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She Ain't Heavy, She's My HEV

The hybrid electric vehicle (HEV) concept is not new. On November 23, 1905 an American engineer, H. Piper, filed for a patent on a hybrid vehicle. Piper's design called for an electric motor to augment a gasoline engine to enable the vehicle to accelerate to 32 miles-per-hour in ten seconds rather than 25 miles-per-hour. However, in the early race for dominance, the internal combustion engine won out as the power system of choice for cars. By the time the patent was issued three and a half years later, engines had developed enough power to achieve this kind of performance on their own. Nevertheless, a few hybrids were actually produced during this period and one built around 1912 even sits in the Ford Museum in Dearborn, Michigan.

Any vehicle combining two or more sources of power is a hybrid. For example, most of the locomotives we see pulling trains are diesel-electric hybrids. Hybrid electric vehicles combine the internal combustion engine of a conventional vehicle with the slimmed-down battery pack and electric motors of an electric vehicle. This combination provides improved fuel economy, greater range of operation, and lower emissions.

Many system configurations are possible for HEVs. Generally, a hybrid combines an energy storage system, a power unit, and a propulsion system. The primary options for energy storage include batteries, ultracapacitors, and flywheels. Batteries are currently the most common energy storage choice, but research is being done in other energy storage areas. Hybrid power unit options include spark ignition engines, compression ignition direct injection engines, gas turbines, and fuel cells. Propulsion can come entirely from an electric motor or the engine might provide direct mechanical input to the vehicle propulsion system in addition to the electric motor. There are also several transmission options for HEVs. A hybrid's efficiency and emissions depend on the particular combination of subsystems, how these subsystems are integrated into a complete system, and the control strategy integrating the subsystems.

The most common hybrid systems used are the series and parallel configurations. In a series hybrid, the internal-combustion engine drives a generator that charges batteries, which power an electric motor. The combustion engine is used to charge the batteries and can be shut down when the batteries are fully charged. The electric motor is the main source of power for the vehicle. The series configuration enables the combustion engine to be smaller and run within its optimum range, reducing emissions and increasing performance. A parallel hybrid combines two drive systems "parallel" to one another. The vehicle can be powered by the combustion engine, the batteries, or both at the same time. In a typical parallel hybrid, the combustion engine is the main source of power. The engine rotor also acts as a generator and charges the batteries. The electric motor is used selectively, for example, when extra power is needed for hills,

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accelerating, or at low speeds when less power is required to move the vehicle.

HEVs can also utilize regenerative braking which captures energy that would normally be lost as heat during braking and acts as a generator to store electricity in the batteries. The power of a hybrid's internal combustion engine generally ranges from one tenth to two thirds that of a conventional automobile's. Not only are these engines highly efficient, they also do not need to run continuously while the vehicle is being operated. Although a HEV emits more pollutants than an electric car when the internal combustion engine is running, it is cleaner than a conventional car. When pollution from the generating sources used to charge an electric vehicle's batteries is taken into account, an electric vehicle is about one tenth as polluting as a conventional automobile. A HEV, in comparison, can be about one eighth as polluting. HEVs provide benefits to the environment and reduce dependence on petroleum products. The cost of maintaining an HEV is about the same as a conventional automobile, with the exception of battery replacement if failure occurs before the end of the vehicle's life.

Oregon offers tax credit incentives to buy HEVs through the Oregon Office of Energy. The Residential Tax Credit provides tax credit incentives of up to $1,500, $750 for the drive system and $750 for the charging system. There is also a Business Energy Tax Credit program, which provides an incentive for businesses to purchase HEVs and alternative fuel vehicles. The federal government is expected to implement a HEV tax credit program as well in the near future.

HEVs pay double the registration fee of conventional vehicles. However, the extra $30 per biennium falls short of replacing gas tax revenue that would have been generated by a conventional vehicle. The Oregon Office of Energy illustrates this point by comparing expenses between HEVs and conventional vehicles in Table 1. There are savings beyond those presented in Table 1 when one considers the savings in purchased fuel as well as the federal gas tax. Under the same assumptions used by the Oregon Office of Energy, a HEV would require 426 fewer gallons of gas a year to operate. This translates into savings of $596 a year in purchased fuel, including $78 less in federal gas tax paid, assuming the fuel price is $1.40 per gallon.

Table 1. Difference In Use Fees: Conventional Vehicle and Hybrid Vehicle

Vehicle Type	Annual Gas Tax	Registration Fee, Biennial	Total Annual Highway User Fees
Conventional	$ 177.00	$ 30.00	$ 192.00
Hybrid	$ 75.00	$ 60.00	$ 105.00

Assumptions: annual mileage of 14,000 miles, state gas tax rate of $.24 per gallon, conventional vehicle 19 mpg., hybrid vehicle 45 mpg.
Source: http://www.energy.state.or.us/trans/hybrider

HEVs are fairly new to the modern automobile market. Currently, the Toyota Prius and Honda Insight are the two most common hybrids on the road. Honda introduced the 2003 Civic hybrid last April. Ford will be introducing a hybrid Escape in 2003 and other hybrid models are expected in the near future. Hybrids cost about $3,000 to $5,000 more than a comparative-model conventional vehicle. The bulk of this price differential would be recouped through savings in fuel costs in four to seven years, sooner if the tax credit is utilized.

The title of this article implies HEVs are lighter than comparable conventional vehicles. That is not necessarily true. The Toyota Prius weighs 2,728 pounds and the comparable model Toyota Corolla weighs 2,590. The Honda Civic EX has a curb weight of 2,564 pounds and the Civic Hybrid 2,643 pounds. The two versions of the same models are very close in weight. The hybrid is heavier most likely because of the additional equipment required for the parallel configuration. The Honda Insight weighs only 1,900 pounds. It seats two people as opposed to seating five like the Prius and Civic, and uses an aluminum alloy body to reduce the weight.

If HEVs capture a significant market share, there will likely be large, negative impacts on Oregon's Highway Fund revenue. Oregon's ability to maintain roads used by HEVs would be reduced as fuel tax revenues decline. Oregon officials are aware of the potential impacts due to HEVs and other fuel-efficient vehicles, and are evaluating available options.

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