TOYOTA FCHV

Fuel Cell Hybrid Vehicle

BOOK

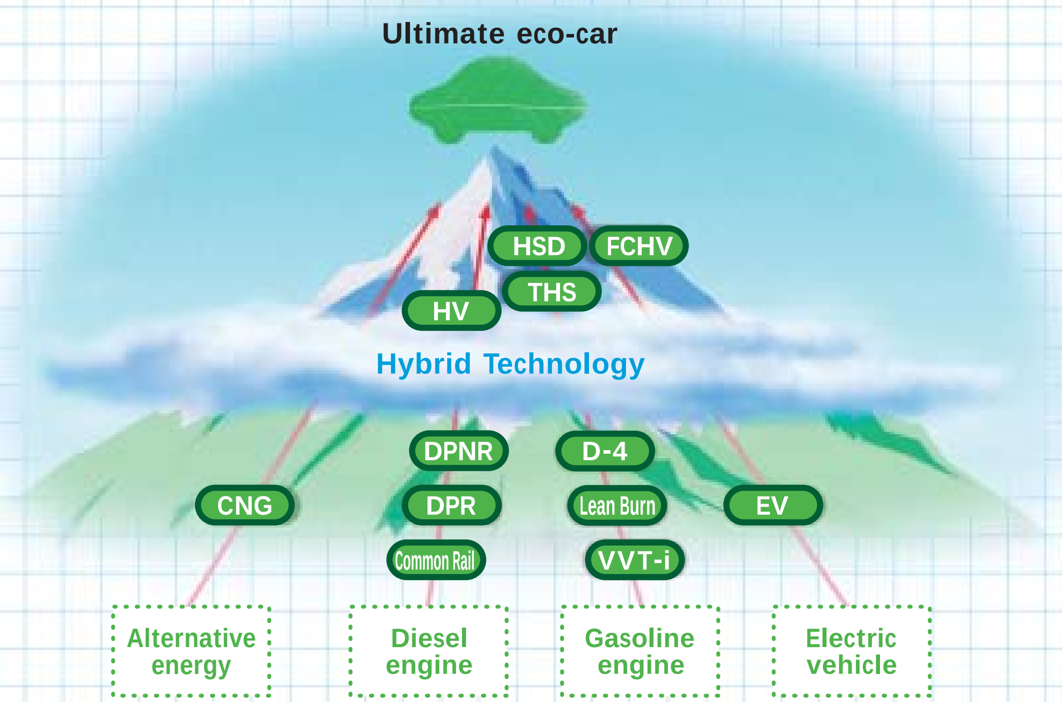
Approaching the Eco-car

Toward the ultimate eco-car, one step at a time

December 12, 2002: Toyota began limited marketing in the U.S. and Japan of the hydrogen-powered TOYOTA FCHV (Fuel Cell Hybrid Vehicle), the closest thing yet to the ultimate eco-car.

Making the ultimate eco-car everyone's car

In pursuit of the ultimate eco-car, Toyota has faced — and overcome — many challenges. In 1997, based on its accumulated experience and expertise, Toyota introduced the Prius, the world's first mass-produced hybrid vehicle. Welcomed around the globe as an environment-friendly car, the Prius was one of the most fuel efficient 5-person mass-produced gasoline passenger vehicles in the world. Toyota considers the hybrid technology it developed for the Prius to be a core technology for the eco-cars of tomorrow. The FCHV introduced on a limited basis in the U.S. and Japan is seen as the closest yet to the ultimate eco-car. However, Toyota will not be satisfied until such ultimate eco-cars become available to everyone.



CNG: Compressed Natural Gas D-4: Direct Injection 4-Stroke Gasoline Engine THS: Toyota Hybrid System
HV: Hybrid vehicle VVT-i: Variable Valve Timing, intelligent DPNR: Diesel Particulate and NOx Reduction system
DPR: Diesel Particulate active Reduction system HSD: Hybrid Synergy Drive

Energy and the Environment

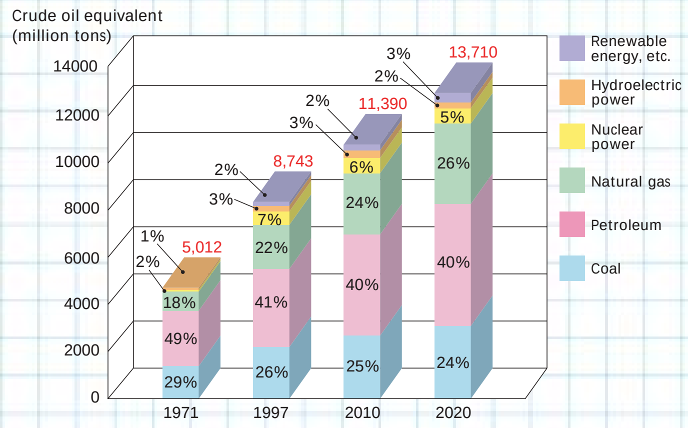
Some 740 million vehicles are driven on our planet. We can't keep on going like this.

In today's society we depend almost entirely upon fossil fuels for our energy.
Affluent societies consume energy in vast amounts, accompanied by a continuous discharge of carbon dioxide, or CO_2. As an integral part of the modern world, the automobile has played a major role in economic and industrial development, not to mention shaping everyday life and culture. However, it is also a fact that cars consume considerable energy and inflict a burden on the environment. It is predicted that the number of vehicles driven — about 740 million today — will continue to increase.

How much petroleum do we have left?

According to some predictions, if we continue to consume energy on the current scale, we may face a petroleum shortage in the latter half of the 21st century. Although nobody is sure how much petroleum is left, one thing is certain — at some point we will run out. We must make our automobiles more fuel efficient and use the planet's oil reserves more wisely. We must also make it a priority to develop cars that run on fuels other than petroleum.

■Trends and forecast of world energy demand by fuel

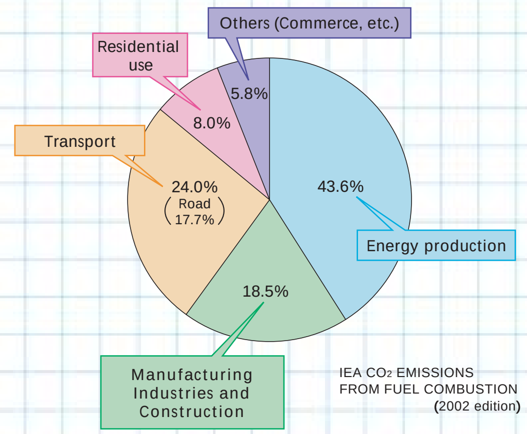


Source: Agency for Natural Resources and Energy (Japan)

About 18% of CO_2 is emitted by motor vehicles.

CO_2 is known as a greenhouse gas that contributes to global warming. Calculations for the year 2000 indicate that automobiles emitted about 18% of all the CO_2 produced by fuel combustion worldwide. Motor vehicle exhaust also contains NOx (nitrogen oxides), HC (hydrocarbons) and PM (particulate matter), affecting air quality in cities and other areas that have heavy traffic.

■World CO_2 emissions arising from fuel combustion, by sector—2000



IEA CO_2 EMISSIONS FROM FUEL COMBUSTION (2002 edition)

Fuel Cells

Electricity made from hydrogen offers an amazingly high 83% theoretical efficiency.

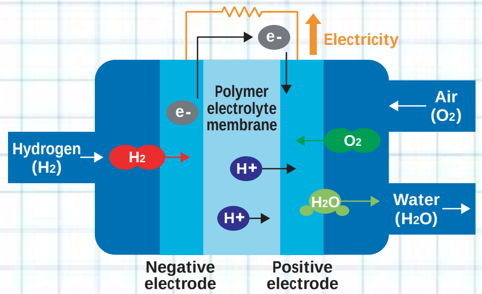
Hydrogen is as an ideal energy source because it has a high energy density for its weight and is friendly to the environment. Hydrogen can be obtained from many different sources, so it can reduce dependency on petroleum and contribute to achievement of energy source diversification without the worry of depletion. With the recognition that the "hydrogen age" is near at hand, considerable effort is going into the development of fuel cells, which generate electricity from hydrogen.

Hydrogen produces no CO_2 or harmful emissions.

A fuel cell makes electricity by combining hydrogen and oxygen in a chemical reaction. It is a kind of miniature power plant. Since the fuel cell generates electricity directly, without burning hydrogen, it is both clean and extremely efficient. Theoretically, if you calculate that a fuel cell can convert 83% of hydrogen energy into electrical energy, we can look forward to extremely high efficiency compared to the maximum of 30% to 40% possible with a gasoline engine. Furthermore, in principle, a fuel cell produces no CO_2 or harmful emissions; its only byproduct is water. Though the fuel cell is an emerging technology and its future is still open to conjecture, it has the potential to change not only energy and environmental issues, but also the automobile itself — in revolutionary ways.

Toyota FC Stack

Making electricity from hydrogen – how it works

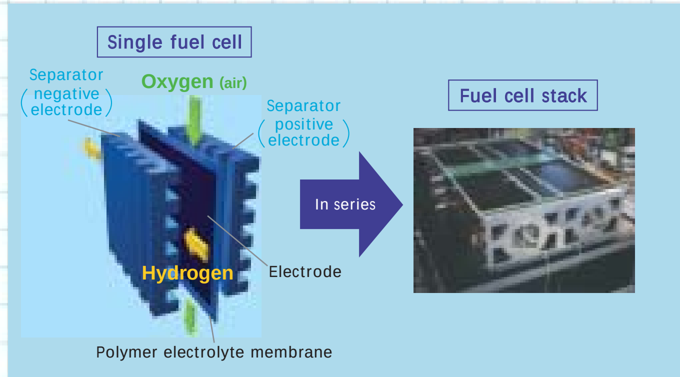


Fuel cells make electricity through a chemical reaction between hydrogen and oxygen (from the air). Hydrogen is supplied to a fuel cell's negative electrode, where a catalyst strips electrons from the hydrogen atoms. The electrons flow from the fuel cell's negative to positive electrode, thereby generating electricity. Meanwhile, the hydrogen atoms that have shed their electrons become hydrogen ions and travel through a polymer electrolyte membrane to reach the positive side. There, with the help of a catalyst on the positive electrode, the hydrogen ions and electrons join with oxygen to form water.

Fuel cell structure

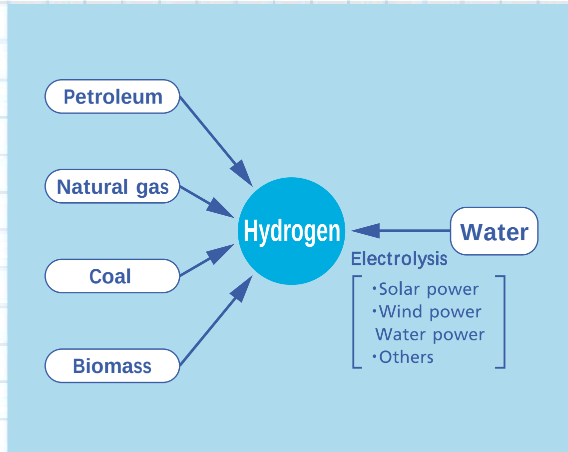
Several kinds of fuel cell exist but automotive applications have focused on the polymer electrolyte fuel cell. This has a polymer electrolyte membrane with integrated electrodes on both sides. This membrane-electrode assembly is sandwiched between separators that form passageways for hydrogen and oxygen. A single cell like this generates less than one volt, so hundreds of cells are stacked in a series connection to raise the voltage. Such a package is called a fuel cell stack and is what most people are referring to when they talk about fuel cells.

■Fuel cell structure



Just what is hydrogen, anyway?

Hydrogen is the lightest gas on our planet. It is colorless and odorless. When burned, it turns into water without producing any harmful substances. Hydrogen does not exist as a primary energy source, but can be derived from other materials including petroleum and natural gas. It can also be produced by electrolysis of water. If we perform electrolysis using electricity from natural energy sources such as solar, wind or water power, then we can make hydrogen without emitting significant amounts of CO_2. Since it is a gas, hydrogen is a little more difficult to manage than gasoline as an automotive fuel. Therefore, new methods of storage and handling must be devised.



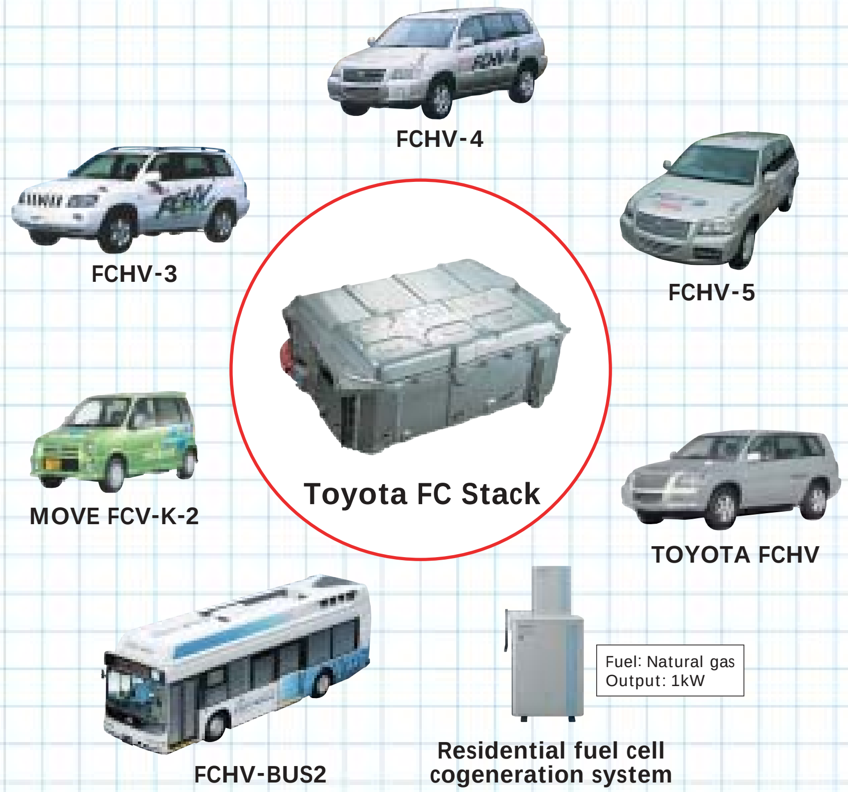
TOYOTA FC STACK

The heart of a fuel cell vehicle

Since setting out in 1992 to create fuel cell cars, Toyota has made a point of keeping fuel cell development in-house. As the heart of a fuel cell vehicle, the fuel cell is no exception to Toyota's basic stance of developing core technologies on its own. Compared to their early application in the Gemini space missions in the 1960s, fuel cells have become astonishingly small and powerful, evolving rapidly since vehicular applications began in earnest. Toyota's completely original fuel cell — the Toyota FC Stack — is a performance leader among vehicular fuel cells worldwide, and is already on the verge of surpassing gasoline engines in power density.

Toyota's original fuel cell: the Toyota FC Stack

Besides passenger cars, Toyota is deploying the Toyota FC Stack in a wide variety of products including city buses, minicars and fuel cells for the home. Two Toyota FC Stacks are used in the FCHV-BUS2, a large, low-floor city bus co-developed with Hino Motors, Ltd. The MOVE FCV-K-2, co-developed with Daihatsu Motor Co., Ltd., uses a compact fuel cell system developed by Toyota for minicars. Also, together with Aisin Seiki Co., Ltd., Toyota is working on a residential fuel cell cogeneration system that runs on natural gas.

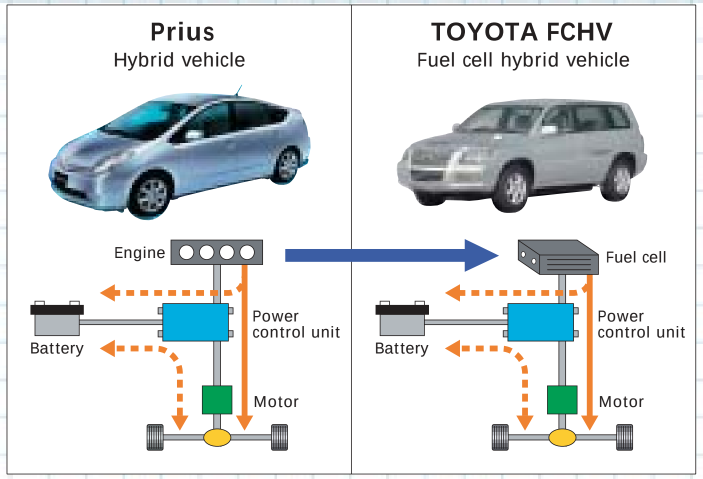


Hybrid technology

Toyota's hybrid technology applied to fuel cell vehicles

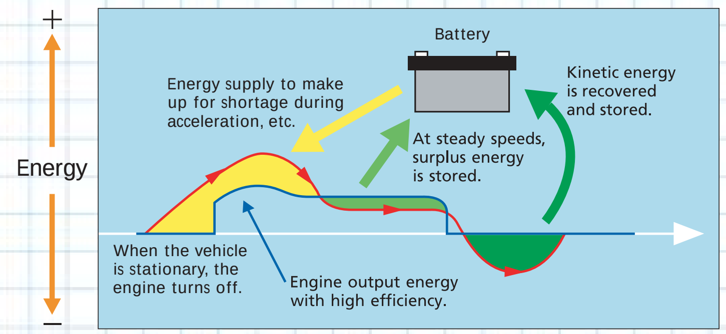
The hybrid system proven in Toyota's Prius, the world's first mass-produced hybrid car, achieves its highly efficient operation through sophisticated energy management of a gasoline engine and battery. Toyota applied this hybrid technology to realize high efficiency in the TOYOTA FCHV as well.

■Hybrid systems of Prius and TOYOTA FCHV



Energy management in a hybrid vehicle

Using the Prius as an example, let's see how the hybrid system works. In the graph below, the red line shows the energy required to move the car, while the blue line shows energy produced by the engine. When the car stops, the gasoline engine stops too, instead of just idling and wasting energy. During start-up and at low speed, gasoline engine efficiency is low, so the car runs on its electric motor, which draws electricity from the battery. At faster speeds, the gasoline engine propels the vehicle but the system gives priority to operating the engine only within its most efficient rpm range, so engine power may not be sufficient when the car accelerates. At such times, the motor provides assistance to make up for the shortage, drawing electricity from the battery (yellow area). However, when the car cruises at a steady speed, the engine, which operates with priority placed on efficiency, may produce more energy than is needed. In this case (light green area), the excess energy is used to generate electricity, which is stored in the battery. If the driver lets up on the accelerator to slow down, the engine stops automatically to avoid wasting energy. During deceleration the motor functions as an electric generator to capture regenerative braking energy (green area).

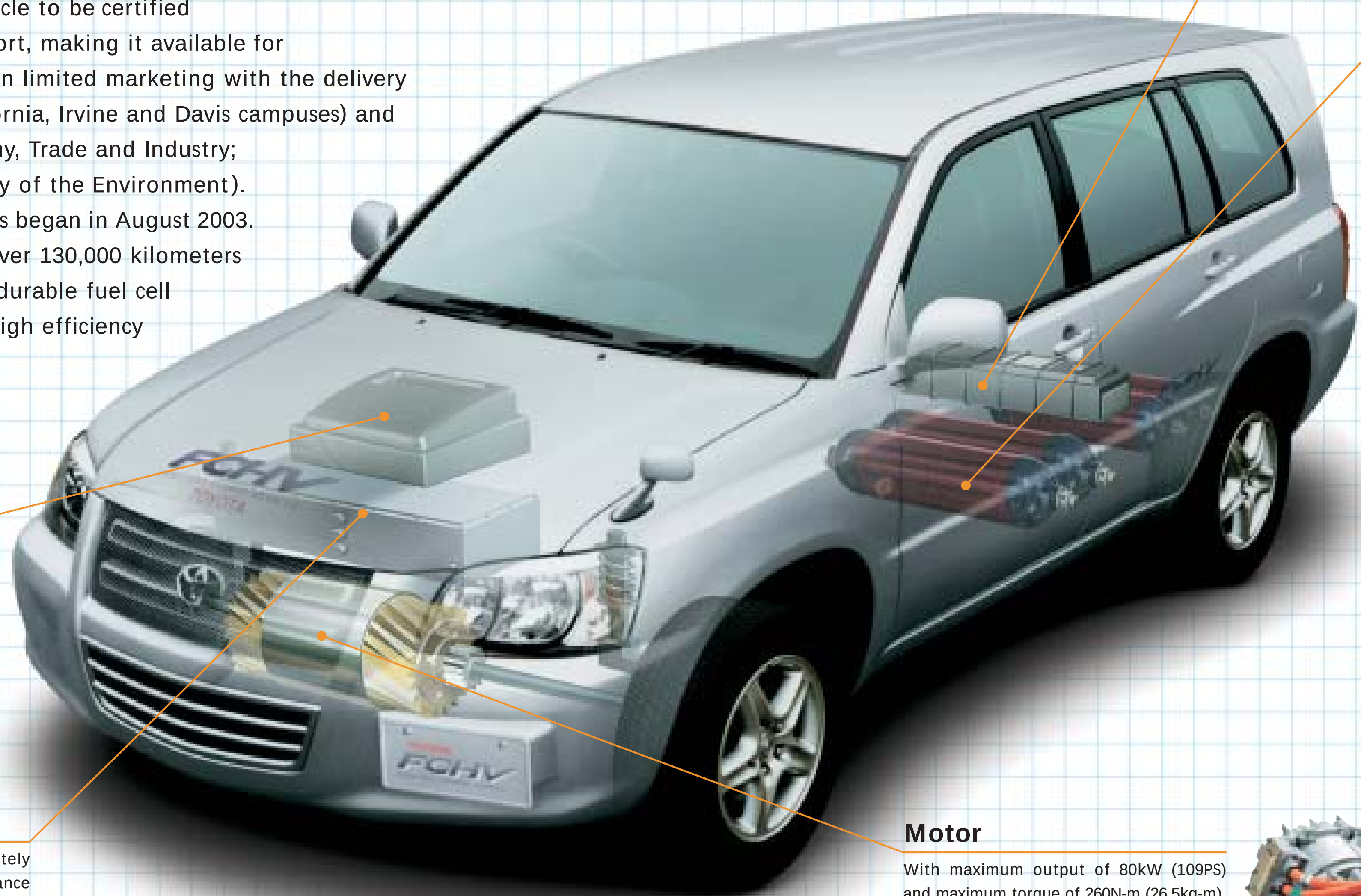


TOYOTA FCHV ①

We're gaining on the ultimate eco-car, but we still have a long way to go.

TOYOTA FCHV takes to the road

The TOYOTA FCHV became the first-ever fuel cell vehicle to be certified by Japan's Ministry of Land, Infrastructure and Transport, making it available for limited marketing. On December 2, 2002, Toyota began limited marketing with the delivery of two TOYOTA FCHVs in the U.S. (University of California, Irvine and Davis campuses) and four in Japan (Cabinet Secretariat; Ministry of Economy, Trade and Industry; Ministry of Land, Infrastructure and Transport; Ministry of the Environment). Delivery to corporate purchasers and local governments began in August 2003. Based on the FCHV-4 prototype, which accumulated over 130,000 kilometers of testing, the TOYOTA FCHV is a highly reliable and durable fuel cell hybrid vehicle that delivers a remarkable balance of high efficiency and luxuriously smooth, hushed cruising performance.



Battery

With an output of 21kW, this nickel/metal hydride battery stores energy recovered during deceleration and supplements fuel cell output during acceleration.

High-pressure hydrogen tank

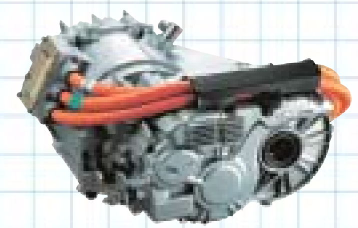
Each tank stores hydrogen at 35MPa (about 350 bars). In-tank pressure reduction technology feeds a steady supply of hydrogen to the fuel cell at fixed pressure.

Power control unit

The "brain" of the hybrid system, this precisely manages fuel cell output and battery charging/discharging, in accordance with driving conditions.

Toyota FC Stack

Developed by Toyota completely in house, this high-performance polymer electrolyte fuel cell has a 90kW output.



Motor

With maximum output of 80kW (109PS) and maximum torque of 260N-m (26.5kg-m), this Toyota-developed permanent magnet motor effortlessly propels the Toyota FCHV. During deceleration it functions as an electrical generator to recover kinetic energy.

TOYOTA FCHV Main Specifications

Vehicle	Name	TOYOTA FCHV
	Overall length/width/height (mm)	4,735/1,815/1,685
	Weight (kg)	1,860
	Seating capacity (persons)	5
Performance	Max cruising range (km)	300※
	Maximum speed (km/h)	155
Fuel cell	Name	Toyota FC Stack
	Type	Polymer electrolyte
	Output (kW)	90
Motor	Type	Permanent magnet
	Maximum output (kW (PS))	80 (109)
	Maximum torque (N-m (kg-m))	260 (26.5)
Fuel	Type	Hydrogen
	Storage system	High-pressure hydrogen tanks
	Maximum storage pressure (MPa)	35
Battery	Type	Nickel-metal hydride

※In the Japanese 10-15 test cycle

1992～

TOYOTA FCHV development history

1992

Toyota begins comprehensive development – from materials, components and systems to control and production technology.

October 1996

In an exhibition parade in Osaka, Japan, Toyota demonstrates its in-house-developed FCHV, equipped with an original fuel cell stack and hydrogen-absorbing alloy tank.

September 1997

Toyota unveils the world's first FCHV with an onboard methanol reformer.

March 2001

FCHV-3

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

June 2001

FCHV-4

Toyota announces the FCHV-4, equipped with high-pressure hydrogen tanks and the original Toyota FC Stack. Testing conducted on public roads in Japan and U.S.

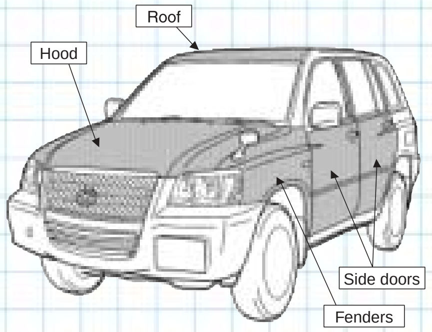
TOYOTA FCHV ②

Eco-technology is in the details.

Weight-saving efforts

Taking a multi-pronged approach to the ultimate eco-car, Toyota pursued efficiency right down to the smallest details in the TOYOTA FCHV. Controlling weight is just one example. By using aluminum in the roof, hood, fenders and side doors, the TOYOTA FCHV achieved weight savings of about 40kg.

Aluminum construction for lighter weight



World-leading aerodynamics

A large rear spoiler suppresses turbulence and a flat underbody reduces wind resistance. The result is a Cd* of 0.326, making this one of the most aerodynamic SUVs on the planet. Fuel-efficient tires also contribute to greatly reduced rolling resistance.

*Cd=coefficient of aerodynamic drag

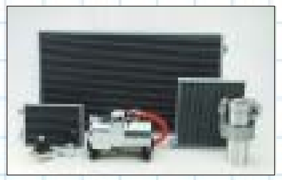
Large rear spoiler

Air flowing across the vehicle's top meets air flowing around the vehicle's sides in a balanced fashion, thereby suppressing turbulence in the vehicle's wake and reducing air resistance.

Global warming coefficient reduced to 1/1300th

Natural CO_2 serves as a non-CFC (chlorofluorocarbon) refrigerant in the air conditioner instead of HFC134a, thereby reducing the potential effect on global warming to the remarkably low level of 1/1300th. Furthermore, low-power-consumption LEDs (light emitting diodes) are employed for the rear combination lamps.

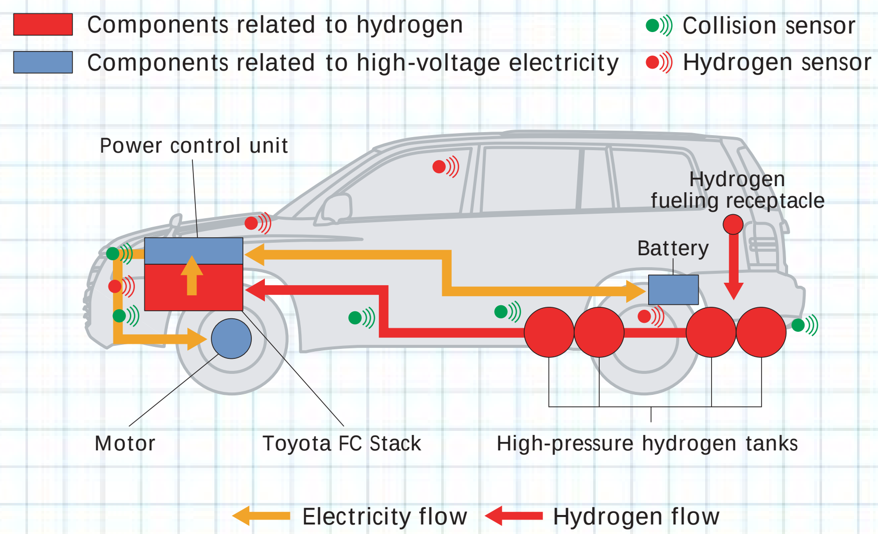
CFC-free CO_2 air conditioner

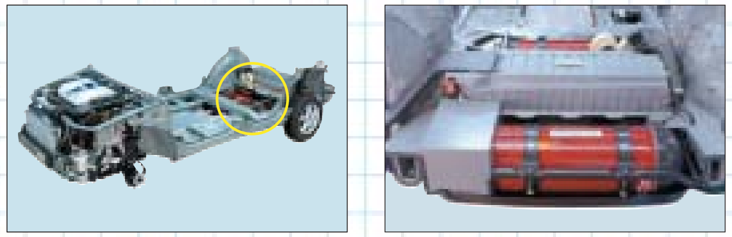


LEDs for rear combination lamps

Comprehensive safety measures

Crash testing of the TOYOTA FCHV was particularly rigorous, with the addition of new safety confirmation tests for high voltage components and for protection against hydrogen leakage. If a collision occurs, sensors in the TOYOTA FCHV's front, rear and sides detect impact and instantly shut the valves on the high-pressure hydrogen tanks. For additional safety, the valves are also closed if leakage is detected by any of the hydrogen sensors placed at multiple locations within the vehicle, namely, on the Toyota FC Stack, the upper end of the hood, the high pressure hydrogen tanks and the cabin ceiling. The high-pressure hydrogen tanks are designed for maximum safety to avoid rupture even if the vehicle suffers a rear-end collision.





Position of the high-pressure hydrogen tanks

June 2001

FCHV-BUS1
Toyota and Hino Motors co-develop a large, low-floor city bus, the FCHV-BUS1, which runs on compressed hydrogen.

October 2001

FCHV-5
Toyota announces the FCHV-5, featuring an onboard CHF reformer, which derives hydrogen from "clean hydrocarbon fuel."

MOVE FCV-K-2
Toyota and Daihatsu co-develop a compact fuel cell system suitable for minicar applications and announce the MOVE FCV-K-2, which runs on compressed hydrogen. Proving on public roads in Japan begins in February 2003.

September 2002

FCHV-BUS2
Toyota and Hino announce the completed development of the FCHV-BUS2, an improved version of the FCHV-BUS1. Public road testing begins in October 2003.

December 2002

TOYOTA FCHV
Toyota begins limited marketing of the TOYOTA FCHV, a refinement of the FCHV-4. Two TOYOTA FCHVs are leased in the U.S. and four in Japan.

August 2003

FCHV-BUS2
FCHV-BUS2 becomes the first fuel cell bus to go into service as part of a municipal bus fleet in Japan.

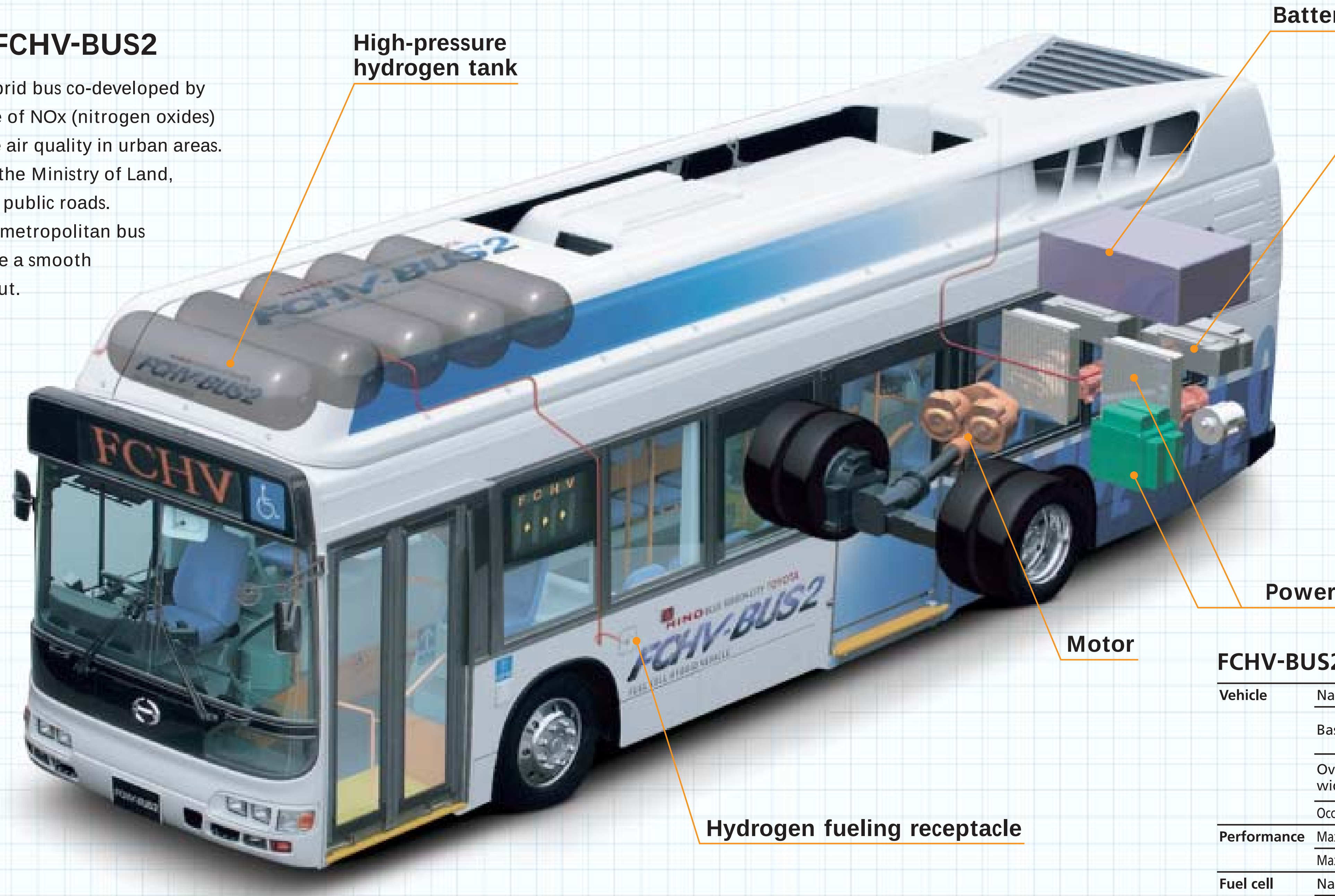
FCHV-BUS2

August 2003: Begins service as a municipal bus on city streets.

Meet you at the bus stop: FCHV-BUS2

The FCHV-BUS2 is a large, low-floor, fuel-cell hybrid bus co-developed by Toyota and Hino Motors. Since its exhaust is free of NOx (nitrogen oxides) and PM (particulate matter), it can help improve air quality in urban areas. In September 2002 certification was granted by the Ministry of Land, Infrastructure and Transport to begin testing on public roads. The FCHV-BUS2 began service as part of Tokyo's metropolitan bus fleet in August, 2003. Additional benefits include a smooth ride and extremely quiet operation inside and out.

Municipal bus model



Position of two Toyota FC Stacks

FCHV-BUS2 Main Specifications

Vehicle	Name	FCHV-BUS2
	Base platform	Blue Ribbon City (Hino low-floor commuter bus)
	Overall length/width/height (mm)	10,515/2,490/3,360
	Occupant capacity (persons)	60
Performance	Max cruising range (km)※	250
	Maximum speed (km/h)	80
Fuel cell	Name	Toyota FC Stack
	Type	Polymer electrolyte fuel cell
	Output (kW)	90×2
Motor	Type	Permanent magnet
	Maximum output (kW (PS))	80 (109)×2
	Maximum torque (N-m (kg-m))	260 (26.5)×2
Fuel	Type	Hydrogen
	Storage method	High-pressure hydrogen storage tank
	Maximum storage pressure (MPa)	35
Battery	Type	Nickel-metal hydride

※Manufacturer's estimate for operation on urban bus routes

An interior with easy-to-use "universal design" for all riders

Pictographs communicate essential information in a format understandable to all ages. The interior design offers an attractive balance of complementary colors and contrasts in brightness.

A smooth start and comfortable ride

The FCHV-BUS2 employs the same Toyota FC Stack as the TOYOTA FCHV. In fact, it uses two of these fuel cell stacks. From the sheer size of this vehicle you might imagine its response would be ponderous. But riding the FCHV-BUS2 soon ends any apprehension. Powerful motor torque assures particularly smooth and quiet acceleration.

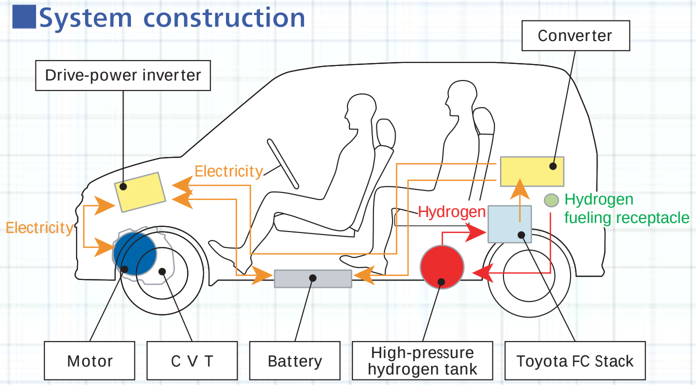
MOVE FCV-K-2

It's the world's smallest.

Road-testing the MOVE FCV-K-2

Jointly developed by Toyota and Daihatsu, the MOVE FCV-K-2 is a fuel cell hybrid that runs on hydrogen carried in a high-pressure tank. In January 2003, it became the first fuel cell minicar approved by Japan's Ministry of Land, Infrastructure and Transport for use on public roads. Road testing began in February 2003. Test data will be used to support further progress in developing the vehicle's potential as a vehicle for urban commuters.

■System construction



Packed with small-car know-how

Compact minivehicles have little free space. Therefore, the power control unit is configured with its drive inverter and converter in separate locations. The Toyota FC Stack and high-pressure hydrogen tank are integrated into a single cartridge-type frame. This modular system is positioned under the rear floor panel to save space. A CVT (continuously variable transmission) makes greater use of the motor's most efficient range.

MOVE FCV-K-2 Main Specifications

Vehicle	Name	Daihatsu MOVE FCV-K-2
	Overall length/ width/height (mm)	3,395/1,475/1,705
	Wheelbase (mm)	2,360
	Seating capacity (persons)	4
Performance	Max cruising range (km)	120※
	Maximum speed (km/h)	105
Fuel cell	Name	Toyota FC Stack
	Type	Polymer electrolyte
	Output (kW)	30
Motor	Type	Permanent magnet
	Maximum output (kW (PS))	32 (44)
	Maximum torque (N-m (kg-m))	65 (6.6)
Fuel	Type	Hydrogen
	Storage system	High-pressure hydrogen tank
	Maximum storage pressure (MPa)	25
Battery	Type	Nickel-metal hydride

※In the Japanese 10-15 test cycle

What's next for the FCHV?

Before fuel cell vehicles can be made available to everybody, a number of technical issues still need to be resolved. In addition to issues of safety and cruising distance, there is the problem that water produced by the fuel cell may freeze when the temperature dips to zero or below, thereby limiting climate suitability. Cost is another major "if." Popularization of fuel cell hybrid vehicles requires further progress in reliability, durability, servicing and recycling. Toyota is committed to tackling these technical issues to quickly bring fuel cell hybrid vehicles to maturity and make FCHV benefits available to the general public as soon as possible.

The low-temperature challenge

When hydrogen and oxygen combine in the fuel cell to generate electricity, the chemical reaction also produces water. If temperatures drop to around −10˚C or −20˚C, this water may freeze inside the fuel cell itself or in the system's pumps and valves, causing difficulties when starting. This may appear a simple problem, but because it is closely related to the principle of fuel cell operation it is not an easy problem to solve.

Looking beyond 300km

The TOYOTA FCHV's current cruising range is about 300km (in the Japanese 10-15 test cycle), which is still far from satisfactory. To match the cruising distance of a gasoline engine vehicle, further improvements in fuel cell and system efficiency are needed and much more hydrogen must be carried on board. Instead of a high-pressure hydrogen tank, we could use a liquid hydrogen tank or a hydrogen-absorbing alloy. However, these are not in themselves solutions. Attaining higher storage efficiency is a difficult challenge that Toyota is facing with further development efforts, including the doubling of maximum tank pressure to 70MPa (about 700 bars).

Well to Wheel

Overall efficiency (well to wheel) is our yardstick.

The conventional way to compare the efficiency of vehicles is by the distance they can travel per unit of fuel (km/l or mpg). However, this method presents difficulties if the cars being compared run on different kinds of fuel such as hydrogen or natural gas.
In such cases, we need to use a yardstick that not only measures how efficiently the car itself uses energy (tank to wheel), but also how efficiently the energy is obtained and transported to the car's tank (well to tank).
This overall measure of efficiency is called "well to wheel."

Overall efficiency (%) ‹well-to-wheel› = **Fuel efficiency (%)*1 ‹well-to-tank›** × **Vehicle efficiency (%)*2 ‹tank-to-wheel›**

*1 Well-to-tank: Efficiency with which the fuel is obtained, processed, stored and transported to the vehicle's tank.
*2 Tank-to-wheel: Efficiency with which the fuel in the vehicle's tank is consumed and converted into vehicle motion at the wheels.

Overall (well-to-wheel) efficiency of the TOYOTA FCHV

	Fuel efficiency ‹well-to-tank› (%)	Vehicle efficiency ‹tank-to-wheel› (%)	Overall efficiency ‹well-to-wheel› (%)
Gasoline vehicle	88	16	14%
Prius (Gasoline HV)	88	37	32%
FCV (compressed hydrogen)	58*3	38	22%
TOYOTA FCHV	58*3	50	29% With hybrid control
FCHV (target)	70	60	42% 3 x Gasoline vehicle

In the Japanese 10-15 test cycle, Toyota in-house testing
*3 Efficiency if hydrogen is produced from natural gas

Comparison makes it clear ... we're not there yet.

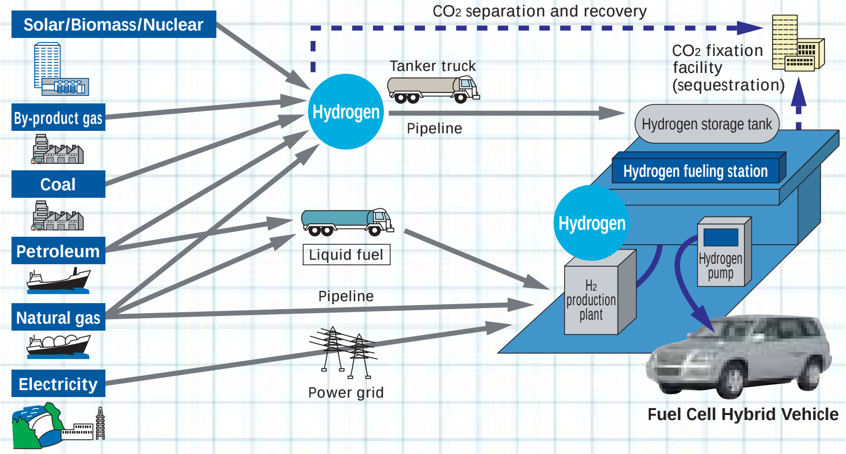
A conventional gasoline car's tank-to-wheel efficiency is 16% and its overall well-to-wheel efficiency is about 14%. In comparison, a hybrid vehicle like the Toyota Prius achieves 37% tank-to-wheel efficiency, more than double that of the conventional gasoline car, for 32% overall efficiency (well to wheel), which is also more than double. The 88% well-to-tank efficiency stays the same for both types of vehicle. The TOYOTA FCHV has a high tank-to-wheel efficiency of 50%, more than triple that of a gasoline car, yet its overall efficiency (well to wheel) remains at 29%. This is because the efficiency with which we currently derive hydrogen from natural gas is still a low 58%. Therefore, Toyota believes that fuel cell hybrid vehicles require at least three times the overall (well-to-wheel) efficiency of gasoline cars if they are to fulfill their role of representing the next generation of automotive technology. Toyota will continue to seek improvements while comparing performance with rival gasoline-hybrid and other types of vehicles.

Hydrogen production

The question is how best to make it.

Hydrogen is an energy carrier that can be made from a variety of sources. The source material and the method of production determine the potential quantity of steady supply, as well as the well-to-tank efficiency and the amount of CO_2 produced during the process. To create a more affluent future society through the use of hydrogen energy, we must think carefully and thoroughly about how best to make, transport, and store hydrogen.

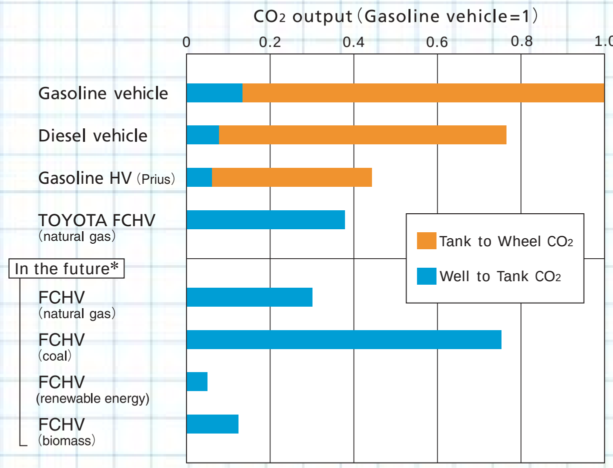
Making hydrogen and supplying it to fuel cell vehicles



The TOYOTA FCHV produces no CO_2, but making hydrogen does.

Although a hydrogen-powered fuel cell vehicle puts out no CO_2 itself, CO_2 is produced when hydrogen is made from fossil fuels. So if we intend to reduce CO_2, we must go beyond tank-to-wheel efficiency and tackle well-to-tank efficiency as well. For example, coal is an abundant and economical natural resource, but making hydrogen from coal produces large amounts of CO_2, so practical CO_2 fixation technologies must be developed to separate, recover and store this carbon in the ground or elsewhere. In addition, while it is true that CO_2 could be reduced if we used renewable energy sources such as solar power or biomass to make hydrogen, the quantity that can be supplied in this way is currently limited. Since hydrogen can be made from many sources, we need to consider production methods from a comprehensive viewpoint, including the economic, supply volume, and environmental (CO_2) aspects.

Well-to-wheel CO_2 output



In the Japanese 10-15 test cycle, Toyota in-house testing
FCHV: Hydrogen fuel

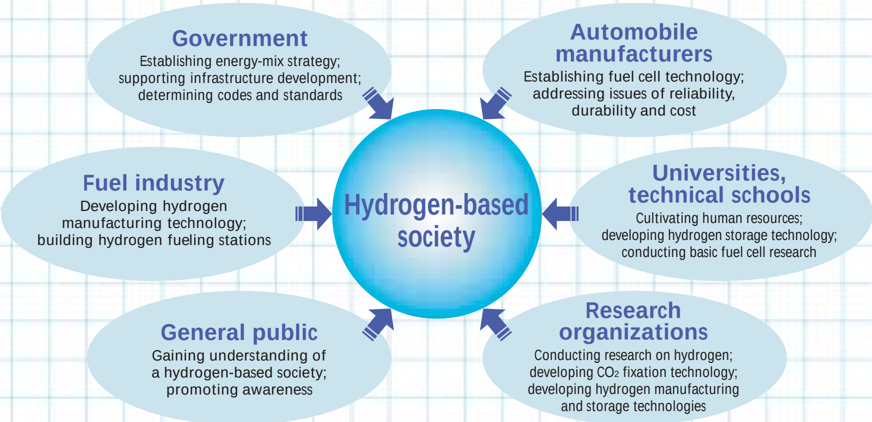
* FCHV refers to direct hydrogen method; items in parentheses are sources of hydrogen.

Preparing our society for hydrogen

At last ... we can see the future.

To promote a smooth shift to a hydrogen-based society,
we need the combined effort of all sectors of society, including the government.
This is clearly the case when it comes to developing hydrogen manufacturing and storage technology,
as well as building the hydrogen fueling station infrastructure.
In our universities and technical schools we must invest in training new specialists.
The establishment of codes and standards is another example of the kinds of issues
that must be tackled in a comprehensive and multifaceted way by society as a whole.

■Promoting a smooth transition to hydrogen



Verification tests are underway

A large project named JHFC is underway in Japan to investigate in detail the energy effectiveness, environmental burden and other aspects of fuel cell vehicle use. Toyota, Nissan, Honda, DaimlerChrysler, GM, Hino, Mitsubishi, and Suzuki are participating to collect basic data through fuel cell vehicle trials on public roads. Also participating are fuel producers who may supply hydrogen in either gas or liquid form at their fueling stations. This hydrogen may be produced by reforming LPG, desulfurized gasoline, methanol or naphtha. Detailed data will be collected on hydrogen production, as well.

■Hydrogen refueling stations in Japan

JHFC hydrogen station name	Hydrogen production method	Built (FY)
Yokohama-Daikoku Hydrogen Station (in JHFC Park)	De-sulfurized gasoline reforming	2002
Yokohama Asahi Hydrogen Station	Naphtha reforming	2002
Senju Hydrogen Station	LPG reforming	2002
Ariake Hydrogen Station	Liquid hydrogen storage (off site)	2002
Kawasaki Hydrogen Station	Methanol reforming	2002
Relocatable Hydrogen Station	High-pressure hydrogen storage	2002
Yokohama Tsurumi Hydrogen Station	Byproduct gas reforming (off site)	2002
Sagamihara Hydrogen Station	Alkali water electrolysis	2003
Hatano Hydrogen Station	Kerosene reforming	2003
Oume Hydrogen Station	City gas reforming	2003

■Japan Hydrogen & Fuel Cell Demonstration Project (JHFC)

JHFC
Japan Hydrogen & Fuel Cell Demonstration Project

1. Period: Fiscal 2002-2004
2. Area: Tokyo, Yokohama and surrounding areas
3. Goal: To achieve the following relating to fuel cell vehicles and hydrogen fueling stations:
   ① Clarification of the significance of introduction (achieving energy security, improving efficiency, protecting the environment)
   ② Collection of data useful for establishing codes and standards related to safety and other issues
   ③ Enhancement of public awareness through promotional activities

Excitement Ahead!

Flexible, innovative design potential

Fuel cell vehicles not only offer potential solutions to environmental and energy issues, but may also change the very shape of the cars we drive. Gasoline vehicle design must accommodate mechanical methods of transmitting engine power to the wheels. In contrast, a fuel cell provides power electrically, while producing little heat, noise or vibration, so it can be mounted almost anywhere on the vehicle. As an example, the Fine-N, shown at the 37th Tokyo Motor Show, has its fuel cell and system components mounted compactly under the floor. Together with its drive-by-wire control system and in-wheel motors, this permits a flat floor and extremely long cabin interior. The result is a new vision of mobility designed with the priority on human comfort.

■All new package, inside and out

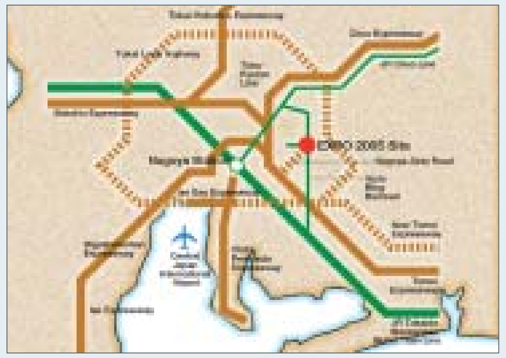
Fine-N, shown at 37th Tokyo Motor Show

See you at EXPO 2005 AICHI!

EXPO 2005 AICHI (Exposition of Global Harmony) will propose solutions for a world society that utilizes nature's wisdom to deal more effectively with the issues we face in the 21st century. Toyota will help transport visitors with a new IMTS public transit system, as well as fuel cell hybrid buses. Don't miss this opportunity to experience the comfortable and convenient future of public transportation!

*IMTS: (Intelligent Multimode Transit Systems)

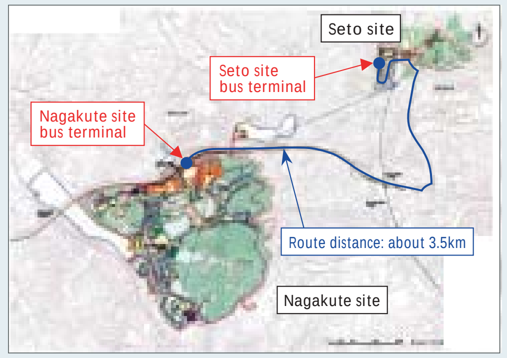
■EXPO 2005 AICHI



Duration: March 25 through September 25, 2005

Site: Aichi Prefecture, east of Nagoya (Nagakute Town, Toyota City, Seto City)

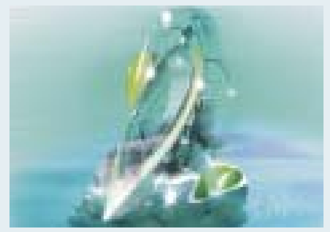
■Fuel cell hybrid bus route



Route planned for FC (fuel cell) bus service

Toyota Group Pavilion

The Toyota Group pavilion at EXPO 2005 AICHI will offer a "Mobility Performance Show" featuring the *i-unit* and other concept vehicles and advanced technologies. This entertainment will dramatize the future of mobile technology and its potential role in society under the theme of "the dreams, pleasure and excitement of mobility in the 21st century." The Toyota Group pavilion will employ renewable/recyclable resources, including wind power generation to minimize CO_2 production.



i-unit

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Revised in January 2004 PRE-04BC01