Hybrid Vehicle Evolution and Future

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Abstract

With the advancement in 21st century, there has been increase in uses of oil and gas leading to problems like global warming, climate change, storage of crude oil, etc. due to this reasons automobile companies have started doing research for making hybrid technology usable into the daily life. Hybrid technology usable into the daily life. The paper start from brief history about hybrid technology and also some brief introduction on it. Paper will also discuss the technologies used in the making of hybrid cars such as “Hybrid Solar Vehicle”, “Hybrid Electric Vehicle” and plug in “hybrid electric vehicles”. Our paper is based on the explanation of such technologies, their function, drawback of this technology, efficiency of hybrid cars, case studies on the present commercial hybrid cars such as Toyota, Prius series, Astrolab, etc. and the fuel and raw materials used in the hybrid cars. Paper concludes on the advantages and disadvantages of hybrid cars and how this technology will take over the world in future and world become the alternative for petrol and diesel cars.
Keywords: Belt Alternator Starter (BAS), Fuel Cell Vehicle (FCVs), Integrated Motor Assist (IMP), Hybrid Vehicle

I. INTRODUCTION

What is a hybrid? A hybrid vehicle combines any two power (energy) sources. Possible combinations include diesel/electric, gasoline/fly wheel, and fuel cell (FC)/battery. Typically, one energy source is storage, and the other is conversion of a fuel to energy. The combination of two power sources may support two separate propulsion systems. Thus to be a True hybrid, the vehicle must have at least two modes of propulsion. For example, a truck that uses a diesel to drive a generator, which in turn drives several electrical motors for all-wheel drive, is not a hybrid. But if the truck has electrical energy storage to provide a second mode, which is electrical assists, then it is a hybrid Vehicle. These two power sources may be paired in series, meaning that the gas engine charges the batteries of an electric motor that powers the car, or in parallel, with both mechanisms driving the car directly.

A. *Hybrid Electric Vehicle (HEV)*

Consistent with the definition of hybrid above, the hybrid electric vehicle combines a gasoline engine with an electric motor. An alternate arrangement is a diesel engine and an electric motor (figure 1).

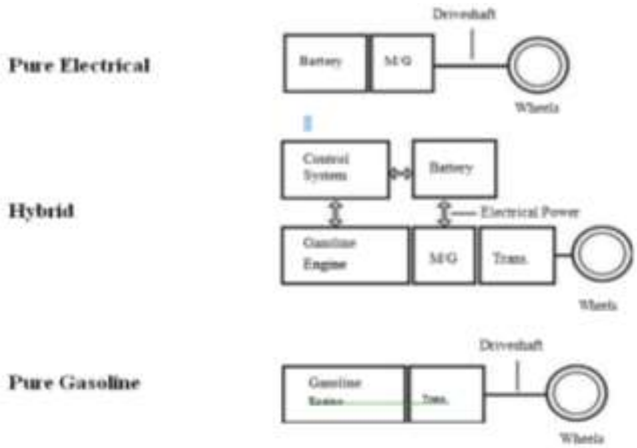

Fig. 1: Components of a hybrid Vehicle that combines a pure gasoline with a pure EV.

As shown in Figure 1, a HEV is formed by merging components from a pure electrical vehicle and a pure gasoline vehicle. The Electric Vehicle (EV) has an M/G which allows regenerative braking for an EV; the M/G installed in the HEV enables regenerative braking. For the HEV, the M/G is tucked directly behind the engine. In Honda hybrids, the M/G is connected directly to the engine. The transmission appears next in line. This arrangement has two torque producers; the M/G in motor mode, M-mode, and the gasoline engine. The battery and M/G are connected electrically. HEVs are a combination of electrical and mechanical components. Three main sources of electricity for hybrids are batteries, FCs, and capacitors. Each device has a low cell voltage, and, hence, requires many cells in series to obtain the voltage demanded by an HEV. Difference in the source of Energy can be explained as:

1) The FC provides high energy but low power.
2) The battery supplies both modest power and energy.
3) The capacitor supplies very large power but low energy.

The components of an electrochemical cell include anode, cathode, and electrolyte (shown in fig2). The current flow both internal and external to the cell is used to describe the current loop.

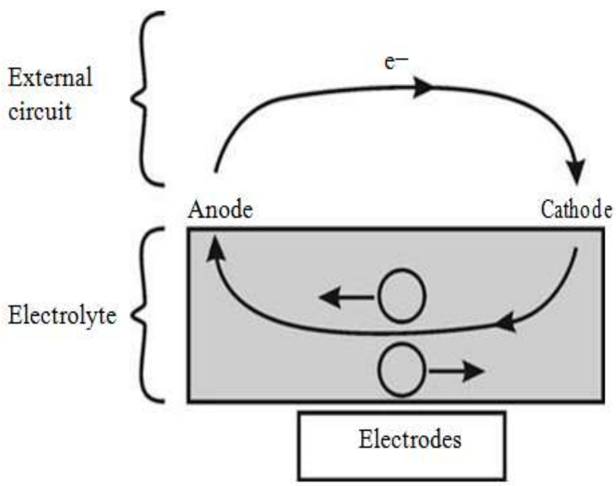

Fig. 2: An electrode, a circuit for a cell which is converting chemical energy to electrical energy. The motion of negative charges is clockwise and forms a closed loop through external wires and load and the electrolyte in the cell.

A critical issue for both battery life and safety is the precision control of the Charge/Discharge cycle. Overcharging can be traced as a cause of fire and failure. Applications impose two boundaries or limitations on batteries. The first limit, which is dictated by battery life, is the minimum allowed State of Charge. As a result, not all the installed battery energy can be used. The battery feeds energy to other electrical equipment, which is usually the inverter. This equipment can use a broad range of input voltage, but cannot accept a low voltage. The second limit is the minimum voltage allowed from the battery. On the road, in the press and even at metals conferences it is becoming increasingly difficult to avoid hybrid vehicles - that is vehicles that draw their power from both an internal combustion engine and an electric motor. By synchronizing the engine and motor hybrids achieve levels of fuel efficiency far beyond that of conventional vehicles, and getting more miles to the gallon is very appealing to consumers faced with high fuel prices. They also produce fewer emissions, making them popular with politicians fighting air pollution.

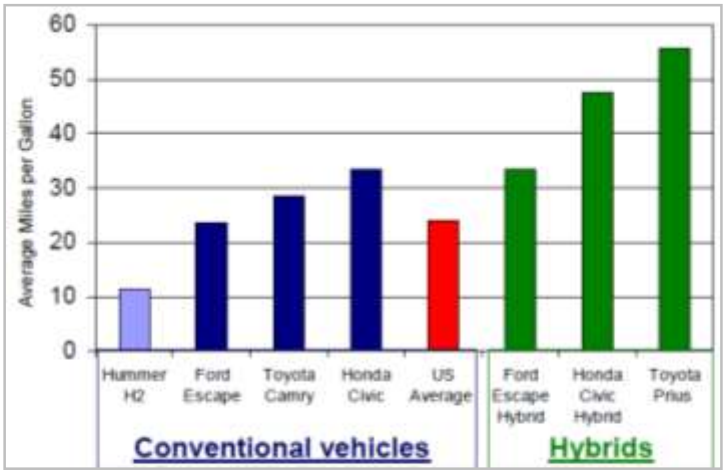

Fig. 3: comparison between coventional and hybrid vehicles

B. Fuel Efficiency Comparison

The relevance of hybrid vehicles to minor metals is in the new materials-recipe that hybrids require. Those metals used in hybrid engineering will see demand increase proportionally to the production rate of hybrid automobiles, a rate that in the last five years has boomed.

II. OVERVIEW

A. Developments in Hybrid Vehicles

Hybrids are among the most intriguing technological trends to appear in the past decade. However, while their mass-production is a recent phenomenon, hybrid technology is not itself new. Like a recessive gene hiding in automobile DNA, electric drive systems have been around ever since engineers first moved carts out of stables and into garages. In the early days of automobiles, before the hegemon of gasoline (petrol) became unquestioned, steam, gasoline, electricity and even peanut oil all competed to be the power system of choice. The shear diversity of automobiles in those early days is telling. In 1900, 4,200 cars were sold in the USA of which 38% were electric, 40% steam and only 22% gasoline. Electric vehicles even held the world road speed record for three years between 1899 & 1902 - a speedy 66 miles per hour (106 km/h). Perhaps the world's first hybrid was built by Dr. Ferdinand Porsche who in 1899 built a vehicle that used a petrol engine to drive a generator that powered four electric motors. However, in 1909 the Model T Ford was launched and from then on gasoline was the unrivalled source of vehicle power.

For decades little changed. Then in 1973 the oil crisis started causing gasoline prices to rise 50% in a year; suddenly fuel efficiency was an issue. Encouraged by government regulations by the late 1980s America's vehicle fleet was considerably more efficient and gradually the path was being prepared for hybrids.

As early as 1989 Toyota was funding research into hybrid technologies and in 1992 they published their first "Earth Charter", a manifesto for low emission vehicles. This ultimately led to the development of the Prius, which first emerged at the 1995 Tokyo Motor Show.

1) Circumstances of US Auto Motives

The first hybrid to be offered in the USA was the Honda Insight in late 1999, followed in 2000 by the Toyota Prius. In just five and a half years' hybrid vehicles have made manufacturers and consumers alike sit up and take notice.

B. High Gasoline Prices

An important factor if not the most important factor, is the rising US gasoline price, reflecting higher crude oil prices. Since December 2001 average gasoline prices have more than doubled from $1.08 to $2.30 per gallon. With gasoline at $108 per s on an economic level the mainstream public respond to strongly. Are nt uy. The less conventional surged gallon and small, quirky designs, the early hybrid had a reputation of being cars for environmentalists. Today, however, with gasoline at $2.30 per gallon and packaged in conventional designs, hybrid vehicles appeal on an economic level the mainstream public respond to strongly.

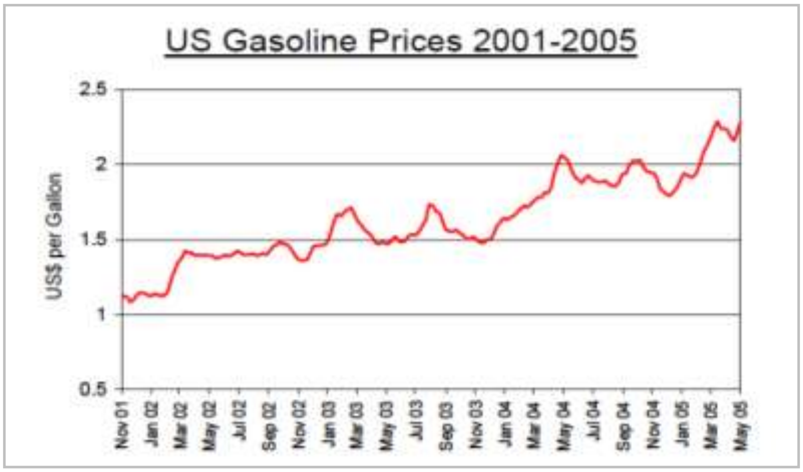

Fig. 4: US Gasoline Prices 2001-2005

High fuel costs make consumers acutely aware of a vehicle's fuel. Efficiency and in a recent survey 40% of consumers indicated that fuel efficiency would play a major part when deciding which new car to buy. The four most efficient vehicles on the market today are all hybrids.

Fig. 5: Early Hybrid Vehicles

C. Capable Hybrid Technology

Both the computer programming and mechanical technology behind hybrid engines has come a long way in the last decade and continues to progress rapidly. Parallel to the gains in hybrid engines, rechargeable batteries have also improved considerably since the early 1990s and are now up to the rigorous demands of hybrid vehicles. Currently hybrids use nickel metal hydride batteries, and while there is an expectation that one-day lithium-ion batteries will be used instead, industry insiders, including one US supplier close to Toyota and Honda, say that the switch is unlikely before 2012.

D. An Underdeveloped Diesel Market

Another reason for the popularity of hybrids is that consumers in the US looking for low-cost vehicles do not have the option of diesels. Tight air quality regulations, which are set to get even tighter in 2007, have meant that today less than 1% of the US vehicle fleet is diesel powered.

Diesel vehicles initially cost $1,000 to $3,000 more to buy, but like hybrids, they save money in the long run with their more efficient engines.

E. Fuel Cells Vehicles (Fcvs) Are Not Yet Commercially Viable

FCVs are electric cars that generate their power from the chemical-electric reaction of hydrogen and oxygen. Their only emission is water, earning them the title "zero emission vehicles" (ZEVs). To many people, fuel cell vehicles are the Holy Grail of automotive design, removing transport pollution at a stroke. However, FCVs currently lack supporting infrastructure, cost $800,000 each and are at least a decade away from commercialization.

F. Toyota

It always helps to have a powerful backer when you are the new show in town, fortunately for hybrids, they have Toyota. Measured by vehicle sales Toyota is the second largest vehicle manufacturer in the world, having overtaken Ford in 2003. But sales figure alone misses the point. In the financial year to end March 2005 Toyota made $11 billion profit and has currently has a market capitalization of just under $130 billion, making it by far the wealthiest vehicle manufacturer in the world.
Although one General Motors Vice Chairman has dismissively referred to Toyota's financial commitment to hybrid vehicles, and the positive association it has gained as a result, as an "advertising expense", Toyota has spent over $800 million so far on this project.

G. Today's Hybrid Vehicles and Their Consumption Of Minor Metals

As with all technologies, hybrids have numerous mechanical configurations. The three main varieties are:
Soft- or Micro-hybrids

These are constructed like conventional vehicles but have an engine programmed to shut down when the car is in stationary traffic, thus saving fuel. Soft-hybrids have Zero impact on cobalt consumption and are not included in the forecasts made later.

1) Mild-hybrids

These vehicles, as well as having stop-start engines, have an electric motor that aids acceleration. The motor's rechargeable battery can be charged either by the engine or the wheels acting as generators during driving or breaking respectively. Mild-hybrids include the Honda Accord, a car that uses up to 17% electric power. Full hybrids possess the abilities of mild-hybrids but can also be driven purely by the electric motor. Such a powerful system requires large motors and batteries to match. The Toyota Prius is a full hybrid and uses up to 46% electric power. From this list variation occur, including plug-in hybrids that are charged off the national electricity grid but this is not relevant here. Hybrid vehicles consume cobalt in the electric motor and generator and in the rechargeable battery.

Fig. 6: Hybrid Technology Chart.

H. Motors and Generators

Hybrid 1kg (2.2 lbs.) of neodymium-iron-boron (NdFeB) vehicles [4]. Vehicles employ approximately magnets in their motors and generators, this is some 800g more than conventional vehicles. These magnets are extremely strong, relatively light and are approximately 5-10% cobalt. A hybrid vehicle will use approximately 75g of cobalt in its magnets.

I. Batteries

In 2004 98% of hybrid vehicle batteries were nickel metal hydride (NiMH) and made by just two companies: Panasonic EV Energy: part owned by Toyota and supplier of batteries for the Toyota Prius and Honda's Civic and Insight hybrids.

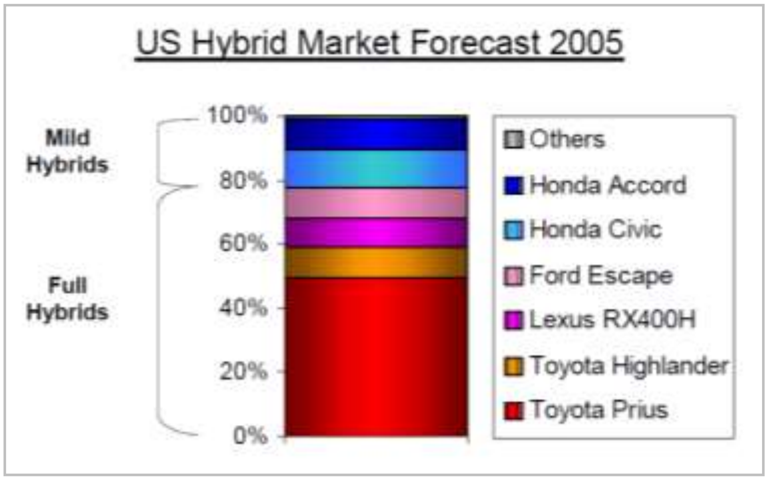

Fig. 7: US Hybrid Market Forecast 2005

J. *Fuel Consumption Reduction*

Hybrid systems can reduce fuel consumption and CO_2 emissions by up to 35%, equivalent to more than a 50% increase in fuel economy. The precise reduction varies with the sophistication of the hybrid system. The reduction can also be difficult to quantify if there is not a directly comparable non-hybrid vehicle. This second point is illustrated by the most comprehensive study to date, an October 2014 analysis done by the consultancy Vincentia, which compared 31 hybrids to the closest non-hybrid vehicle reduction ranged from 24% on the Lexus RX450h to 47% on the Lexus CT 200h. While conducting a detailed analysis of the possible bias for each hybrid vehicle comparison selected by Vincentia is beyond the scope of this report, it is clear that in some cases the non-hybrid vehicle has lower performance and fewer consumer features than the hybrid vehicle (such as the Honda Accord) and in other cases the non-hybrid vehicle has higher performance and features.

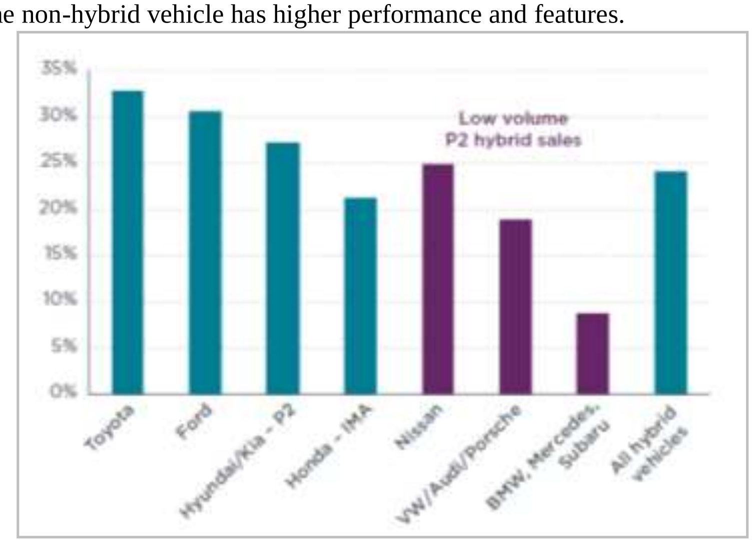

Fig. 8: Fuel saving in various model

K. *Forecasts of Future Developments in Hybrid Vehicles*

On a global level the drive for more efficient vehicles can be boiled down to a single bottom-line issue: the price of oil. Unfortunately for car-drivers, but fortunately for hybrid vehicle sales, long-term oil prices are likely to remain relatively high. Hybrid vehicles are expected to continue their rapid growth to date. By 2010 the US market expected to purchase 800,000 to 1.4 million hybrid vehicles per year, approximately a 5 to % market.

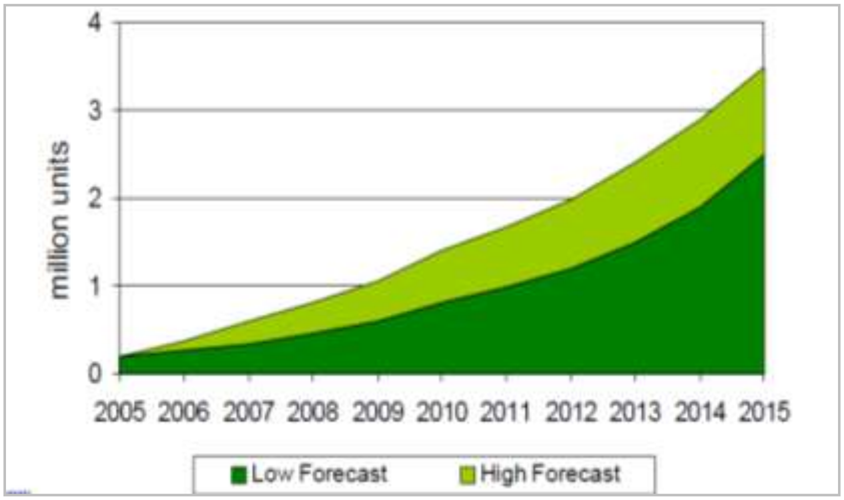

Fig. 9: Forecasts of Future Developments in Hybrid Vehicles

L. Impacts of Learning and Implications for Future Hybrid Development

The Toyota Prius hybrids have delivered about a 10% efficiency improvement with each new generation, while simultaneously reducing costs, increasing vehicle size, engine power, and electric motor power, and multiplying features (table 2 and figure 9). This was accomplished primarily by learning. Toyota built upon the best features of each design to improve the next design, with both better hardware and better integration and control of the various hybrid components. These improvements were delivered while reducing the price of the Prius relative to that of the Corolla LE Data on the cost reduction associated with each generation of the Prius is not directly available. Estimates of the cost reduction for each generation are calculated here based upon changes in the manufacturer's suggested retail price of the Prius relative to the price of the Corolla with the same trim package, and increases in the electric propulsion motor size. The EP A's indirect cost multipliers (IC M) from its 2017–2025 LDV CO2 rule were used to convert the price reductions to reductions in manufacturer cost. EP A's highest IC M value was used for the 2001 Prius (1.77) and its second-highest for the 2004 Prius (1.56), in recognition that this was new technology.

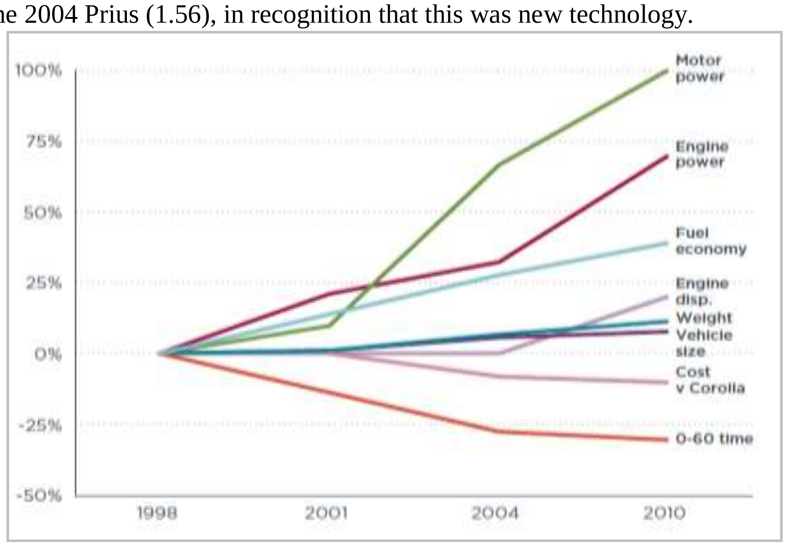

Fig. 10: Improvement for each generation

M. Different Technologies in Hybrid Systems

1) Input Power-Split

As its name implies, this system uses a planetary gear to distribute power between the engine, generator, traction motor, and drive train. It is the most sophisticated of all the currently available hybrid systems and excels in optimizing engine efficiency during city driving. It is also easily adaptable to plug-in operation. The downside is the cost associated with the requirement for two large electric motors and their associated power electronics. This system is used by Toyota and Ford for all of their hybrids. Toyota dominated the U.S. hybrid market with 66% of sales in 2014, and Ford was second with 14% of the market.

2) Two-Motor Systems

These are similar to the input power-split system in that part or all of the energy for the traction motor is provided from the engine through the generator, but they do not use a planetary gear system to transmit power. Two-motor systems offered in the past by

GM, Chrysler, BMW, and Mercedes had similar, if not better, efficiency than the input power-split, but at higher cost. All have been discontinued. Honda recently introduced a two-motor system on the 2015 Accord, which captured 3% of the hybrid market in 2014.

3) Parallel Hybrid with Two Clutches (P2)

Uses a single electric motor and two clutches, one between the engine and the electric motor and the second between the motor and the drive train. This system is highly scalable, from modest electric motor power to motors capable of plug-in hybrid operation. Different variations of this system have been recently introduced by Nissan, Hyundai/Kia, VW/Audi/Porsche, Subaru, BMW, and Mercedes. Hyundai/Kia is by far the leading seller of P2 hybrids, with 8% of total 2014 hybrid sales.

Honda has traditionally used a less efficient version of this system that does not have a clutch between the engine and the electric motor, which they call Integrated Motor Assist (IMA). This system was not discussed in this paper, as it offers significantly lower efficiency gains with only a modest reduction in cost relative to more advanced systems and only has 3% of the 2014 hybrid market. In fact, Honda is starting to replace their IMA system with a P2 hybrid system, beginning with the Japanese version of the 2015 Fit.

4) Belt Alternator-Starter (BAS)

BAS systems replace the conventional alternator with a higher power electric motor and a high-tension belt drive that can work in both directions, to provide power assist to the engine or to capture regenerative braking energy. The system is lower cost than hybrid systems with dedicated motors and minimizes packaging concerns by simply replacing the alternator. However, belt drives are not as efficient as the gear drives used in more advanced systems and the maximum power is limited by the belt. A 12v–24v BAS system is usually referred to as a micro-hybrid, and higher power BAS systems are usually referred to as mild hybrids.

5) Mild Hybrids

“Mild” hybrid is an undefined term loosely applied to hybrid systems that do not have all of the capability of full-function hybrids, such as the two-motor systems and the P2 hybrid, but have more functionality than stop-start systems or micro-hybrids. BAS systems and Honda’s IMA system are examples of mild hybrid systems. New concepts using 48-volt hybrid systems are in development and often include a small, electric motor integrated into the turbocharger to eliminate turbo lag and allow additional engine downsizing.

6) Micro-Hybrids

In addition to stop-start, provides limited amounts of regenerative braking energy and some additional functions, such as providing energy to replace most of the alternator functions, and shutting the engine off and disconnecting it from the drivetrain during higher speed decelerations (commonly called “sailing”). The system also provides faster engine restarts with less vibration than conventional starters.

7) Stop-Start

The most basic system, usually not classified as a real hybrid, which uses an improved battery and a higher-power starter motor to shut the engine off at idle and restart it when the brake pedal is released. Such systems are popular in Europe and are just starting to appear as standard equipment in the US. According to the 2014 EPA Fuel Economy Trends Report, 6% of 2014 models will be equipped with stop-start systems.

III. CONCLUSION

Hybrid gasoline-electric vehicles have come a long way from being a research concept and today they represent a bold statement about the future of vehicle engineering. Hybrids are the latest in a long line of pioneering automotive technologies to have reached economic maturity. High fuel prices, one of the principal drivers behind demand for hybrid vehicles, are expected to remain in place at least in the short term, and, according to the US Department of Energy, probably in the long term too to some extent. This will benefit the hybrid market, not least by neutralizing the hybrid price premium which has been a stumbling block to hybrids’ mass appeal in the past. Toyota believe “hybrids are here to stay and have committed themselves to manufacturing hybrids on a cost parity with conventional vehicles. When this happens hybrid technology will become competitive and commonplace. Twenty first century vehicles will incorporate increasing amounts of hybrid technology and this will cause a profound influence on the cobalt landscape. Backed by the industry giants and caught by the popular imagination, hybrid vehicles are a taste of the future, today, and are on course to become a source of major new demand for cobalt.

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