NEW YORK INDEPENDENT SYSTEM OPERATOR

Alternate Route: Electrifying the Transportation Sector

Potential Impacts of Plug-In Hybrid Electric Vehicles on New York State's Electricity System

June 2009

Contents

The purpose of this report is to review the potential impact of Plug-in Hybrid Electric Vehicle (PHEV) technology on grid operations and electricity system planning in New York State.

Figures

Tables

I. Executive Summary

Using electricity as a source of energy for the transportation sector is not new. Many electric generation and distribution systems were initially built to support electric railroads and trolley systems. Highway transportation, however, has been essentially the exclusive domain of the internal combustion engine and its petroleum fuels. In recent years, however, electricity has begun to play a role in automotive propulsion systems, as Hybrid Electric Vehicles (HEVs) have gained appeal among American drivers.

Plug-in Electric Hybrid Vehicles (PHEVs) represent a new stage in the evolution of hybrid electric vehicles in which the electric “plug” for charging batteries has the potential to supplement the “pump.” Several automobile manufacturers have announced plans to introduce PHEVs. President Barack Obama has called for new programs to support PHEV development and deployment. In New York State, Governor David Paterson has announced the creation of the New York Battery and Energy Storage Technology Consortium (NY BEST). The Consortium, one of the first of its kind in the nation, will focus on the development and manufacturing of advanced and affordable battery technologies for the purpose of advancing the PHEV industry here in New York. General Electric also announced a new initiative for the development of advanced batteries, with manufacturing facilities expected to be built in New York State.

The timing and magnitude of potential electric load from PHEVs will be determined by several key factors. These include consumer acceptance of PHEVs, the advancement of battery storage technologies, and the availability/location of PHEV-charging infrastructure. Two studies, one by Oak Ridge National Laboratory (ORNL) and another conducted jointly by the Electric Power Research Institute (EPRI) and the Natural Resources Defense Council (NRDC) concluded that incremental load for PHEVs in New York would be in the range of 7,000-8,000 gigawatt-hours per year (GWH/yr)by 2030. .

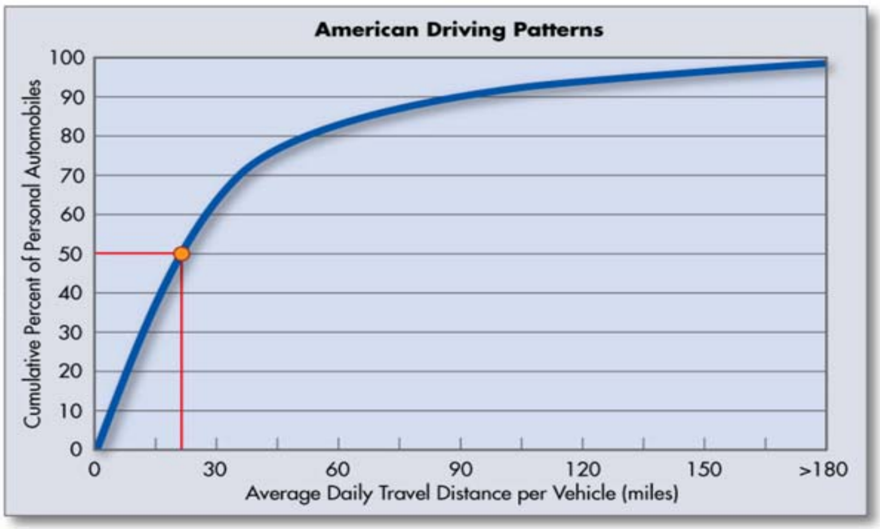
PHEV load can also migrate and occur intermittently, as PHEV-charging opportunities (as an electric load) expand beyond the owner’s home and depend on travel schedules. If charging patterns are managed properly, PHEVs with loads in the range predicted by these studies could be served by the existing New York bulk power system. The migratory nature of this load, however, does require further analysis to fully assess the impact of PHEV load on local electric distribution systems.

If the charging pattern of PHEVs is not managed effectively, loads of this size could require significant additional generation capacity. Rate design to encourage off-peak charging, coupled with time-of-use rates, and Smart Grid/Advanced Metering Initiatives, would facilitate favorable charging behavior. Advanced communication protocols between the recharging location and an evolving Smart Grid could also facilitate effective management of charging patterns.

II. PHEV Characteristics

The Electric Policy Research Institute (EPRI) reports that 50% of American automobiles travel less than 26 miles/day. Thus, PHEVs that could operate 26 miles on battery power alone would have the potential to meet half of America's daily automotive transportation needs.

Figure 1. Average American Daily Vehicle Travel



EPRI

The number of miles a PHEV can travel on electricity varies by vehicle class and size of the battery. The Pacific Northwest National Laboratory (PNNL) has estimated the electric mileage and battery capacity needed to support the operation of a PHEV33 (a vehicle capable of running 33 miles on a single charge), set forth in Table 1 below.

Table 1. Electricity Consumption and Required Battery Capacity for a PHEV33

Vehicle Class	Specific Energy Requirements [kWh/mile]	Size of Battery for PHEV33 [kWh]
Compact sedan	0.26	8.6
Mid-size sedan	0.30	9.9
Mid-size SUV	0.38	12.5
Full-size SUV	0.46	15.2

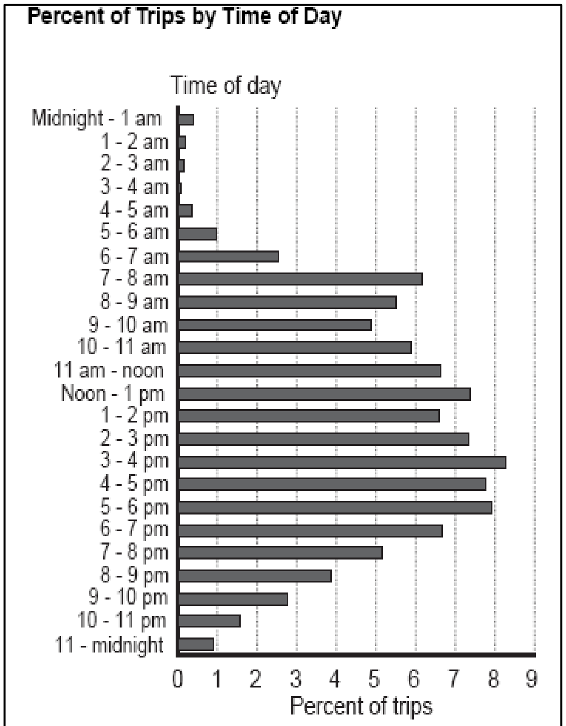
PNNL Kinter-Meyer

Recharge time depends upon the State of Charge (SOC) of the battery and the capacity of the source into which it is plugged. The ORNL study assumed two charging scenarios, one using a 120 VAC circuit supplied through a 15 amp circuit breaker charging at a peak rate of 1.4kw, and a second scenario using 240 VAC with a 30 amp circuit charging at a peak rate of 6kw. A PHEV30 needing a 50% SOC recharge would require 3-4 hours conditioning and recharge time on a 240 VAC circuit and 12 hours on a 120 VAC circuit.

Recharge locations can vary. Suburban single-family homes with a 15-20 amp breaker at either 120 or 240 VAC can adequately supply PHEV-charging needs. Low-rise multiple family residences and more concentrated housing arrangements will require other solutions, which might include parking facilities, office complexes, shopping malls, airports, and commuter rail stations with recharging services.

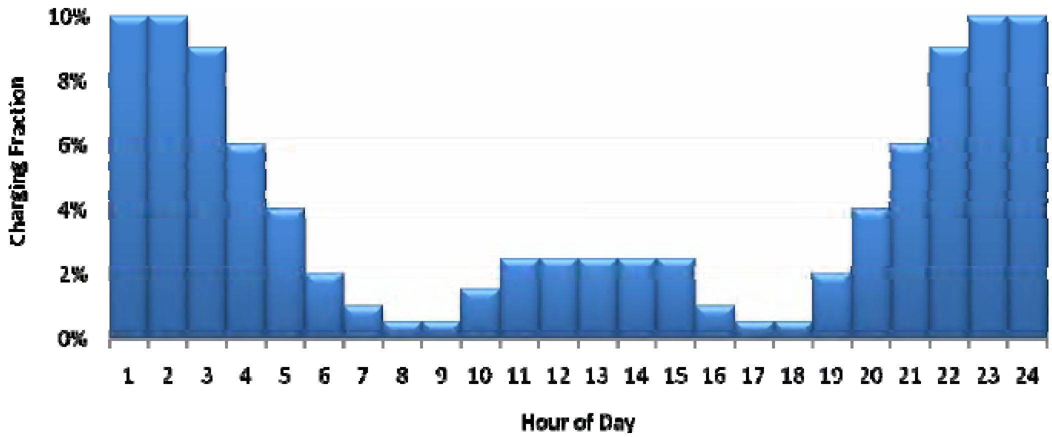
PHEVs recharge when they are not on the road. The typical on-road travel time profile (as show by Figure 2) indicates that charging would likely occur in late evening or early morning. The rest of the answer depends upon the controllability of the charging load as well as possible regulatory approaches to pricing this load. The EPRI/NRDC study was based upon the charging profile in Figure 3 (page 7). The study assumes that 70% of the charging would occur "off-peak," when electric demand is relatively low. Rate designs, such as night rates, and time-of-use rates, could provide electric customers with incentives to utilize "off-peak" charging.

Figure 2. U.S. Daily Driving Patterns



SOURCE: The 2001 National Household Travel Survey, daily trip file, U.S. Department of Transportation.

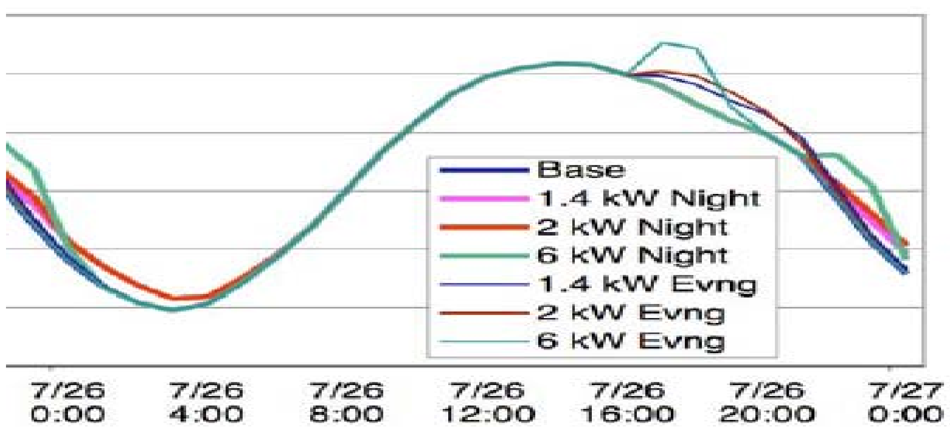
Figure 3. PHEV Daily Charging Availability Profile



EPRI/NRDC

However, if the electricity rate structure does not provide incentives for PHEV owners to charge during off-peak hours, charging would be expected to start when the vehicle returned home. The ORNL study examined this scenario based on the assumption that cars return home between 4pm and 6 pm, and found that it resulted in charging patterns (as illustrated in Figure 4) that could compete for power supply with other electric load. If this charging pattern were to develop, some electrical systems would soon require additional investment to meet this new load. The scenario assumes 25% of the fleet is PHEV by 2030.

Figure 4. Possible PHEV Charging Profiles



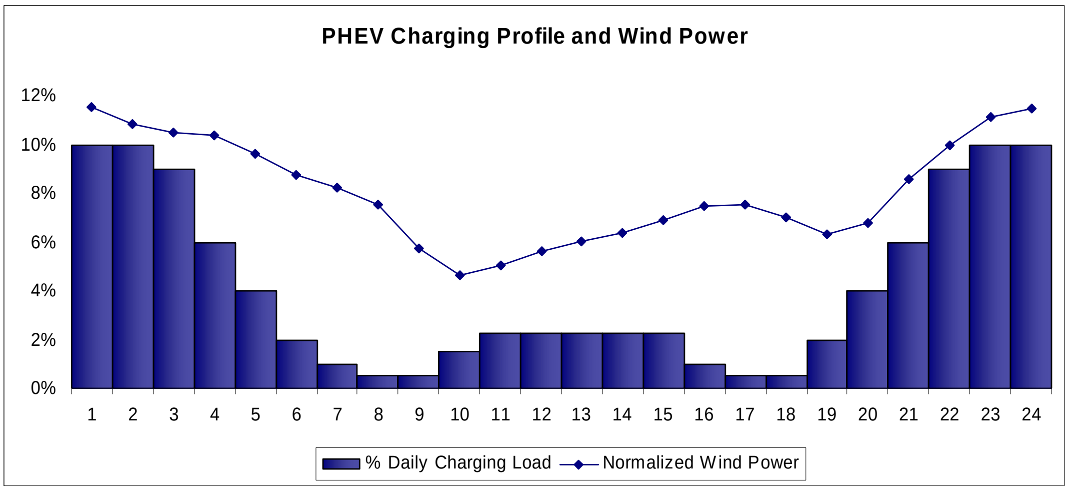
ORNL Hadley

The fact that PHEVs store electrical energy, with the capability to convert gasoline to electricity, and that they will connect to the grid at some point during the day, lead some to suggest that PHEVs may become a resource for either behind-the-meter electric load reduction or for supplying power or ancillary electric services directly to the grid.

Given the current state of PHEV development, it is premature to accurately predict the ability of PHEVs to provide these services. It is worth noting, however, that today's grid and local distribution systems are not designed with this level of distributed generation in mind. The introduction of significant numbers of PHEVs and implementation of Smart Grid/Advanced Metering Initiatives may provide more information with which to understand this issue.

The NYISO has found that, in general, the production profile of wind resources in New York correlates very well with off-peak charging of PHEVs, creating the potential for a synergy between wind generation and transportation energy needs.

Figure 5. PHEV Charging Profile and Wind Power



Charging profile: EPRI/NRDC
Wind power: 2007 average normalized wind load

The environmental impact of switching light duty vehicles to PHEVs has been examined in the studies performed by ORNL, EPRI/NRDC, and a study by the Pacific Northwest National Laboratory (PNNL). All three studies estimated significant net emission reductions in the Northeast if PHEV charging is effectively managed.

III. PHEV Impact on the Grid

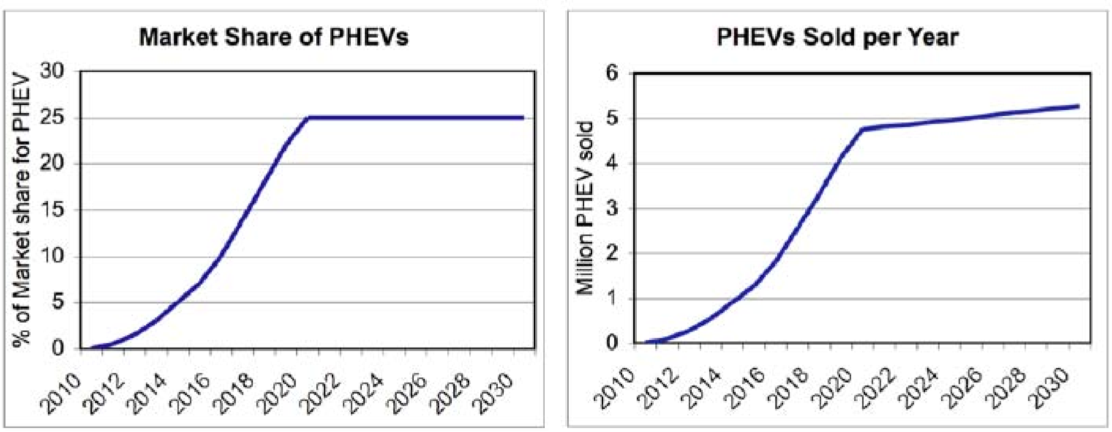
The electric power system is the ultimate "just-in-time" inventory system. Electricity is instantaneously consumed as it is produced. In contrast to the oil and natural gas industries where storage is an intrinsic element of the industry infrastructure, large-scale storage of electricity is extremely limited (with the exception of hydroelectric pumped storage facilities, for which there is a narrow range of possible sites). While energy storage technology is continuing to advance, the lack of storage capability for electricity has necessitated the construction of electric generation capacity to meet peak demand that can be 50% greater than the demand in the off-peak hours of the day. Consequently, during off-peak hours, there is a significant amount of excess generation capacity compared to demand.

The impact of PHEVs on the electric system and electricity markets, such as those administered by the NYISO, require estimates of market penetration, estimates of the amount of load PHEVs will utilize and an understanding of the manner in which these vehicles would be charged. The impact on the electric system will vary considerably depending upon the scope of PHEV penetration of the automobile market and the charging pattern of PHEV owners.

If PHEV technology achieves market penetration in the range of 50,000 to 100,000 vehicles, it will represent several hundred megawatts of electric demand. Knowing when and where this load will show up on the grid will be essential to grid operations and system reliability.

Market penetration estimates from the ORNL study predict annual nationwide sale of 1.5 million PHEVs by 2016 and 50 million PHEVs on the American roadway by 2030, of which 2.5 million PHEVs would be in New York. The EPRI/NRDC and ORNL studies forecast that 25% of all automobile sales in the nation will be PHEVs in 2020.

Figure 6. ORNL Forecast of PHEV Market Share



ORNL Hadley

The EPRI/NRDC study forecasts a 2030 PHEV electric load increase of 8,000 GWHs/year in New York. The ORNL study forecasts an increase in New York's electric load of 2% compared to a base case with no PHEV load, or 7,000 GWH/ year of new electric load due to PHEVs. Both forecasts represent relatively small increases over the no-PHEV base case.

Whether any increases in new electric generation capacity will be necessary is less certain. Any increase will be dependent upon when charging takes place (on-peak vs. off-peak), charging rate and the voltage at the vehicle connection point. The ORNL study (which assumed no incentives for off-peak charging) found that the incremental demand compared to the existing load profile will vary between 3400 and 9500 MW in New York. The EPRI/NRDC study assumed that 74% of the charging would take place off-peak and, as a result, estimated a much lower net increase in peak demand, 900 MW in New York.

If the PHEV load occurs during off-peak hours or is controllable through various Smart Grid approaches such that charging times do not increase peak demand, the bulk power facilities should be able to manage the charging load. The PNNL study, which assumed intermittent charging whenever the vehicle was not operating, concluded:

> The existing electricity infrastructure as a national resource has sufficient available capacity to fuel up to 84% of the nation's cars, pickups, and SUVs (198 million) or about 73% of the light duty fleet (217 million vehicles) for a daily drive of 33 miles on average.

The ORNL study examined the impact of PHEVs on the New York electric system and concluded:

> In 2020, the night recharging patterns do not significantly change the peaks, and even the evening charging scenarios do not approach the local generation capacity. Even in the 2030 scenarios, summer peaks remain below the region's capacity . . . .

The increases in electric load predicted in the ORNL and EPRI/NRDC studies are well within the range of variability usually provided for in the NYISO planning process. It is likely that incremental bulk power system resource requirements driven by PHEV-charging load, if any, will be needed beyond the current 10-year planning horizon of 2009-2018 of the NYISO's planning process. If, and when, the PHEVs achieve significant market penetration, the NYISO will examine the effects of incremental load in its planning process and identify any reliability needs and solutions at that time.

The impact of PHEVs on New York's electric distribution systems, however, has not yet been examined in detail. Consolidated Edison Company of New York, Inc. has begun preliminary evaluations and other utilities can be expected to incorporate PHEV load considerations as such PHEV market penetration increases. Understanding the potential impacts on local distribution systems will be necessary to support any significant PHEV deployment. With the given range of charging demands for PHEVs of 1-6 kW, it is comparable to air conditioning load. So, most individual residences could support PHEV-charging load. However, estimating the number of additional PHEVs that can be supported on each local distribution circuit for simultaneous recharging is currently not known. It is possible that one of the greater challenges for the successful deployment of PHEVs will be delivering the electricity to the last mile on the local distribution system.

IV. Retail Ratemaking and Smart Grid Policies for PHEVs can Impact Grid Utilization

The electric grid is planned, designed, built, and operated in such a fashion to meet the reliability criteria adopted by the North American Electric Reliability Corporation (NERC), the Northeast Power Coordinating Council, Inc., (NPCC), and the New York State Reliability Council (NYSRC), which have been approved by the Federal Energy Regulatory Commission (FERC) or the New York Public Service Commission (NYPSC) as appropriate. Unlike other loads, however, PHEV load is immediately elastic since gasoline is an instantly available substitute fuel. Should an entire charging cycle be missed, the vehicle remains fully capable of unrestricted operation on gasoline.

Charging PHEVs during the off-peak hours when there is surplus generation capacity could significantly mitigate their impact on electric utility infrastructure requirements. Indeed, the magnitude of the economic, energy, and environmental savings available from PHEVs will be dependent upon when and how the PHEVs are recharged. The impact of charging PHEVs in middle and late afternoon periods, particularly during periods of hot, weather-related seasonal demand will have adverse impacts on all electric consumers by raising energy prices, increasing capacity needs, and potentially reducing reliability. Given the elasticity of the PHEV load, and the opportunity to avoiding costly generation resource additions and lower PHEV-charging costs by charging when the system is not constrained, appropriate metering initiatives and retail rate structures are critical elements. Metering and retail rate structures are also likely to be significantly influential elements in the success of any PHEV initiative.

PHEV owners may be encouraged to charge their vehicles in the hours least disruptive to the electric system through pricing incentives in the off-peak period and/or the use of advanced communication technologies.

PHEV load is schedulable and interruptible. Consequently, it may be price sensitive and highly compatible with "vehicle-to-grid" communication initiatives. Smart Grid designs could manage PHEV impact on the electric grid by allowing PHEVs to communicate location, desired charge amount, and desired charge completion time, as well as other pertinent technical or financial account information. Some researchers have postulated that vehicle-to-grid communication can take place as an extension of the Advanced Metering Infrastructure (AMI), while others have suggested that the communication could use on-board mobile phone technology.

Vehicle charging communications through remote control via mobile communications could control the charging of vehicles equipped with these systems. When plugged into a charging station in the vehicle owner's home, for instance, the actual charging of the vehicle could be controlled by a third party and optimally timed to ameliorate or avoid adverse grid impacts.

Advanced meters at the residential level may also allow for the control of individual devices by utilities, end-use customers, or alternate third parties. Using advanced meters, PHEV-charging would be one of several home energy uses that could be managed through automation. Pool pumps, central air-conditioning, water heaters, and other energy intensive home applications are significant contributors to home energy usage that could be managed through automation with minimal disruption to the customer. Advanced metering technologies to manage energy usage at the individual device level could be offered as a service in exchange for reductions on utility bills.

Even simple time-of-use residential meters could provide customers with the incentive and the ability to manage their energy usage for charging PHEVs. Metering that records usage at the hourly level, coupled with time-of-use rate offers, could encourage PHEV owners to charge their vehicles at times that would minimize impacts on the electricity system. Currently, most residential electric customers have simple meters that record cumulative energy usage. These meters are read and usage is calculated for a single time period; typically an entire month. Interval meters record usage in more precise detail, allowing utilities to charge time-of-use rates that more accurately reflect the underlying cost of energy at the time.

Vehicle charging communications has received some support from automakers because it could allow for a single industry standard for recharging mechanisms to meet the needs of the electric utility system. Automakers would prefer to see a single vehicle standard that could be universally implemented as opposed to a patchwork of standards and technologies across state boundaries or utility service territories. Remote-controlled charging could also occur by allowing a customer to charge their vehicle at any location and be billed for the energy at a rate determined by the location of the vehicle rather than at a residential rate.

The NYISO will continue to monitor PHEV, charging infrastructure and protocol developments, as this new segment of the transportation sector matures to identify the potential impact on the electric system. Identifying the impacts of emerging PHEV technology under a host of charging scenarios can also assist policy makers to make informed decisions on how energy regulation and rate structure can beneficially influence PHEV development.

Literature Search on Key PHEV Studies

The Potential GHG and Energy Security Implications of Plug-In Hybrid Vehicles: A Scenario Analysis, EPA, [Simon Mui, Dan Chartier, Michael Shelby], TBD, *Spring 2007*

Effects of Plug-In Hybrid Electric Vehicles in California Energy Markets, UC Berkeley, [Derek Lemoine, Daniel M. Kammen, Alexander E. Farrell], *January 2007*

Impacts Assessment of Plug-In Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids Part 1: Technical Analysis, PNNL, [Michael Kintner-Meyer, Kevin Schneider, Robert Pratt], *January 2007*

Energy Consumption and CO_2 Emissions of Plug-In Hybrid Electric Vehicles, EPRI, *January 2007*

Plug-In Hybrid Vehicle Analysis, NREL, [T. Markel, A. Brooker, J. Gonder, M. O'Keefe, A. Simpson and M. Thornton], *November 2006*

Impact of Plug-in Hybrid Vehicles on the Electric Grid, ORNL, [Stanton Hadley], *October 2006*

Electricity Generation Costs and Emissions Associated with Plug-In Hybrid Electric Vehicle Charging in the Xcel Colorado Service Territory, NREL - Keith Parks, Paul Denholm, and Tony Markel, *October 2006*

Plug-In Hybrids: an Environmental and Economic Performance Outlook, ACEEE, [James Kliesch and Therese Langer], *September 2006*

Summary Report Discussion Meeting on Plug-In Hybrid Electric Vehicles, DOE, *May 2006*

A Preliminary Assessment of Plug-In Hybrid Electric Vehicles on Wind Energy Markets, NREL, [Walter Short and Paul Denholm], *April 2006*

Overview of Methodologies for Determination of Fuel-Cycle Emissions for Plug-In Hybrid Electric Vehicles, EPRI, *February 2006*

Driving the Solution the Plug-In Hybrid Vehicles, EPRI, *2005*

Vehicle-to-grid power fundamentals: Calculating Capacity and Net Revenue, University of Delaware, [Willett Kempton and Jasna Tomic], *December 2004*

Vehicle-to-Grid Power Implementation: From Stabilizing the Grid to Supporting Large-Scale Renewable Energy, University of Delaware, [Willett Kempton and Jasna Tomic], *December 2004*

Development and Evaluation of a Plug-in HEV with Vehicle-to-Grid Power Flow, AC Propulsion, Inc., [Thomas B. Gage], *December 2003*

Advanced Batteries for Electric-Drive Vehicles A Technology and Cost-Effectiveness Assessment for Battery Electric, Power Assist Hybrid Electric, and Plug-in Hybrid Electric Vehicles, EPRI, [Mark Duvall], *March 2003*

Vehicle-to-Grid Demonstration Project: Grid Regulation Ancillary Service with a Battery Electric Vehicle, AC Propulsion, Inc., [Alec N. Brooks], *December 2002*

Literature Search on Key PHEV Studies (Continued)

Lithium Ion Batteries for Hybrid Electric Vehicles: Opportunities and Challenges, Advanced Automotive Batteries, *October 2007*

Batteries for Plug-in Hybrid Electric Vehicles (PHEVs): Goals and the State of Technology Circa 2008, Institute of Transportation Studies, University of California Davis, CA, [John Axsen, Andrew Burke, Ken Kurani], *May 2008*

Effects of Plug-In Hybrid Electric Vehicles in California Energy Markets, [Derek Lemoine, Daniel M. Kammen, Alexander E. Farrell], *November 15, 2006*

From the Pump to the Plug What Is the Potential of Plug-in Hybrid Electric Vehicles? [Patricia A. Diorio, Aaron F. Brady], *June 2008*

Vehicle to Grid - A Control Area Operators Perspective, California Independent System Operator, [David Hawkins], *December 13, 2001*

Designing Low Cost Infrastructure, EDF, [Cyriacus Bleijs, Technical Advisor], *December 2007*

Plug-In Electric Hybrid Vehicles, Edison Electric Institute, *January 2007*

Driving the Solution – The Plug-In Hybrid Vehicle, EPRI, [Lucy Sanna], *Fall 2005*

Plug-In Hybrid Vehicles, EPRI, [Mark Duvall, Program Manager, Electric Transportation], *2007*

Environmental Assessment of Plug-In Hybrid Electric Vehicles Volume 2: United States Air Quality Analysis Based on AEO-2006 Assumptions for 2030, EPRI, *2007*

Environmental Assessment of Plug-In Hybrid Electric Vehicles (PHEVs) Greenhouse Gas Emissions and Air Quality Impacts of PHEVs, EPRI, [Mark Duvall], *November 2, 2007*

Environmental Assessment of Plug-In Hybrid Electric Vehicles Volume 1: Nationwide Greenhouse Gas Emissions, EPRI, [Project Managers, M. Duvall, E. Knipping], *July 2007*

Environmental Assessment of Plug-In Hybrid Electric Vehicles Volume 2: United States Air Quality Analysis Based on AEO-2006 Assumptions for 2030, EPRI, [Project Managers, M. Duvall, E. Knipping], *June 2007*

EMISSIONS PROCESSING AND RESULTS, EPRI, *2007*

DRIVING THE VOLT An Extended-Range Electric Vehicle, [Peter Savagian, Engineering Director, Hybrid Powertrain Engineering, General Motors], *No Date Available*

FACT SHEET – Hybrid Electric Vehicle Industry, Siemens VDO, Automotive Corporation, [Brad Warner, Bridgette LaRose], *January 2007*

H.R. 5351 Renewable Energy and Energy Conservation Tax Act of 2008, [Unknown Author], *February 12, 2008*

Final Report: Development and Evaluation of a Plug-in HEV with Vehicle-to-Grid Power Flow, [Principal Investigator: Thomas B. Gage, Prepared by: AC Propulsion, Inc., 441 Borrego Ct., San Dimas, CA 91773], *December 17, 2003*

Literature Search on Key PHEV Studies (Continued)

POSITION STATEMENT PLUG-IN ELECTRIC HYBRID VEHICLES, Adopted by the IEEE-USA Board of Directors, *June 15, 2007*

Vehicle to Grid Power Workshop at IEEE Conference Plug-In Hybrids: Accelerating Progress, [Willett Kempton], College of Marine and Earth Studies University of Delaware, *September 19, 2007*

IEEE - PHEV Symposium GE Point of View, General Electric, [Robert King, James Lyons, Tim Richter, Lembit Salasoo, Herman Wiegman], *September 2007*

IEEE Symposium - Plug-In Hybrids: Accelerating Progress 2007, [Senator Maria Cantwell], *September 19, 2007*

IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA., *April – May 2007*

2007: Transport and its infrastructure. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, *2007*

Standards for V2G Interconnection to the Grid, [Frank C. Lambert, Chair, Hybrid Electric Vehicle WG of the IWC], *June 6, 2005*

Cost-Benefit Analysis of Plug-In Hybrid Electric Vehicle Technology, [Tony Markel, Andrew Simpson], *2006*

Plug-In Hybrid Vehicle Analysis, National Renewable Energy Laboratory, [T. Markel, A. Brooker, J. Gonder, M. O'Keefe, A. Simpson, M. Thornton], *November 2006*

A Preliminary Assessment of Plug-In Hybrid Electric Vehicles on Wind Energy Markets, [National Renewable Energy Laboratory, W. Short, P. Denholm], *April 2006*

Cost-Benefit Analysis of Plug-In Hybrid Electric Vehicle Technology, [National Renewable Energy Laboratory, A. Simpson], *November 2006*

New York State Plug-In Hybrid Electric Vehicle Initiative, [NYSERDA, Joseph R. Wagner, Senior Project Manager, Transportation Research], *No Date Available*

Potential Impacts of Plug-in Hybrid Electric Vehicles on Regional Power Generation, [Prepared by: Stanton W. Hadley, Alexandra Tsvetkova, OAK RIDGE NATIONAL LABORATORY, Oak Ridge, Tennessee 37831, Managed by UT-BATTELLE, LLC for the U.S. DEPARTMENT OF ENERGY], *January 2008*

PHEV-EV Charging Evaluation – Potential Impact on the Utility, [BC HYDRO, Alec Tsang, Technical Support: Ken Lau, Dylan Gothard], *November 2007*

Preliminary Analysis of Plug-In Hybrid Electric Vehicles (PHEV) Using Objects Mini Cam, [JGCRI, Sonny Kim], *May 23, 2007*

Literature Search on Key PHEV Studies (Concluded)

IMPACTS ASSESSMENT OF PLUG-IN HYBRID VEHICLES ON ELECTRIC UTILITIES AND REGIONAL U.S. POWER GRIDS PART 1: TECHNICAL ANALYSIS, [Pacific Northwest National Laboratory, Michael Kintner-Meyer, Kevin Schneider, Robert Pratt], *November 2007*

Public Utilities Fortnightly: NEW LOAD, The Industry Must Join a Growing Chorus in Calling for New Technology, [By: Steven Letendre, Ph.D, Paul Denholm, Ph.D], *December 2006*

Air Emissions Impacts of Plug-In Hybrid Vehicles in Minnesota's Passenger Fleet, [Minnesota Pollution Control Agency, David Thornton, Assistant Commissioner, Todd Biewen, Manager, Environmental Analysis and Outcomes Division], *March 2007*

Wisconsin Global Warming Task Force Increase Market Shares of HEVs, PHEVs, EVs, [Unknown Author], *February 14, 2008*

Toyota Will Offer a Plug-In Hybrid Vehicle by 2010, [Micheline Maynard], *January 14, 2008*

Testing Electric Vehicle Demand in 'Hybrid Households' Using a Reflexive Survey, [Institute of Transportation Studies (University of California, Davis) Kenneth Kurani, Thomas Turrentine, Daniel Sperling], *1996*

Summary Report: Discussion Meeting on Plug-In Hybrid Electric Vehicles, [US Department of Energy], *May 2006*

Plug-In Hybrids: Background and Scenario Analysis, [Transportation and Climate Division, US EPA], *October 5, 2006*

A Comparative Assessment of Electric Propulsion Systems in the 2030 US Light-Duty Vehicle Fleet, [Matthew A. Kromer, John B. Heywood], *2008*

Websites

http://www.udel.edu/V2G/

http://www.epri-reports.org/

http://www.dec.ny.gov/environmentdec/25412.html

http://www.eere.energy.gov/afdc/vehicles/hybrid_electric.html

http://www.nrel.gov/vehiclesandfuels/hev/plugins.html

http://www.keystone.org/spp/documents/03_15_2007_NYSERDA%20PHEV%20Program_Final.pdf