NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Mitigation of Vehicle Fast Charge Grid Impacts with Renewables and Energy Storage



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Overview

Timeline

Project Start Date: 10/1/11
Project End Date: 9/30/12
Percent Complete: 80%

Budget

Total Project Funding: $120k
DOE Share: 100%
Contractor Share: 0%

Funding Received in FY11: $0

Funding for FY12: (see notes for details)

Barriers

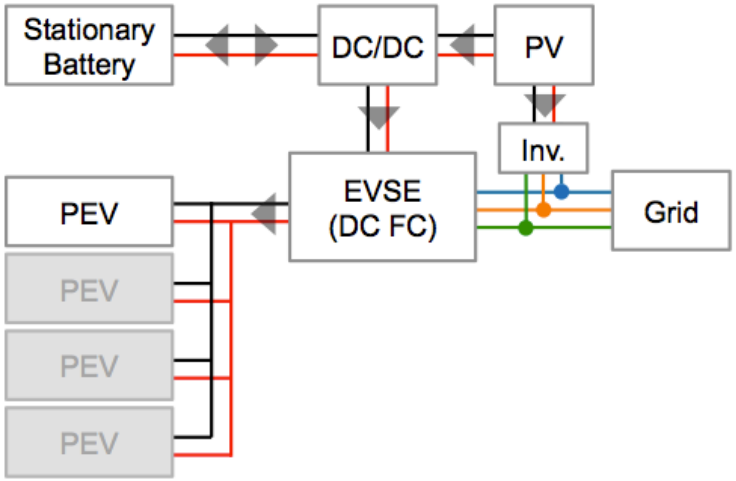
- **Barriers addressed**
  - Uncertainty of fast charger usage/market demand
  - Electricity demand spikes during usage

Partners

- Interactions/ collaborations
  - Aerovironment, Inc.
  - Mitsubishi North America

Relevance/Objective(s)

- Identify fast charge system benefits as aligned with VTP goals
  - Add efficient, electric transportation miles cost-effectively (Time = Money)
  - Enable competitive performance from all-electric vehicles
    - long-distance travel fueled with renewables
- Address fast charging concerns / barriers
  - Minimize power spikes on the local grid
  - Avoid exacerbating peak demand
  - Reduce system costs
  - Quantify battery utilization



Milestones

Date	Milestone or Go/No-Go Decision	Status
9/30/12	**Task 1: Reduce Grid Impact of PEV Charge Methods** *Develop unique vehicle-grid integration models and report on the results of analysis of grid impact reduction strategies of PEVs using wireless and fast charge methods.*	On-Track

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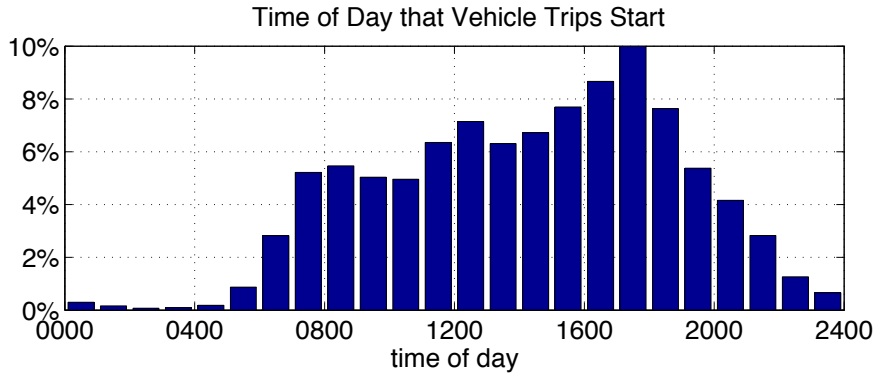
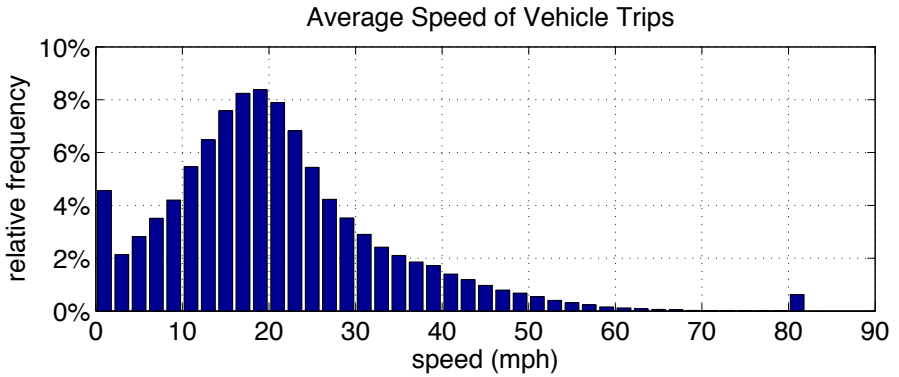
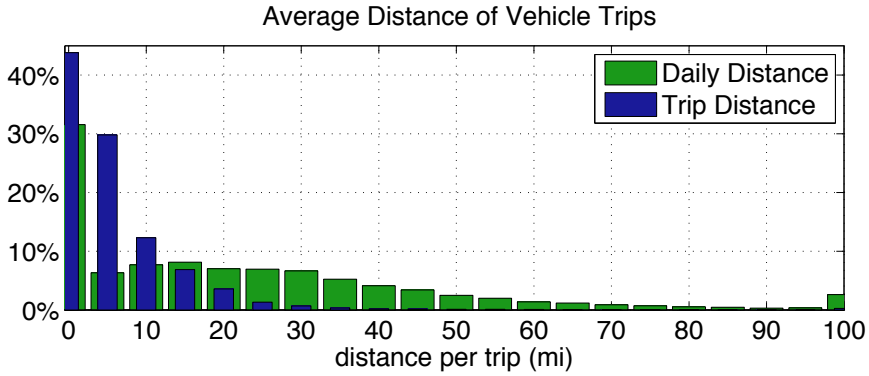
Approach/Strategy

- Analyze real-world travel patterns for charging needs
  - Utilize Puget Sound Regional Council *Traffic Choices Survey*
    - GPS tracking of 445 vehicles over 3-month control period
    - Include all daily trips (~150,000 total)
  - Model each trip with an all-electric vehicle (EV)
- Assume home charging occurs most often (with occasional "forgetting to plug in")
- Model fast charge when battery is empty
- Delay fast charge when station ports are in-use
- Calculate total load to grid
- Compare with real-world solar power profile from PV array







Assumptions

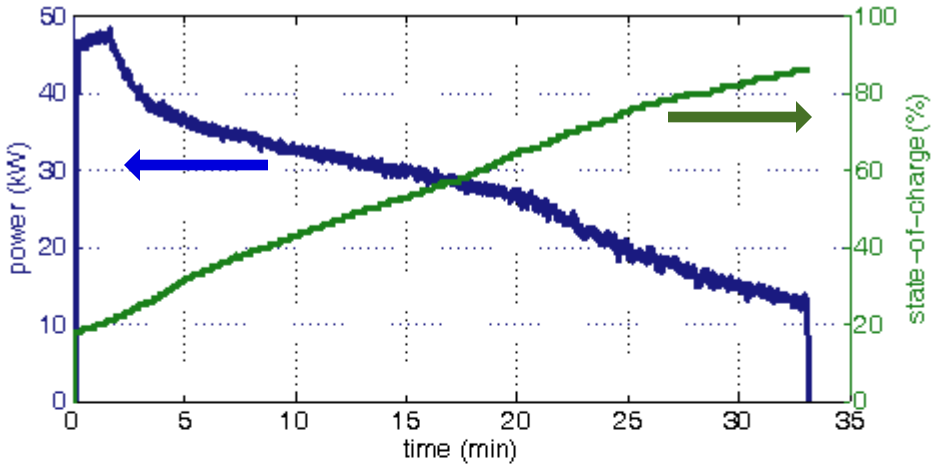
Assumption	Value	Units/Notes
Vehicle State-of-Charge Window	80%	*Min: 10%, Max: 90%*
Vehicle Energy Consumption Rate	300	Wh/mi
Forgetfulness Factor	10%	*User forgets to plug-in roughly 1 in every 10 days of driving*
Home Charge Power	3.3	kW
Fast Charger Efficiency	85%	*Source-to-Battery*
Fast Charger Power (max)	50	kW
Fast Charger Max State-of-Charge	80%	*Charger cuts off at 80% SOC*
Stationary Battery State-of-Charge Window	75%	*Min: 15%, Max: 90%*

- Home charging begins at midnight if the car is stationary and the driver doesn't 'forget'
- Fast charges occur only secondary to home charging when, in the middle of a trip, the battery approaches minimum SOC

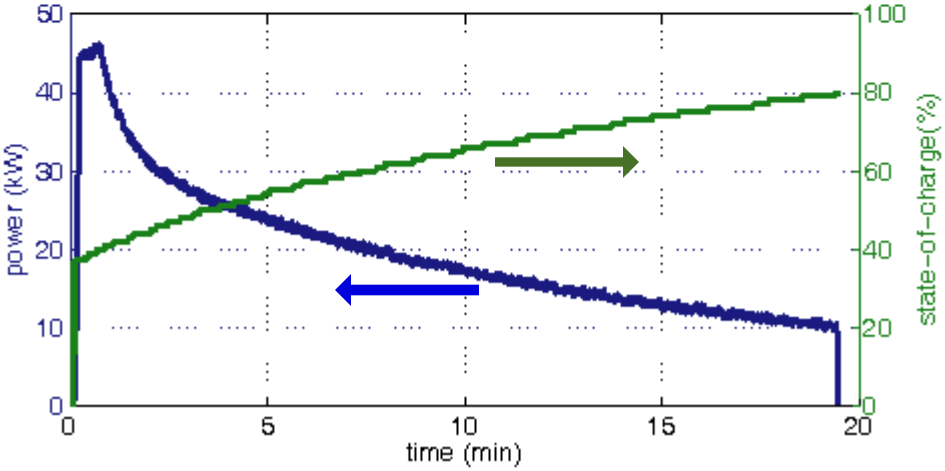
Technical Accomplishments and Progress

- Multiple fast charges of both CHAdeMO compliant vehicles monitored at NREL Vehicle Testing and Integration Facility (VTIF)
- Real-world traffic patterns and solar data gathered to capture system variability
- Simulation developed to assess impacts of multiple vehicle adoption rates and station configurations
- Design of Experiments conducted to size PV and storage needed to mitigate grid impacts from fast charge peak demand

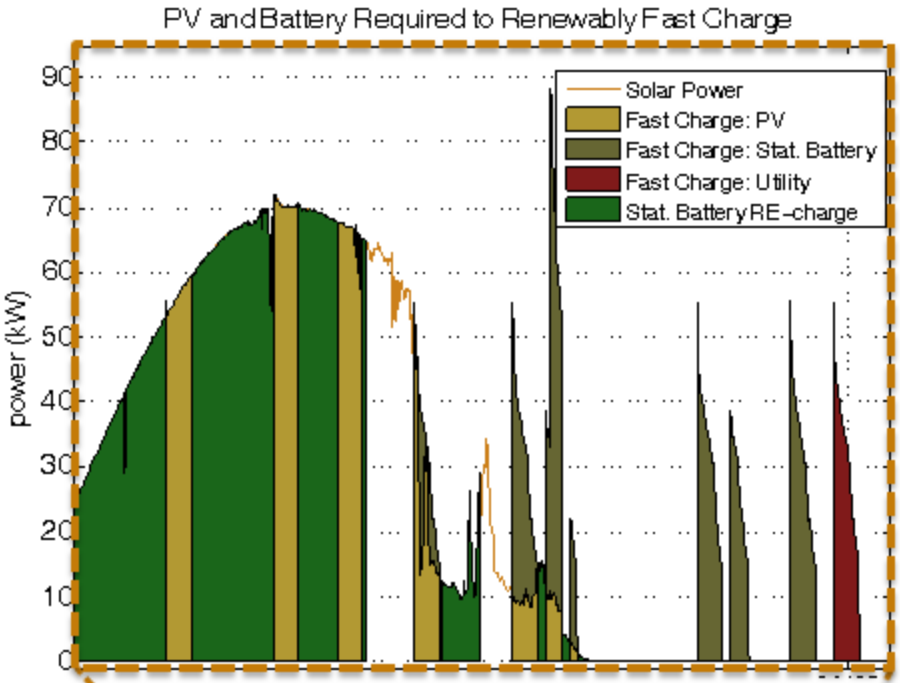
Leaf Fast Charge Profile

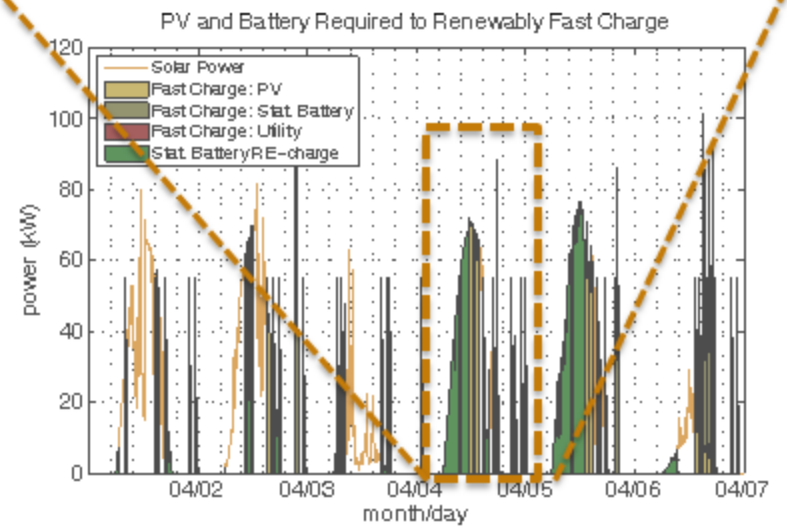


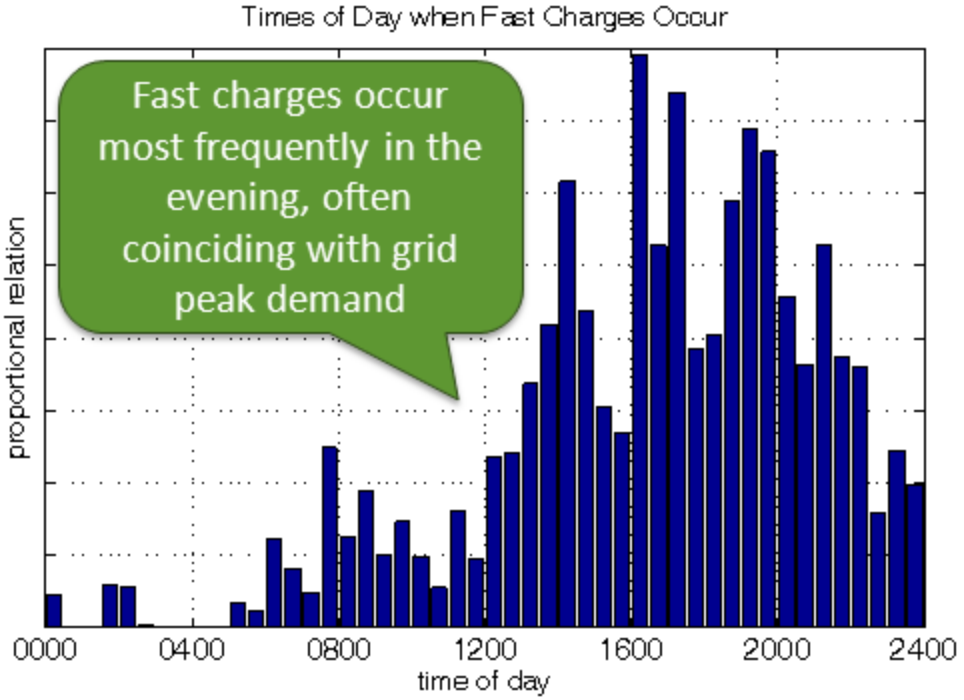
i-MiEV Fast Charge Profile

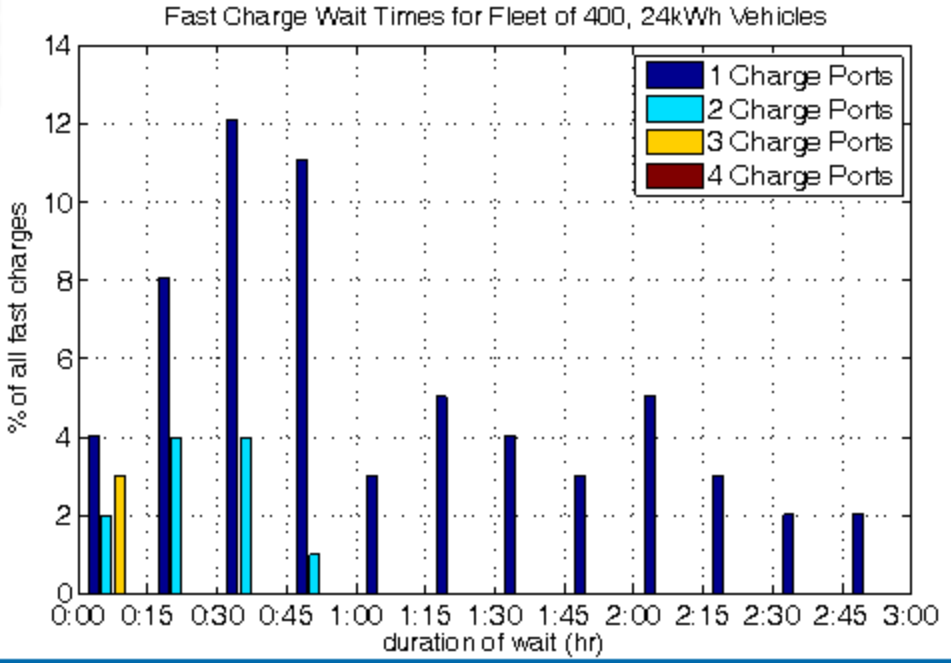


Study Findings



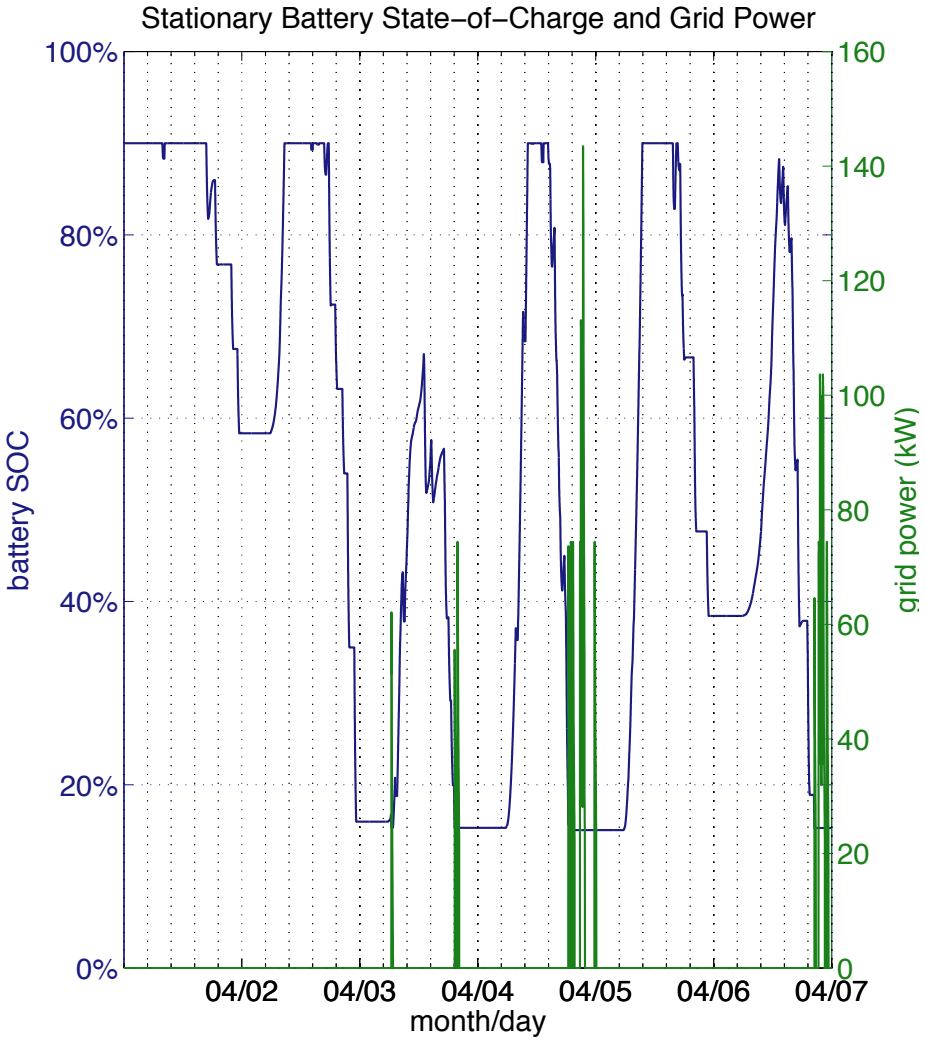


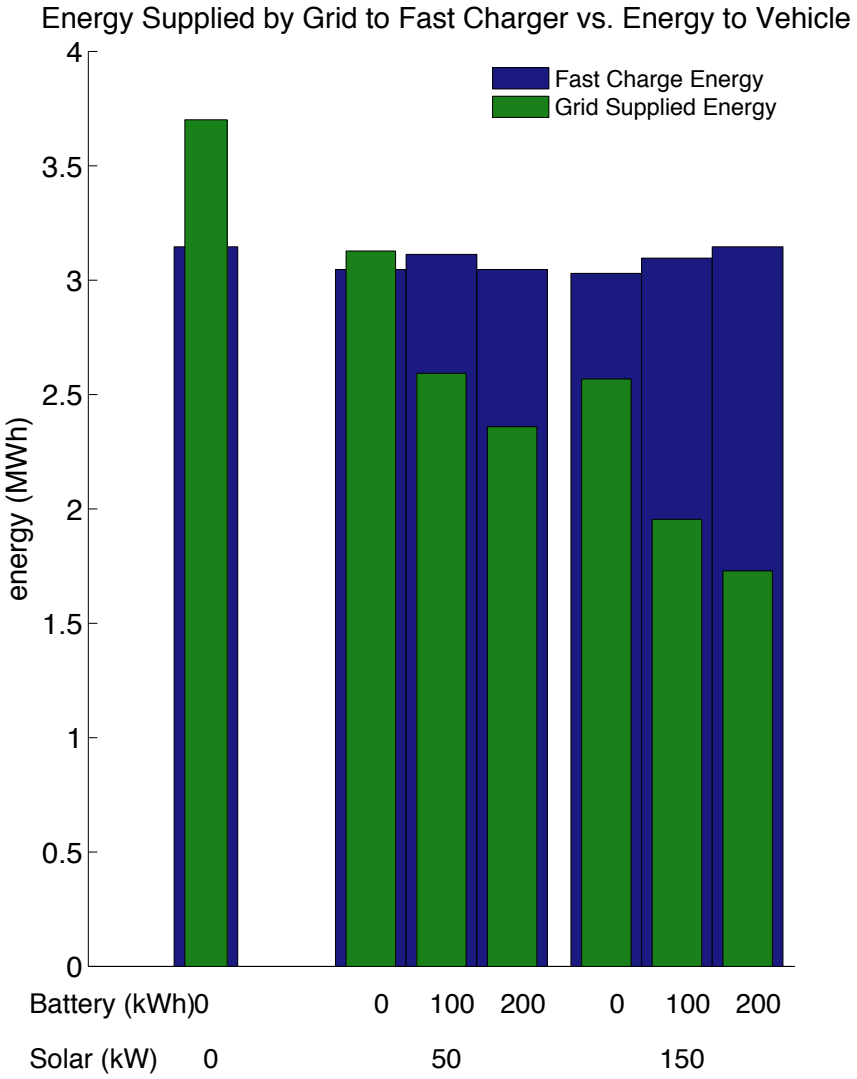




Grid Impact Mitigation

- Stationary battery and PV added to system analysis





Collaboration and Coordination

- Brought in various sets of equipment:
  - AeroVironment™ AV50 Fast Charger
  - Mitsubishi i-MiEV
  - Nissan Leaf
- Paper presented at EVS 26 communicating usage, benefits, and potential concerns
  - If users treat Fast Charge stations like conventional fueling stations, high utilization may exacerbate local peak electricity demand.
  - Identified concern mitigation with PV and Stationary Battery

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Proposed Future Work

- Initiating follow-up paper to capture fast charger business case
  - Including installation costs, permitting costs, energy bills, and consumer fees
- Continuing investigation of DC charging and communication standards
  - Integration of SAE J2847™ with J1772™ (and combo configuration)
- Developing and testing charge management strategies


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NREL PIX #19757