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DEPARTMENT OF AUTOMOBILE

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A SEMINAR REPORT ON

HYBRID VEHICLES

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Certificate

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INTRODUCTON

A **hybrid vehicle** is a vehicle that uses two or more distinct power sources to move the vehicle. The term most commonly misinterpreted as hybrid electric vehicles (HEVs), which combine an internal combustion engine and one or more electric motors. When one mentions HYBRID VEHICLES, it refers to vehicles using two or more different power sources out of which the sources might be onboard or externally supplied.

A hybrid vehicle is a vehicle which uses a mixture of power or fuel sources.
Hybrid vehicle may also refer to:

- Hybrid electric vehicle, increasingly common automobiles which employ both a traditional internal combustion engine and an electric battery motor/generator to provide motive force and energy recovery.
  - Plug-in hybrid, an electric hybrid vehicle that can be plugged into a power grid to recharge its battery.
- Hydraulic hybrid, a hybrid vehicle which employs both a traditional internal combustion engine and a hydraulic motor/pump to provide motive force and energy recovery. Currently developed for big trucks/buses that start/stop often.
- Dual-mode vehicle, a hybrid vehicle which uses power from two sources of the same type
- Flexible-ugly & gorse vehicle, a hybrid vehicle which can use more than one type of liquid fuel for its internal combustion engine (commonly gasoline/LPG or gasoline/alcohol or gasoline/ethanol) The military has used gasoline/diesel/JP5 combos.
- Motorized bicycle, a bicycle powered by human and another power source such as liquid fuels or electricity
- Hybrid train, a locomotive with more than one power source

Sources of hybrid vehicles:

Power sources for hybrid vehicles include:

- On-board or out-board rechargeable energy storage system (RESS)
- Compressed air
- Coal, wood or other solid combustibles
- Electricity
- Electromagnetic fields, Radio waves
- Compressed or liquefied natural gas
- Human powered e.g. pedaling or rowing
- Hydrogen
- Liquid nitrogen
- Petrol or Diesel fuel
- Solar
- Wind
- Waste heat from internal combustion engine.

Types of hybrid vehicles:

Two-wheeled and cycle-type vehicles

Mopeds, electric bicycles, and even electric kick scooters are a simple form of a hybrid, as power is delivered both via an internal combustion engine or electric motor and the rider's muscles. Early prototypes of motorcycles in the late 19th century used the same principles.

- In a **parallel hybrid bicycle** human and motor power are mechanically coupled at the pedal drive train or at the rear or the front wheel, e.g. using a hub motor, a roller pressing onto a tire, or a connection to a wheel using a transmission element. Human and motor torques are added together. Almost all manufactured models are of this type. See Motorized bicycles, Mopeds and for more information.

- In a **series hybrid bicycle** (SH) the user powers a generator using the pedals. This is converted into electricity and can be fed directly to the motor giving a chainless bicycle but also to charge a battery. The motor draws power from the battery and must be able to deliver the full mechanical torque required because none is available from the pedals. SH bicycles are commercially available, because they are very simple in theory and manufacturing.

The first known prototype and publication of an SH bicycle is by Augustus Kinzel (US Patent 3'884'317) in 1975. In 1994 Bernie Macdonalds conceived the Electrilite SH lightweight vehicle which used power electronics allowing regenerative braking and pedaling while stationary. In 1995 Thomas Müller designed a "Fahrrad mit elektromagnetischem Antrieb" in his 1995 diploma thesis and built a functional vehicle. In 1996 Jürg Blatter and Andreas Fuchs of Berne University of Applied Sciences built an SH bicycle and in 1998 mounted the system onto a Leitra tricycle (European patent EP 1165188). In 1999 Harald Kutzke described his concept of the "active bicycle": the aim

is to approach the ideal bicycle weighing nothing and having no drag by electronic compensation. Until 2005 Fuchs and colleagues built several prototype SH tricycles and quadricycles.

Heavy vehicles

Hybrid power trains use diesel-electric or turbo-electric to power railway locomotives, buses, heavy goods vehicles, mobile hydraulic machinery, and ships. Typically some form of heat engine (usually diesel) drives an electric generator or hydraulic pump which powers one or more electric or hydraulic motors. There are advantages in distributing power through wires or pipes rather than mechanical elements especially when multiple drives—e.g. driven wheels or propellers—are required. There is power lost in the double conversion from typically diesel fuel to electricity to power an electric or hydraulic motor. With large vehicles the advantages often outweigh the disadvantages especially as the conversion losses typically decrease with size. With the exception of non nuclear submarines, presently there is no or relatively little secondary energy storage capacity on most heavy vehicles, e.g. auxiliary batteries andhydraulic accumulators—this is changing.

Rail transport

Europe

An is the new Autorail à grande capacité (AGC or high-capacity railcar) built by the Canadian company Bombardier for service in France. This has dual mode (diesel and electric motors) and dual voltage capabilities (1500 and 25000 V) allowing it to be used on many different rail systems. The locomotive has been on trials in Rotterdam, the Netherlands withRailfeeding, a Genesse and Wyoming company.

China

The First Hybrid Evaluating prototype locomotive was designed and contracted by rail research center MATRAI in 1999 and the sample was ready in 2000. it was a G12 locomotive that was converted to hybrid by using a 200KW diesel generator and batteries and also was equipped with 4 AC traction motors (out of 4) retrofited in the cover of the DC traction motors.

Japan

The first operational prototype of a hybrid train engine with significant energy storage and energy regeneration capability was introduced in Japan as the KiHa E200. It utilizes battery packs of lithium ion batteries mounted on the roof to store recovered energy.

North America

In the U.S., General Electric introduced a prototype railroad engine with their "Ecomagination" technology in 2007. They store energy in a large set of sodium nickel chloride (Na-$NiCl_2$) batteries to capture and store energy normally dissipated during dynamic braking or coasting downhill. They expect at least a 10% reduction in fuel use with this system and are now spending about $2 billion/yr on hybrid research. [8]

Variants of the typical diesel electric locomotive include the Green Goat (GG) and Green Kid (GK) switching/yard engines built by Canada's Railpower Technologies. They utilize a large set of heavy duty long life (~10 yr) rechargeable lead acid (Pba) batteries and 1000 to 2000 HP electric motors as the primary motive sources and a new clean burning diesel generator (~160 Hp) for recharging the batteries that is used only as needed. No power or fuel are wasted for idling—typically 60–85% of the time for these type locomotives. It is unclear if dynamic braking (regenerative) power is recaptured for reuse; but in principle it should be easily utilized.

Since these engines typical need extra weight for traction purposes anyway the battery pack's weight is a negligible penalty. In addition the diesel generator and battery package are normally built on an existing "retired" "yard" locomotive's frame for significant additional cost savings. The existing motors and running gear are all rebuilt and reused. Diesel fuel savings of 40–60% and up to 80% pollution reductions are claimed over that of a "typical" older switching/yard engine. The same advantages that existing hybrid cars have for use with frequent starts and stops and idle periods apply to typical switching yard use. "Green Goat" locomotives have been purchased by Canadian Pacific Railway, BNSF Railway, Kansas City Southern Railway and Union Pacific Railroad among others.

Cranes

Railpower Technologies Corp. engineers working with TSI Terminal Systems Inc. in Vancouver, British Columbia are testing a hybrid diesel electric power unit with battery storage for use in Rubber Tyred Gantry (RTG) cranes. RTG cranes are typically used

for loading and unloading shipping containers onto trains or trucks in ports and container storage yards. The energy used to lift the containers can be partially regained when they are lowered. Diesel fuel and emission reductions of 50–70% are predicted by Railpower engineers. First systems are expected to be operational in 2007.

Road transport, commercial vehicles

GM has launched hybrid versions of its full-size GMC Yukon (*pictured*) andChevrolet Tahoe SUVs for 2008

Early hybrid systems are being investigated for trucks and other heavy highway vehicles with some operational trucks and buses starting to come into use. The main obstacles seem to be smaller fleet sizes and the extra costs of a hybrid system are yet compensated for by fuel savings, but with the price of oil set to continue on its upward trend, the tipping point may be reached by the end of 1995. Advances in technology and lowered battery cost and higher capacity etc. developed in the hybrid car industry are already filtering into truck use as Toyota, Ford, GM and others introduce hybrid pickups and SUVs. Kenworth Truck Company recently introduced a hybrid-electric truck, called the Kenworth T270 Class 6 that for city usage seems to be competitive. FedEx and others are starting to invest in hybrid delivery type vehicles—particularly for city use where hybrid technology may pay off first.

Military off-road vehicles

Since 1985, the U.S. military has been testing serial hybrid Humvees and have found them to deliver faster acceleration, a stealth mode with low thermal signature/ near silent operation, and greater fuel economy.

Ships

Ships with both mast-mounted sails and steam engines were an early form of hybrid vehicle. Another example is the diesel-electric submarine. This runs on batteries when submerged and the batteries can be re-charged by the diesel engine when the craft is on the surface.

Newer hybrid ship-propulsion schemes include large towing kites manufactured by companies such as SkySails. Towing kites can fly at heights several times higher than the tallest ship masts, capturing stronger and steadier winds.

Aircraft

Taxiing and other ground operations of Boeing 737NGs will soon be done using hybrid electric drives as WheelTug ground propulsion systems become available. By using the APU(powered by a turbine) to energize a Chorus electric motor mounted in the landing gear for ground movement, aircraft will be operating in a hybrid configuration where the main engines are used only for take off, landing, and flight.

Boeing 737-800 : The Boeing Fuel Cell Demonstrator Airplane has a Proton Exchange Membrane (PEM) fuel cell/lithium-ion battery hybrid system to power an electric motor, which is coupled to a conventional propeller. The fuel cell provides all power for the cruise phase of flight. During takeoff and climb, the flight segment that requires the most power, the system draws on lightweight lithium-ion batteries.

The demonstrator aircraft is a Dimona motor glider, built by Diamond Aircraft Industries of Austria, which also carried out structural modifications to the aircraft. With a wing span of 16.3 meters (53.5 feet), the airplane will be able to cruise at approximately 100 kilometers per hour (62 miles per hour) on power from the fuel cell.

Types of engines

Hybrid electric-petroleum vehicles

Hybrid New Flyer Metrobus

Hybrid Optare Solo

When the term *hybrid vehicle* is used, it most often refers to a Hybrid electric vehicle. These encompass such vehicles as the AHS2 (Chevrolet Tahoe, GMC Yukon, Chevrolet Silverado, Cadillac Escalade, and the Saturn Vue), Toyota Prius, Toyota Camry Hybrid, Ford Escape Hybrid,Toyota Highlander Hybrid, Honda Insight, Honda Civic Hybrid Lexus RX 400h and 450h and others. A petroleum-electric hybrid most commonly uses internal combustion engines (generally gasoline or Diesel engines, powered by a variety of fuels) and electric batteries to power the vehicle. There are many types of petroleum-electric hybrid drivetrains, from **Full hybrid** to Mild hybrid, which offer varying advantages and disadvantages.

Ferdinand Porsche in 1900 developed the first gasoline-electric series-hybrid automobile in the world, setting speed records using two motor-in-wheel-hub arrangements with a combustion generator set providing the electric power. While liquid fuel/electric hybrids date back to the late 19th century, the braking regenerative hybrid was invented by David Arthurs, an electrical engineer from Springdale, Arkansas in 1978–79. His home-converted Opel GT was reported to return as much as 75MPG with plans still sold to this original design, and the "Mother Earth News" modified version on their website.[22]

The plug-in-electric-vehicle (PEV) is becoming more and more common. It has the range needed in locations where there are wide gaps with no services. The batteries can be plugged in to house (mains) electricity for charging, as well being charged while the engine is running.

Continuously outboard recharged electric vehicle (COREV)

Given suitable infrastructure, permissions and vehicles, BEVs can be recharged while the user drives. The BEV establishes contact with an electrified rail, plate or overhead wires on the highway via an attached conducting wheel or other similar mechanism. The BEV's batteries are recharged by this process—on the highway—and can then be used normally on other roads until the battery is discharged.

This provides the advantage, in principle, of virtually unrestricted highway range as long as you stay where you have BEV infrastructure access. Since many destinations are within 100 km of a major highway, this may reduce the need for expensive battery systems. Unfortunately private use of the existing electrical system is nearly universally prohibited.

The technology for such electrical infrastructure is old and, outside of some cities, is not widely distributed (see Conduit current collection, trams, electric rail, trolleys, third rail). Updating the required electrical and infrastructure costs can be funded, in principle, by toll revenue, gasoline or other taxes.

Hybrid fuel (dual mode)

Ford Escape Hybrid the first hybrid electric vehicle with a flexible fuelcapability to run on E85(ethanol).

In addition to vehicles that use two or more different devices for propulsion, some also consider vehicles that use distinct energy sources or input types ("fuels") using the same engine to be hybrids, although to avoid confusion with hybrids as described above and to use correctly the terms, these are perhaps more correctly described as dual mode vehicles:

- Some electric trolleybuses can switch between an on board diesel engine and overhead electrical power depending on conditions (see dual mode bus). In principle, this could be combined with a battery subsystem to create a true plug-in hybrid trolleybus, although as of 2006, no such design seems to have been announced.
- Flexible-fuel vehicles can use a mixture of input fuels mixed in one tank — typically gasoline and ethanol, or methanol, or biobutanol.
- Bi-fuel vehicle:Liquified petroleum gas and natural gas are very different from petroleum or diesel and cannot be used in the same tanks, so it would be impossible to build an (LPG or NG) flexible fuel system. Instead vehicles are built with two, parallel, fuel systems feeding one engine. While the duplicated tanks cost space in some applications, the increased range and flexibility where (LPG or NG) infrastructure is incomplete may be a significant incentive to purchase.
- Some vehicles have been modified to use another fuel source if it is available, such as cars modified to run on autogas (LPG) and diesels modified to run on waste vegetable oil that has not been processed into biodiesel.
- Power-assist mechanisms for bicycles and other human-powered vehicles are also included.

Fluid power hybrid

Hydraulic and pneumatic hybrid vehicles use an engine to charge a pressure accumulator to drive the wheels via hydraulic or pneumatic (i.e. compressed air) drive units. The energy recovery rate is higher and therefore the system is more efficient than battery charged hybrids, demonstrating a 60% to 70% increase in energy economy in EPA testing. Under tests done by the EPA, a hydraulic hybrid Ford Expedition returned 32 miles per US gallon (7.4 L/100 km; 38 mpg_{-imp}) City, and 22 miles per US gallon (11 L/100 km; 26 mpg_{-imp}) highway. UPS currently has two trucks in service with this technology.

While the system has faster and more efficient charge/discharge cycling and is cheaper than gas-electric hybrids, the accumulator size dictates total energy storage capacity and requires more space than a battery.

Electric-human power hybrid vehicle

Another form of hybrid vehicle are human power-electric vehicles. These include such vehicles as the Sinclair C5, Twike, electric bicycles, and electric skateboards.

Power train configurations

Parallel hybrid

The Honda Insight is a Mild Parallel Hybrid.

The Toyota Prius is a series-parallel hybrid.

The Ford Escape Hybrid has a series-parallel drivetrain.

In a parallel hybrid the single electric motor and the internal combustion engine are installed so that they can both individually or together power the vehicle. In contrast to the power split configuration typically only one electric motor is installed. Most commonly the internal combustion engine, the electric motor and gear box are coupled by automatically controlled clutches. For electric driving the clutch between the internal combustion engine is open while the clutch to the gear box is engaged. While in combustion mode the engine and motor run at the same speed.

The first mass production parallel hybrid is the Honda Insight.

Mild parallel hybrid

These types use a generally compact electric motor (usually <20 kW) to provide auto-stop/start features and to provide extra power assist during the acceleration, and to generate on the deceleration phase (aka regenerative braking).
On-road examples include Honda Civic Hybrid, Honda Insight, Mercedes Benz S400 BlueHYBRID, BMW 7-Series hybrids, General Motors BAS Hybrids and Smart with micro hybrid drive.

Power-split or series-parallel hybrid

Typical passenger car installations include the Toyota Prius, the Ford Escape, the Lexus RX400h, RX450h, GS450h and LS600h.

In a power-split hybrid electric drive train there are two motors: an electric motor and an internal combustion engine. The power from these two motors can be shared to drive the wheels via a power splitter, which is a simple planetary gear set. The ratio can be from 0-100% for the combustion engine, or 0-100% for the electric motor, or an anything in between, such as 40% for the electric motor and 60% for the combustion engine. The electric motor can act as a generator charging the batteries.

On the open road, the primary power source is the internal combustion engine, when maximum power is required, for example to overtake, the electric motor is used to assist maximizing the available power for a short period, giving the effect of having a larger engine than actually installed. In most applications, the engine is switched off when the car is stationary reducing curbside emissions.

Series hybrid

The Chevrolet Volt is a series plug-in hybrid released at the end of 2010.

A Honda Civic Hybrid used by Zipcar, a car sharing service at Washington, D.C.

Ford Escape plug-in hybrid.

A **series- or serial-hybrid vehicle** has also been referred to as an Extended Range Electric Vehicle or Range-Extended Electric Vehicle (EREV/REEV); however, range extension can be accomplished with either series or parallel hybrid layouts.

Series-hybrid vehicles are driven by the electric motor with no mechanical connection to the engine. Instead there is an engine tuned for running a generator when the battery pack energy supply isn't sufficient for demands.

This arrangement is not new, being common in diesel-electric locomotives and ships. Ferdinand Porsche used this setup in the early 20th century in racing cars, effectively inventing the series-hybrid arrangement. Porsche named the arrangement "System Mixt". A wheel hub motor arrangement, with a motor in each of the two front wheels was used, setting speed records. This arrangement was sometimes referred to as an *electric transmission*, as the electric generator and driving motor replaced a mechanical transmission. The vehicle could not move unless the internal combustion engine was running.

The setup has never proved to be suitable for production cars, however it is currently being revisited by several manufacturers.

In 1997 Toyota released the first series-hybrid bus sold in Japan. Meanwhile, GM will introduce the Chevy Volt EREV in 2010, aiming for an all-electric range of 40 miles, and a price tag of around $40,000. Supercapacitors combined with a lithium ion battery bank have been used byAFS Trinity in a converted Saturn Vue SUV vehicle.
Using supercapacitors they claim up to 150 mpg in a series-hybrid arrangement.

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 (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 CO_2 terms, is 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.

Fuel cell, electric hybrid

The fuel cell hybrid is generally an electric vehicle equipped with a fuel cell. The fuel cell as well as the electric battery are both power sources, making the vehicle a hybrid. Fuel cells use hydrogen as a fuel and power the electric battery when it is depleted.
The Chevrolet Equinox FCEV, Ford Edge Hyseries Drive and Honda FCX are examples of a fuel cell/electric hybrid.

Environmental issues

Fuel consumption and emissions reductions The hybrid vehicle typically achieves greater fuel economy and lower emissions than conventional internal combustion engine vehicles(ICEVs), resulting in fewer emissions being generated. These savings are primarily achieved by three elements of a typical hybrid design:

1. Relying on both the engine and the electric motors for peak power needs, resulting in a smaller engine sized more for average usage rather than peak power usage. A smaller engine can have less internal losses and lower weight.
2. Having significant battery storage capacity to store and reuse recaptured energy, especially in stop-and-go traffic,which is represented by the city driving cycle.

3. Recapturing significant amounts of energy during braking that are normally wasted as heat. This regenerative braking reduces vehicle speed by converting some of its kinetic energy into electricity, depending upon the power rating of the motor/generator;

Other techniques that are not necessarily 'hybrid' features, but that are frequently found on hybrid vehicles include:

1. Shutting down the engine during traffic stops or while coasting or during other idle periods;
2. Improving aerodynamics; (part of the reason that SUVs get such bad fuel economy is the drag on the car. A box shaped car or truck has to exert more force to move through the air causing more stress on the engine making it work harder). Improving the shape and aerodynamics of a car is a good way to help better the fuel economy and also improve handling at the same time.
3. Using low rolling resistance tires (tires were often made to give a quiet, smooth ride, high grip, etc., but efficiency was a lower priority). Tires cause mechanical drag, once again making the engine work harder, consuming more fuel. Hybrid cars may use special tires that are more inflated than regular tires and stiffer or by choice of carcass structure and rubber compound have lower rolling resistance while retaining acceptable grip, and so improving fuel economy whatever the power source.
4. Powering the a/c, power steering, and other auxiliary pumps electrically as and when needed ; this reduces mechanical losses when compared with driving them continuously with traditional engine belts.

These features make a hybrid vehicle particularly efficient for city traffic where there are frequent stops, coasting and idling periods. In addition noise emissions are reduced, particularly at idling and low operating speeds, in comparison to conventional engine vehicles. For continuous high speed highway use these features are much less useful in reducing emissions.

Hybrid vehicle emissions

Hybrid vehicle emissions today are getting close to or even lower than the recommended level set by the EPA (Environmental Protection Agency). The

recommended levels they suggest for a typical passenger vehicle should be equated to 5.5 metric tons of carbon dioxide. The three most popular hybrid vehicles, Honda Civic, Honda Insight and Toyota Prius, set the standards even higher by producing 4.1, 3.5, and 3.5 tons showing a major improvement in carbon dioxide emissions. Hybrid vehicles can reduce air emissions of smog-forming pollutants by up to 90% and cut carbon dioxide emissions in half.

Environmental impact of hybrid car battery

Though hybrid cars consume less petroleum than conventional cars, there is still an issue regarding the environmental damage of the Hybrid car battery. Today most Hybrid car batteries are one of two types: (1) nickel metal hydride, or (2) lithium ion; both are regarded as more environmentally friendly than lead-based batteries which constitute the bulk of car batteries today. There are many types of batteries. Some are far more toxic than others. While batteries like lead acid or nickel cadmium are incredibly bad for the environment, the toxicity levels and environmental impact of nickel metal hydride batteries—the type currently used in hybrids—are much lower. Nickel-based batteries are known carcinogens, and have been shown to cause a variety of teratogenic effects.