

2011 DOE Vehicle Technologies Program Review: ADVANCED VEHICLE ELECTRIFICATION & TRANSPORTATION SECTOR ELECTRIFICATION



U.S. DEPARTMENT OF
ENERGY



Greg Cesiel

**General
Motors LLC (GM)**

May 12, 2011



OVERVIEW

Timeline

- Start: March 2010
- Finish: Sept 2013
- % Complete: 33%

Budget

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

Barriers

- Cost of the advanced technology for electric vehicles
- Utility infrastructure needs to be put in place to support electric vehicles

Partners

- | | |
|-------------------|--------------------------|
| ▪ DOE | ▪ EPRI |
| ▪ Nine Utilities: | |
| DTE Energy | Duke |
| PEPCO | Dominion |
| Progress | Pacific Gas and Electric |
| So Cal Edison | Austin Energy |
| SMUD | |

OBJECTIVE

- **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
- **This will be done:**
 - In real world conditions
 - With customers in several diverse locations across the United States including installation, demonstration and testing of 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 for the first 25 to 50 miles
- 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

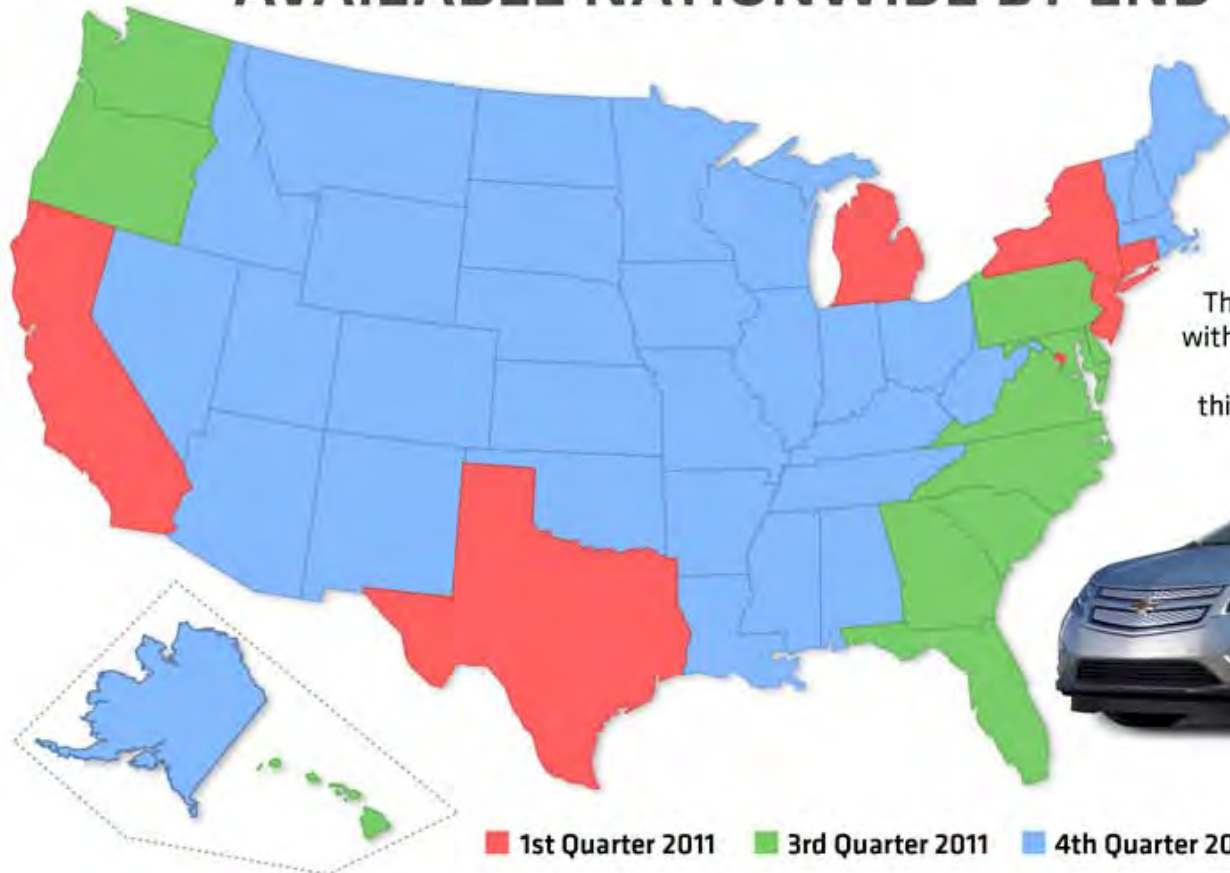
APPROACH – DEVELOPMENT & DEPLOYMENT

- **Chevrolet Volt is an electric vehicle with extended range capability:**
 - Powered by electricity all the time
 - Battery provides 25 to 50 miles driving, using no gasoline and with no tail pipe emissions
 - Battery can be charged with grid energy
 - Driver 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 including: Washington D.C., Michigan, California, Texas, and New York**
- **Utilities are installing charging stations in residential houses, workplaces, and in public areas**

EXPANDED LAUNCH MARKETS



AVAILABLE NATIONWIDE BY END OF 2011



The Chevrolet Volt electric vehicle with extended range will be available across the U.S. by the end of this year – six months sooner than originally planned.



2011 Chevrolet Volt Honors



OnStar MyLink
Volt Mobile App



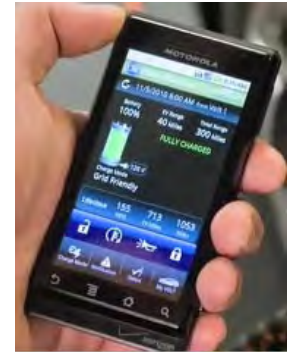
"TOP PRODUCTS" Award

Popular Mechanics
EDITOR'S CHOICE AWARD



TECHNICAL ACCOMPLISHMENTS

- ✓ **Program kickoff meeting with DOE in March 2010**
- ✓ **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**
Features include door lock & unlock, and start & end charging
- ✓ **Efficiency gauge and green leaf screens developed to guide the driver to drive more efficiently**



APPROACH – DATA DEMONSTRATION

- **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) verses 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**

▪ **Idaho National Labs (INL)**

- Has received data on multiple DOE hybrid and electric vehicle projects
- Will receive Volt raw data (fuel used, miles driven, etc.) and amalgamate
- Will facilitate common presentation of data to DOE

▪ **Electric Power Research Institute (EPRI)**

- Will facilitate involvement of additional utilities in data demonstration
- Will provide information and facilitate demonstrations of smart charging, fast charging and battery to grid

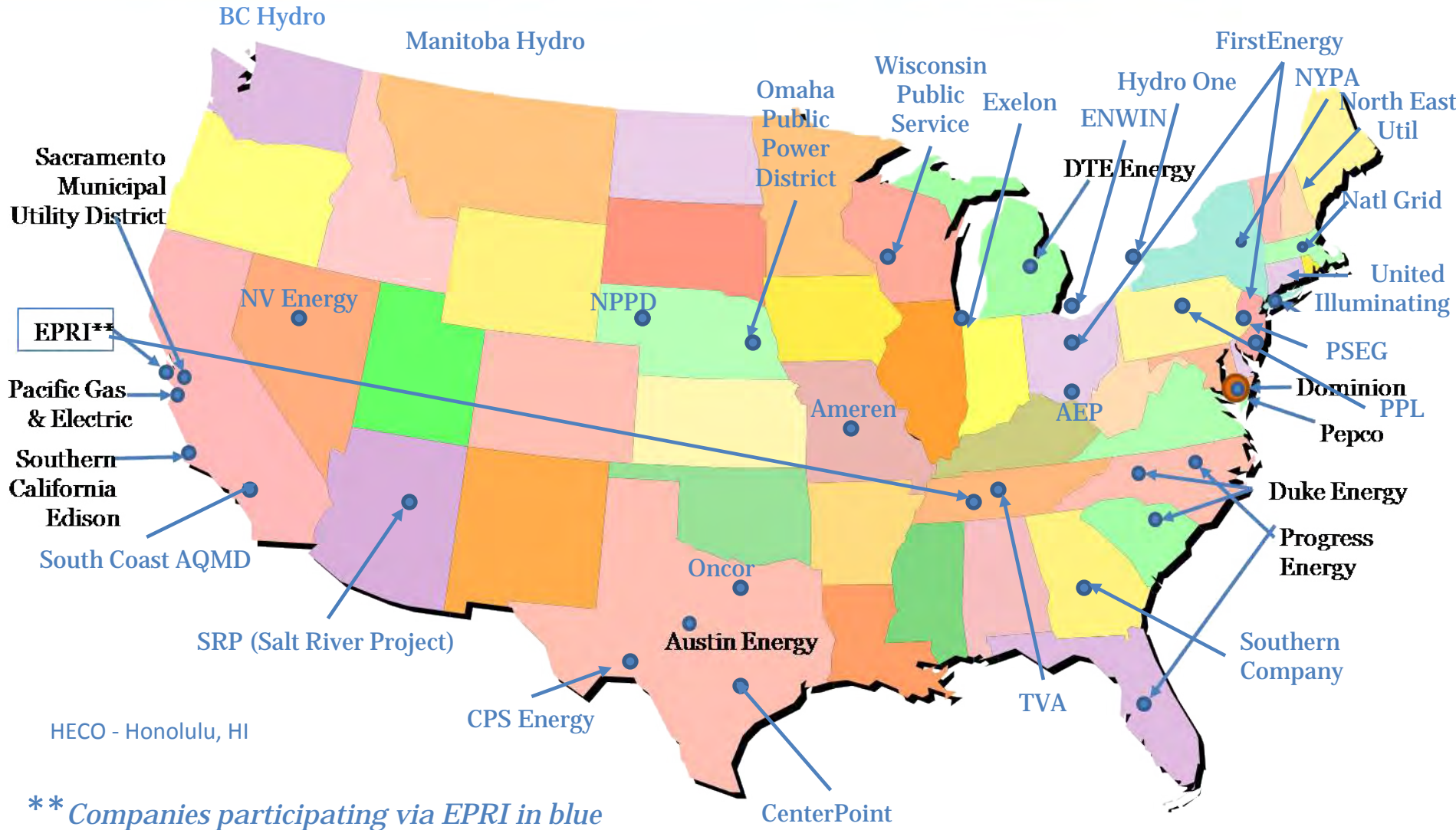
▪ **9 Utility Partners**

- DTE, Duke, PEPCO, Dominion, Pacific Gas and Electric, Southern California Edison, Progress, SMUD, Austin Energy
- Will install charging stations and participate in vehicle demonstrations

▪ **North Carolina State University**

- Will study charging infrastructure in a parking structure

UTILITY DEMONSTRATION LOCATIONS



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

DATA COLLECTED AND 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

PROPOSED FUTURE WORK

- Chevrolet Volt electric vehicle will transition from the GM fleet to utilities in the first half of 2011. The vehicle data demonstration and the infrastructure demonstration will continue until December 2012
- 550+ charging stations will be installed by GM and the utilities
- Data will be gathered to document charging station installation, and driving and charging events
- Data will be aggregated and sent to the Department of Energy for review
- Special projects will be performed to support fast charging, smart charging and battery secondary use



Special Projects

CHARGING INFRASTRUCTURE

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



Current: Portable
120 Volt
1.2 kW
9 hour charging time



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

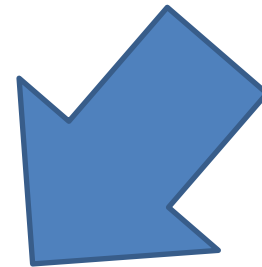
FAST CHARGING DEVELOPMENT

Goals

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

Tasks

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



SMART CHARGING DEVELOPMENT

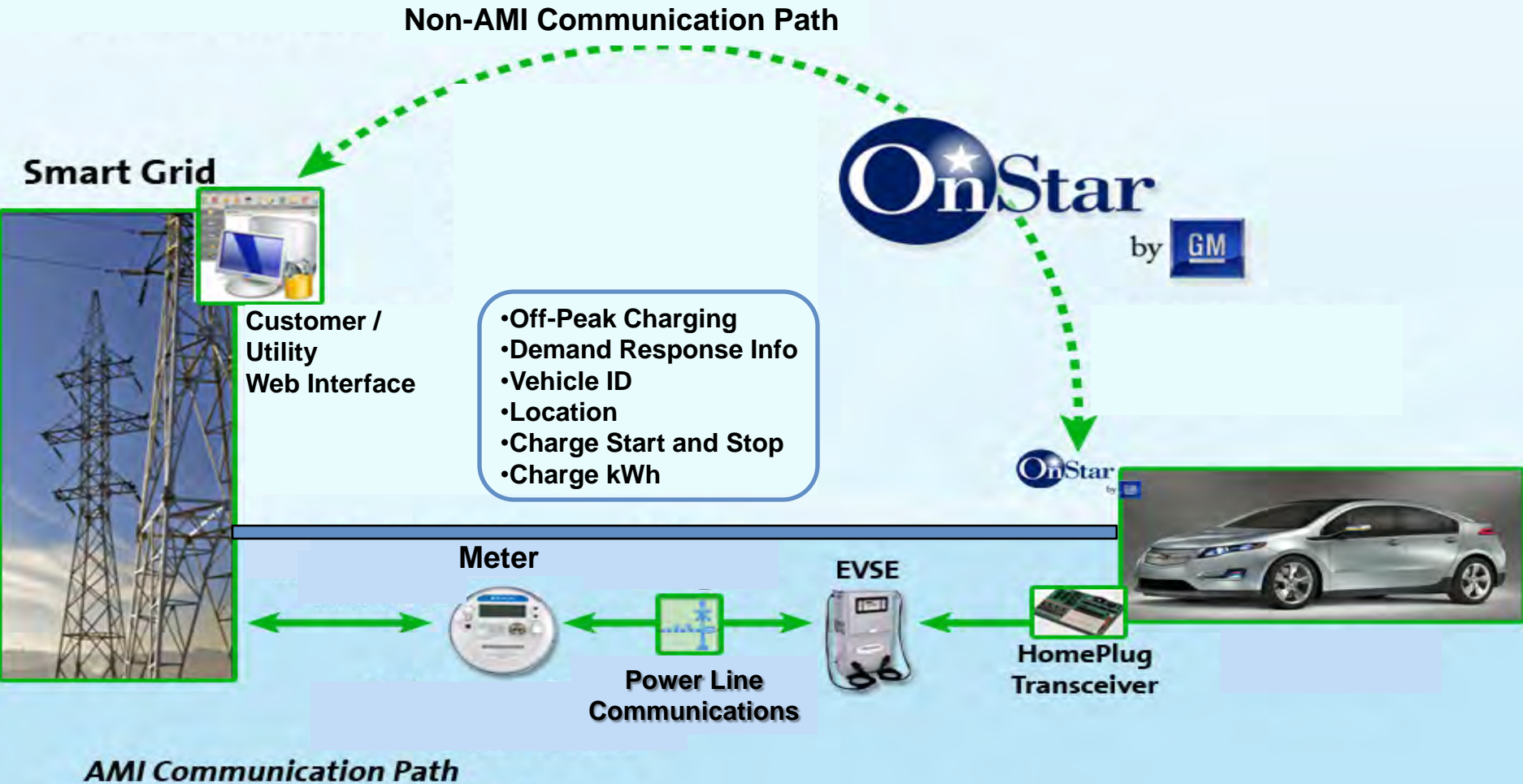
Goals

- 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

SMART CHARGING TECHNOLOGY VISION



Source: EPRI

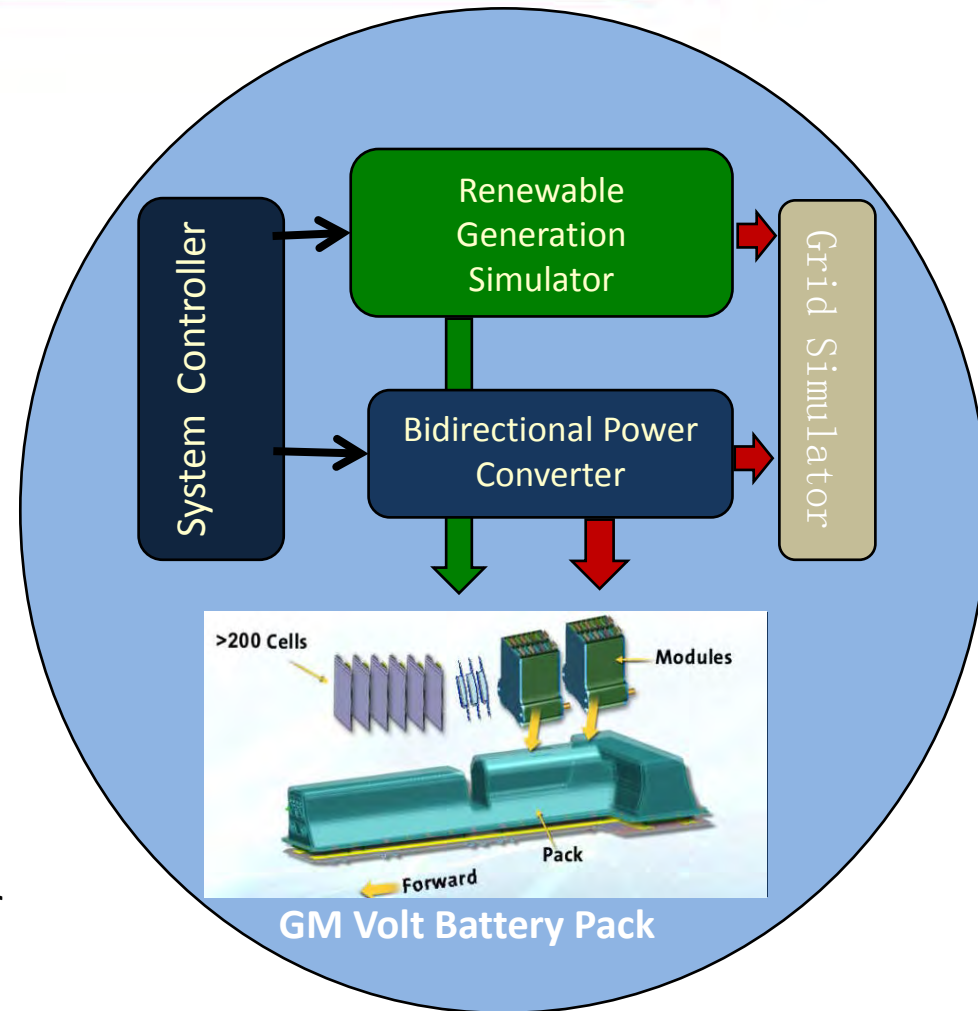
SECONDARY USE OF BATTERIES AS GRID STORAGE

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



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, ten utilities and North Carolina State University
- **Proposed Future Work:** Data will be collected on driving and charging events to December 2012. Information will be used to support next generation vehicle and infrastructure