HYBRID VEHICLES – THE AUTOMOBILE FUTURE

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ABSTRACT

A Hybrid Vehicle is a vehicle that uses two or more distinct power sources to move the vehicle. Today the whole world is running out of power. Again the environment is also polluted to a great extent. To eliminate both the problems we can use the Hybrid Vehicles. This paper is all about the Hybrid Vehicles and its recent advances. A Hybrid Vehicle can reduce the pollution to a great extent. It can also reduce the power consumption. The main aim of this paper is to make everybody aware of the Hybrid Vehicles. Another aim of this presentation is to see the recent trends in the Hybrid Vehicles. The world is on the cusp of a major transition to hybrid power vehicles, which use highly efficient electric motors to boost the fuel efficiency of vehicles powered by internal combustion engines. This is a game-changing technology that promises to increase energy efficiency substantially, make a broad range of fuels available for powering vehicles, and meaningfully reduce demand for oil from the transportation sector.

Keywords: Distinct Power Sources, Environment Friendly, Game Changer, Hybrid Vehicles, Oil Demand Reduction.

I. INTRODUCTION

The hybrid car has been developed during the past decade as a combination of the traditional automobile, which uses a gasoline engine, and the electric car, which derives its power solely from a charged electric battery/electric motor system. Many consumers are finding that hybrid cars strike an ideal balance between the two alternatives; it is more environmentally friendly and fuel efficient than a traditional vehicle and does not require the inconvenience of battery charging via a wall plug, as electric cars do. My objective in this report is to form a technical definition of hybrid car technology, in particular the mechanical and electrical workings of the hybrid automobile.

Given that rising petroleum/diesel gasoline prices, the demand for alternative fuel vehicles, or vehicles that use other methods to obtain power, has increased dramatically in the past decade. These alternative fuel vehicles include electric cars, biodiesel cars, and of course, hybrid cars. The hybrid car is unique because the system contains both a rechargeable car battery and a small gasoline engine; the car battery is recharged while the car is running on the gasoline engine. Below you will see the Toyota Prius dashboard energy monitor, which contains a diagram of the Toyota Prius energy sources and consumption. This monitor diagram depicts the flow of the power from the battery to electric motor to the wheels; the other route is directly from the small gasoline engine. Using this monitor, the driver knows where the power for the car is coming from, the amount of battery power left, and when the battery is recharging.

II. HISTORY

Honda unveiled its Insight hybrid car at the 1999 North American International Auto Show in Detroit. But the Insight wasn't the first hybrid car on the road. See more pictures of hybrid car models.

Generally speaking, a hybrid car is any car that uses more than one fuel source. Nowadays, however, we mainly use the term to describe cars that combine a gas-fueled internal combustion engine with a battery-driven electric motor. Until recently such hybrid electric vehicles (or HEVs) were relatively rare, but the success of the Toyota Prius has raised public awareness of these gas-saving vehicles and spawned a number of similar cars from manufacturers such as Honda (the Honda Insight) and Ford (the Ford Fusion Hybrid). In fact, these fuel efficient vehicles are one of the most rapidly growing segments within the auto industry. They help us achieve the ideal of green driving.

In the late 19th and very early 20th centuries, back when the idea that cars must run on gasoline wasn't yet set in stone, inventors tinkered with a number of ways in which automobiles could be powered -- including electricity, fossil fuels, steam and combinations of these things. The history of hybrid electric vehicles, however, began shortly after the dawn of the 20th century. Here are some of the highlights of that history:

1900: The Lohner-Porsche Elektromobil makes its debut at the Paris Exposition. Although initially a purely electric vehicle, designer Ferdinand Porsche soon added an internal combustion engine to recharge the batteries, making it the first hybrid electric vehicle.

1917: Woods Motor Company introduces the Woods Dual Power, a hybrid electric vehicle with a 4-cylinder internal combustion engine. The Dual Power had a top speed of around 35 miles per hour (56.3 kilometers per hour). It was not a success.

1960s and 1970s: Electrical engineer Victor Wouk builds a prototype HEV based on the Buick Skylark. When the U.S. government decided not to invest in the vehicle's further development, Wouk ran out of money and abandoned the project.

1968: GM develops the GM 512, an experimental vehicle that runs on electricity at low speeds and gasoline at high speeds.

1989: Audi demonstrates the experimental Audi Duo. It combines a 12-horsepower electric motor with a 139-horsepower internal combustion engine. Audi develops further generations of the Duo over much of the following decade.

1997: In response to a challenge from Executive Vice President Akihiro Wadi to develop more fuel-efficient vehicles, Toyota introduces the Prius and begins marketing it in Japan.

1999: Honda introduces the Insight.

2000: Toyota begins marketing the Prius (as a 2001 model) in the United States.

2002: Hybrids start to become fairly common in the marketplace. Honda introduces the Accord Hybrid. Many more hybrid cars follow over the next few years.

2004: Ford introduces first hybrid SUV, the 2005 Ford Escape.

III. TYPES

There are two types of hybrid cars, parallel hybrids and series hybrids. These classifications are based on the arrangement of the parts previously described.

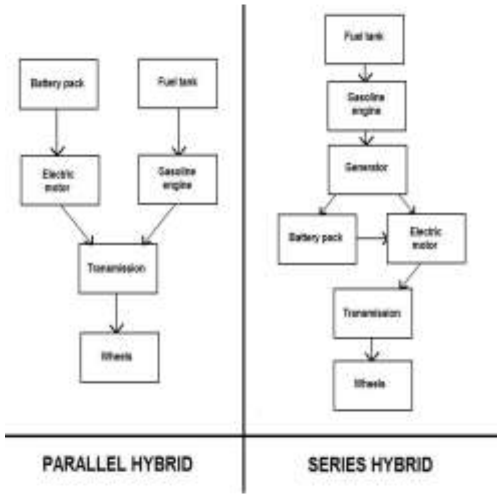

Figure 1. Comparative Block Diagram of Parallel and Series Hybrid

3.1 Parallel Hybrids

These hybrid cars have two different circuits from which their power is derived. One pathway originates from the fuel tank, which activates the engine, which powers the transmission; the other originates from the electric battery pack to the electric motor, which also powers the transmission. These two pathways do not intersect in a parallel hybrid. The transmission then transfers power to the wheels. Most hybrid cars today are powered with a parallel system. Examples of parallel hybrids include the Honda Insight and Toyota Prius.

3.2 Series Hybrids

Series hybrid cars generally have a generator act as the mediator between the engine and the batteries/electric motor. Therefore, the gasoline engine is not connected directly to the transmission. In this scenario, the flow chart begins with the fuel tank, which activates the engine, which transfers energy to the generator. The generator then is connected to the battery pack and the electric motor, and the electric motor provides power to the transmission and ultimately the wheels. Examples of series hybrids include the Saturn Vue, Green Line, and Honda Civic Hybrid.

The serial type has a downsized engine on board that drives a generator that supplements the batteries and can charge them when they run low. In the parallel type the ICE and the electric motor can both deliver propulsion power to the wheels [1].

Special attention is given to series hybrid drivelines, because they benefit much more directly than parallel hybrid drive lines from the recent large improvements in the specific weight and volume of electric drive motors/electronics. The results of the present study indicate that series hybrid vehicles with an electric range of 90-100 km and good acceleration performance (0-88 km/h acceleration times of less than 12 seconds) can be designed with a powertrain weight and volume comparable to that of a parallel hybrid of the same performance [2].

In order to understand the functioning of a hybrid vehicle, one must first know the mechanical components and their functions.

IV. WORKING OF HYBRID CARS

To know the working of a hybrid car, we must understand the basics of Mild Hybrid cars and Full Hybrid cars.In mild hybrid cars, the electrical motor is used only when additional power is needed. The conventional engine is used to provide most of the power. The electrical motor alone cannot operate the vehicle. Whenever power is needed the electric motor acts as a side-kick to the conventional engine. Some vehicles that carry this concept is the Honda Civic and Insight.

In a full hybrid car, the electrical energy is used while the car needs less power. The gasoline energy is used when the car needs less power. Thus at lower speeds the battery drives the vehicle and at higher speed the gasoline drives the vehicle. This technology has been used in cars like Toyota Prius and Ford Escape.

Both of them though have a little different mode of operation provide the same amount of efficiency.

Since both electric motor and an engine are used simultaneously, the size of the engine will be considerably smaller than the usual ones. But they will be a lot more advanced than the usual ones. The motor, on the other hand is also used to give power for the air conditioner, power windows, water pump and also power steering.

Take a look at the diagram given below. It shows the actual working of the hybrid car Toyota Prius. During the starting position, none of the system is working. After the car starts to move, it is in the normal driving mode. Thus the car will automatically change to the use of electric motor. Later when the car is accelerated and gains speed, it switches from the use f motor to the use of engine. Thus the gasoline engine supplies the required power. This switching is carried out automatically, with the help of an on-board computer. Since the battery has lost some of its charge, it needs to be immediately recharged. This is also done automatically. When the car starts to go in a uniform speed or when it is descending a road, the generator starts charging the battery.

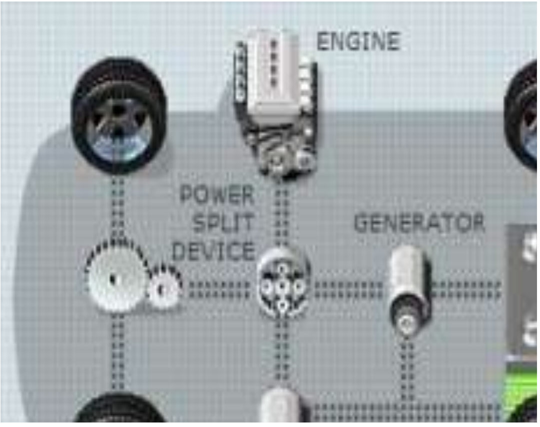

Figure 2. Working of a Toyota-Prius

V. ADVANTAGES OF HYBRID CARS

- Very less pollution.
- Better mileage.
- More reliable and comfortable.
- Very clean cars due to less emission.
- Batteries need not be charged by an external source.
- Warranties available for batteries as well as motors.
- Less dependence on fuels.

VI. LIMITATIONS OF HYBRID CARS

- The initial cost will be very high – higher than other cars.
- Since a lot of batteries will be needed, the car will be very heavy.
- As there are electrical components, there is risk of shock during an accident.
- The vehicle can be repaired only by professionals.
- Spare parts will be very costly and rare.

VII. TIPS TO IMPROVE FUEL EFFICIENCY

Most people buy tires that provide good traction for all weather conditions. Little do they look out for efficiency. If stiffer tires with higher pressure are used they reduce the friction by two times than the usual.

For any car, as the weight and size of the car increases, the efficiency decreases. So remove the unwanted weight and thus increase efficiency. Make the body using lighter metals like aluminium and magnesium.

Aerodynamics plays an important role in the fuel consumption of your car. For this you have to reduce the frontal area of the car, thereby reducing the air drag.

The energy wasted from your hybrid car includes the energy wasted as heat. If you could recycle that energy and reuse it, you can surely get more fuel efficiency. When you apply brakes, you are throwing out energy from the car. This energy can be stored in the battery through a process called regenerative braking. Instead of applying the brakes, the electric motor drives the hybrid to reduce the speed of the car. This way, the electric motor acts as a generator and charges the batteries while the car is slowing down.

VIII. BATTERIES OF HYBRID CARS

Figure 3. Rechargeable Batteries are Used In Hybrid Cars

A hybrid car battery is like any other battery—except that it is rechargeable and has enough juice to move a large heavy vehicle down the road for a few feet or a few miles.

8.1 Today's Hybrid Car Battery: Nickel Metal Hydride

Toyota Prius Hybrid Battery The battery pack of the second generation Toyota Prius consists of 28 Panasonic prismatic nickel metal hydride modules—each containing six 1.2 volt cells—connected in series to produce a nominal voltage of 201.6 volts. The total number of cells is 168, compared with 228 cells packaged in 38 modules in the first generation Prius. The pack is positioned behind the back seat.

The weight of the complete battery pack is 53.3 kg. The discharge power capability of the Prius pack is about 20 kW at 50 percent state-of-charge. The power capability increases with higher temperatures and decreases at lower temperatures. The Prius has a computer that's solely dedicated to keeping the Prius battery at the optimum temperature and optimum charge level. The Prius supplies conditioned air from the cabin as thermal management for cooling the batteries. The air is drawn by a 12-volt blower installed above the driver's side rear tire well.

8.2 Lithium Ion Battery – For Next Generation Hybrids and Electric Cars

Lithium ion (or Li-ion) batteries are important because they have a higher energy density—the amount of energy they hold by weight, or by volume—than any other type. The rule of thumb is that Li-ion cells hold roughly twice as much energy per pound as do the previous generation of advanced batteries, nickel-metal-hydride (NiMH)—which are used in all current hybrids including the Toyota Prius. NiMH, in turn, holds about twice the energy per pound of the conventional lead-acid (PbA) 12-Volt battery that powers your car's starter motor. It's Li-ion's ability to carry so much energy that makes electric cars possible.

Compare the batteries from GM's legendary EV1 to those for its upcoming Volt extended-range EV. The 1997 EV1 pack used lead-acid cells; it was almost 8 feet long and weighed 1200 pounds. But today's Volt pack, using lithium-ion cells, stores the same amount of energy (16 kilowatt-hours) in a 5-foot-long container weighing just 400 pounds.

IX. FUTURE SCOPE OF HYBRID SYSTEM

Speculations are on about the future of hybrid cars. With relatively new technology, some believe that hybrid cars are fast turning into the cars of future. Consumers are ready to take chance with the advance technology which hybrid cars have on offer. Today, Honda and Toyota are the two prominent companies producing hybrid cars.

While Honda launched its Honda Civic Hybrid, Toyota is ready with its Prius. With brands such as Nissan, Mazda, Ford, Fiat, Peugeot, Audi, Mercury and even Porsche, all these vehicles are licensed to use Toyota's Hybrid technology in future. In spite of this much hyped show, hybrid cars are somehow falling flat on consumer market.

Hybrid cars lack in mileage which is a great setback for all the hybrid car owners. Currently a hybrid car gets up to a mileage of 31 mpg on city and 45 mpg on highway. Unless manufacturers seriously look into this aspect, the car may fail to sustain the on-going hybrid mania for long.

The hybrid car designs of the future are including sports car models that have been all-time favorites with the world in the past and are now being revived with the brand new hybrid engine in mind.

With a mindset of grasping and expanding the propulsion features that are somewhat limited in today's hybrid car designs, there are retro styling efforts that are focusing on providing hybrid cars with optional V8 engine capacities.

There are considerations in place to use solar cells in the framework of hybrid automobiles. The future hybrid car will need to focus more on greenhouse gases that negatively affect the environment as well as a hybrid car that will be even more fuel efficient.

X. PLUG-IN HYBRIDS

Plug-in hybrids, sometimes called Plug-in Hybrid-Electric Vehicles (PHEVs), are hybrids with high-capacity batteries that can be charged by plugging them into an electrical outlet or charging station. They can store enough electricity from the power grid to significantly reduce their petroleum consumption under typical driving conditions.

Plug-in hybrid electric vehicle (PHEV) drive trains are predominantly dependant on the energy storage system (ESS), compared to those of regular HEV. One of the major current issues in the auto-industry related to PHEVs is the type of battery system which favours the technology the most [3].

Plug-in hybrid electric vehicles (PHEVs) are hybrid electric vehicles that can draw and store energy from an electric grid to supply propulsive energy for the vehicle. This simple functional change to the conventional hybrid electric vehicle allows a plug-in hybrid to displace petroleum energy with multi-source electrical energy. This has important and generally beneficial impacts on transportation energy sector petroleum consumption, criteria emissions output, and carbon dioxide emissions, as well as on the performance and makeup of the electrical grid. PHEVs are seen as one of the most promising means to improve the near-term sustainability of the transportation and stationary energy sectors [4].

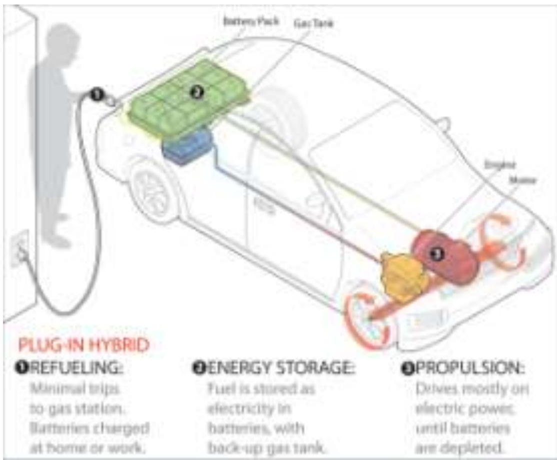

Figure 4. Basics of A Plug-In Hybrid

10.1 Different Kinds of Plug-in Hybrids

There are two basic plug-in hybrid configurations:

- Series plug-in hybrids, also called Extended Range Electric Vehicles (EREVs). Only the electric motor turns the wheels; the gasoline engine is only used to generate electricity. Series plug-ins can run solely on electricity until the battery needs to be recharged. The gasoline engine then generates electricity to power the electric motor. For shorter trips, these vehicles might use no gasoline at all.
- Parallel or Blended Plug-in Hybrids. Both the engine and electric motor are mechanically connected to the wheels, and both propel the vehicle under most driving conditions. Electric-only operation usually occurs only at low speeds.

Plug-in hybrids also have different battery capacities, allowing some to travel farther on electricity than others. Their fuel economy, like that of electric vehicles and regular hybrids, can be sensitive to driving style, driving conditions, and accessory use.

10.2 Benefits and Challenges

Less petroleum use. Plug-in hybrids are expected to use about 40% to 60% less petroleum than conventional vehicles. Since electricity is produced mostly from domestic resources, plug-in hybrids reduce oil dependence.

Less greenhouse gas emissions. Plug-in hybrids typically emit less greenhouse gas than conventional vehicles, but the amount generated depends partly on the fuel used at electrical power plants—nuclear and hydroelectric plants are cleaner than coal-fired power plants.

Higher Vehicle Costs, Lower Fuel Costs. A plug-in hybrid can cost roughly $4 to $8 thousand more than a comparable non-plug-in hybrid. Using electricity is much cheaper than using gasoline, but whether fuel savings will offset the higher vehicle cost depends on the vehicle purchased, the percentage of miles operating on electricity, fuel costs, and ownership length. Federal tax incentives up to $7,500 are currently available for qualifying plug-ins.

Re-charging Takes Time. Re-charging the battery using a 120-volt household outlet can take several hours; re-charging using a 240-volt home or public charger can take roughly 1 to 4 hours; while a "quick charge" to 80% capacity may take as little as 30 minutes. However, these vehicles don't have to be plugged in. They can be fueled solely with gasoline but will not achieve maximum range or fuel economy without charging.

Estimating fuel economy. Since a plug-in can operate on electricity alone, gasoline alone, or a mixture of the two, EPA provides a fuel economy estimate for gasoline-only operation and an estimate for electric-only or gas-and-electric operation—both for combined city-highway driving.

Assuming that current low-end battery cost projections can be met in the future, a plug-in should be able to recover its incremental cost through fuel savings in well under the life of the vehicle. Plug-ins with more than modest electric-only range will have difficulty passing the often-cited “three-year payback” test, however, even under such a favorable battery cost scenario and with $3 per gallon gasoline. A further increase in fuel prices or a shift in consumer priorities could nonetheless create a sizable market for plug-ins [5].

TABLE 1. COST COMPARISION BETWEEN DIFFERENT PHEV

Cost comparison between a PHEV-10 and a PHEV-40 (prices for 2010)							
Plug-in type by EV range	Similar production model	Type of drivetrain	Manufacturer additional cost compared to conventional non-hybrid mid-size	Cost of battery pack	Cost of electric system upgrade at home	Expected gasoline savings compared to a HEV	Annual gasoline savings compared to a HEV(2)
PHEV-10	Prius Plug-in(1)	Parallel	US$6,300	US$3,300	More than US$1,000	20%	70 gallons
PHEV-40	Chevy Volt	Series	US$18,100	US$14,000	More than US$1,000	55%	200 gallons
Notes: (1) Considers the HEV technology used in the Toyota Prius with a larger battery pack. The Prius Plug-in estimated all-electric range is 14.5miles (23km) (2) Assuming 15,000 miles per year.							

10.3 Fuel Efficiency

The actual fuel economy for PHEVs depends on their powertrain operating modes, their all-electric range, and the amount of driving between charges. If no gasoline is used the miles per gallon gasoline equivalent (MPG-e) depends only on the efficiency of the electric system. The first mass production PHEV available in the U.S. market, the 2011 Chevrolet Volt, with an EPA rated all-electric range of 35 miles (56 km), and an additional gasoline-only extended range of 344 miles (554 km) has an EPA combined city/highway fuel economy of 93 MPG-e in all-electric mode, and 37 mpg-US (6.4 L/100 km; 44 mpg-imp) in gasoline-only mode, for an overall combined gas-electric fuel economy rating of 60 mpg-US (3.9 L/100 km; 72 mpg-imp) equivalent (MPG-e). The EPA also included in the Volt's fuel economy label a table showing fuel economy and electricity consumed for five different scenarios: 30, 45, 60 and 75 miles (121 km) driven between a full charge, and a never charge scenario. According to this table the fuel economy goes up to 168 mpg-US (1.40 L/100 km; 202 mpg-imp) equivalent (MPG-e) with 45 miles (72 km) driven between full charges.

Trade-offs between fuel economy improvement, and thus petroleum savings, and economic factors, such as vehicle cost differential and break-even gasoline price, are studied for mild (15% of total driveline power electric) and full (engine and electric power are about equal) hybrid vehicles. The study considered compact and mid-size passenger cars and mid-size SUVs. The same weights and road loads were used for the conventional ICE and hybrid vehicles. It was found that the fractional fuel savings are greater for the full hybrids (40-50%) than for the mild hybrids (30-40%). However, the break-even gasoline prices for the mild hybrids are significantly lower than that for the full hybrids. In the cases of the mild hybrids using conventional PFI gasoline engines, the break-even gasoline prices were found to be $1.25-1.50/gal for a vehicle use of 100,000 miles over 8 years and a discount rate of 4%. For the full hybrids, the corresponding break-even gasoline prices were $2.00-2.30/gal [6].

For the more comprehensive fuel economy and environment label that will be mandatory in the U.S. beginning in model year 2013, the National Highway Traffic Safety Administration (NHTSA) and Environmental Protection Agency (EPA) issued two separate fuel economy labels for plug-in hybrids because of their design complexity, as PHEVS can operate in two or three operating modes: all-electric, blended, and gasoline-only. One label is for series hybrid or extended range electric vehicle (like the Chevy Volt), with all-electric and gasoline-only modes; and a second label for blended mode or series-parallel hybrid, that includes a combination of both gasoline and plug-in electric operation; and gasoline only, like a conventional hybrid vehicle.

10.4 Disadvantages

10.4.1 Cost of Batteries

Disadvantages of plug-in hybrids include the additional cost, weight, and size of a larger battery pack. According to a 2010 study by the National Research Council, the cost of a lithium-ion battery pack is about US$1,700/kW·h of usable energy, and considering that a PHEV-10 requires about 2.0 kW·h and a PHEV-40 about 8 kW·h, the manufacturer cost of the battery pack for a PHEV-10 is around US$3,000 and it goes up to US$14,000 for a PHEV-40. According to the same study, even though costs are expected to decline by 35% by 2020, market penetration is expected to be slow and therefore PHEVs are not expected to significantly impact oil consumption or carbon emissions before 2030, unless a fundamental breakthrough in battery technologies occurs.

10.5 Charging Systems

Batteries are DC devices while grid power is AC. In order to charge the batteries, a DC charger must be utilized. The charger can be located in several locations:

On-board chargers are mounted inside the vehicle. Since the charger takes up space and adds weight, its power capacity is generally limited by practical considerations, avoiding carrying a more powerful charger that can only be fully utilized at certain locations. However, carrying the charger along with the vehicle ensures that power will be available anywhere a power connection can be found.

Off-board chargers can be as large as needed and mounted at fixed locations, like the garage or dedicated charging stations. Built with dedicated wiring, these chargers can handle much more power and charge the batteries more quickly. However, as the output of these chargers is DC, each battery system requires the output to be changed for that car. Modern charging stations have a system for identifying the voltage of the battery pack and adjusting accordingly.

Using electric motor's inverter allows the motor windings to act as the transformer coils, and the existing high-power inverter as the AC-to-DC charger. As these components are already required on the car, and are designed to handle any practical power capability, they can be used to create a very powerful form of on-board charger with zero additional weight or size. AC Propulsion uses this charging method, referred to as "reductive charging".

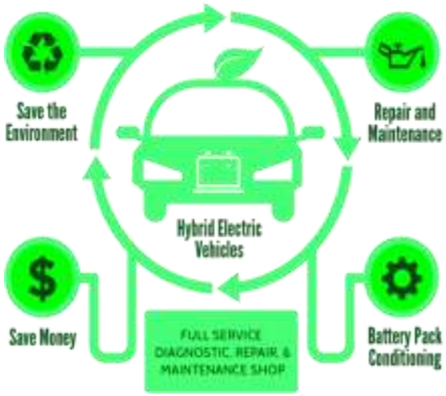

Figure 5. All About Hybrids

XI. CONCLUSION

Hybrid Vehicles is truly a revolutionary concept. If widely used, it would help in reducing many serious problems like Global Warming, Environmental Pollution, etc. It would also help in conservation of the nearly extinct Fossil Fuels.

REFERENCES

[1] V. Wouk, "Hybrids: Then and now", IEEE Spectrum, vol. 32.

[2] F. Burke, Hybrid/electric vehicle design options and evaluations.

[3] Frank, A. A.: Plug-in hybrid vehicles for a sustainable future.

[4] G. Zorpette "The Smart Hybrid", IEEE Spectr., vol. 41.

[5] Kliesch, J.; Langer, T., Plug-in hybrids: An environmental and economic performance outlook; American Council for an Energy Efficient Economy.

[6] A. F. Burke "Saving petroleum with cost-effective hybrids", Powertrain and Fluids Conf.