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# Advanced Vehicle Testing Activity Data Collection Overview

**Matt Shirk**

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Infrastructure Data Collection and Reporting  
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# ***Presentation Outline***

- **Introduction to the Advanced Vehicle Testing Activity**
- **Testing and On-Road Data Collection Sequence**
- **Vehicle Performance Testing**
- **Fleet Data Collection**
- **On-Road Data Collection**
- **Component Testing**
- **Reporting**


# Introduction

- INL manages the **Advanced Vehicle Testing Activity for the United States Department of Energy**
- **Test vehicles with high *petroleum reduction potential***
  - Electric Vehicles (Full size, urban, and neighborhood)
  - Plug-In Hybrid Electric
  - Hybrid Electric & Idle-Stop
  - Alternative Fuel (CNG, H<sub>2</sub>)
  - Advanced Internal Combustion
- **Test and report on**
  - Vehicle performance
  - Fuel and electricity consumption
  - On-Road Operation
  - Ownership cost & maintenance
  - Battery performance and aging



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**2011 Chevrolet Volt – VIN 0815**

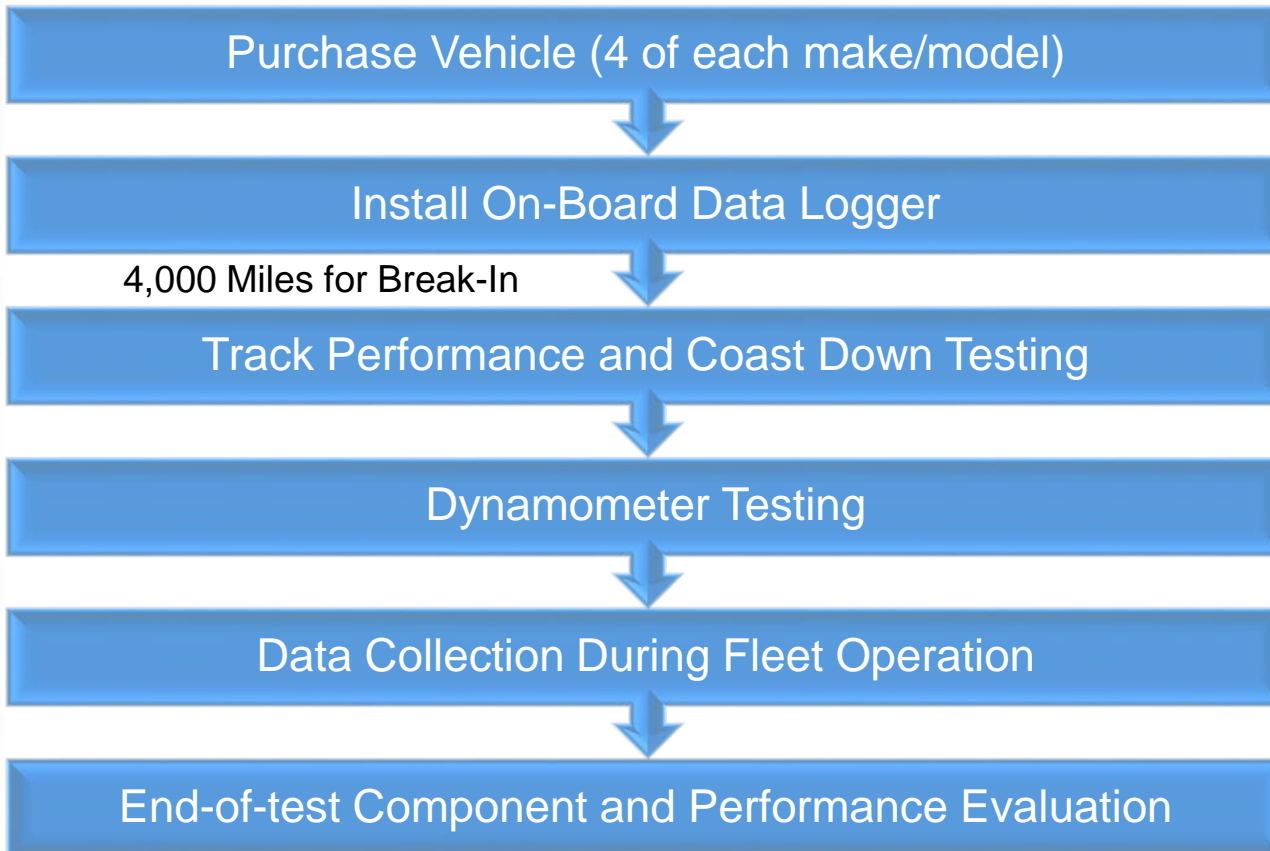
Advanced Vehicle Testing – Baseline Testing Results



VEHICLE SPECIFICATIONS <sup>1</sup>		
Vehicle Features	Battery	Weights
<p><b>Base Vehicle:</b> 2011 Chevrolet Volt</p> <p><b>VIN:</b> 1G1R D6E48BU000815</p> <p><b>Class:</b> Compact</p> <p><b>Seatbelt Positions:</b> 4</p> <p><b>Type<sup>2</sup>:</b> Multi-Mode PHEV (EV, Series, and Power-split)</p> <p><b>Motor</b></p> <p><b>Type:</b> 12-pole permanent magnet AC synchronous</p> <p><b>Max. Power/Torque:</b> 111 kW/370 Nm</p> <p><b>Max. Motor Speed:</b> 9500 rpm</p> <p><b>Cooling:</b> Active – Liquid cooled</p> <p><b>Generator</b></p> <p><b>Type:</b> 16-pole permanent magnet AC synchronous</p> <p><b>Max. Power/Torque:</b> 55 kW/200 Nm</p> <p><b>Max. Generator Speed:</b> 6000 rpm</p> <p><b>Cooling:</b> Active – Liquid cooled</p>	<p><b>Manufacturer:</b> LG Chem</p> <p><b>Type:</b> Lithium-ion</p> <p><b>Cathode/Anode Material:</b> LiMn<sub>2</sub>O<sub>4</sub>/Hard Carbon</p> <p><b>Number of Cells:</b> 288</p> <p><b>Cell Config.:</b> 3 parallel, 96 series</p> <p><b>Nominal Cell Voltage:</b> 3.7 V</p> <p><b>Nominal System Voltage:</b> 355.2 V</p> <p><b>Rated Pack Capacity:</b> 45 Ah</p> <p><b>Rated Pack Energy:</b> 16 kWh</p> <p><b>Weight of Pack:</b> 435 lb</p> <p><b>Pack Location:</b> Underneath vehicle center</p> <p><b>Cooling:</b> Active – Liquid cooled</p> <p><b>Engine</b></p> <p><b>Model:</b> DOHC I-4</p> <p><b>Output:</b> 63 kW @ 4800rpm</p> <p><b>Configuration:</b> Inline 4-Cylinder</p> <p><b>Displacement:</b> 1.4 L</p> <p><b>Fuel Tank Capacity:</b> 9.3 gal</p> <p><b>Fuel Type:</b> Premium Gasoline</p>	<p><b>Design Curb Weight:</b> 3,781 lb</p> <p><b>Delivered Curb Weight:</b> 3,770 lb</p> <p><b>Distribution F/R (%):</b> 61/39</p> <p><b>GVWR:</b> 4,548 lb</p> <p><b>GAWR F/R:</b> 2,515/2,033 lb</p> <p><b>Max. Payload:</b> 750 lb</p> <p><b>Performance Goal:</b> ≥400 lb</p> <p><b>Dimensions</b></p> <p><b>Wheelbase:</b> 105.7 in</p> <p><b>Track F/R:</b> 61.2 / 62.1 in</p> <p><b>Length/Width:</b> 177.1 in/70.4 in</p> <p><b>Height:</b> 56.6 in</p> <p><b>Ground Clearance:</b> 6.0 in</p> <p><b>Performance Goal:</b> ≥6.0 in</p> <p><b>Tires</b></p> <p><b>Manufacturer:</b> Goodyear</p> <p><b>Model:</b> Assurance</p> <p><b>Size:</b> P215/55R17</p> <p><b>Pressure F/R:</b> 35/35 psi</p> <p><b>Spare Installed:</b> N/A - Tire sealant and inflator</p>



Page 1 of 8

# Testing & Data Collection Sequence



EV end-of-test:	60,000 Miles	} <i>Try to capture failure modes</i>
PHEV end-of-test:	195,000 Miles	
HEV, ICE end-of-test:	255,000 Miles	

# Vehicle Performance Tests

- **Closed Track Performance Tests**

- 0-60 mph, ¼ mile, 1 mile acceleration
- Coast Down for road-load determination
- Braking
- Battery transients during tests
- Testing performed by ETEC Labs



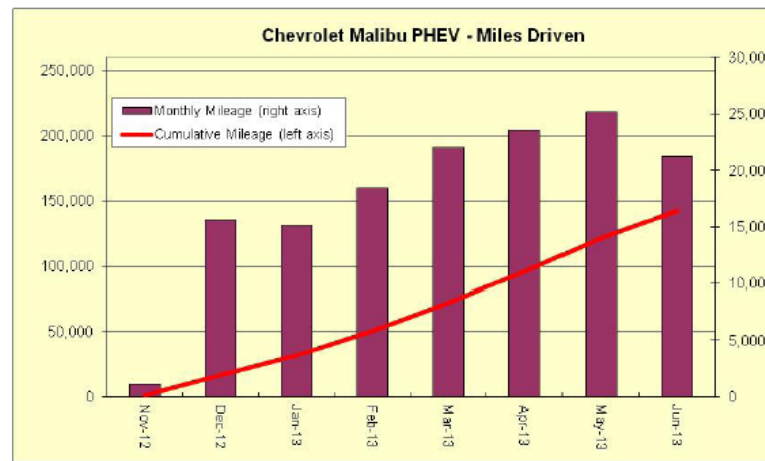
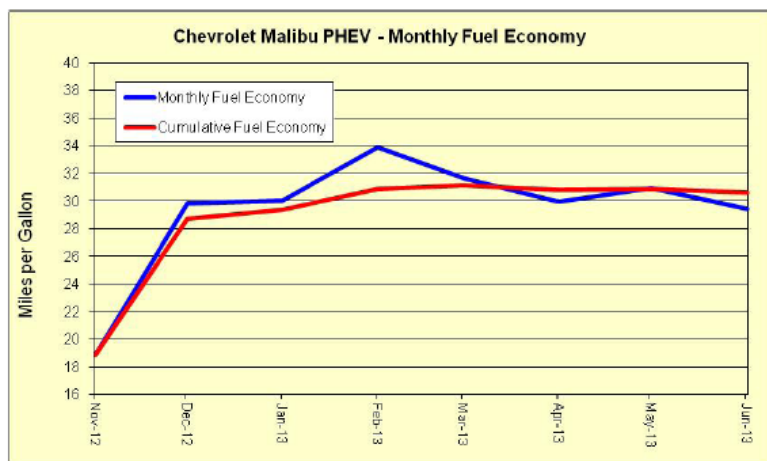
- **Chassis Dynamometer Tests**

- Drive cycle based fuel economy or energy consumption/range
  - UDDS, HWFET, US06, SC03 (US EPA Cycles) at 20°F, 72°F, 95°F
- Steady-state speed fuel economy/energy consumption, gradeability
- Testing performed by Argonne National Laboratory



# Fleet Data - Fuel & Electricity

- Fuel dispensed for each vehicle is logged by fleet operator by date and odometer reading
- Electricity metered by Blink EVSE, collected from Blink database, with unique access cards for each vehicle



# Fleet Data – Maintenance and Costs

- Maintenance is recorded and compiled
- Reports detail every maintenance item
- Operating costs based on purchase price, fuel costs, maintenance costs, insurance, and state registration

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## HEV Fleet Testing

### Advanced Vehicle Testing Activity

#### Maintenance Sheet for 2011 Hyundai Sonata

VIN# KMHEC4A47BA003539


Date	Mileage	Description	Cost
7/19/2011	5,720	Changed oil and filter	\$14.67
10/12/2011	11,152	Changed oil and filter and rotated tires	\$60.49
10/21/2011	12,342	Upgraded ECU (TG5), replaced NVLD pressure sensor (TG6), and replaced cooling fan resistor (TG8)	warranty
11/21/2011	16,442	Changed oil and filter	\$43.22
12/20/2011	22,497	Changed oil and filter and rotated tires	\$56.85
1/24/2012	28,205	Changed oil and filter	\$41.85
2/6/2012	30,100	30K service	\$109.16
2/9/2012	30,460	Recall: replaced two high voltage connectors at the HPCU	n/c
2/27/2012	33,208	Changed oil and filter and rotated tires	\$56.85
3/24/2012	40,809	Changed oil and filter	\$41.85
4/20/2012	47,580	Changed oil and filter and rotated tires	\$57.94
5/10/2012	53,152	Changed oil and filter	\$40.74
6/1/2012	59,199	Changed oil and filter	\$40.74
7/2/2012	66,189	Changed oil and filter and purchased spare tire	\$122.94
7/2/2012	66,300	60K mile service	\$148.78
7/9/2012	67,342	Replaced four tires	\$522.78
7/24/2012	71,637	Changed oil and filter and rotated tires	\$57.94
8/14/2012	77,060	Changed oil and filter	\$42.94
9/1/2012	82,419	Changed oil and filter and rotated tires	\$57.94
9/24/2012	89,569	Changed oil and filter	\$42.94
9/25/2012	90,000	90K mile service	\$148.78

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## HEV Fleet Testing - Summary Fact Sheet

Advanced Vehicle Testing Activity



**2011 Hyundai Sonata**  
VIN# KMHEC4A47BA003539

**Vehicle Specifications**

Engine: 2.4 L  
Electric Motor: 30 KW  
Battery: Lithium Polymer  
Seatbelt Positions: Five  
Payload: 1074 lbs  
Features:  
Regenerative braking  
Traction control

**Fleet Performance**

Operating Cost:  
Purchase Cost: \$31,152 (\$11)\*  
Kelley Blue Book: \$9,140 (\$413)  
Sale Price: In Operation  
Maintenance Cost: \$0.02/mile  
Operating Cost: \$0.14/mile\*\*  
Total Ownership Cost: \$0.31/mile

**Operating Performance:**

Total miles driven: 147,808  
Cumulative MPG: 34.0


**Major Operations & Maintenance Events:**  
None

\*Purchase includes dealer price with optional plus taxes. \*\*Does not include tire, license, registration, extended warranty or delivery fee costs.

\*\*Operating costs includes insurance, fuel, and registration costs.

**Description:**  
This vehicle is operated throughout the valley of Phoenix, Arizona by EZ Messaging, a legal document courier business. It is operated five days a week, transferring documents between courts, law offices, and medical facilities on city streets and urban freeways.

See AFV America Baseline Performance Fact Sheet for more information



Monthly MPG (in miles driven/gallons of fuel purchased). Monthly variation in reported MPG may occur due to the difference in fuel tank level at the beginning and end of the month.

U.S. DEPARTMENT OF ENERGY EERE Information Center  
1-877-EERE-INFO (1-877-337-3463)  
www.eere.energy.gov/vehiclesandfuels

# ***On Road Data Collection***

- **Data is collected, second-by-second for each drive by a mixture of OBD-2 and ‘Normal’ CAN messages.**
  - Speed
  - Engine speed
  - Fuel consumption
  - Battery current
  - Battery voltage
  - Battery temperature
  - Air conditioning usage
  - Coolant temperature
  - Ambient temperature
  - Catalyst temperature
  - Brake on/off
  - Accelerator pedal position
- **Charging data is also collected for Plug-In Electric Vehicles.**
- **Other interesting data is collected, as available, depending on the vehicle**
  - i.e. electric motor torque, electric motor speed, transmission gear, brake pressure, etc





# Component Testing - Battery

- Batteries are baseline tested in the laboratory after break in (4,000 Miles)
- Interim tests occur at 6, 18, 30 months from baseline
- Final lab test at the end of mileage accumulation
- Tests based on United States Advanced Battery Consortium (USABC) standard test manuals
  - Constant current capacity test
  - Pulse power characterization

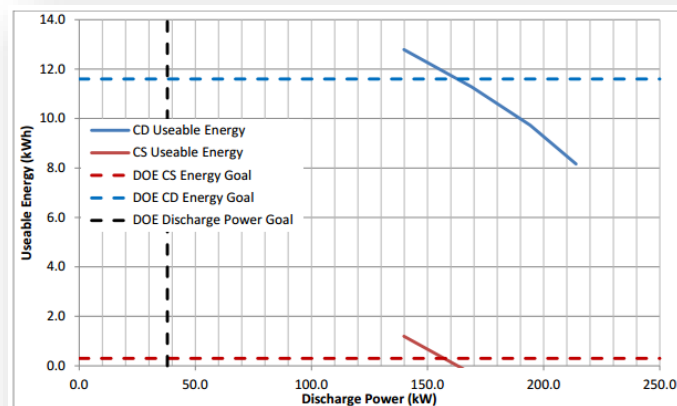





Figure 7. Useable Energy vs. Power

**2013 Chevrolet Volt – VIN 3929**  
Advanced Vehicle Testing – Beginning-of-Test Battery Testing Results

VEHICLE DETAILS AND BATTERY SPECIFICATIONS <sup>1</sup>	
<b>Vehicle Details</b> Base Vehicle: 2013 Chevrolet Volt VIN: 1G1RA6E40DU103929 Propulsion System: Multi-Mode PHEV (EV, Series, and Power-split) Engine: DDMC 1.4, 1.4 L, 63 kW @ 4800 rpm Number of Electric Machines <sup>2</sup> : 2 Motor: 111 kW (peak), AC induction, Air cooled Generator <sup>2</sup> : 55 kW (peak), DC Permanent Magnet, Liquid cooled Peak Electric Drive and Engine Power: 111 kW	<b>Battery Specifications</b> Manufacturer: LG Chem Type: Lithium-ion Number of Cells: 288 Nominal Cell Voltage: 3.7 V Nominal System Voltage: 355.2 V Rated Pack Energy: 45 Ah Rated Pack Energy: 16.5 kWh Maximum Cell Charge Voltage <sup>3</sup> : 4.15 V Minimum Cell Discharge Voltage <sup>3</sup> : 3.00 V Thermal Management: Active – Liquid cooled
BATTERY LABORATORY TEST RESULTS SUMMARY	
<b>Vehicle Mileage and Test Date</b> Vehicle Odometer: 4,007 mi Date of Test: December 13, 2012 <b>Static Capacity Test</b> Measured Average Capacity: 46.5 Ah Measured Average Energy Capacity: 16.6 kWh	<b>HEPC Test</b> CD Available Energy Margin <sup>4</sup> : 1.1 kWh CS Available Energy Margin <sup>4</sup> : 0.89 kWh <b>Constant-Power Discharge Test</b> Capacity Discharged: 46.7 Ah Energy Discharged: 16.7 kWh

**NOTES:**  
 1. Vehicle details and battery specifications were either supplied by the manufacturer or derived from a literature review.  
 2. Not all electric machines (EM) always provide tractive power; use of the EMs is a function review with the motor state of the other is used as a generator.  
 3. Maximum cell charge voltage and minimum cell discharge voltage are based on similar battery chemistries from the same battery manufacturer.  
 4. Available energy at the DOE measured PHEV power performance goals.



Page 1 of 6

# Reporting

- Reports all link to database
  - Baseline Performance Testing
  - Fleet Testing Fuel Economy
  - Maintenance History
  - On-Road Performance Results
  - Battery Report
  - Fact Sheet
  - Other reports for focused analysis

Date	Mileage	Description	Cost
9/18/2011	9,720	Changed oil and filter	\$14.67
10/12/2011	11,112	Changed oil and filter and rotated tires	\$60.48
10/21/2011	12,342	Upgraded ECU (TCG), replaced NVLD pressure sensor (T06), and replaced coolant fan resistor (T06)	WASB07
11/21/2011	18,442	Changed oil and filter	\$43.22
12/29/2011	22,497	Changed oil and filter and rotated tires	\$56.83
1/24/2012	28,295	Changed oil and filter	\$41.81
2/8/2012	30,190	HOE service	\$109.18
3/9/2012	30,640	Recall: replaced two high voltage connectors at the MPCU	0/
3/27/2012	33,206	Changed oil and filter and rotated tires	\$56.83
3/24/2012	40,339	Changed oil and filter	\$41.81
4/20/2012	47,580	Changed oil and filter and rotated tires	\$57.94
5/10/2012	51,112	Changed oil and filter	\$40.74
6/1/2012	58,189	Changed oil and filter	\$40.74
7/2/2012	66,189	Changed oil and filter and purchased spare tire	\$122.94
7/2/2012	66,360	HOE, wiper service	\$148.78
7/8/2012	67,142	Replaced front wiper	\$122.78
7/24/2012	71,487	Changed oil and filter and rotated tires	\$57.94
8/14/2012	77,060	Changed oil and filter	\$42.94
8/1/2012	82,418	Changed oil and filter and rotated tires	\$57.94
9/24/2012	88,569	Changed oil and filter	\$42.94
9/21/2012	90,900	HOE, wiper service	\$148.78

# *Summary*

- **Vehicles are performance tested when new**
- **Sub-components of interest are lab tested on intervals**
- **Vehicle on-board data gathered for duration of fleet deployment**
- **All data in databases**
- **Reports generated from multiple databases**
- **Signal validation and data quality assurance processes produce reliable results**