NW Energy Coalition
for a clean and affordable energy future

# Comments of the NW Energy Coalition on UM 1461 Investigation into Electric Vehicle Charging Rates and Infrastructures

*August 27, 2010 – Steven Weiss*

The NW Energy Coalition (NWEC or "Coalition") is a coalition of over 110 groups, including utilities, environmental, faith-based, consumer and low-income organizations, unions, government entities and businesses working for a clean and affordable energy future.

We are pleased that the Commission is proactively addressing how best to deal with what we believe will be a rapid transformation of the transportation sector. Due to this state's "green" ethic, combined with increasing concerns over energy independence, over-reliance on oil and global warming, we expect that electric vehicle use will grow more quickly than some predict. We have seen rapid market transformation for other energy end-uses such as horizontal-axis washers and CFLs that have achieved penetrations in this region that are two to three times faster than other parts of the country. There is every reason to believe that this will be true for electric vehicles as well.

The results of this docket can help encourage this trend, or put up serious roadblocks. We hope that the utilities and regulators not only design rules to *accommodate* EVs, but also *encourage* their use. One major way to do this is to tap into the extraordinary value that EVs can bring to the grid if tariffs and other policies are done right.

Our comments will address a number of the Staff's issues list, though we will not comment on the legal issues.

## I. Commission's Goals and Objectives

First and foremost, NWEC urges that any policies regarding EVs be flexible and encouraging of third-party participation. One cannot yet know the business models that will evolve around EVs, so we cannot predict the final roles for the utility. While it might seem easy at first to allow utilities a direct role in developing charging infrastructure, we do not want that role to end up being a barrier to entry for innovative business ideas.

Instead we believe that <u>the utility's role should best be one of facilitation and providing incentives for activities that reduce utility costs.</u> We describe possible mechanisms later under Section III C.

Secondly, we urge the Commission to not take too narrow a view regarding allocation of the costs—and benefits—of accommodating and encouraging EV use. Many of the benefits of expanded EV use will be environmental, so it is reasonable for ratepayers as a whole to contribute to costs that may be incurred to incorporate EVs. Likewise, many of the benefits that a utility can obtain through the ancillary services it can acquire through smart charging are the result of general investments also made by all ratepayers, so the value of those benefits should be shared widely. It would be counterproductive to burden early adopters with expensive infrastructure requirements or spend a lot of effort trying to prevent, much less determine, "undue shifting" of costs (and benefits).

## III. Regulatory Policies and Guidelines

### A. Policies related to development of public charging infrastructure

We support the Staff's straw proposal except for #3. (Our comments on this point are also applicable to the third point under private charging.)

3. Utility Ability to Dispatch EV Charging – Staff's proposal refers to providing the ability to control charging rates "during peak load periods," and only to reducing or interrupting power flow to the vehicle. But in our opinion this is way too narrow a view of the potential for EVs to provide ancillary services. Staff's proposal also does not address a process to determine the size of the tariff, and whether it might be negative if it turns out that the value to the utility of charging control is greater than the cost of the power. We address this value issue in section C, below.

As more wind is added to the grid, we are finding that key integration problems occur during high ramp periods. Most often this occurs in the evening when loads decrease while the wind is picking up, and in the morning when the opposite occurs. The problem is one of intra-hour balancing due to the difficulty of accurately forecasting rapid wind ramps. This problem is causing utilities to need large amounts of expensive reserves that could easily be provided by controlled charging of EVs.

A second problem is that of over-generation during very low load periods. Due to the asymmetric nature of wind turbine output (having average generation of only a third of peak generation), one can see that under 33% penetration, there could be times that wind provides *all* of a utility's load, forcing it to back down all of its other generation.[1] This is impossible, given minimum hydro and thermal requirements, so the ability of EVs to accept higher amounts of energy during these periods would be very valuable.

It is clear that the value of smart charging EVs is much more than just controlling peaks, and should include the ability of the utility to both increase and decrease the charging pace. And, any rate schedule that allows the utility to "dispatch" EVs by controlling the charging pace must reflect the value of the ancillary service the EV is providing to the grid.

Of special interest to us, and we predict to the early adopters of EVs, is the ability of using their vehicles to help integrate renewable resources and reduce their and society's carbon footprint. The knowledge that their vehicle can help their utility integrate renewable resources can be an additional motivation for purchase, as well. Attached is an article from the August 13, 2010 Clearing Up

---

[1] This is somewhat simplistic; in reality, geographic diversity would mean it is highly unlikely for *every* turbine to produce maximum output at once.

(Attachment A) describing a BPA pilot project that accomplishes this using electric water heaters, but the same concept could be applied to EVs.

We propose that utilities be required to offer a rate schedule that gives EV owners the option to allow their utility to actively manage the charging pace to maximize its consumption of renewable energy. That is, it would use as a control signal a measure of the generation output of its renewable resources. A recent announcement from BPA about a pilot (using hot water heaters) at Mason County PUD #3 in Washington whose heating rate is guided by a wind generation signal is evidence that this is possible.

NWEC believes EV owners will be much more motivated to choose such a renewable integration control scheme than simply a time-of-use or peak period control scheme—which can have the unintended consequence of actually causing the charging to come mainly from baseload coal plants.

**B. Policies related to private charging**

1. Rate Schedules for Private EV Charging – We are concerned with giving customers a perverse incentive to switch between two different rates: i.e., using a TOU rate for at-premise charging (perhaps at higher voltages) during off-peak periods, and then switching to a second outlet that is seeing a flat rate during other times. Perhaps the best solution is to require that all meters at a premise be on the same rate schedule.

In addition, we believe that it would be useful for utilities to provide information to EV buyers and retailers at point of sale regarding the reasons to charge their vehicles off-peak, and of choosing time-of-use or, if our recommendation is adopted, real-time renewable energy pricing, if they will be charging their vehicles at home. Typical bill impacts should be included. Probably many customers do not even know that a time-of-use option currently exists.

2. Costs of Distribution Upgrades or Re-configurations – We are nervous about placing responsibility for a distribution upgrade on any one particular marginal load. Every load served by a distribution circuit contributes to the point where an upgrade is needed. It could be EVs, but it could also be bigger TVs, new air conditioners, hot tubs, etc., that are pushing the limits. We are not opposed to Staff's proposal in general, but urge that it be applied rarely and only to specific large multi-family or business-related charging stations.

3. Utility Ability to Dispatch EV Charging – See our comments in Section B, #3 above.

4. Information on Emissions to Customers – Utilities should also provide an approximation of the generation mix and CO2 emissions from the renewable integration tariff described in #3, above.

**C. EV's as a provider of Ancillary Services**

Attached to our comments is a report from the December, 2006 issue of Public Utilities Fortnightly (Attachment B) that provides a preliminary estimate of the value to the utility of the ancillary services provided by a plugged-in vehicle. The article uses the (optimistic) assumption that the entire battery pack could be put under grid control, both for charging and discharging. This is usually known as "Vehicle to Grid" or V2G. While ultimately model this might be realized, most people believe that at least for now, discharging the batteries into the grid will not be practical due to battery design and lifetime concerns.

But this does not mean that most, if not all of the ancillary services discussed in the article cannot essentially be secured via variable charging rates (or "acceptance rates") controlled by the utility. There is little difference, on an aggregate basis, between slowing down or halting charging on many vehicles and discharging those vehicles into the grid. The effect is much the same: a drop in net load served from the utility's resources. This provides up regulation, while increasing the rate of charging provides instantaneous down regulation.

The article's bottom line is this (Table 3, p. 33): controlling an EV battery is worth from $184 to $3,285 per year.

Obviously this study is somewhat dated and contains assumptions that may not apply to our region or control technologies. However, it is a good indication of the potential value to the grid of smart charging.

Staff's proposal for this section is to move this issue completely into the realm of utility IRPs; basically calling for some generic evaluation of ancillary services. This approach needs more focus, however, given the potential value of this "resource." We would recommend adding two bullets:

4. **Utilities should be required to evaluate as part of the IRP or in a separate investigation: (a) the potential of controlled charging of EVs for the provision of ancillary services; and, (b) the value of those services consistent with other sources of the services.**

5. **Develop tariffs to provide owners of EVs who allow utility control that contain incentives or discounts commensurate with the value determined in #4.** EVs are expensive. However, if a good proportion of their value to the utility, in terms of ancillary services, can be rebated back to the owner (as a bill discount or credit, for example), it would go a long way toward making them more affordable.

In conclusion, the NW Energy Coalition urges the Commission and parties to think broadly regarding the potential value of controlled charging of EVs (and other devices, such as hot water heaters, freezers and HVAC, which we will address in UM 1460). In our opinion, EVs are not a problem utilities must solve, but a possible solution to many utility problems, especially the low-cost integration of renewables.

The Sierra Club's data, provided by PGE as part of the company's 2009 IRP filing, shows that retiring Boardman at the end of 2015 would have essentially the same "net present value cost" for ratepayers as retiring the plant at the end of 2018.

The same data showed that both of these scenarios--retirement at the end of 2015 or 2018--"would be less expensive for ratepayers than operating the plant through the end of 2020."

Sierra Club contends that PGE's IRP modeling did not reflect the full costs of either DEQ Option 1 (closure at the end of 2020) or DEQ Option 2 (closure at the end of 2018).

"PGE assumed in its IRP modeling that it would only have to install a low NOx burner system in 2011 in order to be able to operate Boardman through the end of 2018 or 2020. PGE did not include the additional $285 million investment that it would have to make in 2014 to operate through the end of 2020 under DEQ Option 1 or the additional $67 million investment that the company would have to make in order to operate through the end of 2018 under DEQ Option 2," according to the Sierra Club's analysis.

The group says the overall net present value cost for ratepayers of retiring Boardman in 2015 or 2016 (Option 3) would be slightly lower than the cost of retiring Boardman at the end of 2018 (DEQ Option 2).

In addition, the overall net present value cost for ratepayers of retiring Boardman in 2015 or 2016 (Option 3) or at the end of 2018 (Option 2) would be substantially lower than the cost of operating Boardman through the end of 2020, the Sierra Club says.

And the overall net present value costs of all of the early closure scenarios (DEQ Options 1, 2 and 3) would be substantially lower than the cost of continuing to operate the plant through the end of 2040, according to the analysis.

The environmental group also argued that PGE could easily replace the coal-fired generation with a PPA from one of the region's fleet of IPP-operated natural gas-fired plants.

Boardman's current challenge is to meet the Regional Haze Act, but sometime around 2014 the EPA is expected to release new rules for Maximum Available Control Technology (MACT) air quality standards to control mercury and acid gas emissions from power plants. Those rules could also require the installation of scrubbers at Boardman.

The Oregon PUC plans to hold a workshop on the updated IRP and proposed DEQ options on Aug. 23. The commission is expected to review the IRP in November ***[Steve Ernst].***

## [13] BPA Smart Grid Pilot Links Water Heaters With Wind Generation ■ *from [3]*

A pilot project involving BPA and Mason County PUD No. 3 will directly test the smart grid communications concept by linking customer water heaters with wind generation on BPA's system.

The $500,000 pilot--one of four resulting from a February funding opportunity announcement for residential demand-response pilot projects--involves installing a wireless device on customer water heaters that will communicate with the electrical grid and control the appliances according to the amount of wind energy available.

The devices will primarily "talk" to Energy Northwest's Nine Canyon wind project, said BPA spokeswoman Katie Pruder-Scruggs. When the devices detect sufficient wind power, the water heaters will be turned on; at times when no wind power is being generated, the water heaters will be turned off.

The controls aren't expected to negatively affect consumers' hot water supply, Pruder-Scruggs said, since modern hot water heaters are able to keep water warm for some time. For example, the devices will take advantage of wind power generated overnight, when winds are typically stronger, to pre-heat water for use during the morning peak hours. Customers will also be able to override the controls at any time.

BPA is providing $230,000 to fund the project. Mason County PUD No. 3 and other partners are covering the remaining costs, primarily through in-kind contributions, said Jay Himlie, the PUD's power supply and energy services manager.

**The controls aren't expected to negatively affect consumers' hot water supply.**

Partners include a company in the PUD's service area--Allyn Technology of Allyn, Wash., which is manufacturing the wireless device--and Grid Mobility LLC, which is providing the software that the devices will use to connect the water heaters with the wind generation.

Himlie said Grid Mobility's founder, Jim Holbery, has developed "renewable demand response" software that will monitor the actual load on the system as well as the percentage of load being met with renewable energy. "These devices will control the (water heater) loads, to try to help reduce it when renewable availability is low and increase it when renewable availability is high," Himlie said.

Another partner is 3Tier, which provides wind forecasting services. If 3Tier's wind forecast indicates wind generation is going to increase at a time when there is not enough load on the system to absorb it, "what we are going to attempt to do is anticipate how long it will take the wind to hit the wind farms and generate power," Himlie said. The Allyn Technology devices will power down the water heaters beforehand, "so when the wind surge goes up, the water heaters come on."

Mason plans to install 100 of the devices and is asking customers interested in participating to contact the PUD. The pilot is expected to get underway in October.

BPA will be looking for a variety of information during the pilot, said Pruder-Scruggs, including consumer behavior--"do they like it?"--and whether the communication works. "In the end we are looking to gather data to see if this can be implemented on a larger scale," she said.

"This pilot is particularly interesting and unique, and certainly the first time BPA has done anything like this," she added.

The other projects awarded funding under the $1.5-million funding opportunity include a city of Port Angeles pilot, in which the city will use $367,000 to purchase and install 500 residential water heating demand-response controls, 90 in-home displays with controllable home area network capabilities and 10 thermal-storage devices for home heating.

Orcas Power & Light Cooperative will get $270,000 for a pilot that will use Aclara's home area network and real-time customer communication through the Internet to determine how this changes customer behavior.

Emerald PUD was awarded $185,000 for a project that will purchase and install water-heater control devices and programmable thermostat devices using the Cooper AMI system.

Mason No. 3's Himlie said another partner has been added to the PUD's pilot. Demand Energy Networks of Spokane will provide the PUD with two 1-KW battery storage units to test, as well.

When a surge of wind power is detected, the units will be activated to absorb the energy, Himlie said. When the wind generation falls off, that electricity will be returned to the grid.

One unit will be installed at the PUD's office in Shelton, and the other at the Hood Canal Salmon Enhancement Center ***[Jude Noland].***

## [14] IPUC Accepts Idaho Power 20-Year Resource Plan ■ *from [5]*

Idaho regulators have acknowledged Idaho Power's biennial electric integrated resource plan, which calls for adding about 3000 MW of capacity to meet load growth, while also reducing load by 127 aMW through energy efficiency efforts over the plan's 20-year horizon.

The plan *[IPC-E-09-33]*--filed Dec. 28, 2009 (CU No. 1423 [2/11])--also explains how the utility intends to trim 323 MW by 2012 from its summertime peak load using demand reduction programs aimed at the commercial, industrial and irrigation sectors.

While the preferred resource and conservation portfolios adopted by the plan would wean Idaho Power from coal-fired generation--assuming that federal carbon regulation is implemented--the utility said it might be more economical to continue operation of its coal resources if the carbon regulation cost is less than $30 per ton of CO2 equivalent.

Idaho Power's customer base, which currently numbers about 486,000 in southern Idaho and eastern Oregon, is expected to grow to 680,000 by 2029. Over the same period, the utility expects an annual growth in its summer peak of 53 MW, and 13 aMW in its average load.

Over the next 10 years, Idaho Power will address load growth by expanding its demand-management programs, and with 540 MW of new generation--including the 300-MW Langley Gulch CCCT now under construction, 150 MW of wind, and 40 MW of geothermal generation. Also, a 20-MW upgrade of the Shoshone Falls hydroelectric facility will be operational by 2015.

The completion of its new 500-KV transmission line between the Boardman and Hemingway substations in Oregon and Idaho--still in the permitting stage--will provide the utility with another 425 MW of capacity. The line dominates the preferred resource and conservation portfolio of this first decade.

In the subsequent decade, from 2020 through 2029, Idaho Power's preferred portfolio turns to wind and peakers. The utility plans another 1400 MW of generation from natural gas plants, and an additional 500 MW of wind, contingent on completion of the Gateway West Transmission Project--jointly proposed with PacifiCorp--planned for southern Wyoming and southern Idaho.

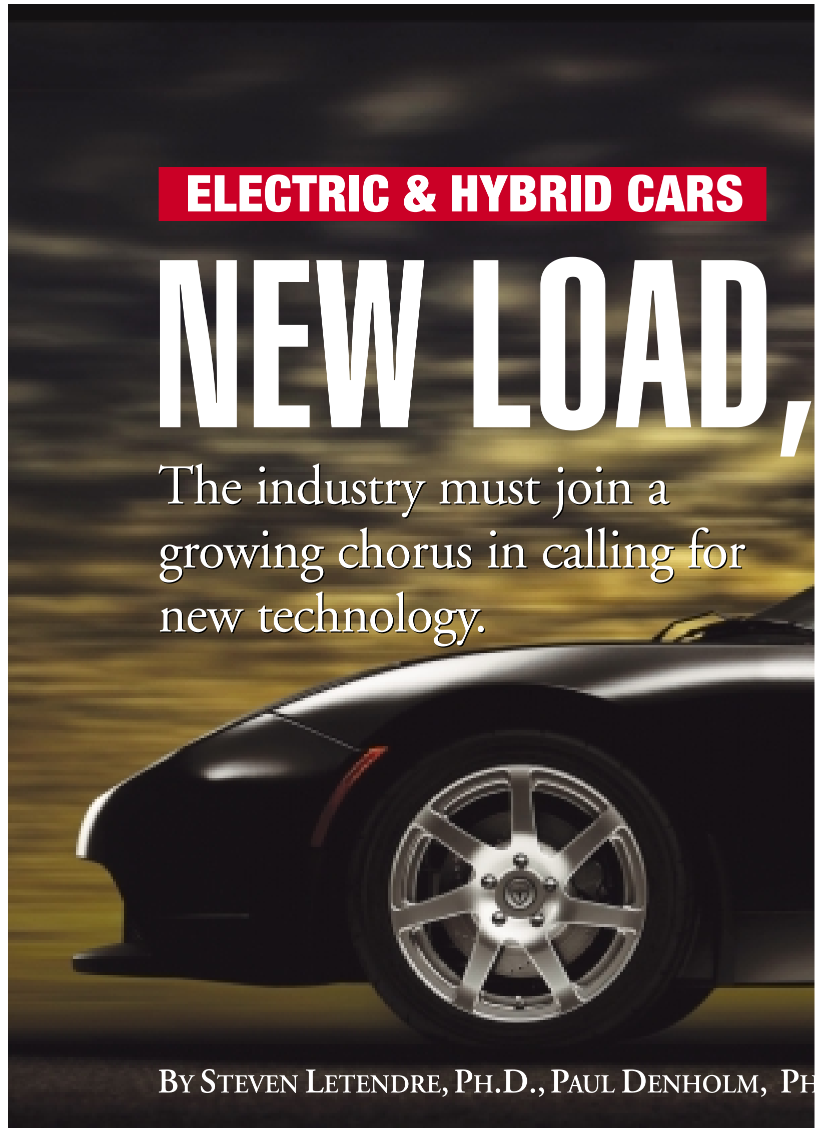
Industry group Renewable Northwest Project, a member of the utility's IRP advisory council, "commended" the utility in filed comments for adopting a strategy that eliminates the use of coal-fired generation by 2029. It expressed concern that this was contingent on carbon regulation pricing, a caveat it said was at odds with PGE's plan to close the Boardman coal plant in 2020. PGE owns 65 percent of the plant, and Idaho Power owns 10 percent.

RNP was also concerned about the "wind and peakers" portfolio, because it might subject the utility's customers to natural gas price volatility.

This IRP was filed more than a year later than its nominal due date of June 2008 because the PUC wanted Idaho Power to synchronize with the state's other investor-owned utilities, Avista and PacifiCorp.

While June 2009 was the target date for the shifted filing, it was delayed another half-year in order to provide information on the Boardman-to-Hemingway 500-KV transmission project ***[Rick Adair].***

**CLEARING UP** is a weekly report to clients of Energy NewsData, covering public utility and energy policy development, markets, litigation and resource development in the United States Pacific Northwest and Westerm Canada. *ISSN 0738-2332.* Report text section copyright date of publication, NewsData Corporation. All rights reserved; no reprinting without permission. News clippings reproduced in CLEARING UP are copyrighted by the newspaper or magazine of original publication. For newsletter subscription information, call [206] 285-4848, ext. 203; email sub information to John Malinowski johnm@newsdata.com. Voice: [206] 285-4848; Fax: 281-8035. **EDITORIAL OFFICES:** Mail: Box 900928 Queen Anne Station, Seattle, WA. 98109-9228; Express delivery: 117 West Mercer Ave., Seattle, WA 98119. Email: newsdata@newsdata.com. Website: www.newsdata.com. **MANAGEMENT AND STAFF:** President & Publisher, Cyrus Noë • Vice President & Controller, Mary Noe • Executive Editor & Associate Publisher, Mark Ohrenschall • Business Manager, Jackie Fields • Director of Information Systems, Daniel Sackett • Client Services Director, John Malinowski • Clearing Up Editor, Steve Ernst • News Editor, Rick Adair • Associate Editors, Bill Rudolph and Penelope Kern • Senior Contributing Editors, Ben Tansey and Jude Noland • BC Correspondent, Brian Lewis • Contributing Editors, Hilary Corrigan, Jim DiPeso, Alan Mountjoy-Venning, Chris Raphael, Mavis Scanlon, and Linda Dailey Paulson • Office Manager & Graphics, Jennifer West McCarthy • Production Coordinator, Amber Schwanke • Clearing Up Production Editor, Michelle Noe.



ELECTRIC & HYBRID CARS

# NEW LOAD,

## The industry must join a growing chorus in calling for new technology.

By Steven Letendre, Ph.D., Paul Denholm, Ph

The prospect of millions of vehicles plugging into the nation's electric grid in the coming decades never has been better. In 2005, hybrid electric vehicles (HEV) reached 1.2 percent of new cars sold in the United States, more than doubling the number sold in the prior year. Vehicle manufacturers, betting on this trend accelerating in the coming years, are rushing to bring HEVs to their dealers' showrooms.

The evolution of HEVs to allow charging from the electric grid—so called plug-in hybrids (PHEV)—is assumed by many to be desirable, even inevitable. Indeed, a growing movement to bring PHEVs to market has emerged, bolstered by the undeniable economic and national-security benefits that result from displacing gasoline with electricity.

One highly visible grassroots campaign called Plug-In Partners seeks to demonstrate to the major automobile manufacturers that a national market exists for flexible-fuel PHEVs; dozens of businesses, utilities, municipal governments, and environmental groups have joined the Plug-In Partners campaign.

While there are no commercially available PHEVs on the market, a number of prototypes have been built and tested. The most established PHEV program is housed at the University of California Davis, where Professor Andrew Frank works with students designing and building prototype PHEVs. A second development project involves collaboration between the Electric Power Research Institute (EPRI) and DaimlerChrysler. They produced, and are in the process of testing, several prototype plug-in hybrid vans using the Sprinter platform. (*Editor's Note: Tesla Motors recently introduced an all-electric vehicle. See sidebar, p. 34.*)

▶ **The all-electric Tesla Roadster can go from 0 to 60 in about 4 seconds (*see p. 34*).**

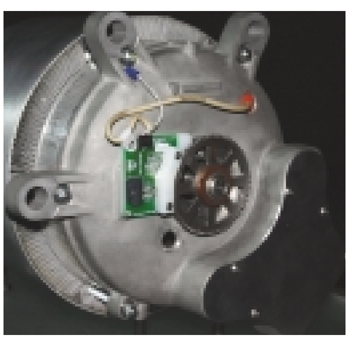
Two startup firms plan to offer conversion kits for current generation hybrid electric vehicles to allow grid charging of the on-board battery pack. These conversions kits offer the potential to almost double an HEV's fuel efficiency rating to 100+ miles per gallon by increasing the size of the battery storage system and installing the hardware and controls to allow charging from the electric grid.

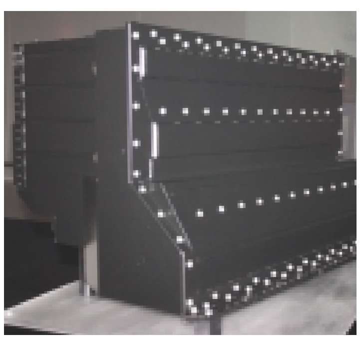
There is some indication that at least one major auto manufacturer is developing next generation PHEV technology. This summer, Jim Press, president of Toyota's North American subsidiary, announced that the company was looking at developing a plug-in hybrid that travels greater distance without gasoline than their current hybrid models. Toyota is the leading manufacturer of HEVs, selling over 50 percent of all hybrids purchased in the US in 2005.

The authors believe that the commercial success of PHEVs will hinge on an aggressive development and marketing effort by a major auto maker. Support from the electric-power industry could provide further impetus for a major automobile manufacturer, such as Toyota, to pursue PHEV technology.

Photos courtesy of Tesla Motors

The potential that PHEVs offer to lower fuel costs, reduce petroleum consumption, and decrease harmful emissions is described elsewhere.[1] The likely impact on the electric grid from an increasing number of vehicles plugging in is not yet fully understood. This is due in part to key variables that are difficult to predict, such as likely PHEV design characteristics (*e.g.*, battery size and efficiency) and market penetration rates.



This article sheds light on these important issues using reasonable assumptions for each of these key variables.

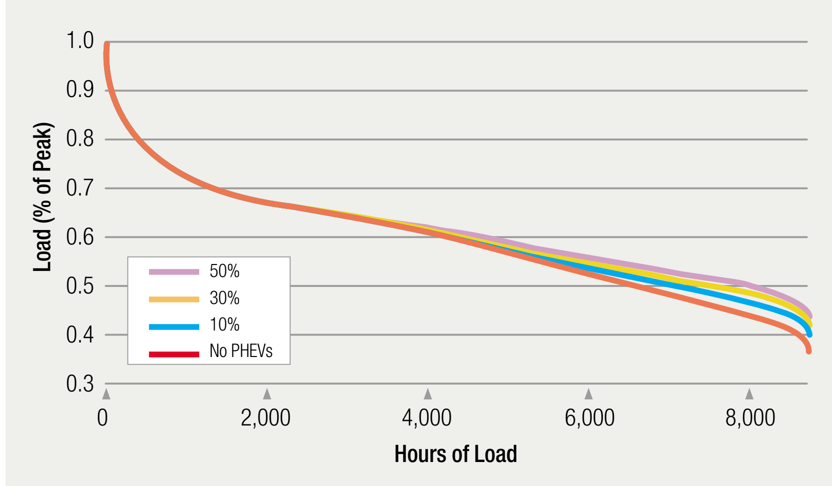
We begin with an assessment of the increased load that PHEVs would represent under a range of assumptions. Next, we evaluate PHEVs serving as distributed-power resources, targeting high-value markets for fast response, short duration grid-support services; this concept has become known as vehicle to grid.[2] Finally, we summarize the opportunity and challenge that PHEVs represent to the electric power industry.

We believe the system-wide impacts of an emerging fleet of PHEVs are fully understood only when these vehicles are considered as both new load and new, distributed resources.

## Electrons for Gasoline

Ultimately, the economics of displacing gasoline with electricity should drive consumer demand for PHEVs. The cost of electricity to drive a vehicle the same distance as one gallon of gasoline is equal to approximately $1—or even less if off-peak electricity prices are assumed.[3] Furthermore, as discussed later in this article, PHEVs potentially could generate revenue for the vehicle owner by providing grid-support services. Combined, these value propositions could serve to usher in an era

Fig. 1 Impact of PHEV Charging on System Load Duration Curve, Midwestern Region




Source: Denholm and Short, 2006

of advanced vehicles with dramatic reductions in gasoline use and tailpipe emissions.

Can the current and planned electric-power infrastructure meet the increased demand from PHEVs?

Fig. 1 presents load-duration curves under a range of assumption about PHEVs, from a base case with no PHEVs to an aggressive case assuming 50 percent penetration. The graph illustrates that PHEV charging does not necessarily contribute to the system peak, provided an optimized PHEV charging regime is adopted. The graph was generated using a PHEV-load tool, which simulates PHEV charging on an optimized 24-hour cycle for a utility control area in the Midwest. This simulation was performed for six different regions for which hourly electric load data was available. The results presented in Fig. 1 were consistent across the six regions.

The NREL study assumed that 40 percent of the PHEV daily miles traveled were obtained using electricity. This is equivalent to a PHEV with an all-electric range of between 20 to 40 miles—so called PHEV20 and PHEV40 respectively. While uncertainty exists about the PHEV architecture that is most marketable, the National Economic Council's Advanced Energy Initiative established PHEV40 as its goal.[5] Depending on the average vehicle miles traveled in each region, between 4 kWh and 6 kWh on average per day are needed to meet 40 percent of drive miles with electricity. Fig. 2 presents estimates of the increased energy consumption for each region by PHEV penetration rate. This type of new load represents an opportunity for the electric utility industry to expand sales without contributing to system peak.

Further benefit to the electric-power sector from the introduction of PHEVs include increased load factor, for both generation and transmission facilities, and reduced cycling of generation facilities. The economic value of these benefits, which are a function of the cost structure for each individual utility operating within a particular geographic location, was not calculated.

## What's the Real Potential For PHEVs?

Conventional thinking suggests that PHEVs would plug in at night and recharge during the late evening and early morning hours—end of story. This perspective is limited, and misses a significant value proposition that is made possible by the fact that vehicles are parked over 90 percent of the time. These idle resources, if connected to the grid when parked, could be tapped to provide any number of grid services.

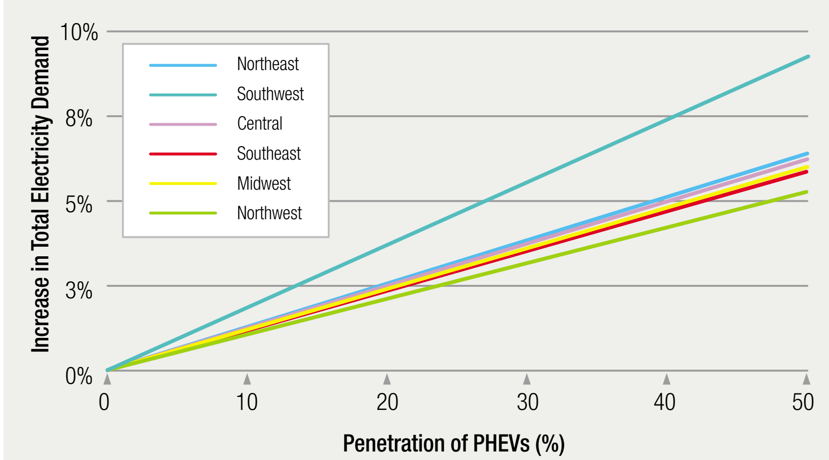
It should be noted here that we consider only the stored energy in the onboard battery pack of a PHEV as available for vehicle-to-grid (V2G) power, unlike earlier studies of PHEVs providing V2G power.[6] We do not consider remote starting of vehicles to access the liquid fuel onboard as reserve energy for V2G power. While this is technically feasible, the control and safety issues associated with starting engines remotely are a cause for concern and thus we do not consider this as a near-term option. PHEVs have larger battery packs than HEVs, and unlike a pure battery-only electric vehicle, the entire available energy in a PHEV can be used for V2G services given that when the owner begins the next trip the vehicle can use the liquid fuel to drive the vehicle.

While the authors know of just one demonstration project,[7] V2G has been analyzed primarily from a theoretical perspective.[8] While no major technical barriers to V2G emerged from the demonstration project or the research, several issues bearing on the economic potential of cars providing grid support services were identified.

While V2G-capable cars could provide peak power or serve as a demand-response resource, their economic values do not generally justify the expense.[9] These services are needed for just a few hours each year, and thus the potential revenue from providing these services is limited. Research on the subject found that the most promising markets for V2G power are for those services that the electric industry refers to as ancillary services. These are services that grid operators must obtain 24 hours per day 7 days per week, and thus take advantage of the extended availability of the vehicle fleet to provide these services.

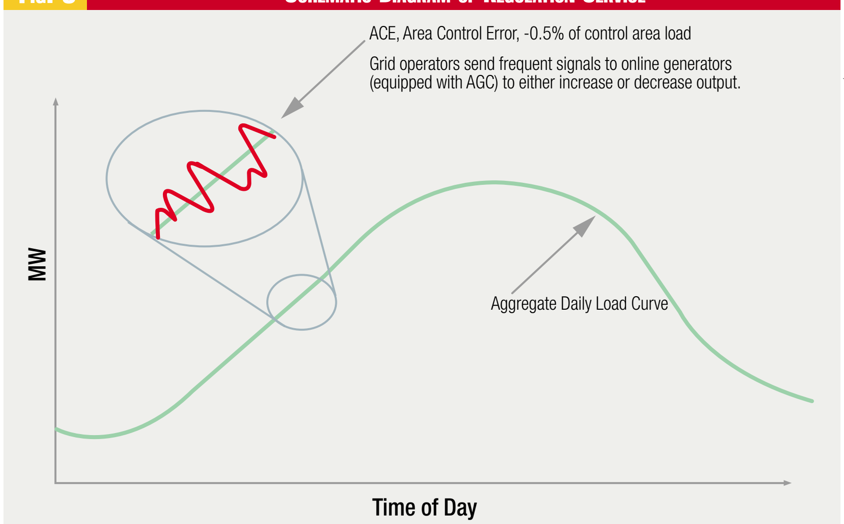
Earlier studies identified two specific ancillary services, for which hourly wholesale markets exist, as particularly promising for V2G power—regulation and spinning reserves. Vehicles with an electric-drive system and battery storage, like those found in PHEVs, particularly are well suited to provide these services, which fall under the general category of operating reserves. These services require fast and accurate responses to electric-grid operator signals, and typically are used for short durations. Grid operators across the country require each of these services for every one of the 8,760 operating hours in a year, and they represent a multi-billion-dollar combined market.

**Fig. 2** **Percentage Increase in Total Electric Demand vs. PHEV Penetration**




Source: Denholm and Short, 2006

**Fig. 3** **Schematic Diagram of Regulation Service**




Source: Denholm and Short, 2006

Regulation (frequency response) services today are supplied by generators on automatic generation control (AGC), which are deployed based on a measurement called area control error (ACE)—a measure that characterizes the instantaneous mismatch between supply and demand. Control area operators are required by the national and regional reliability organizations to carry sufficient regulation reserves equal to approximately 1.5 percent of the control area's peak demand for power in a given day. These reserves must provide both regulation up and regulation down, depending on the ACE, in response to a signal sent by the control area's energy management system, which go out literally every two to six seconds. If demand is greater then supply at any given moment, then regulation up is required, and a signal would go out requiring generators to increase the power delivered to the grid. In contrast, in a situation when demand is less than supply, the AGC signal would call upon the regulation reserves to reduce the power delivered to the grid. In the case of a distributed storage system like a PHEV, regulation up entails discharging of the battery and regulation down entails charging of the battery pack.

The second most valuable category of fast-response, short-duration ancillary services is referred to as spinning reserves. These typically are provided by generators that are spinning and ready to deliver power to the grid in a matter of minutes when called upon in the case of a contingency. These reserves are used only when a scheduled generator trips offline or a transmission or distribution facility fails, and must be up to full power within 10 minutes. Experience shows that spinning reserves rarely are called upon and when they are called, are required for only a short amount of time. In fact, the PJM Interconnect, the regional transmission organization (RTO) serving the Atlantic coastal states and much of the Midwest, experienced 105 events that required deployment of spinning reserves in 2005 with an average duration of 12 minutes.

The central issue dictating the potential V2G revenue from providing these ancillary services is the quantity of power in kilowatts (or capacity credit) per vehicle or fleet. Ultimately, the regulatory authority responsible for qualifying resources to participate in ancillary services markets, like an independent system operator (ISO), RTO, or regional reliability councils, establish methods to determine the amount of power a resource is able to sell in a given market.

Although emerging competitive markets for grid services purport to be technology neutral, the rules are written to accommodate the incumbent technologies and are not necessarily appropriate for new technologies such as a fleet of V2G capable vehicles. For example, the Northeast Power Coordinating Council, the reliability council covering the Northeastern section of North America, requires minimum run times of one hour for resources providing 10-minute spinning reserves. In practice, however, spinning reserves rarely are called, and when they are, the typical dispatch duration is much less than one hour. Thus, as discussed below, a one-hour dispatch requirement severely would limit the per-vehicle power a PHEV would be able to sell in a market for spinning reserves, and fails to appreciate the value of a rapid and accurate response that a V2G system is capable of.

**While grid-capable cars could provide peak power….the most promising markets are for ancillary services.**

The key parameter for resources providing regulation reserves is the generating unit's ramp rate.[10] Most regions specify regulation as a five-minute service. Thus, a generator with a ramp rate of 3 MW/minute in a region that defines regulation as a five-minute service, would be approved to provide 15 MW of regulation. The rules do not specify the power output duration that a resource must maintain, and for which it was approved. PHEVs providing regulation would have ramp rates far superior than the incumbent technologies. Industry experts indicated that inaccurate response to AGC signals requires grid managers to carry greater amounts of regulation reserves than would be necessary if resources were responding precisely to an AGC signal. Again, PHEVs with a communication and control infrastructure would be capable of very accurate responses to signals received from a central grid operator.

For the moment we set aside the regulatory requirements for resources to qualify as providers of ancillary sources, and look at the infrastructure and vehicle constraints that dictate the reverse power flow potential from PHEVs. Kempton and Tomic (2005)[11] identify three key factors that limit the amount of power a grid-connected car can deliver back to the grid. These include the onboard vehicle electronics, capacity of the plug circuit, energy storage capacity, and state of charge when the vehicle is plugged in to provide grid services. The key question is which of these serves as the limiting factor to the reverse power flow potential from a PHEV?

We don't anticipate that a PHEV vehicle's power electronics would create a binding limit on the amount of power that can be exported to the grid. PHEVs require high-power components for acceleration and to optimize vehicle performance. An existing electric drive train developed and manufactured by AC Propulsion provides 80 amps in either direction, allowing 19.2 kW of power output.

Thus, the critical factors dictating the reverse power potential come down to the capacity of the plug circuit and the size and state of charge of the PHEV's battery pack. We assume that PHEVs would plug in to conventional residential and commercial circuits with a 120-V 20-amp service allowing approximately 2 kW of reverse power flow. Most homes and commercial buildings contain higher capacity circuits like 240 V at 50 amps for large appliances like ovens and dryers: These circuits could accommodate about 10 kW of reverse power flow from a vehicle back to the electric grid.

The parameters to evaluate with the most potential for variability that limits the amount of power a PHEV could deliver to the grid are: 1) size of the onboard battery pack; and 2) state of charge when plugged in and ready to provide regulation or spinning reserves. For purposes of demonstration, we assume that the average available energy from a fleet of PHEVs is 10 kWh: This is consistent with the energy storage needs of vehicles designated as PHEV20 (larger, less efficient vehicles) and PHEV40 (smaller, compact cars with higher efficiencies). Table 1 illustrates the available V2G power from a PHEV based on a range of assumptions regarding battery state of charge and the duration of the dispatch. The values in Table 1 are calculated simply by multiplying the available energy by the state of charge and then dividing by the dispatch duration. For simplicity, we do not account for the slight losses associated with the inverter to convert the DC battery power to AC grid power. These results are based on a PHEV with 10 kWh of available energy, and thus would scale down for smaller battery packs and scale up for PHEVs with larger battery storage systems.

The data in Table 1 suggests that, as expected, the power capacity per vehicle is highest with a full battery and shorter dispatch durations. In these cases, the capacity of the plug circuit presents the limiting constraint on available power per vehicle. In all but two cases presented in Table 1, a conventional wall outlet allowing 2 kW of reverse power flow sets the limit on the power being exported to the grid and thus what a vehicle can sell. A higher power circuit allowing 10 kW of reverse power flow readily is available for most homes, but may need to be installed at a location that would allow grid charging of a parked PHEV. With these higher power circuits, about half of the possible situations presented in Table 1 would be limited by the 10-kW plug circuit limit.

We provide some basic calculations on the potential annual revenue assuming a 2-kW and 10-kW limit on reverse power flow from a parked PHEV. Assuming 50 percent state of charge and that the regulatory authority specifies run times of 30 minutes for spinning reserves and 15 minutes for resources providing regulation services, the PHEV would be allowed to sell 10 kW and 20 kW of power into the market for spinning reserves and regulation respectively. In both cases the limiting factor for reverse power flow is the rating of the plug circuit—2 kW and 10 kW.

Kempton and Tomic (2005)[12] provide detailed equations for calculating revenue and costs for various vehicle configurations. Here, we take average market clearing prices from two control areas—PJM and ERCOT (the Electric Reliability Council of Texas)—to estimate the annual revenue to a PHEV owner from providing regulation and spinning-reserve services. Table 2 provides for the average 2005 market-clearing prices from both regions and both grid services.

Further, we assume that the vehicle is plugged in and ready to provide grid services for 75 percent of the available hours in a given year. We consider only capacity payments, however most rules include compensation to resources for energy delivered. We found that this generally nets out when one considers the energy that must be purchased to charge the vehicle. Fig. 4 presents the annual potential revenue to a vehicle owner assuming 2 kW and 10 kW power availabilities.

The results in Table 3 suggest that PHEVs could generate significant revenue to a PHEV owner, from a low of $184/year to a high of $3,285/year. Relaxing the run-time requirement for resources providing spinning reserves from 60 minutes to 30 minutes dramatically improves the revenue potential of vehicles providing this service. When regulation resources are used appropriately, as we assume a maximum of 15-minute dispatch duration, as the capacity of the plug circuit always will serve as a binding constraint and thus dictate the potential annual revenue from providing this service. Larger circuits could be installed to address this constraint at a cost.

An issue that is not yet fully understood for storage resources providing regulation relates to the random nature of providing regulation services. As mentioned above, the storage resource would need to release energy on to the grid when a regulation up signal is received and absorb energy (charge) when a regulation down cycle is received. A prolonged period of regulation down, for example, could result in the battery pack becoming fully charged. In this case, the vehicle would be unable to provide regulation down if the need persisted. Related to this issue is what has been labeled the "dispatch-to-contract" ratio, which indicates on average what portion of the regulation reserves being held by the grid operator actually are deployed.[13] This has implications for the amount of energy throughput for an energy storage system providing this service.

Fig. 4 presents data from ERCOT comparing the amount of regulation being held in reserve versus what was actually deployed to correct the mismatch between supply and demand on a particular day. The AGC signals are given in 15-minute intervals, whereas in practice these signals are sent every few seconds. We assume that this 15-minute data is the average AGC signal during that interval. We are unaware of ISOs or RTOs that make actual AGC signal datasets available to the public. This data would be valuable to clearly understand AGC signal patterns, and their impact on a storage resource providing this service.

While Table 3 provides only revenue, the key *(Cont. on p. 36)*

**Table 1 — Potential Power Output from PHEV (kW): State of Charge (SOC) vs. Duration of Dispatch (minutes)**

| | Duration of Dispatch (minutes) | | | |
|---|---|---|---|---|
| SOC | 15 | 30 | 45 | 60 |
| 100% | 40 | 20 | 13 | 10 |
| 90% | 36 | 18 | 12 | 9 |
| 80% | 32 | 16 | 11 | 8 |
| 70% | 28 | 14 | 9 | 7 |
| 60% | 24 | 12 | 8 | 6 |
| 50% | 20 | 10 | 7 | 6 |
| 40% | 16 | 8 | 5 | 4 |
| 30% | 12 | 6 | 4 | 3 |
| 20% | 8 | 4 | 3 | 2 |
| 10% | 4 | 2 | 1 | 1 |

**Table 2 — 2005 Average Market-Clearing Prices for Regulation and Spinning Reserves: PJM & ERCOT**

| | Spinning Reserves | Regulation |
|---|---|---|
| PJM | $14 / MW-h | $50 / MWh |
| ERCOT | $17 / MW-h | $38 / MWh |

**Table 3 — Annual Revenue Potential to V2G-Capable PHEV**

| | | Spinning Reserves | Regulation |
|---|---|---|---|
| PJM | 2 kW | $ 184 | $ 657 |
| | 10 kW | $ 920 | $ 3,285 |
| ERCOT | 2 kW | $ 223 | $ 499 |
| | 10 kW | $ 1,117 | $ 2,497 |

# TESLA: REDEFINING THE ELECTRIC CAR

**By Michael T. Burr**

Photo courtesy of Tesla Motors

"Golf-cart syndrome" long has afflicted the electric-vehicle market. That is, most electric vehicles offered to date have been underpowered and dorky. Thus, the market for EVs effectively has been limited to a few tree-huggers and utility vehicle users.

A well-funded Silicon Valley startup, however, systematically is obliterating golf-cart syndrome. Tesla Motors Inc. has begun selling the Tesla Roadster, a lithium-ion powered sports car that goes from 0 to 60 mph in about 4 seconds. It cruises extremely efficiently, at the equivalent of 135 mpg, with a 250-mile range. And, as the photos illustrate, it's gorgeous—probably because it was designed by a Lotus engineer.

Goodbye golf cart, hello sweet ride.

*Public Utilities Fortnightly* recently spoke with Tesla Motors CEO Martin Eberhart to learn how Tesla's future might affect electric utilities, and vice versa.

**Fortnightly:** What's your long-term business plan for Tesla Motors?

**Eberhart:** Our long-term goal is to become a major car manufacturer. It's bold and audacious, but that's what we are trying to do.

Instead of starting at the bottom end, we're starting with a car that people will aspire toward. This will change the way people think about electric cars in a fundamental way, and open the door for a whole line of vehicles.

Our second model, currently code-named White Star, will be a five-seater sedan that will appeal to more people. We want to build a factory for the White Star program somewhere in the United States. We're doing it as fast as we can. We hope to begin production in 2009.

**Fortnightly:** What's the exit strategy for your investors? IPO, buyout, or something else?

**Eberhart:** We don't have plans for either an IPO or buyout. I can't imagine who would buy us out of this market; most car companies are jettisoning assets rather than buying them. But an IPO is on the minds of our investors. It is a path we will consider.

**Fortnightly:** What market potential do you see for electric vehicles?

**Eberhart:** All cars will be electric eventually. It's only a matter of when. In 20 years they will be the predominant vehicles people buy.

This will happen because the technology is becoming radically more efficient, and our ability to make cars cheaply will get better with time. Already we can go 250 miles, and [fuel] cells are increasing capacity by 8 percent per year. The efficiency doubles every 10 years—like a slow Moore's law. In 10 years, the power plant will be smaller than an equivalent gasoline-powered engine. It will go 400 to 500 miles on a charge and it will last at least 100,000 miles. In 20 years, it will be a no-brainer.

It also will happen because electric cars are the ultimate multi-fuel vehicle. We generate electricity with all kinds of different fuels. With electric cars, the country will be free to adapt its energy supply.

**Fortnightly:** I hear about new developments in battery technology every week. Your vehicle is using thousands of small lithium-ion batteries, like the ones in camcorders. Do you expect to use larger batteries when the technology advances?

**Eberhart:** Our strategy is to use »

"Power companies have an opportunity to become a major player in the world of transportation."

— *Martin Eberhart, Tesla Motors CEO*

the best commercially available cells, but the trick is to use a massive number of small cells. That is the crazy idea we are using here, for many reasons that aren't crazy at all. For example, with lots of small cells, you get a massive surface area that helps to keep them cool and happy.

Big cells are a mistake. If a company comes along and says "We have these big batteries," we say "No, thank you."

**Fortnightly:** What role would you like to see utilities play in developing the electric transportation market?

**Eberhart:** Power companies have an opportunity to become a major player in the world of transportation, and some of them realize it. We are getting a lot of interest from utilities. Based on conversations I've had with PG&E, they really understand the vehicle-to-grid (V2G) concept. There's a measurable value to having storage capacity available in vehicles plugged into the grid.

Utilities can help in a lot of ways. One practical issue is to rationalize rate structures so the same rate works for both solar roofs and electric cars. There is a lot of synergy between them.

Also utilities should take ownership of charging standards. They should promote all the necessary standards and infrastructure for V2G, and tell me what standards I should be using. That's the only way it can happen, because it will depend on metering and billing.

Our customers would love it if we could work with power companies to offer programs that allow a customer to pay in advance for green generating capacity, to fund construction of new solar or other generation. But it shouldn't be any fuzzy carbon-offset crap. It should be attached in some way to generating capacity.

The magic in making it appealing is in billing. The bright marketing minds at power companies can do this.

**Fortnightly:** Who is going to buy these cars? Most people won't pay more—or at least not much more—for environmental benefits.

**Eberhart:** Let me clarify. People care about oil conservation for two reasons: because of the environment, and just as much because of national security. People realize this oil situation is really screwed up.

That is becoming a new conservative position, by the way. People who care are more than just greenies.

But to address the point, we are mainly selling to people who care enough to spend a lot of money on it. They will create the market for our next car. The White Star won't be cheap, but it will be much cheaper than the Roadster. We will build tens of thousands of them, which is puny compared to the big automakers. But it enables my next car, which will be cheaper and we'll build many more of them. You see?

**Fortnightly:** Are you advocating policy changes?

**Eberhart:** Yes, a whole bunch of them, mainly tactical. For example, today there's an income-tax credit for hybrids, but the electric-vehicle credit expired because of neglect. And it's ridiculous now that you can get a tax credit for buying a Hummer. We'd like to see a level playing field, thank you very much.

**Fortnightly:** What about metering policies? They are changing in many states. What would you like to see regulators and utilities do in terms of metering infrastructure and policies?

**Eberhart:** Advanced metering is an opportunity for power companies to really help the electric-car and solar industries. The ability to shut off the power remotely, so the lineman can install solar panels, would be very helpful. And net metering and time-of-use rates are good for everyone.

Power companies are in a great position to tie everything together—me and other EV people, and plug-in hybrids, and solar and other clean generation sources—all together in a coherent system. Power companies have the opportunity to play a really major role, and become bigger than they are now.

We are very interested in talking and working with power companies to make it happen. We are small, but we are very interested in promoting cooperation. ■

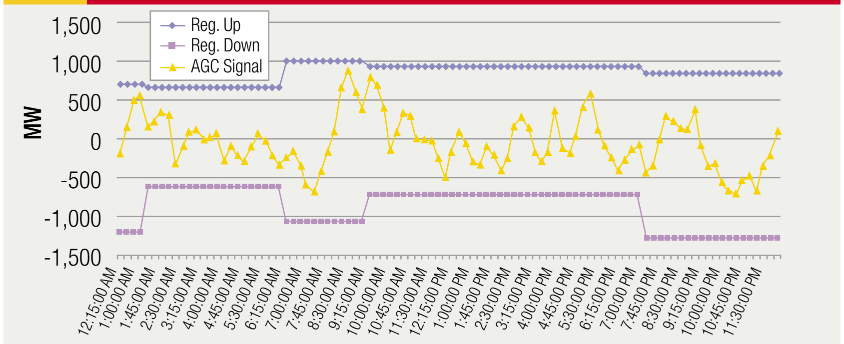
## Electric & Hybrid Cars

*(Cont. from p. 33)*

question has to do with costs. Calculating the cost of providing these services includes both fixed and variable costs. The fixed costs include the additional cost to provide V2G functionality to a PHEV and the communication and control equipment necessary to allow remote dispatching of an aggregated fleet of PHEVs. The additional cost to allow V2G on the vehicle side should be minimal given that PHEVs will have most of the necessary power electronics onboard. The cost of a system to allow communication and control between the grid operator and a fleet of V2G PHEVs is yet unknown, but given the rapid development and reduced costs of these technologies we expect that this—when amortized over a fleet of tens of thousands of vehicles—would be minimal.

The variable costs resulting from PHEVs providing these services is a function of the energy throughput and the associated cost of battery degradation. We are confident that the variable cost of providing spinning reserves would be minimal, as these services rarely are used and when they are dispatched, it typically occurs for just several minutes. Using the experience of PJM given above, spinning reserves were deployed for only 21 hours during the entire year in 2005. Thus, in the case of a PHEV providing 10 kW of spinning reserves, assuming they were dispatched for every event during the year, it translates into total energy throughput of 210 kWh of energy. It is likely that this level of energy throughput would contribute little to overall battery degradation. In contrast, regulation reserves would require short and frequent charging and discharging of the onboard battery pack. Given limited knowledge of how the next generation battery technology likely to find its way into PHEVs would be affected by this type of cycling, we are unable to provide an estimate of potential battery degradation from providing this service.

**Fig. 4** **Regulation Held in Reserve vs. AGC Signals, ERCOT 8/01/2004**




Source: www.ercot.com

## Windfall or Headache?

PHEVs represent an exciting opportunity to create greater energy independence and at the same time reduce harmful emissions. Furthermore, as the electric-supply mix becomes greener, this affords additional environmental benefits as the vehicle fleet becomes increasingly reliant on electricity as a form of energy for transportation.

We believe that PHEVs represent an historic business opportunity for the electric utility industry that is not yet fully appreciated. Rarely in history has an emerging technology offered such an attractive opportunity for the industry, as both a new load and resource, to enhance overall performance of the electric-power infrastructure.

Are there challenges to realizing the vision? Yes. But the time is now for the industry to take a serious look at the PHEV potential. We believe that the evidence is sufficiently compelling that the industry should lend its voice to a growing chorus of stakeholders calling for the major auto manufacturers to deliver a commercial PHEV to the market, begin V2G demonstrations, and develop business models that could serve to efficiently and profitably exploit the emerging V2G potential.

*Steven Letendre is associate professor at Green Mountain College. Contact him at letendres@greenmtn.edu. Paul Denholm is an energy analyst at National Renewable Energy Laboratory. Contact him at Paul_Denholm@nrel.gov. Peter Lilienthal is senior economist at National Renewable Energy Laboratory. Contact him at peter_lilienthal@nrel.gov.*

## Endnotes


1. Romm, J. and A. Frank. (2006) Hybrid vehicles. *Scientific America*. April 2006. pp. 72 – 79. and Sanna L. 2005. Driving the solution: The plug-in hybrid electric vehicle. *The EPRI Journal*, pp. 9 – 17.
2. Letendre, S. and W. Kempton, 2002. "The V2G concept: A new model for power?" *Public Utilities Fortnightly* 140(4): 16-26.
3. Denholm, P. and W. Short. 2006. *An evaluation of utility system impacts and benefits of optimally dispatched plug-in hybrid electric vehicles*, National Renewable Energy Laboratory Technical Report, TP-620-40293.
4. Denholm, P. and W. Short. 2006. *An evaluation of utility system impacts and benefits of optimally dispatched plug-in hybrid electric vehicles*, National Renewable Energy Laboratory Technical Report, TP-620-40293.
5. Markel, T., M. O'Keefe, A. Simpson, J. Gonder, and A. Brooker. 2005. "Plug-in HEV's: a near-term option to reduce petroleum consumption FY05 Milestone Report," National Renewable Energy Laboratory, Golden, Colorado August, 2005. and National Economic Council. 2006. *Advanced energy initiative*, via http://www.whitehouse.gov/stateoftheunion/2006/energy/
6. Kempton, W., Jasna T., Letendre, S., Brooks, A., & Lipman, T. 2001. *Electric drive vehicles-battery, hybrid, and fuel cell-as resources for distributed electric power in California*, University of California Davis, ITS-RR-01-03.
7. Brooks, A. 2002. *Vehicle-to-grid demonstration project: Grid regulation ancillary service with a battery electric vehicle* Report, AC Propulsion, December 2002. Sponsored by CARB.
8. Kempton, W. and S. Letendre. 1997. "Electric Vehicles as a New Source of Power for Electric Utilities" *Transportation Research*-D 2(3): 157-175., Kempton, W., Jasna T., Letendre, S., Brooks, A., & Lipman, T. 2001. *Electric drive vehicles-battery, hybrid, and fuel cell-as resources for distributed electric power in California*, University of California Davis, ITS-RR-01-03. and Kempton, W. and Tomic J. 2005. Vehicle to grid power fundamentals calculating capacity and net revenue. *The Journal of Power Sources*. Vol.
9. Kempton, W., Jasna T., Letendre, S., Brooks, A., & Lipman, T. 2001. *Electric drive vehicles-battery, hybrid, and fuel cell-as resources for distributed electric power in California*, University of California Davis, ITS-RR-01-03.
10. Kirby, B. 2004. *Frequency regulation basics and trends*. Oak Ridge National Laboratory, December.
11. Kempton, W. and Tomic J. 2005. Vehicle to grid power fundamentals calculating capacity and net revenue. *The Journal of Power Sources*. Vol.
12. Kempton, W. and Tomic J. 2005. Vehicle to grid power fundamentals calculating capacity and net revenue. *The Journal of Power Sources*. Vol.
13. Kempton, W. and Tomic J. 2005. Vehicle to grid power fundamentals calculating capacity and net revenue. *The Journal of Power Sources*. Vol.

**UM 1461 CERTIFICATE OF SERVICE**

I hereby certify that I served the foregoing **Reply Comments of the NW Energy Coalition in docket UM 1461** on the following persons on August 27, 2010 by hand-delivering, e-mailing, or mailing to each a copy thereof, and if mailed, contained in a sealed envelope, with postage paid, addressed to said attorneys at the last known address of each shown below and deposited in the post office on said day at Salem, Oregon.

DATED this 27th day of August, 2010.

By: /s/ Steven Weiss
steve@nwenergy.org
NW Energy Coalition
steve@nwenergy.org
503-851-4054

DEPARTMENT OF JUSTICE
JANET L PREWITT ASSISTANT AG
NATURAL RESOURCES SECTION
1162 COURT ST NE
SALEM OR 97301-4096
janet.prewitt@doj.state.or.us

OREGON DEPARTMENT OF ENERGY
VIJAY A SATYAL
SENIOR POLICY ANALYST
625 MARION ST NE
SALEM OR 97301
vijay.a.satyal@state.or.us

CITIZENS' UTILITY BOARD OF OREGON
GORDON FEIGHNER
ENERGY ANALYST
610 SW BROADWAY, SUITE 308
PORTLAND OR 97205
gordon@oregoncub.org

ROBERT JENKS
EXECUTIVE DIRECTOR
610 SW BROADWAY STE 308
PORTLAND OR 97205
bob@oregoncub.org
G. CATRIONA MCCRACKEN
LEGAL COUNSEL/STAFF ATTY
610 SW BROADWAY - STE 308
PORTLAND OR 97205
catriona@oregoncub.org

RAYMOND MYERS
ATTORNEY
610 SW BROADWAY - STE 308
PORTLAND OR 97205
ray@oregoncub.org

KEVIN ELLIOTT PARKS
STAFF ATTORNEY
610 SW BROADWAY STE 308
PORTLAND OR 97205
kevin@oregoncub.org

DEPARTMENT OF JUSTICE
MICHAEL T WEIRICH
ASSISTANT ATTORNEY
GENERALREGULATED UTILITY & BUSINESS SECTION
1162 COURT ST NE
SALEM OR 97301-4096
michael.weirich@doj.state.or.us

ECOTALITY, INC.
ALANA CHAVEZ-LANGDON

80 E RIO SALADO PKY, SUITE 710
TEMPE AZ 85281
achavez@ecotality.com

ETEC
DAVE MAYFIELD
308 SW FIRST AVE. SUITE 181
PORTLAND OR 97204
dmayfield@etecevs.com

NW Energy Coalition
Steven Weiss
4422 Oregon Trail Ct. NE
Salem, OR 97305
steve@nwenergy.org

OREGON DEPARTMENT OF ENERGY
WALLACE RICK
625 MARION STREET NE
SALEM OR 97301-3737
rick.wallace@state.or.us

ANDREA F SIMMONS
625 MARION ST NE
SALEM OR 97301-3737
andrea.f.simmons@state.or.us

OREGON PUBLIC UTILITY
COMMISSION
ED DURRENBERGER
PO BOX 2148
SALEM OR 97308-2148
ed.durrenberger@state.or.us

**PACIFICORP**
RYAN FLYNN
LEGAL COUNSEL
825 NE MULTNOMAH, SUITE 1800
PORTLAND OR 97232
ryan.flynn@pacificorp.com

**PACIFICORP, DBA PACIFIC POWER**
OREGON DOCKETS
825 NE MULTNOMAH ST, STE 2000
PORTLAND OR 97232
oregondockets@pacificorp.com

**PGE RATES & REGULATORY AFFAIRS**
PORTLAND GENERAL ELECTRIC
121 SW SALMON STREET, 1WTC0702
PORTLAND OR 97204
pge.opuc.filings@pgn.com

**PORTLAND GENERAL ELECTRIC**
RICK DURST
121 SW SALMON ST - 1WTC1711
PORTLAND OR 97204
rick.durst@pgn.com

DOUG KUNS
121 SW SALMON ST
1WTCO702
PORTLAND OR 97204
doug.kuns@pgn.com

**PORTLAND GENERAL ELECTRIC COMPANY**
J RICHARD GEORGE121 SW SALMON
ST 1WTC1301
PORTLAND OR 97204
richard.george@pgn.com