

Plug-in hybrid electric vehicles (PHEVs) let drivers plug in instead of fill up.

The Next Generation of Hybrid Cars: Plug-in Hybrids Can Help Reduce Global Warming and Slash Oil Dependency

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With today's persistently high oil prices, Americans are spending more money than ever on gasoline. The production and use of gas and diesel in cars, trucks, and buses also account for 27 percent of U.S. global warming pollution. Promising new transportation technology called plug-in hybrid electric vehicles (PHEVs) could help Americans spend less money at the pump, and at the same time reduce global warming pollution and decrease our reliance on oil. NRDC has developed a set of policy recommendations for making this new fuel-efficient technology part of a smart transportation package.

Plug-in Hybrids Are Part of a Mix of Strategies That Can Solve Global Warming and Reduce Oil Dependence

Transportation accounts for two-thirds of our oil demand, and this sector is 97 percent reliant on oil. While there is no silver bullet, PHEVs can be part of an effective mix of strategies to dramatically cut our global warming pollution and oil usage in the transportation sector, including higher fuel efficiency, biofuels, and smart growth. Raising the fuel efficiency of conventional gasoline vehicles to 40 miles per gallon (mpg) is still the fastest,

cheapest way to reduce transportation sector global warming pollution and oil consumption, and it's possible to reach this goal in 10 years using existing and emerging technologies. But ultimately, eliminating carbon emissions and oil usage means switching to cleaner fuels, such as electricity and biofuels. Because it will take time for new technologies like plug-ins to replace the more than 200 million conventional gasoline vehicles on the road today, we need to start working on commercializing such technologies right away.



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The Next Generation of Fuel-Efficient Vehicles: PHEVs Top Today's Hybrids

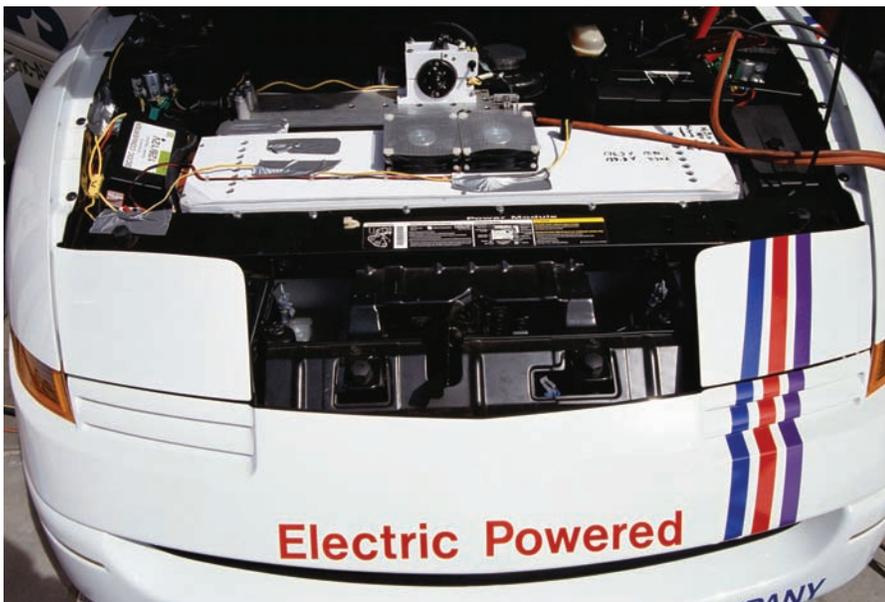
Plug-in hybrids are an evolution from today's so-called "full" hybrid vehicles, such as the Toyota Prius or Ford Escape. A "full" hybrid has the ability to start and accelerate to low speeds without starting the gasoline engine, but the battery pack is charged exclusively from the on-board internal combustion engine and regenerative braking. A plug-in hybrid operates in the same way but has a larger battery pack and gives the driver the option of charging the battery from a household outlet and then running their vehicle on grid electricity instead of petroleum.

Plug-in hybrids have an advantage over pure battery electric vehicles because drivers don't have to worry about running out of electricity—when the battery runs down, plug-ins operate like conventional hybrids and use the engine and regenerative braking to charge the battery and drive the vehicle. Because they have both gasoline and electric drive systems, PHEVs can also have smaller, less expensive battery packs than pure battery electric vehicles.

Better Batteries Mean More Efficient Hybrids

Today's popular hybrid vehicles use nickel metal hydride (NiMH) batteries, which can be engineered for relatively short battery-only driving distances in plug-in hybrids. For PHEVs with longer electrical range, the larger energy storage and electrical power requirements are expected to be met with lithium-ion (Li ion) battery technology. Li ion batteries are popular in consumer electronics such as cell phones and laptops and can store two to three times more energy than NiMH batteries of the same weight. NiMH batteries are a mature technology, but Li ion technology is ripe for new innovation.

Continued Li ion battery development is focused on making relatively low cost Li ion batteries that can safely withstand vehicle charge and discharge duty cycles over the life of the vehicle. Li ion battery cells are more sensitive than NiMH cells to abuses, such as overcharges and short circuits. Although these severe abuse situations are unexpected during normal vehicle operations, engineers of Li ion vehicle battery systems have developed multiple layers of protection to prevent dangerous failure conditions. Researchers at the Department of Energy (DOE) are studying materials that hold promise to further reduce Li ion battery sensitivity to abuse conditions, reduce engineering and production costs, and extend battery life.



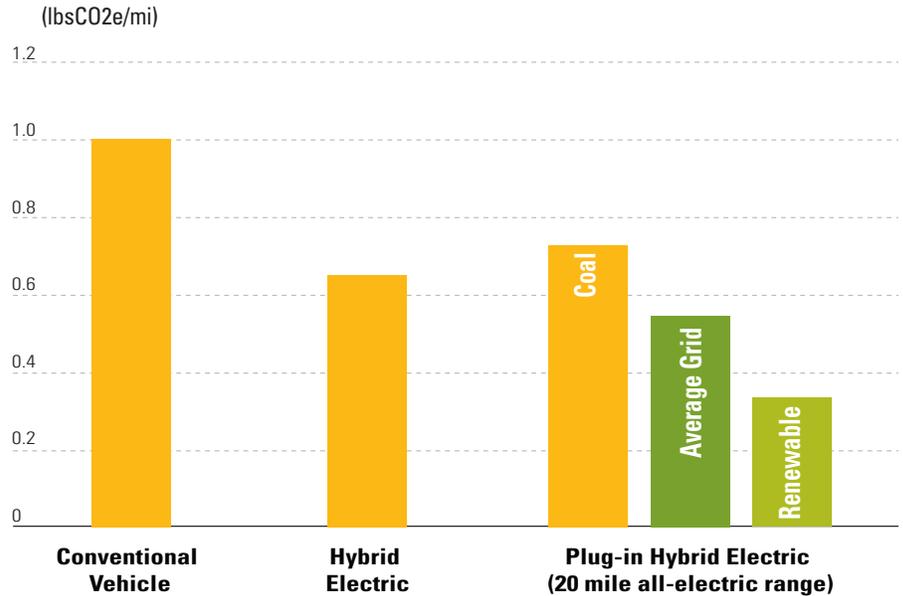
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PHEVs Can Cut Global Warming Pollution and Oil Consumption

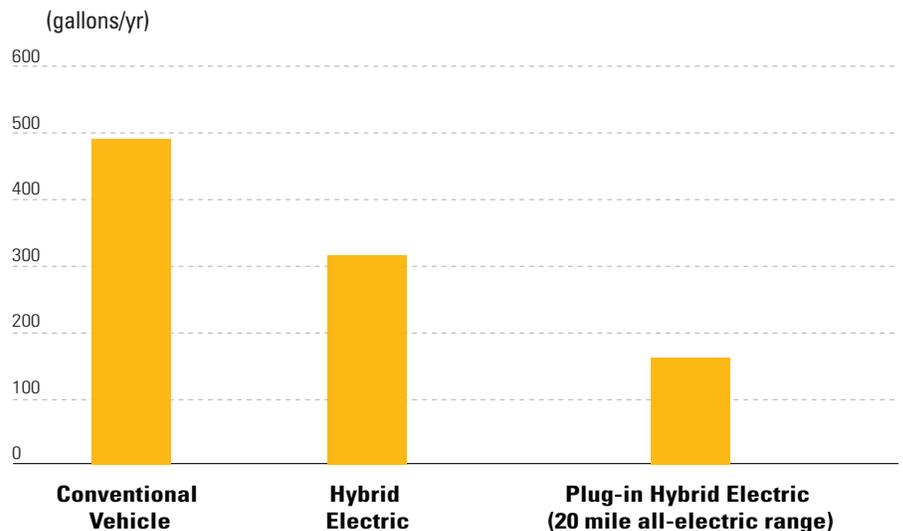
A PHEV's global warming pollution is significantly lower than a conventional vehicle of comparable size, even when factoring in emissions from the production and transmission of the electricity. However, if a PHEV's electrical charge comes from today's coal power, the plug-in would have higher global warming pollution compared to a non-pluggable hybrid electric vehicle. And although driving a plug-in saves more oil than a conventional hybrid, the plug-in hybrid will not produce significant global warming reductions unless it is charged with cleaner electricity. PHEVs deliver the largest global warming reductions compared to other cars and trucks when they are charged with renewables, such as wind and solar, or power plants that capture and dispose of their global warming pollution. A plug-in running on renewable energy emits only as much global warming pollution as a 74 mpg car.

In regions of the country that have a relatively clean generation mix, PHEVs are also likely to reduce soot and smog-forming pollution. However, in regions that are heavily dependent on dirty, coal-fired power plants, there is a possibility for significant increases of soot and mercury. Promotion of PHEVs in these regions must be done only after a careful assessment of the pollution impacts and after the necessary power plant controls are in place.

Global Warming Emissions, PHEVs Compared to Other Mid-Sized Cars



Oil Consumption, PHEVs Compared to Other Mid-Sized Cars



Source: EPRI-NRDC Joint Technical Report, *Environmental Assessment of Plug-In Hybrid Electric Vehicles, Volume 1: Nationwide Greenhouse Gas Emissions* (1015325), July 2007.

■ For PHEVs, per mile global warming emissions are greatly affected by what is used to charge them. Today's typical pulverized coal power plant (2.5 pounds CO2e/kWh) results in the highest emissions. The average grid (1.3 pounds CO2e/kWh) is a mix of generation sources of mainly coal, natural gas, nuclear and large hydro. Non-emitting renewable electricity sources such as wind, geothermal, and solar provide the lowest emissions per mile.

■ We assume all vehicles travel 12,000 miles per year. On-road efficiency for conventional vehicles 24.6 miles per gallon while hybrid drivetrains achieve 37.9 mpg on gasoline. PHEV electrical efficiency is 3.2 mi/kWh and 49 percent of the PHEV miles are using stored grid electricity.

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Policy Recommendations for Reducing Global Warming with Plug-In Hybrids

■ **Promote the advancement of commercial plug-in hybrid technology.** Currently, no automaker is offering PHEVs for sale, but their participation in the market is critical to wide-scale acceptance by consumers. Early orders for PHEVs should be aggregated to entice automakers to begin production. Additionally, funding should be directed at a national electric vehicle technology advancement program of research and demonstration designed to reduce battery cost, ensure battery safety, evaluate PHEV performance under different electric drive control scenarios, and educate the public on costs and benefits of electric vehicles.



■ **Ensure air quality benefits.** Careful assessment of power plant emissions should be done before a region decides to promote PHEVs. If there are significant pollution problems, then large-scale adoption should not be encouraged until proper standards are in place. Early adopters of plug-ins should be encouraged to purchase low-pollution, or green, power.

■ **Clean up electric power plants.** To maximize global warming pollution reductions from a shift to electric transportation, we need clean power plants that emit little global warming pollution or capture and lock the pollution underground. In many regions, coal plants supply most night-time electricity and these carbon-intensive generators could emit large amounts of additional global warming pollution with increased demand from PHEVs charged overnight. Policies that encourage PHEVs to be supplied with clean, renewable sources such as wind, solar and biomass or other sources that capture and dispose global warming pollution will help make PHEVs a valuable solution to global warming.

Caps on the emissions of nitrogen oxides and sulfur dioxide prevent power producers from allowing greater emissions of these pollutants across their portfolio of generation units (emission levels, however, could shift from one region to another). Direct emissions of particulate matter and mercury, which come predominantly from coal plants, are insufficiently regulated, so regions dominated by dirty coal plants should carefully analyze the impacts of increased electricity loads and set policies to promote cleaner electricity production.

■ **Establish programs for battery recycling and proper disposal.** Recycling programs should be in place before PHEVs proliferate to keep batteries out of landfills.

■ **Encourage off-peak battery charging.** Power companies have excess capacity at night and should price electricity to encourage battery charging during low-demand periods. However, because significant amounts of off-peak power could come from existing coal plants, this increases the importance of cleaning up these sources, both for conventional pollutants and for global warming pollution.

We must use everything in our transportation solutions toolbox to solve global warming and oil dependence, including efficiency improvements, smart growth, and low-carbon alternative fuels. Electric drive vehicles like plug-in hybrids that run on clean power sources can help provide a smooth ride to a healthy future.