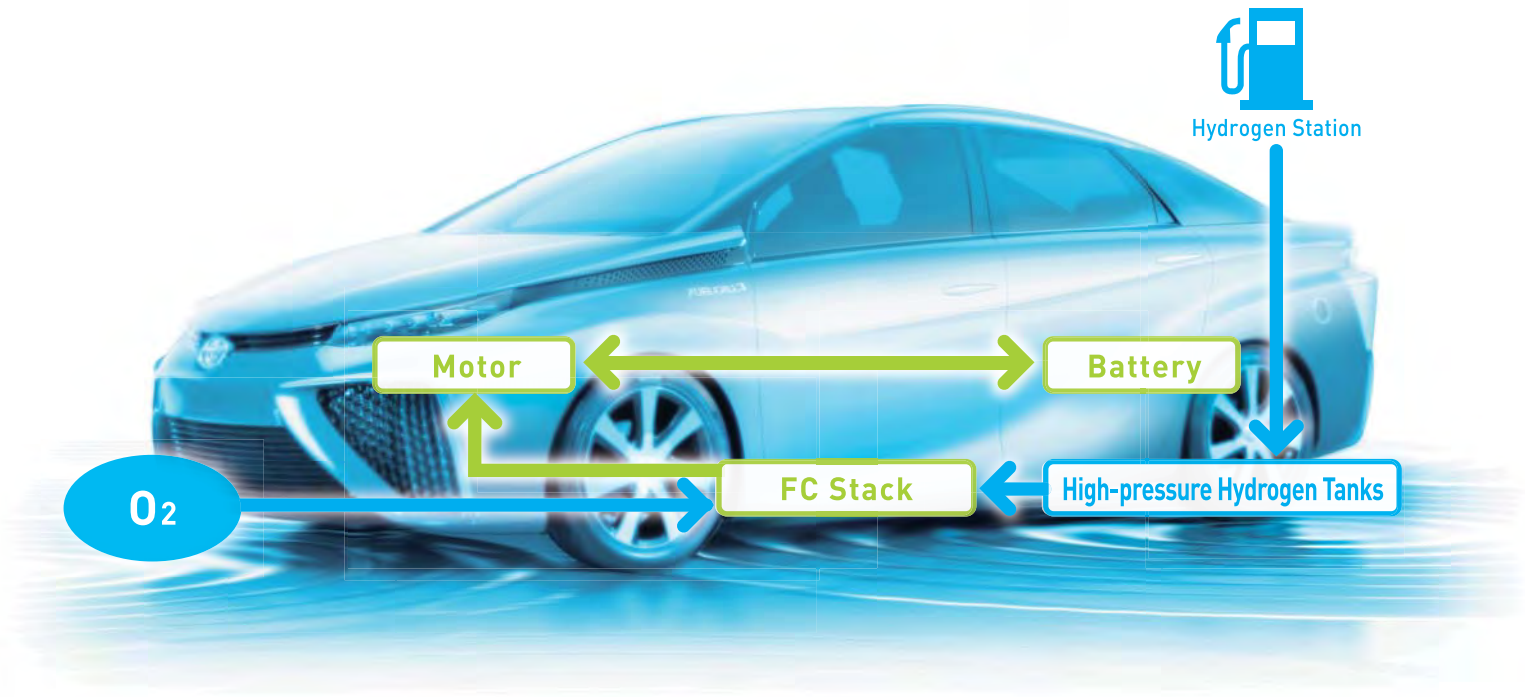
TOYOTA

FC

Fuel Cell Technology



Fuel cell vehicles (FCVs) are ideal "clean" cars that offer solutions to energy and emissions issues.

FCVs are powered by fuel cells that generate electricity from hydrogen, a fuel which is environment-friendly and highly energy-efficient, and can be produced using a variety of readily available raw and renewable materials. This makes fuel cell vehicles ideal for achieving sustainable mobility, and it's why Toyota, with its strong track record in fuel cell development, is striving to make this vehicle technology widely available as soon as possible.

Since 2002, Toyota has made available for lease in the U.S. and Japan its Toyota FCHV (fuel cell hybrid vehicle) —the first market-ready fuel cell vehicle—based on the "Highlander" SUV.

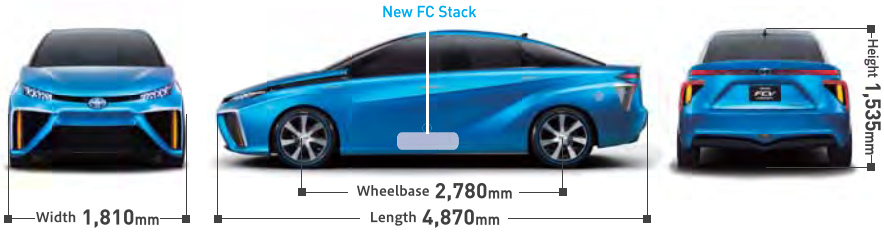
In around 2015, Toyota plans to launch a fuel cell sedan for sale to the general market.

Next-generation fuel-cell vehicle
TOYOTA FCV CONCEPT

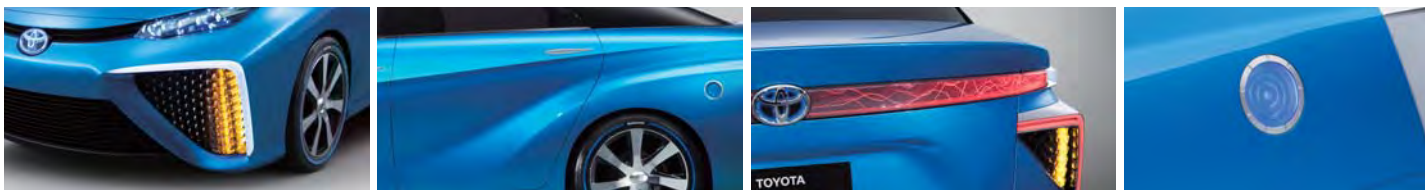
World premiere at the 2013 Tokyo Motor Show

POINT 01 Highly efficient package

Reduced size and increased power of the FC system, which includes Toyota's proprietary small, light-weight FC Stack and two 70 MPa high-pressure hydrogen tanks, has enabled a smaller vehicle with greater performance. Furthermore, with the tanks placed beneath the specially designed sedan body, the Toyota FCV Concept can accommodate up to four occupants.



POINT 02 Unique exterior design

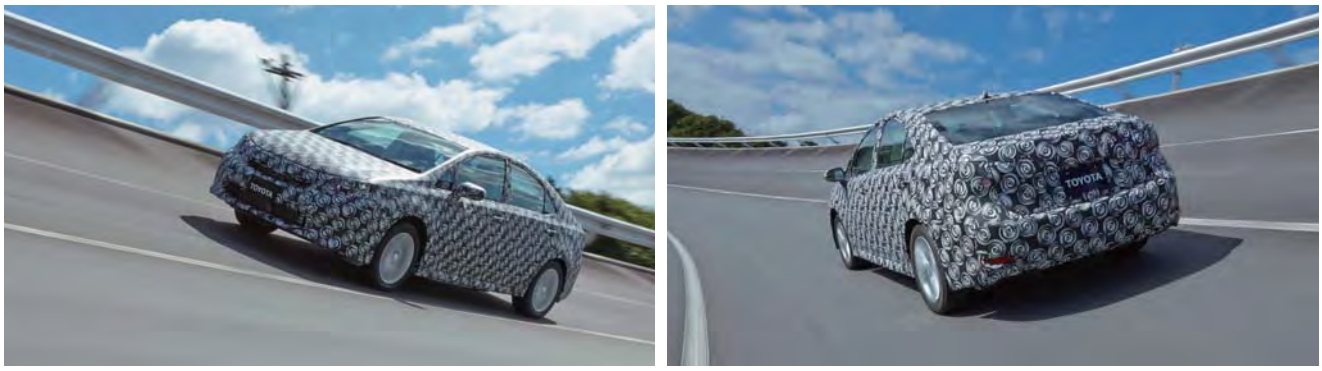


The vehicle's exterior design evokes two key characteristics of a fuel cell vehicle: the transformation of air into water as the system produces electricity, and the powerful acceleration enabled by the electric drive motor.

The bold front view features pronounced air intakes, while the sleek side view conveys the air-to-water transformation with its flowing-liquid door profile and wave-motif fuel cap. The theme carries to the rear view, which conveys a catamaran's stern and the flow of water behind.

Progress on the road to a 2015 launch

At Toyota's 2013 Advanced Technology Media Briefing held in Tokyo, journalists from around the world were able to test-drive an FCV sedan prototype.



FCV sedan prototype in tests

Toyota's small, light-weight FC Stack, made even more efficient.

The new FC Stack has more than twice the power output density of the current model

Toyota's new FC Stack has a power output density of 3 kW/L, more than twice that of the current Toyota FCHV-adv FC Stack. In addition, the new FC system is equipped with Toyota's high-efficiency boost converter. Increasing the voltage has made it possible to reduce the size of the motor and the number of fuel cells, leading to a smaller system offering enhanced performance at reduced cost.

FC Stack

Driving range of about 700 km

The vehicle has a driving range of approximately 700 km (under the Japanese MLIT JC08 test cycle; based on in-house calculations), and has at least 500 km range in real-world conditions. Refueling time is as low as three minutes, roughly the same as for a gasoline vehicle.

The number of high-pressure hydrogen tanks has been reduced from four to two

With Toyota's proprietary two 70 MPa high-pressure hydrogen tanks, the new FCV sedan can accommodate up to four occupants.

High-pressure Hydrogen Tank

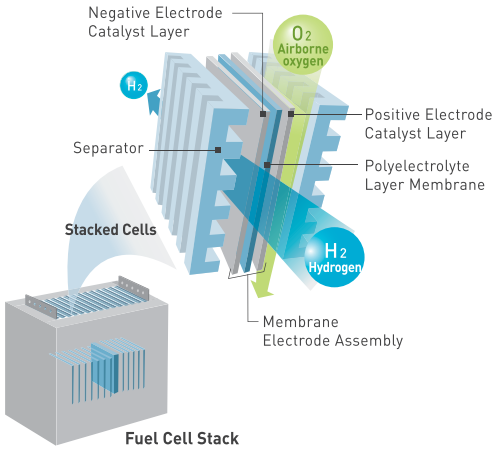
Toyota's FC Stack: Providing world leading performance

Using hundreds of individual fuel cells to make a fuel cell "stack"

This device generates electricity through a chemical reaction between hydrogen and oxygen. Hydrogen and ambient air are respectively supplied to the anode (negative) and the cathode (positive) of the fuel cell to generate electricity. A fuel cell unit consists of a stack of cells called an MEA (Membrane Electrode Assembly) sandwiched between separators. The MEA is a polymer electrolyte membrane with catalyst layers applied. Since one cell can only yield less than one volt, several hundred cells are connected in series to increase the voltage. This combined body of cells is called a fuel cell stack (FC stack). This FC stack is commonly referred to as a fuel cell unit.

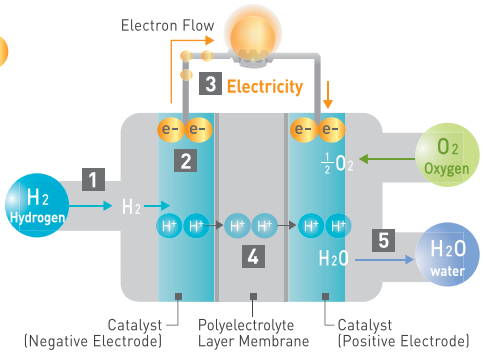
Toyota's basic philosophy is to develop key technologies in-house, and its completely original Toyota FC Stack is a performance leader among vehicular fuel cells worldwide.

Energy efficiency is one of the fuel cell's most noteworthy characteristics. As the fuel cell directly generates electricity from hydrogen, it is extremely efficient. A fuel cell can convert 83 percent of hydrogen's energy into usable power, and this is about twice the efficiency possible with current gasoline engines.



Making electricity from hydrogen and oxygen—how it works

1. Hydrogen (H_2) is supplied to the anode side.
2. Hydrogen molecules activated by the anode catalyst release electrons. (e^-)
3. The electrons released from hydrogen travel from the anode to the cathode, creating an electrical current.
4. Hydrogen molecules that released electrons become hydrogen ions (H^+) and move through the polymer electrolyte membrane to the cathode side.
5. Hydrogen ions bond with airborne oxygen and electrons on the cathode catalyst to form water. (H_2O)



Toyota fuel cell technology in a broad range of products

Besides passenger cars, Toyota is putting the Toyota FC Stack to use widely, including in buses and residential power generation. In addition to the FCV sedan planned for launch in around 2015, Toyota and Hino Motors plan to launch the co-developed FC Bus in 2016. Toyota is also working with Toyota Industries on its fuel cell lift truck and with Aisin Seiki on a residential fuel cell cogeneration system.

Cars

FCV

Buses

FC Bus

Toyota fuel cell technology

Industrial & stationary applications

Fuel Cell Lift Truck

Residential fuel cell cogeneration system

Significant milestones on the road to broad market use

Toyota fuel cell vehicle development history

2008.6 — Toyota FCHV-adv

Toyota announces the FCHV-adv, capable of a cruising range of approximately 830km (10-15 Japanese test cycle; in-house test data).

2005.3 — FCHV-Bus

During the 185-day Expo 2005 Aichi, an FCHV-Bus serves the 4.4km route between the event's Seto and Nagakute areas.

2002.11 — Toyota FCHV

Toyota receives Japanese government certification for the Toyota FCHV, an improved FCHV-4 and begins limited marketing in the U.S. and Japan. Leasing in Japan begins in Tokyo metropolitan area.

2002.9 — FCHV-Bus2

The FCHV-Bus2, which uses two Toyota FC Stacks, is developed and certified by Japanese government. Testing on public roads begins in October.

2001.10 — FCHV-5

Toyota announces the FCHV-5, featuring an onboard CHF*reformer.

*Clean Hydrocarbon Fuel

2001.6 — FCHV-Bus1

Toyota and Hino Motors co-develop the FCHV-Bus1, a large, low-floor city bus that runs on compressed hydrogen.

2001.6 — FCHV-4

Toyota develops the FCHV-4, equipped with high-pressure hydrogen tanks and a proprietary Toyota FC Stack. Testing begins on public roads in Japan and the U.S.

2001.3 — FCHV-3

Toyota announces the FCHV-3, equipped with a fuel cell stack that achieves greatly increased power output, and a hydrogen-absorbing alloy tank.

1996.10 — FCEV

Toyota develops the FCEV (fuel cell electric vehicle), equipped with a proprietary fuel cell stack and a hydrogen-absorbing alloy tank. The FCEV takes part in a parade in Osaka, Japan.

1992

Toyota begins development of fuel cell vehicles.