Standards for PHEV/EV Communications Protocol

Michael Kintner-Meyer
Krishnan Gowri

Pacific Northwest National Lab.
June 09, 2010

Project ID #
VSS024

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Pacific Northwest
NATIONAL LABORATORY

Overview

Timeline

- Start – Oct. 2009 (FY Start)
  – Jan. 2010 (Project Start)
- Finish – Sept. 2010
- 25% Complete

Budget

- Total project funding
  - DOE share -320k
    - SAE Standard: 250k
    - GITT Project: 70k
- Funding Received in 2009
  - DOE share - None
- Funding for FY10
  - DOE share -320k

Barriers

- Lack of codes and standards for communication between PHEV and Grid
- Communication technology options are unproven for automotive application

Partners

- Society of Automobile Engineers
- Argonne National Lab.
- Ford, Echelon, Coulomb
- DTE Energy

Pacific Northwest
NATIONAL LABORATORY

Objectives

MYPP Relevance:

> *Address codes and standards needed to enable wide-spread adoption of electric-drive transportation technologies.*

- Develop functional requirements for vehicle-grid communication (VGC) user interface to support demand response and optimized charging
- Contribute to SAE and NIST activities to accelerate the development and harmonization of VGC codes and standards
- Develop testing and validation procedures for VGC standards and technologies based on SAE Documents J2847 and J2931
- Build “VGC Virtual Testbed” to test validation procedures for VGC. Requires collaboration with industry partners

Pacific Northwest
NATIONAL LABORATORY

Technical Approach

Objective: *Develop functional requirements for vehicle-grid communication user interface (Human Machine Interface - HMI)*

- Define data requirements to enable customers' preferences of how to schedule charging
- Develop input screens that enable the interactions of customer, vehicle, and utility
- Define J2847 compliant message protocol for retrieving data from a Utility

Pacific Northwest
NATIONAL LABORATORY

Technical Approach

Objective: *Contribute to SAE and NIST activities to accelerate the development and harmonization of VGC codes and standards*

- Harmonization of vehicle to grid communication use cases developed by SAE, SEP 2.0 and IEC
  - Compare/contrast the use cases
  - Document differences between documents, and identify for each document any use cases that are absent, but appear in other documents.
  - Evaluate use cases for
    - completeness and comprehensiveness to enable VGC
    - level of detail
- Contribute to SAE Documents J2847/1, J2847/2 and J2931
  - Review utility communication messages and VGC architecture to provide feedback on updates to the initial balloted documents
  - Propose application layer level data structure, communication module performance requirements for inclusion in J2931 for OEM VGC module development

Pacific Northwest
NATIONAL LABORATORY

Technical Approach

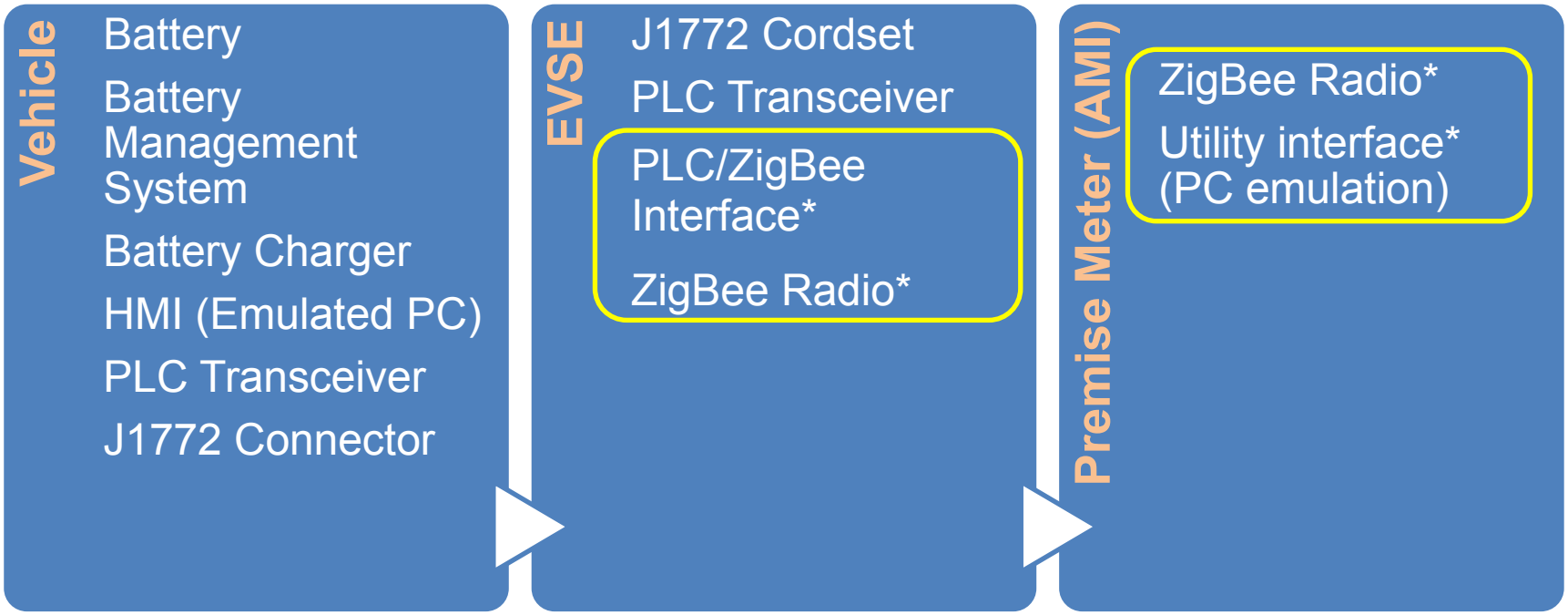
Objective: *Develop test plan and performance requirements for testing and validation of VGC standards and technologies based on SAE Documents J2847 and J2931*

- Select Power Line Communication (PLC) technologies for testing J2847/1 messages from vehicle to electric vehicle supply equipment (EVSE)
  - Participate in SAE PLC Selection Competition to help evaluate the PLC technologies
  - Low-frequency, narrow-band solutions will be investigated as these have not been tested for automotive use
- Establish functional performance requirements for application layer level communication
  - Review EMC testing by Ford and EPRI to identify performance requirements
  - Develop test procedures for association and authentication
  - Perform integrated laboratory testing of PLC technologies with bench set up using battery, charger, and EVSE.
  - Perform co-existence and attenuation tests for data transmission and error rates

Pacific Northwest
NATIONAL LABORATORY

Technical Approach - Test Bench Schematic

Objective: *Develop "VGC Virtual Testbed" and collaborate with industry partners to develop a prototype for testing and validation of VGC in laboratory.*

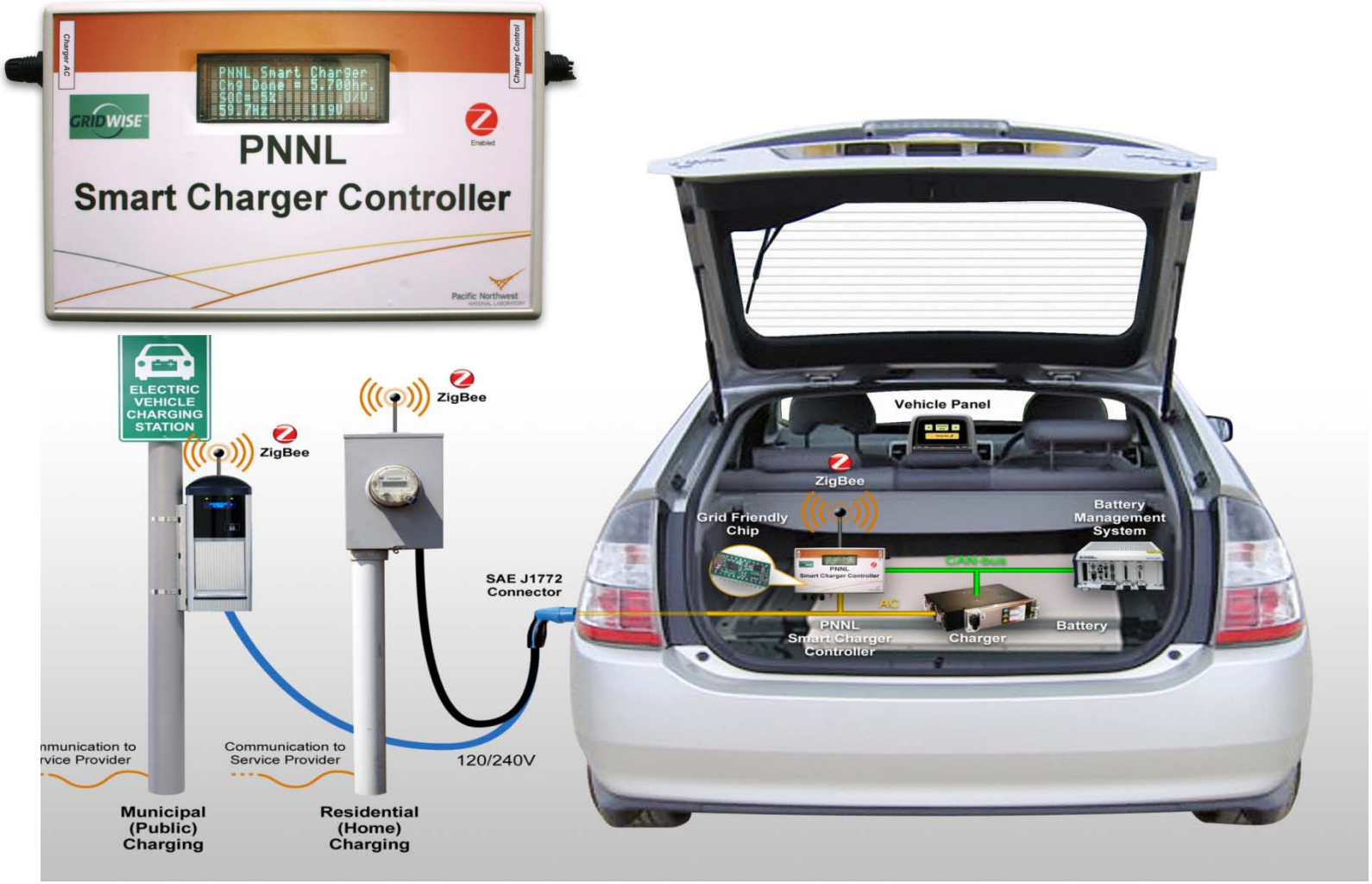


Test Scenario: Send message from vehicle and receive at utility interface

* Yellow highlighted components developed in collaboration with ANL and DTE

Pacific Northwest NATIONAL LABORATORY

FY'09 Accomplishments
(DOE/OE funded FY'09 activity, leveraged for this project)



Pacific Northwest
NATIONAL LABORATORY

Smart Charger Controller Summary

Functionality

- **Price-Based Charging Strategy:**
  optimal-cost start/stop, time of use, critical peak pricing and real-time pricing
- **Regulation Services:**
  detects grid stress and adjusts charging rate.
- **Grid Events:**
  monitor and stop charging if a “grid event” occurs.
- **Grid Services:**
  utility directed reduction or increase in allowable charge rates.
- **Charge Now:**
  override all other charging methods.

Communication Strategy

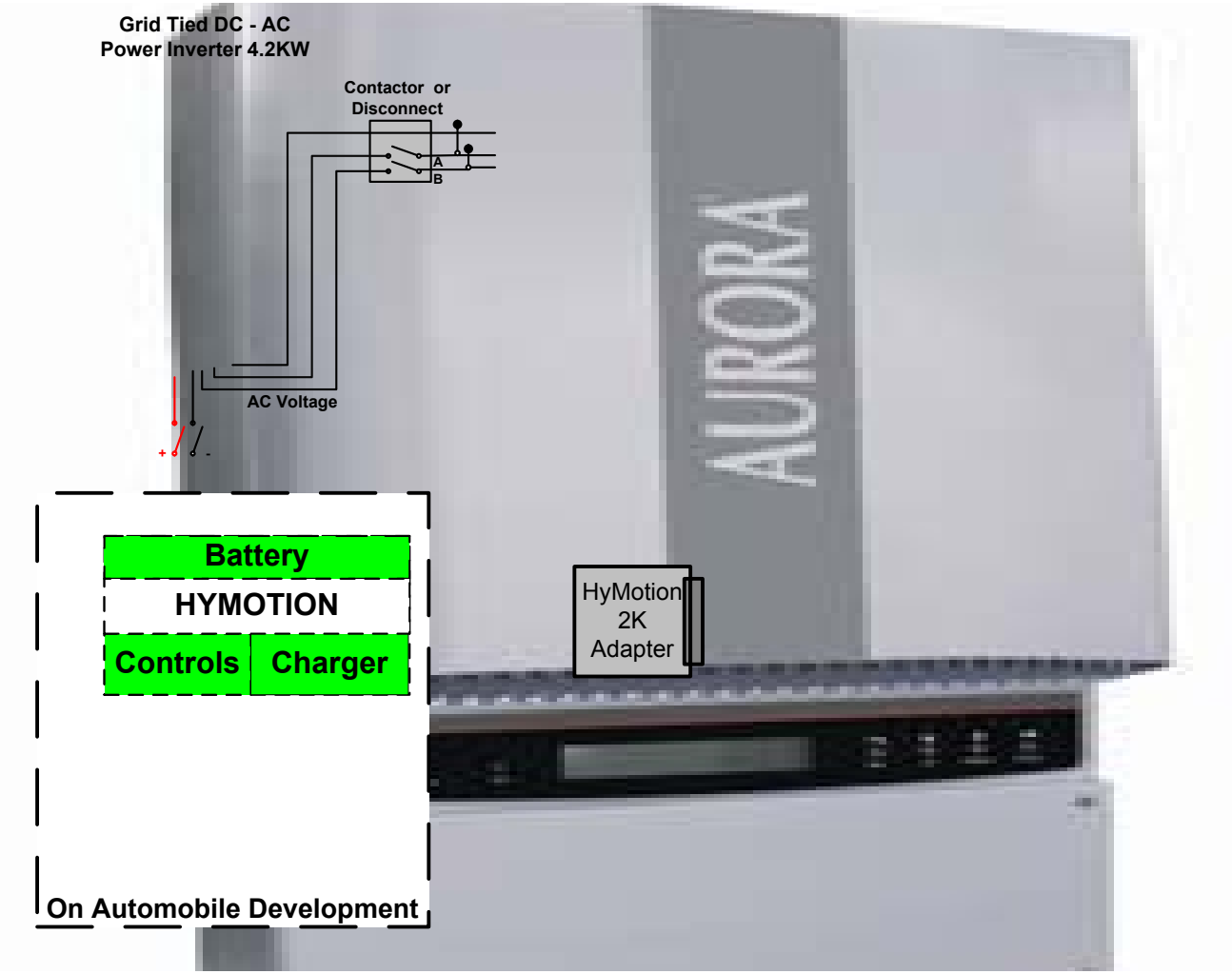
- **Premises/Charging Station:**
  Supported: ZigBee and RS-232;
  Optional: USB,Ethernet, 802.11
- **Battery Charger:**
  Supported: CAN-bus; Optional: USB, RS-232, RS-485, Ethernet, 802.11 and PWM.
- **Battery Management System:**
  Supported: CAN-bus; Optional: USB, RS-232, RS-485, Ethernet and 802.11.
- **Display / Operator Interface:**
  I^2C, SPI, RS-485, CAN-bus, ZigBee.

FY'10 – Progress

- Outreach:
  - Summary report on vehicle-grid communication standards activities completed and published in November 2009.
  - Report on differences between SAE and IEC standards prepared and presented to the NIST PAP-11 working group in April 2010.
  - Grid Interaction Tech Team proposal developed in collaboration with ANL and DTE Energy.
- Technology development
  - Two PLC technologies identified and development work started in March 2010.
  - Charging station, Battery, Charger equipment selected and test bench design completed in April 2010.
  - Functional requirements for Human-Machine-Interface developed and hardware platform identified for touch screen interface.

Pacific Northwest
NATIONAL LABORATORY

Test Bench Block Diagram



Collaborators

- **SAE** – Leading North American Standards development organization developing the electrical connection and communication standards for vehicle-grid communication (J1772, J2836, J2847, J2931)
- **NIST** – US National Standards coordination activity developing the Smart Grid Roadmap and framework for standards and protocols
- **EPRI** – Research and development organization representing the electric utility industry and involved in use case development and communication testing coordination with Ford for SAE and NIST.
- **ANL** – National lab involved in advanced vehicle testing and technology development related to electric vehicle charging, communication and meteorology.
- **DTE Energy** – ARRA recipient of advanced metering technology. Provide metering lab for EVSE to smart meter communication testing
- Industry partners:
  - **Echelon** – Power line communication technology manufacturer
  - **Coulomb** – Electric vehicle charging station manufacturer
  - **Hymotion** – Electric vehicle battery and charger manufacturer

Pacific Northwest NATIONAL LABORATORY

On-going Activities for FY'10

- **April/June 2010**
  - Functional requirements for HMI, software prototype for HMO
  - Testbed development with PLC prototype
  - Vehicle to EVSE integration testing with charger, PLC prototype, J1772 connector and an EVSE
  - J2847/2 Document Development
- **July/Aug. 2010**
  - EVSE to Utility advanced metering infrastructure (AMI) testing with the PLC/ZigBee interface
- **Sept. 2010**
  - Complete integrated testing from Vehicle to EVSE to Meter
  - Final report on communication module development and testing
  - Present results to SAE and prepare input for J2847/J2931 document

Pacific Northwest
NATIONAL LABORATORY

Project Summary

- Codes and Standards for vehicle-grid communication are not fully developed and no standard communication protocols are available yet.
- The communication technology needs to be developed and tested in laboratory setting and tested in demonstration vehicles before performance specifications can be provided to automobile manufacturers.
- This PNNL project addresses critical issues in communications standards development by:
  - Harmonizing use cases from various standards organizations
  - Developing a HMI for charging strategies
  - Testing and validating J2847 communication messages in a PLC prototype
  - Developing a test bench for integrated testing of communication modules

Assumptions and Outcomes

- Assumptions
  - EVSE and vehicle manufacturers will be engaged in project and provide equipment for integrated testing
  - DTE Energy will provide advanced metering and HAN testbed
- Outcome
  - Contribute to SAE and NIST activities to accelerate the development and harmonization of VGC codes and standards
  - PNNL functional testing will assist SAE make the final choice of PLC technology selection

Questions ?

Contact:

- *Michael Kintner-Meyer at (509) 375-4306*
  Michael.kintner-meyer@pnl.gov

or

- *Krishnan Gowri at (425) 273-0190*
  krishnan.gowri@pnl.gov

Pacific Northwest
NATIONAL LABORATORY