How Hybrid Cars Work
by Karim Nice

Have you pulled your car up to the gas pump lately and been shocked by the high price of gasoline? As the pump clicked past $20 or $30, maybe you thought about trading in that SUV for something that gets better mileage. Or maybe you're worried that your car is contributing to the greenhouse effect. Or maybe you just want to have the coolest car on the block.

The auto industry now has the technology that might answer all of these needs. It's the **hybrid car**, and a few manufacturers are selling their versions in the United States. You're probably aware of hybrid cars because they've been in the news a lot. In fact, most automobile manufacturers have announced plans to manufacture their own versions -- you can even expect some hybrid SUVs to hit the streets this year.

The 2000 Honda Insight hybrid electric car

How does a hybrid automobile work? What goes on under the hood to give you 20 or 30 more miles per gallon than the standard automobile? And does it pollute less just because it gets better gas mileage? In this article, we'll help you understand how this amazing technology works. We'll show you what is going on in the Toyota and Honda hybrids, and even give you some advice about how to drive one for maximum efficiency!

What Makes it a "Hybrid"?

Any vehicle is a hybrid when it combines two or more sources of power. In fact, many people have probably owned a hybrid vehicle at some point. For example, a **mo-ped** (a motorized pedal bike) is a type of hybrid because it combines the power of a gasoline engine with the pedal power of its rider.

Hybrid vehicles are all around us. Most of the locomotives we see pulling trains are **diesel-electric hybrids**. Cities like Seattle have diesel-electric **buses** -- these can draw electric power from overhead wires or run on diesel when they are away from the wires. Giant **mining trucks** are often

diesel-electric hybrids. **Submarines** are also hybrid vehicles -- some are **nuclear-electric** and some are **diesel-electric**. Any vehicle that combines two or more sources of power that can directly or indirectly provide propulsion power is a hybrid.

The **gasoline-electric hybrid car** is just that -- a cross between a gasoline-powered car and an electric car. Let's start with a few diagrams to explain the differences.

Figure 1 shows a gas-powered car. It has a fuel tank, which supplies gasoline to the engine. The engine then turns a transmission, which turns the wheels.

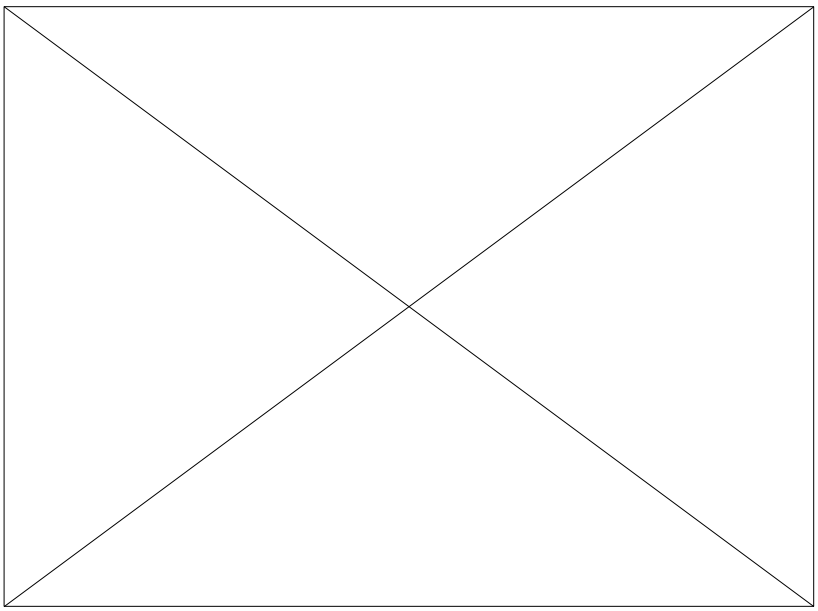

Figure 1. Gasoline-powered car
Move your mouse over the parts for a 3-D view.

Figure 2 below shows an electric car, which has a set of batteries that provides electricity to an electric motor. The motor turns a transmission, and the transmission turns the wheels.

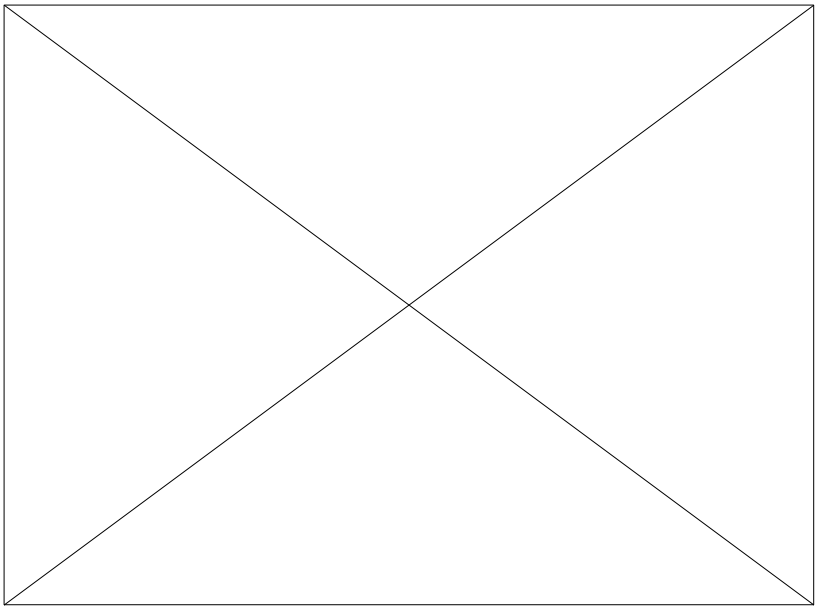

Figure 2. Electric car
Move your mouse over the parts for a 3-D view.

To learn about the structure of a **parallel hybrid car** and a **series hybrid car**, go on to the next page!

Hybrid Structure

You can combine the two power sources found in a hybrid car in different ways. One way, known as a **parallel hybrid**, has a fuel tank, which supplies gasoline to the engine. But it also has a set of batteries that supplies power to an electric motor. Both the engine and the electric motor can turn the transmission at the same time, and the transmission then turns the wheels.

Figure 3 shows a typical parallel hybrid. You'll notice that the fuel tank and gas engine connect to the transmission. The batteries and electric motor also connect to the transmission independently. As a result, in a parallel hybrid, both the electric motor and the gas engine can provide propulsion power.

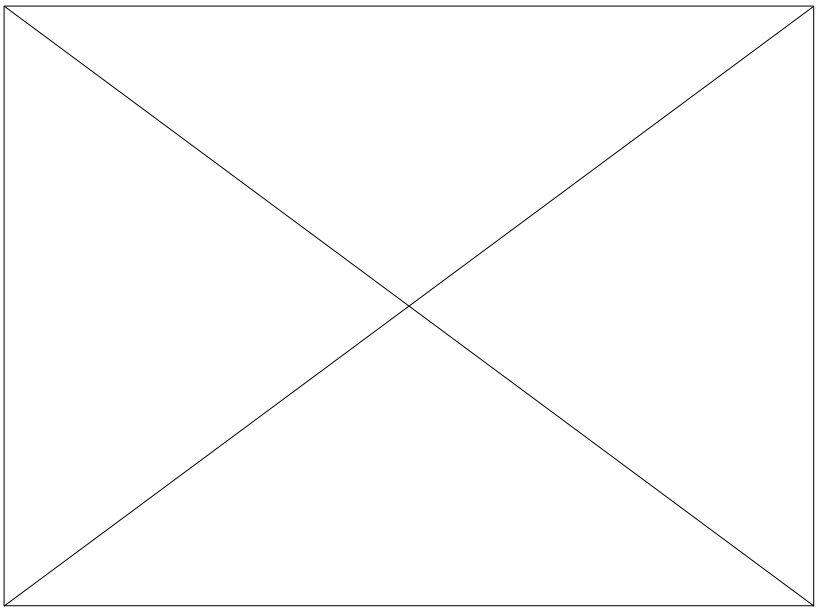

Figure 3. Parallel hybrid car
Move your mouse over the parts for a 3-D view.

By contrast, in a **series hybrid** (**Figure 4** below) the gasoline engine turns a generator, and the generator can either charge the batteries or power an electric motor that drives the transmission. Thus, the gasoline engine never directly powers the vehicle.

Take a look at the diagram of the series hybrid, starting with the fuel tank, and you'll see that all of the components form a line that eventually connects with the transmission.

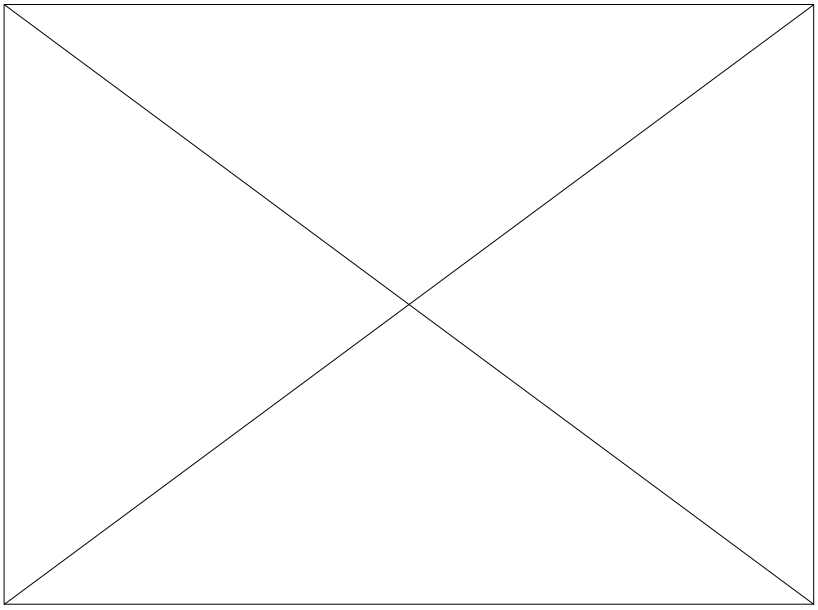

Figure 4. Series hybrid car
Move your mouse over the parts for a 3-D view.

Now let's get into the individual components of a hybrid car.

Hybrid Components

Hybrid cars contain the following parts:

- **Gasoline engine** - The hybrid car has a gasoline engine much like the one you will find on most cars. However, the engine on a hybrid is smaller and uses advanced technologies to reduce emissions and increase efficiency.
- **Fuel tank** - The fuel tank in a hybrid is the energy storage device for the gasoline engine. Gasoline has a much higher energy density than batteries do. For example, it takes about 1,000 pounds of batteries to store as much energy as 1 gallon (7 pounds) of gasoline.
- **Electric motor** - The electric motor on a hybrid car is very sophisticated. Advanced electronics allow it to act as a motor as well as a generator. For example, when it needs to, it can draw energy from the batteries to accelerate the car. But acting as a generator, it can slow the car down and return energy to the batteries.
- **Generator** - The generator is similar to an electric motor, but it acts only to produce electrical power. It is used mostly on series hybrids.
- **Batteries** - The batteries in a hybrid car are the energy storage device for the electric motor. Unlike the gasoline in the fuel tank, which can only power the gasoline engine, the electric motor on a hybrid car can put energy into the batteries as well as draw energy from them.
- **Transmission** - The transmission on a hybrid car performs the same basic function as the transmission on a conventional car. Some hybrids, like the Honda Insight, have conventional transmissions. Others, like the Toyota Prius, have radically different ones, which we'll talk about later.

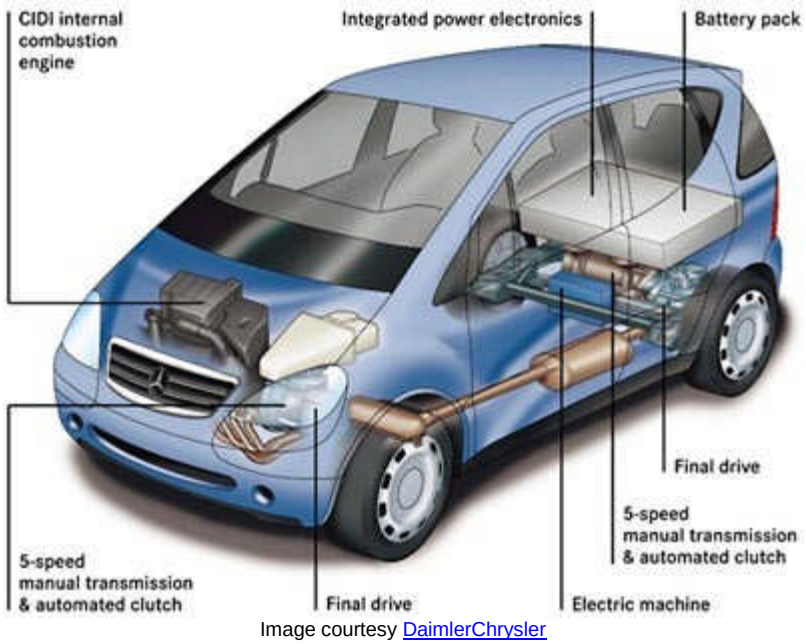

Image courtesy DaimlerChrysler

The Mercedes-Benz M-Class HYPER -- a hybrid concept vehicle

Why Build Such a Complex Car?

You might wonder why anyone would build such a complicated machine when most people are

perfectly happy with their gasoline-powered cars. The reason is twofold: to **reduce tailpipe emissions** and to **improve mileage**. These goals are actually tightly interwoven.

California emissions standards dictate how much of each type of pollution a car is allowed to emit in California. The amount is usually specified in grams per mile (g/mi). For example, the low emissions vehicle (**LEV**) standard allows 3.4 g/mi of carbon monoxide.

The key thing here is that the amount of pollution allowed does not depend on the mileage your car gets. But a car that burns twice as much gas to go a mile will generate approximately twice as much pollution. That pollution will have to be removed by the emissions control equipment on the car. So decreasing the fuel consumption of the car is one of the surest ways to decrease emissions.

Carbon dioxide (CO_2) is another type of pollution a car produces. The U.S. government does not regulate it, but scientists suspect that it contributes to **global warming**. Since it is not regulated, a car has no devices for removing CO_2 from the exhaust, so a car that burns twice as much gas adds twice as much CO_2 to the atmosphere.

Automakers in the U.S. have another strong incentive to improve mileage. They are required by law to meet **Corporate Average Fuel Economy** (CAFE) standards. The current standards require that the average mileage of all the new cars sold by an automaker should be 27.5 mpg (8.55 liters per 100 km). This means that if an automaker sells one hybrid car that gets 60 mpg (3.92 liters per 100 km), it can then sell four big, expensive luxury cars that only get 20 mpg (11.76 liters per 100 km)!

Evolution of the Hybrid

The hybrid is a compromise. It attempts to significantly increase the mileage and reduce the emissions of a gas-powered car while overcoming the shortcomings of an electric car.

The Problem with Gas-powered Cars

To be useful to you or me, a car must meet certain minimum requirements. The car should be able to:

- Drive at least 300 miles (482 km) between re-fueling
- Be refueled quickly and easily
- Keep up with the other traffic on the road

A gasoline car meets these requirements but produces a relatively large amount of pollution and generally gets poor gas mileage. An electric car, on the other hand, produces almost no pollution, but it can only go 50 to 100 miles (80 to 161 km) between charges. And the problem has been that it is very slow and inconvenient to recharge.

A driver's desire for **quick acceleration** causes our cars to be much less efficient than they could be. You may have noticed that a car with a less powerful engine gets better gas mileage than an identical car with a more powerful engine. Just look at the window stickers on new cars at a dealership for a city and highway mpg comparison.

The amazing thing is that most of what we require a car to do uses only a small percentage of its horsepower! When you are driving along the freeway at 60 mph (96.6 kph), your car engine has to provide the power to do three things:

- Overcome the aerodynamic drag caused by pushing the car through the air
- Overcome all of the friction in the car's components such as the tires, transmission, axles and brakes
- Provide power for accessories like air conditioning, power steering and headlights

For most cars, doing all this requires less than 20 horsepower! So, why do you need a car with 200 horsepower? So you can "floor it," which is the only time you use all that power. The rest of the time, you use considerably less power than you have available.

Smaller Engines are More Efficient

Most cars require a relatively big engine to produce enough power to accelerate the car quickly. In a small engine, however, the efficiency can be improved by using smaller, lighter parts, by reducing the number of cylinders and by operating the engine closer to its maximum load.

There are several reasons why smaller engines are more efficient than big ones:

- The big engine is heavier than the small engine, so the car uses extra energy every time it accelerates or drives up a hill.
- The pistons and other internal components are heavier, requiring more energy each time they go up and down in the cylinder.
- The displacement of the cylinders is larger, so more fuel is required by each cylinder.
- Bigger engines usually have more cylinders, and each cylinder uses fuel every time the engine fires, even if the car isn't moving.

This explains why two of the same model cars with different engines can get different mileage. If both cars are driving along the freeway at the same speed, the one with the smaller engine uses less energy. Both engines have to output the same amount of power to drive the car, but the small engine uses less power to drive itself.

Hybrid Performance

The key to a hybrid car is that the gasoline engine can be much smaller than the one in a conventional car and therefore more efficient. But how can this smaller engine provide the power your car needs to keep up with the more powerful cars on the road?

Let's compare a car like the Chevy Camaro, with its big V-8 engine, to our hybrid car with its small gas engine and electric motor. The engine in the Camaro has more than enough power to handle any driving situation. The engine in the hybrid car is powerful enough to move the car along on the freeway, but when it needs to get the car moving in a hurry, or go up a steep hill, it needs help. That "help" comes from the electric motor and battery -- this system steps in to provide the necessary extra power.

The gas engine on a conventional car is sized for the peak power requirement (those few times when you floor the accelerator pedal). In fact, most drivers use the peak power of their engines less than one percent of the time. The hybrid car uses a much smaller engine, one that is sized closer to the average power requirement than to the peak power.

Hybrid Efficiency

Besides a smaller, more efficient engine, today's hybrids use many other tricks to increase fuel efficiency. Some of those tricks will help any type of car get better mileage, and some only apply to a hybrid. To squeeze every last mile out of a gallon of gasoline, a hybrid car can:

- **Recover energy and store it in the battery** - Whenever you step on the brake pedal in your car, you are removing energy from the car. The faster a car is going, the more **kinetic** energy it has. The brakes of a car remove this energy and dissipate it in the form of heat. A hybrid car can capture some of this energy and store it in the battery to use later. It does this by using "regenerative braking." That is, instead of just using the brakes to stop the car, the electric motor that drives the hybrid can also slow the car. In this mode, the electric motor acts as a generator and charges the batteries while the car is slowing down.
- **Sometimes shut off the engine** - A hybrid car does not need to rely on the gasoline engine all of the time because it has an alternate power source -- the electric motor and batteries. So the hybrid car can sometimes turn off the gasoline engine, for example when the vehicle is stopped at a red light.

- **Use advanced aerodynamics to reduce drag** - When you are driving on the freeway, most of the work your engine does goes into pushing the car through the air. This force is known as **aerodynamic drag**. This drag force can be reduced in a variety of ways. One sure way is to reduce the frontal area of the car (**Figure 5**). Think of how a big SUV has to push a much greater area through the air than a tiny sports car.

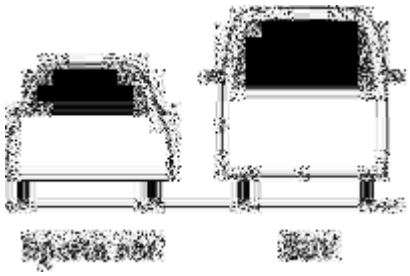

Figure 5. The frontal area profile of a small and large car

  Reducing disturbances around objects that stick out from the car or eliminating them altogether can also help to improve the aerodynamics. For example, covers over the wheel housings smooth the airflow and reduce drag. And sometimes, mirrors are replaced with small cameras.

- **Use low-rolling resistance tires** - The tires on most cars are optimized to give a smooth ride, minimize noise, and provide good traction in a variety of weather conditions. But they are rarely optimized for efficiency. In fact, the tires cause a surprising amount of drag while you are driving. Hybrid cars use special tires that are both stiffer and inflated to a higher pressure than conventional tires. The result is that they cause about half the drag of regular tires.
- **Use lightweight materials** - Reducing the overall weight of a car is one easy way to increase the mileage. A lighter vehicle uses less energy each time you accelerate or drive up a hill. Composite materials like carbon fiber or lightweight metals like aluminum and

magnesium can be used to reduce weight.

What's Available Now?

Three hybrid cars are now available in the United States -- the Honda Civic Hybrid, the Honda Insight and the Toyota Prius. We will be discussing the latter two, and although both of these cars are hybrids, they are actually quite different in character.

The Honda Insight

The Toyota Prius

The Honda Insight price starts around $19,570, and the Toyota Prius starts around $20,510. Both cars have a gasoline engine, an electric motor and batteries, but that is where the similarities end.

The **Honda Insight**, which was introduced in early 2000 in the United States, is designed to get the best possible **mileage**. Honda used every trick in the book to make the car as efficient as it can be. The Insight is a small, lightweight two-seater with a tiny, high-efficiency gas engine.

The **Toyota Prius**, which came out in Japan at the end of 1997, is designed to reduce **emissions** in urban areas. It meets California's super ultra low emissions vehicle (SULEV) standard. It is a four-door sedan that seats five, and the powertrain is capable of accelerating the vehicle to speeds up to 15 mph (24 kph) on electric power alone. The Prius was honored as the 2004 North American Car of the Year.

Coming Soon!

Over the past four years, more than 100,000 hybrids have been sold in the United States. (The Prius and the Honda Civic Hybrid account for the majority of these sales.) Even though that's not a huge percentage of the more than 17 million new cars and trucks that are sold in the U.S. each year, it's enough of an incentive to get more manufacturers on the hybrid bandwagon. Analysts suggest that the market this year, alone, could muster up the sales of the past four combined.

Below are some of the models manufacturers soon plan to integrate into the consumer market.

Manufacturer	Model	Model Year
Daimler-Chrysler	Dodge Ram	2005
Daimler-Chrysler	Mercedes S-class	2006
Ford	Escape	2005
General Motors	Chevy Equinox	2006
General Motors	Chevy Silverado	2005
General Motors	GMC-Sierra	2005
General Motors	Saturn-VUE	2005
Lexus	RX Hybrid SUV	2005
Toyota	Highlander	2005

Source www.fueleconomy.gov

Below is the hybrid-electric version of Daimler-Chrysler's Dodge Ram pickup. Recently dubbed the "Contractor Special," according to the folks at Daimler-Chrysler, this hybrid truck boasts 15 percent better fuel efficiency, lower emissions and better performance than the comparably-powered conventional Ram.

Photo courtesy DaimlerChrysler
The new "contractor special" hybrid Dodge Ram pickup.

Some other hybrids that are being considered for production are:

Photo courtesy DaimlerChrysler
Chrysler Citadel concept vehicle

Photo courtesy DaimlerChrysler
Dodge PowerBox hybrid concept vehicle. The PowerBox is powered by natural gas and electricity.

Now let's look at how the Honda Insight and the Toyota Prius work.

The Honda Insight

Figure 6 shows the layout of the Honda Insight, which is a simplified **parallel hybrid**. It has an electric motor coupled to the engine at the spot where the flywheel usually goes. Honda calls this system "Integrated Motor Assist." The Insight also has a conventional five-speed manual transmission. For those of you that have trouble changing gears, or prefer an automatic transmission, the Insight CVT (Continuously Variable Transmission) is now available. Prices start at $21,280.

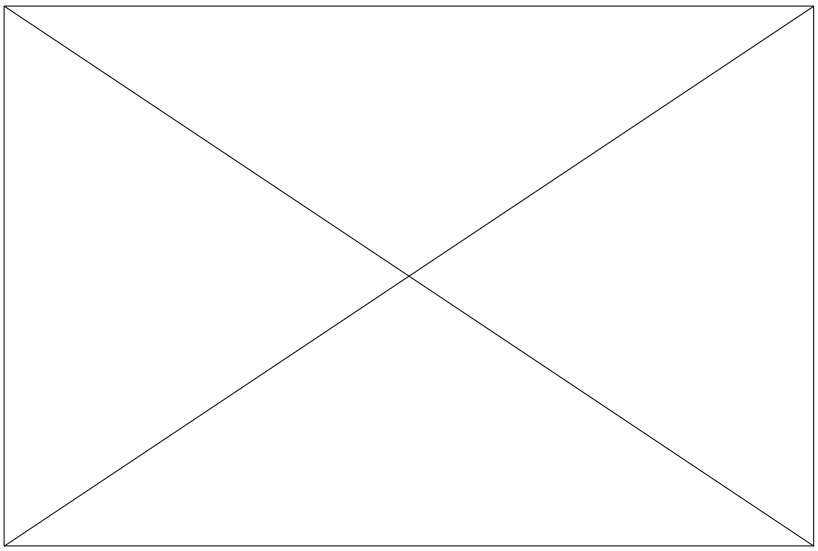

Figure 6. Layout of the Honda Insight
Move your mouse over the parts for a 3-D view.

The electric motor on the Insight helps in several ways. It can:

- Assist the gasoline engine, providing **extra power** while the car is accelerating or climbing a hill
- Provide some **regenerative braking** to capture energy during braking
- **Start the engine**, eliminating the need for a starter

However, the motor cannot power the car by itself; the gas engine must be running for the car to move.

Insight Fuel Efficiency

Because the Insight was designed to get the best mileage possible, Honda used all of the tricks discussed in the previous section. But the Insight relies mainly on three areas:

- **It reduces the weight** - Already a small car, the Insight uses a lightweight aluminum body and structure to further reduce weight. By making the car lightweight, Honda was able to use a smaller, lighter engine that could still maintain the performance level we have come to expect from our cars. The Insight weighs less than 1,900 pounds (862 kg), which is 500 pounds (227 kg) less than the lightest Honda Civic.
- **It uses a small, efficient engine** - The engine in the Insight, shown in **Figure 7**, weighs only 124 pounds (56 kg) and is a tiny, 1.0-liter three-cylinder that produces 67 horsepower at 5,700 rpm. It incorporates Honda's VTEC system and uses lean burn technology to maximize efficiency. The Insight achieves an EPA mileage rating of 61 mpg/city and 70 mpg/highway. Also, with the additional power provided by the small electric motor, this system is able to accelerate the Insight from 0 to 60 mph in about 11 seconds.

- With the electric motor running, the Insight produces 73 horsepower at 5,700 rpm. If you compare that to the engine horsepower alone, it looks like the electric motor only adds 6 horsepower. But the real effectiveness of the electric motor occurs at **lower engine speeds**. The electric motor on the Insight is rated at 10 kilowatts (about 13 horsepower) at 3,000 rpm.
- It's the peak torque numbers that really tell the story. Without the electric motor, the Insight makes its peak torque of 66 pound-feet at 4,800 rpm. With the electric motor, it makes 91 pound-feet at 2,000 rpm. So the motor adds a lot of torque to the low end of the speed range, where the engine is weaker. This is a nice compromise that allows Honda to give a very small engine the feel of a much larger one.

Figure 7. Insight engine

- **It uses advanced aerodynamics** - The Honda Insight is designed using the classical **teardrop** shape: The back of the car is narrower than the front. (Note that real teardrops do not behave this way aerodynamically -- click here for an interesting article on the aerodynamics of falling water droplets.) The rear wheels are partially covered by bodywork to provide a smoother shape, and some parts of the underside of the car are enclosed with plastic panels. These tricks result in a drag coefficient of 0.25, which makes it one of the most aerodynamic cars on the market (click here for a comparison table of drag coefficients for lots of car models).

Driving the Insight

The Insight is actually not very different from a conventional car once you get behind the wheel. When you accelerate, the gas engine does most of the work. If you accelerate quickly, the electric motor kicks in to provide a little extra power.

When you are cruising along the freeway, the gas engine is doing all of the work. When you slow down by hitting the brakes or letting off the gas, the electric motor kicks in to generate a little electricity to charge the batteries. You never have to plug the Insight into an electrical outlet; the motor generates all of the power needed to charge the battery.

One interesting thing to note is that in the Insight, the manual transmission is separated from the engine and motor by the clutch. This means that if you are the type of driver who likes to put the clutch in or put the car in neutral when you slow down to a stop, you are not going to get any regenerative braking. In order to recover energy when you slow down, the car has to be in gear.

The Toyota Prius

One of the main goals of the Toyota Prius is to improve emissions in urban driving. To accomplish this, Toyota has designed a **parallel hybrid powertrain**, called the Toyota Hybrid System (THS), that adds some of the benefits of a series hybrid.

Unlike Honda, Toyota has focused primarily on the powertrain to achieve its emissions and mileage goals. The Prius weighs 2,765 pounds (1,255 kg) and has as much interior space and trunk space as

a Toyota Corolla. **Figure 8** provides a layout of all the pieces.

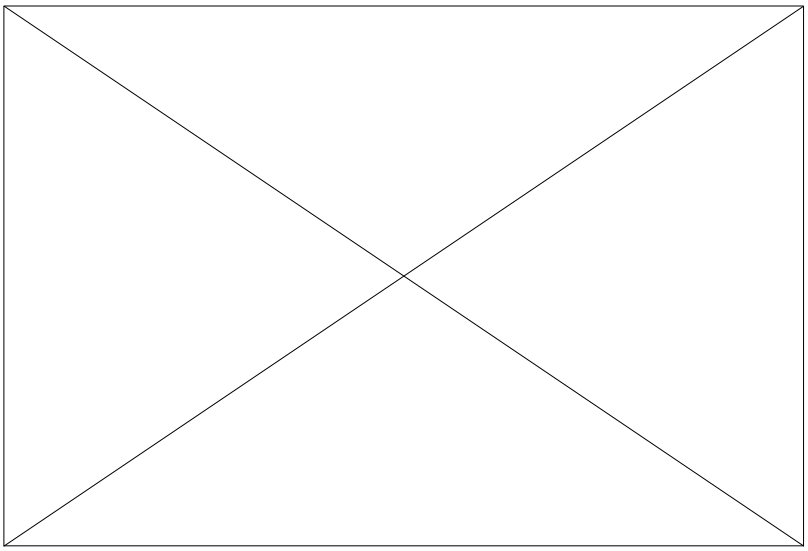

Figure 8. Prius layout
Move your mouse over the parts for a 3-D view.

Efficiency and Reduced Emissions

The Prius mainly relies on two features to optimize efficiency and reduce emissions:

- **Its engine only runs at an efficient speed and load** - In order to reduce emissions, the Prius can accelerate to a speed of about 15 mph (24 kph) before switching on the gasoline engine. The engine only starts once the vehicle has passed a certain speed. And once the engine starts, it operates in a narrow speed band.
- **It uses a unique power split device** - Gasoline engines can be tuned to run most efficiently in certain speed and load ranges. The **power split device** on the Prius, which we'll talk about in a minute, allows the engine to stay in its most efficient load and speed range most of the time.

  Toyota designed the 1.5-liter engine in the Prius to run at a maximum speed of only 4,500 rpm, where it makes 70 horsepower. Keeping the maximum speed of the engine low allows for the use of lighter components that improve efficiency.

  The electric motor on the Prius is rated at 44 horsepower from 1,040-5,600 rpm. It produces 258 pound-feet of torque from 0 to 400 rpm, which is more than enough to get the car going without the aid of the gasoline engine.

The "Power Split Device"

The **power split device** is the heart of the Toyota Prius. This is a clever gearbox that hooks the gasoline engine, generator and electric motor together. It allows the car to operate like a **parallel hybrid** -- the electric motor can power the car by itself, the gas engine can power the car by itself or they can power the car together.

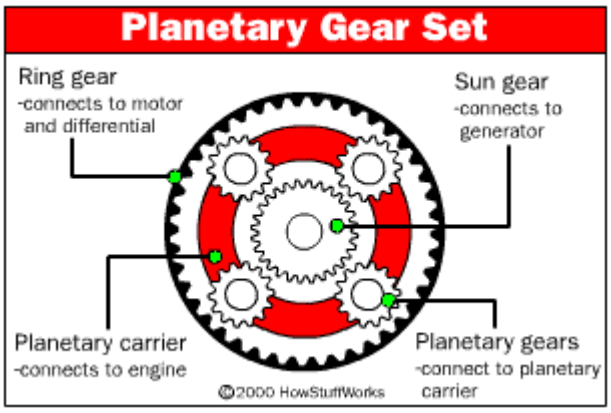

Figure 9. The Prius planetary gear set

The power split device also allows the car to operate like a **series hybrid** -- the gasoline engine can operate independently of the vehicle speed, charging the batteries or providing power to the wheels as needed. It also acts as a **continuously variable transmission** (CVT), eliminating the need for a manual or automatic transmission. Finally, because the power split device allows the generator to start the engine, the car does not need a starter.

The power split device is a planetary gear set (**Figure 9**). The electric motor is connected to the ring gear of the gear set. It is also directly connected to the differential, which drives the wheels. So, whatever speed the electric motor and ring gear spin at determines the speed of the car.

The generator is connected to the sun gear of the gear set, and the engine is connected to the planet carrier. The speed of the ring gear depends on all three components, so they all have to work together at all times to control the output speed.

Driving the Prius

When you accelerate, initially the electric motor and batteries provide all of the power. The ring gear of the power split device is connected to the electric motor, so it starts to spin with the motor. The planet carrier, which is connected to the engine, is stationary because the engine is not running. Since the ring gear is spinning, the planets have to spin, which causes the sun gear and generator to spin. As the car accelerates, the generator spins at whatever speed it needs to in order for the engine to remain off. You can see all of this in **Figure 10**.

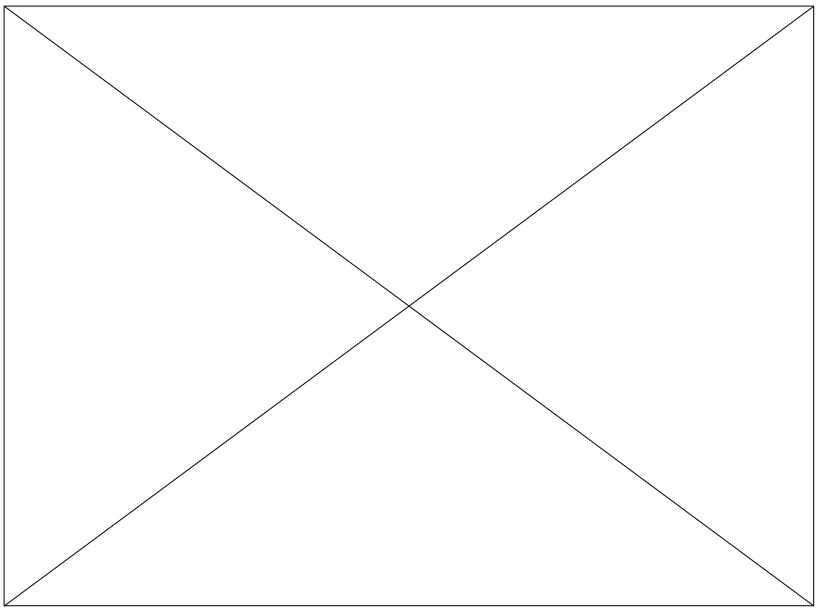

Figure 10. Watch the Prius' power split device as the car accelerates from 0 to 30 mph.

Once you reach about 15 mph (24 kph), the gasoline engine will turn on. The generator suddenly changes speed, causing the planet carrier to turn and start the engine. Once the engine is running, it settles into a constant speed while the generator varies its speed to match the output speed with the electric motor. If you are really accelerating hard, the motor will draw extra power from the batteries. Once you are up to freeway speed, the car will move under a combination of gas and electric power, with all of the electricity coming from the generator.

Like the Insight, the Prius never needs to be recharged; the onboard generator automatically maintains the proper level of charge in the batteries.

Hybrid Maintenance

Both the Honda and the Toyota have long **warranties** on the hybrid systems. The Insight has an eight-year/80,000-mile warranty on most of the powertrain, including batteries, and a three-year/36,000-mile warranty on the rest of the car. The Prius has an eight-year/100,000-mile warranty on the battery and hybrid systems and a three-year/36,000-mile warranty on everything else.

The motors and batteries in these cars don't require any **maintenance** over the life of the vehicle. And the engine doesn't require any more maintenance than the one in any other car. And because both hybrids have regenerative braking, the brake pads may even last a little longer than those in most cars.

However, if you do have to replace the batteries after the warranty expires, it will most likely cost you several thousand dollars.

Hybrid Mileage Tips

You can get the best mileage from a hybrid car by using the same kind of driving habits that give

you better mileage in your gasoline-engine car:

- **Drive slower** - The aerodynamic drag on the car increases dramatically the faster you drive. For example, the drag force at 70 mph (113 kph) is about double that at 50 mph (81 kph). So, keeping your speed down can increase your mileage significantly.
- **Maintain a constant speed** - Each time you speed up the car you use energy, some of which is wasted when you slow the car down again. By maintaining a constant speed, you will make the most efficient use of your fuel.
- **Avoid abrupt stops** - When you stop your car, the electric motor in the hybrid acts like a generator and takes some of the energy out of the car while slowing it down. If you give the electric motor more time to slow the vehicle, it can recover more of the energy. If you stop quickly, the brakes on the car will do most of the work of slowing the car down, and that energy will be wasted.

For more information on hybrid cars and related topics, check out the links on the next page.

Lots More Information

Related HowStuffWorks Articles

- How Electric Motors Work
- How Batteries Work
- How Car Engines Work
- How Electric Cars Work
- How the Hydrogen Economy Works
- How Fuel Cells Work
- How Gasoline Works
- How Manual Transmissions Work
- How Horsepower Works
- How Force, Power, Torque and Energy Work
- How Gas Prices Work
- What speed should I drive to get maximum fuel efficiency?

More Great Links

- Ford Escape Hybrid
- Insightman.com - site run by a fan of the Honda Insight
- Toyota Prius Site
- Honda Insight Site
- Cornell University Hybrid Electric Vehicle Team
- Virginia Wesleyan College: The Alternative-fuel Vehicle Directory
- Prius Club: A club for Prius owners and fans alike
- Epinions.com: Honda Insight
- IEEE Spectrum Magazine: Hybrid electric vehicles take to the streets
- Automotive Engineering International Online: Toyota readies gasoline/electric hybrid

system
- Program Simulates Performance of a Hybrid Automobile
- Automobile Design: Year 2010 and Beyond
- MotorWeek: Road Test: Honda Insight
- InsightCentral.net - independent site for information about the Honda Insight
- The Auto Channel: Ford Escape to Have Clean, Efficient Hybrid-Electric Powertrain in 2003