2011 DOE Annual Merit Review
Plug-in Hybrid (PHEV) Vehicle Technology
Advancement and Demonstration Activity

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May 11, 2011
Overview

Timeline
- Project Start: September 30, 2008
- Project End: July 31, 2015
- Percent Complete: 65%

Budget
- Project Funding: $54 M
  - DOE Share: $10 M
  - MEDC Share: $2 M
  - GM Share: $42 M
- Funding received in FY08: $64.7K
- Funding received in FY09: $4.6M
- Funding received in FY10: $3.1M

Barriers
- High cost of advanced technology
  - Drive cost down
- Risk aversion
  - UMTRI collaboration to address consumer behavior and increase public excitement
- Infrastructure
  - Interface and interaction with electric power grid

Partners
- Michigan Economic Development Corporation (MEDC) - Funding
- University of Michigan Advanced Battery Coalition for Drivetrains – Research
- University of Michigan Transportation Research Institute (UMTRI) – Consumer Behavior

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Objectives

Overall Program Objective
- Develop components and subsystems required for a plug-in hybrid electric vehicle (PHEV) and fully integrate them in a production 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
  - Plug-in charging at 120 & 240 volts
  - New customer focused gauges and displays

- 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 – Validation of Year 3 Vehicles
  - Validate vehicle systems and produce preproduction vehicles

- Phase 4 – DOE Demonstration Fleet Data Collection
  - Vehicle performance data collection utilizing OnStar
  - UMTRI consumer behavior data collection and analysis
  - OnStar to provide remote diagnostic reports
Milestones

- Deep dive DOE Onsite Review: 10/22/10
  - DOE feedback from review demonstrates exceptional development progress
- Hot Weather Development Trip
- Calibration Ride
- Cold Weather Development Trips
- Integration Vehicle Builds
- High Altitude Development Trip

Cold Weather Canada

High Altitude Colorado

Hot Weather Arizona

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Approach/Strategy

- Build upon the success of the GM 2-mode strong hybrid family

- PHEV is a blended gas and electric drive propulsion system
- PHEV is an extension of the 2-Mode hybrid charge sustaining technology
  - Two electric motors/generators for traction and regenerative braking
  - Two fixed mechanical gears for performance and fuel economy
  - Replaced nickel metal hydride power battery pack with lithium-ion energy battery pack

- PHEV Controls operate in real-time, optimized for fuel economy

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• Hot Weather & Altitude Development Trip
  • Demonstrated powertrain & battery thermal stability and capability in hot climate conditions
  • Engine cold starts, Powertrain calibrations, battery thermal calibrations, Plug-in Charging

• Argonne National Lab
  • Collaborative testing of GM supplied PHEV
  • 2 weeks of Fuel Economy & emissions testing

• Integration Vehicle Build
  • Integration vehicles produced
  • Significant technology improvements

• Cold Weather Development Trip
  • General drive ability and diagnostics development
  • Engine cold starts, Powertrain calibrations, battery thermal calibrations, HVAC Cabin warm up, Plug-in charging => environmental temperatures down to -40C with successful operation
Objective Phases on track to completion
- Engineering development of year 1 Mule vehicles successfully completed
- Partial Phase 1 Mule vehicles updated with the latest production intent batteries, thermal systems, and battery chargers
- Integration vehicles being built to enable Phase 2 development

Testing and Development Accomplishments
- Fuel economy and emissions development continues to be on track to meet technical specifications
- 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
- High voltage battery thermal management system proves capable to provide a good balance of fuel economy & battery life
- Plug-in charging system proved capable in extreme cold and hot temperatures

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Collaboration/Coordination with 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 relates to alternative energy resources and efficient hybrid vehicles

- University of Michigan Transportation Research Institute (UMTRI)
  - GM Prime/U of M Sub
  - UMTRI to develop a survey to capture consumer behavior and experience with the PHEV
  - Within Vehicle Technology scope as it relates to the consumer and adds to the public excitement from development of technology
Future Work

- Demonstrate architectural changes required to support plug-in content
  - Structure, chassis & mounting changes
  - Electric Power Steering
  - Hybrid Brake Control
  - Enhanced thermal management systems capabilities
  - Aero enablers and mass reduction enablers
- Argonne National Lab – collaborative testing of GM supplied PHEV
  - October 2011 (2 weeks of Fuel Economy & emissions testing)
- Next onsite review scheduled
  - Q2 2011
  - Q3 2011
- Phase 3 Engineering Validation
- DOE Demonstration and Data collection
  - Vehicle performance data collection utilizing OnStar
  - UMTRI consumer behavior data collection and analysis
Project Summary

- Production 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
- Data collection and analysis parameters identified