

# TOWARD THE ULTIMATE ECO-CAR

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*Toyota Powertrain Technology for Sustainable Mobility*



**TOYOTA**



## MAKING THE WORLD GREENER, ONE STEP AT A TIME

**T**oyota believes in doing what we can “today for tomorrow”. That belief led to the launch in 1997 of the world’s first mass-produced gasoline-electric hybrid car, the Toyota Prius. The Prius was more than just a revolution in powertrain technology. It also catalyzed a revolution in consciousness. Sustainable mobility would never again be merely a dream. It was achievable ... if automakers, consumers and governments wanted it to happen. Here are the many ways Toyota is working to make the dream come true.



# INNOVATION FOR SUSTAINABLE MOBILITY

**B**y providing freedom of mobility for people and goods, automobiles make people's lives more convenient and fulfilling. But automakers have a responsibility to minimize the negative impact of automobiles and help achieve sustainable mobility. Powertrain innovation can contribute to this endeavor in three ways: 1) by improving fuel efficiency, 2) by making exhaust emissions cleaner and 3) by supporting energy diversification.



## 1) Greater **EFFICIENCY** –

Since humans learned to harness fossil fuels to operate machines, the concentration of carbon dioxide in the atmosphere has steadily risen. Toyota is developing more efficient automobile engines and transmissions to help control CO<sub>2</sub> emissions and mitigate the dangers of global warming.

*Powertrain innovation can contribute to sustainable mobility in three key ways.*



2) Greater **CLEANLINESS** –

In Japan and many other countries and regions, air quality has steadily improved since the early 1970s, thanks to technological innovation, often in advance of regulatory changes. However, there is still room for improvement. The entire Toyota Group is working toward this goal.

3) Greater **DIVERSITY** –

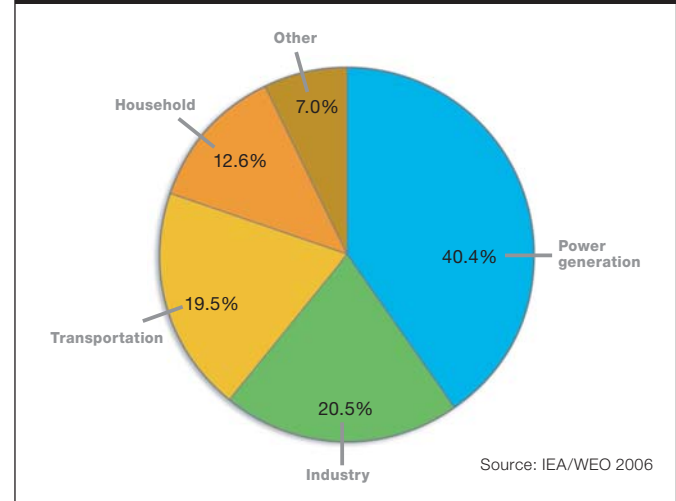
As the world's energy needs escalate, automotive fuels will also have to diversify in response to soaring petroleum prices, concern about depletion of petroleum reserves and other pressures. Alternative fuels, such as biofuels, hydrogen and electricity, hold promise for the future.

## EFFICIENCY



**T**ransportation accounts for about 20% of the world's CO<sub>2</sub> emissions from energy sources, so it is critical for the auto industry to reduce CO<sub>2</sub> emissions. As an automaker, Toyota is striving to raise fuel economy and thereby help control CO<sub>2</sub> emissions. Hybrid technology is a core technology in this endeavor.

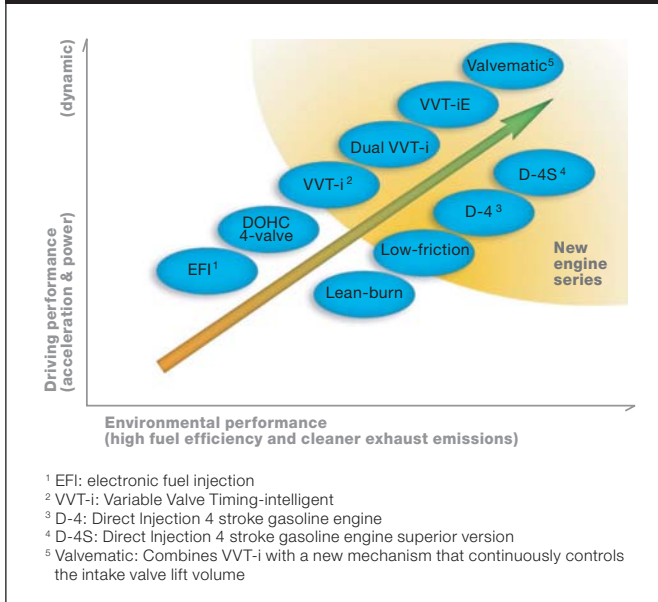
Worldwide CO<sub>2</sub> emissions by sector — 2004



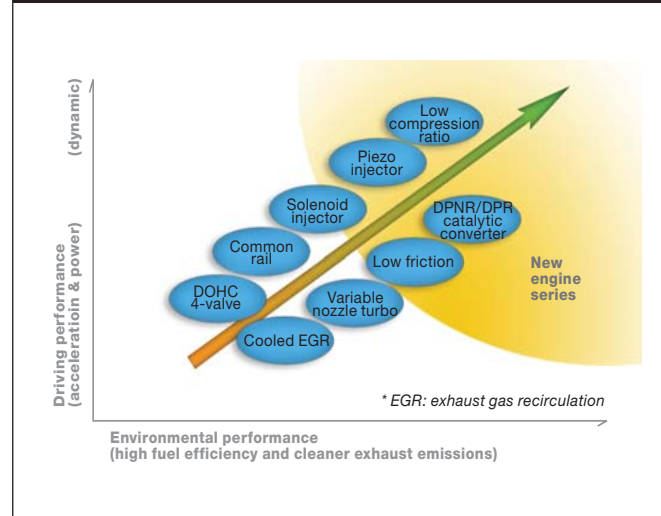
### A new generation of engines

Toyota has made significant progress on the environmental front by introducing the latest engine design and electronic control technologies. Beginning

#### Efficient & clean gasoline engine evolution



#### Efficient & clean diesel technology evolution

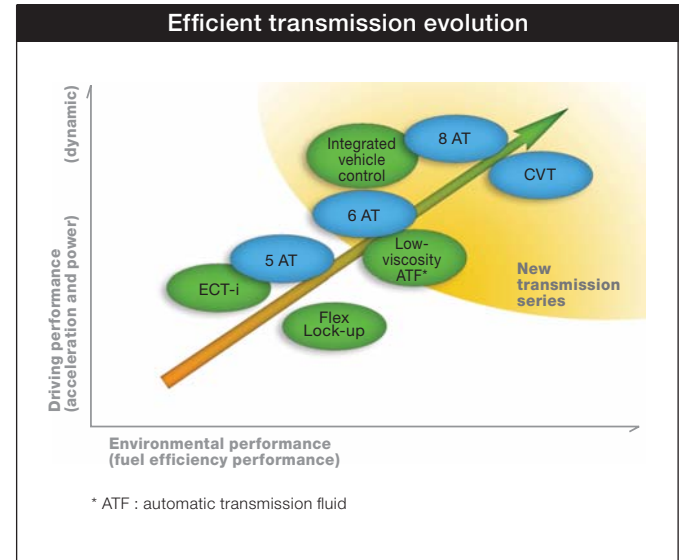


with the V6 engine developed in 2003, Toyota intends to completely revamp its engine and transmission lineup by 2010, to pursue improved fuel efficiency and cleaner exhaust emissions.

# EFFICIENCY

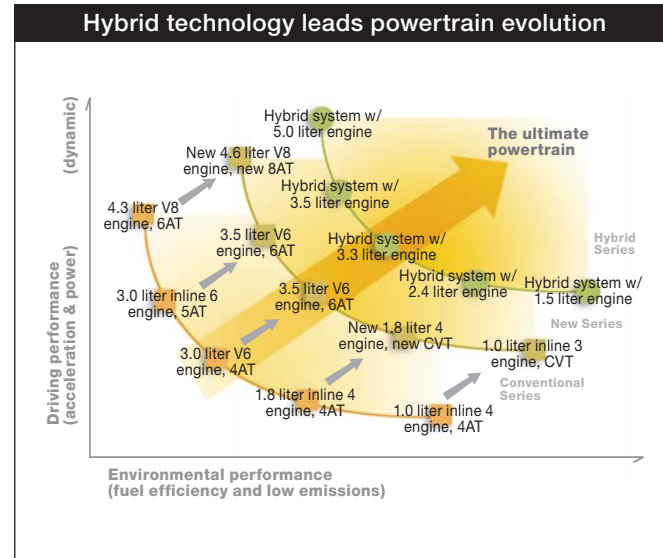
## A new generation of transmissions

Toyota is enhancing efficiency together with “acceleration feel” in multi-range automatic transmissions such as our 8-speed AT and new CVT (continuously variable transmission).



### Powertrain evolution

Toyota's engine and transmission technologies seek a sophisticated fusion of environmental performance and driving performance. Hybrid technology has the potential to raise this fusion to an even higher level. Toyota plans to double its hybrid vehicle lineup by the early 2010s.

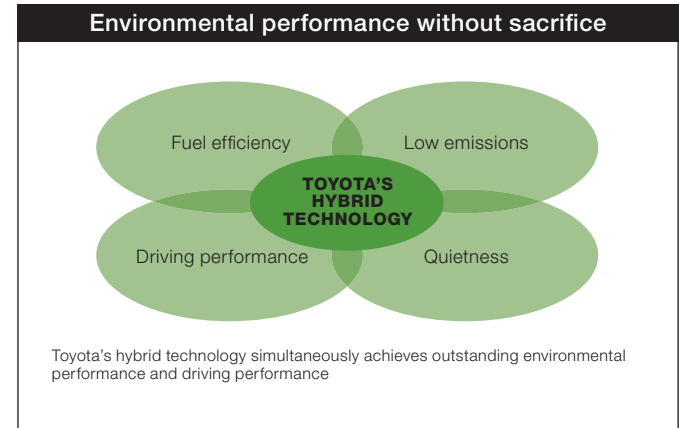


# EFFICIENCY

## Expanding hybrid popularity

Toyota's hybrid system, as implemented in the Prius, is a new type of powertrain that combines the advantages of two kinds of power sources: the electric motor and the gasoline engine. The result is world-class performance in terms of the fuel efficiency, clean emissions, driving excitement and quiet operation desired in today's motor vehicles.

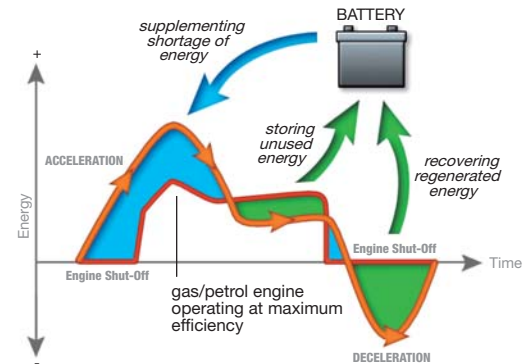
In May 2007, global cumulative sales of Toyota hybrid vehicles topped the 1 million mark. Over the 10 years since the Prius was launched in 1997, Toyota hybrid vehicles have produced approximately 3.5 million tons less CO<sub>2</sub> compared with the same class of gasoline-powered vehicles of similar size and driving performance (according to Toyota calculations).



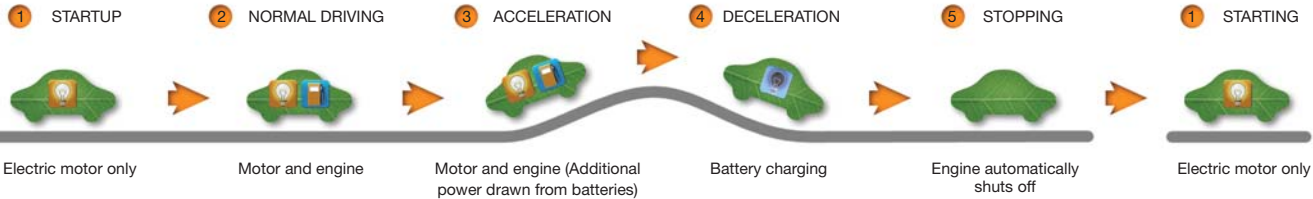
### The HYBRID advantage

Hybrid technology is an energy management technology that aims to raise efficiency in every way possible. Hybrid vehicles recover energy that in conventional powertrains is lost during deceleration or that appears as surplus energy during cruising. Therefore, hybrid technology can significantly raise efficiency and reduce CO<sub>2</sub>, while also delivering excellent driving performance.

### How hybrid technology maximizes efficiency



### How it works



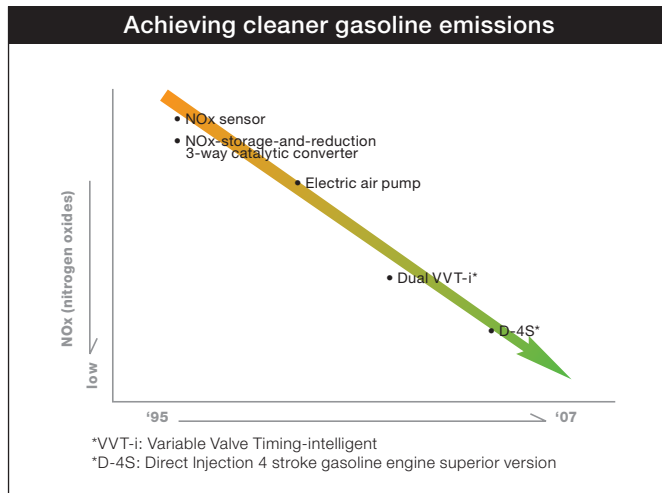
A background image of a waterfall with water cascading over rocks, creating a sense of movement and freshness. The water is a vibrant blue-green color, and the rocks are dark and textured.

## CLEANLINESS

Cleaner emissions can be achieved in several ways: by burning conventional fuels more efficiently, by implementing technology that removes noxious substances, and by using energy sources that are clean-burning or that do not “burn” at all. Toyota’s policy for emissions reduction is to take appropriate measures based on assessment of the urban environmental conditions in each country and each region.

### Even cleaner gasoline engines

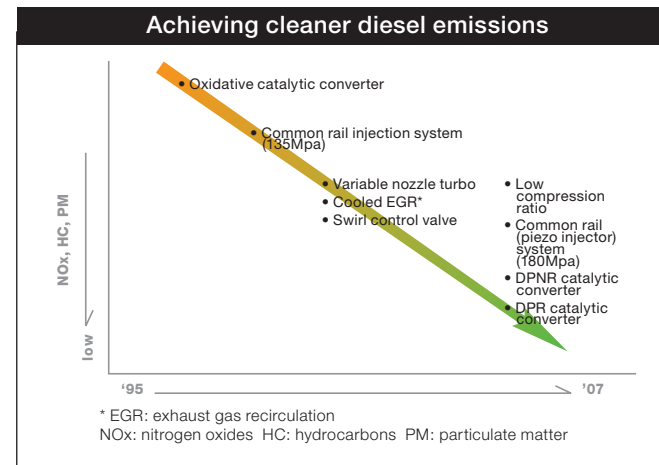
Though much progress has been made in gasoline engines, Toyota keeps setting its sights higher. Through the proactive development and introduction of advanced technologies, Toyota is seeking to improve engine operation and provide cleaner emissions in today's and tomorrow's motor vehicles.



### The “clean diesel” challenge

A major challenge for improving air quality today is cleaning up diesel engine exhaust gases. Toyota D-CAT<sup>1</sup> (Diesel Clean Advanced Technology) with DPNR (Diesel PM and NOx Reduction system) reduces NOx and PM emissions 50% and 90% below EURO4<sup>2</sup>, respectively.

<sup>1</sup>D-CAT: In 2003, Toyota revolutionized the diesel engine by combining different technologies into a single new integrated concept called Toyota D-CAT  
<sup>2</sup>EURO4: emissions regulations implemented in EU from 2005



# CLEANLINESS

## Cleaner fuels

Besides making cleaner-running engines, Toyota is also working with the energy industry to develop cleaner fuels.

- **Fischer-Tropsch (FT) synthetic diesel fuel**

Using this ultra-clean GTL (gas-to-liquids) fuel in Toyota D-CAT enables extremely low emissions with a dramatic reduction of NOx and particulate matter compared with conventional diesel performance.



*To verify the clean potential of FT synthetic diesel, Toyota and Shell conducted road tests using the Avensis with Toyota D-CAT technology*

### **The HYBRID advantage**

*Carbon dioxide (CO<sub>2</sub>) is always produced when an engine burns gasoline. Other emissions are carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>) and hydrocarbons (HC).\** Hybrid technology addresses this issue in three ways: (1) outstanding fuel efficiency, to use less fuel and thereby produce less CO<sub>2</sub> and other emissions; (2) cleaner combustion, to suppress generation of CO, NO<sub>x</sub> and HC; and (3) by employing various devices to clean the exhaust gases. As a result, hybrid technology achieves exhaust emissions that are among the cleanest in the world.

*\* CO<sub>2</sub> is recognized worldwide as a factor in global warming; CO/NO<sub>x</sub> can be harmful to health if inhaled; NO<sub>x</sub>/HC are factors in the production of photochemical smog; NO<sub>x</sub> is one of the substances in acid rain.*

### **About half the CO<sub>2</sub> and NO<sub>x</sub>/HC emissions**

*Prius produces about 55% less CO<sub>2</sub> and nearly half the NO<sub>x</sub>/HC of other cars of the same class equipped with emissions control devices.\**

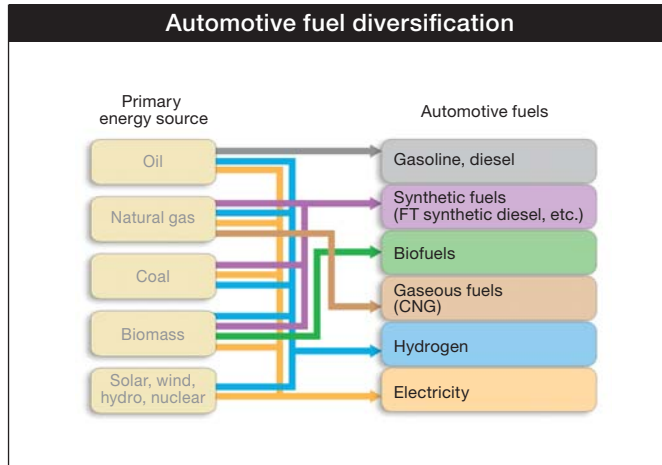
*\* For Prius of 1,260kg or less kerb weight, driving under specific testing conditions.*





## DIVERSITY

In the short term, we must conserve oil as the mainstream transportation fuel. Over the medium and long term, however, energy sources will gradually diversify, so we must begin now to develop technologies that support the most promising of these.



*Automotive energy sources will diversify along with primary energy diversification. Technological development must take into account the merits and demerits of each type of alternative fuel*

### **Biofuel**

The term “biofuel” refers to automotive fuels made from plant sources such as sugarcane. Biofuels can help reduce CO<sub>2</sub> emissions and control fossil-fuel consumption. Toyota already has the technology to

allow all its gasoline engines to run reliably on gasoline with 10 percent bio-ethanol content. Toyota began selling 100% bio-ethanol-compatible Corolla flex-fuel vehicles (FFV) in Brazil in 2007 and is planning to launch a Tundra FFV in the U.S. market in 2008. Together with Nippon Oil Corporation, Toyota is also developing new biodiesel fuel technology.

### **Synthetic fuel**

Synthetic gas-to-liquid (GTL) fuel can be derived from natural gas and supplied as a diesel blend or clean alternative to diesel fuel. Toyota believes that Fischer-Tropsch (FT) synthetic diesel is the appropriate choice among the GTL technology options. It is sulfur free and aroma free and has a high cetane rating.

# DIVERSITY

## Hydrogen

Hydrogen can be made from a variety of raw materials and does not produce any CO<sub>2</sub> when it is consumed as a fuel. The need for a refueling infrastructure is one of several issues that must be addressed if hydrogen is to gain wider use. Since 2002, Toyota has leased the Toyota FCHV (fuel-cell hybrid vehicle), the first-ever market-ready fuel cell vehicle, in the U.S. and Japan. Toyota has also overcome the issues of sub-zero startup and cruising range: In 2006,



*FCHV can start up at -30°C*

the Toyota FCHV achieved -30°C startup; in 2007, it drove 560 kilometers, from Osaka to Tokyo, without refueling. As R&D continues, Toyota is accelerating toward FCHV vehicle popularization.

## Electricity

An adequate supply of electricity can be generated from a wide variety of sources. Besides providing clean operation, electricity offers potential cost advantages. As battery technology progresses, vehicles using electricity will become an increasingly viable alternative, particularly in urban areas.

## **CNG**

Compressed natural gas (CNG) is a clean and efficient fuel with low CO<sub>2</sub> and noxious emissions discharge characteristics.




*Dyna CNG truck introduced in Japan*

## **The HYBRID advantage**

*Hybrid technology can help maximize the merits of all energy sources, whether they are conventional fuels such as gasoline and diesel or alternative fuels such as bio-ethanol, hydrogen and electricity.*

## FUTURE TECHNOLOGY



**T**o make the dream of the “ultimate eco-car” a practical reality as soon as possible, Toyota is developing innovative technologies for the future.

## Fuel-cells

Toyota's FCHV is one of the most tantalizing combinations of hybrid technology and alternative energy. The Toyota Group is pursuing the development and commercialization of fuel-cell technology for passenger cars, buses and other applications.

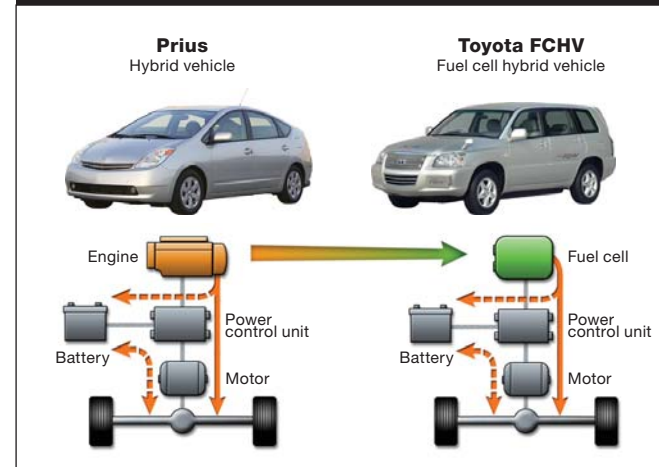


Toyota Group companies cooperate in fuel-cell technology R&D

## Zero emissions?

A fuel cell makes electricity by combining hydrogen and oxygen in a chemical reaction. Since the fuel cell generates electricity without hydrogen combustion, it is both clean and extremely efficient. In principle, a fuel cell produces no CO<sub>2</sub> or harmful emissions; its only by-product is water.

### Hybrid systems of Prius and Toyota FCHV



# FUTURE TECHNOLOGY

## Plug-in hybrid

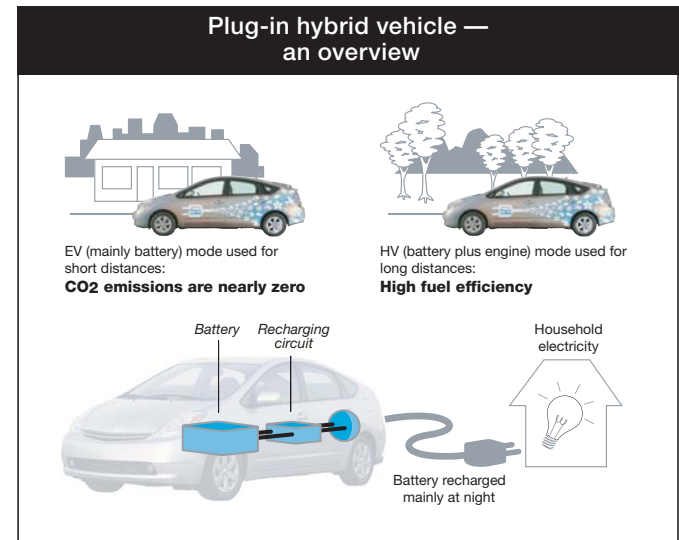
A plug-in hybrid vehicle operates as an electric vehicle (EV) mainly for short trips around town. But for longer trips and high-speed driving, it operates as a conventional gasoline-electric hybrid vehicle (HV). It can be recharged at night using ordinary household current. Plug-in hybrids can be expected to help improve local air quality, not to mention reducing CO<sub>2</sub> output.

In 2007, Toyota began testing its plug-in hybrid vehicle prototype on public roads in Japan, Europe and North America as a step toward commercial feasibility.

*Doing what we can today for the earth of tomorrow*

## Innovation toward commercialization

Acceptance of plug-in hybrids depends on extending their EV mode cruising range and energy saving performance. Therefore, Toyota is seeking innovations in battery technology that can raise energy capacity and output while reducing size and weight.

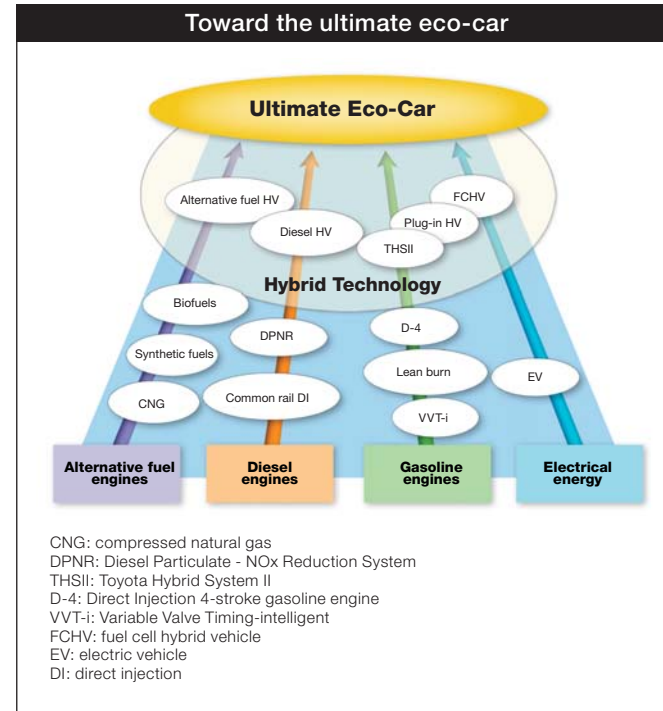


# HYBRID TECHNOLOGY

*Multiple pathways to the ultimate eco-car*

Hybrid is a core technology for the 21st century

On the way to the ultimate eco-car, Toyota is developing innovative technologies for the future while continuously improving the mainstream technologies of today. In this way, Toyota aims to satisfy the diverse needs of customers around the world and simultaneously bring us closer to sustainable mobility. Hybrid technology plays a key role in this endeavor as a core technology for the 21st century that can be applied to all types of powertrains.



*Toyota is developing hybrid technology as a core technology applicable to all powertrains*

*Toyota Motor Corporation positions global environmental preservation as one of its priority management issues in terms of corporate social responsibility. TMC is continuing to enhance its development of environmentally friendly vehicles and environmental technologies as it strives to deliver technologies and products that contribute to realizing sustainable mobility. TMC is also working to actively implement measures in accordance with its basic environmental policy, the Toyota Earth Charter, and in line with the Toyota Environmental Action Plan, which sets out specific medium and long-term activity targets.*

For further details, please visit [www.toyota.co.jp/en](http://www.toyota.co.jp/en)



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