Hybrid Vehicles

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Hybrid Vehicle Technology

As of this writing in March 2005 there is a demand for hybrid vehicles that exceeds current production of them. And this is for models of vehicles that are typically in the $20,000+ range. But the availability of hybrid cars need not be limited to cars coming out of the factory. Existing vehicles as well can be converted to hybrid vehicles by replacing their engines, transmissions and drive train components. Existing cars trucks and vans can be converted to either hybrid or all electric vehicles and potentially much more economically than brand new hybrid cars and trucks coming out of factories. In fact cars that are 3 years old and older can be economically converted and practically given a second life when the entire engine and drive train are replaced with new hybrid components. The vast majority of the components that fail from wear and tear on the vehicle are replaced with new hybrid or electric components. Such a refurbished vehicle would then have a new book value reflecting its value as a refurbished hybrid vehicle. The conversion to a hybrid drive train itself can be financed or companies can generate profits taking older vehicles converting them to hybrids and reselling them. It makes economic sense to offer not only new hybrid cars and trucks but to develop, market and install hybrid conversion kits for existing cars, trucks and vans. Part of the iENERGY business plan is to do just that and to facilitate a much more rapid conversion of existing vehicles on the road to more economical, fuel efficient and environmentally friendly cars, trucks and vans. Hybrid vehicle From Wikipedia, the free encyclopedia. Jump to: navigation, search

Honda Insight, a hybrid gas-electric vehicle

2004 Toyota Prius, a hybrid gas-electric vehicle

Whispering Wheel Bus, a hybrid bus with an in wheel motor design.

A hybrid vehicle uses multiple propulsion systems to provide motive power. This most commonly refers to gasoline-electric hybrid vehicles, which use gasoline (petrol) and electric batteries to power internal-combustion engines (ICEs) and electric motors. Modern mass-produced hybrids, such as the Toyota Prius, recharge their batteries by capturing kinetic energy via regenerative braking. As well, when cruising or idling, some of the output of the combustion engine is fed to a generator (merely the electric motor(s) running in generator mode[2]) which produces electricity to charge the batteries. This contrasts with all-electric cars which use batteries charged by an external source such as the grid, or a range extending trailer. Nearly all hybrids still require gasoline as their sole fuel source though diesel and other fuels such as ethanol or plant based oils have also seen occasional use.

The term hybrid when used in relation with cars also has other uses. Prior to its modern meaning of hybrid propulsion, the word hybrid was used in the United States to mean a vehicle of mixed national origin; generally, a European car fitted with American mechanical components. This meaning has fallen out of use. In the import scene, hybrid was often used to describe an engine swap, such as the common Honda B16 engine into a Honda Civic. Some have also referred to flexible-fuel vehicles as hybrids because they can use a mixture of different fuels — typically gasoline and ethanol alcohol fuel.

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History

The first successful hybrid-electric car was engineered by Ferdinand Porsche in 1899. A recent working prototype was built by Herman Wouk's brother Victor Wouk (known as the Godfather of the Hybrid[3]) into a 1972 Buick Skylark provided by GM for the 1970 Federal Clean Car Incentive Program, but the program was killed by the EPA in 1976. Since then, hobbyists have continued to build hybrids but none was put into mass production by a major manufacturer until the waning years of the twentieth century. A forgotten attempt was by the Bill Clinton administration with the Partnership for a New Generation of Vehicles (PNGV)[4] program in September 29, 1993 that involved Chrysler, Ford, General Motors, USCAR, the DoE, and other various governmental agencies to engineer the next efficient and clean vehicle. The resulting hybrid prototypes[5] never made it into production as the program was replaced by the hydrogen focused FreedomCAR initiative[6] of George W. Bush's administration in 2001.

In the intervening period, the widest use of hybrid technology was actually in diesel-electric submarines, which operate in essentially the same manner as hybrid electric cars. However, in this case the goal was to allow operation underwater without consuming large amounts of oxygen, rather than economizing on fuel. Since then, many submarines have moved to nuclear power, which can operate underwater indefinitely, though a number of nations continue to rely on diesel-electric fleets.

Automotive hybrid technology became successful in the 1990s when the Honda Insight and Toyota Prius became available. These vehicles have a direct linkage from the internal combustion engine to the driven wheels, so the engine can provide acceleration power. The 2000s saw development of plug-in hybrid electric vehicles (PHEVs), which can be recharged from the electrical power grid and don't require conventional fuel for short trips. The Renault Kangoo was the first production model of this design, released in France in 2003. However, the environmental benefits of plug-in hybrids depend somewhat on the source of the electrical power. In particular, electricity generated with wind would be cleaner than electricity generated with coal, the most polluting source. On the other hand, electricity generated with coal in a central power plant is still much cleaner than pure gasoline propulsion, due to the much greater efficiencies of a central plant. Furthermore, coal is only one source of centrally generated power, and in some places such as California is only a minor contributor, overshadowed by natural gas and other cleaner sources.

The Prius has been in high demand since its introduction. Newer designs have more conventional appearance and are less expensive, often appearing and performing identically to their non-hybrid counterparts while delivering 50% better fuel efficiency. The Honda Civic Hybrid appears identical to the non-hybrid version, for instance, but delivers about 50 US mpg (4.7 L/100km). The redesigned 2004 Toyota Prius improved passenger room, cargo area, and power output, while increasing energy efficiency and reducing emissions. The Honda Insight, while not matching the demand of the Prius, is still being produced and has a devoted base of owners. Honda has also released a hybrid version of the Accord.

2005 saw the first hybrid SUV released, Ford Motor Company's Ford Escape Hybrid. Toyota and Ford entered into a licensing agreement in March 2004 allowing Ford to use 20 patents from Toyota related to hybrid technology, although Ford's engine was independently designed and built. In exchange for the hybrid licences, Ford licensed patents involving their European diesel engines to Toyota. Toyota announced model year 2005 hybrid versions of the Toyota Highlander and Lexus RX 400h with 4WD-i which uses a rear electric motor to power the rear wheels negating the need for a differential. Toyota also plans to add hybrid drivetrains to every model it sells in the coming decade.

For 2007 Lexus is offering a hybrid version of their GS sport sedan dubbed the GS450h with "well in excess of 300hp". The 2007 Camry Hybrid has been announced and is slated to launch in late Spring as a 2007 model. It will be built in Kentucky, USA. Also, Nissan announced the release of the Altima hybrid (technology supplied by Toyota) around 2007.

An R.L. Polk survey of 2003 model year cars showed that hybrid car registrations in the United States rose to 43,435 cars, a 25.8 % increase from 2002 numbers. California, the nation's largest state with 1/8th of the country's population, had the most hybrid cars registered with 11,425. The proportionally high number may be partially due to the state's higher gasoline prices and stricter emissions rules, which hybrids generally have little trouble passing.

Honda, which offers Insight, Civic and Accord hybrids, sold 26,773 hybrids in the first 11 months of 2004. Toyota has sold a cumulative 306,862 hybrids between 1997 and Nov. 2004 and Honda has sold a total of 81,867 hybrids between 1999 and November 2004.[7] [edit]

Hybrids currently available

- Ford:
- Ford Escape Hybrid
- Mercury Mariner Hybrid
- Honda:
- Honda Insight (International Engine of the Year 2000)
- Honda Civic Hybrid
- Honda Accord Hybrid
- General Motors:
- Chevrolet Silverado/GMC Sierra Hybrid (debatable, see Mild hybrid)
- New Flyer hybrid buses using Allisons electric drive system
- Opel Astra Diesel Hybrid.
- Mazda:
- Mazda Demio (Japan-only, debatable, see Assist hybrid)
- Renault:
- Renault Kangoo (France)
- Toyota and Lexus:
- Toyota Prius (Motor Trend Car of the Year 2004, International Engine of the Year 2004, European Car of the Year 2005)
- Lexus RX 400h
- Toyota Highlander
- Toyota Estima (Japan-only)
- Motorized bicycle
- Moped
- Power-assisted bicycle
- Electric bicycle
- Whispering Wheel Bus [edit]

Trains, trucks and buses

In May 2003 JR East started test runs with the so called NE (new energy) train and validated the system's operability (series hybrid with lithium ion battery) in cold regions. In 2004 Railpower had been running pilots in the US with the so called Green Goats which lead to orders starting in early 2005. Also in 2005 GE introduced its hybrid shifters on the market. Toyota claims to have started with the Coaster Hybrid Bus in 1997 on the Japanese market. In May 2003 GM started to tour with hybrid buses developed together with Allison. Several hundreds of those buses have entered into daily operation in the US. The Blue Ribbon City Hybrid bus was presented by Hino, a Toyota affiliate, in January 2005.

In 2003 GM introduced a diesel hybrid military (light) truck, equipped with a diesel electric and a fuel cell auxiliary power unit. Hybrid light trucks were introduced 2004 by Mercedes (Hybrid Sprinter) and Micro-Vett SPA (Daily Bimodale). International Truck and Engine Corp. and Eaton Corp. have been selected to manufacture diesel-electric hybrid trucks for a US pilot program serving the utility industry in 2004. In mid 2005 Isuzu introduced the Elf Diesel Hybrid Truck on the Japanese Market. They claim that approximately 300 vehicles, mostly route buses are using Hinos HIMR (Hybrid Inverter Controlled Motor & Retarder) system.

An absolutely ideal application for hybrid vehicle technology would be a garbage truck for suburban residential collection, since an incredible amount of stop-start driving and lots of idling time is required of these vehicles. [edit]

Taxicabs

In 2005, New York City added six Ford Escape Hybrids to their taxi fleet and city officials said the entire fleet of 13,000 vehicles could be converted within five years.[8] [edit]

Types

There are many types of hybrids, differentiated by how the electric and fueled halves of the powertrain connect, and at what times each portion is in operation. Two major categories are series hybrids and parallel hybrids, though parallel designs are most common today. Some hybrid vehicles don't even use electricity for auxiliary energy storage.

Most hybrids, no matter the specific type, use regenerative braking to recover energy when slowing down the vehicle. This simply involves running the motor backwards as a generator.

Many designs also shut off the internal combustion engine when it is not needed in order to save energy. That concept is not unique to hybrids; Subaru pioneered this feature in the early 1980s, and the Volkswagen Lupo 3L is one example of a conventional vehicle that shuts off its engine when at a stop. Some provosion must be made, however, for accessories such as air conditioning which are normally driven by the engine. Furthermore, the lubrication systems of internal combustion engines are inherently least effective immediately after the engine starts; since it is upon startup that the majority of engine wear occurs, the frequent starting and stopping such systems cause may reduce the lifespan of the engine considerably. Also, start and stop cycles may reduce the engine's ability to operate at its optimum temperature, thus reducing the engine's efficiency. [edit]

Series

In a series design, the internal combustion engine is not directly connected to the drivetrain at all, but powers an electrical generator instead. This is similar to the operation of diesel-electric train locomotives, but they do not store auxiliary power in batteries for later use, and in fact is similar to an electric car which is recharged by electricity from a stationary fossil fuel power plant, except that the power plant is carried on board.

Electricity from the generator is fed to the motor or motors that actually move the car, and excess energy can be used to charge batteries. When large amounts of power are required, electricity comes from both the battery pack and the engine-generator section. Because electrical motors can operate quite efficiently over a wide range of speeds, this design removes or reduces the need for a complex transmission. The internal combustion engine can also be finely tuned to operate at its most efficient speed whenever it is running, for a great gain in efficiency. Separate small electric motors installed at each wheel are featured in some prototypes and concept cars; this allows the possibility of easily controlling the power delivered to each wheel, and therefore simplifies traction control, all wheel drive, and similar features.

The advantage of this type of hybrid is the flexibility afforded by the lack of a mechanical link between the internal combustion engine and the wheels. A weakness of a series hybrid system, however, is that series hybrids require separate motor and generator portions, which can be combined in some parallel hybrid designs; the combined efficiency of the motor and generator will be lower than that of a conventional transmission, offsetting the efficiency gains that might otherwise be realized. Still, series hybrids are useful in driving cycles that incorporate many stops and starts, such as for delivery vehicles. It is likely that some hydrogen cars running on fuel cells will use a series-style setup, with fuel cells replacing the engine-generator section. [edit]

Parallel

Parallel systems, which are most common at present, connect both the electrical and internal combustion systems to the mechanical transmission. They can be subcategorized depending upon how balanced the different portions are at providing motive power. In some cases, the internal combustion engine is the dominant portion and is used for primary power, with the motor turning on only when a boost is needed. Others can run with just the electric system operating alone. Most designs combine a large electrical generator and a motor into one unit, often situated between the internal combustion engine and the transmission, in the location of the flywheel, replacing both the conventional starter motor and the generator or alternator. A large battery pack is required, providing a higher voltage than the normal automotive 12 volts. Accessories such as power steering and air conditioning are powered by electric motors, so that they continue to function when the internal combustion engine is stopped; this offers the possibility of further efficiency gains, by modulating the electrical power delivered to these systems, rather than having them run directly from the engine at a speed which depends on engine speed. [edit]

Full hybrid

A full hybrid, sometimes also called a strong hybrid, is a vehicle that can run on just the engine, just the batteries, or a combination of both. The Prius and Escape Hybrids are examples of this, as both cars can be moved forward on battery power alone. A large, high-capacity battery pack is needed for battery-only operation. These vehicles have a split power path that allows more flexibility in the drivetrain by interconverting mechanical and electrical power, at some cost in complexity. To balance the forces from each portion, the vehicles use a differential-style linkage between the engine and motor connected to the head end of the transmission.

The Toyota brand name for this technology is Hybrid Synergy Drive, which is being used in the Prius and the Highlander sport-utility vehicle (SUV). A computer oversees operation of the entire system, determining which half should be running, or if both should be in use, shutting off the internal combustion engine when the electric motor is sufficient to provide the power. The normal mode of operation is on electrical power alone, with the gasoline engine running only in cases where the extra power is required, or where the batteries are discharged. The hybrid drivetrain of the Prius, in combination with aerodynamics and optimizations in the engine itself to reduce drag, results in 80%–100% gains in fuel economy compared to four-door conventional cars of similar weight and size.

The main principle behind this system is the more-or-less complete decoupling of the power supplied by the engine (or other primary source) from the power demanded by the driver. Thus a smaller, less flexible engine may be used, which is designed for maximum efficiency (often using variations of the conventional Otto cycle, such as the Miller or Atkinson cycle). This contributes significantly to the higher overall efficiency of the vehicle, with regenerative braking playing a much smaller role.

The differing torque vs. RPM characteristics of the internal combustion and electrical motors operate synergistically; an internal combustion engine's torque is minimal at lower RPMs, since the engine must be its own air pump. Thus, the need for reasonably rapid acceleration from a standing start results in an engine which is much larger than required for steady speed cruising. On the other hand, an electrical motor exhibits maximum torque at stall; therefore this engine is well suited to complement the internal combustion engine's torque deficiency at low RPMs, allowing the use of a much smaller and therefore more fuel efficient engine.

General Motors, BMW, and DaimlerChrysler are working together on a so-called Two-Mode Hybrid system which is a full hybrid plus additional efficiency improvements. The technology will be released in 2008 on the Chevrolet Tahoe Hybrid. The system was also features on the GMC Graphite SUV concept vehicle at the 2005 North American International Auto Show in Detroit.[9] [edit]

Assist hybrid

Engine compartment of a 2006 Mercury Mariner Hybrid

Assist hybrids use the engine for primary power, with a torque-boosting electric motor also connected to a largely conventional powertrain. The electric motor is essentially a very large starter motor, which operates not only when the engine needs to be turned over, but also when the driver "steps on the gas" and requires extra power. Honda's hybrids including the Insight use this design, leveraging their reputation for design of small, efficient gasoline engines; their system is dubbed Integrated Motor Assist (IMA). Assist hybrids differ fundamentally from full hybrids in that they cannot run on electric power alone. However, since the amount of electrical power needed is much smaller, the size of the battery systems is reduced.

A variation on this type is Mazda's e-4WD system, offered on the Mazda Demio sold in Japan. This front wheel drive vehicle has an electric motor which can drive the rear wheels when extra traction is needed. The system is entirely disengaged in all other driving conditions, so it does not enhance performance or economy.

Ford has dubbed Honda's hybrids "mild" in their advertising for the Escape Hybrid, arguing that the Escape's full hybrid design is more efficient. However, assist hybrids should not be confused with actual mild hybrids like the Chevrolet Silverado Hybrid. [edit]

Mild hybrid

Engine compartment of a 2006 GMC Sierra Hybrid

Mild hybrids are essentially conventional vehicles with oversized starter motors, allowing the engine to be turned off whenever the car is coasting, braking, or stopped, yet restart quickly and cleanly. Accessories can continue to run on electrical power while the engine is off, and as in other hybrid designs, the motor is used for regenerative braking to recapture energy. The larger motor is used to spin up the engine to operating rpm speeds before injecting any fuel.

Many don't consider these to be hybrids at all, and these vehicles do not achieve the fuel economy of full hybrid models. A major example is the 2005 Chevrolet Silverado Hybrid, a fullsize pickup truck. Chevrolet was able to get a 10% improvement on the Silverado's fuel efficiency by shutting down and restarting the engine on demand. Mild hybrids often use 48 volt systems to supply the power needed for the startup motor, as well as to compensate for the increasing number of electronic accessories on modern vehicles.

General Motors followed the pickup truck hybrid with their Belt alternator starter (BAS) hybrid system, used in the 2006 Saturn VUE Green Line. It operates in much the same manner as the "start-stop" system in the Silverado, but the electric motor can also provide modest assist under acceleration. [edit]

Plug-in hybrid Main article: Plug-in hybrid electric vehicle

A plug-in hybrid electric vehicle (PHEV) is a full hybrid, able to run in electric-only mode, with larger batteries and the ability to recharge from the electric power grid. They are also called gas-optional, or griddable hybrids. Their main benefit is that they can be gasoline-independent for daily commuting, but also have the extended range of a hybrid for long trips. They can also be multi-fuel, with the electric power supplemented by diesel, biodiesel, or hydrogen. The Electric Power Research Institute's research indicates a lower total cost of ownership for PHEVs due to reduced service costs and gradually improving batteries. The "well-to-wheel" efficiency and emissions of PHEVs compared to gasoline hybrids depends on the energy sources of the grid (the US grid is 50% coal; California's grid is primarily natural gas, hydroelectric power, and wind power). Particular interest in PHEVs is in California where a "million solar homes" initiative is under way, and global warming legislation has been enacted.

Prototypes of plug-in hybrid cars, with larger battery packs that can be recharged from the power grid, have been built in the U.S., notably at Prof. Andy Frank's Hybrid Center[10] at UC Davis and one production PHEV, the Renault Kangoo, went on sale in France in 2003. DaimlerChrysler is currently building PHEVs based on the Mercedes-Benz Sprinter van. Light Trucks are also offered by Micro-Vett SPA[11] the so called Daily Bimodale.

The California Cars Initiative has converted the '04 and newer Toyota Prius to become a prototype of what it calls the PRIUS+. With the addition of 300 lb of lead-acid batteries, the PRIUS+ achieves roughly double the gasoline mileage of a standard Prius and can make trips of up to 10 miles using only electric power.[12]

See also: vehicle to grid [edit]

Hydraulic hybrid

A hydraulic hybrid vehicle uses hydraulic and mechanical components instead of electrical ones. A variable displacement pump replaces the motor/generator, and a hydraulic accumulator replaces the batteries. The hydraulic accumulator, which is essentially a pressure tank, is potentially cheaper and more durable than batteries. Hydraulic hybrid technology was originally developed by Volvo Flygmotor and was used experimentally in buses from the early 1980s and is still an active area.

Initial concept involved a giant flywheel for storage connected to a hydrostatic transmission, but it was later changed to a simpler system using a hydraulic accumulator connected to a hydraulic pump/motor. It is also being actively developed by Eaton and several other companies, primarily in heavy vehicles like buses, trucks and military vehicles. An example is the Ford F-350 Mighty Tonka concept truck shown in 2002. It features an Eaton system that can accelerate the truck up to highway speeds. [edit]

Engines and fuel sources [edit]

Gasoline

Gasoline engines are used in most hybrid designs, and will likely remain dominant for the foreseeable future. While petroleum-derived gasoline is the primary fuel, it is possible to mix in varying levels of ethanol created from renewable energy sources. Like most modern ICE-powered vehicles, hybrids can typically use up to about 15% ethanol. Manufacturers may move to flexible-fuel engines, which would increase allowable ratios, but no plans are in place at present. [edit]

Diesel

One particularly interesting hybrid vehicle combination uses a diesel engine for power. Diesels are excellent at delivering constant power for long periods of time, suffering less wear while operating at higher efficiency. However, the engines also suffer from poor acceleration due to having a limited rpm range (which, incidently, is one reason it is easy to pass a semitruck on an uphill). This poor acceleration can be addressed with the hybrid technique, and such designs may offer performance in a car of over 100 mpg US (2.35 L per 100 km).

Diesel vehicles, and therefore diesel hybrids, have the advantage they can use 100% pure biofuels (biodiesel), so they don't need petroleum at all. Diesels are not widely used for passenger cars in the United States,as US diesel fuel has long been considered very "dirty", with relatively high levels of sulfur and other contaminants in comparison to the Eurodiesel fuel in Europe, where greater restrictions have been in place for many years. Despite the dirtier fuel, the US has tough restrictions on exhaust, and it has been difficult for car manufacturers to meet emissions levels given what is put into the engine. However, ultra-low sulfur diesel is set to be mandated in the United States in June 2006.

General Motors has been testing the Opel Astra Diesel Hybrid.

Far away, VW made a prototype diesel-electric hybrid car that achieved 118 mpg US fuel economy (2 liters per 100 km), but has yet to sell a hybrid vehicle. So far, hybrid diesels have primarily appeared in mass transit buses, primarily made by General Motors' New Flyer division in the United States, and by Japanese manufacturers (Toyota, Hino, Isuzu) since 1997 for sale in Japan only. [edit]

Fuel cells

Some fuel cell-powered vehicles currently in development use some hybrid-like technology to store auxiliary energy. Like diesels above and steam power outlined below, fuel cells are best at delivering a fairly constant flow of electricity, so having a secondary system is helpful. In some cases, batteries have been replaced with ultracapacitors, which can store and retrieve energy quickly, but are inappropriate for long-term electrical storage. [edit]

Steam and turbines

At present, no current or planned mass-market car is driven by a steam engine, but hybrid technology could bring back the steam-powered car. In the early 20th century, steam-powered cars made by the Stanley Steamer Company did compete successfully with the internal combustion engine. Steam engines can be much more efficient (and generate less pollution) than internal combustion engines, which is why most of the world's electric power comes from steam turbines heated by fossil fuels or a nuclear heat source. However, steam engines have not been able to compete with internal combustion for vehicles for several reasons:

- Lower power-to-weight ratio
- Smaller range of operating speeds
- Much longer warm-up time (and likewise slow throttle response) — this is not so much an issue for locomotives and ships which are restricted from quick acceleration by their huge mass
- More complex controls and can go at most 300 miles fully charged which takes 2 days.

The driver of a Stanley Steamer had to keep a close eye on several pressure and temperature gauges while driving. With modern computers, much of this could be handled automatically. Similarly, the availability of relatively lightweight turbines increases the power-to-weight ratio and reduces thermal inertia.

Similarly, turbine engines directly burning fuel could also be used. From the 1950s to the 1970s Chrysler created several turbine-powered vehicles, though only small numbers were produced. They had complex drivetrains and achieved relatively slow starting speeds, with effects reminiscent of "turbo lag," but demonstrated that turbines could be used for automobiles (see Chrysler Turbine engines). [edit]

Hybrid fuel

In addition to vehicles that use two or more different devices for creating motive power, some also consider vehicles that use distinct energy input types (fuels) to be hybrids:

- Some electric trolleybuses can switch between an onboard diesel engine and overhead electrical power depending on conditions.
- Flexible-fuel vehicles can use a mixture of input fuel (typically gasoline and ethanol, though diesel-biodiesel and liquid petroleum gas-natural gas (LPG-NG) vehicles would also qualify).
- Some vehicles have been modified to use another fuel source if it is available. Cars modified to run on propane, and diesels modified to run on waste vegetable oil are possibilities.
- Power-assist mechanisms for bicycles and other human-powered vehicles are also included. [edit]

Human Power

Motorized bicycles use human pedal power and an attached motor. Some bicycle conversion kits aided popularisation of "hybrid" vehicle bicycles that used electric hub motors (such as Bionx[13] and Wilderness Energy[14]), internal combustion engines (such as the 1940s "Pixie" bicycle motor), and pedal power. Such machines include electric bicycles and mopeds, which may often be simultaneously propulsed by human and engine power. [edit]

Benefits

Median mpg (US) with boxplot from GreenHybrid.com[1]

Benefits of the hybrid design include:

- The internal-combustion engine in a hybrid vehicle is much smaller, lighter, and more efficient than the one in a conventional vehicle, because the engine can be sized for slightly above average power demand rather than peak power demand. The power curve of electric motors is better suited to variable speeds and can provide substantially greater torque at low speeds compared with internal-combustion engines.
- Like many electric cars, but in contrast to conventional vehicles, braking in a hybrid is controlled in part by the electric motor which can recapture part of the kinetic energy of the car to partially recharge the batteries. This is

called regenerative braking and one of the reasons for the high efficiency of hybrid cars. In a conventional vehicle, braking is done by mechanical brakes, and the kinetic energy of the car is wasted as heat.
- Hybrids are more environmentally-friendly than traditional internal combustion engine vehicles because they generally provide greater fuel economy.
- Reduced wear and tear on the gasoline engine.

Government agencies in the United States and elsewhere offer various incentives to encourage the purchase of certain qualifying hybrid or electrical vehicles.
- The purchase of hybrid cars qualifies for a $2000 tax deduction on the IRS 1040 form for the year of 2003. The deduction reduces by $500 each year until it reaches zero. HR 1308 Sec. 319 proposed the phasing out of the deduction to put on hold for the year 2004 and 2005 (i.e., hybrid car buyers can enjoy the $2000 deduction before the phasing out resumes at $500 in 2006).
- The Federal tax deduction will turn into a tax credit starting Jan 1, 2006. However only 60,000 new cars sold by each car manufacturer would qualify for such tax credit.
- Many states give tax credits to hybrid car buyers.
- Certain states (e.g., California, Virginia and Florida) allow singly-occupied hybrid vehicles to enter the HOV lanes on the highway. Initially, the Federal Highway Administration ruled that this was a violation of federal statute[15] until August 10, 2005 when George W. Bush signed the Transportation Equity Act of 2005 into law.
- Some states, e.g. California, exempt hybrid cars from the biennial smog inspection, which costs over $50 (as of 2004).
- Hybrid cars can go on certain toll roads for free.
- City of San Jose, CA issues a free parking tag for hybrid cars that were purchased at a San Jose dealership. The qualified owners do not have to pay for parking in any city garage or road side parking meters
- City of Los Angeles, CA offers free parking to all hybrid vehicles starting on October 1, 2004. The experiment is an extension to an existing offer of free parking for all pure electrical vehicles.
- In October, 2005, City of Baltimore, MD started to offer discount on monthly parking in the city parking lots, and is considering free meter parking for hybrid vehicles. On November 3, 2005, the Boston Globe reports that the city council of Boston is considering the same treatment for hybrid cars.
- Annual vehicle registration fees in the District of Columbia are half ($36) that paid for conventionally vehicles ($72).
- Drivers of hybrid vehicles in the United Kingdom benefit from the lowest band of Vehicle Excise Duty (car tax) which is based on CO_2 emissions. In London, these vehicles are also exempt from the £8 ($14) daily congestion charge in Central London. [edit]

Trade-offs

In some cases, manufacturers are producing hybrid vehicles that used the added energy provided by the hybrid systems to give vehicles a power boost, rather than significantly improved fuel efficiency compared to their traditional counterparts.[16] The trade-off between added performance and improved fuel efficiency is mainly something controlled by the software within the hybrid system. In the future, manufacturers may provide hybrid-owners with the ability to set this balance (fuel efficiency vs. added performance) as they wish, through a user-controlled setting.[17] Toyota announced in January, 2006 that it was considering a "high-efficiency" button.

It has been observed that the success of the hybrid systems comes despite the need to carry two complete power systems, with the attending increase in weight and size and therefore greater losses in acceleration and aerodynamic drag.[citation needed] In fact, the relative desirability of this concept rests on the deficiencies of the two underlying systems; the unfavorable torque curve of the internal combustion engine, referred to above, and the lack of a system of storing and delivering electrical power with anything near the energy density of combustible liquid fuels, so that a fuel tank, internal combustion engine, and generator together still represent a better source of electrical power than the equivalent weight and volume of batteries. In the event of relatively large leaps forward in battery or fuel cell technology, the internal combustion portion of the hybrid will become superfluous. Somewhat less likely is the possibility of a change in the general popular mode of automobile use largely supplanting short trips by use of mass transportation, so that the majority of automotive operation becomes steady speed cruising rather than stopping and starting; this would eliminate the advantage gained from regenerative braking and the low RPM torque boost of the electrical portion of the hybrid, and allow very small forced induction internal combustion engines to become viable competitors of the heavier hybrid systems.[citation needed]

It must also be noted that mechanics are not fond of working on hybrid vehicles due to added complexity.[citation needed] This may result in greater repair costs [citation needed], which may reduce the overall lifespan of hybrid vehicles - though this is based solely on anecdotal evidence; first generation hybrids are still not found in wrecking yards in substantial quantities.

Disposal is an additional issue. By its very nature, a battery must be made of highly reactive chemicals; the more power density the battery offers, the more reactive the chemicals it contains. In no case will all discarded hybrid vehicles be returned for proper recycling and disposal; the environmental effects of leachates from hybrid battery packs must be considered in the total assessment of the system.

Finally, the typical hybrid vehicle is more expensive than corresponding non-hybrids (e.g., Civic vs Civic Hybrid). Although the variables involved are many, those more concerned about economics than the environment might steer away from hybrids in favor of traditional economy vehicles, as they would result in a lower cost in most cases.[18] [edit]

Hybrids vs. electric vehicles

All-electric cars are more popular in Europe than in the U.S. The major U.S. automobile manufacturers argue that customer demand for pure electric cars is small. In addition, the long suburban commutes common in the U.S. make range an important criterion for electric vehicle design. However, if advances in battery technology allow increased range at comparable cost to gasoline-powered vehicles, manufacturers will likely mass-market electric vehicles. The relative cost of gasoline to an equivalent amount of electrical energy will also be a critical factor in the electric vehicle market.

For now, car manufacturers are focusing on fuel cell-based cars and hybrids. Toyota intends that all of its vehicles be hybrid electric by 2012.[citation needed] [edit]

Other hybrid vehicles

Railpower[19] offers hybrid road switchers, as does GE.[20] Diesel-electric locomotives may not always be considered hybrids, not having energy storage on board, unless they are fed with electricity via a collector for short distances (for example, in tunnels with emission limits). [edit]

See also

- Advanced Hybrid System 2
- Alternative propulsion
- Auto show
- Battery pack
- Battery electric vehicle
- Diesel-electric locomotive
- Electric vehicle
- Energy conservation
- Future energy development
- Gas-electric hybrid engine
- Green technology
- Greenhouse gas
- Hybrid Synergy Drive (HSD)
- Hyper mileage
- List of hybrid vehicles
- Renewable energy
- Super Ultra Low Emission Vehicle
- Tribrid cars
- Vehicle to grid
- Whispering Wheel [edit]

Footnotes & references

- ^ Real Hybrid Mileage Database. GreenHybrid.com. URL accessed on January 11, 2006.
- ^ Electric motors can in general also be used as generators, depending on the applied voltage, direction of current flow, and the phase of commutation in the motor. The principal difference between a motor and a generator is one of design optimization only. See also motor-generator
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- Hybridcars.com.
- ResearchHybrids.com - Comparison data and charts.
- InsightCentral.org: The Independent Honda Insight Website.
- The History of the Hybrid Vehicle
- John's Stuff - Toyota Prius and more A very detailed site from a long-term owner of the Toyota Prius, includes logs, pictures, and videos.
- Hybrid Car information for the UK. [edit]

Hybrid powertrains

- ISE ThunderVolt® Electric and Hybrid-Electric Buses and Trucks Drive Systems also using Ultracapacitators
- diesel electric hybrid Ricardo i-MoGen Integrated Motor Generator
- TM4 motor generator
- Lombardini ECOMOVE Hybrid Power Engine
- Siemens Integrated Powertrain Management [edit]

Hybrids in logistics

- Mercedes Hybrid Sprinter
- SHEP Technologies, Inc. Hydraulic hybrids.
- Permo-Drive Australian hydraulic hybrids. [edit]

Hybrids in public transport

- Hybrid Diesel-Electric Buses TriMet
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