Overview

Timeline
- Start: Late 2006
- End: March 2010
- 100% Complete

Barriers
- Barriers addressed
  - Address codes and standards needed to enable wide-spread adoption of electric-drive transportation technologies.

Budget
- Total project funding
  - $0k in FY08
    (included in benchmarking activity)
  - $300k in FY09
  - $150k in FY10
- Benchmarking program heavily leveraged (standards activity not possible without ANL benchmark testing program)

Partners
- ANL staff is Chair of J1711
- Task Force includes experts from, Toyota, Honda, Ford, Chrysler, GM, Nissan, JARI, Mitsubishi, NREL, EPA, CARB, Environment Canada
Relevance: Industry and Certification Bodies Will Use This Updated PHEV Test Procedure

“The choice of the ways to test and compare fuel economy has never been more critical - or more complex ” – Peter Savagian, Engineering Director, GM Powertrain in address to SAE Congress, April 2010

Updated PHEV test procedure allows testing any conceivable PHEV concept with level playing field, no technology forcing

- Original J1711 components required many changes and updates to match contemporary PHEV designs
- EPA will adopt features in balloted J1711 document
- J1711 is applicable to Mileage Label and CAFE
- J2841 will be sited by anyone doing fuel consumption studies of PHEVs
Approach: Leverage PHEV Benchmarking Activities, Find Robust, Unbiased Methodology

Objective:
- Update conventional hybrid procedures where needed
- Develop test procedures resulting in proper measurement of both electricity and fuel consumption over 5 standard EPA cycles
- Harmonize as much as possible with the numerous organizations also developing PHEV test procedures

Approach:
1. ANL chair J1711 Task Force as arbiter of competing OEM interests
2. Test as many available PHEV prototypes, find issues (2006 to 2008)
4. Investigate short-cut methods (2008, objective tabled for a few years)
5. Sensitivity studies into many test details requiring decisions (2008 to 2009)
   - test pause lengths, charging details, soak details for SC03 and Cold UDDS
6. Final Concept drafted, meetings every 2 weeks (2009)
7. Concept written into J1711 document (late 2009)
8. Pre-ballot periods, JARI, ISO, ECE (early 2010)
9. Sent to ballot (March 2010)
New Accomplishment: “Multi-Day Individual Utility Factor” Completed

- UF’s determine the appropriate mix of depleting operation
- “Individual” UF is vehicle-weighted, not miles-weighted
- DOT NHTS survey does not have multi-day data to find this information
- Multi-day can be calculated from Commute Atlanta (CA), a two year study
- ANL managed entire sub-contract and analysis involving many parties
  - Key metrics of Commute Atlanta data matched NHTS data eliminating the need to employ tricky scaling techniques

NHTS vs CA Data – Ind 1-Day UF

NHTS vs CA Data – Fleet UF
New Accomplishment: J2841 Re-Written With “Multi-Day Individual Utility Factor (MDIUIF)” And Guidance for City/Highway Specific UF Curves

- Document sponsored by ANL staff, re-written to include MDIUF and City/Hwy specific UF data
- The MDIUF alternative may be helpful in conveying average consumer experience with a particular PHEV
  - Long distance drivers reduce the apparent utility of depleting operation in the Fleet Utility Factor (FUF)
New Accomplishment: Finally, A Rigorous Analysis Defining SOC Corrections

Charge-balanced results from PHEV testing in CS mode is a challenge, new J1711 offers more sophisticated instruction in utilizing SOC corrections:

- Many SOC correction proposals in the literature, but committee decided a robust concept derived from real data with a contextual error analysis was needed
- ANL provided error analysis
  - Monte Carlo methods
  - Several years of HEV testing from dozens of productions HEVs
- A simple approach was developed satisfying two test scenarios
  - Find SOC = 0 regression result by specifying necessary criteria of 4 (or more) tests
  - Valid line SOC regression used to correct a single test (use in certification or development testing)
New Accomplishments: Harmonized Charge Depleting Range and End of Test Criterion

- Robust End of Test Criterion was focus of extensive investigation, research and harmonization

- Charge-depleting range definition made compatible with end of test

Challenge: Unusual SOC behavior shall not invalidate methods or result in undesired anomalies
New Accomplishment: Alternative Results Calculations (Not Using UFs)

J1711 Appendix offers a CD result associated with a calculated depleting range

- Single result from the UF method may not satisfy all stakeholders
- Method developed that splits transition cycle into depleting and sustaining segments based upon SOC trends
- The depleting consumption rate (fuel and electricity) is associated with a precisely calculated range

Example Description:

180 MPG and 120Wh/mi
After 36 Miles, 52 MPG

or for EREV PHEV:
260Wh/mi
After 40 Miles, 45 MPG
New Accomplishment: J1715 HEV Terminology Document Updating

- APRF staff doing research into HEV technology since 1989
- ANL adding input to reconcile recent terminology compared to terms used in the past literature
  - ANL provided memo citing “range-extender” usage in past literature
- ANL staff sits on ISO committee now doing similar document
- ANL harmonizing terms used in J1711 document
- **Status**: Still under development
Collaborations
- EPA, DOT Will Reference SAE Standard
- CARB and J1711 Procedures Made Compatible
- ISO and J1711 Collaborate

Considerable effort has gone into keeping CARB and ISO compatible with J1711...
Collaboration With INL in Investigate How J1711 Test Results Compare to Fleet PHEV Data

Purpose: Put Goals of J1711 in Context

- Any vehicle is sensitive to in-use conditions lowering MPG
- PHEVs are sensitive to driving distances,
  - AVTA fleet has slight bias to shorter distances
- Hymotion conversion PHEV has specifically intense sensitivities to:
  - Higher speeds
  - Higher acceleration rates
- High energy use at high speeds actual lower electric consumption per unit distance (lowering MPG)
Collaborations: CARB, Environment Canada, and Chrysler Provided Test Data to Task Force

- CARB Provided early test data in support of new procedures
- Chrysler investigated charge-sustaining HEV in Cold UDDS to decide hybrid test requirements
- Environment Canada tested a Hymotion Prius to validate procedures for all cycles described in J1711 (UDDS, Highway, US06, SC03, Cold UDDS)
Future Work: Near Term and Longer Term

Near Term
- Journal article explaining J1711 rationale. A companion for any test engineer wanting to understand the background, limitations, and possible alternative options

Longer Term
- SAE Procedures require re-ballot or rewrite every 5 years
- Early work on a J1711 “short-cut” could be revisited after more test experience is gained with early production PHEVs

Update Dyno Results and On-Road Experience
- Understanding In-Use PHEV performance:
  - DOE’s fundamental predictions of PHEV effectiveness requires precise understanding of in-use petroleum displacement
- Outreach activities on MPG or consumption of PHEVs
J1711 Summary

- Three years of development and supporting dynamometer test have culminated into a well-received procedure suitable for R&D, OEMs and potentially EPA.
- Experts from USA, Europe and Japan provided many contributions and expert review.
- Dozens of PHEV conversions and prototypes were tested at ANL supporting J1711.
- Many final details required intense review and discussions in the last phase of J1711 development.
- A comprehensive J2841 document is finalized with several UF curves available for characterizing PHEVs according to specific desired questions.
- After several international pre-ballot reviews, a final document was sent to balloting in March 2010.
- Superior institutional knowledge in testing electrified vehicles has become a key enabler to developing electric vehicle (J1634) standard.