Ford Plug-In Project: Bringing PHEVs to Market

Greg Frenette
Manager, Sustainable Mobile Technologies
Ford Motor Company

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Overview

Timeline

- Start: October, 2008
- Finish: June, 2012
- 15% Complete

Budget

- Total Project Funding
  - DOE: $ 10,000,000
  - Ford: $ 10,027,792
- Funding received in FY08 = $2,091,823
- Funding for FY09 = pending approval

Partners

- Johnson Controls-Saft (JC-S)
- Electric Power Research Institute
- Southern California Edison
- Detroit Edison
- NY Power Authority
- Consolidated Energy
- NY State Energy Research & Development Authority
- Progress Energy
- Southern Company

Barriers

- Battery Cost
- Battery Charge Time
- Extreme Temperature Operation
- Lack of Uniform Codes & Standards

Objectives

- Identify a sustainable pathway toward accelerated and successful mass production of PHEV's.
- Launch a 21-vehicle demonstration fleet
  - Provide real-world usage data
  - Provide laboratory data
- Support a customer-valued PHEV production program
  - Propulsion system design
  - Vehicle controls
  - Two-way Communication
    - Vehicle to Meter
    - Meter to Vehicle

2008 Completed Milestones

Project Management	- Reached agreements with 6 Partners for vehicle demonstration testing - DOE approval of Phase I milestones and completion
Vehicle & Design Build Updates	- 11 vehicles built - 6 vehicles delivered to utility companies across the U.S.
Battery Controls & Development	- Limited Operating Strategy (LOS) and Quit on Road (QOR) Strategy completed and implemented
Vehicle Controls & Development	- Engine/Transmission/Battery cooling optimized - Silent Key Start enabled
Testing	- FE testing completed at Argon National Labs

2009 Milestones

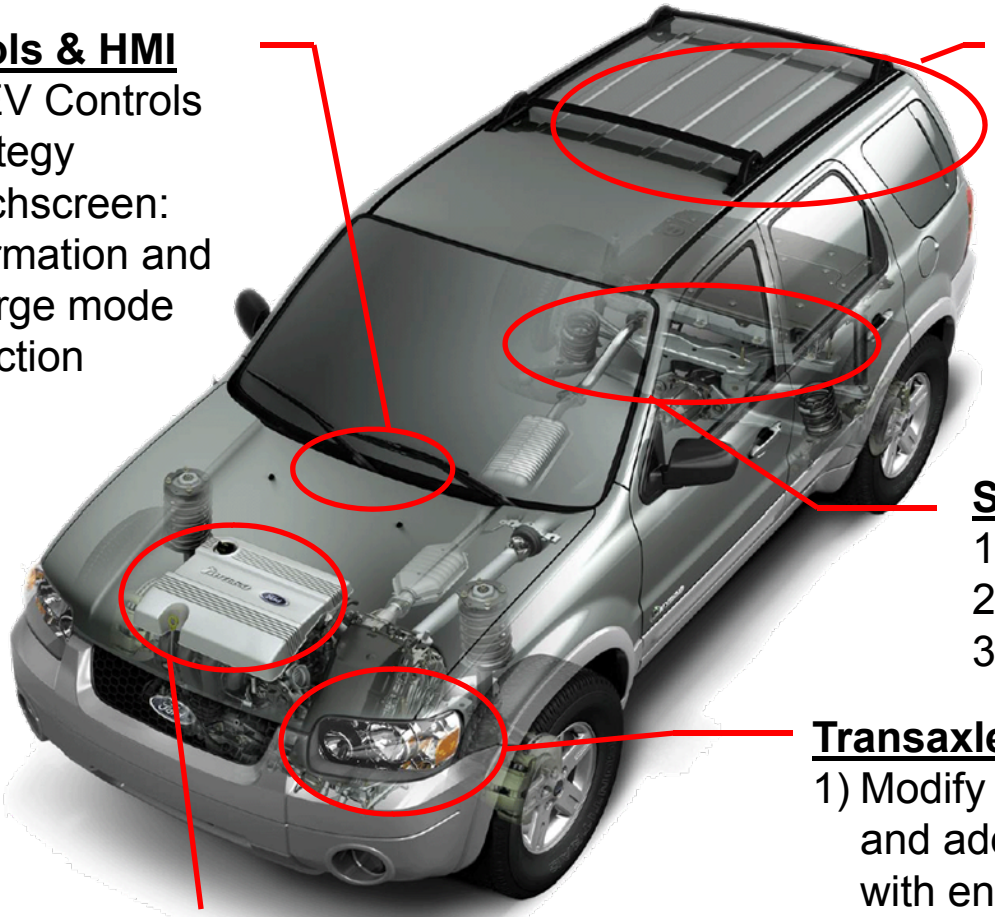
Project Management	- Support PHEV public awareness opportunities - Finalize remaining utility partnerships
Vehicle & Design Build Updates	- Complete build and commissioning for remaining 10 vehicles - Two-way communication roll-out
Battery Controls & Development	- Receive, integrate and validate JC-S designed and built HV battery system/controls
Vehicle Controls & Development	- Finalize development of Flex Fuel (E-85) calibration and strategy for remaining vehicles - Optimize cabin heating/cooling strategy
Testing	- Support DOE sponsored fuel economy and emission testing - Finalize launch of on-vehicle data collection and reporting system

Approach

- Phase I
  - Validate battery/control enhancements
  - Demonstrate the technology on a new, more fuel efficient engine
- Phase II
  - Progress the battery/control system closer to production intent.
  - Demonstrate two-way communication
  - All Phase II vehicles will be flex-fuel capable
- Phase III
  - Continues with fleet demonstration, data analysis
  - Demonstrates V2G and G2V communications
  - Redirect resources from bi-directional power flow demonstration to other high priority scope elements consistent with production roll-out
- Phase IV
  - Continues vehicle demonstrations from Phase III, and demonstrates the vehicle advanced metering interface

Phase I Vehicle Design & Build

Controls & HMI
1) PHEV Controls Strategy
2) Touchscreen: Information and Charge mode selection



Rear Cargo Area
1) Replace production high voltage battery with a ~10 kWh Li-Ion battery from JCS
2) Add 1.4 kW, 120V battery charger
3) Add Data Acquisition Module
4) Add ZigBee module (V2G to G2V communication)

Structure and Suspension
1) Rear Suspension modifications
2) Structural enhancements
3) Exhaust System

Transaxle Modifications
1) Modify transaxle oil lubrication/cooling circuit and add external electric oil pump for oil flow with engine off
2) Add oil to air heat exchanger to increase continuous operating capability of electric machines

Engine & Fuel System
1) Flex Fuel (E-85) hardware and software

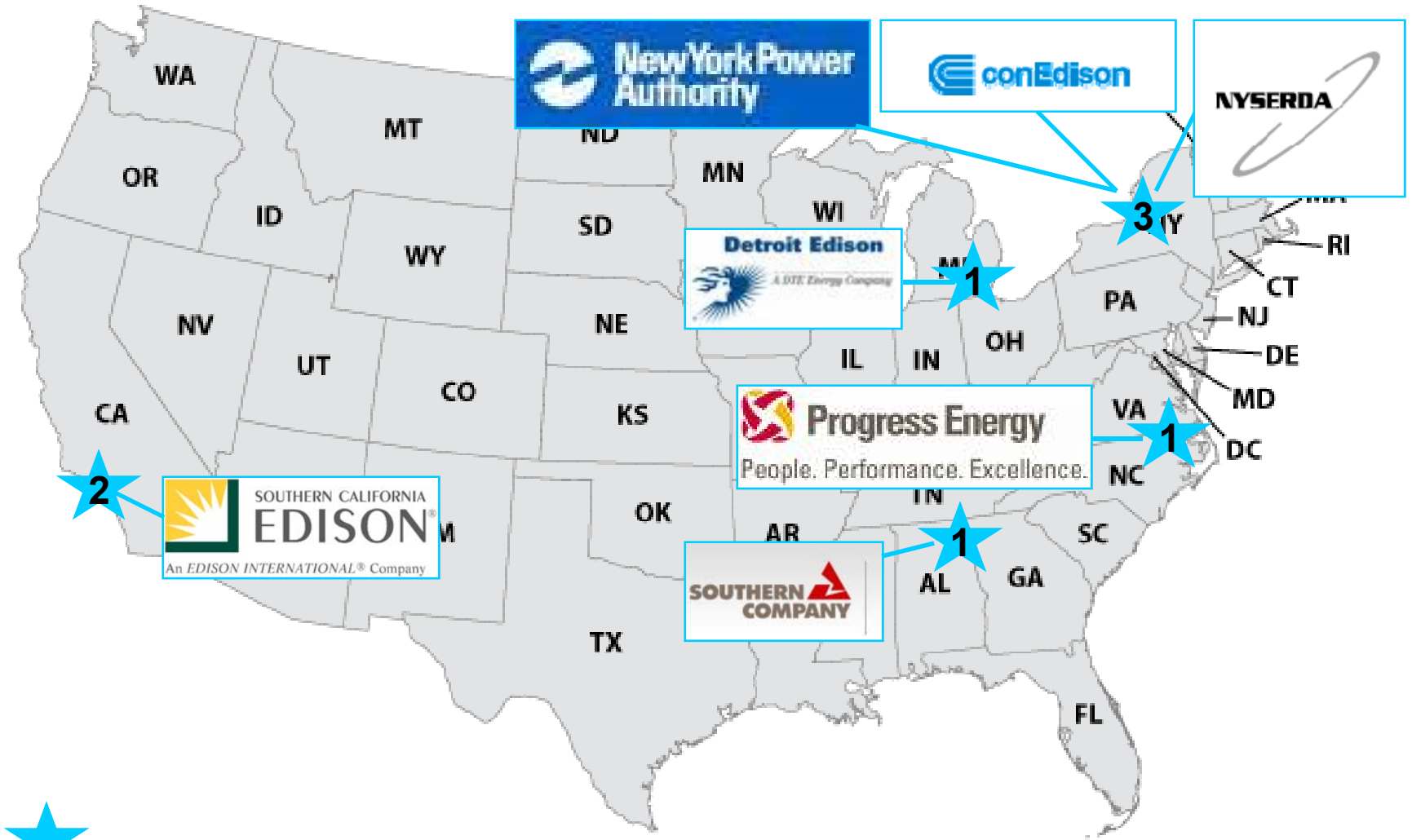
Technical Accomplishments: Phase I

- Vehicle & Design Build Updates
  - High Voltage (HV) Battery optimization
    - Improved power and State of Charge (SOC)
  - Implemented AC current and charger temperature controls
  - Low temperature robustness transaxle improvements
- Battery Controls and Development
  - LOS / Quit On Road Strategy completed and validated
  - Initial evaluations of vehicle battery management systems communications are completed

Technical Accomplishments: Phase I

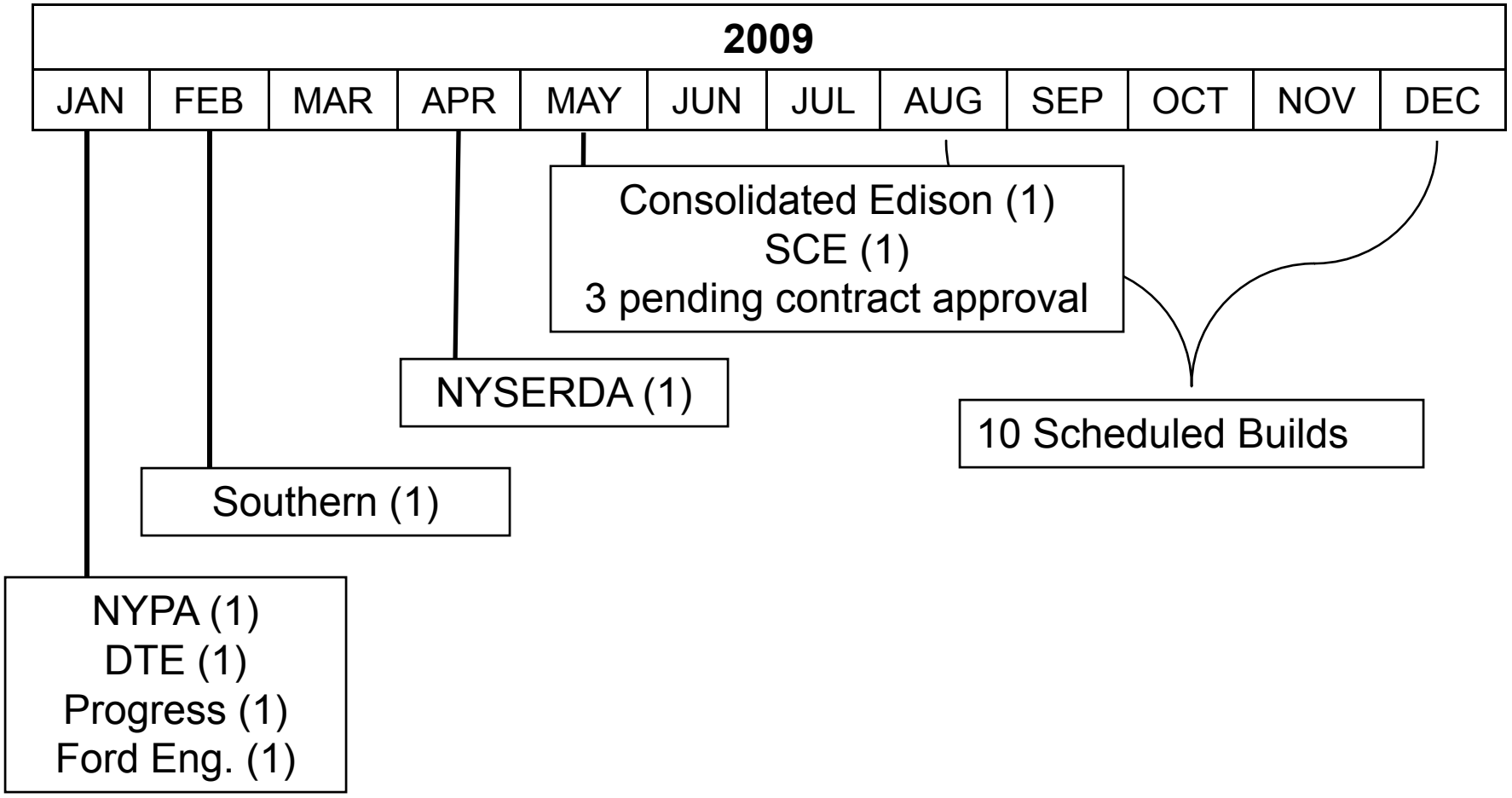
- Vehicle Controls & Development
  - Software modifications to allow Silent Key Start
  - Implemented a new charge port design
  - Engine and control system modifications have been made to allow for E-85 operation (08MY engine)
  - E-85 strategy and calibration under development for Phase II vehicles (09MY engine)
  - Sourced broadband on-vehicle data acquisition and transfer supplier
  - Sourced on-vehicle data organization and web-based access supplier
- Testing
  - FE testing completed at Argon National Labs
  - Pre-delivery NVH and Performance evaluations completed

Partners & Vehicle Distribution



Number inside represents the number of vehicles delivered

Vehicle Delivery Schedule



Deployment Accomplishments

Partner	Mileage	Verbatims
Southern	6192	- Very positive feedback from multiple drivers
SCE	7870 5300	
Detroit Edison	5657	- "*Overall impression the vehicle is great*"
DOE	5100	
Progress	1000	- "*Overall experience is very positive*" - "*Transition between engine-on and engine-off is very smooth and the electric drive under 40mph is also very nice"* - Investigating potential battery charging issue
NYSERDA	618	

Public Education & Events

Partner	Major Event
SCE	• President Barack Obama Visits SCE's Electric Vehicle Technical Center • Innovation and Globalization in Green, Hyatt Regency Irvine, CA • Western Automotive Journalists, San Francisco, CA • 8th annual Ford Motor Company all-brands drive, San Francisco, CA • Edison Electric Institute Chief Executive Officers Meeting, Phoenix, AZ • West Coast Inauguration Parade, Santa Monica, CA
Southern	• Alabama Power Local Media Event - Birmingham, AL • Alabama Power Employee Information Event • American Cancer Society Run for the Reason • Used for storm duty after the recent rounds of tornados throughout AL
Detroit Edison	• The Michigan Petroleum Association Convention - Grand Rapids MI • NCAA Final Four - Detroit MI • Ford Motor Co. Board Meeting - Dearborn MI • Earth Day - Bad Axe MI • Associated Food and Petroleum Dealers Annual Trade Show - Novi MI • Engineering Society of Detroit/DTE Energy Conference - Novi MI
NYPA	• PHEV Event in New York

Public Education & Events

Partner	Major Event
Progress Energy	• North Carolina Auto Show • North Carolina Auto Expo • Raleigh Hillsborough Street Festival • Southern Ideal Homeshow • Ford Sustainability Forum • North Carolina Sustainable Energy Conference • Planet Earth Day Celebration
Ford Motor	• Green Fair – Ann Arbor • SEE Conference – New Orleans • Drive One Event – Dearborn • Detroit Science Center Fun Day • Green Car Conference –Novi • Alt Wheels 2008 – Boston • Consumer Reports – Delaware • JARI Delegation - Dearborn, MI • North American International Auto Show - Detroit • Washington Auto Show - Washington, DC • NHTSA Ride and Drive - Dearborn, MI • Advanced Energy Storage Systems- Lansing, MI • Alternative Fuel Vehicles Conference - Orlando, FL

Future Work

- Finalize partnerships
- Build and deliver remaining fleet vehicles
- Continue V2G/G2V Communications Development
- Demonstrate Two-way Communication
- Validate Next-Gen HV Battery Design
- Continue development of Flex Fuel (E-85) calibration and strategy on future vehicles

Summary

- Engineering development continues to drive Phase II vehicle designs
- Strong interest from future fleet customers
- Fleet customers are very satisfied with battery charging and driving experience
- Further development needed in areas of battery design, control system optimization and supplier development before high-volume production
- DOE-sponsored program leads to the announcement of a 2012 mass production PHEV program