PNNL-SA-75999

Smart Charger Technology Development

Analysis and Development

Presented by:
Frank Tuffner
Pacific Northwest National Laboratory

Smart Grid R&D Peer Review
November 4, 2010
Golden, CO

Project Team:
Michael Kintner-Meyer, *PI*
Krishnan Gowri
Richard Pratt
Nathan Tenney
Frank Tuffner

Grid Capabilities for the Electrification of Transportation

Goals and Objectives

GOAL:

- Assure grid can support electrification of transportation
- Assure that EVs/PHEVs will not create new peaks (locally or regionally) or electricity prices will not support large adoption of EVs/PHEVs

Objectives:

- Assess grid benefits and impacts of electrification of transportation
- Technology demonstration
- Actively engage in codes and standards

Funding Summary ($K)

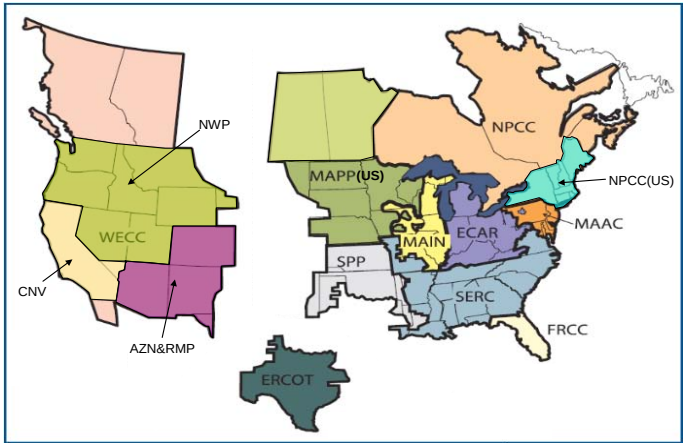
FY09	FY10	FY11
$350	$500	$500

Technical Scope

1. Perform assessment
   - Impacts of PHEVs on bulk power system
   - Benefits of PHEVs for integrating renewable energy resources
2. Demonstrate Grid Friendly™ charging technologies
3. Work with Standards Committees to Advance Vehicle Electrification

Assessment: Impacts of PHEVs on bulk power system

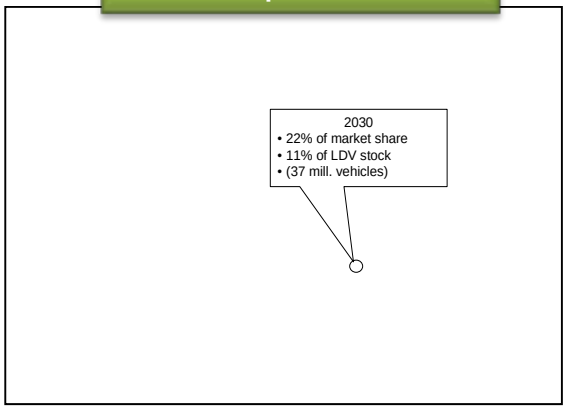
- Questions to answer:
  - What are the impacts of a plausible penetration of PHEVs on the US electricity production cost in 2030?
  - What are the impacts on the CO_2 intensity at a regional level?



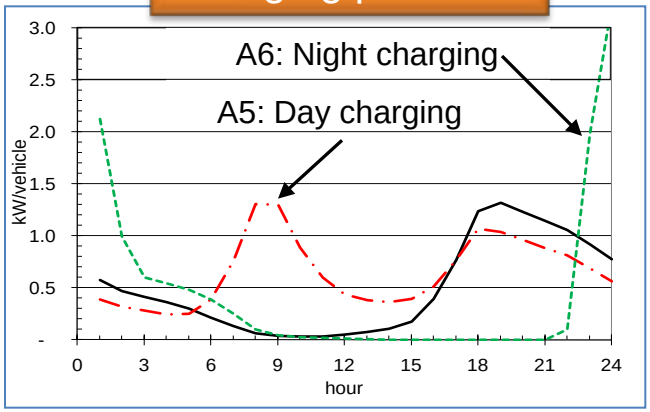
- Methodology
  - Utility-grade production cost model PROMOD
  - AEO 2009 power plant additions (2008-2030)

- Assumptions
  - Market penetration
    - 22% of annual sales
    - 37 million vehicles
  - Chargers
    - 50% level 1 (120 V)
    - 50% level 2 (240 V)

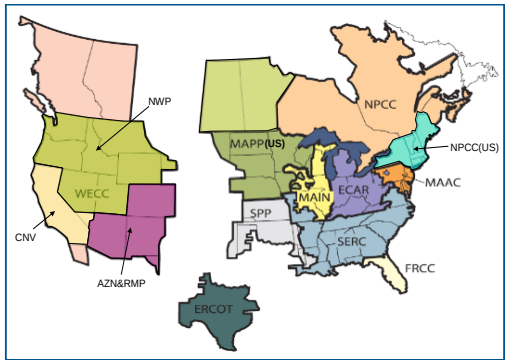
Market penetration



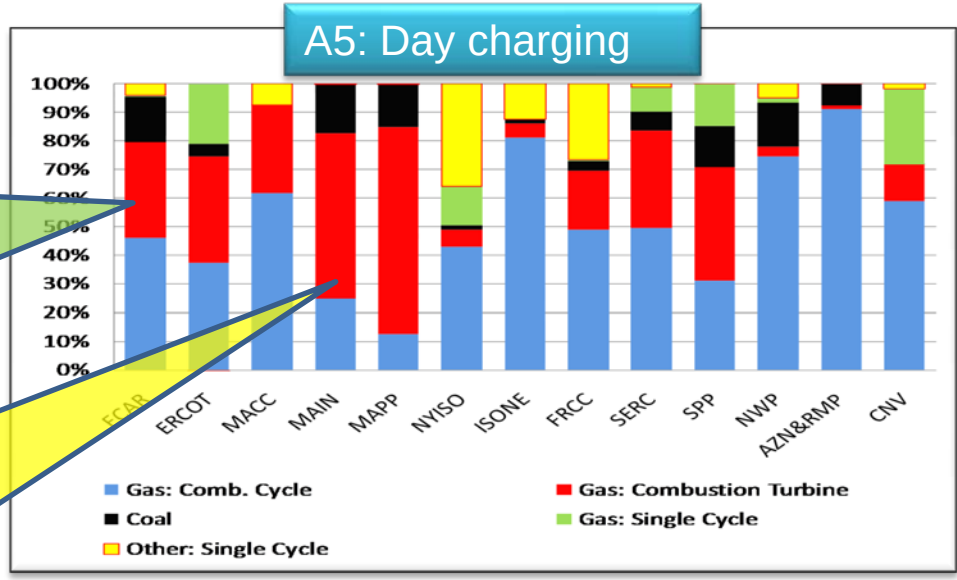
Charging profiles

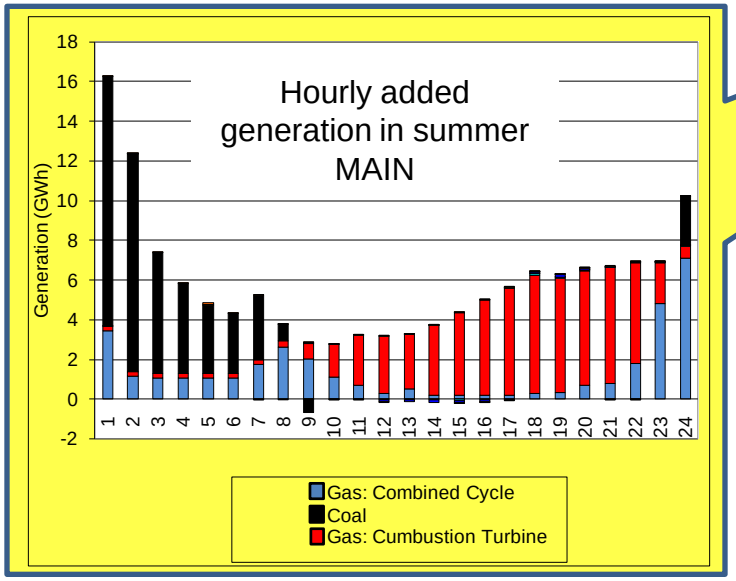


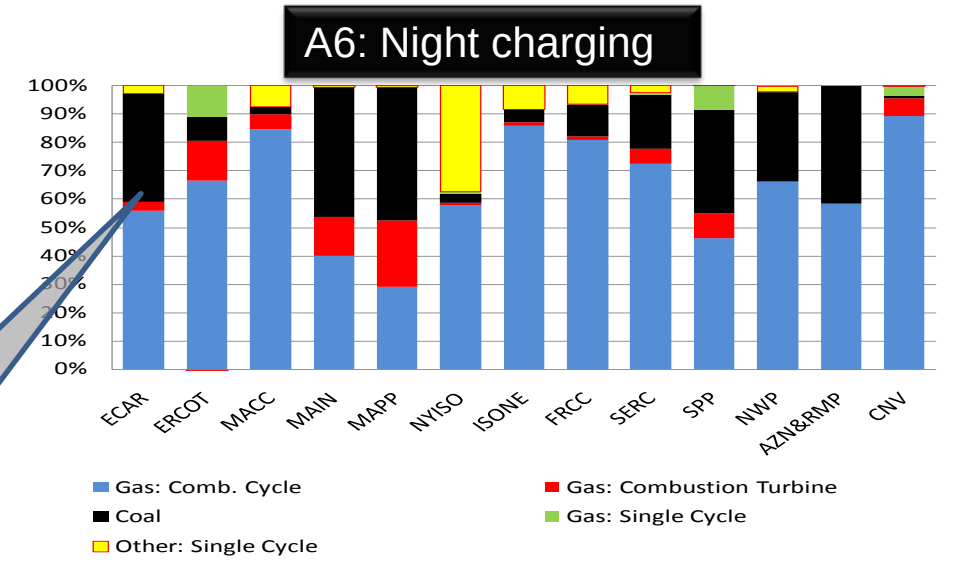
Assessment Results: Added generation mix depends on the regions and the time of day when vehicles are charged



Natural gas primary fuel for day-charging







Significant coal resources available for night-charging

Assessment: Impacts of PHEVs on Bulk Power System

Cost impacts

- Day-charging requires an increase twice that of night-charging
  - Day-charging – 8%
  - Night charging – 2-3%
- Cost impacts (%) are high in
  - High-cost regions (CNV, ISONE)
  - And in regions with fully utilized low-cost hydro resources (NWP)

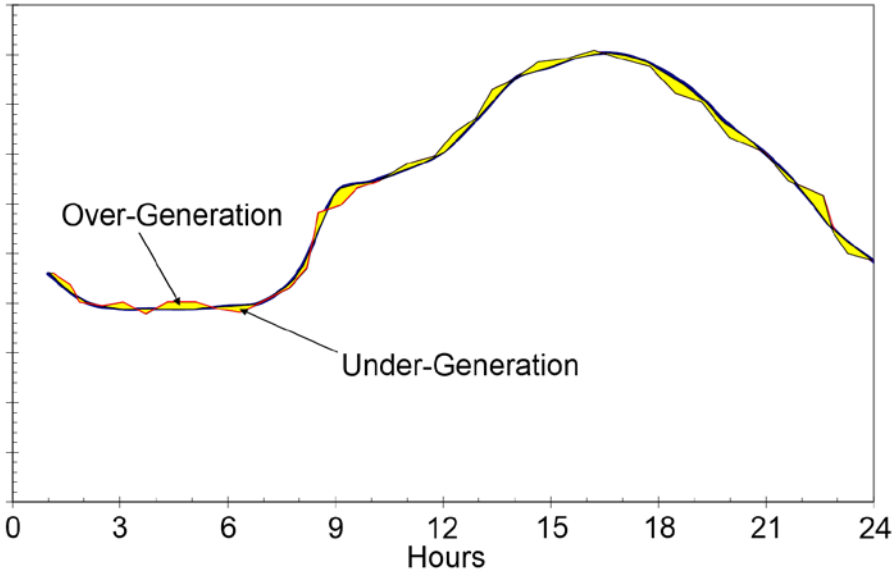
Emissions impacts

- Regions with clean generation (CNV, NWP) will likely increase emissions intensity (tons CO_2 per MWh) because vehicle load is met with fossil generation
- Midwestern regions (ECAR, MAIN, MAPP, etc.) show a slight reduction because of the additional natural gas generation

Economics suggest to charge at night, resulting in about ½ of the cost increases compared to day-charging

Assessment: Benefits of PHEVs for Integrating Renewable Energy Resources

- Question to answer:
  - How many electric vehicles are necessary to meet new balancing requirements for integrating wind generation?
- Methodology
  - MATLAB simulation of vehicle population to meet balancing requirements
- Assumptions
  - Basic assumptions from PNNL report on storage integration into NWPP (WA, ID, MT, OR, UT)[1]
  - Wind capacity to increase from 4.2 to 14.4 GW (RPS of 12%)
  - Requires 1.8 GW up and 1.8 GW down for intra-hour balancing
  - NHTS 2001 travel patterns[2]



Number of vehicles performing V2G half to meet new balancing requirements

BEV 110		
	Home Only	Home & Work
Number of Vehicles	62.5 million	5.1 million
% of Present Vehicle Stock	379%	31%

Home charging alone will not meet regulation demand!

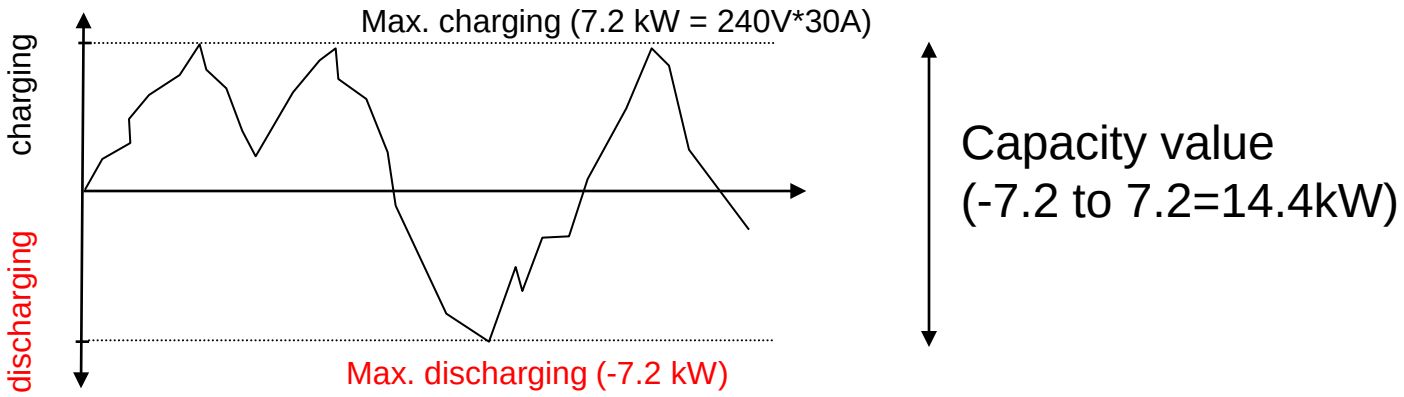
[1] Source: PNNL-19300. Energy Storage for Power Systems Applications: A Regional Assessment for the Northwest Power Pool (NWPP)

[2] Source: Department of Transportation: 2001. National Household Travel Survey

Assessment: Load can provide balancing/regulation services (V2G half) – Definition and value

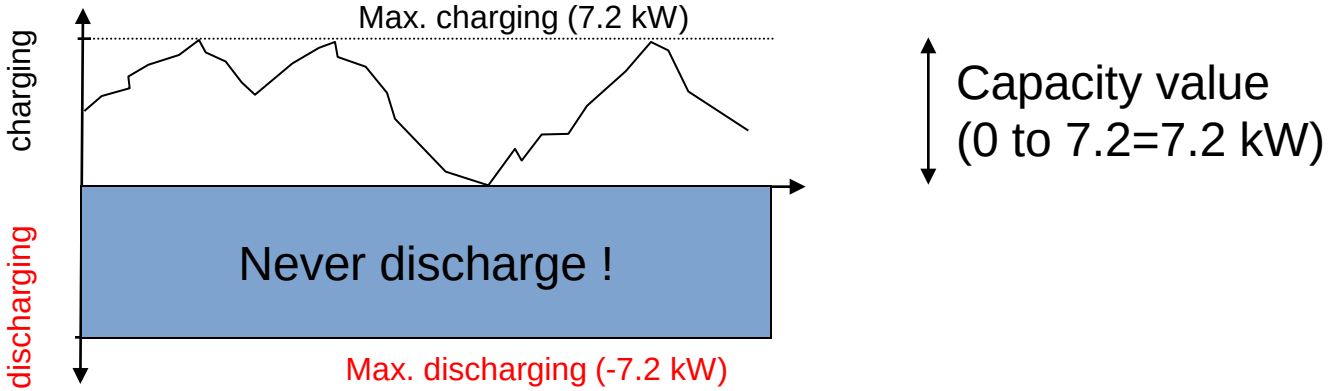
V2G

- provides regulation service as a load and generator
- requires charging and discharging according to grid operators signal



V2G half

- provides regulation service as a load only
- requires only charging
- modulates charging



Attribute of "V2G half":

- provides regulation service with ½ the capacity value of V2G
- however, less than half the cost because
  - no interconnection gear with grid necessary because no electricity goes back into grid
  - removes any uncertainties regarding battery life reduction because of extra cycling

Demonstrate Grid Friendly™ Charging Technologies

- Question to answer:
  - What are the implementation issues of the grid friendly charging strategies?
- Implementation
  - Grid Friendly Charger Controller
    - PNNL Test Vehicle
    - Coulomb Charging Station
- Scope
  - Demonstrate Grid Friendly Charging
    - Strategies
      - Price-based
      - Time-of-use
      - Regulation services (V2G half)
    - Communications
      - Utilize emerging SAE standards
  - Collaborate with ANL and NREL
  - Collaborate with ARRA Projects

Work with Standards Committees to Advance Vehicle Electrification

- Question to answer:
  - How can we help ratify EV standards sooner?
- Committees
  - NIST
    - PAP 11 Work
      - Examine standards and use cases between SAE and IEC ISO
        - Highlight similarities and differences
        - Look for gaps in the standards
  - SAE
    - Writing and revising code and standards definitions
    - Analysis of differences and gaps between SAE and SEP 2.0
    - Follow up of analysis to ensure challenges addressed
  - Grid Interaction Tech Team (GITT)
    - Address technology deployment issues
    - Communications between vehicle and utility
      - HMI – identifies messages between vehicle and utility
      - PLC Communications – prototype implementation

Impacts

- Assessment
  - PNNL analyses widely cited. It informed Washington State Legislature and NW Power and Conservation Council, WGA, FERC commissioner
  - Paper published in EVS25 on bulk power impacts
  - Report on renewable energy resource integration using EV/PHEV forthcoming
  - IEEE paper in progress
- Demonstrate Grid Friendly Charging Technologies
  - Creation of platform for implementing and testing emerging standards
  - Collaboration with other national laboratories – ANL and NREL
  - Collaboration with other ARRA participants
    - Promote electrification of transportation
    - Demonstration of charging strategies
  - Grid Friendly Charger Controller licensed to ZAP, a California Vehicle Company
- Work with Standards Committees to Advance Vehicle Electrification
  - Influenced standards
    - PAP 11 document to SGIP ballot
    - Provisions to ISO IEC standard for ballot
  - Invited speaker at NY PUC to report on standards
  - UCLA EV forum – potential collaboration for testing

Path Forward

- Renewable integration study on a national scale
- Investigate “drive cycles” of vehicle batteries for grid services
- Work with utilities for further demonstration and improvement of Grid Friendly Charger Controller
  - DTE Energy demonstration of end-to-end communications
  - Seattle City Light investigation of vehicle impact
- Continue work with SAE and NIST on emerging standards
- Continue participation in DOE’s Grid Interaction Tech Team to examine electric vehicle to grid communications

Questions?

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