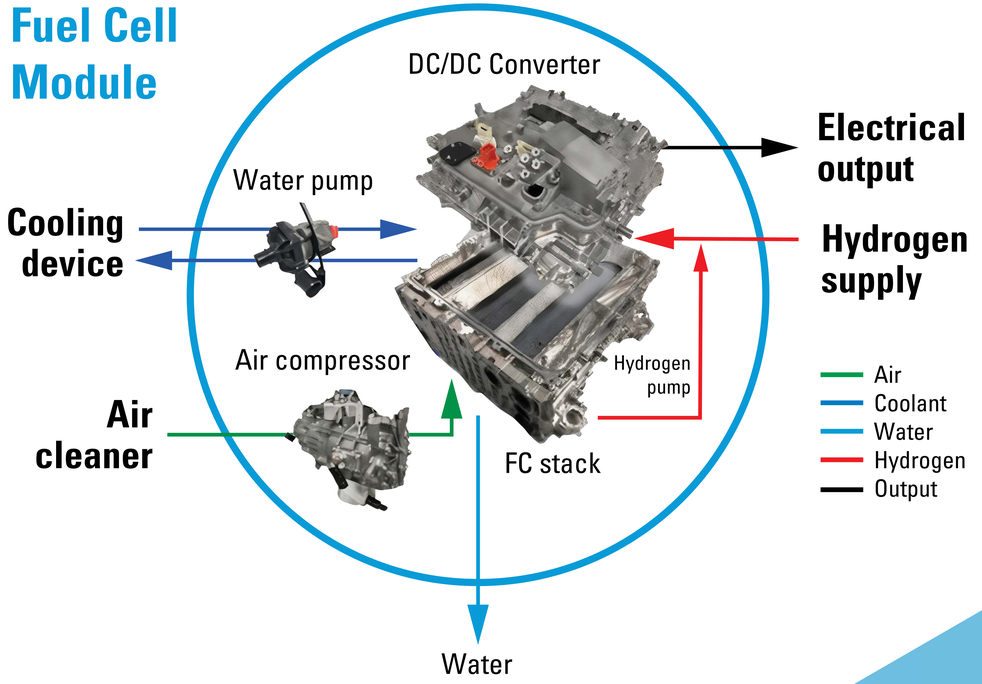
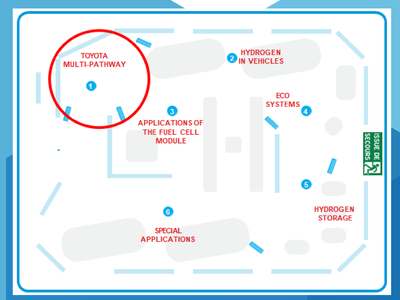
The main components (the Fuel Cell stack and components that handle air supply, hydrogen supply, cooling, and power control) are thus integrated in a compact package which can be easily adapted into a variety of products and applications.

The modules are available in two shapes: a box and a flat, rectangular shape – to allow greater flexibility and easier adaptation into new applications.

CONTACT US

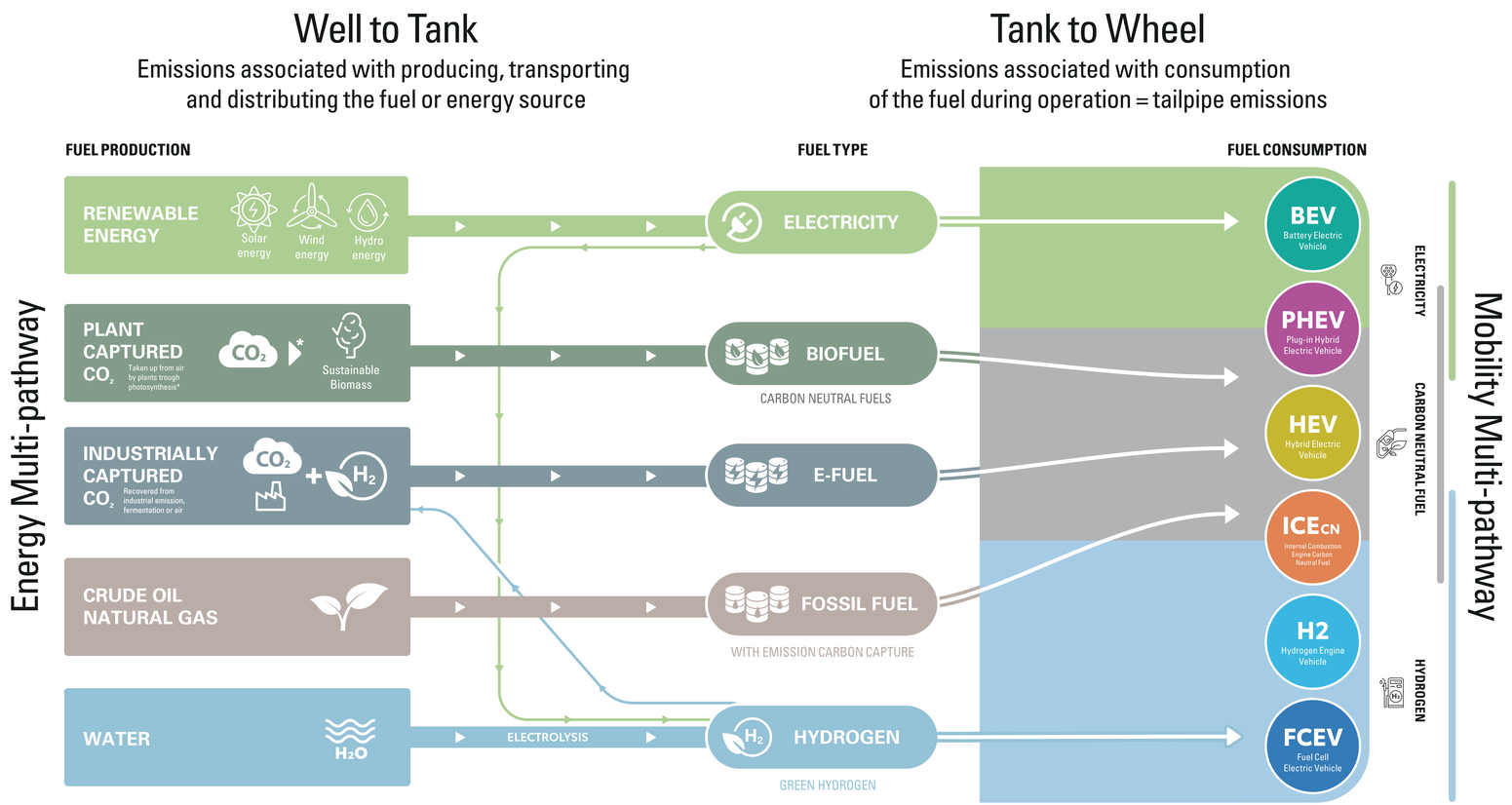


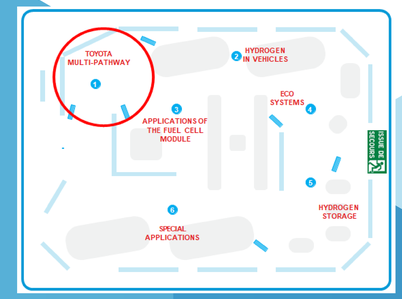



# MULTI-PATHWAY FOR ENERGY & MOBILITY

Over the medium to long term, renewable energy sources will continue to proliferate, with electricity and hydrogen emerging as the primary energy sources sustaining society.

That is why we are committed to providing mobility options that are in tune with a diverse range of energy situations and customer needs.



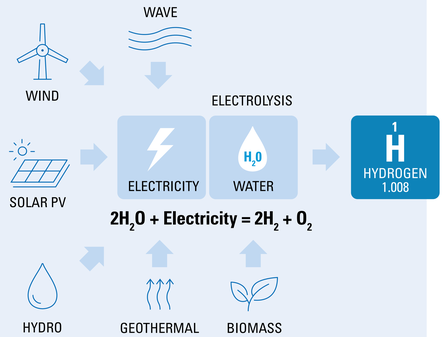
# HYDROGEN BASICS - BACK TO SCHOOL!

## THE POWER OF HYDROGEN

Hydrogen is 'nature's energy source'. It's the most abundant atom on earth – meaning it can be found almost everywhere. In pure form contains 3 times more energy per kilogram than petrol but has no emissions, it's nontoxic, is inexhaustible and can be stored indefinitely.

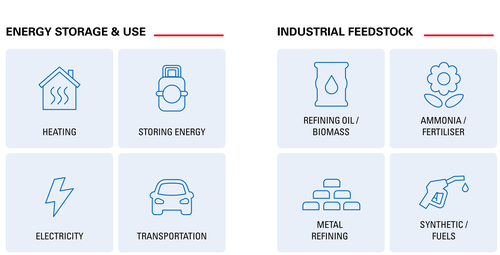
## HYDROGEN PRODUCTION

**Whilst hydrogen can be extracted from all fossil fuels, water ($H_2O$) is the most sustainable source.**




## HYDROGEN USE

Hydrogen is very versatile and has been used for over 100 years.



## HYDROGEN STORAGE

**Fuel cell module requires supply of hydrogen. TOYOTA developed in-house $H_2$ storage system.**

\+ 700 bar $H_2$ storage system (more than 63,000 units were produced)

\+ Various operating environments taken into account (low/high temperature -40°C to +85°C, collisions, hydrogen refueling)

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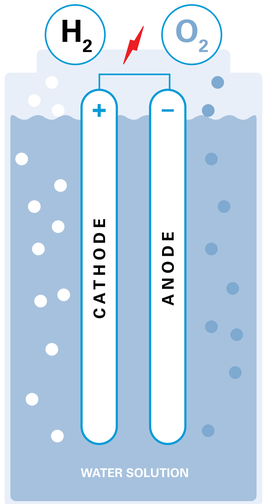
## ELECTROLYSIS

**Electrolysis is the process that takes the $H_2$ from $H_2O$. The application of electricity to the water separates the hydrogen and oxygen atoms.**




# TOYOTA FUEL CELL STACK: PROVIDING ELECTRICITY FROM HYDROGEN

## WHAT IS FUEL CELL & HOW IT WORKS?

TOYOTA fuel cells use PEM (Proton Exchange Membrane) technology.
A proton exchange membrane fuel cell transforms the chemical energy liberated during the electrochemical reaction of hydrogen and oxygen to electrical energy.

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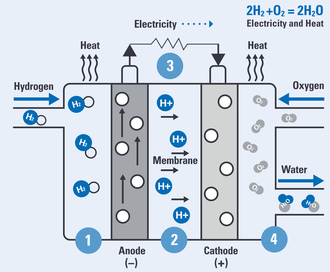
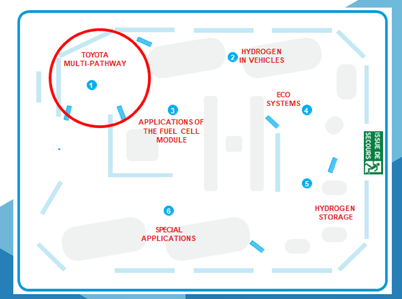
The membrane of Hydrogen Fuel Cell, generates electricity and water, from the reaction of hydrogen with oxygen.

It produces no emissions, except water. Moreover, using a unique TOYOTA technology, part of this produced water is diverted back to the membrane to humidify it. This is why the TOYOTA Fuel Cell Module does not need a separate humidifier.

## 4 SIMPLE STEPS

1. The hydrogen atoms enter at the anode where the catalyst separates from the hydrogen's negatively charged electrons from the positively charged protons (Ions).
2. The positively charged protons pass through the membrane to the cathode.
3. The negatively charged electrons flow around the membrane and are forced through a circuit, generating electricity.
4. After passing through the circuit, at the cathode, the negatively charged electrons and positively charged hydrogen Ions combine with oxygen.



# TOYOTA FUEL CELL TECHNOLOGY

## BASED ON 30 YEARS OF R&D

TOYOTA has been investing in fuel cell technology since 1992. Through our most recent technological developments we are now able to offer fuel cell modular systems for applications beyond automotive.

**1992 — FCEV**

FCEV (Fuel Cell Electric Vehicle) with a fuel cell stack.

**1999 — FCHV-4**

FCHV-4 equipped with high-pressure hydrogen.

**2002 — FCHV**

1st homologated tanks. FCEV sales begins in USA & Japan.

**2008 — FCV-R**

TOYOTA shows the Mirai precursor, the FCV-R.

**2015 — TOYOTA MIRAI GEN2**

TOYOTA launches 2nd gen Mirai. Range up by 30% (ca. 650 km), refuelling in 5 min.

**2022 — TFCM2-B,TFCM2-F**

2nd generation fuel cell modules for stationary applications, marine, trucks & buses, etc.

**1992 — START**

TOYOTA begins development of fuel cell vehicles.

**1999 — FCHV-3**

FCHV-3 equipped with fuel cell stack with increased power output.

**2002 — FCHV-5**

FCHV-5 features hydrogen generated on-board.

**2008 — FCHV-ADV FUEL**

FCHV-adv with a cruising range of approx. 830 km.

**2015 — TOYOTA MIRAI GEN1**

Titanium stack, 3.1 kW/L world record. Sales in UK, Germany & Denmark.

**2023 — FCEV HILUX PROTOTYPE**

**2020**

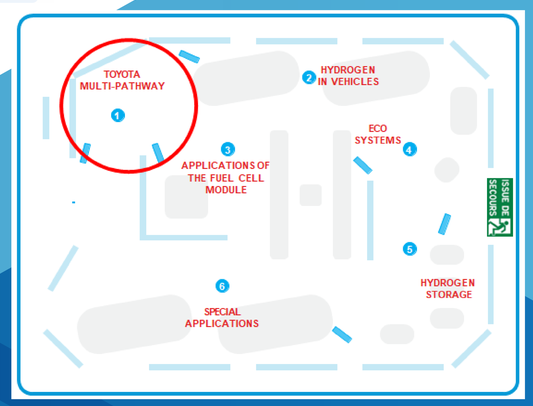
**2011**

**2005**

**2001**

**1996**

**MORE WILL FOLLOW**



# HILUX FUEL CELL - STEP UP INTO LIGHT COMMERCIAL VEHICLES

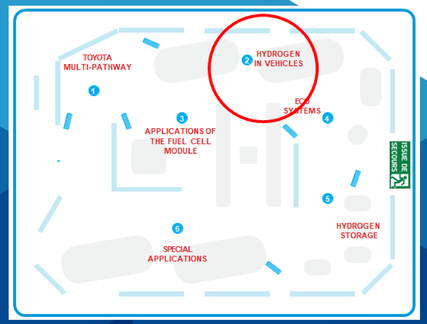
**A number of roadworthy prototypes are used to understand customers needs. Insights will be potentially reflected in series of production vehicles.**

The project is a further demonstration of the broad scope of TOYOTA's multi-path strategy for achieving carbon-free mobility, applying different powertrain solutions – hybrid electric, plug-in hybrid electric, battery electric and fuel cell electric – to suit different user needs and operating environments worldwide.

READ MORE

**SPECIFICATION**

| | |
|---|---|
| + Body type | **Extra Cab** |
| + Drivetrain | **Rear-wheel drive** |
| + Suspension type (Fr/Rr) | **Double Wishbone / de Dion** |
| + Fuel Cell stack type | **TOYOTA designed Polymer Electrolyte, 330 cells** |
| + Max. Fuel Cell Output | **128 kW / 174 DIN hp** |
| + Battery type/cap. | **Lithium-ion / 84 Cells / 4.0 Ah** |
| + Motor type | **Permanent magnet, synchronous** |
| + Max. motor power/torque | **134 kW-182 DIN hp / 300 Nm** |
| + 700 bar Hydrogen tanks/cap. | **TOYOTA designed type IV Carbon fibre, 7.8 kg (3 x 2.6 kg)** |



# THE NEW MIRAI TAKES FUEL CELL ELECTRIC VEHICLES TO A NEW LEVEL

## Equipped with a new fuel cell system that is high performance, compact and lightweight, with a long cruising range.

The new Mirai is the next evolution of TOYOTA's efforts to create a car well-suited for the promise of the hydrogen society. The Mirai stands out for its great style and driving performance first and as an FCEV second.

TOYOTA sees hydrogen as an effective fuel for the future. Our aim is to help address environmental and energy issues through mass production of fuel cell vehicles (FCEV).

FCEVs use hydrogen to operate and are very efficient, can travel long distances, have fast refueling times, and emit only water. They have enormous potential as environment-friendly cars, or ultimate eco-cars.

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### HIGH-PRESSURE HYDROGEN TANKS

The high-pressure tanks hold the hydrogen fuel. Cruising (reference value):

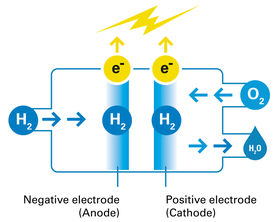
**Approx. 650 km***

### HIGH-PRESSURE HYDROGEN TANKS

The high output, high efficiency motor was designed to deliver smooth and powerful driving performance for the FCEV.

**134 kW** **182 PS**

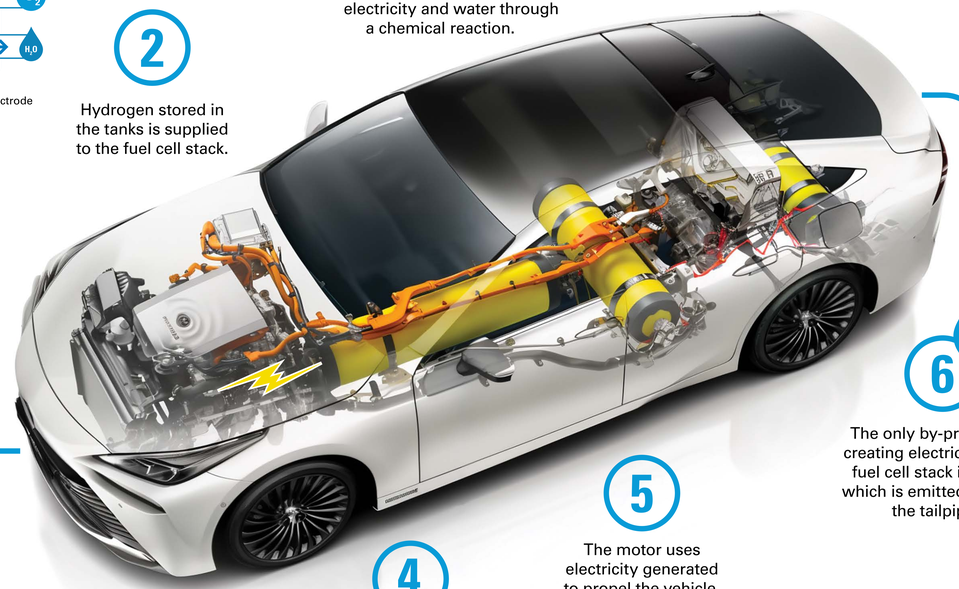
* Distances are calculated by multiplying the effective hydrogen capacity (kg) of the fuel cell vehicle (according to JEVS Z 902-2018) by its fuel effciency in WLTC test mode (km/kg). Hydrogen capacity for the high-pressure hydrogen tanks depends on the flling capability of each hydrogen station, and fuel effciency varies depending on usage conditions (weather, traffc congestion, etc.) and driving methods (sudden starts, air conditioning, etc.), so actual cruising range varies.




**1** Air (oxygen) flows through front intake grills and is supplied to the fuel cell stack.

**2** Hydrogen stored in the tanks is supplied to the fuel cell stack.

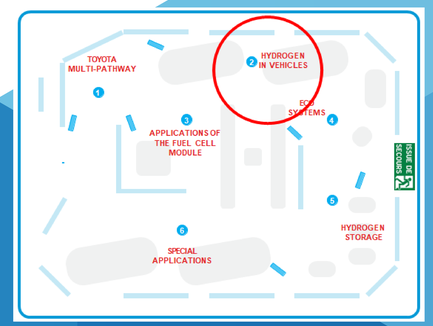
**3** Hydrogen and Oxygen react inside the fuel cell stack and generate electricity and water through a chemical reaction.



**4** The generated electricity is supplied to the electric motor.

**5** The motor uses electricity generated to propel the vehicle.

**6** $H_2O$ The only by-product of creating electricity in the fuel cell stack is water, which is emitted through the tailpipe.



# HYDROGEN POWER FOR ALL TYPES OF MOBILITY

## DRIVE H2 - YAMAHA $H_2$ GOLF CART

Yamaha developed a hydrogen powered engine golf car concept model.

Yamaha DRIVE H2 is equipped with two high-pressure hydrogen tanks (25L each) positioned under the driver's seat and on the back of the rear seat.

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## SUZUKI BURGMAN

Demonstrates Suzuki research and development of hydrogen engines as one of the multi-pathway initiatives for realizing carbon neutrality.

Test model based on commercially available BURGMAN 400 ABS fitted with a 70 MPa hydrogen tank and hydrogen engine.

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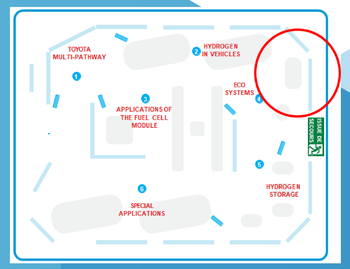


# TOYOTA FUELL CELL MODULES APPLICATIONS

TOYOTA is increasing the diversity of applications beyond passenger car and LCV, to heavy-duty transport, stationary generators, maritime vessels and more.

TOYOTA sees Europe as one of the most advanced hydrogen regions with high potential for growth, hence our strong support for developing hydrogen society with European partners.

## SCALE MODELS

+ TOYOTA Crown FCEV
+ TOYOTA Mirai FCEV
+ TOYOTA GR Yaris H2 ICE
+ TOYOTA Hilux FCEV
+ TOYOTA Material Handling Forklift FCEV
+ TOYOTA H2 Cartridge

**Buses**

+ Caetano Bus
+ GCK Coach

**Trucks**

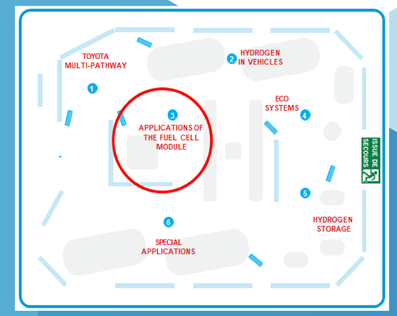
+ Hyliko FCEV Truck with TOYOTA Accessible People Movers (APMs)
+ VDL FCEV Truck

**Bicycles**

+ PRAGMA H2 Cartridge Cargo Bike
+ PRAGMA FCEV Bike

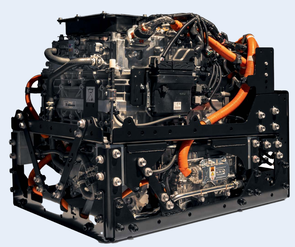
**Stationary**

+ EODev GEH2
+ EODev REXH2
+ Boats & Yachts
+ FinX Boat
+ Energy Observer Yacht
+ Fountaine Pajot Samana 59

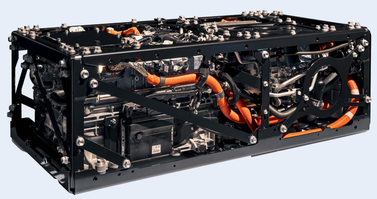


# TOYOTA FUEL CELL MODULE

## PROVIDING ELECTRICITY FROM HYDROGEN



TFCM2-B



TFCM2-F

### VERSATILE AND FLEXIBLE

+ Modularity enables easy integration and installation.
+ Wide voltage range and integrated boost converter enable direct connection to existing electrical systems fuel.
+ Fast response time: 40 kW per second.

### SAFETY IN OPERATIONS

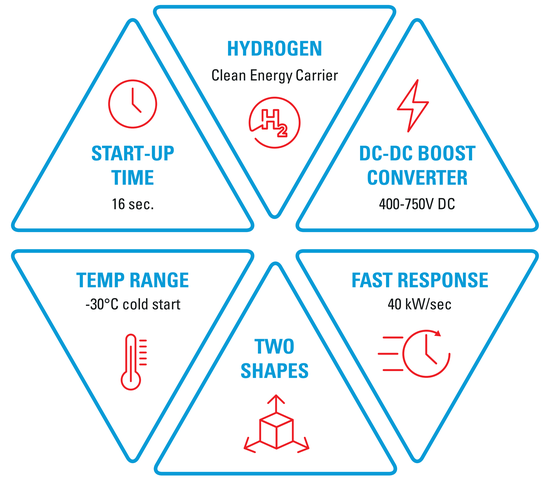
+ Strict hydrogen and high-voltage safety measures are inherited from our experience with Fuel Cell Electric Vehicles (FCEV) and Hybrid Electric Vehicles (HEV).
+ Suitable for a broad range of conditions in regard to temperature, altitude and vibration.

### EXTENSIVE GLOBAL SUPPORT

TOYOTA Motor Europe provides Fuel Cell Module technology to partners in Europe region who would like to use TFCM in their applications and products.

CONTACT US

### QUALITY, DURABILITY AND RELIABILITY




TOYOTA's values in the automotive world have always been rooted in QDR: Quality, Durability and Reliability. The same high attention to these values is applied to our hydrogen products.

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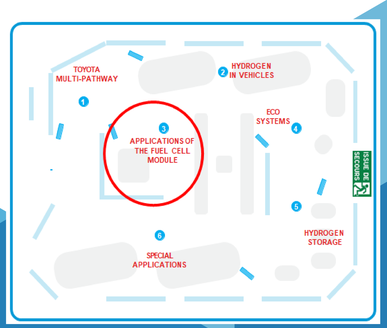
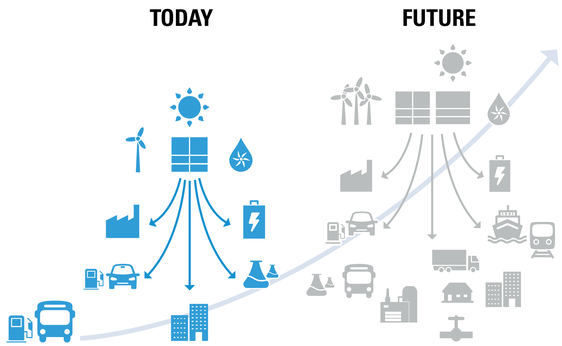
This ensures that our Fuel Cell Modules are designed and assembled with outstanding craftsmanship and offer superior safety and reliability.



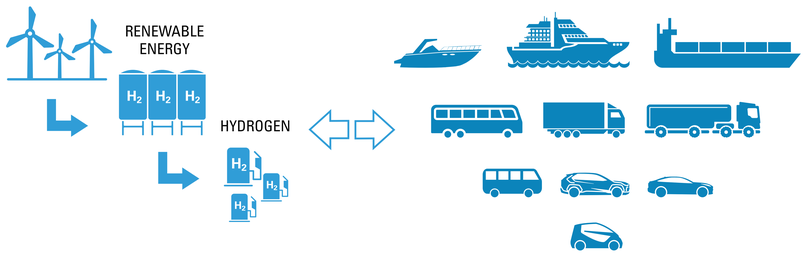
# $H_2$ ECOSYSTEMS: BALANCING $H_2$ DEMAND & SUPPLY

## HYDROGEN VALLEYS

$H_2$ eco-clusters can function as an intermediate step towards freedom of mobility using hydrogen.




## WHY $H_2$ ECOSYSTEMS AND HYDROGEN VALLEYS MAKE SENSE?




+ $H_2$ stable infrastructure
+ Predictable TCO

**BUSINESS VIABILITY**

+ Predictable $H_2$ consumption
+ Positive Business Case / ROI

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## EXAMPLES OF TOYOTA POWERED ECO-SYSTEMS

### TOYOTA LOGISTICS BASED ON FUEL CELL TRUCKS

In 2024, Toyota Motor Europe will start a trial to decarbonise logistics using $H_2$ Fuel Cell trucks.

Routes will cover four countries: France, Belgium, The Netherlands, Germany; centered around our European Service Parts warehouse.

### MIRAI AS CAPTIVE FLEET

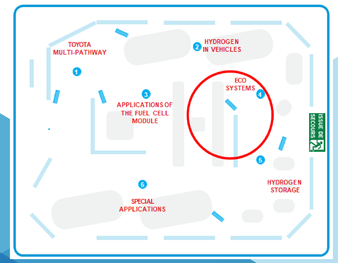
#### IN PARIS, FRANCE

**HYSETCO JOINT VENTURE**

- 1000+ Mirai
- 4 stations
- Air Liquid ($H_2$), Total Energy ($H_2$), Kouros (funding), Slota (taxi licence)

#### IN BERLIN & HAMBURG, GERMANY

| BERLIN SINCE THE END OF 2022 | HAMBURG SINCE 2024 |
|---|---|
| up to 200 Mirai | up to 105 Mirai |
| 5 stations | 3 stations + 1 H2'24 |
| Safe Driver Taxis, Anglo American | Local dealer Anglo American |



# HYDROGEN THRILLS - H24EVO

## THE NEW MISSIONH24 RACING CAR IS NOW CALLED

# THE H24EVO

The electric-hydrogen prototype is the new flagbearer of the project to promote hydrogen in racing initiated by the Automobile Club de l'Ouest and orchestrated by H24Project.

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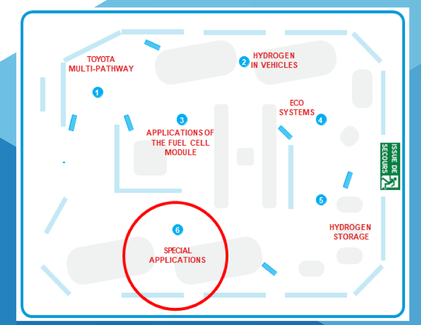
**SPECIFICATION**

- Fuel Cell Stack output **300 kW**
- Number of $H_2$ tanks **2**
- Pressure **700 bar**
- $H_2$ weight **7,8 kg**
- EV motor output **872 hp**
- Chassis weight **1300 kg**
- Battery **Lithium 400 kW**

The H24EVO takes up the baton from the H24 and the LMPH2G in the race to achieve zero-carbon motor racing. Its maiden outing is scheduled for 2025 when it will be set out to demonstrate the role that hydrogen can play in terms of performance and the energy transition we need to undertake to save the planet.

MissionH24's aim is to introduce a class for hydrogen prototypes at the 24 Hours of Le Mans. A dozen constructors from around the world have been working towards this goal for several years now. As a pioneer in hydrogen-powered racing, the H24EVO is a precious tool with which to experiment the technology.



# **TOYOTA MIRAI:** A POWER SUPPLY DURING DISASTERS & EMERGENCY SITUATIONS

With oxygen and hydrogen, Fuel Cell Vehicles [FCEV] can produce large amounts of electricity through chemical reactions that can be easily feed back to house or other applications outside of the Grid.

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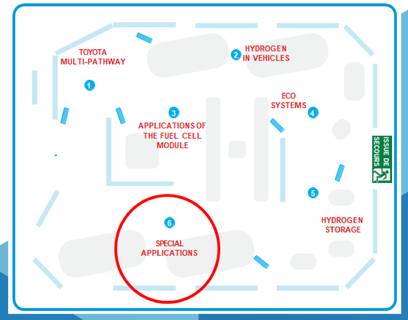
During disasters and other emergencies, Mirai can supply high output electric power to homes and electrical products.

In the new Mirai, accessory power outlets inside the cabin can be used even when the external DC power supply system is in operation.