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ADVANCED VEHICLE TESTING & EVALUATION

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PRINCIPAL INVESTIGATOR

Intertek Testing Services, North America

June 17, 2014

VSS029

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OVERVIEW – NEW AGREEMENT

TIMELINE

Project Start; Oct. 01, 2011
Project End; Sep. 30, 2016
Percent Complete; 15%

BUDGET

Total Project; $ 33,088,218
DOE Share; $ 26,400,000
Cost Share; $ 6,688,218
Current Auth; $ 6,351,700

BARRIERS

Vehicle Availability
Vehicle Reliability
Infrastructure Requirements

PARTNERS

EZ Messenger
Total Transit
Idaho National Laboratory
Argonne National Laboratory
Peloton Technology
National Renewable Energy Lab
SAE
University of Nebraska - Lincoln

Relevance

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OBJECTIVES

- Test and evaluate advanced vehicle technologies intended to reduce the consumption of petroleum
- Produce lifecycle cost data for vehicles that are utilizing these advanced technologies
- Provide fleet operations data to the Idaho National Laboratory database in order to disseminate the results of vehicle and infrastructure testing & analysis
- Provide benchmark data and performance trends for advanced technology vehicles

Relevance

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MILESTONES

- Advanced Technology Vehicles on test (2013)
  - BEV 12
  - PHEV 18
  - HEV 16
  - ICE 8
  - 3 vehicles completed testing & 28 vehicles started, rest ongoing
- Advanced Technology Vehicles to be tested in CY 2014 (difference is those to be started)
  - BEV 16 (4)
  - PHEV 22 (4)
  - HEV 16 (0)
  - ICE 20(12)

Approach

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PROCEDURE/DOCUMENTATION DEVELOPMENT

- Administrative Procedures for Control of Test Conduct
- Vehicle Specifications Defining Key Vehicle and Performance Parameters
- Battery Test Procedures Defining Implementation of Standard Test Requirements
- Develop Interim Component Durability Test Procedures

Approach

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BASELINE TESTING

- Baseline Vehicle Performance at outset of testing
  - Acceleration
  - Maximum speed
  - Braking
  - Fully electric range (when applicable)
  - Vehicle coast-down testing to obtain drag coefficients for chassis dynamometer testing
- End-of-Test Performance

Approach

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FLEET TESTING

- Production Vehicles
- 60,000 to195,000 Miles (depending upon technology)
- On-Board Data Logger with Automatic Data Upload
- Fuel and Maintenance Logs
- Interim Component Durability Testing

Approach

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ACCELERATED TESTING

- **Alternative to Fleet Testing is a Fixed Route Mileage Accumulation**

Cycle (mi)	Urban (10 mi)	Highway (10 mi)	Charge (hr)	Reps (N)	Total (mi)	Reps (%)	Miles (%)
10	1	0	4	60	600	37%	11%
20	1	1	8	30	600	19%	11%
40	4	0	12	15	600	9%	11%
40	2	2	12	15	600	9%	11%
40	0	4	12	15	600	9%	11%
60	2	4	12	10	600	6%	11%
80	2	6	12	8	640	5%	12%
100	2	8	12	6	600	4%	11%
200	2	18	12	3	600	2%	11%
Total	**2,340**	**3,100**	**1,344**	**162**	**5,440**		
Average	43%	57%	8.3	18			

Approach

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TRACTION BATTERY TESTING

- Hybrid Vehicles
  - C_1 capacity
  - Hybrid pulse power characterization
- Plug-In Hybrid Vehicles
  - C_3 capacity
  - Hybrid pulse power characterization
- Battery Electric Vehicles
  - C_3 capacity
  - Electric vehicle power characterization

Accomplishments

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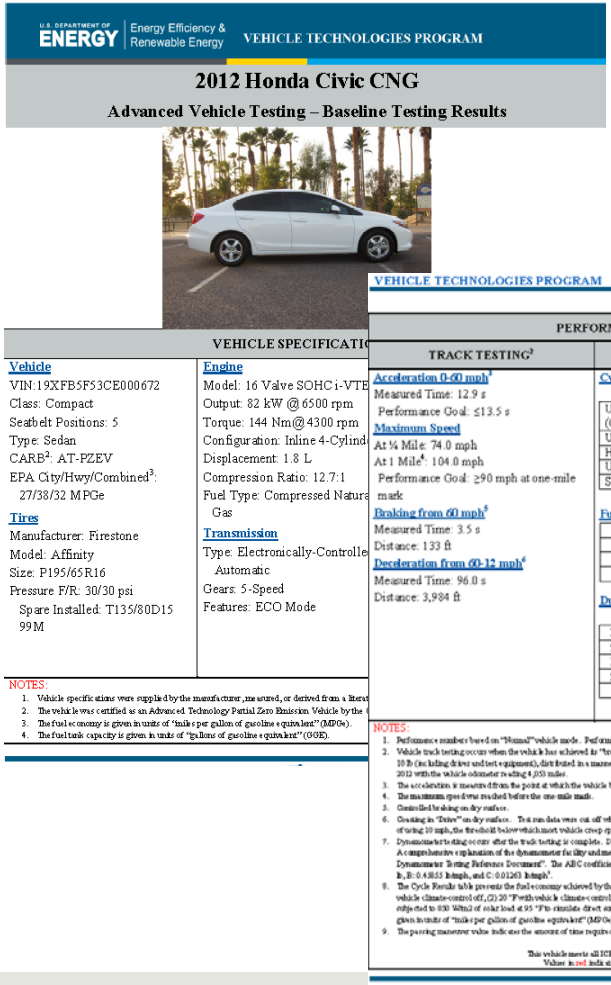
2013 BASELINE TESTS COMPLETED

- 2013 Honda Civic Hybrid
- 2013 Toyota Prius Plug-in
- 2013 Ford C-Max Hybrid
- 2013 Ford C-Max Energi
- 2013 Ford Fusion Energi
- 2014 VW Jetta Hybrid



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy VEHICLE TECHNOLOGIES PROGRAM

2012 Honda Civic CNG

Advanced Vehicle Testing – Baseline Testing Results

VEHICLE SPECIFICATIO

Vehicle
VIN:19XFB5F53CE000672
Class: Compact
Seatbelt Positions: 5
Type: Sedan
CARB[2]: AT-PZEV
EPA City/Hwy/Combined[3]: 27/38/32 MPGe

Tires
Manufacturer: Firestone
Model: Affinity
Size: P195/65R16
Pressure F/R: 30/30 psi
Spare Installed: T135/80D15 99M

Engine
Model: 16 Valve SOHC i-VTE
Output: 82 kW @ 6500 rpm
Torque: 144 Nm@4300 rpm
Configuration: Inline 4-Cylind
Displacement: 1.8 L
Compression Ratio: 12.7:1
Fuel Type: Compressed Natura Gas

Transmission
Type: Electronically-Controlle Automatic
Gears: 5-Speed
Features: ECO Mode

NOTES:
1. Vehicle specifications were supplied by the manufacturer, measured, or derived from a liter
2. The vehicle was certified as an Advanced Technology Partial Zero Emission Vehicle by the
3. The fuel economy is given in units of "miles per gallon of gasoline equivalent" (MPGe).
4. The fuel tank capacity is given in units of "gallons of gasoline equivalent" (GGE).

VEHICLE TECHNOLOGIES PROGRAM

PERFORMANCE STATISTICS[1]

TRACK TESTING[2]

Acceleration 0-60 mph[3]
Measured Time: 12.9 s
Performance Goal: ≤13.5 s

Maximum Speed
At ¼ Mile: 74.0 mph
At 1 Mile[4]: 104.0 mph
Performance Goal: ≥90 mph at one-mile mark

Braking from 60 mph[5]
Measured Time: 3.5 s
Distance: 133 ft

Deceleration from 60-12 mph[6]
Measured Time: 96.0 s
Distance: 3,984 ft

DYNAMOMETER TESTING[7]

Cycle Results[8]

	72 °F	20 °F	95 °F + 850 W/m²
UDDS (Cold Start)	29.3 MPGe	24.4 MPGe	25.4 MPGe
UDDS	31.9 MPGe	29.0 MPGe	26.5 MPGe
HWFET	49.5 MPGe	46.4 MPGe	46.3 MPGe
US06	31.2 MPGe	30.7 MPGe	28.7 MPGe
SC03	31.1 MPGe	--	25.9 MPGe

Fuel Economy at Steady-State Speed, 0% Grade

10 mph	30.1 MPGe	50 mph	47.1 MPGe
20 mph	39.7 MPGe	60 mph	41.5 MPGe
30 mph	54.3 MPGe	70 mph	38.0 MPGe
40 mph	47.5 MPGe	80 mph	31.8 MPGe

Duration of Passing Maneuver at Grade[9]

	0% Grade	3% Grade	6% Grade
35-55 mph	5.8 s	7.0 s	9.7 s
55-65 mph	3.5 s	4.4 s	6.5 s
35-70 mph	11.9 s	14.6 s	21.7 s
55-80 mph	10.8 s	15.8 s	29.3 s

Maximum Speed at 25% Grade from Stop: 35.5 mph

NOTES:
1. Performance numbers based on "Normal" vehicle mode. Performance numbers are averages from multiple tests.
2. Vehicle track testing occurs when the vehicle has achieved its "break-in mileage" of between 4,000 to 6,000 miles, and at the delivered curb weight plus 332 ± 10 lb (including driver and test equipment), distributed in a manner similar to the original curb loading of the vehicle. Track testing began on December 17, 2012 with the vehicle odometer reading 4,050 miles.
3. The acceleration is measured from the point at which the vehicle begins to move.
4. The maximum speed was reached before the one-mile mark.
5. Controlled braking on dry surface.
6. Coasting in "Drive" on dry surface. Test run data were cut off when the vehicle reached 12 mph, this ending value is a deviation from the normal procedure of using 10 mph, the threshold below which most vehicle creep speeds typically fall. This vehicle has a higher creep speed.
7. Dynamometer testing occurs after the track testing is complete. Dynamometer testing began on April 29, 2013, with the vehicle odometer reading 4,254 miles. A comprehensive explanation of the dynamometer facility and methodology can be found at http://www.transportation.anl.gov/D3/, titled "Chassis Dynamometer Testing Reference Document". The ABC coefficients derive from track coastdown testing and matched on the dynamometer were A: 22.2037 lb, B: 0.4855 lb/mph, and C: 0.01263 lb/mph².
8. The Cycle Results table presents the fuel economy achieved by the vehicle on five EPA drive cycles at three different ambient temperatures: (1) 72 °F with vehicle climate control off, (2) 20 °F with vehicle climate control set to 72°F, and (3) 95 °F with vehicle climate control set to 72°F. The vehicle is also subjected to 850 W/m2 of solar load at 95 °F to simulate direct sunlight. The drive cycles include a hot start unless otherwise indicated. The fuel economy is given in units of "miles per gallon of gasoline equivalent" (MPGe).
9. The passing maneuver value indicates the amount of time required for the vehicle to transition from the first to the second speed listed, at the specified grade.

This vehicle meets all ICEV America listed at the end of this document.
Values in red indicates that the Performance Goal was not met.

Accomplishments

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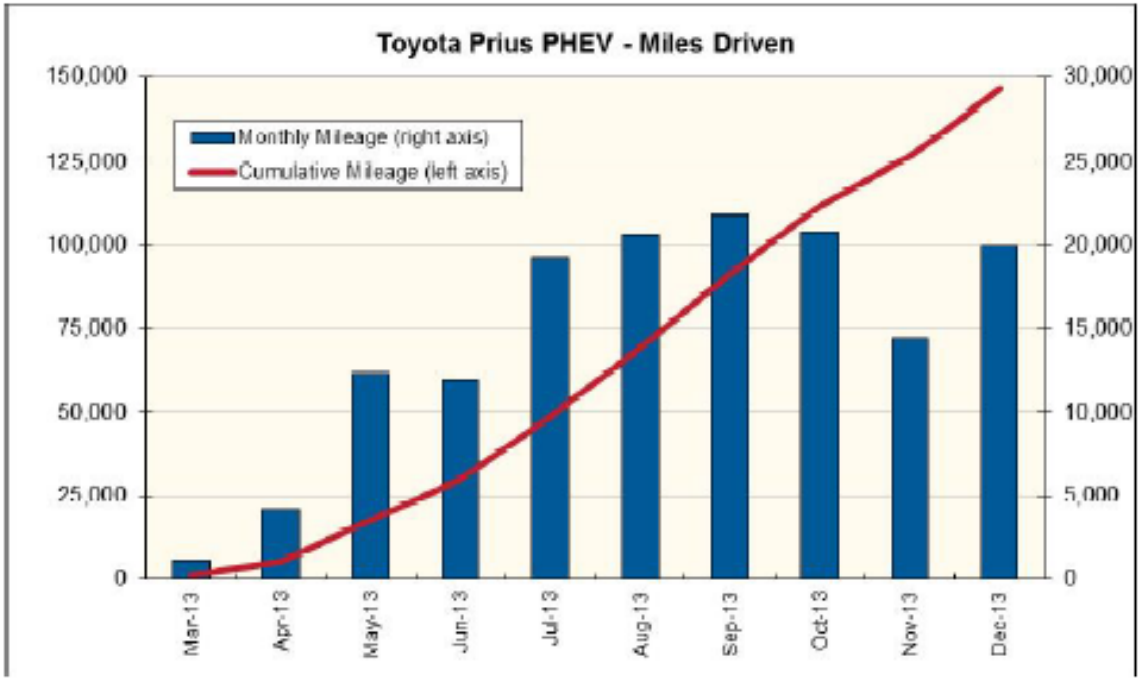
2013 FLEET TEST VEHICLES

- 2 Honda CR-Z HEV
- 2 Hyundai Sonata HEV
- 2 Chevrolet Volt PHEV (MY11)
- 2 Nissan Leaf BEV (MY11)
- 4 Honda Civic CNG
- 4 VW Jetta Turbo Diesel
- 4 Chevrolet Volt PHEV (MY13)
- 4 Chevrolet Malibu ECO
- 4 Honda Civic HEV
- 4 Toyota Prius PHEV
- 4 Nissan Leaf BEV (MY13)
- 2 Mitsubishi IMiEV BEV
- 4 Ford C-Max HEV
- 4 Ford C-Max Energi (PHEV)
- 4 VW Jetta HEV



Collaborations

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NATIONAL LABORATORIES

- Idaho National Laboratory
  - Procedure development
  - Data collection & analysis
  - Reporting
- Argonne National Laboratory
  - Vehicle Test Procedure development
  - Chassis Dynamometer testing
  - Level 2 AC EV Charging Interoperability tests
- National Renewable Energy Laboratory
  - Semi-autonomous vehicle performance evaluation

Collaborations

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INDUSTRY PARTNERS

- EZ Messenger
  - Document delivery fleet
  - Mileage accumulation
  - Route design
- Total Transit
  - Taxi service
  - Mileage accumulation

Collaborations

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OTHER PARTNERS

- Peloton Technologies
  - Semi-autonomous HD vehicle system
- Society of Automotive Engineers
  - L2 EVSE interoperability
- University of Nebraska
  - Advanced Agricultural equipment evaluation

Future Work

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CONTINUOUS IMPROVEMENT

- Update test procedures
- Develop new test procedures for new technologies and new vehicle types
- Develop test procedures for interim component durability testing
- Continue to automate test reporting
- Identify & expand test fleet operators
- Expand scope to include Medium Duty vehicles

Future Work

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ONGOING TESTING

- Over 50 vehicle models scheduled for evaluation
- A dozen fueling infrastructure evaluations

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2013 SUMMARY

- Award novation in Q4 to Intertek
- At year end, over 50 vehicles (15 models) in test fleets employing 5 different technologies and various strategies to reduce petroleum consumption
- Implemented fleet management software
- Added fleet operators
- Auto-populated test reports with ANL & INL
- Test results posted to AVTA Website

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TECHNICAL BACKUP SLIDES

vss029

2013 Chevrolet Volt Baseline Testing Results (Page 1 of 5)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

VEHICLE TECHNOLOGIES PROGRAM

2013 Chevrolet Volt

Advanced Vehicle Testing – Baseline Testing Results

VEHICLE SPECIFICATIONS[1]

Vehicle

VIN: 1G1RA6E40DU103929
Class: Compact
Seatbelt Positions: 4
Type[2]: Multi-Mode PHEV (EV, Series, and Power-split)
CARB[3]: BIN 4
EPA: 350 Wh/mi (Electricity only); 37 mpg (Hybrid mode, Combined)

Dimensions

Drag Coefficient: 0.29
Wheelbase: 105.7 in
Track F/R: 61.2 / 62.1 in
Length/Width: 177.1 in/70.4 in
Height: 56.6 in
Ground Clearance: 6.0 in

Weights

Design Curb Weight: 3,781 lb
Delivered Curb Weight: 3,770 lb
Distribution F/R (%): 61/39
GVWR: 4,539 lb
GAWR F/R: 2,512/2,027 lb
Max. Payload: 758 lb

Battery

Manufacturer: LG Chem
Type: Lithium-ion
Cathode/Anode Material: $LiMn_2O_4$/Hard Carbon
Number of Cells: 288
Cell Config.: 3 parallel, 96 series
Nominal Cell Voltage: 3.7 V
Nominal System Voltage: 355.2 V
Rated Pack Capacity: 45 Ah
Rated Pack Energy: 16.5 kWh
Weight of Pack: 435 lb
Pack Location: Underneath vehicle center
Cooling: Active – Liquid cooled

Engine

Model: DOHC I-4
Output: 63 kW @ 4800rpm
Configuration: Inline 4-Cylinder
Displacement: 1.4 L
Fuel Tank Capacity: 9.3 gal
Fuel Type: Premium gasoline

Motor

Type: 12-pole permanent magnet AC synchronous
Max. Power/Torque: 111 kW/370 Nm
Max. Motor Speed: 9500 rpm
Cooling: Active – Liquid cooled

Generator

Type: 16-pole permanent magnet AC synchronous
Max. Power/Torque: 55 kW/200 Nm
Max. Generator Speed: 6000 rpm
Cooling: Active – Liquid cooled

Tires

Manufacturer: Goodyear
Model: Assurance
Size: P215/55R17
Pressure F/R: 35/35 psi
Spare Installed: N/A - Tire sealant and inflator

2013 Chevrolet Volt Baseline Testing Results (Page 2 of 5)

CHARGE-DEPLETING PERFORMANCE STATISTICS[4]

TRACK TESTING[5]

Acceleration 0-60 mph[6]

Measured Time: 10.2 s

Performance Goal: ≤13.5 s

Peak Power from Battery: 111.9 kW

Maximum Speed

At ¼ Mile: 79.6 mph

At 1 Mile[7]: 100.9 mph

Performance Goal: ≥90 mph at 1-mile mark

Braking at 50% SOC from 60-0 mph[8]

Measured Time: 3.4 s

Distance: 125.1 ft

Peak Power into Battery: 27.1 kW

Braking at 100% SOC from 60-0 mph[8]

Measured Time: 3.7 s

Distance: 123 ft

Peak Power into Battery: 46.6 kW

Deceleration from 60-10 mph[9]

Measured Time: 88.8 s

Distance: 3915.2 ft

Peak Power into Battery: 15.7 kW

Total Energy into Battery: 53.8 Wh

DYNAMOMETER TESTING[9]

Duration of Passing Maneuver at Grade[11]

	0% Grade	3% Grade	6% Grade
35-55 mph	4.1 s	4.6 s	5.3 s
55-65 mph	3.6 s	3.4 s	4.3 s
35-70 mph	9.1 s	9.8 s	12.1 s
55-80 mph	9.1 s	11.5 s	14.8 s
Maximum Speed at 25% Grade from Stop: 46.6 mph			

Energy Consumption at Steady-State Speed, 0% Grade

10 mph	219.5 Wh/mi	50 mph	253.1 Wh/mi
20 mph	160.8 Wh/mi	60 mph	294.2 Wh/mi
30 mph	180.0 Wh/mi	70 mph	361.6 Wh/mi
40 mph	207.8 Wh/mi	80 mph	411.4 Wh/mi

Cycle Results[12]

	72 °F	20 °F	95 °F + 850 W/m^2
UDDS (Cold Start)	258.5 Wh/mi	270.3 Wh/mi, 46.4 mpg	337.4 Wh/mi
UDDS	253.6 Wh/mi	213.3 Wh/mi, 93.2 mpg	323.0 Wh/mi
HWFET	261.9 Wh/mi	234.5 Wh/mi, 173.9 mpg	283.4 Wh/mi
US06	364.8 Wh/mi	--	--
SC03	--	--	333.8 Wh/mi

NOTES (also from previous page):

1. Vehicle specifications were either supplied by the manufacturer or derived from a literature review.
2. The powertrain of this vehicle has multiple configurations, which allows the vehicle to operate in various modes to maximize fuel economy and/or performance under different conditions and driver demands.
3. The vehicle was certified as BIN4 by the California Air Resources Board (CARB). The 2013 Chevrolet Volt can also be designated as an Advanced Technology Partial Zero Emission Vehicle by CARB if the Low Emissions Package is purchased.
4. Performance numbers based on "Normal" vehicle mode. Performance numbers are averages from multiple tests. Performance numbers for acceleration and deceleration are averages from multiple tests as the battery is depleted from full to the transition to charge-sustaining mode point.
5. Vehicle track testing occurs when the vehicle has achieved its "break-in mileage" of between 4,000 to 6,000 miles, and at the delivered curb weight plus 332 ± 10 lb (including driver and test equipment), distributed in a manner similar to the original curb loading of the vehicle. Track testing took place between January 8 and January 15, 2013 with a beginning vehicle odometer reading of 4,064 miles. The ambient temperature ranged from 50 °F to 68 °F.
6. The acceleration is measured from the point at which the vehicle begins to move. The peak power from the battery value was taken from a single run.
7. The maximum speed was reached before the one-mile mark.
8. Controlled braking on dry surface. Brake testing was performed when the battery was at 50% state of charge (SOC) and also at 100% SOC. The peak power into the battery value was taken from a single run.
9. Coasting in drive on dry surface. Test run data were cut off when the vehicle reached 10 mph, as vehicle creep speeds are typically below this threshold. The peak power into the battery value and total energy into the battery value were both taken from a single (but different) run.
10. Dynamometer testing occurs after the track testing is complete. Dynamometer testing began on March 11, 2013 with the vehicle odometer reading 4,752 miles. A comprehensive explanation of the dynamometer facility and methodology can be found at http://www.transportation.anl.gov/D3/, titled "Chassis Dynamometer Testing Reference Document". The ABC coefficients derived from track coastdown testing and matched on the dynamometer were A: 26.2096 lb, B: 0.288318 lb/mph, and C: 0.0148293 lb/mph^2. All electrical consumption values are given in AC Wh/mi.
11. The passing maneuver value indicates the amount of time required for the vehicle to transition from the first to the second speed, at the specified grade.
12. The Cycle Results table presents the fuel economy achieved by the vehicle on five EPA drive cycles at three different ambient temperatures: (1) 72 °F with vehicle climate-control off, (2) 20 °F with vehicle climate-control set to 72°F Auto, and (3) 95 °F with vehicle climate-control set to 72°F Auto. The vehicle is also subjected to 850 W/m^2 of solar load at 95 °F to simulate direct sunlight. The drive cycles include a hot start unless otherwise indicated. Fuel consumption occurred only at 20 °F.

This vehicle meets all PHEV America Minimum Requirements listed at the end of this document. Values in red indicate that the Performance Goal was not met.

2013 Chevrolet Volt Baseline Testing Results (Page 3 of 5)

CONSTANT-SPEED RANGE AND CHARGE TESTING IN CHARGE-DEPLETING MODE[1]

	45-mph Test[2]	60-mph Test[3]	70-mph Test[4]
Average DC power out of battery (kW):	10.0	17.8	26.7
(A) DC energy out of battery (kWh):	11.0	10.2	10.0
Battery capacity discharge (Ah):	30.0	29.3	28.9
(B) Range at the set speed (mi)[5]:	49.5	34.5	26.3
(C) Post-test charge AC energy from EVSE @ 240 V to onboard charger (kWh):	12.3	11.8	12.5
(D) Post-test charge DC energy into battery from onboard charger (kWh):	11.2	10.7	11.3
Post-test charge duration (HH:MM):	04:03	03:51	04:05
AC electricity consumption rate (Wh/mi)[6]:	248	342	475
DC electricity consumption rate (Wh/mi)[7]:	226	310	430
(A/D) Battery Roundtrip Efficiency[8]:	98%	95%	88%
(D/C) On-Board Charger Efficiency[9]:	91%	91%	90%
(A/C) Overall Trip Efficiency[10]:	89%	86%	80%

NOTES:

1. Vehicle track testing at delivered curb weight plus 332 ± 10 lb (including driver and test equipment), distributed in a manner similar to the original curb loading of the vehicle. Values obtained from drive cycle data without accessories.
2. During the 45-mph range test, the maximum battery temperature was 21 °C and the average ambient temperature was 12 °C. During the post-test charge, the beginning and ending battery state of charge (SOC) was 19.9% and 83.5%, respectively, the maximum battery temperature was 24 °C, and the average ambient temperature was 13 °C.
3. During the 60-mph range test, the maximum battery temperature was 17 °C and the average ambient temperature was 8 °C. During the post-test charge, the beginning and ending battery state of charge (SOC) was 21.5% and 83.5%, respectively, the maximum battery temperature was 21 °C and the average ambient temperature was 16 °C.
4. During the 70-mph range test, the maximum battery temperature was 22 °C and the average ambient temperature was 4 °C. During the post-test charge, the beginning and ending battery state of charge (SOC) was 18.3% and 83.5%, respectively, the maximum battery temperature was 23 °C and the average ambient temperature was 17 °C.
5. In addition to the range measured for the 45-mph, 60-mph, and 70-mph tests, drives of approximately 0.7, 0.9, and 1.1 miles, respectively, from test prep area to point at which vehicle test speed is achieved and maintained were required and these distances can be added to the distance traveled during the range test **(B)** to obtain the total distance traveled. These drives required 0.29, 0.45, and 0.65 kWh to complete, and this energy can be added to the energy consumed during the range test **(A)** to obtain the total output from the battery. Range is considered reached when vehicle operational mode transitions from charge-depleting to charge-sustaining.
6. The AC electricity consumption rate is calculated by dividing the AC energy from the EVSE **(C)** by the total distance travelled **(B)**.
7. The DC electricity consumption rate is calculated by dividing the DC energy from the on-board charger into the battery **(D)** by the total distance travelled **(B)**.
8. Battery Roundtrip Efficiency is calculated by dividing the DC energy out of the battery **(A)** by the DC energy from the on-board charger into the battery **(D)**.
9. On-Board Charger Efficiency is calculated by dividing the DC energy from the on-board charger into the battery **(D)** by the AC energy from the EVSE **(C)**.
10. Overall Vehicle Efficiency is calculated by dividing the DC energy out of the battery **(A)** by the AC energy from the EVSE **(C)**.

This vehicle meets all PHEV America Minimum Requirements listed at the end of this document.
Values in red indicate that the Performance Goal was not met.

2013 Chevrolet Volt Baseline Testing Results (Page 4 of 5)

CHARGE-SUSTAINING PERFORMANCE STATISTICS[1]

TRACK TESTING[2]

Acceleration 0-60 mph[3]

Measured Time: 9.6 s

Performance Goal: ≤13.5 s

Peak Power from Battery: 108.2 kW

Maximum Speed

At ¼ Mile: 83.8 mph

At 1 Mile[4]: 100.9 mph

Performance Goal: ≥90 mph at 1-mile mark

Braking from 60-0 mph[5]

Measured Time: 3.4 s

Distance: 120 ft

Peak Power into Battery: 83.3 kW

Deceleration from 60-10 mph[6]

Measured Time: 97.3 s

Distance: 2,715 ft

Peak Power: 37.2 kW

Total Energy into battery: 255.5 Wh

DYNAMOMETER TESTING[7]

Duration of Passing Maneuver at Grade[8]

	0% Grade	3% Grade	6% Grade
35-55 mph	3.8 s	4.8 s	5.8 s
55-65 mph	3.5 s	4.4 s	5.9 s
35-70 mph	7.8 s	11.2 s	13.6 s
55-80 mph	8.4 s	11.5 s	16.6 s
Maximum Speed at 25% Grade from Stop: 47.3 mph			

Fuel Economy at Steady-State Speed, 0% Grade

15 mph	39.8 mpg	60 mph	44.8 mpg
30 mph	63.5 mpg	75 mph	38.1 mpg
45 mph	72.8 mpg		

Cycle Results[9]

	72 °F	20 °F	95 °F + 850 W/m^2
UDDS (Cold Start)	40.7 mpg	27.8 mpg	29.2 mpg
UDDS	46.5 mpg	40.7 mpg	31.7 mpg
HWFET	49.2 mpg	49.2 mpg	41.5 mpg
US06	35.3 mpg	--	--
SC03	--	--	24.0 mpg

NOTES:

1. Performance numbers based on "Normal" vehicle mode.
2. Vehicle track testing occurs when the vehicle has achieved its "break-in mileage" of between 4,000 to 6,000 miles, and at the delivered curb weight plus 332 ± 10 lb (including driver and test equipment), distributed in a manner similar to the original curb loading of the vehicle. Track testing took place between January 8 and January 15, 2013 with a beginning vehicle odometer reading of 4,064 miles. The ambient temperature ranged from 50 °F to 68 °F.
3. The acceleration is measured from the point at which the vehicle begins to move. The peak power from the battery value was taken from a single run.
4. The maximum speed was reached before the one-mile mark.
5. Controlled braking on dry surface. The test is not run at a set SOC value in charge-sustaining mode. The peak power into the battery value was taken from a single run.
6. Coasting in drive on dry surface. Test run data were cut off when the vehicle reached 10 mph, as vehicle creep speeds are typically below this threshold. The total energy into the battery value was taken from a single run.
7. Dynamometer testing occurs after the track testing is complete. Dynamometer testing began on March 11, 2013 with the vehicle odometer reading 4,732 miles. A comprehensive explanation of the dynamometer facility and methodology can be found at http://www.transportation.anl.gov/D3/, titled "Chassis Dynamometer Testing Reference Document". The ABC coefficients derived from track coastdown testing and matched on the dynamometer were A: 30.1456 lb, B: 0.37653 lb/mph, and C: 0.01566 lb/mph^2.
8. The passing maneuver value indicates the amount of time required for the vehicle to transition from the first to the second speed, at the specified grade.
9. The Cycle Results table presents the fuel economy achieved by the vehicle at three different temperatures: (1) 72 °F, (2) 20 °F, and (3) 95 °F. The vehicle is also subjected to 850 W/m^2 of irradiation at 95 °F to simulate direct sunlight. The Cycle drive schedules include a hot start unless otherwise indicated.

This vehicle meets all PHEV America Minimum Requirements listed at the end of this document.
Values in red indicate that the Performance Goal was not met.

2013 Chevrolet Volt Baseline Testing Results (Page 5 of 5)

CUMULATIVE FUEL ECONOMY DYNAMOMETER PERFORMANCE STATISTICS[1]

UDDS			HWFET		
Miles	Cumulative Fuel Economy (mpg)	Cumulative Electricity Consumption Rate (AC Wh/mi)	Miles	Cumulative Fuel Economy (mpg)	Cumulative Electricity Consumption Rate (AC Wh/mi)
10	N/A[2]	268.2	10	N/A[2]	293.8
20	N/A[2]	258.8	20	N/A[2]	280.8
40	N/A[2]	254.1	40	N/A[2]	271.1
60	3837.3[3]	210.2[3]	60	215.3[5]	211.4[5]
67.1	414.5[4]	187.2[4]	80	118.3	155.7
			82.0	116.8[6]	153.0[6]

NOTES:

1. Values for fuel economy and electricity consumption rate obtained from drive cycle data without accessories and using SAE J1711 methodology. The vehicle is driven on consecutive drive cycles, with fuel economy and electricity consumption rates calculated for each cycle. Where a distance travelled is during a drive cycle, the values have been interpolated.
2. No fuel is used in charge-depleting mode.
3. During the consecutive UDDS cycles, the engine started, i.e., the vehicle transitioned from charge-depleting to charge-sustaining mode, at the 50.7-mile mark, over 6.8 UDDS cycles (the full UDDS cycle is 7.45 miles long). The Performance Goal is to complete two UDDS cycles or 14.90 miles in charge-depleting mode.
4. The consecutive UDDS testing ended at 67.2 miles, after 9 consecutive cycles.
5. During the consecutive HWFET cycles, the engine started, i.e., the vehicle transitioned from charge-depleting to charge-sustaining mode, at the 47.8-mile mark, over 4.7 HWFET cycles (the full HWFET cycle is 10.25 miles long). The Performance Goal is to complete two HWFET cycles or 20.50 miles in charge-depleting mode.
6. The consecutive HWFET testing ended at 82.0 miles, after 8 consecutive cycles.

This vehicle meets all PHEV America Minimum Requirements listed at the end of this document.
Values in red indicate that the Performance Goal was not met.

PHEV Battery Testing Results

2013 Ford CMaxEnergi - VIN 3813

Vehicle Details And Battery Specifications[1]

Vehicle Details

Base Vehicle: 2013 Ford CMaxEnergi	VIN: 1FADP5CUXDL543813
Propulsion System: PHEV	

Battery Specifications

Manufacturer: Panasonic	Rated Pack Energy/Capacity: 7.6 kWh / 26 Ah
Type: Lithium-ion	Min/Max Cell Voltage: 3.00/4.20 V
Number of Cells: 84	Pack weight: 272 lb
Nominal Cell/System Voltage: 3.7/310.8 V	Thermal Management: Active - Forced Air

[1] Vehicle details and battery specifications were either supplied by the manufacturer or derived from a literature review

Battery Laboratory Test Results Summary

Test Number	Vehicle Odometer (Miles)	Date of Test	Measured Average Capacity (Ah)	Measured Average Energy Capacity (kWh)	CD Usable Energy Margin[2] (Wh)	CS Usable Energy Margin[2] (Wh)
Baseline	4,756	3/6/2014	25.6	7.9	416.0	416.0
ICD 1						
ICD 2						
ICD 3						
End-of-Test						

[2] The CD and CS Usable Energy margins are defined as the difference between the battery usable energy values obtained from testing and the corresponding targets as defined in the Battery Test Manual for Plug-In Hybrid Electric Vehicles. A negative margin value indicates performance below the target, however it does not necessarily indicate any deficiency in the performance of the battery as it was designed to operate by the vehicle manufacturer.

2013 Ford C-Max Battery Testing Results (page 1 of 5)

PHEV Battery Test Results Analysis

Battery test results include those from the Static Capacity Test and the Hybrid Pulse Power Characterization (HPPC) Test, based on test procedures from the United States Advanced Battery Consortium Battery Test Manual For Plug-In Hybrid Electric Vehicles at the time of testing. These tests were performed for the US Department of Energy Vehicle Technology Program's Advanced Vehicle Testing Activity which is conducted by the Idaho National Laboratory and Intertek Testing Services, North America.

Static Capacity Test Results

The static capacity test measures the charge and energy capacities of the battery between maximum and minimum pack voltages when discharged at a constant current calculated to approximate a 10 kW discharge rate.[3] Pack voltage versus capacity discharged during the static capacity test is shown in figure 1. Three iterations of the static capacity test are performed at each interval, and the average results from each interval test are shown in the test results summary table on page 1.

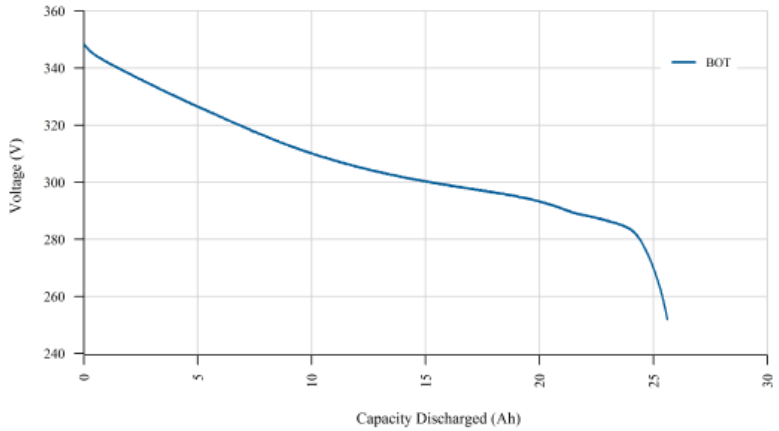

Figure 1. Voltage versus capacity discharged during the static capacity test.

Hybrid Pulse Power Characterization Test Results

The HPPC test is performed to characterize the discharge and charge pulse power capability of the battery at each 10-percent depth-of-discharge interval. Numerical results derived from the HPPC test results are summarized in the table on the first page, including comparison of the measured results to the United States Advanced Battery Consortium goals for PHEV batteries. The results from these tests are in relation to the targets for a Medium PHEV Battery, having an equivalent electric range of 20 miles.

[3] Discharge rate is determined by taking the average of the maximum and minimum voltage values for a particular pack and dividing that value into 10 kW, per the PHEV manual. For this vehicle, the value is 10kW / 302.4 V = 33.07 A.

Figures 2 and 3 illustrate the battery charge and discharge calculated pulse resistance, which indicate internal resistance at each 10-percent depth-of-discharge interval.

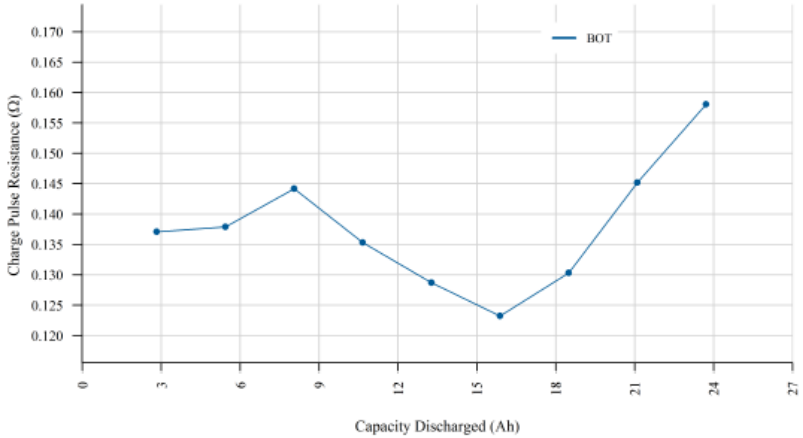

Figure 2. Ten-second charge pulse resistance versus capacity discharged.

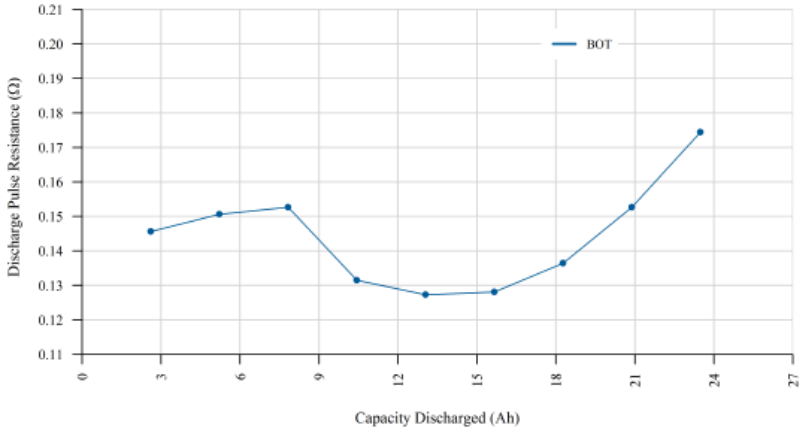

Figure 3. Ten-second discharge pulse resistance versus capacity discharged.

2013 Ford C-Max Battery Testing Results (page 3 of 5)

Figure 4 shows the battery's 10-second charge and discharge pulse power capabilities as a function of energy discharged. The Medium PHEV battery target performance goals of 37 kW discharge power and 25 kW charge power are shown as a dashed line. Note that the axes are scaled such that the charge and discharge pulse power goals align.

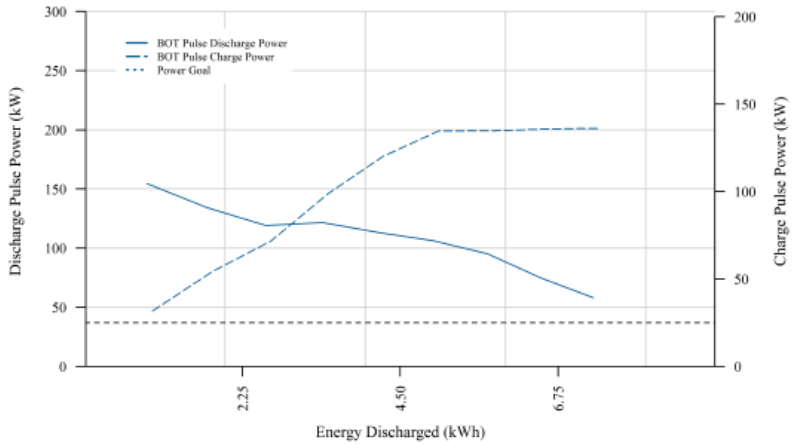

Figure 4. Discharge and charge power capability versus energy discharged.

Figure 5 shows the charge-depleting (CD) and charge-sustaining (CS) usable energy curves as a function of discharge power. The y-axis indicates the usable energy, as calculated using the methods from the PHEV battery test manual, at the power level indicated on the x-axis. The two dotted horizontal lines show the USABC Medium PHEV Battery available energy goals for CS and CD modes of 0.3 kWh and 5.8 kWh, respectively. The dotted vertical line shows the Medium PHEV Battery CS power target of 37 kW. Available Energy is defined as the usable energy, on the y-axis, exactly where the curves cross the discharge power goal. If the entire usable energy line falls to the right of the power goal, the usable energy at each discharge power level exceeds the discharge power target, and vice versa.

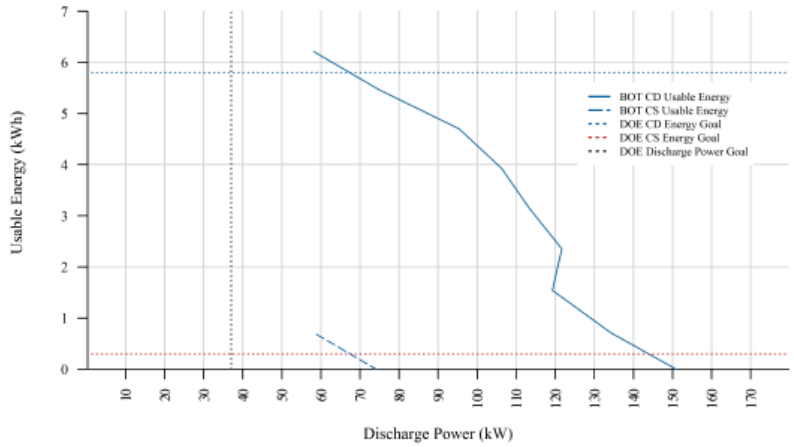

Figure 5. Usable energy versus power.