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A Green Technology for Automobiles - Regenerative Braking Control of Hybrid Cars

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***Abstract*- This document gives an alternative way of automobiles in future. As the automobile Industry totally depends up on the principles of engines, now let our electrical and mechanical engineers can solve the environmental problems and also the lack of fuels by fixing millions of hybrid cars in the future. This document mainly focuses about the Hybrid vehicle technology and its challenge to eliminate the fuel cars in the forthcoming years. In this article, I'll help you understand how this technology works, and we'll even give you some tips on how to drive a hybrid car for maximum efficiency.**

Keywords: Hybrid Car, Automobiles, Electrical Vehicles, Braking Control, Speed Control

I. INTRODUCTION

Due to the rising cost of fuel and the environmental damage it causes to our planet, many car owners or buyers are looking for an alternative way to save money. Let's face it, fuel supply is finite and the prices of gas are only going to rise higher and higher. A few analysts forecast that by 2020, hybrid vehicles will make up almost a third of new car sales in the United States. Plug-in hybrids are nothing but the cars that require energy to move and that energy is not totally depends up on the fuel and also electrical energy.

II. WHAT IS A HYBRID CAR?

A hybrid car, also known as an HEV or hybrid electric vehicle, is an automobile that is powered by two sources; an internal combustion engine, and an electric motor. Hybrid cars have no use for plugs, as they are amply charged by the movement of the wheels, and storing the kinetic energy that is generated through a process called regenerative braking. Hybrid cars have many environmental benefits and economical benefits.

How we classify Hybrids:
Not all hybrids are created equal. In fact, there are degrees of hybridization such as "mild" and "full" and even different drive trains utilized depending on which hybrid you're looking at. If we approach hybrids by looking at five technology steps that separate conventional vehicles from battery electric vehicles, we can better evaluate how a particular hybrid operates. To be a true hybrid, a vehicle needs the first three steps. The fourth and fifth create the potential for hybrids with superior energy and environmental performance, but remember, don't just rely on the type of hybrid, always check the fuel economy and emissions data available at our Hybrid.

5 Steps to Hybridization

- Idle-off capability
- Regenerative braking capacity
- Power Assist and Engine downsizing (at this step you reach a "mild" hybrid)
- Electric-only drive (at this step you reach a "full" hybrid)
- Extended battery-electric range (at this step you become a "plug-in" hybrid)

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The major concerns about hybrid cars are follows

A. Gasoline Power vs. Electric Power

The gasoline-electric hybrid car is just what it sounds like -- a cross between a gasoline-powered car and an electric car. A gas-powered car has a fuel tank, which supplies gasoline to the engine. The engine then turns a transmission, which turns the wheels.

An electric car, on the other hand, has a set of batteries that provides electricity to an electric_motor. The motor turns a transmission, and the transmission turns the wheels.

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.

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) before 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, however, 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 the electric car is very slow and inconvenient to recharge.

A gasoline-electric car combines these two setups into one system that leverages both gas power and electric power.

B. Gasoline-electric Hybrid Structure

Gasoline-electric 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.

- **Power Electronics**- fuel and electricity are used in hybrid cars will be dictated by a computer aided by power electronics. An inverter will convert direct current (dc) from the car's batteries to alternating current (ac) to drive the electric motor that provides power to the wheels. The inverter also converts ac to dc when it takes power from the generator to recharge the batteries

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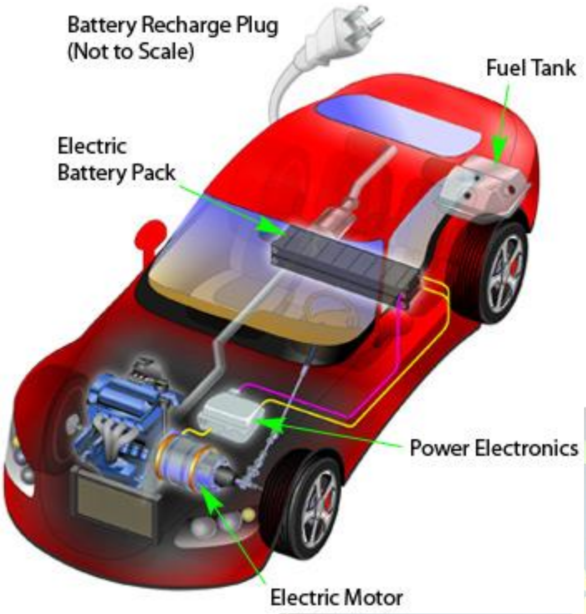

Fig.1 Smart picture of a hybrid

- **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. 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.

C. Hybrid vehicle Configurations

You can combine the two power sources found in a hybrid car in different ways. One way, known as a Parallel hybrid and the other way is known as Series Hybrid

1) *Parallel Hybrid Cars:* With a parallel hybrid electric vehicle, both the engine and the electric motor generate the power that drives the wheels. The addition of computer controls and a transmission allow these components to work together. This is the technology in the Insight, Civic, and Accord hybrids from Honda. Honda calls it their Integrated Motor Assist (IMA) technology. Parallel hybrids can use a smaller battery pack and therefore rely mainly on regenerative braking to keep it recharged. However, when power demands are low, parallel hybrids also utilize the drive motor as a generator for supplemental recharging, much like an alternator in conventional cars. Since, the engine is connected directly to the wheels in this setup, it eliminates the inefficiency of converting mechanical power to electricity and back, which makes these hybrids quite efficient on the highway. Yet the same direct connection between the engine and the wheels that increases highway efficiency compared to a series hybrid does reduce, but not eliminate, the city driving efficiency benefits (i.e. the engine operates inefficiently in stop-and-go driving because it is forced to meet the associated widely varying power demands).

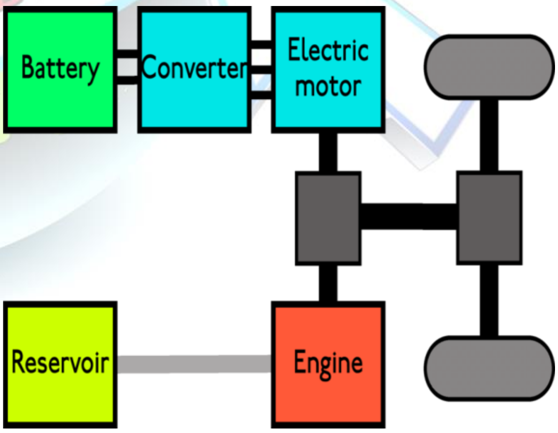

Fig.2 structure of parallel hybrid

2) *Series Hybrid Cars:* This is the simplest hybrid configuration. In a series hybrid, the electric motor is the only means of providing power to get your

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wheels turning. The motor receives electric power from either the battery pack or from a generator run by a gasoline engine. A computer determines how much of the power comes from the battery or the engine/generator set. Both the engine/generator and regenerative braking recharge the battery pack. The engine is typically smaller in a series drive train because it only has to meet average driving power demands; the battery pack is generally more powerful than the one in parallel hybrids in order to provide remaining peak driving power needs. This larger battery and motor, along with the generator, add to the cost, making series hybrids more expensive than parallel hybrids. While the engine in a conventional vehicle is forced to operate inefficiently in order to satisfy varying power demands of stop-and-go driving, series hybrids perform at their best in such conditions. This is because the gasoline engine in a series hybrid is not coupled to the wheels. This means the engine is no longer subject to the widely varying power demands experienced in stop-and-go driving and can instead operate in a narrow power range at near optimum efficiency. This also eliminates the need for a complicated multi-speed transmission and clutch. Because series drive trains perform best in stop-and-go driving they are primarily being considered for buses and other urban work vehicles.

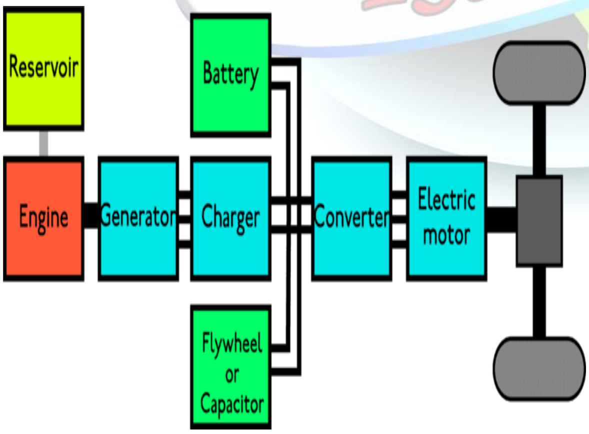

Fig.3 structure of series hybrid

3) *Series/Parallel Drive trains:* This drive train merges the advantages and complications of the parallel and series drive trains. By combining the two designs, the engine can both drive the wheels directly (as in the parallel drive train) and be effectively disconnected from the wheels so that only the electric motor powers the wheels (as in the series drivetrain). The Toyota Prius has made this concept a popular, and a similar technology is also in the new Ford Escape Hybrid. As a result of this dual drive train, the engine operates at near optimum efficiency more often. At lower speeds it operates more as a series vehicle, while at high speeds, where the series drive train is less efficient, the engine takes over and energy loss is minimized. This system incurs higher costs than a pure parallel hybrid since it needs a generator, a larger battery pack, and more computing power to control the dual system. However, the series/parallel drive train has the potential to perform better than either of the systems alone.

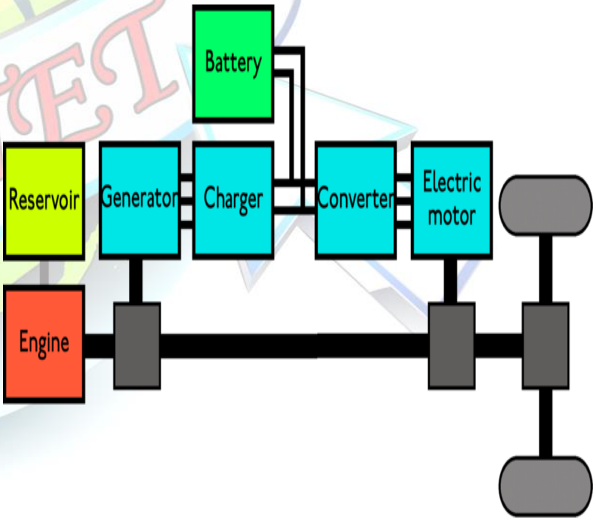

Fig.4 structure of series/parallel hybrid

4) *Plug-in hybrid electrical vehicle (PHEV):* Another subtype added to the hybrid market is the Plug-in Hybrid Electric Vehicle (PHEV). The PHEV is usually a general fuel-electric (parallel or serial) hybrid with increased energy storage capacity

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(usually Li-ion batteries). It may be connected to mains electricity supply at the end of the journey to avoid charging using the on-board internal combustion engine.

This concept is attractive to those seeking to minimize on-road emissions by avoiding – or at least minimizing – the use of ICE during daily driving. As with pure electric vehicles, the total emissions saving, for example in CO2 terms, are dependent upon the energy source of the electricity generating company.

For some users, this type of vehicle may also be financially attractive so long as the electrical energy being used is cheaper than the petrol/diesel that they would have otherwise used. Current tax systems in many European countries use mineral oil taxation as a major income source. This is generally not the case for electricity, which is taxed uniformly for the domestic customer, however that person uses it. Some electricity suppliers also offer price benefits for off-peak night users, which may further increase the attractiveness of the plug-in option for commuters and urban motorists.

III. HYBRID-CAR PERFORMANCE

The key to a hybrid car is that the gasoline engine can be much smaller than the one in a conventional carand therefore 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 bigger 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. 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.

Don Adams, leader of the Power Electronics and Electric Machinery Research Group in ORNL's Engineering Technology Division (ETD), is spearheading an effort to reduce the sizes, weights, and costs and to increase the efficiencies and useful life of automotive electric motors and inverters. Using Department of Energy funding, he and his colleagues are collaborating with researchers in the U.S. automobile industry to reach these technical targets.

"We are trying to reduce the electric motor to about one-third the volume and one-half the weight of today's motors," says Adams. "So we have developed a series of highly efficient electric motors. Another goal is to develop the right materials and manufacturing techniques to reduce the cost of inverters from $200/kilowatt to $7/kilowatt. The industry knows how to

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achieve cost, size, or performance goals, but not all three simultaneously."

IV. IMPROVING FUEL ECONOMY

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. Think of how a big SUV has to push a much greater area through the air than a tiny sports 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.

V. MODIFIED PARALLEL HYBRIDS

The first successful hybrid electric car was engineered by Ferdinand Porsche in 1928. All of the hybrid cars on the market utilize some or all of these efficiency tricks. We will be looking closely at the technology of the Honda Insight and the Toyota Prius.Although both of these cars are modified parallel hybrids, they are actually quite different in character. TheHonda Insight and the Toyota Prius both have a gasoline engine, an electric motor and batteries, but that is where the similarities end. Let's start with the Insight.

A. *The Toyota Prius*

The Toyota Prius, which came out in Japan at the end of 1997, is designed to reduce emissions in urban areas. To accomplish this, Toyota has designed a parallel hybrid power train, called the Toyota Hybrid System (THS) that adds some of the benefits of a series hybrid. The Prius meets California's super ultra low emissions vehicle (SULEV) standard. It is a four-door sedan that seats five, and the power train is capable of accelerating the vehicle to speeds up to 15 mph (24 kph) on electric power alone. This contributes to the better city mileage than highway mileage. The Prius was the 2004 North American Car of the Year.

Unlike Honda, Toyota has focused primarily on the power train to achieve its emissions and mileage goals. The Prius weighs 2,900 pounds (1,315 kg) and has as much interior space and trunk space as a Toyota Corolla. Here's a layout of all the pieces:

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 5,000 rpm, where it makes 76 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 67 horsepower from 1,200 to 1,540 rpm. It produces 295 pound-feet of torque from 0 to 1,200 rpm, which is more than enough to get the car going without the aid of the gasoline engine.

B. *The Honda Insight*

The Honda Insight, which was introduced in early 2000 in the United States, is designed to get the best possible mileage. The Insight is no longer part of Honda's line, but it's still a good example of how a hybrid car can work.

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 Insight has the best EPA mileage ratings of any hybrid car on the market.
The Honda Insight 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 has either a conventional, five-speed manual transmission or an automatic CVT (continuously variable transmission).
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.

To get the best mileage possible, Honda used all of the efficiency tricks discussed previously. 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 is able to use a smaller, lighter engine that can 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 below, 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 60 mpg/city and 66 mpg/highway. Also, with the additional power provided by the small electric

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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 79 pound-feet at 1,500 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.
- 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.

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.

Now let's take a look at the technology of the Toyota Prius. The Prius works in a very different way from the Insight.

VI. HYBRID CAR EMISSIONS INFORMATION

Today's production hybrid cars are marketed by a singular benefit; increased fuel economy. Even though it is true that hybrid cars can save drivers a bundle on gasoline and even earn them a tax rebate. The much more important benefit is the very significant reduction in emissions. Generally, hybrid cars produce 80% less harmful pollutants and greenhouse gases than comparable gasoline cars. This translates to less airborne pollutants, and a cleaner earth.

TABLE1

HYBRID CAR EMISSIONS PER YEAR

Toyota Prius	3.5
Honda Accord	6.9
Chevrolet Malibu	8.1
Toyota Camry	7.2
Mazda 6	7.0
Nissan Altima	7.5

The chart shows the emissions of greenhouse gases in tons from the most fuel efficient mid sized cars of 2004. Greenhouse gases are the gases which are thought to contribute to the greenhouse effect - the warming of the Earth's climate due to the major buildup of carbon dioxide, nitrous oxide, methane and other gases in the atmosphere. These gases are released by the combustion of fossil fuel, primarily by cars and other methods of transportation. The calculations for emissions in tons per year are based on 45% highway driving, 55% city driving, and 15,000 miles per year.

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For the fifth consecutive year, Honda's natural gas-powered Civic GX took top honors as the greenest vehicle, according to the American Council for an Energy-Efficient Economy (ACEEE)The ACEEE score incorporates unhealthy tailpipe emissions, fuel consumption, and global warming emissions to produce its annual environmental scorings of all model year 2008 cars and passenger trucks.

VII. THE BENEFITS OF A HYBRID 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.

Let's take the example of the California emissions standards, which 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 (CO2) 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 CO2 from the exhaust. A car that burns twice as much gas adds twice as much CO2to the atmosphere.

Auto makers in the United States 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 auto maker should be 27.5 mpg (8.55 liters per 100 km). This means that if an auto maker 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).

VIII. WHY BUY A HYBRID CAR?

Hybrid cars are popular because they appeal to such a wide range of consumers. The ecologically conscious can appreciate the the ultra low emissions and amazing fuel economy, while the economically conscious can appreciate the low depreciation and great savings at the pump.

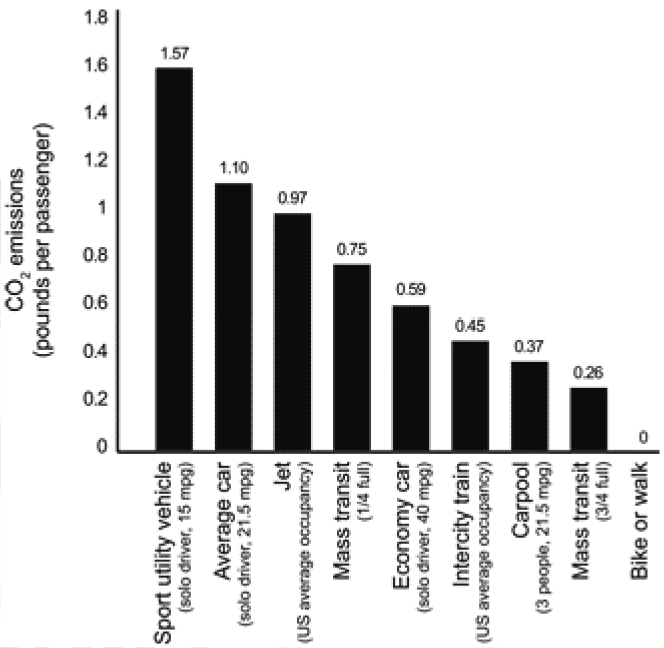

Fig. 2 Automobile emission chart

- Lower fuel emissions help to curb the infamous "Greenhouse Effect."
- Hybrid cars are in high demand, and because of this, they hold their value much better than most gasoline automobiles.
- Burning fossil fuel releases potentially harmful pollutants, but reducing the amount of fuel that needs to be burned may allow the environment to dispose of these pollutants by natural means.
- Hybrid cars offer huge savings at the pump. Switching from the average sedan to the average hybrid could save the driver over 500 dollars a year!

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- Hybrid car technology has been accepted as a solution for the automobile pollution problems of the day.

HYBRIDS ARE NOT UNSAFE

Crash Test Results
New Car Assessment Program (Ncap)

Crash tests are designed by the New Car Assessment Program, by the U.S. government. The crash tests scores for car safety are given as a number of stars, 5 stars being the best safety record, and 1 star the worst.
5 stars = 10% or less chance of serious injury
4 stars = 11% to 20% chance of serious injury
3 stars = 21% to 35% chance of serious injury
2 stars = 36% to 45% chance of serious injury
1 star = 46% or greater chance of serious injury

The Insurance Institute for Highway Safety (IIHS)
This nonprofit research and communications organization is funded by auto insurers. They rate results of areas of car safety concern in Good, Acceptable, Marginal, Poor.

Honda Insight Safety Ratings
NCAP: 5 Stars All Areas - Frontal Star Rating, Side Star Rating, Rollover
IIHS: Good in all areas.

Toyota Prius Safety Ratings
NCAP: 5 Stars All Areas - Frontal Star Rating, Side Star Rating, Rollover
IIHS: Not available.

IX. 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 take 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. The same reasoning applies to gasoline-powered cars: Abrupt stops waste a lot of energy.

X. BATTERY FEATURES

Battery content

1. Nickel-metal hydride (NiMH) batteries are used in electric hybrid vehicles. They contain plastic, a steel case, chemicals, wiring and nickel and cobalt, which are toxic metals.

Battery life

2. Hybrid batteries are designed to last for at least 150,000 to 200,000 miles, and so are disposed of infrequently.

Recycling procedures

3. Each battery has a phone number on it to call for recycling information. The car companies remove as much of the metal that they can and recycle it. They recycle all of the remaining materials that they can and dispose of everything else according to local and state environmental requirements.

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Incentives

4. Toyota paid dealers $200 in 2009 for each battery that was returned for recycling.

Future options

5. The car companies are doing research to develop lithium ion batteries. Lithium is considered less harmful to the environment than nickel, but the environmental effects from recycling will depend on what other materials it is combined with and the recycling procedures.

XI. FUTURE PLANS OF US AND INDIAN GOVERNMENT

President Barack Obama today announced the launch of two major programs that will drive the development of the next generation of electric vehicles in the United States and support the growth of domestic jobs. As part of the American Recovery and Reinvestment Act, the U.S. Department of Energy announced the release of two competitive solicitations for up to $2 billion in federal funding for competitively awarded cost-shared agreements for manufacturing of advanced batteries and related drive components as well as up to $400 million for transportation electrification demonstration and deployment projects.

By contributing to the reduction of petroleum use and greenhouse gas emissions, these projects will advance the United States' economic recovery, national energy security, and environmental sustainability. Today's announcement will also help meet the president's goal of putting one million plug-in hybrid vehicles on the road by 2015.

This funding has been divided between two new Funding Opportunity Announcements:

- Recovery Act - Transportation Electrification (DE-FOA-0000026)
- Recovery Act - Electric Drive Vehicle Battery and Component Manufacturing Initiative (DE-FOA-0000028)

The Indian government is planning to ensure that at least a million hydrogen-fuelled vehicles hit the roads by 2020 - and this would require generating 1,000 MW from hydrogen.

So far, India has not seen any hydrogen-fuelled car at all - and the only hybrid car India has seen to date has been the hybrid SUV Mahindra Scorpio unveiled in January at the Auto Expo 2006 in Delhi. The Scorpio hybrid should hit the streets sometime in 2008.

XII. WHY HYDROGEN CAR IS NOT A SOLUTION?

The major concern is very low efficiency. It means that for a PHEV, electric power transmission is about 93% efficient, but for H_2 Cars (fuel cars), the efficiency is only 40%. It's big and cumbersome. Your gas tank already uses a nice portion of your car, but a hydrogen fuel cell will be three times bigger than a gas tank. But that is not that all. The fuel cell has to be insulated to keep it safe and protected.

Safety issues. Liquid hydrogen has the ability to freeze air. There have also been reports of accidents with the fuel cell itself. Sometimes a valve will get plugged up when there is too much pressure in the cell. The only place to go is out, and the cell explodes. There is no way of knowing, yet, if this problem can be fixed, but there are many working on it. In a car accident, the tank might rupture, but the good news is the hydrogen will evaporate quickly. However, it is a more serious condition in a closed area such as a garageThe hydrogen evaporates. Strange, but true. The insulation is not a perfect process and the hydrogen evaporates out of the cell at roughly 1.7 percent a day. Also for a hydrogen internal combustion engine,The combustion of hydrogen with oxygen produces water as its only product:

$$2H_2 + O_2 = 2H_2O$$

The combustion of hydrogen with air however can also produce oxides of nitrogen (NO_x):

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$$H_2 + O_2 + N_2 = H_2O + N_2 + NO_x$$

Where under sunlight, oxides of nitrogen and volatile organic compound would form smog.

- WHY HYBRID AND NOT ALL-ELECTRIC?

Most electric cars cannot go faster than 50-60 mph, and need to be recharged every 50-100 miles. Hybrids bridge the gap between electric and gasoline-powered cars by traveling further and driving faster.

XIII. CONCLUSION

Concerns over global warming and rising oil prices have focused attention on alternative energy, and in particular alternative, environmentally friendly car designs. The most accessible of these designs was the hybrid car, with working models already on the road. With their highly fuel efficient design, they deliver much of what they promise, but the hybrid picture is not entirely problem free Hybrid car manufacturers are continually researching for more ways to reduce fuel consumption and better fuel efficiency. If you're concerned about the carbon foot print and green house effect to our atmosphere, then definitely buy hybrid cars, as it has less pollution compared to others and also it provides more mile age than Electric Cars. In the near future, hybrid cars are expected to get fuel mileage as high as 190 miles per gallon!

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