2013 DOE Vehicle Technologies Annual Merit Review

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

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Project ID #: VSS018

Overview

Timeline

- Project Start: 9/30/08
- Project End: 9/30/13
- Percent Complete: 88%

Barriers

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

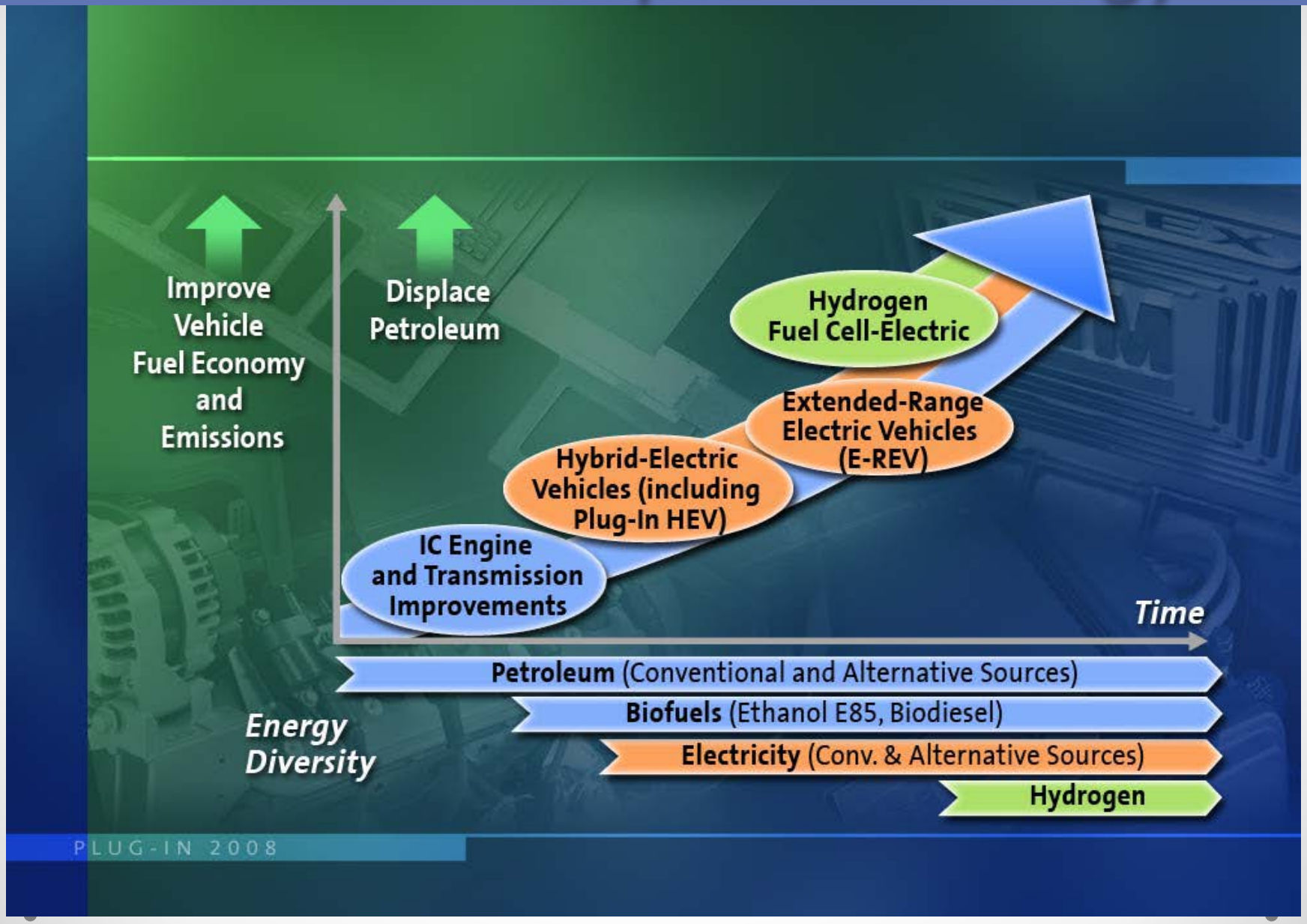
Budget

- Project Funding: $67.1 M
  - DOE Share: $9.3 M
  - MEDC Share: $2 M
  - GM Share: $57.8 M

Partners

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

Advanced Propulsion Strategy



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
  - Engineering development
    - Charge depletion
    - Lithium-Ion battery development
    - Battery system integration
      - Charger development
  - Vehicle and Powertrain systems integration

- 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
  - Engineering development
    - Charge depletion
    - Lithium-Ion battery development
    - Battery system integration
    - Charger development
    - Vehicle and Powertrain systems integration

Objectives

- Phase 3 – Battery Thermal Development of Alpha Module
  - Development of a new thermal management design to help maintain proper operating temperatures
    - Increase range
    - Improved reliability
    - More durable
  - Reduced complexity → more cost efficient design
- Phase 4 – Battery Thermal Development of Mule Module
  - Further development and refinement of the new thermal management design (thermal, vibration, aging, sealing evaluations)

Milestones

- Battery module concept work initiated with FEV, Inc and concept selection complete
  - January 27, 2012
- Onsite DOE Technical Reviews
  - April 3, 2012
  - September 18, 2012
  - April 16, 2013
  - September 2013
- Battery module Proof of Concept
  - Procurement – October 15, 2012
  - Assembly complete – December 13, 2012
- Battery module development testing complete
  - June 15, 2013
- Battery module design refinement complete
  - July 31, 2013

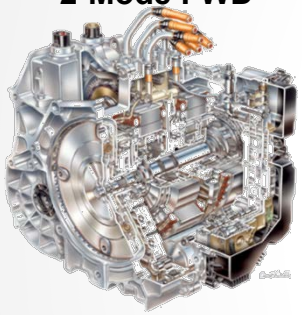
Approach/Strategy

- Hot Weather, Altitude and Cold Weather Development Trips
- Integration Vehicle Build
  - Integration vehicles produced
  - Significant technology improvements
- Argonne National Lab
  - Vehicle dynamometer testing
- 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
- Module Vibration Development
  - Verification of structural integrity of the module to vibration
- Module Aging Evaluations
  - Verification of brazing integrity after thermal aging of the:
    - Heat exchanger braze
    - Hose to outlet/inlet interface
    - Heat sink to outlet interface
- Module Sealing Evaluations
  - Determine brazing capability with coolant of the:
    - Heat exchanger braze
    - Hose to outlet/inlet interface
    - Heat sink to outlet interface
- Thermal Cycling Life Assessment of Module Sealing System
  - Braze integrity and hose interface capability after thermal life assessment
    - Overall braze integrity
    - Hose to outlet/inlet interface
    - Heat sink to outlet/inlet interface

Technical Accomplishments & Progress

- OnStar data collection was customized to meet DOE reporting requirements
- Virtual modeling and simulation of vehicle hardware completed

2-Mode FWD



Hybrid Transmission

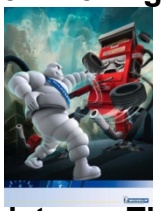
SIDI High Tech

Flex Fuel Engine

High Voltage

Power Electronics

Low Rolling



Resistance Tires

Advanced

Lithium-ion Battery

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
- Analytical and physical development of available module designs, down-selected to one concept based on developed thermal design concepts
- Conducted detailed design and engineering analysis based on developed module performance metrics and manufacturability requirements

Technical Accomplishments & Progress

- Fabricated prototype components of down-selected concept for early development phase
- Assembled prototype modules/sections (different sizes) from these components to enable building 2 sections and 3 modules
- Testing soon to be initiated on prototypes for critical functions – thermal performance structural performance and manufacturability
- Analyze test results to improve the initial design to deliver a refined design, based on test results and physical build evaluations

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
  - Task completion mid-2012

- FEV, Inc
  - Collaboration of design and development of new module thermal management system

Future Work

- DOE Onsite Visit
  - April 16, 2013
- Battery module development testing complete
  - June 15, 2013
- Battery module design refinement complete
  - July 31, 2013
- Final review – Washington
  - September 2013

Project Summary

- Project extended to Q3 2013 to ensure a successful completion
- On track to meet new program milestones and project deliverables
- Project development testing and refinement defined and on track to meet program completion in the third quarter of 2013