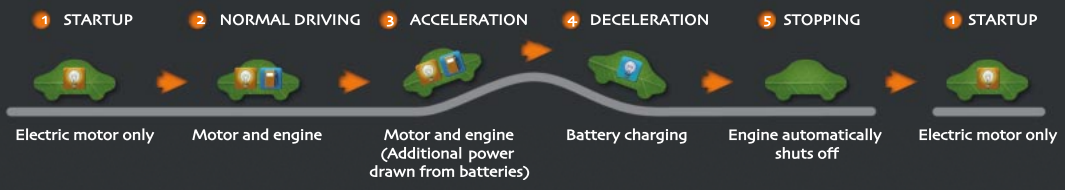
Q. *Is it really feasible to produce a car that offers advanced performance features while also preserving the environment?*

A GUIDE TO HYBRID SYNERGY DRIVE

HOW IT WORKS



STARTUP:
Only the electric motor is used for start-up and low to mid-range speeds.

NORMAL:
When cruising, the engine and motor both drive the wheels: engine power is split between the wheels and an electric generator, which in turn drives the motor. Power allocation is controlled to maximize efficiency. As necessary, the generator also recharges the battery from surplus engine power.

HARD ACCELERATION:
The battery supplies additional energy to boost drive power, while the engine and motor provide smooth acceleration response.

DECELERATION/ BRAKING:
The high-output motor acts as a high-output generator, driven by the car's wheels. This "regenerative braking system" recovers kinetic energy as electrical energy, which is stored in the high-performance battery.

... and it never needs to be plugged in for recharging.

TOYOTA

Q.

Is it really feasible to produce a car that offers advanced performance features while also preserving the environment?

WHAT IS A HYBRID SYSTEM?

The best features of both a gasoline engine and a battery-power system, but only one fuel – gasoline.

A hybrid system combines different power sources to maximize each one's strengths, while compensating for each other's shortcomings. A gasoline-electric hybrid system, for example, combines an internal combustion engine's high-speed power with the clean efficiency and low-speed torque of an electric motor that never needs to be plugged in.

A. YES!

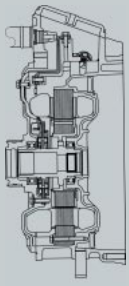
Ordinary powertrains waste energy at stoplights, during braking, and all other times the engine is not running at optimum speed under ideal load conditions. By reducing energy wastage and applying energy more efficiently, a hybrid system can simultaneously double fuel economy, slash emissions and deliver "fun to drive" performance.

HIGH EXPANSION RATIO ATKINSON CYCLE GASOLINE ENGINE

The engine operates at optimum speed for high efficiency. This 1.5-liter engine also extracts more energy from gasoline combustion by using the high expansion-ratio Atkinson Cycle.

GENERATOR

To charge the battery and supply power to the high-output motor, the generator is rotated at up to 10,000 rpm (vs. 6,500rpm in Toyota's previous hybrid system). This improves acceleration at low and medium speed.



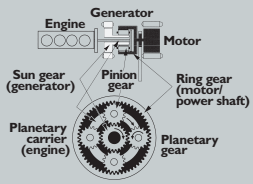
BATTERY

The sealed nickel-metal hydride (Ni-MH) battery is more compact and has higher power density than Toyota's previous battery. It is charged by the engine via the generator at cruising speed, and by the motor during regenerative braking.

New Prius, Japanese-market model

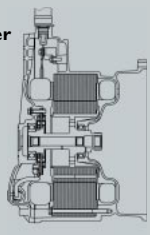
POWER SPLIT DEVICE

This splits power from the engine into two routes: mechanical and electrical. Its planetary gear can transfer power between engine, motor, generator, and wheels in almost any combination. Also called "hybrid transaxle."



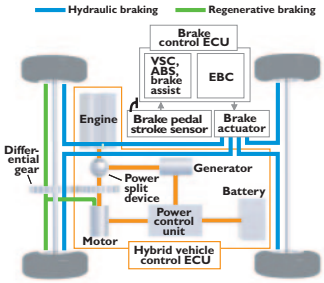
MOTOR

This permanent-magnet electric motor features neodymium magnets in an optimum V shape, to produce 50kW high output and high torque at 500V, a 1.5 times improvement over Toyota's previous hybrid system.



REGENERATIVE BRAKING

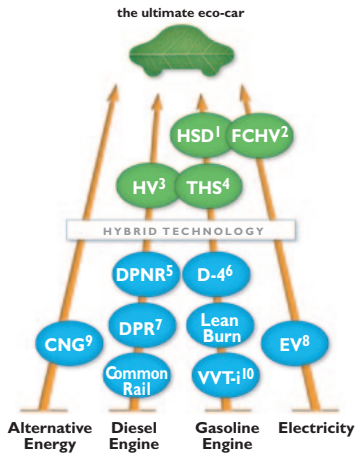
Instead of wasting energy as heat, this system uses the motor as a generator to convert braking energy into electricity. It is particularly effective in stop-and-go city driving.



POWER CONTROL UNIT (INVERTER)

This contains an inverter that converts DC from the battery into AC for driving the motor. Its high-voltage power circuit raises the power supply to 500V, up from 274V in Toyota's previous hybrid system.

Toyota has a long history of continuous improvement when it comes to conventional engines, including lean-burn gasoline engines, direct injection gasoline engines and common rail direct-injection diesel engines, as well as engines modified to use alternative fuels, such as compressed natural gas (CNG) or electricity (EV). In December 2002, we launched limited sales of the Toyota FCHV, a Fuel Cell Hybrid Vehicle that runs on high-pressure hydrogen.



1 **HSD**: Hybrid Synergy Drive, 2 **FCHV**: Fuel Cell Hybrid Vehicle, 3 **HV**: Hybrid Vehicle, 4 **THS**: Toyota Hybrid System, 5 **DPNR**: Diesel Particulate NOx Reduction, 6 **D-4**: Direct Injection 4-stroke, 7 **DPR**: Diesel Particulate active Reduction System 8 **EV**: Electric Vehicle, 9 **CNG**: Compressed Natural Gas, 10 **VVT-i**: Variable Valve Timing with intelligence

This is all part of our search for the ultimate eco-car.

Hybrid technology's potential is becoming clearer by the day. At Toyota, we do not regard hybrid technology as simply a steppingstone to the age of fuel cell vehicles. We see it as the core technology that will become dominant in the eco car market and eventually evolve to form the basis of what we call the "ultimate eco car."

Our engineers may disagree about which fuel or car propulsion system is best. But they do agree that hybrid technology is the core for eco-car development.

We develop these key technologies in-house to reduce costs and rapidly commercialize their application.

One of the yardsticks to assess the environmental cost of a future technological scenario is well-to-wheel efficiency. This expresses the overall efficiency of an energy source, from extraction to when it turns a vehicle's wheels.

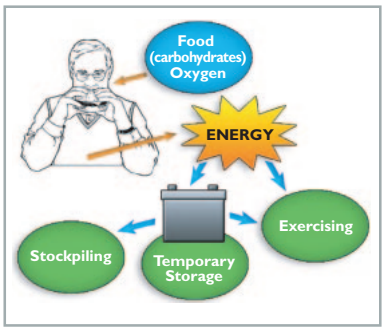
	Well-to-Tank[1] (fuel production efficiency) (%)	Tank-to-Wheel[2] (vehicle efficiency) (%)	Overall efficiency (Well-to-Tank x Tank-to-Wheel) (%) 10 20 30 40
Recent Gasoline Car	88	16	14
Previous Prius	88	32	28
New Prius		37	32
Toyota FCHV[3]	58	50	29
FCHV Target[3]	70	60	42

1. Source: Toyota study, Japanese energy conditions 2. Source: Toyota in-house testing, Japanese 10/15 mode 3. Hydrogen from CNG

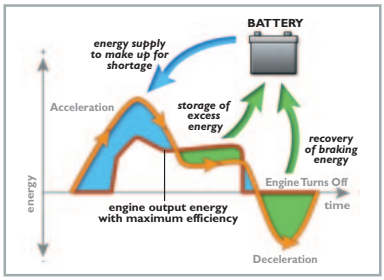
Well-to-wheel calculations (see-chart) illustrate that, regardless of power source, Toyota's hybrid technologies increase efficiency substantially.

A STRATEGY FOR LIFE

Hybrid technology is a rediscovery of an energy strategy that living things depend on. Humans and other animals store energy temporarily so that they can access it quickly when needed.

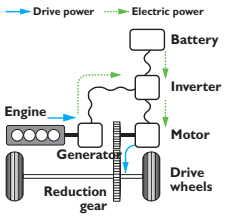


Like our metabolic system, Toyota's hybrid technology saves fuel by storing energy and adjusting intelligently to each situation.



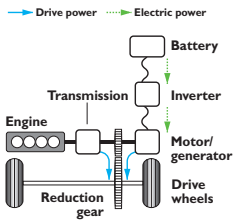
A high-performance battery stores energy that is ordinarily wasted while driving or stopping, and then applies the stored energy when starting and to supplement engine power when accelerating. Since the system recharges itself, it never needs plugging in.

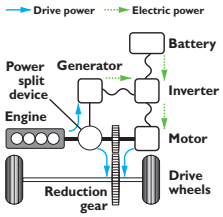
3 KINDS OF HYBRIDS



SERIES HYBRID: Electric motor drives wheels; engine's only job is to generate electricity.

PARALLEL HYBRID: Engine is main way of driving wheels; motor assists for acceleration.





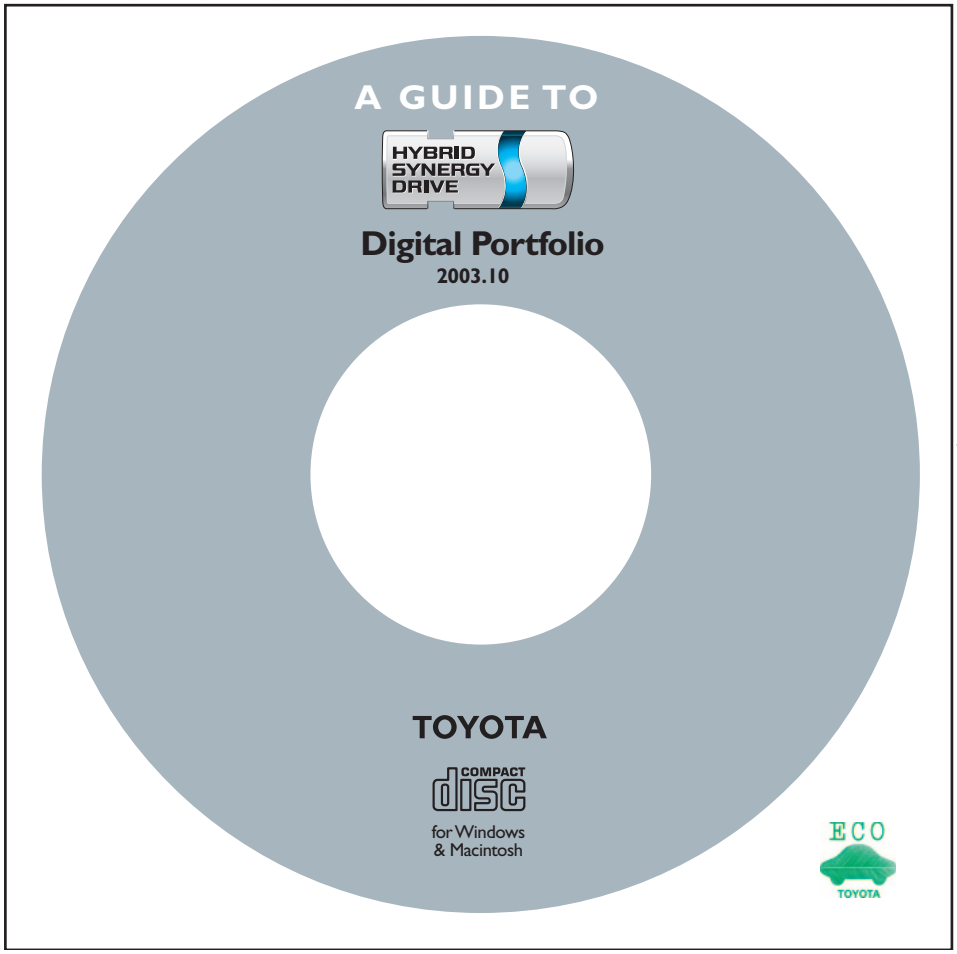
SERIES/PARALLEL HYBRID (Prius): "Power split device" delivers a continuously variable ratio of engine/motor power to wheels. Can run in "stealth mode" on its stored electricity alone.

ARE ALL HYBRIDS CREATED EQUAL?

Toyota perfected the series/parallel or "strong" hybrid to deliver the energy-saving benefit of a series hybrid together with the acceleration benefit of a parallel hybrid. Two key technologies – the power split device and sophisticated energy management – make this possible. They constantly optimize the flows of mechanical power and electric power for safe and comfortable vehicle operation at the highest possible efficiency.

	Fuel economy improvement				Driving performance	
	Idling stop	Energy recovery	High-efficiency operation control	Total efficiency	Acceleration	Continuous high output
Series	●	◎	●	●	○	○
Parallel	●	●	○	●	●	○
Series/ parallel	◎	◎	◎	◎	●	●

◎ Excellent ● Superior ○ Somewhat unfavorable



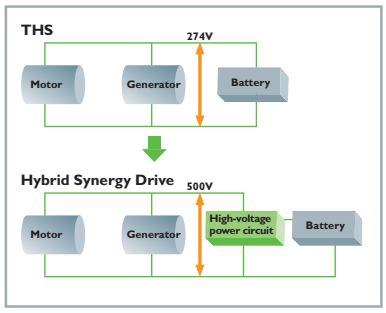
CD contains a digital portfolio of the contents of this brochure. Windows and Macintosh compatible.

GOALS ~ of ~ HYBRID SYNERGY DRIVE DEVELOPMENT

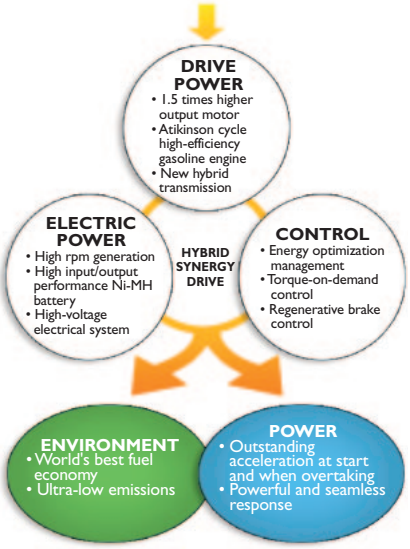
A MORE POWERFUL SYNERGY

In a conventional powertrain, there is a tradeoff between power and efficiency. If you try to raise one, you reduce the other. All things being equal, the larger your engine, the lower your gas mileage. Hybrid Synergy Drive rearranges this relationship. Instead of compromising or sacrificing, it seeks synergies.

In the new Prius, Hybrid Synergy Drive achieves a more powerful synergy by boosting the hybrid system's voltage to a maximum of 500V (up from 274V in the previous Prius). A higher voltage means that electrical power can be supplied to the motor using a smaller current to increase efficiency. Or, if current is kept the same, the higher voltage can be used to raise power.



Objective: Compatibility of Environmental & Power Performance

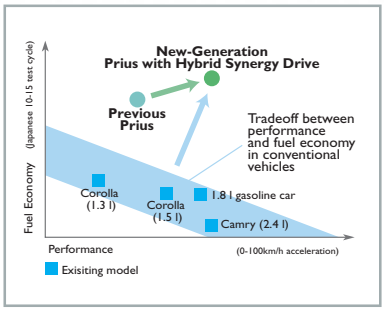


In developing Hybrid Synergy Drive, Toyota sought ways to strengthen engine and motor power, raise electric power, and improve energy management for more efficient and effective control of the energy made available. The benefits are world leading environmental performance and more powerful acceleration for a higher "fun to drive" quotient.

MORE FUN TO DRIVE

In addition to its high-voltage power circuit, Hybrid Synergy Drive also employs a higher-performance battery and a higher-speed motor and generator. Together with enhanced energy management, these enable 1.5 times the motor power of Toyota's previous hybrid system, while attaining even greater fuel economy.

Side benefits include "torque on demand," an innovation that gives added traction on slick roads by taking advantage of the power split device.



For the driver, the combination of greater motor power and engine power, plus greater control in Hybrid Synergy Drive provides a more powerful, smoother and safer driving experience.

It's a solution whose time has come, just in time.

HYBRID — PAST, PRESENT, FUTURE

A "strong hybrid" system like Hybrid Synergy Drive can use its gasoline engine and electric motor in any combination and even run on just its stored electricity.

New Toyota Prius is first to use Hybrid Synergy Drive. Japanese model, shown here, achieves 35.5km/l fuel efficiency, more than twice that of a 1.5-liter Corolla, and is fully compliant with Japan's most stringent Ultra-Low Emissions Level regulations.*

**10-15 Japanese test cycle*

We have also created other kinds of hybrids to help lighten the environmental load every way we can.

Our latest SU-HV1 concept features a Hybrid Synergy Drive application optimized for the large displacement and output of a V6 engine. It uses a faster 120kW front motor and a 50kW rear motor for higher torque and higher output with a more powerful electrical system. A V6 (3.3-liter) engine using this technology can deliver V8-level performance, with fuel efficiency and emissions at compact car levels, twice as good as those of an SUV of equal displacement.

First-generation Prius, introduced in 1997, was world's first mass-produced gasoline-electric hybrid car.

We will keep on developing further applications of hybrid technology because we believe it is a core technology. Toyota's hybrid systems can be integrated with many kinds of propulsion systems – not just gasoline engines, but also diesel engines, alternative energy vehicles, and fuel cell vehicles. And Toyota's Hybrid Synergy Drive technology is robust, powerful and flexible enough to enhance the environmental and driving performance of virtually any type of car, from family sedans to minivans and luxury vehicles.

SU-HV1 concept: New-generation SUV with high-power hybrid system.

This is really just the beginning. Hybrid technology will continue to evolve even further.

MILESTONES IN TOYOTA HYBRID VEHICLE DEVELOPMENT

1977
Toyota Sports 800 Gas Turbine (GT) Hybrid prototype

1997
Coaster Hybrid Bus*

1997
Prius launched in Japan (2000 in U.S., Europe & other regions)

2001
Estima Hybrid*

2001
Crown Hybrid*

2002
Toyota FCHV (Fuel Cell Hybrid Vehicle) launched in Japan & U.S.

2003
New Prius

...and more to come.

** Only for Japanese market*

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