DOE PHEV R&D Plan, External Draft, March 2007

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* Disclaimer: These comments do not reflect nor are they intended to represent the views of the Federal Energy Regulatory Commission or the University of Delaware. They are solely the views of the authors.

The following comments are provided to DOE on its PHEV R&D Plan, External Draft, March 2007. They have been submitted in outline form for efficiency and conciseness. The authors would welcome the opportunity to provide additional input or clarification to DOE at your convenience.

Our purpose in submitting these comments to DOE is to bring to the attention of both DOE PHEV program managers and senior DOE staff our strong belief that the expressed direction of the DOE PHEV R&D effort as portrayed in the External Draft ignores an opportunity to realize significant benefits that are readily attainable. It is our opinion that the potential benefits of vehicle-to-grid (V2G) PHEVs (or the "CashBack" hybrid) are so compelling that the technology is clearly an enabler of both the "smart grid" and the successful market penetration of the PHEV itself. As such, DOE should incorporate the CashBack hybrid into the PHEV R&D Plan.

Key Comment Points:

1. Both the PHEV R&D Plan, February 2007, and the DOE PHEV Discussion Meeting, May 4-5, 2006, state that "…cost is the primary impediment to producing PHEVs…"
2. No analysis has been conducted by DOE to consider the ability to offset increased costs from batteries and other electronic components

of PHEVs through the payments that could be realized by use of V2G technology. Indeed, cost is not a primary impediment in the short term if payments are considered. (See attached study by Dr. Steven Letendre of Green Mountain College, and Paul Denholm and Peter Lilienthal of NREL, Public Utilities Fortnightly (PUF), December 2006, at 28)

3. The PUF article indicated that the payments to individual PHEV owners using V2G technology could be as much as $2,000 to $4,000 per year per vehicle for just spinning reserve or regulation services. This is consistent with the earlier Kempton and Tomic article ("Vehicle to Grid Fundamentals", J. Power Sources Volume 144, Issue 1, 1 June 2005), which calculates revenue up to $6,000/year/vehicle. This is a sufficient payment to the prospective CashBack hybrid purchaser to completely offset the higher incremental cost of the vehicle in less than 5 years. While these numbers assume a high-power plug and do not include costs that could reduce them by approximately half, there is still a large net payback.
4. Such offsetting payments have the potential to accelerate the marketability of PHEVs by 5 years or more by effectively bringing down first costs. Such payments could be incorporated into the vehicle financing, effectively eliminating all incremental first costs to the consumer and making the CashBack hybrid financed cost equivalent to a conventional gas-powered vehicle.
5. The DOE PHEV R&D Plan explicitly chooses to ignore the CashBack hybrid and dismisses V2G technology as "…not considered an enabler for vehicle technology in the short term." (DOE PHEV R&D Plan, February 2007, p. 32 of 36) DOE provides no support for this position. By ignoring the demonstrated economics of CashBack hybrid and V2G technology, DOE comes to an incorrect conclusion in its earlier statement that "cost is the primary impediment…"
6. Substantial work on analysis of technology, CashBack economics, and development of V2G hardware have been done by:
    a. University of Delaware – development of fundamental equations for power capacity and economics, customer interface, appropriate markets, cost factors (wear, losses, etc.)
    b. AC Propulsion – develop, produce, and market full drive system with V2G capability, test a running vehicle on ISO regulation signal, drive system production and limited vehicle production

c. Delmarva Power and Light (a PHI company) – develop business model for aggregator, interactions with PJM
d. PJM – outline signal flow and offer devices for small unit test and ramp-up to MW power aggregation (regulation services market via AGC signal)
e. NREL – validation of Delaware equations and results; impact of V2G on electrical system, including reserve margin; model increased wind penetration with V2G
f. Green Mountain College – work with Delaware and NREL, per above

Additional institutions have reviewed, supplemented, or internally analyzed V2G, and have some in-house capabilities:

g. BART
h. UC Berkeley, Coalition for a New California Infrastructure
i. UC Davis
j. Southern California Edison
k. Pacific Gas & Electric
l. EPRI
m. Tesla Motors
n. IIASA (Laxenburg, Austria)

7. This work includes development of the electronics necessary for V2G communications and the development of protocols necessary to allow grid operators to schedule ancillary services from grid-enabled vehicles.
8. FERC has adopted regulations (Order No. 890) requiring organized wholesale markets (RTOs/ISOs) and other transmission operators to establish tariffs that would allow demand side resources (such as CashBack hybrids) to participate in ancillary services markets and be paid by the grid operators for the provision of those services. FERC has also provided in rules issued on grid reliability that demand response must be incorporated into reliability calculations.
9. A cursory review of the potential of CashBack hybrid technology indicates that not only will individual consumers benefit from reduced energy costs (electricity to run cars is cheaper than gasoline) CO2 emissions and foreign oil imports will be substantially reduced as will urban pollution. In addition, the benefits to the electric grid could also be substantial (perhaps in the 10s of billions of dollars per year) from the following:

- Efficient Grid Management
  - +Ancillary Services (Spinning Reserve & Regulation)
  - +Dispatchable Reactive Power
  - +Peak Demand Services (Demand Response)
  - +Reduced Operating and Planning Reserves
  - +Distribution/Substation Level Support
  - +Reduced Line Losses
  - +Improved Power Plant Efficiency
  - +Improved Load Factor
- •Storage & Integration of Renewables- Wind & PV
- •Electric Transit Power Support
- •Emergency Power Supply (building level)

10. DOE has neither undertaken to quantify these benefits nor attempted to investigate the cost/benefit equation of rapidly accelerating a CashBack hybrid program. Because the benefits both from a transportation perspective and an electric grid efficiency improvement perspective are potentially so enormous from rapid market penetration of grid-enabled PHEVs, and the main market impediment of first cost can be overcome with a CashBack solution, we believe it is only prudent for DOE to revise its PHEV R&D Plan to fully incorporate the CashBack hybrid concept on a parallel path with other PHEV R&D.
11. DOE has not analyzed the critical steps and actors needed to overcome current barriers to implementation of V2G technology. The attached sample proposal summarizes the state of that industry and existing barriers. This proposal is included as an example of the type of background analysis and approach that might create solutions to overcome such barriers.

For most articles and reports referenced above, see www.udel.edu/V2G.

Proposal for V2G power plant demonstration
By Dr. Willett Kempton
Rev 1, March 26, 2007

This document describes the current state of V2G and electric vehicle technology, the problems blocking commercial development of the technology, and a proposed project to demonstrate at utility scale and deliver technology transfer packages to relevant industries.

Completed development to date:

• Drive system for 100 kW drive and 20 kW V2G demonstrated, fully tested on multiple vehicles, and moving into limited production--100/year production already ramping up. (AC Propulsion).

• Individual vehicle tested, running V2G off pre-recorded ISO signal. Primitive driver interface software. (AC Propulsion with CalISO and SCAQMD.)

• Several vehicles with 150-mile range and 20 kW V2G power electronics (no communications nor connected to ISO), produced and delivered to customers (AC Propulsion)

• Algorithms for provision of regulation services written and published, vetted by several groups and National Labs (U of Delaware).

• DE state funding approved for single test vehicle with real-time link to PJM, using existing PJM wireless controls. (U of Delaware, with Delmarva Power, AC Propulsion, PJM, and other partners).

In progress:

• Testing of 1 to 5 vehicles with real-time signals from PJM, continuous refinement of software—V2G algorithms, driver interface and aggregator interface.

Mismatch of timing and industries:

• *Chicken and egg problem* -- Need to develop the utility and ISO rate, revenue, and business models, prior to V2G becoming attractive enough to OEMs to invest in production vehicles.

• *Minimum size problem* -- Need for 3 MW contract in order for ISOs to be able to realistically test V2G as a generation/ancillary service resource. Minimum dispatch and minimum contract is 3 MW in PJM system. (Minimum of 1 MW or smaller for some purposes, e.g. "demand response", but these are not yet serious assets from an ISO/TSO perspective.).

• *Wrong designer problem* -- The drive system and power grid interface have to be designed by a design team most responsive to the electric power markets and interfaces.
This will have to be a delivered, full specification made available to the automotive industry. So paradoxically, the auto industry cannot design the initial batch of cars (or at least not their drive systems).

Proposed demonstration:

• Set up fabrication in a public-private partnership with a reassembler or electric drive train designer/manufacturer. Design specifications must meet electrical needs.

• Set up software team for public domain, open-specification version of software.

• Set up aggregator business for V2G dispatch and power aggregation. One model: a local distribution company (electric utility).

• Build 300 – 400 vehicles with V2G at 20 kW, over a 2-3 year build period. Estimated cost per vehicle $65,000. Sale price of vehicle approx $5,000 - $10,000 over market for comparable gasoline vehicle, with anticipated share of V2G revenue.

• Vehicles operated by fleets (approx 300 vehicles) and individuals (remainder). Operators purchase vehicles. Probably all operated within a single control area, at a minimum within a single ISO.

• Extensive testing from perspectives of driver/operator, fleet manager, repair history, battery stress at different levels of V2G, aggregator experiences, and value of power to ISO.

• Deliver technology transfer packages, targeted for: OEM design specifications, ISOs, aggregators, automobile marketing.

Duration: 5 years
Budget: $25 M, with $12 M first year