Project ID#ARRAVT071

2012 DOE Vehicle Technologies Annual Merit Review
Advanced Vehicle Electrification & Transportation Sector Electrification

PI: Greg Cesiel
Presenter: Sandra Monterosso
General Motors LLC
May 17, 2012

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

OVERVIEW

Timeline

- Start: March 2010
- Finish: Sept 2013
- 62% Complete

Barriers

- Cost of the advanced technology for electric vehicles
- Availability of utility infrastructure to support electric vehicles

Budget

- $61 M project
  - $30.5 M DOE
  - $30.5 M GM

Partners

- DOE
- EPRI
- Utilities:
  - Austin
  - DTE
  - Dominion
  - Duke
  - PGE
  - PEPCO
  - Progress
  - Southern Cal Edison
  - SMUD

OBJECTIVES

- **Develop electric vehicle with extended range advanced propulsion technology and demonstrate a fleet of vehicles to:**
  - Gather data on vehicle performance and infrastructure
  - Understand impacts on commercialization
- **Accomplished:**
  - By leveraging the unique telematics of OnStar, standard on all Chevrolet Volts, to capture the operating experience that shall lead to a better understanding of customer usage
  - Through customers in several diverse locations across the United States
  - Installation, demonstration and interaction with charging infrastructure

RELEVANCE

- **The Chevrolet Volt introduces new vehicle technologies powered by domestically produced alternative fuels that will:**

- Reduce our dependence on petroleum
  - 25 to 50 mile electric vehicle range
  - Increases use of domestic resources

- Decrease greenhouse gas emissions
  - No tailpipe emissions while operating in EV mode
  - Provides additional options, including renewables, for fueling vehicles

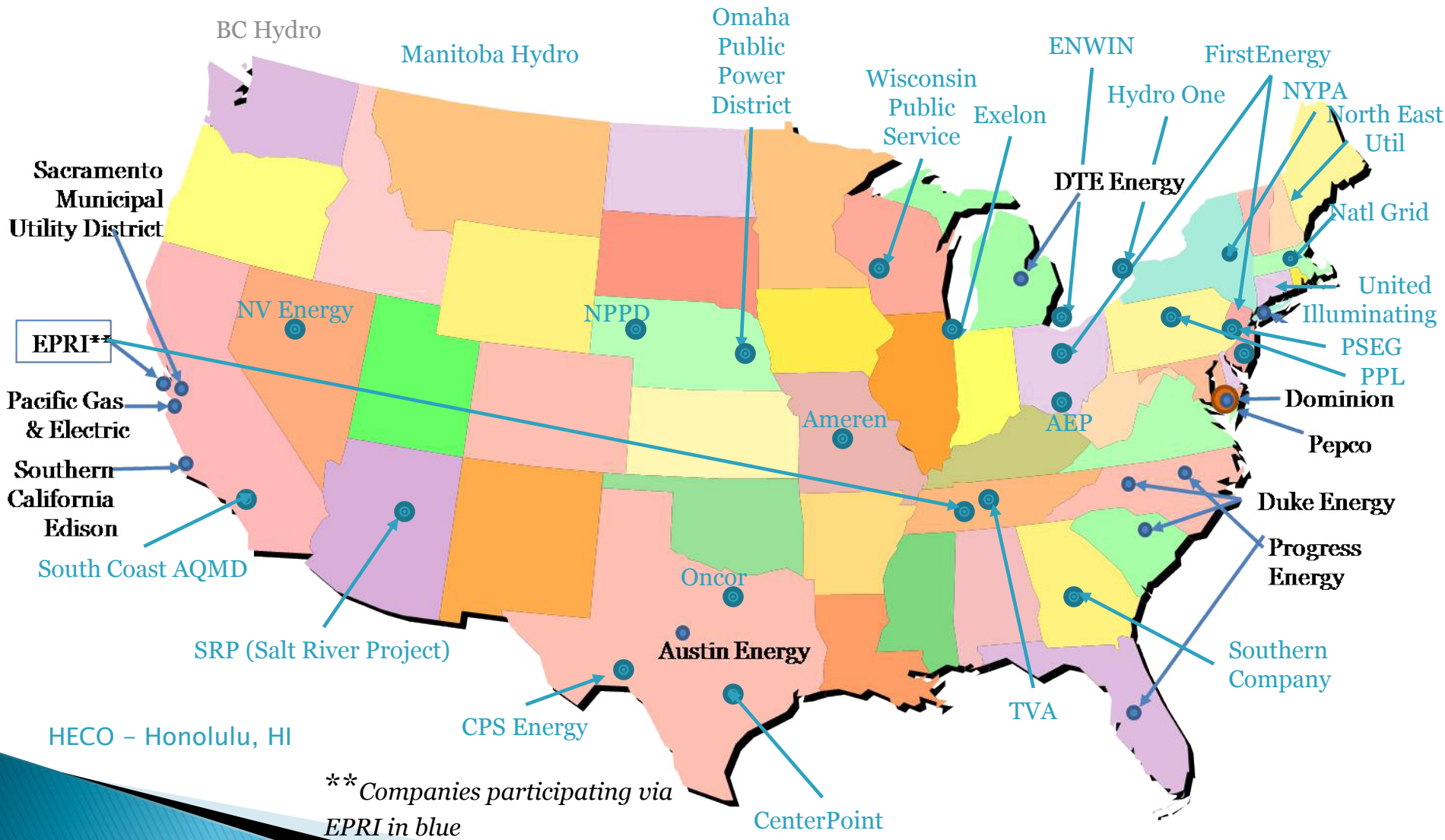
- Maintain skilled jobs required to sustain U.S. technical leadership
  - Vehicle and battery engineering

- **Vehicle usage and typical operation needs to be understood to**
  - Accelerate the vehicle usage learning curve
  - Achieve mass market penetration

MILESTONES

- **First aggregate data available on INL Website**
  - Second quarter, 2011
- **Secondary use of batteries for grid storage demonstration**
  - Fourth quarter, 2011
- **146 vehicles deployed to the utilities for demonstration**
  - Between Q2 and Q4 2011

UTILITY DEMONSTRATION LOCATIONS



***Companies participating via EPRI in blue*

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

TECHNICAL ACCOMPLISHMENTS

- **Validation of key vehicle components and subcomponents**
- **Completion of all FMVSS and compliance testing**
- **Volt's smartphone application by OnStar developed to help drivers stay connected to their Volt 24/7 with features including:**
  - Scheduling or initiating charging, displaying charge status and level
  - Getting status reports such as how much electric driving range is available?
  - Warming or cooling the vehicle before getting in
  - Sending text messages to remind drivers to plug in
  - Showing MPG, EV miles and miles driven for last trip and lifetime
- **Efficiency gauge and green leaf screens developed to guide the operator to drive more efficiently**

APPROACH – Development & Deployment

- **Chevrolet Volt is an electric vehicle with extended range capability**
  - Powered by electricity all the time
  - Battery provides 25 to 50 miles of driving, using no gasoline = no tail pipe emissions
  - Battery can be charged with grid energy
  - Unlike purely electric vehicles, drivers can take long trips as total vehicle range is up to 379 miles when the onboard generator engine is utilized

- **Volt was developed and validated by General Motors with shipment of vehicles to customers starting December 13, 2010**

- **Initial Volt launch was in key markets**
  - Washington D.C., Michigan, California, Texas and New York

- **Utilities are installing charging stations in residential houses, workplaces and public areas**

APPROACH - Data

Data has been collected on vehicles since Fall 2010

- **Demonstration data will be used to:**
  - Better understand customer expectations
  - Evaluate how well the system addresses customer needs
  - Focus upon understanding operating costs and the customer value equation
  - Understand driver behavior effects on fuel economy
- **Charging and vehicle usage data will be critical for making informed decisions about infrastructure development and integration into smart grid networks**
  - Charging behavior (home verses public)
  - Level 1 (120 volt) vs Level 2 (240 volt) experience
  - Installation of charging infrastructure
- **Information gathered during this period will support the next generation battery designs and infrastructure while expediting learning cycle progression**

APPROACH - Data

Chevrolet Volt Vehicle Demonstration

Fleet Summary Report

Number of vehicles: 135

All operation

Overall gasoline fuel economy (mpg)	68.6
Overall AC electrical energy consumption (AC Wh/mi)	175
Average Trip Distance	12.2
Total distance traveled (mi)	272,366
Average Ambient Temperature (deg F)	54.1

Electric Vehicle mode operation (EV)

Gasoline fuel economy (mpg)	No Fuel Used
AC electrical energy consumption (AC Wh/mi)	368
Distance traveled (mi)	129,389
Percent of total distance traveled	47.5%
Average driving style efficiency (distance weighted)[1]	75%

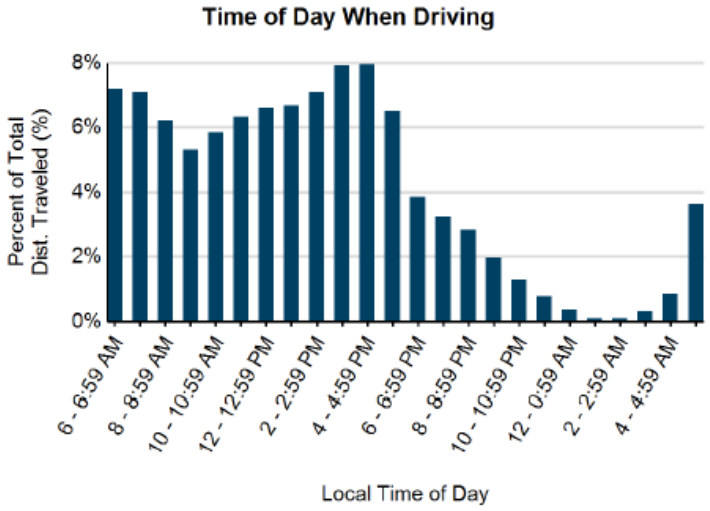
Extended Range mode operation (ERM)

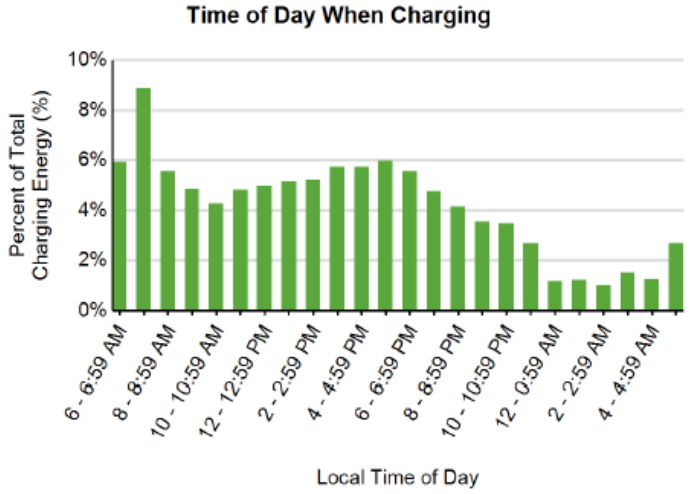
Gasoline fuel economy (mpg)	36.0
AC electrical energy consumption (AC Wh/mi)	No Elec. Used
Distance traveled (mi)	142,977
Percent of total distance traveled	52.4%
Average driving style efficiency (distance weighted)[1]	77%

Reporting period: October 2011 through December 2011

Number of vehicle days driven: 4,746

http://avt.inel.gov/evproject.shtml





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

DATA COLLECTED & REPORTED

All trips combined

- Overall fuel economy
- Total number of trips
- Total distance traveled
- Average ambient temperature
- Vehicle maintenance records

Trips in charge depletion mode

- Fuel economy
- Number of trips
- Percent of trips city / highway
- Distance traveled
- Average trip aggressiveness (on scale of 0-10)
- Percent of total distance traveled

Trips in both charge depletion and charge sustaining mode

- Fuel economy
- Number of trips
- Percent of trips city / highway
- Distance traveled
- Average trip aggressiveness (on scale of 0-10)
- Percent of total distance traveled

Trips in charge sustaining mode

- Fuel economy
- Number of trips and Distance traveled
- Percent of trips city / highway
- Average trip aggressiveness (on scale of 0-10)
- Percent of total distance traveled

Charging

- Number of charging events
- Average number of charging events per day when vehicle is driven
- Average number of trips between charging events
- Average duration and Energy of charging event
- Total charging energy

Infrastructure

- Installation process, steps and number of contacts
- Time for permit , inspection and installation
- Installation cost, reliability and customer satisfaction
- Grid impact analysis

TECHNOLOGY TRANSFERS & COLLABORATIONS

- **Idaho National Labs (INL)**
  - Has received data on multiple DOE hybrid and electric vehicle projects
  - Is receiving Volt raw data (fuel used, miles driven, etc.) and amalgamating
  - Facilitation of a common format presentation of data for DOE via INL Website (http://avt.inel.gov/evproject.shtml)

- **Electric Power Research Institute (EPRI)**
  - Facilitating involvement of additional utilities in data demonstration
  - Providing information and facilitating demonstrations of smart charging, fast charging and battery to grid

- **9 Utility Partners**
  - Austin, DTE, Dominion, Duke, PGE, PEPCO, Progress, Southern Cal Edison, SMUD
    - Installing charging stations and participating in vehicle demonstrations

- **North Carolina State University**
  - Charging infrastructure analysis in a parking structure

PROPOSED FUTURE WORK

- Vehicle data demonstration and the infrastructure demonstration will continue through the third quarter of 2013
- 300+ charging stations installed to date by GM and the utilities
- Data will continue to be gathered to document charging station installation and driving/charging events
- Data will continue to be aggregated and sent to the Department of Energy for review
- Special projects will continue to support fast charging, smart charging and battery secondary use

SUMMARY

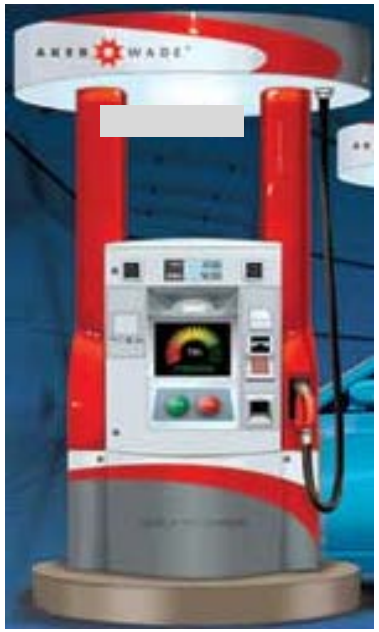
- **Relevance:** Consistent with DOE goals to reduce petroleum consumption, reduce greenhouse gases and maintain skilled jobs
- **Approach:** Demonstrate electric vehicle with extended range
- **Technical Accomplishments and Progress:** Extensive validation work and new technologies
- **Collaborations:** Idaho National Labs, EPRI, nine utilities and North Carolina State University
- **Proposed Future Work:** Data will be collected on driving and charging events until the third quarter of 2013. Information will be used to support next generation vehicle and infrastructure.

Special Projects

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

CHARGING INFRASTRUCTURE

Current: Hardwired
240 Volt, 3.3 kW
4 hour charge time



Current: Portable
120 Volt, 1.2 kW
10.5 hour charge time

Future: Fast
480 Volt 3 phase AC
30 – 80 kW
<1/2 hour charge time

FAST CHARGING

Goals

- Support development of industry standard electrical and communication interfaces
  - ➢Increase understanding of vehicle and grid impacts of fast charging

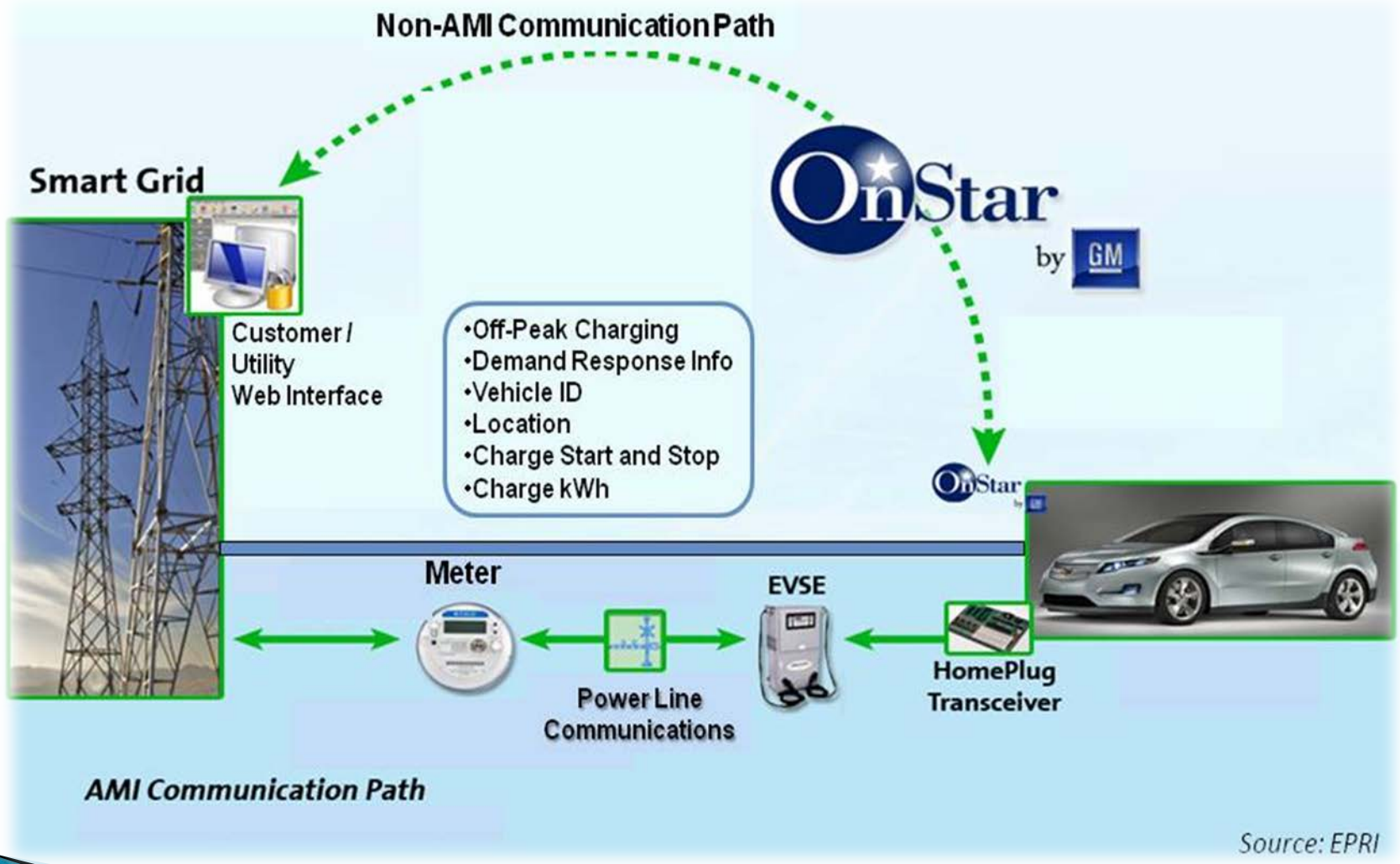
Tasks

- Support the development of standard connection interface and communication standard
- Design and integrate into the vehicle
- Install fast charging systems
- Modify demonstration vehicles
- Collect data and analyze:
  - ➢Grid impacts
  - ➢Vehicle impact
  - ➢User ergonomics and efficiency

Progress

- Team continues to provide feedback & development towards the completion of fast charging standards
- Vehicle inlet durability & integration testing ongoing
- UL testing for standardization scheduled to be complete Q2 2012

SMART CHARGING TECHNOLOGY VISION



SMART CHARGING DEVELOPMENT

Goals

- Electrical usage varies throughout the day with
  - Peak usage during the day
  - Non-peak usage at night
- Charging during off-peak times can save energy, reduce costs, and increase grid reliability

Tasks

- Method 1: Basic: Demonstrate OnStar, a non-AMI (non-automated meter infrastructure) solution, to have customers and utilities control when vehicles are being charged.
- Method 2: Advanced: Develop and demonstrate a home area network solution using AMI (automated meter infrastructure), power line communications and OnStar. Communicate pricing information from the utility to the vehicle to further align charging to off-peak time of use rates.

Progress

- Proof of concepts and mock-ups are complete
- Road worthy vehicles integration and demonstration scheduled to be complete by end of 2012

VOLT

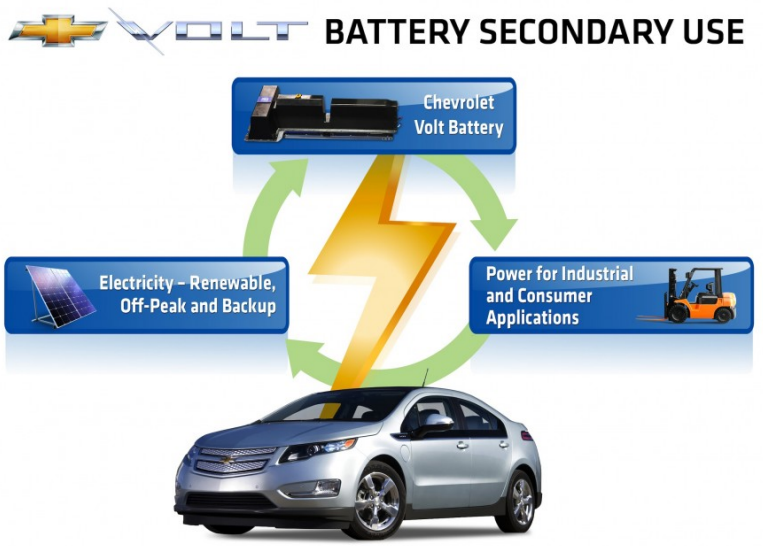
SECONDARY USE OF BATTERIES AS GRID STORAGE

Goals

- Create post vehicle residual value by extending the use of automotive batteries to satisfy stationary use requirements
- Enable renewable energy sources
- Reduce infrastructure stress through load management

Tasks

- Ancillary Function Study and System Technical Specification is complete
- Integrate a grid-tied bidirectional power converter with a battery pack to demonstrate battery to grid functionality
- Collect and analyze data to study the grid and battery impacts of bidirectional power flow



Progress

- Power module testing ongoing
- Demo unit to follow testing complete
- EPRI to provide the messaging structure for the software completion