Advanced Vehicle Electrification and Transportation Sector Electrification

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## Overview

### Timeline
- Work start: 11/09
- DOE signing & official start: 3/10
- End: 9/13

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

### Budget
- $61 mil project
  - $30.5 mil DOE
  - $30.5 mil GM

### Partners
- DOE
- EPRI
- Ten Utilities:
  - DTE Energy
  - PEPCO
  - Con Edison
  - So Cal Edison
  - SMUD
  - Duke
  - Dominion
  - Pacific Gas and Electric
  - Progress
  - Austin Energy
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

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

- Reduce our dependence on petroleum
  - Up to 40 mile electric vehicle range
  - Increases use of domestic resources
- Decrease greenhouse gas emissions
  - No tailpipe emissions for up to the first 40 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
Milestones for 2009 & 2010: Vehicle

✓ Milestone 1: Over one-quarter of a million miles driven in Volt fleet
✓ Milestone 2: Hot weather testing – Death Valley
✓ Milestone 3: Mountain testing – Pike’s Peak and Baker’s Grade
✓ Milestone 4: Achieved 65% calibration test drive
✓ Milestone 5: Full vehicle simulator test competed 700,000 miles
Milestones for 2009 & 2010: Battery

✅ Milestone 1: >67,000 cells on test – all without failure
✅ Milestone 2: >300 prototype battery packs built
✅ Milestone 3: >700,000 miles of customer use lab testing to date
✅ Milestone 4: >30 Battery Systems Laboratory test channels fully dedicated to Volt battery
✅ Milestone 5: Brownstown Battery Assembly Plant in process tests developed
✅ Milestone 6: Battery Lab achieves ISO certification March 2010
Project Schedule – Vehicles & Batteries

- **Engineering Development:** On time!
- **Mule:** On time!
- **Pre-Production:** On time!
- **Vehicle Assembly:** On time!

**2007** - **2008** - **2009** - **2010**

- **1st Supplier Built Pack**
- **First 300 packs GM /Supplier Built**
- **1st GM Built**
- **Start of Production**: Late 2010

**Battery Plant**

Brownstown, MI

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Approach – Deployment

- **Chevrolet Volt is an electric vehicle with extended range capability:**
  - Powered by electricity all the time
  - Battery provides up to 40 miles driving, using no gasoline and with no tail pipe emissions
  - Batteries can be charged from the grid, but engine generator means driver will not be stranded
  - Driver can take long trips

- **Volt will be developed and validated by General Motors with start of production in late 2010**

- **GM will launch Volts in key markets including: Washington D.C., Michigan and California**

- **Utilities will install charging stations in residential houses, workplaces, and in public areas**
Approach – Data Demonstration

- Data will be collected on vehicles starting in 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 versus public)
  - Level 1 (120 volt) versus Level 2 (240 volt) experience
  - Installation of charging infrastructure
- Information gathered during this period will support the next generation battery designs and infrastructure and to expedite learning cycle progression
Technical Accomplishments

- Built 80 pre-production cars currently in use for engineering and crash testing
- 30 Crash tests performed
- 300 pre-production battery packs built with excellent test results
- Volt’s smartphone application by OnStar developed to help drivers stay connected to their Volt 24/7
- Efficiency gauge and green leaf screens developed to guide the driver to drive more efficiently
- Program kickoff meeting with DOE in March 2010
Volt Battery is an Integral Part of Vehicle Structure

- Cell
- Modules
- Pack

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Cell Tests Ensure Superior Cell Performance

**Over 150 Tests Conducted**

- Cell penetration
- Cell crush
- Cell life cycling
- Cell thermal testing stress
- Cell overcharge
- Cell performance characterization
Battery Pack Tests Evaluate Performance under Real Life Conditions

- Over 20 Tests Conducted
  - Crash
  - Mechanical vibration (shaker table)
  - Corrosion
  - Thermal cycling and shock
  - Customer use life cycle
Driving over Various Pavements Assess Effect on Vehicle Structure

- Twisted ditch – subjects vehicle and pack to torsional stress

- Belgian block test – tests impact of very rough roads on electronics

- Pothole test – effect on suspensions and shock absorbers

See battery and vehicle testing videos at www.chevroletvoltage.com
Vehicle Tests Simulate Aggressive Environments

- **Volt water trough tests**
  - Measures how well the battery is sealed

- **Full vehicle vibration test**
  - Analyze effect of vibration on vehicle components

See battery and vehicle testing videos at www.chevroletvoltage.com
Technology Transfers / Collaborations

- 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

- 10 Utility Partners
  - DTE, Duke, PEPCO, Dominion, Con Edison, 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

(115 Vehicles)

**EPRI vehicles will be placed with multiple member utilities throughout the US at locations to be determined**
Proposed Future Work

- Chevrolet Volt electric vehicle launch and transition to utilities will continue the vehicle data demonstration and the infrastructure demonstration for an additional two years.

- 600+ charging stations will be installed by GM and the utilities.

- Data will be gathered to document installation, charging and driving events.

- Data will be aggregated and sent to the Department of Energy for their review.

- Special projects will be performed to support fast charging, smart charging and battery secondary use.
## 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 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

### 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 of charging event
- Average energy per 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
Electric Vehicle Charging Infrastructure supported by Project including future Fast Charging

Current: Portable
120 Volt
1.2 kW
9 hour charging time

Current: Hardwired
240 Volt, 3.3 kW
4 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
Goals
- Electrical usage varies throughout the day with
  - Peak usage during the day
  - Non-peak usage at night
- Charging during non-peak times can save energy, reduce costs, increase grid reliability and address energy independence and global warming issues

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 non-peak time of use rates
Smart Charging Technology Vision
Develop Automated Meter Infrastructure (AMI) and Non-AMI Methods

Non-AMI Communication Path

Customer / Utility Web Interface

- Off-Peak Charging
- Demand Response Info
- Vehicle ID
- Location
- Charge Start and Stop
- Charge kWh

AMI Communication Path

Meter

Power Line Communications

EVSE

HomePlug Transceiver

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
- Study the technical challenges and stationary energy storage requirements
- 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

- **Status:** First Annual Merit Review for this project
- **Relevance:** Consistent with DOE goals to reduce petroleum consumption, reduce greenhouse gases and maintain skilled jobs
- **Approach:** Develop 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 from Fall 2010 to December 2012. Information will be used to support next generation vehicle and infrastructure