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Industry

V2G Primer for Utilities

By Guest Editorial

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The Vehicle to Grid (V2G) concept uses vehicles as electrical storage, buying and selling power from the grid. Proposed by Amory Lovins in 1995 and further developed by William Kempton at the University of Delaware, the concept has recently gained momentum. Driven by the popularity of plug-in hybrid electric vehicles (PHEVs) and advances in battery technology, V2G has caught the interest of several utilities and several startup companies.

The addition of PHEVs and battery-electric vehicles (BEVs) as a daily load could potentially place an increased burden on the grid, requiring more investment in both generation and infrastructure. A better approach, argue V2G proponents, is to use off-peak, baseload generation to charge their batteries. This would increase the asset utilization of the utilities providing the power. It would allow vehicle owners to sell power back to the grid during peak hours, at least partially offsetting the higher cost of electric vehicles.

V2G theoretical capacity

According to a 2005 article by Professor William Kempton, the current generation capacity of U.S. utilities stands at roughly 602 GW, with another 209 GW available from non-utility generators. The current light duty vehicle (LDV) fleet stands at about 176M vehicles. If one-fourth of that fleet (44M vehicles), were converted to electric vehicles with 15 kW rated output, it would provide a total capacity of 660 GW. The utilization of this capacity, however, would be limited by battery capacities, typically 8 to 15 kWh for today's PHEVs. Because of the wear and strain caused by deep-cycle battery discharge for batteries and the lower efficiencies, V2G is not likely to replace base loading generation. However, V2G could provide regulation services, replace spinning reserves, or replace peak generation units.

V2G drivers

The benefits of widespread adoption of the V2G concept could, in theory at least, accrue to utilities, utility customers and vehicle owners alike. Immediate benefits include:

- Increasing asset utilization by using expensive baseload plants to fuller capacity through the overnight charging of electric vehicles
- Replacing spinning reserves and regulation services with fast responding, distributed energy storage
- Offsetting the cost of electric vehicles through electricity sales at peak hours
- Increasing the reliability of electric service

Long-term benefits of a wider adoption of V2G include:

- Decreasing price volatility
- Reducing the need for capital investment in new generation and infrastructure
- Enabling higher percentages of renewable energy by creating an energy storage buffer
- Making the electricity market more like other commodity markets through the temporal substitution of electricity through energy storage
- Reducing greenhouse gas emissions through the use of electric vehicles

V2G blockers

There are few, if any, fundamental technical blockers to V2G, as it is built on existing technology. In fact, V2G can build on the R&D of other industries. One example is the improvements in battery performance due to the portable electronics industry. Another is the advances in power inversion/conversion due to the growth in wind and solar power. Yet another is the improvements in grid metering and monitoring due to the Smart Grid revolution.

Even so, V2G needs to have its own purpose-built demonstrations if it is to be adopted by the electric power

industry. Potential challenges that could be resolved by utility-guided R&D include:

- Communications standards and networks
- Connection standards (Where does the intelligence reside: in the vehicle, at the utility, or at a third-party aggregator? How do they talk to each other?)
- Integration of control methods
- Appropriate payment and subsidy schemes (How are customers rewarded or compensated for the use of their batteries?)
- Necessary infrastructure investments and cost sharing schemes (Who puts in the new two-way, smart metered plugs for all the homes, the apartment buildings, and the parking garages?)

Where to learn more

Those who want to know more about V2G can review the articles and papers below. Where available, we have included a link to downloadable papers.

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[Email Alex Zheng](#)

[V2G: Threat or Opportunity article in SGN](#)

[Plug-In Austin. Building a Market for Gas-Optional Hybrids](#)

[Pacific Gas and Electric Company Energizes Silicon Valley With Vehicle-to-Grid Technology](#)

[SoCal Edison Joins Plug-In Hybrid Development Consortium](#)

[University of Delaware's V2G page with additional links](#)

[Plug-in Hybrid Development Consortium](#)

[Electric Vehicles as New Power Source for Electric Utilities \(PDF\)](#)

W. Kempton and S. Letendre, *Transportation Research*. 1997.

The original formulation of the V2G concept. Overview of key concepts and ideas in V2G.

[Integration of Electric Drive Vehicles with the Electric Power Grid – A New Value Stream \(PDF\)](#)

A. Brooks and T. Gage. *AC Propulsion*. 2001.

Overview of the value added from the introduction of plug-in hybrid vehicles to the California grid as part of a V2G deployment.

[Vehicle-to-Grid Demonstration Project: Grid Regulation Ancillary Service with a Battery Electric Vehicle \(PDF\)](#)

A. Brooks, Final Report. *AC Propulsion*. December 2002.

Discusses results from the test of an electric vehicle with a bi-directional power interface, and general issues surrounding V2G.

[Vehicle to Grid Fundamentals: Calculating Capacity and Net Revenue \(PDF\)](#)

W. Kempton and J. Tomic, *Journal of Power Sources*. June 2005.

Presents general economic models for evaluating the value of electric vehicles used in a V2G deployment. Evaluates the economic perspectives of various participants and suggests business models to reconcile these perspectives.

[Vehicle to Grid Implementation: From Stabilizing the Grid to Supporting Large-Scale Renewable Energy \(PDF\)](#)

W. Kempton and J. Tomic, *Journal of Power Sources*. June 2005.

Technical analysis of the impacts of a widespread deployment of V2G in the context of the current grid.

[Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional US Power Grids \(PDF\)](#)

M. Kintner-Meyer, K. Schneider, and R. Pratt. Pacific Northwest National Laboratory. 2006.

A technical and economic study of the impacts of increasing the use of plug-in hybrids in terms of consumers and utilities. Case studies analyzed are Cincinnati Gas and Electric and San Diego Gas and Electric.

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