Scientists explore putting electric cars on a two-way power street

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Think of it as the end of cars' slacker days: No more sitting idle for hours in parking lots or garages racking up payments, but instead earning their keep by providing power to the electricity grid.

Scientists at the University of Michigan, using a $2 million grant from the National Science Foundation (NSF), are exploring plug-in hybrid electric vehicles (PHEV) that not only use grid electricity to meet their power needs, but return it to the grid, earning money for the owner.

"Cars sit most of the time," said Jeff Stein, a professor in the Department of Mechanical Engineering. "What if it could work for you while it sits there? If you could use a car for something more than just getting to work or going on a family vacation, it would be a whole different way to think about a vehicle, and a whole different way to think about the power grid, too."

The concept, called vehicle-to-grid (V2G) integration, is part of a larger effort to embrace large-scale changes that are needed to improve the sustainability and resilience of the transportation and electric power infrastructures. If V2G integration succeeds, it will enable the grid to utilize PHEV batteries for storing excess renewable energy from wind and the sun, releasing this energy to grid customers when needed, such as during peak hours.

This will lead to more sustainable transportation and grid infrastructures, and will also increase the resilience of these infrastructures to sharp

changes in energy costs, supply, or demand.

The NSF's Emerging Frontiers in Research and Innovation program created a topic for a 2007-2008 call for proposals on resilient and sustainable infrastructures. This topic argues that the nation's infrastructures over the past century have evolved largely independently but new technologies have emerged that coupled some of these infrastructures. This has created a need for fundamental tools to design and develop these new technologies and to evolve these coupled infrastructures.

Stein and others see the PHEV as a perfect example of such a new technology that in this case is coupling the transportation and power grid infrastructures.

V2G is an opportunity to look at vehicles beyond shaving miles per gallon. A team of experts in mechanical and power systems engineering, economics, and industrial ecology will examine every aspect of a PHEV and how it interacts with the electrical grid.

If PHEVs, which are anticipated to be on the market in 2010, fulfill their promise, millions could be on the road in the decades to come. This potentially will provide unprecedented shared battery storage to the grid and transportation infrastructures, thereby allowing these infrastructures to store renewable energy when available and use it when needed.

Aging electric plants are good at generating power, Stein said, but they face challenges in storing it, and lack ways to buffer against either big surges in demands, or interruptions in supply. Massive storage systems can be costly and problematic.

But, Stein said, think of all the "distributed" storage packed into millions of PHEVs on the road. He and his colleagues envision a world where the

electric cars could double as mobile holding tanks for electricity, ready to serve in their down time.

"If we had lots of PHEVs all plugged into the grid, then what seems like an insignificant amount of energy storage becomes a large energy storage," he said.

Using gasoline-fueled conventional vehicles to generate electricity would be neither cost effective nor clean. But Stein says that hydrogen fuel cells could in the future power both the transportation and grid infrastructures. Stein and his colleagues see this as a long-term possibility likely to become more and more attractive as fuel cell costs continue to fall.

The team's success will depend on its ability to bring together expertise in transportation and grid systems, economics, industrial ecology, and natural resources. This explains the impressive size of the team, which also includes Hosam Fathy, Zoran Filipi and Huei Peng in the Department of Mechanical Engineering; Duncan Callaway and Greg Keoleian in the School of Natural Resources and Environment; John Sullivan in the Transportation Research Institute; Jing Sun in the Department of Electrical Engineering and Computer Science and Carl Simon, in the Gerald R. Ford School of Public Policy; as well as Mariesa Crow from the Missouri University of Science and Technology.

The four-year project has several components, including:

- Designing new generations of PHEV powertrains, grid systems, and intelligent controllers for these powertrains and systems, to maximize the benefit of V2G integration.
    - Understanding the impacts of PHEVs – no small task since the supply chains for an automobile contain some 20,000 parts and components – and from there

developing environmental and energy sustainability models. The research team will look at life-cycle assessment, that is, understanding how energy is distributed through a system throughout its life, what kind of demands PHEV will place on the electric grid, and what needs the grid will have.

- Building computer models to help understand and predict market penetration of PHEVs. The team will evaluate the long-term sustainability of joining transportation and electricity systems.
    - Developing models to understand how PHEVs can influence the reliability and stability of the electrical grid. The team will look at issues both of resilience and redundancy---how well a system can shift to a back up plan. The models they create ultimately can be turned over to industry.

"Only by applying thoughtful, well developed science will the nation be able to make the right decisions to effectively address our energy challenges," said Gary Was, director of the Michigan Memorial Phoenix Energy Institute which develops, coordinates and promotes multidisciplinary energy research and education at U-M. "This project will provide policy makers, industry leaders and the public with critical information so that they can make well informed decisions. It is the new face of informed decision making."

Source: University of Michigan