

Electric Vehicle Grid Integration - Highlights



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EVGI Relevance – Grid Modernization Alignment

- **10% reduction in economic cost of power outages by 2025**
 - Ability for a vehicle to be a “friendly” element of a microgrid
 - Export power function with grid-awareness
- **33% decrease in cost of reserve margins while maintaining reliability by 2025**
 - Ability of a vehicle/driver to forecast demand, reserve, and flexibility
 - In aggregate, manage local variability of renewable generation
- **50% decrease in the net integration costs of distributed energy resources by 2025**
 - Standardization, standardization, standardization
 - Accelerated testing and demonstrate

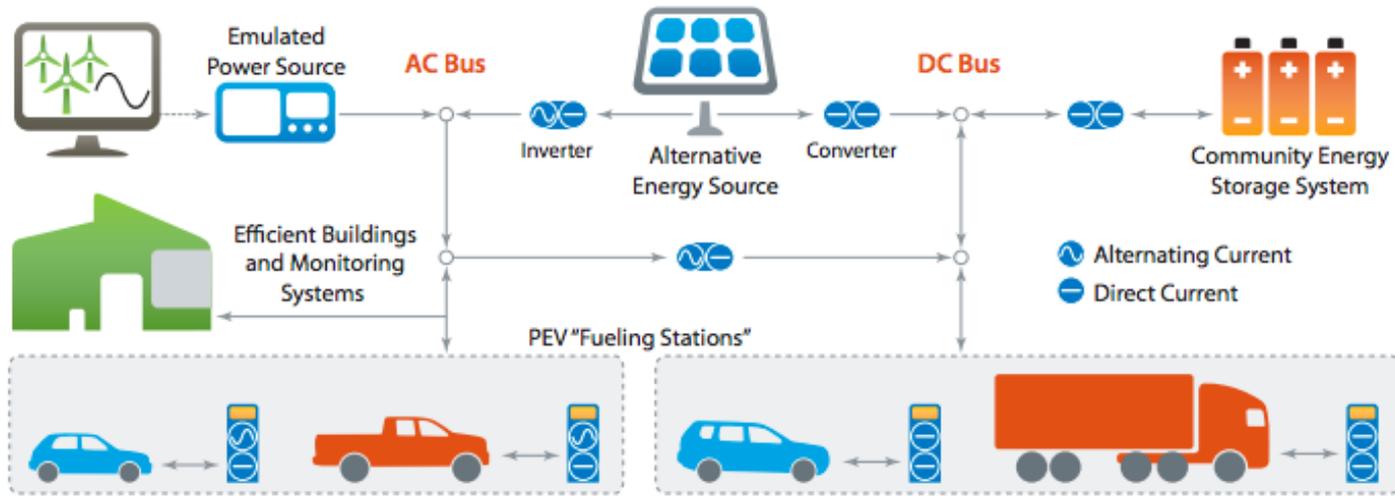
Vehicles Program Relevance

Integration of features that enhance the plug-in electric vehicle (PEV) value proposition

Approach

Electric Vehicle Grid Integration at NREL

Vehicles, Renewable Energy, and Buildings Working Together



Developing Systems Integrated Applications

Managed Charging

Evaluate functionality and value of load management to reduce charging costs and contribute to standards development

Local Power Quality

Leverage charge system power electronics to monitor and enhance local power quality and grid stability in scenarios with high penetration of renewables

Emergency Backup Power

Explore strategies for enabling the export of vehicle power to assist in grid outages and disaster-recovery efforts

Bi-Directional Power Flow

Develop and evaluate integrated V2G systems, which can reduce local peak-power demands and access grid service value potential

Vehicle-to-Grid Challenges

Life Impacts

Can functionality be added with little or no impact on battery and vehicle performance?

Information Flow and Control

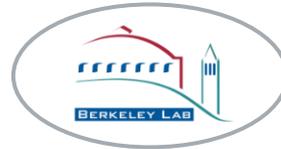
How is information shared and protected within the systems architecture?

Holistic Markets and Opportunities

What role will vehicles play and what value can be created?

Technical Accomplishment and Progress

Multi-lab EV SG Requirements Study Completed



- Leverage the expertise of multiple national laboratories to evolve the implementation scenarios and requirements for PEV integration with smart grid systems
- Produce a guidance document for DOE that details PEV grid integration system implementation methods and remaining research gaps
- Report Published May 2015



Multi-Lab EV Smart Grid Integration Requirements Study

Providing Guidance on Technology Development and Demonstration

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National Renewable Energy Laboratory

K. Hardy, B. Chen, and T. Bohn
Argonne National Laboratory

J. Smart, D. Scofield, and R. Hovsopian
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Oak Ridge National Laboratory

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Pacific Northwest National Laboratory

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Technical Report
NREL/TP-5400-63963
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Technical Accomplishment and Progress

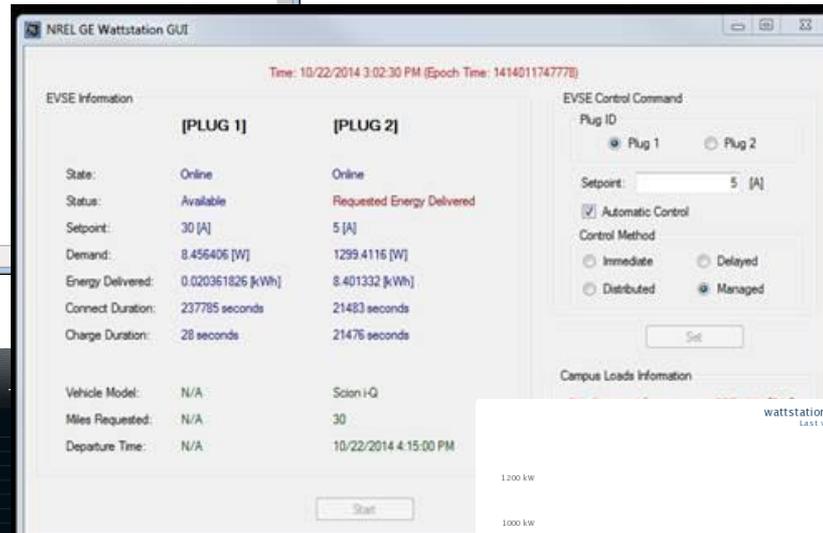
Charge Management System Integration

Driver Entries

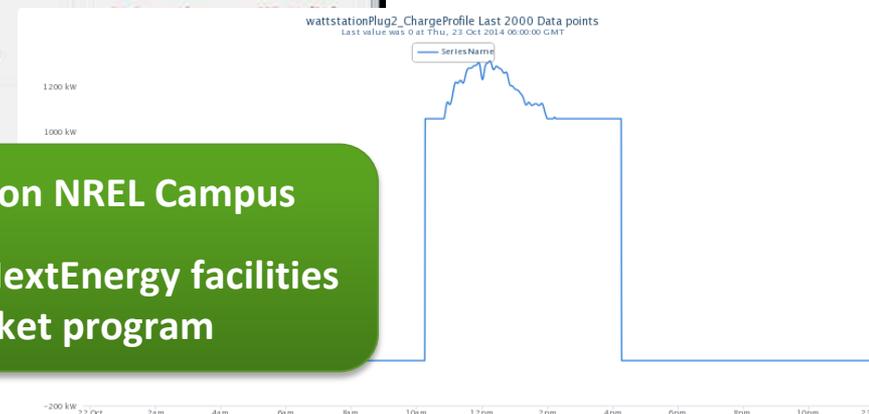
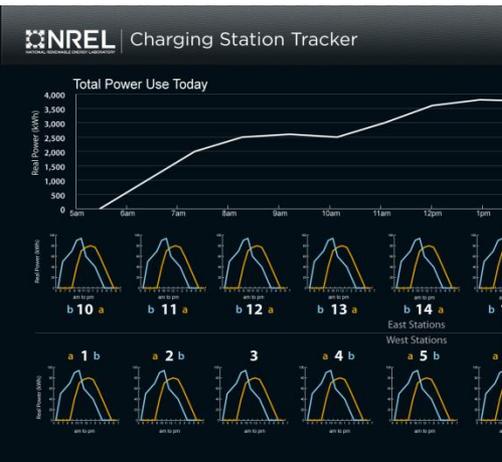


Source: Tony Markel, NREL

Building and Renewables Integrated Management Tool



Scheduled Charge



Initially – Test and Demo on NREL Campus
Next step – Application to NextEnergy facilities through Tech to Market program

Technical Accomplishment and Progress

Mini-E with Export Power Capability

- **19 kW of AC export power**
- **Communication between electric vehicle supply equipment (EVSE) and vehicle supports enhanced features**
- **Central management aggregating vehicle demands/resource and EVSE attributes to meet driver and grid expectations**
- **Completed much of IEEE 1547.1 test procedures – ensures grid safe operations**



INTEGRATE RFP Awardee – New Project kickoff May 2015

Work will include detail standards evaluation for both light duty and heavy duty vehicle grid integration systems opportunities

Technical Accomplishment and Progress

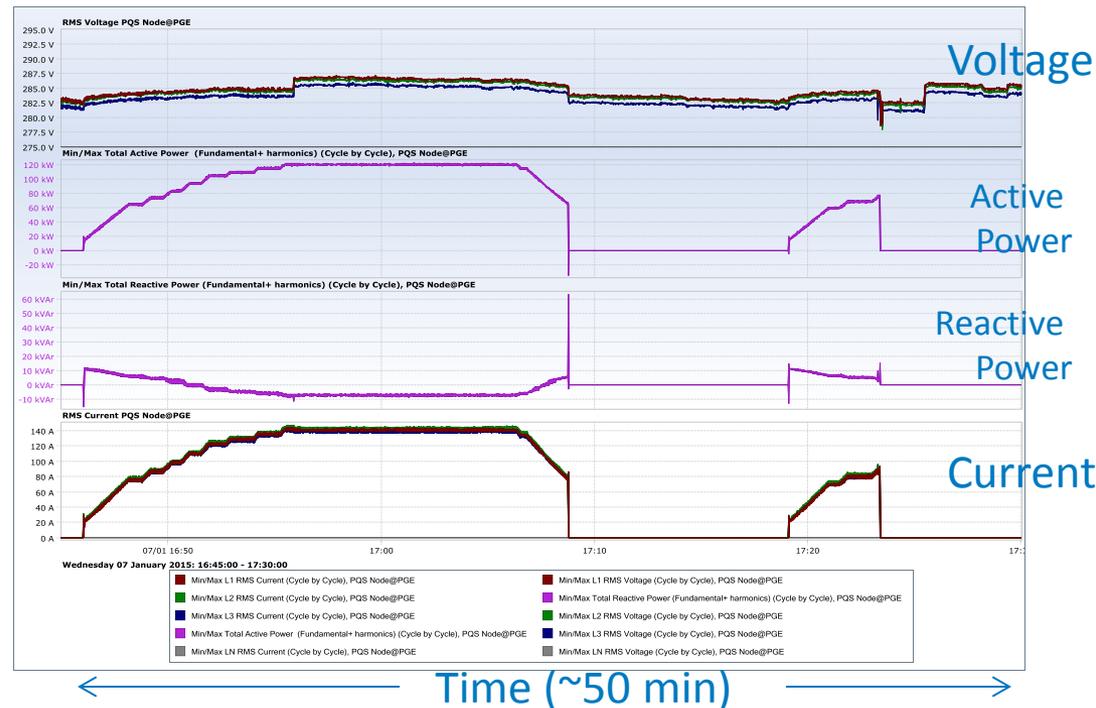
PGE/EDI V2G Truck – Electrical Characterization



Photo by Dennis Schroeder, NREL 32537

PF – power factor
PU – per unit

- Provided test support for EDI to perform PF control tuning of inverter software
- Islanded power-up testing utilizing load banks
- Demonstrated grid synchronized export at 120 kVA
- Completed export tests from 0.97 to 1.03 PU grid voltage using grid simulation.
- Initial results of testing to PGE support RFP development



Technical Accomplishment and Progress

ESIF Vehicle Grid Integration Capabilities Development

Successfully integrated operations across 3 ESIF laboratory spaces to research EV, PV, and Grid power quality challenges

