Environmental and Energy Study Institute

Fact Sheet

Plug-in Electric Vehicles

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Plug-in electric vehicles use electricity from the energy grid to charge large battery packs, then use the batteries to power an electric motor. Because they are primarily powered by electricity instead of liquid fuels, these vehicles produce no tailpipe emissions. Plug-in vehicles can also generate power from a regenerative braking system, which converts kinetic energy from the vehicle's brakes into electricity and stores it in the battery pack. Because plug-in vehicles rely on rechargeable batteries for power, each vehicle has an **electric range**—the maximum number of miles it can travel on battery power before it needs to recharge. Based on national driving statistics, electric vehicles with a range of 60 miles could satisfy 83 percent of daily travel needs, while a range of 120 miles would likely satisfy 95 percent.[1]

There are two main types of plug-in electric vehicles:

- **All-electric vehicles (EVs)** only use electric power from the grid; they do not have an internal combustion engine and do not use any type of liquid fuel. Because they have an electric motor instead of a combustion engine, they require less maintenance than most conventional cars. They do not need radiator fluid, timing belts, fuel filters, oil or oil changes. EVs use large battery packs to give the vehicle a long electric range—a typical EV will have a range of 70 to 100 miles, though some can travel up to 265 miles on a single charge.
- **Plug-in hybrid electric vehicles (PHEVs)** are powered by a combination of grid electricity and liquid fuel. A PHEV runs on battery power until the battery charge is exhausted, and then it switches over to its internal combustion engine. If a trip is within the vehicle's electric range, a PHEV will run entirely on its battery pack.

Because plug-in vehicles consume electricity instead of liquid fuel, the U.S. Environmental Protection Agency (EPA) rates them on their **miles per gallon equivalent (MPGe),** which indicates how efficient the vehicle is with the electricity it consumes. The EPA's MPGe equates using 33.7 kilowatt hours (kWh) of electricity to consuming one gallon of gasoline.[2] The EPA's MPGe methodology has come under criticism, because it assumes that the power plants producing the electricity are 100 percent efficient. When accounting for the real-world efficiencies of electricity production, plug-in vehicles' MPGe may be lower than the EPA-rated MPGe. A PHEV receives an MPGe rating for the battery-electric motor and a separate MPG rating for the combustion engine. It is important to note that while plug-in vehicles produce no tailpipe emissions, generating the electricity a plug-in uses may produce pollution (depending on the energy source). Nevertheless, a recent study found that even plug-in vehicles running on electricity from the 'dirtiest' coal-powered electric grids in the United States produce less greenhouse gas emissions than the average gasoline-powered vehicle.[3]

The U.S. market for plug-in vehicles is currently dominated by two models: the Chevrolet Volt (PHEV) and the Nissan Leaf (EV), both of which debuted at the end of 2010. To date nearly 17,000 Chevrolet Volts have been sold, with strong sales continuing in the first half of 2012. The Leaf has sold nearly 13,000 units, but it has experienced slumping sales in 2012.[4] This year has also seen the introduction of a number of new plug-in models, including the

first plug-in hybrid Toyota Prius, the Ford Focus Electric and the Tesla Model S. Plug-in vehicle sales currently account for less than one percent of all vehicle sales, but that number is projected to grow as the cost of plug-in vehicles decreases.

POPULAR MODELS

Vehicle Model	Price	Electric Range	Vehicle Efficiency
Chevrolet Volt (PHEV)	$39,145	35 miles (EV mode)	94 MPGe (37 MPG gasoline-only)
The Chevrolet Volt is the most popular PHEV in the United States today. The Volt is a four-door compact car that was introduced nationwide in December 2010. After reaching its initial 35-mile electric range, the Volt can switch over to its combustion engine to travel an additional 345 miles. The Volt has won many awards, including 2011 Car of the Year, the 2011 Auto Magazine Car of the Year, the 2011 Green Car of the Year, and the 2011 Motor Trend Car of the Year.			
CODA (EV)	$37,250[5]	88 miles	73 MPGe
The CODA EV is produced by a relatively new automotive company, CODA Automotive of Los Angeles, CA. The CODA EV is an all-electric car that was released in March 2012. It is currently available only in California, though CODA Automotive is planning a wider release in the near future. The interior is made of 42 percent recycled materials, and the battery is 99 percent recyclable.			
Ford Focus Electric (EV)	$39,200	76 miles	105 MPGe
The 2012 Ford Focus Electric is the first plug-in electric vehicle from Ford. The vehicle's 105 MPGe rating is the highest ever for a five-passenger car. Sales of the Focus Electric began in New York, California and New Jersey in May 2012, with a wider release planned for the third quarter of this year.			
Mitsubishi i (EV)	$29,125	62 miles	112 MPGe
The Mitsubishi i is an all-electric four-door hatchback from the Japanese automaker and is currently the most fuel efficient automobile on the market. The American version of the i, first sold in December 2011, is slightly larger than the Japanese version with upgraded interior and safety features. The i was initially available only in California, Hawaii, Oregon and Washington but is now sold nationwide.			
Nissan Leaf (EV)	$35,200	73 miles	99 MPGe
The 2012 Nissan Leaf is the top selling EV in the United States today. This four-door hatchback was first sold in the United States and Japan in December 2010. The lithium ion battery pack sits under the back seat, and there is a small accessory battery under the hood that charges the radio and air conditioning unit. The Leaf features a solar cell on the rear spoiler that recharges the accessory battery. The Leaf won numerous awards in 2011, including the 2011 World Car of the Year, and the 2011 Kelley Blue Book's Green Car of the Year.			
Tesla Model S (EV)	$92,400[6]	265 miles[7]	89 MPGe
The Tesla Model S is an all-electric luxury sedan manufactured by Tesla Motors of California. Unlike most plug-in cars, the Model S was designed as a high performance vehicle—it has a top speed of 125 miles per hour and can accelerate from 0 to 60 mph in 5.6 seconds. Its 265-mile range is the largest of any EV. The Model S is currently sold-out for 2012, though Tesla hopes to increase production by the end of the year to meet demand.			
Toyota Prius Plug-in (PHEV)	$32,760	11 miles (EV mode)	95 MPGe (50 MPG as a hybrid)
The 2012 Toyota Prius Plug-in is the first Prius hybrid that can travel on electric power alone, though only for a short distance. The vehicle can travel 540 miles total by switching to its electric/combustion hybrid engine. Sales of the PHEV Prius began in 14 states in February 2012, with a nationwide rollout of the four-door hatchback planned for 2013.			

All vehicle information is for Model Year 2012 / All prices are base manufacturer's suggested retail price (MSRP)

PLUGGING IN TO THE GRID

Plug-in vehicles can be recharged at home in about eight to 14 hours using a standard 110 volt wall outlet. However, many plug-in owners choose to install a dedicated 220 volt charger in their home, which can recharge their vehicle in four to eight hours, depending on the size of the battery pack. A 220 volt outlet is the same as those used by household washers and dryers. Some plug-in vehicles are also equipped to receive charges from a 400 volt direct current (DC) charger, which can fully charge most electric vehicles in an hour.[8] DC chargers are presently available in only a few locations, but they may become the standard method for recharging plug-in vehicles in the future. However, multiple 220 and 400 volt chargers can create a serious strain on a local electric grid, and utilities and their customers may need to coordinate with smart grid technology to ensure that rapid charging does not lead to overloads and blackouts.

Because electricity is a cheaper power source than liquid fuel, ownership of a plug-in vehicle can result in large savings over the life of the vehicle. The amount saved, however, depends on oil and electricity prices and on the number of miles driven by the vehicle. So while the initial price of a plug-in vehicle may be more expensive than a conventional car, the **total cost of ownership**—the initial cost, plus the cost of fuel and maintenance over the life of the vehicle—of a plug-in vehicle may be substantially less.

OUTLOOK

The single biggest expense in any plug-in vehicle is the battery pack. The Nissan Leaf's lithium ion battery accounts for one third the cost of the entire vehicle. Current battery packs cost an average of $690 per kWh, which is 30 percent lower than battery prices in 2009.[9] Recent studies suggest that prices could fall to $200 per kWh in 2020 and $160 per kWh in 2025.[10] California-based startup Envia Systems recently announced the development of a battery with nearly twice the energy density of today's batteries. If this technology is able to be brought to scale, Envia believes it can produce a battery that costs only $125 per kWh.[11] [12] Cheaper battery packs could bring down the price of plug-in vehicles dramatically, making them more commercially viable and competitive with conventional cars. For example, the average 24 kWh battery pack for a plug-in vehicle costs about $16,500 today, but battery prices of $125 per kWh could result in a vehicle price reduction of $13,500.

As the number of plug-in vehicles on the road increases, there is a greater need for electric vehicle infrastructure. There are currently only 8,000 public charging stations in the United States, compared with 150,000 gasoline stations.[13] Public charging stations are vital, as they can help extend the electric range of plug-in vehicles and make them more viable for long-range trips. However, the federal government tax credit for commercial charging stations expired at the end of 2011. Proponents of electric vehicles say that the infrastructure for routine daily driving already exists, as plug-in vehicles can connect to almost any wall outlet.

INCENTIVES

As part of the 2009 American Clean Energy and Security Act, the federal government grants tax credits of $2,500 for new qualified plug-in vehicles plus an additional $417 for each kilowatt hour of battery capacity over four kWh, with a maximum credit of $7,500. Because they typically have very large battery packs, most EVs are eligible for the full $7,500 credit. PHEVs have a wider range of battery sizes—the plug-in Toyota Prius has a small battery and is only eligible for a $2,500 credit, while the Chevrolet Volt has a larger battery pack and is eligible for the full $7,500 credit. The full federal tax credit is available for the first 200,000 eligible plug-in electric vehicles produced by each automaker. The tax credit will be gradually phased out as individual automakers pass this threshold.[14]

Many states also offer incentives for electric vehicles. For example, California offers rebates of up to $2,500 for plug-in vehicles and gives them free access to the state's high occupancy vehicle (HOV) lanes. In Washington, plug-

in vehicles are exempt from the state's sales tax and motor vehicle tax. Colorado offers a tax credit of up to $6,000, plus a 20 percent rebate for an electric vehicle charger installation at home. The U.S. Department of Energy maintains a full list of state incentives and laws for alternative fuels and advanced vehicles.

For more information see:

Fuel Economy Guide: Model Year 2012 by the U.S. Environmental Protection Agency and U.S. Department of Energy
Advanced Technology Vehicles Manufacturing Loan Program by the U.S. Department of Energy

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