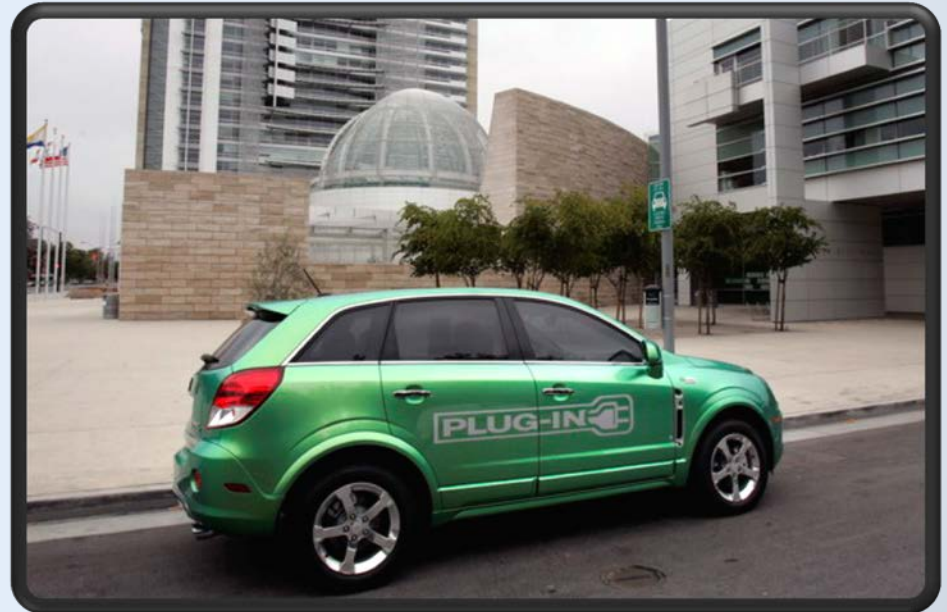


# 2012 DOE Vehicle Technologies Annual Merit Review

## Plug-in Hybrid (PHEV) Vehicle Technology Advancement and Demonstration Activity

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



**Project ID #: VSS018**

# Overview

## Timeline

- Project Start: September 30, 2008
- Project End: December 31, 2012
- Percent Complete: 84%

## Budget

- Project Funding: \$54 M
  - DOE Share: \$9.3 M
  - MEDC Share: \$2 M
  - GM Share: \$72.9 M

## Barriers

- High cost of advanced technology
  - Drive cost down
- Infrastructure
  - Interface and interaction with electric power grid

## Partners

- Michigan Economic Development Corporation (MEDC) - Funding
- University of Michigan Advanced Battery Coalition for Drivetrains – Research



# Objectives

- Overall Program Objective
  - Develop components and subsystems required for a plug-in hybrid electric vehicle (PHEV) and fully integrate them in a production-intent vehicle
    - Incorporate advanced lithium-ion battery technology
    - Feature high tech E85-capable Flex Fuel engine technology
    - Balance fuel economy, emissions, vehicle performance and battery life trade offs
    - Achieve battery cell performance and life requirements
- Phase 1 – Development of Year 1 Mule Vehicles
  - Achieve performance targets and proceed to Phase II
    - Hot weather, cold weather and altitude development
- Phase 2 – Development of Year 2 Integration Vehicles
  - Merge developed components and subsystems with production intent hardware content
  - Produce and refine calibrations/software with Integration level vehicles
- Phase 3 – Battery Thermal Development of Alpha Module
  - Development of a new thermal management design (thermal, vibration, aging, sealing evaluations)
- Phase 4 – Battery Thermal Development of Mule Module
  - Further development and refinement of the new thermal management design (thermal, vibration, aging, sealing evaluations)



# Milestones

- 65% program review and ride milestone achieved and demonstrated to the DOE
  - May 26, 2011
- Integration vehicle builds completed
- Battery module concept work initiated with FEV, Inc
  - January 5, 2012
- Initial concepts review
  - January 20, 2012
- Concept selection complete
  - January 27, 2012
- Onsite DOE Technical Review
  - April 3, 2012



# Approach/Strategy

- Hot Weather, Altitude and Cold Weather Development Trips
- Integration Vehicle Build
  - Integration vehicles produced
  - Significant technology improvements
- Argonne National Lab
- Module Thermal Development
  - Total temperature of the module
  - Internal heat temperature difference of the module
  - Maximum & minimum cell temperature
  - Module temperature at beginning & end of test
  - Heat capacity of the battery coolant
  - Thermal interface material evaluation
- Module Vibration Development
  - Verification of structural integrity of the module to vibration
- Module Aging Evaluations
  - Verification of seal integrity after thermal aging of the:
    - Heater seal
    - Hose to outlet/inlet interface
    - Heat sink to outlet interface
- Module Sealing Evaluations
  - Determine sealing capability with coolant of the:
    - Heater seal
    - Hose to outlet/inlet interface
    - Heat sink to outlet interface



# Technical Accomplishments & Progress

- Two physical builds completed producing vehicles for internal deployment at General Motors
  - 50+ vehicles built
  - 180,000+ miles driven
- Charge depleting (CD) and charge sustaining (CS) hybrid functionality has been successfully completed and demonstrated to the DOE
- Cold weather testing was performed and exceeded technical specification using both gasoline and alcohol fuels
- Module concept definition and development progressing on time to a successful completion



# Collaboration & Coordination w/Other Institutions

- University of Michigan Advanced Battery Coalition for Drivetrains
  - Cooperative agreement between U of M and GM
  - Five year development agreement
  - Within Vehicle Technology scope as it related to alternative energy resources and efficient hybrid vehicles
- FEV, Inc
  - Collaboration of design and development of new thermal management system



# Future Work

- Module concept detailed engineering
  - Feasability study
  - Detailed design
    - 3D CAD Modeling
    - CAE Analysis
    - DFMEA
    - Manufacturing Plan
  - Physical property build
  - Development testing
  - Design refinement





# Project Summary

- Production-intent program, building on proven GM 2-Mode strong hybrid technology
- On track to meet new program milestones and project deliverables
- Development Phases on track to a successful completion

