MAGICC
Mid-Atlantic Grid Interactive Cars Consortium

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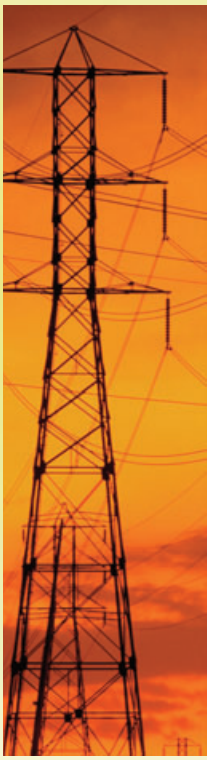
"Vehicle-to-Grid" (V2G) technology uses electric vehicle batteries to store and return energy to the electric grid based on a real-time signal that communicates the grid's reliability conditions to the vehicle. Widespread adoption of V2G enabled electric vehicles will help reduce carbon emissions by decreasing petroleum consumption and enabling broader integration and more efficient use of intermittent renewable energies, such as wind and solar power. Additionally, revenue from V2G can partially offset the higher upfront cost of electric vehicles.

What is V2G? Electric vehicles, whether powered by batteries, fuel cells, or gasoline generators, have within them the energy source and power electronics capable of producing the 50 or 60 hertz (Hz) alternating current (AC) electricity that powers our homes and offices. When connections are added to allow this electricity flow to and from cars to power lines, we call it "Vehicle-to-Grid" or V2G. Cars pack a lot of power. A plug-in hybrid electric vehicle (PHEV) designed for overnight charging on any circuit might draw 1.5 kilowatts (kW), the average load of one U.S. house. A vehicle powered only by energy stored in batteries, typically called a battery electric vehicle (BEV), can draw or return up to 19 kW – the average power needs of 13 U.S. houses. The key to realizing economic value from V2G is to have sufficient vehicles connected and aggregated to satisfy the power requests of the grid, communicated to vehicles via a real-time signal, while at the same time not compromising the functionality and availability of the individual vehicle to its owner.

Significance: As V2G enters the marketplace, it will facilitate a new industry that connects the automotive fleet with the electric power system. V2G-capable cars with wide-scale access to the grid will improve the economics of purchasing an electric vehicle by offering grid-service revenue streams to the vehicle's owner. As this market grows, grid-responsive storage will help balance and facilitate more efficient use of fluctuating renewable energy outputs, such as wind and solar power. A transition of passenger vehicles to V2G electric vehicles would reduce petroleum use in the transportation sector, enhance the feasibility of adding a higher percentage of renewables in the electric grid, and provide the grid operator with a fast-responding resource to use for grid balancing and other energy services.



Research and Development: The MAGIC Consortium (MAGICC) was created in 2007 to further develop, test, and demonstrate Vehicle-to-Grid (V2G) technology. MAGICC includes partners from academia and the electric, automotive, and communications industries, as well as observers from many different disciplines. Our goal is to explicitly demonstrate the economic viability of V2G and bring its many benefits to market in a timely fashion.

For more information about MAGICC and Vehicle-to-Grid technology, please visit:

www.magicconsortium.org.

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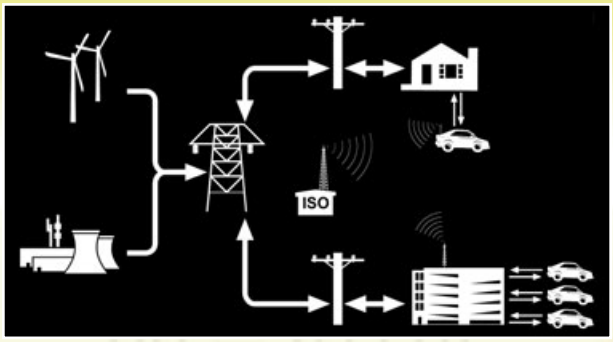
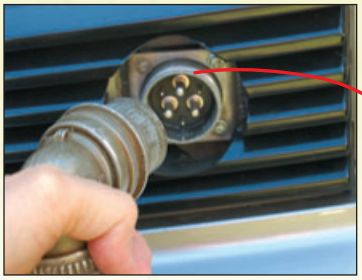
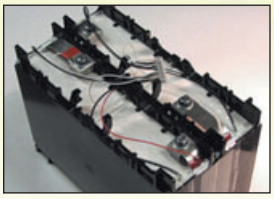


Kempton and Tomic 2005, *Journal of Power Sources*

Vehicle-to-Grid Infrastructure and Communications System

The average U.S. car is driven about one hour a day. The opportunity is emerging today for the electric power system to make good use of that vehicle for the other 23 stationary hours. Using Internet, or other broadcast protocols, grid operators and regional transmission organizations (RTO, ISO in the graphic above) can "talk" to plugged-in cars (top-right) and vehicle aggregators (bottom-right) buying electricity for grid stabilization and selling it back to them when these services have been met or when vehicles need to charge.





Results of a V2G system

Reliability and efficiency of existing electric grid.

Currently, there is minimal energy storage on the electric grid. This means that electricity production (generation) must always equal electricity demand (load) at any point in time. When generation and load are out of sync, the grid needs an additional resource to restore balance. Today, these resources are typical fossil fuel generators, hydroelectric plants, or turning off electric loads (demand response). These balancing resources need to be available 24 - hours a day and able to respond quickly to the grid's dynamic reliability conditions. Aggregated batteries in V2G - connected electric vehicles meet both of these requirements and can thus be a valuable supplemental resource to the grid operator.

Electric Storage

V2G creates a network of tightly integrated, yet distributed energy storage elements that are centrally and automatically controlled by signals that balance supply and demand within the electric grid. Having this "aggregated energy storage buffer" throughout the grid system could encourage broader deployment of clean, but intermittent, sources of renewable energy. Intermittent renewable energy sources, such as wind power, are often only able to participate in the energy market when the wind is blowing. V2G technology provides a means of storing that energy and discharging it when the market demands.

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