

## Electric Transportation - Program 18

### Program Overview

#### Program Description

Electricity is the only potential energy source for transportation that addresses the simultaneous need for fuel diversity, energy security, reductions in greenhouse gas emissions, and improvements in air quality that is widely available and produced domestically. Electric utilities must understand the paradigm shift that will occur with an inevitable transition of transportation energy from petroleum to electricity—as well as their new role as a fuel provider for vehicles.

The major automotive companies, including General Motors, Ford, and Toyota, are competing to be first to market with plug-in hybrid electric vehicles (PHEVs).

Nearly all of the major automakers are reaching out to the utility industry to develop and standardize infrastructure for recharging plug-in hybrids.

Fleets can offset high fuel costs and meet environmental requirements by incorporating plug-in hybrid or battery electric vehicles into operations.

Adoption of non-road electric vehicles at customer sites can reduce fuel costs and increase customer satisfaction. Emission-constrained sites like seaports and airports can reduce the cost of environmental compliance.

#### Research Value

The Electric Transportation program conducts research and development on vehicle and infrastructure technologies that enable the use of electricity as a transportation fuel. The program has played a leading role in the development of plug-in hybrid electric vehicle (PHEV) technologies that are now at the forefront of automotive industry development efforts. The Electric Power Research Institute (EPRI) also serves as the focal point for the development of infrastructure standards and technology to support PHEV adoption by utility customers. EPRI's non-road electric transportation efforts have demonstrated the cost-effective use of battery electric vehicles in numerous commercial and industrial applications and serve as the technical foundation for successful, customer-focused utility non-road electric transportation market expansion programs.

#### Approach

EPRI research in electric transportation will yield a variety of data and knowledge that will be beneficial to members of the program. This information will come in a number of forms and is expected to include the following:

- Formation of major collaborative PHEV programs with the automotive industry, including General Motors, Ford Motor Company, and Eaton Corporation
- Developing proof-of-concept plug-in hybrid-drive systems in multiple transportation platforms
- Expanding market penetration of electric drive in the non-road market through value demonstrations
- Validating the environmental benefit of electric vehicles (EVs) to commercial and industrial entities and communities in which the entities are located
- Analysis of potential impacts to utility systems

## Accomplishments

The electric transportation program has delivered valuable information that has helped its members and the industry in numerous ways. Examples include the following:

**On Board Smart Charging Requirements for PHEVs – Product ID # 1015877**The first plug-in electric vehicles (PEVs) are expected to start production in late 2010. Both vehicle owners and utility companies would benefit if PEVs could draw power during off peak periods, but implementing a demand response program will require grid-to-PEV bidirectional communications to allow the utility system to influence the timing and amount of energy the PEV draws from the grid. This report defines the technology needed for such "Smart Charging" and reviews the current status of the initiatives underway to accomplish it.

**Smart Charging Development for PHEVs – Preliminary Use Case Development for SAE Recommended Practice J2836 - Product ID # 1015886**This technical update covers the complete set of functional requirements for integrating plug-in electric vehicles (PEVs) into the smart grid, along with the utility programs they will be able to participate in and a vision for getting these requirements into standardized implementations. The document will help utility and original equipment manufacturer (OEM) staff gain a complete understanding of how they should go about developing PEV-utility requirements that will support programs for demand response and energy efficiency through their automated metering infrastructure.

**Impact of Plug-in Electric Vehicle Technology on Electricity Infrastructure, Preliminary Analysis of Capacity and Economic Impacts - Product ID # 1016853**This report covers the evaluation of macro-level grid capacity impact of plug-in electric vehicles (PEVs) over the next two decades. The document covers both the EPRI Prism base case of 30% PEVs in 2030 and a more realistic penetration scenario that results in about 6% PEVs in 2030, mimicking the growth rate of hybrid-electric vehicles in the last decade. Also evaluated is the impact of the smart grid on load shifting and economic benefits in terms of deferred capacity investment.

## Current Year Activities

- Demonstrate utility fleet prototype PHEVs and acquire and analyze field test data
- Develop the utility value proposition for PHEVs
- Develop and test an advanced battery. Develop a battery production cost model
- Develop communication protocols for PHEVs connecting to the electrical grid
- Demonstrate advanced electric-drive technologies in non-road applications

## Estimated 2010 Program Funding

\$4.5M

## Program Manager

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## Summary of Projects

### PS18A Plug-In Hybrid Electric Vehicle Development (056053)

#### Project Set Description

This project set addresses the technologies and products that demonstrate the value of electric-drive systems and components in plug-in hybrid electric vehicle (PHEV) and battery electric vehicle (BEV) applications.

| Project Number | Project Title   | Description  |
|----------------|---|--|
| P18.001        | Plug-in Hybrid Electric Vehicle Evaluation and Test Data Analysis | This project provides a comprehensive real-world test program for PHEV demonstration fleets using sophisticated systems for collecting and processing detailed vehicle information and reporting the results to members. |
| P18.002        | Advanced Technology Development for PHEV Systems                  | This project utilizes modeling of performance characteristics to interpret the test results obtained from PHEV prototype testing and to develop specifications to feed back the findings for improving the designs.      |
| P18.003        | Advanced Battery System Development and Testing                   | This project will continue its industry-leading battery technology evaluation program and identify and address research gaps in development and verification of PHEV battery systems.                                    |
| P18.004        | PHEV Systems Analysis   | This project monitors current actions and issues relating to electric transportation and help members to respond to such trends and developments.  |

### P18.001 Plug-in Hybrid Electric Vehicle Evaluation and Test Data Analysis (062128)

#### Key Research Question

Several large automotive manufacturers have publicly stated their intent to commercialize plug-in hybrid electric vehicles (PHEVs) as early as late 2010. In 2009, there will be a number of active PHEV prototype test and demonstration programs in utility and public fleets and with customers. These programs are important opportunities to collect and analyze real-world operating data. This activity will enable utilities to understand the performance and operation of different types of PHEVs and to determine benefits and impacts to their systems.

#### Approach

This project provides a comprehensive real-world test program for the Electric Power Research Institute (EPRI) and utility PHEV demonstration fleets. EPRI has developed a sophisticated system for collecting and processing detailed vehicle systems information and reporting the results to members. This information is valuable for utilities to understand how real-world PHEV use impacts their system and business, to guide fleet “greening” and other environmental compliance issues, and to determine the most promising PHEV technological approaches.

The scope of data collection and analysis includes

- development of test procedures for field testing of prototype PHEV fleets;
- acquisition and analysis of vehicle and system data—including PHEV Sprinter, PHEV Trouble Truck, among other demonstration fleets;
- reporting and dissemination of vehicle test data;
- comparison to laboratory battery and component tests and verification of vehicle simulation data; and

- surveying transportation applications to determine potential PHEV candidates and performing performance profile analyses on these candidates.

### Impact

This project may have the following impacts:

- Increased understanding of PHEV product performance
- Reduced fleet operating costs
- Facilitation of fleet environmental compliance
- Real-world data to support PHEV benefit and impact analysis at the utility

### How to Apply Results

Utilities can incorporate PHEV test results into their internal analyses. Fleet managers can use the test data and vehicle specifications to acquire PHEV technology for utility fleet operations. In addition, this project will enable EPRI and its advisors to carefully review the transportation sector and to identify transportation operating profiles and specific vehicle platforms as candidates for PHEV operation.

### 2010 Products

| Product Title & Description                                       | Planned Completion Date | Product Type     |
|---|-------------------------|------------------|
| Plug-in Hybrid Electric Vehicle Evaluation and Test Data Analysis | 12/31/10                | Technical Report |

## P18.002 Advanced Technology Development for PHEV Systems (065233)

### Key Research Question

Plug-in hybrid vehicles (PHEVs) will not realize their energy saving and carbon dioxide (CO<sub>2</sub>) emission reduction potential until the market has matured to the point that vehicle manufacturers are providing PHEV systems that take full advantage of advanced batteries and drive systems. Stakeholders will benefit from a careful review of the optimal methods of combining internal combustion and electric motor and engine power to maximize PHEV's operational benefits while meeting performance requirements.

### Approach

This project will utilize the modeling competency developed at the Electric Power Research Institute (EPRI) to interpret the test results obtained from the PHEV prototype testing and to develop a specification for an optimized design. The modeling effort will compare the performance characteristics of the various PHEV potential configurations. The information compiled will enable EPRI to recommend to vehicle manufacturers new design approaches that will lead to next-generation PHEV technology. Finally, this project will define a 2010 initiative that will lead to the establishment of projects that advance specific PHEV technologies.

### Impact

This project may have these impacts:

- Increase benefits and reduce costs of utilizing PHEVs across multiple platforms
- Contribute to reduction of CO<sub>2</sub> emissions through decreased petroleum consumption

### How to Apply Results

The specifications developed for optimized vehicles will be used by the project participants and their customers to acquire PHEV drive systems that maximize the benefits of fuel savings and emission reductions. Procurement specifications ensure that the vehicles acquired will achieve the maximum desired benefits.

## 2010 Products

| Product Title & Description                      | Planned Completion Date | Product Type     |
|--|-------------------------|------------------|
| Advanced Technology Development for PHEV Systems | 12/31/10                | Technical Update |

### P18.003 Advanced Battery System Development and Testing (063272)

#### Key Research Question

The potential for plug-in hybrid electric vehicles (PHEVs) to achieve widespread market acceptance depends heavily on the cost, performance, and durability of advanced lithium-ion (Li-ion) battery systems. Early testing by the Electric Power Research Institute (EPRI) and utilities of Li-ion battery systems against PHEV duty cycles provided some of the earliest evidence of the capability of the technology to meet PHEV requirements. New PHEV design requirements and emerging battery technologies will continue to require additional systems development, technology evaluation, and testing.

#### Approach

EPRI will continue its industry-leading battery technology development and evaluation program. This project will identify and address issues of importance to the development and verification of PHEV battery systems, including the following:

- Development of suitable test procedures and methods for evaluation of advanced batteries for PHEV applications
- Long-term life-cycle testing of candidate battery technologies
- Identification of technical issues related to PHEV battery systems, including cost, environmental impact, recycling, or manufacturing technology
- Analysis and recommendations regarding the current status of battery technology for PHEVs

#### Impact

This project may have the following impacts:

- Verify maturity and readiness of PHEV battery technology
- Reduce PHEV battery system cost and environmental impact
- Obtain early identification and testing of promising emerging battery technologies
- Identify and address issues that affect PHEV battery commercialization

#### How to Apply Results

The results from this project will provide utilities with world-class, specific technical and cost information regarding battery technology for PHEVs. Utilities will gain a thorough understanding of the readiness of Li-ion battery technology for PHEVs—the single most substantial technical challenge to the development and commercialization of these vehicles.

## 2010 Products

| Product Title & Description               | Planned Completion Date | Product Type     |
|---|-------------------------|------------------|
| Advanced Batteries for PHEVs: Status 2011 | 12/31/10                | Technical Update |

## P18.004 PHEV Systems Analysis (065234)

### Key Research Question

Historically, the Electric Power Research Institute (EPRI) has provided leadership in the development of electric-drive solutions. As the focus on energy security, energy efficiency, and carbon dioxide (CO<sub>2</sub>) emissions reductions becomes even more prevalent, EPRI should continue its leadership role in representing its members to ensure that the benefits of electric transportation are clearly understood and recognized. This will help ensure a positive transition away from imported oil to electricity as an energy source through federal, state, and local actions.

### Approach

This project will fund a full-time position dedicated to monitoring current actions and issues relating to electric transportation, as well as continuing to respond to member advisor guidance in implementing the necessary leadership actions to influence developments. The scope of work will be as follows:

- Define the leadership expectation for EPRI and its electric transportation advisors
- Identify critical path actions that should be implemented
- Execute the above actions

### Impact

- Foster recognition of the electric power industry's proactive role in leading electric transportation developments
- Ensure accurate dissemination of information about electric transportation
- Provide timely responses to issues and concerns about electric transportation

### How to Apply Results

On behalf of its members, EPRI will develop timely responses to issues and concerns expressed by policy makers and other interested parties. This information will be shared with the utility industry to ensure accurate repeatable responses.

### 2010 Products

| Product Title & Description      | Planned Completion Date | Product Type     |
|----------------------------------|-------------------------|------------------|
| Summary of PHEV Systems Analysis | 12/31/10                | Technical Update |

## PS18B Non-Road Electric Transportation Market Expansion (056054)

### Project Set Description

This project set focuses on the application of electric-drive systems in non-road industrial, commercial, and airport and seaport markets whose technology successes will advance the awareness of the value of electric-drive systems.

| Project Number | Project Title                       | Description   |
|----------------|-------------------------------------|---|
| P18.005        | Non-Road Utility Education Campaign | This project will assess technical, societal, and economic impacts that non-road transportation applications may have. It also provides surveillance of existing non-road electrification programs. |

| Project Number | Project Title  | Description   |
|----------------|--|---|
| P18.006        | Market Transformation Demonstrations                 | This project will execute non-road EV demonstration projects.   |
| P18.007        | PHEV Drive Systems for Airport and Port Applications | This project will focus on electrification of transportation in seaports and airports and may include food service and airline fueling trucks as well as yard hostlers. |

## P18.005 Non-Road Utility Education Campaign (065237)

### Key Research Question

The value proposition for electrifying non-road transportation has been established for a number of applications and in select geographic regions. Non-road transportation programs conducted by several utilities have shown that when adopting electrification of non-road applications, charging may be shifted to off-peak periods and satisfied users are able to lower the cost of energy while simultaneously lowering their carbon footprint. This project will strive to identify options for expanding the number of applications and understand and document technical and other barriers and opportunities for electrification of non-road transportation.

### Approach

This project will develop facts and executive documentation that focuses on technical, societal, and economic impacts that non-road transportation applications may have. In addition, it will document best practices of utilities already executing non-road electrification programs. Utilities may use the findings of the benefits document along with best practices to start their own non-road electric vehicle (EV) program. The scope of work is as follows:

- Determine which utilities are currently conducting non-road EV programs
- Establish criteria to identify candidates for demonstrating additional non-road EV applications
- Conduct regional or individual utility workshops
- Develop case studies of non-road technology demonstration projects documenting the technical, environmental, and economical impact

### Impact

- Increase number of applications of EVs for non-road transportation
- Benefits include lower cost and higher customer satisfaction from more efficient use of energy when electrifying non-road transportation applications
- Achieve greater carbon dioxide (CO<sub>2</sub>) emissions reductions

### How to Apply Results

The project may enable members to more easily establish effective non-road EV electrification programs. The material could be used by the commercial and industrial account manager to provide guidance to their customers by sharing the findings of the demonstration projects.

### 2010 Products

| Product Title & Description | Planned Completion Date | Product Type                      |
|-----------------------------|-------------------------|-----------------------------------|
| Non-Road Utility Campaign   | 08/31/10                | Workshop, Training, or Conference |

## P18.006 Market Transformation Demonstrations (060498)

### Key Research Question

Increased success of non-road electric vehicle (EV) market penetration has most often resulted from actual product demonstrations spanning a diverse industry base that includes airports, food processing plants, and automotive manufacturers. Continued efforts in this area will enable ongoing market expansion.

### Approach

This project will continue to seek and execute non-road EV demonstration projects across the United States. The scope of work is as follows:

- Review past demonstrations to identify types, locations, and level of success
- Define criteria that resulted in successful demonstrations
- Identify potential future demonstration projects across the United States and develop a scope of work for these projects

### Impact

This project may have these impacts:

- Increase penetration of EVs in the non-road market
- Expand the market for utility products while enhancing customer satisfaction
- Achieve greater carbon dioxide (CO<sub>2</sub>) emissions reductions
- Demonstrate EV technology validation in increasingly diverse applications
- Provide valuable market information to a national audience

### How to Apply Results

Utility account executives will use case studies and reports that document the value of EV applications to establish interest in electric transportation from customers in their service territories as part of a non-road EV campaign.

### 2010 Products

| Product Title & Description            | Planned Completion Date | Product Type     |
|--|-------------------------|------------------|
| Non-road Electrification Demonstration | 12/31/10                | Technical Update |

## P18.007 PHEV Drive Systems for Airport and Port Applications (065238)

### Key Research Question

Market penetration of electric vehicles (EVs) in airport applications has been successful, with the exception of trucks that operate on airport tarmacs. In previous years the first demonstrations of EV technologies in seaport applications were conducted. Further work is necessary to further EV penetration in these market sectors.

### Approach

Seaport and airport applications will be continued, with a strong focus on bringing the plug-in hybrid electric vehicle (PHEV) drive system technology to vehicles operating in these complex environments, such as food service and airline fueling trucks at airports and hostlers at seaports. The scope of work is as follows:



- Extending the audit of airports and seaports to determine vehicle applications with service requirements that can be met by plug-in hybrid vehicle (PHEV) drive systems
- Preparing a scope of work that would enable the conversion of an internal combustion vehicle to a PHEV and initiate efforts to develop a supplemental project to demonstrate PHEVs in airports and ports

### Impact

This project may have these impacts:

- Further extend the applicability of PHEVs in non-road airport and seaport applications
- Help to reduce carbon dioxide (CO<sub>2</sub>) emissions in airport and seaport environments

### How to Apply Results

Utility representatives calling on seaports and airports can utilize results from technology demonstrations of PHEVs in these sectors to engage those customers with applicable product solutions. Demonstrations of the PHEV technologies can be implemented at additional airports and seaports, further documenting the value.

### 2010 Products

| Product Title & Description                                   | Planned Completion Date | Product Type     |
|---|-------------------------|------------------|
| Study of PHEV Technology within Airport and Port Applications | 12/31/10                | Technical Update |

## PS18C Environmental and Economic Analysis of Electrifying Transportation (056055)

### Project Set Description

This project set utilizes environmental knowledge to advance the cause of electric-drive technology in metropolitan regions.

| Project Number | Project Title   | Description   |
|----------------|---|---|
| P18.008        | Economic Analysis for Electric Transportation                 | Apply the findings of previous environmental and economic impact studies at a regional level.   |
| P18.009        | Environmental and Policy Analysis for Electric Transportation | This project will identify and conduct detailed analyses of environmental and policy approaches that affect electricity as a transportation fuel, including both on-road and non-road applications. |

## P18.008 Economic Analysis for Electric Transportation (063274)

### Key Research Question

In prior years, the Electric Power Research Institute (EPRI) initiated an environmental analysis that assessed the environmental benefits of electric transportation with a regional analysis conducted around the Cleveland metropolitan area and state of Ohio. Further analysis needs to be performed to assess the environmental benefits in other U.S. regions that take into account unique regional differences.

### Approach

EPRI will continue to explore the impacts of plug-in hybrid vehicles (PHEVs) at a regional level. Using the results from the initial analysis, EPRI will create region-specific reports that demonstrate the environmental,

economic, and societal benefits of electrifying on-road and off-road transportation in easily understandable language suitable for decisionmakers and their constituencies. The scope of work is as follows:

- Review of the California, Ohio, and other 2007 studies for lessons learned, with an application of this knowledge to a regional project scope of work
- Establish utility champions within each recommended region
- Develop a schedule, budget, and work plan for each region
- Initiate the regional analysis with utility champions located in each region

### Impact

- Demonstrate the environmental benefits of electric transportation
- Demonstrate the proactive utility response to reduce the environmental impact of transportation on a regional basis
- Eliminate barriers to greater adoption of electric transportation solutions

### How to Apply Results

Environmental managers within the funding utilities will either conduct the analysis in their own specific regions or apply results to estimate similar benefits of implementing broader electric transportation solutions throughout their area of operation. The EPRI analysis team will be able to join the interested manager to extrapolate the results to the specific region in question or to conduct a detailed environmental analysis if required.

### 2010 Products

| Product Title & Description                                       | Planned Completion Date | Product Type     |
|---|-------------------------|------------------|
| <b>Economic Analysis of the Impact of Electric Transportation</b> | 12/31/10                | Technical Report |

## **P18.009 Environmental and Policy Analysis for Electric Transportation (063273)**

### Key Research Question

Assessments of the environmental impacts of plug-in hybrid electric vehicles (PHEVs) by the Electric Power Research Institute (EPRI) and other organizations point to significant environmental benefits, particularly with respect to greenhouse gas emissions and air quality. Policy treatment of emissions offsets or other treatment of PHEVs as agents of positive impact to energy security or the environment could create incentives for greater adoption of electric transportation, leading to increased energy savings as well as further reductions in CO<sub>2</sub> emissions. Understanding the impact of proposed policies and developing new approaches can improve PHEV adoption significantly.

### Approach

This project will identify and conduct detailed analyses of environmental and policy approaches that affect electricity as a transportation fuel, including both on-road and non-road applications. These include the following:

- Develop approaches to determine and capture the value of PHEV CO<sub>2</sub> and greenhouse gas offsets, including Low Carbon Fuel Standards (LCFS)
- Identify and address analytically other environmental issues affecting electricity as a transportation fuel
- Develop recommended approaches to capturing the environmental value of electricity as a transportation fuel

## Impact

- Enable the determination and utilization of CO<sub>2</sub> offsets from PHEVs
- Identify and address issues that impact the environmental value of electricity as a transportation fuel

## How to Apply Results

Members that finance this project will be able to use the strategy developed to implement a simplified emission credit process to enable mobile source credits to be substituted for stationary credits in their area of operation.

## 2010 Products

| Product Title & Description       | Planned Completion Date | Product Type     |
|-----------------------------------|-------------------------|------------------|
| Environmental Assessment of PHEVs | 12/31/10                | Technical Report |

## PS18D Advanced Infrastructure Development for Plug-In Hybrid Electric Vehicles (056057)

### Project Set Description

This project set addresses issues surrounding electric vehicle (EV) infrastructure and impacts on the utility grid as electric-drive systems enter the marketplace. Special attention is paid to the potential of plug-in hybrid and fuel cell vehicles to provide power to homes, commercial sites, and potentially the grid itself.

| Project Number | Project Title   | Description   |
|----------------|---|---|
| P18.010        | Infrastructure Working Council                            | This project will provide support to IWC for the execution of infrastructure analysis that affects the commercialization of plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) in the automotive and truck industries. |
| P18.011        | Identification of PHEV Infrastructure Requirements        | This project will compile the knowledge accumulated from infrastructure technology demonstrations and will update recommendations for plug-in hybrid electric vehicle (PHEV) charging infrastructures.  |
| P18.012        | Vehicle and Infrastructure Connectivity and Communication | This project will provide the technical analysis and development work to support a single standard communication protocol and physical media for vehicle-to-grid communications.  |
| P18.013        | Infrastructure Technology Demonstrations                  | This project will focus on development and testing of the vehicle, battery, and on-board communication systems to maximize potential benefits when PHEVs are connected to the grid  |

## P18.010 Infrastructure Working Council (065239)

### Key Research Question

The Infrastructure Working Council (IWC) was established to provide a forum for utilities, automotive manufacturers, suppliers, and other stakeholders to address issues regarding electric infrastructure for plug-in hybrid and electric vehicles. The IWC focuses on ensuring interoperability, safety, and simplicity of grid infrastructure as electrically powered vehicles enter the marketplace. The Electric Power Research Institute (EPRI) is well-positioned to represent its members through support of the IWC and its activities to foster continued adoption of electric transportation technologies.

## Approach

The IWC will continue to serve the industry as the facilitator of infrastructure review, analysis, and standardization. Project 18.010 will provide support to IWC for the execution of infrastructure analysis that positively affects the commercialization of plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) in the automotive and truck industries. This project also will conduct a representative sample audit of airports and seaports across the United States and prepare a report with recommendations on airport and seaport infrastructure issues that should be addressed by the IWC. The scope of work is as follows:

- Lead utility industry participation in SAE J2293 standards development.
- Review related U.S. and international standards (IEEE 1547 and others) and participate in these efforts on an as-needed basis.
- Continue to identify and execute infrastructure projects that address issues, concerns, and standards that impact PHEV and BEV commercialization.

## Impact

This project may have the following impacts:

- Standardization of vehicle and stationary charging connection, equipment, and infrastructure to ensure interoperability and the safety of vehicle recharging
- Ensure that new standards facilitate communication between vehicle and grid to support industry needs for off-peak charging and electricity billing and tracking
- Minimize connectivity costs from both the grid and vehicle perspectives

## How to Apply Results

Results from the IWC analysis will enable clean vehicle technology management teams at funding utilities and their customers to implement connectivity between the grid and electric vehicle (EV) systems. The reports developed will be used by members to ensure that connections are achievable and cost-effective.

## 2010 Products

| Product Title & Description                   | Planned Completion Date | Product Type     |
|---|-------------------------|------------------|
| Infrastructure Working Council Annual Report: | 12/31/10                | Technical Report |

## P18.011 Identification of PHEV Infrastructure Requirements (065240)

### Key Research Question

Plug-in hybrid vehicle technology development is accelerating within the automotive industry. Existing and new standards are in the process of being updated. Technology is changing rapidly—including the proposed methods of interfacing these vehicles to the grid.

### Approach

This project will compile the knowledge accumulated from these technology demonstrations into a single document and will update recommendations for plug-in hybrid electric vehicle (PHEV) charging infrastructures. The scope of work is as follows:

- Review and catalogue the PHEV infrastructure issues and concerns regarding grid connectivity
- Establish and prioritize a list of actions and recommendations for PHEV infrastructure standards
- Develop a scope of work to initiate projects required to address specific PHEV infrastructure actions

## Impact

- Enable simple and safe connectivity between PHEV systems and the grid
- Enable intelligent communication between electric vehicles (EVs) and the grid
- Provide guidance to members in preparation for programs to implement EV market penetration

## How to Apply Results

Utility distribution management will use work papers and planning documents based on PHEV knowledge and prior supplemental infrastructure projects to execute a review of their own infrastructure and to implement a plan for PHEV market penetration.

## 2010 Products

| Product Title & Description         | Planned Completion Date | Product Type     |
|-------------------------------------|-------------------------|------------------|
| Requirements of PHEV Infrastructure | 12/31/10                | Technical Update |

## P18.012 Vehicle and Infrastructure Connectivity and Communication (067434)

### Key Research Question

Communication between plug-in hybrid electric vehicles (PHEVs) and grid infrastructure is the key element to maximizing the value of PHEVs as a connected load. As the market adopts PHEVs, utilities will need a means of communicating with these vehicles to incentivize off-peak charging, tracking, and billing the consumption of electricity as a transportation fuel and to optimize their use as distributed storage devices. There are a number of communication protocols and physical media—both wired and wireless—and their integration in advanced metering and other Smart Grid applications must be well understood.

### Approach

This project will provide the technical analysis and development work to support a single communication protocol and physical media that can be adopted as a standard by the automotive industry for vehicle-to-grid communication. The technical results of this project will support ongoing standards efforts in Project 18.010 and physical demonstrations in Project 18.013.

## Impact

- A technical specification for vehicle-to-grid communication
- Understanding of technical issues regarding vehicles communicating to grid infrastructure
- Development of a viable approach to create a single communication methodology applicable to plug-in hybrid vehicles from all automotive manufacturers

## How to Apply Results

Results will be used in advanced planning for the integration of PHEVs into distribution systems. Utilities will receive a technical specification document that can be used to clearly designate requirements to advanced metering infrastructure suppliers, regulators, and other stakeholders.

## 2010 Products

| Product Title & Description   | Planned Completion Date | Product Type     |
|---|-------------------------|------------------|
| Infrastructure Communication and Connectivity Requirements for Plug-in Vehicles | 12/31/10                | Technical Update |

## P18.013 Infrastructure Technology Demonstrations (065241)

### Key Research Question

This project will conduct field demonstrations of advanced infrastructure connected to prototype plug-in hybrid electric vehicles (PHEVs) to address the issues, concerns, and technologies required to maximize the benefits of PHEV technology as it connects to the utility grid. The project is focused on four major objectives:

- Determining the feasibility of PHEVs as distributed resources for generating electrical power to improve the security and reliability of electrical power distribution
- Defining and testing a communication protocol that would enable PHEVs to communicate with tomorrow's intelligent grid and smart home
- Validating interoperability between PHEVs and charging stations, charging stations and building emergency medical services (EMS), and building EMS and energy service providers
- Analyzing current urban and rural distribution systems to understand the impacts of PHEV/battery electric vehicle (BEV) charging on the current infrastructure, with recommendations on near-, mid-, and long-term modifications needed to support the merging of transportation and electricity

### Approach

This project will focus on continued development and testing of the vehicle, battery, and on-board communication systems to ensure potential benefits are maximized when PHEVs are connected to the grid. The scope of work is as follows:

- Review of findings from the 2007 advanced infrastructure connectivity supplemental projects to identify the vehicle-specific issues and concerns to be addressed
- Prepare a project plan that addresses the identified issues and concerns
- Establish alliances within the automotive and utility industries to address the issues and concerns
- Develop a project plan for 2009 to evaluate the systems required as part of a vehicle and intelligent grid system

### Impact

- Increase knowledge about advanced issues of PHEV-grid connectivity
- Provide planning information for mid- and long-term conversion to PHEV commercialization
- Enable necessary modifications to infrastructure to support anticipated consumer demand

### How to Apply Results

Distribution managers and fleet operators will receive detailed information on infrastructure impacts, enabling mid- and long-term planning to accommodate PHEV charging and support consumer demand. The knowledge resulting from this project will enable distribution and communication planners to ensure the linkage of electric-drive vehicles to the intelligent grid and smart home through advanced metering systems.

### 2010 Products

| Product Title & Description   | Planned Completion Date | Product Type     |
|---|-------------------------|------------------|
| Preliminary Test Protocol for Vehicle-to-Grid Power Systems Testing | 12/31/10                | Technical Report |