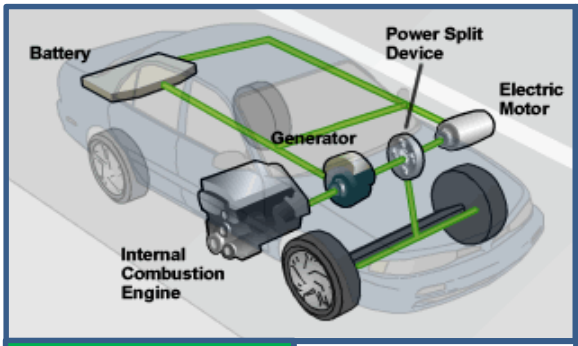
Hybrid Electric Vehicles

Raji Gunasekera
Spring 2015
LAFAYETTE COLLEGE



How Hybrids Work

HEVs combine the benefits of gasoline engines and electric motors, giving improved fuel economy and lower emissions. Powered by an internal combustion engine and by an electric motor that uses energy stored in a battery, the extra power provided by the electric motor allows for a smaller engine without sacrificing performance; the battery also powers auxiliary loads like audio systems and headlights and can reduce engine idling when the vehicle is stopped. Some HEVs can drive short distances at low speeds on electric power alone.

Advanced Technologies used by HEVs

- **Regenerative Braking.** The electric motor applies resistance to the drivetrain causing the wheels to slow down. In return, the energy from the wheels turns the motor, which functions as a generator, converting energy normally wasted during coasting and braking into electricity, which is stored in a battery until needed by the electric motor.
- **Electric Motor Drive/Assist.** The electric motor provides additional power to assist the engine in accelerating, passing, or hill climbing. This allows a smaller, more efficient engine to be used. In some vehicles, the motor alone provides power for low-speed driving conditions where internal combustion engines are least efficient.
- **Automatic Start/Shutoff.** Automatically shuts off the engine when the vehicle comes to a stop and restarts it when the accelerator is pressed. This prevents wasted energy from idling.

Advantages

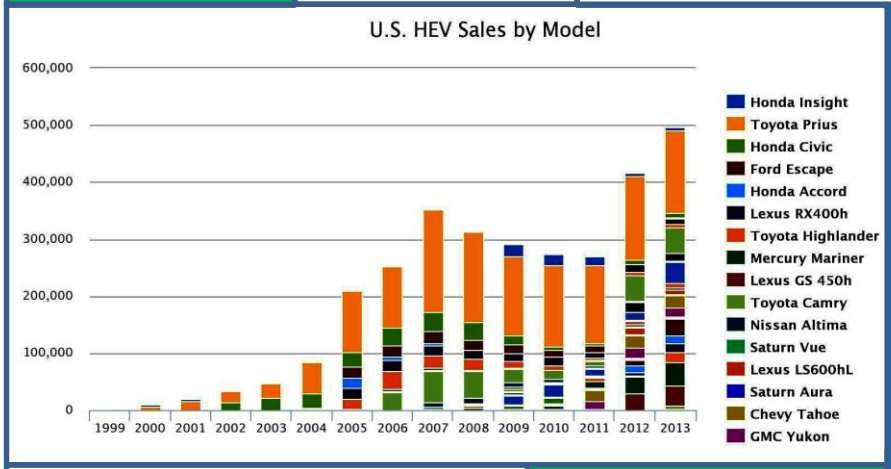
- Increased fuel economy (better gas mileage)
- Low operating/fuel costs
- Reduced carbon emissions and environmentally friendly
- Supported by tax credits & financial incentives
- Higher resale value

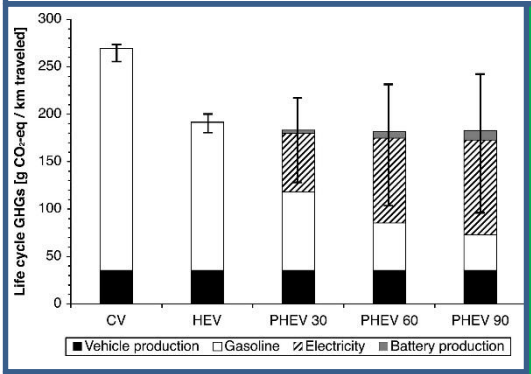
Disadvantages

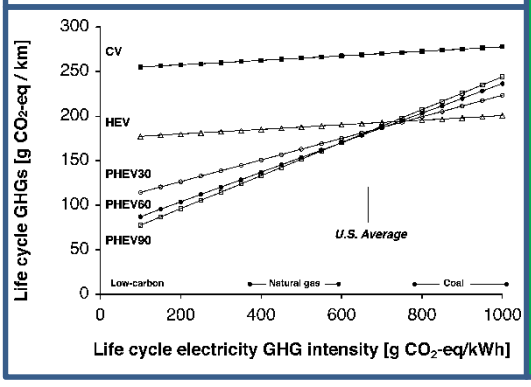
- Higher capital cost
- More car batteries need to be made, creating a larger problem for their disposal
- Less power, therefore better suited for city driving
- Poor handling due to reduced weight

Energy, Economics & the Environment

- Transportation accounts for 28% of total U.S. energy consumption
- Dependence on oil cost the U.S. economy $200 billion in 2013
- Almost 18% of household expenditures are for transportation
- An estimated 30% of national GHGs are directly attributed to transportation, which is also the fastest-growing source of GHGs in the U.S., accounting for 47% of the net increase in total emissions since 1990







Other Alternatives.

There are approximately 20 million alternative fuel vehicles on U.S. roads today, this includes:

- **Plug-in hybrids** (PHEVs) are essentially HEVs that can be plugged into the grid in order to charge their batteries, giving all electric ranges of 10 – 40 plus miles for light duty models. They have zero tailpipe emissions when in electric-only mode. Major challenges with PHEVs include long charging time. PHEVs are slightly more expensive than HEVs
- **Electric Vehicles** (EVs) use batteries to store the electrical energy that powers one or more motors. Batteries are charged by plugging the vehicle into the grid. EVs have zero tailpipe emissions at all times. Major challenges with EVs include lack of infrastructure, low energy density in batteries and long charging time (much longer than PHEVs). They are also significantly more expensive than HEVs and PHEVs.

- **Vehicle Availability.** Dozens of light-duty HEV models are available from major auto manufacturers. A variety of medium and heavy-duty options are also available.
- **Emission Benefits.** HEVs produce lower levels of emission that conventional vehicles do. HEV emissions benefits vary by vehicle and type of hybrid power system.
- **Vehicle Safety.** HEVs undergo the same rigorous safety testing as conventional vehicles (CVs) sold in the United States and must meet Federal Motor Vehicle Safety Standards. Their battery packs meet testing standards that subject batteries to conditions such as overcharge, vibration, extreme temperatures, short circuit, humidity, fire, collision, and water immersion. Manufacturers design vehicles with insulated high-voltage lines and safety features that deactivate electric systems when they detect a collision or short circuit.
- **Maintenance Requirements.** Because HEVs have internal combustion engines (ICEs), their maintenance requirements are similar to those of CVs. The electrical system (battery, motor, and associated electronics) requires minimal scheduled maintenance. Break systems on HEVs typically last longer than those on CVs, because regenerative braking reduces wear.
- **Fuel Costs.** HEVs typically use significantly less gasoline/diesel than their CVs, therefore fuel costs for HEVs are generally lower. HEV owners can expect to save thousands of dollars in fuel costs, relative to the average new vehicle.

Don't want to be seen in a Prius? As of 2015 luxury/sports car manufacturers such as Acura, BMW, Mercedes, Porsche, Ferrari and McLaren have released a multitude of hybrid Vehicles. Lamborghini also unveiled a hybrid concept planned for release in 2017.

Hybrid Electric Vehicles

Raji Gunasekera
Spring 2015
LAFAYETTE COLLEGE

Hybrid Electric Vehicle (image)

U.S. Department of Energy
https://www.fueleconomy.gov/feg/hybridtech.shtml

How hybrids work

U.S. Department of Energy
https://www.fueleconomy.gov/feg/hybridtech.shtml

Alternative Fuels Data Center
U.S. Department of Energy
http://www.afdc.energy.gov/uploads/publication/hybrid_plugin_ev.pdf

Advanced technologies

U.S. Department of Energy
https://www.fueleconomy.gov/feg/hybridtech.shtml

Energy, Economics & the Environment

2014 Vehicle Technologies Market Report
Center for Transportation Analysis
Oak Ridge National Laboratory
http://cta.ornl.gov/vtmarketreport/pdf/2014_vtmarketreport_full_doc.pdf

U.S. HEV Sales by Model

Alternative Fuels Data Center
U.S. Department of Energy
http://www.afdc.energy.gov/data/10301

Important information for potential buyers

Alternative Fuels Data Center
U.S. Department of Energy
http://www.afdc.energy.gov/uploads/publication/hybrid_plugin_ev.pdf

Life Cycle Analysis

Samaras, Constantine, and Kyle Meisterling. "Life Cycle Assessment of Greenhouse Gas Emissions from Plug-in Hybrid Vehicles: Implications for Policy." *Environmental Science & Technology* 42.9 (2008): 3170-176. Web.
http://pubs.acs.org/doi/pdfplus/10.1021/es702178s

Other Alternatives

Alternative Fuels Data Center
U.S. Department of Energy
http://www.afdc.energy.gov/uploads/publication/hybrid_plugin_ev.pdf

BMW i8 (image)

http://www.bmw.com/com/en/newvehicles/i/i8/2014/showroom/images_and_videos.html

Life Cycle Analysis

Samaras, Constantine, and Kyle Meisterling. "Life Cycle Assessment of Greenhouse Gas Emissions from Plug-in Hybrid Vehicles: Implications for Policy." *Environmental Science & Technology* 42.9 (2008): 3170-176. Web.
http://pubs.acs.org/doi/pdfplus/10.1021/es702178s