

## VEHICLE TO GRID V2G TECHNOLOGY

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### Power to the People: Run Your House on a Prius

WHEN Hurricane Frances ripped through Gainesville, Fla., in 2004, Christopher Swinney, an anesthesiologist, was without electricity for a week. A few weeks ago, Dr. Swinney lost power again, but this time he was ready.

He plugged his [Toyota Prius PHEV](#) into the backup uninterruptible power supply unit in his house and soon the refrigerator was humming and the lights were back on. "It was running everything in the house except the central air-conditioning," Dr. Swinney said.

Without the Prius, the batteries in the U.P.S. unit would have run out of power in about an hour. The battery pack in the car kept the U.P.S. online and was itself recharged by the gasoline engine, which cycled on and off as needed. The U.P.S. has an inverter, which converts the direct current electricity from the batteries to household alternating current and regulates the voltage. As long as it has fuel, the Prius can produce at least three kilowatts of continuous power, which is adequate to maintain a home's basic functions.

This form of vehicle-to-grid technology, often called V2G, has attracted hobbyists, university researchers and companies like Pacific Gas & Electric and Google. Although there is some skepticism among experts about the feasibility of V2G, the big players see a future in which fleets of hybrid cars, recharged at night when demand is lower, can relieve the grid and help avert serious blackouts.

Willett Kempton, a senior scientist in the Center for Energy and Environmental Policy at the [University of Delaware](#), said the power capacity of the automotive fleet was underutilized.

Mr. Kempton is helping to explore the V2G capabilities of a fuel-cell bus and battery-electric vehicles. The technology is also well-suited for so-called plug-in hybrids, which are being developed by General Motors, Toyota and other automakers. Plug-in hybrids will use larger battery packs and recharge from a household outlet for 10 to 30 miles of electric-only driving. When modified, they can return electricity to the grid from their batteries.

Google has four Priuses with plug-in capacity at its headquarters in Mountain View, Calif. With some advice from P.G.& E., Google equipped one to supply power to the grid.

Keith Parks, an analyst at the Minneapolis-based utility Xcel Energy, offers what he calls a “pie-in-the-sky vision” for V2G in which a company would offer incentives to its employees to buy plug-in hybrids. The parking lot would be equipped with recharging stations, which could also return power to the grid from the vehicles.

Both Xcel Energy and the federal National Renewable Energy Laboratory, Mr. Parks’s former employer, are investigating V2G technology.

“We see this as a win-win,” said Sven Thesen, director of P.G.& E.’s Clean Air Transportation office. The utility owns Sparky, a Prius converted to plug-in operation by EnergyCS of Monrovia, Calif.

“It’s the first new use for the electric power infrastructure in 100 years,” said Jesse Berst of [Smartgridnews.com](http://Smartgridnews.com).

But the V2G vision is not likely to be realized soon because engineers are wrestling with battery technology, cost and weight. A word of caution is added by John DeCicco, a mechanical engineer and senior fellow for automotive strategies at the nonprofit group Environmental Defense. “It’s hard to take seriously the promises made for plug-in hybrids with 30-mile all-electric range or any serious V2G application any time soon,” he said. “It’s still in the science project stage.”

No automaker is selling a plug-in hybrid vehicle, but some ambitious people are making their own. Converting a stock Prius to back up the grid is much easier, and the guru for such conversions is Richard Factor, 61, an inventor from Kinnelon, N.J.

Mr. Factor says that small U.P.S. units, often used to provide backup power for computer servers, are inexpensive. His system, which he estimates would cost \$2,000 to \$4,000 to duplicate, incorporates a large U.P.S. mounted in his home and a long electrical cord to the Prius, where it connects through the car’s built-in relay terminals. His system is designed to integrate with the grid, but he said more rudimentary systems could be built for as little as \$200.

During a recent six-hour power failure, Mr. Factor estimated that his 2005 Prius used less than one gallon of gasoline.

The V2G potential of Honda’s full hybrid vehicles is unexplored, but the company is doubtful of using them to power homes. “We would not like to see stresses on the battery pack caused by putting it through cycles it wasn’t designed for,” said Chris Naughton, a Honda spokesman. “Instead, they should buy a Honda generator that was made for that purpose.”

PG&E and Tesla Motors Co-Pilot Vehicle-to-Grid

SAN FRANCISCO, Sept. 12 /PRNewswire-FirstCall/ -- Pacific Gas and Electric Company today announced it has partnered with Tesla Motors to further evolve vehicle-to-grid (V2G) technology by researching smart charging - a form of V2G designed to allow remote control charging of electric vehicles connected to the power grid. The project partnership will combine Tesla Motors' leading electric vehicle expertise with PG&E's electric infrastructure experience to explore the ancillary grid benefits of remote charging.

"V2G technology is one of the most promising solutions to help meet our growing energy needs while reducing the transportation sector's impact on the environment", said Brad Whitcomb, vice president of customer products and services for PG&E. "By teaming up with Tesla, we are taking another key step to bring V2G's benefits to our customers."

"We are focusing our initial V2G implementation on smart charging," said JB Straubel, Chief Technology Officer, Tesla Motors. "Smart charging is a form of V2G in which the vehicle does not provide power back to the grid. Instead, the vehicle charging rate is controlled remotely in order to support the operation of the grid or to best match load to the availability of intermittent renewable energy resources such as wind and solar. Tesla Motors' goal in developing V2G is to eventually provide our customers with an option that could reduce their cost of electricity for vehicle charging while supporting greater penetration of renewable energy on the grid."

Using the all-electric Tesla Roadster, PG&E will demonstrate smart charging, which allows remote access to the electric vehicle's charging power level through communication with the utility. Tesla Motors will work with PG&E to equip a demonstration Roadster with the communications technology that enables intelligent charging. PG&E will also install monitoring equipment at the auto manufacturer's San Carlos location for testing purposes.

### About V2G & Smart Charging

V2G technology allows for the bi-directional transfer of electricity between Electric Vehicles (EVs) and Plug-in Electric Hybrid Vehicles (PHEVs) and the electric power grid. The technology turns each vehicle into a remotely-controllable energy storage system. If deployed on a wide scale, V2G has the potential to provide a large remotely-controllable energy storage resource that can support a greater share of electricity generation from intermittent renewable resources.

V2G is conventionally considered as the delivery of power from a vehicle back to the power grid. However, vehicles can also provide useful services to the grid even without delivering power back to the grid. For example, by allowing the vehicle charging rate to be ramped up and down remotely through smart metering a vehicle can perform a grid ancillary service called regulation. Regulation is currently performed 24/7 by power plants in order to fine tune the balance between generation and load.

If this demonstration project is successful, and smart charging is deployed on a wider scale, it is expected to be interfaced with PG&E's SmartMeter technology, which continually reads circuits and electric meter usage and has the ability to provide financial incentives to customers who voluntarily shift electricity usage away from critical peaks.

#### Additional

In addition to partnering with Tesla on V2G research, PG&E is working with the auto manufacturer to support the installation of Tesla Motors' charging stations into their customers' homes or businesses. PG&E is working with Tesla Motors to ensure proper connection in its customers' homes within the utility's northern and central California service territory and advising the auto manufacturer on its collaboration with utilities nationwide.

PG&E became the first utility in the nation to publicly demonstrate the possibility of electric vehicles to supply homes and business with electricity at a Silicon Valley Leadership Group event in April 2007. More recently, PG&E shared this technical expertise with Google in June 2007 to upgrade a number of company-owned Toyota Prius PHEVs to be V2G capable for a demonstration at the search leader's Mountain View campus.

PG&E's PHEV/EV and V2G program is part of its broader strategy to develop innovative energy solutions that deliver the cleanest and most reliable power to its customers. In addition to its PHEV and dedicated electric vehicles, PG&E owns and operates a clean fuel fleet of fuel cell vehicles and more than 1,300 natural gas vehicles - the largest of its kind in the United States. PG&E's clean fuel fleet consists of service and crew trucks, meter reader vehicles and pool cars that run either entirely on compressed natural gas or have bi-fuel capabilities. Over the last 15 years, PG&E's clean fuel fleet has displaced over 3.4 million gallons of gasoline and diesel, and helped to avoid 6,000 tons of carbon dioxide from entering the atmosphere.

For more information about Tesla Motors, please visit the company's website at <http://www.teslamotors.com/>

For more information about Pacific Gas and Electric Company, please visit the company's web site at <http://www.pge.com/>

4.27.07) Plug-in Hybrid Electric Cars: Can They Solve the Fuel Crunch? "The only time you would have to gas up is when you go out of town," says Felix Kramer, who founded the nonprofit California Cars Initiative to promote PHEVs.

Efficient, affordable, 110-volt-powered vehicles could be on dealers' lots within three years—if engineers can get the lithium-ion batteries right.

What Do You Know About Plug-in Hybrids?

They could be the next big thing in automotive tech—cars that you can fill up at the gas station or an electrical outlet. How well do you understand hybrids, plug-ins and pure electrics?

Plug-In Hybrid EV Technology Explained

[The Facts About Plug-in Technology Explained](#)