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Advancing Clean Energy for a Sustainable Economy

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# HYBRID ELECTRIC VEHICLES

**What is a hybrid electric vehicle?**

Hybrid electric vehicles (HEVs) have both an internal combustion engine and an electric motor. Their batteries are recharged by regenerative braking, which recovers energy typically lost to heat in the brakes, or by an onboard generator, which works similarly to a conventional vehicle's alternator. Hydraulic hybrids, which do not use an electric motor or batteries but rather use an accumulator and hydraulic fluid to capture braking energy, are also options in the trucking market.

Some HEVs can also be recharged from a wall outlet or charging station. These vehicles are referred to as plug-in hybrid electric vehicles (PHEVs).

**What are the benefits of using a hybrid electric vehicle?**

HEVs can be substantially more fuel-efficient than conventional vehicles — 30 to 50 percent more efficient on average, depending on the hybrid technology used and on the individual driver. This reduces emissions and cuts fuel costs. With gas prices above $3 per gallon, a mid-size HEV costs about $0.08- 0.09 per mile to drive, compared to $0.11 or more for a similar gasoline vehicle (DOE AFDC). HEVs also tend to last longer and need less engine maintenance than conventional vehicles, because the electric motor assists the combustion engine. HEVs' brakes will also typically last longer, since the regenerative braking mechanism absorbs a large portion of the vehicle's braking energy.

**What types of hybrid electric vehicles are manufactured?**

Hybrid passenger vehicles, SUVs, buses, and a variety of trucks are available. HEVs of all kinds can be classified by how their gasoline engine and electric motor interact.

A *series hybrid* is the simplest type of HEV. In series hybrids, the wheels are always driven by the electric motor. The motor can draw power from the batteries, a generator powered by the gasoline engine, or both simultaneously, but the gasoline engine can't directly power the wheels.

Series hybrids perform best in city driving conditions. Unlike gasoline engines, electric motors can easily provide the high torque needed to accelerate from a stop. This means that series hybrids' gasoline engines can be very small and

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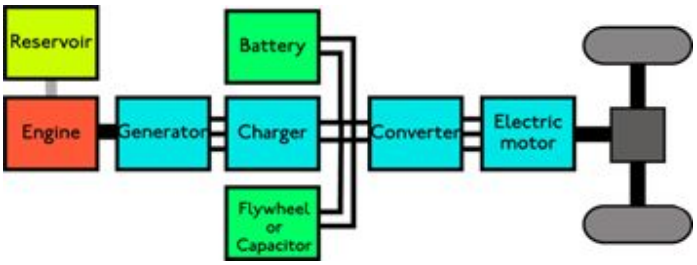
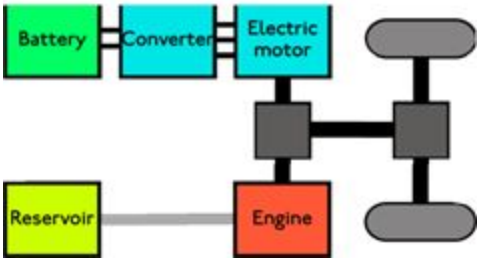
efficient since they don't have to meet widely varying power demands. The tradeoff is that they need a generator and a large battery pack, typically making these hybrids heavier and more expensive than similar conventional vehicles or other hybrids. The Chevrolet Volt usually operates as a series hybrid when its battery is drained (with a full battery, it operates as an all-electric vehicle).



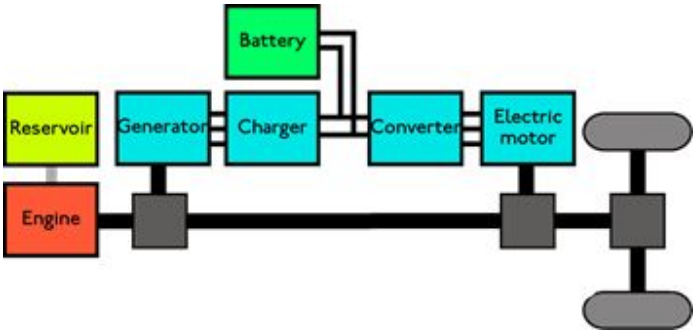

**Series hybrid drivetrain**

In a *parallel hybrid*, the wheels can be directly driven by the electric motor, the gasoline engine, or both simultaneously. Some parallel hybrids power one axle with the electric motor and power the other with the gasoline engine, but most connect the two inputs to a single axle.




**Parallel hybrid drivetrain**

Parallel hybrids perform best on the highway. Since the gasoline engine can directly power the wheels, a parallel hybrid cuts out the inefficiency of converting gasoline power to electricity. Their batteries can also be much smaller than series hybrids' batteries. The tradeoff is that the gasoline engine still has to meet varied power demands in stop-and-go traffic and can't run as efficiently as in a series hybrid. Honda's HEVs are parallel hybrids.




**Power-split hybrid drivetrain**

*Power-split* or *series-parallel hybrids* combine the advantages of both types of drivetrains. These HEVs can act as series hybrids for city driving and parallel hybrids for highway driving. The disadvantage, though, is that just like series hybrids, they need generators and large battery packs, making them heavier and more expensive. Toyota and Ford's HEVs are power-split hybrids.

**Where can I find more information about hybrid electric vehicles?**

- Clean Transportation Program website: http://www.cleantransportation.org
- Alternative Fuels Data Center: http://www.afdc.energy.gov/afdc/vehicles/electric.html
- Union of Concerned Scientists' Hybrid Center: www.hybridcenter.org
- U.S. Department of Energy: http://www.fueleconomy.gov/feg/hybridtech.shtml

*This document is supported in part through the Clean Fuel Advanced Technology project with funding from the N.C. Department of Transportation.*

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