Electric Drive and Advanced Battery and Components Testbed (EDAB)

and

Baseline Testing and Fleet Data Collection and Analysis of USPS eLLV

US DOE Merit Review May 11, 2011
Project ID# VSS033

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INL/MIS-11-21291

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Electric Drive and Advanced Battery and Components Testbed (EDAB)

Overview

Timeline

- FY10 - Project planning, vehicle design, and test plan development
- FY11 - Vehicle conversion, integrate 1st ESS, begin ESS testing
- FY12 – Continue ESS testing

Barriers

- Test advanced technology ESS's in on-road conditions
- Test a wide range of ESS's sizes and capabilities (BEV, EREV, PHEV)
- Test power electronics and components in on-road conditions

Budget

- FY10 – $ 356,000
- FY11 – $ 660,000

Partners

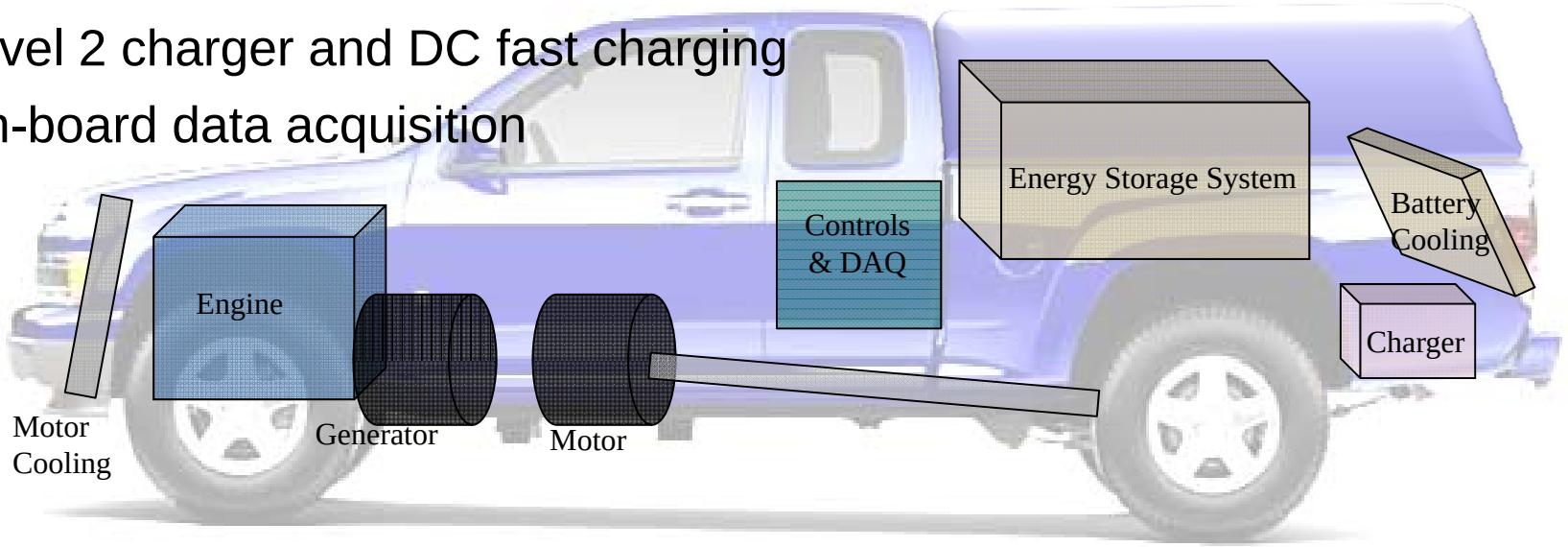
- Idaho National Lab - lead
- ECOtality North America - testing
- Oak Ridge National Lab - control system
- AVL North America - vehicle integration

Objective

- Provide an on-road and dynamometer capable platform for testing Energy Storage Systems (ESS's) developed via DOE ESS supported funding projects
  - Electric Vehicles (BEV)
  - All-Electric Capable Plug-in Hybrid Electric Vehicles (EREV)
  - Blended Plug-in Hybrid Electric Vehicles (PHEV)
- Capture data from ESS performance, capacity fade, and operating condition data during on-road operation
- Capture data from motor and power electronic during on-road operation
- Phase 1 – Project Planning
  - Vehicle specifications, and test plan
- Phase 2 – Convert vehicle into Series PHEV to enable on-road testing
  - Safety and Flexibility to accept a wide range of ESS to be tested
  - Controls to enable proper operation of each type of ESS
- Phase 3 – Test ESS
  - Battery laboratory testing (beginning of life, during, and end of life)
  - Dynamometer (Finalize calibrations and Baseline tests)
  - On-road testing until ESS "end of life" (or 3 yrs max or 100k miles)

Approach - Vehicle Testbed

- Mid sized Pickup truck
  - ESS mounted in truck bed
  - Truck cap will cover / protect ESS
- Series powertrain configuration
- Controls system has three control configurations with a weight / road load emulation algorithm to test ESS for intended operation
  - BEV compact 4 door electric sedan (3000 lbs)
  - EREV mid sized 4 door sedan (3500 lbs)
  - Blended PHEV mid sized SUV (4000 lbs)
- Level 2 charger and DC fast charging
- On-board data acquisition



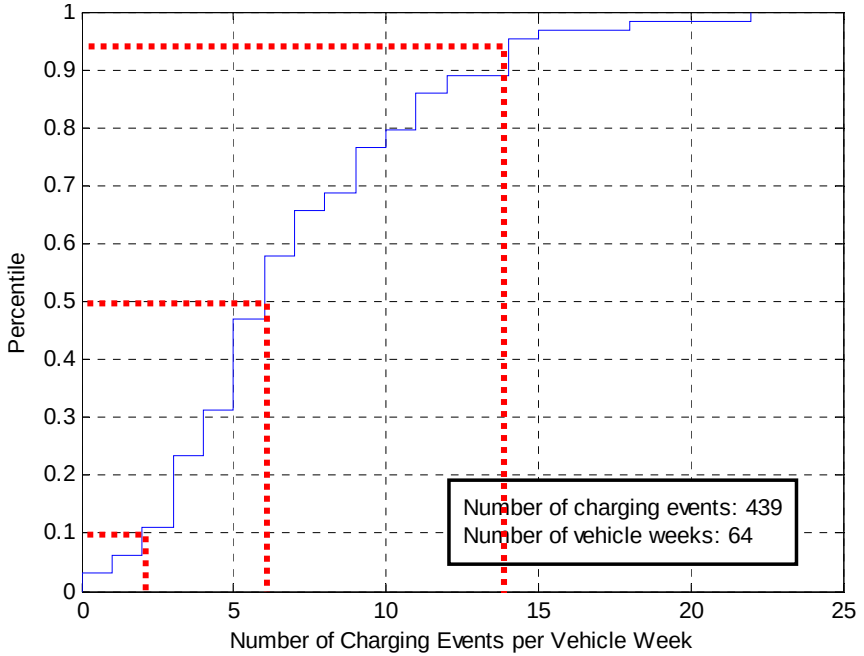
Approach - Overall Test Plan

- Chassis Dynamometer
  - Finalize calibrations specific to each ESS
  - Vehicle baseline testing for each ESS
- ESS laboratory testing (Constant Current Discharge and HPPC)
  - Beginning of life (BOL)
  - Periodically during on-road testing
    - every 3,000 miles or 20 testing days (~ 60 full cycles)
  - End of life (EOL)
- On-Road Testing
  - In Phoenix area
  - Approx. 50% city, 50% highway driving
  - Approx. 100 to 150 miles per day
  - Varying range of driving and charging patterns

Approach - On-Road Test Plan

- **Charging Pattern from previous PHEV household fleet data**
- Mean (50th percentile) number of charging events per week = 6
- 10th percentile number of charging events per week = 2
- 95th percentile number of charging events per week = 14

- Each ESSs to be tested 10th, 50th and 95th percentile driving and charging pattern
- Example: an EREV with a 40mi EV range with a daily driving distance of 50 miles
  - 10th perc. → charge after 150 mi
    - mainly charge sustaining operation
  - 50th perc. → charge after 50 mi
    - charge depleting and sustaining operation
  - 95th perc. → charge after 25 mi
    - entirely charge depleting operation



Milestones

- Dec 2010 – started vehicle conversion
- April 2011 – received 1st ESS
- June 2011 – vehicle conversion complete
- July 2011 – commence 1st ESS testing

Technical Accomplishments

- Vehicle conversion into Series PHEV nearly complete
- Initial ESS selection completed
- Control system developed to properly control the ESS as designed
- 1st ESS to be tested selected and purchased

Collaboration

- Results from ESS testing will be provide to Tech Teams, DOE, and other National Labs for use with modeling tools, energy storage development, and improved understanding of operating conditions of ESS's on-road
- After ESS has reached End of Life (EOL), the ESS will be transferred to 2nd Use ESS projects

Future Work

- Test several ESS's
  - BEV, EREV, PHEV
  - Various chemistries
- Two to Four additional test platforms to be built after successfully demonstrating on-road testing capabilities and flexibility
- Utilize and test various motor and power electronics technologies

Summary

- Provide data/results from on-road operation of advanced technology ESS
  - Power and Capacity Fade results
  - Impact of driving / charging patterns on ESS
  - Temperature operation effects
  - Power and energy utilization effects
  - Provide EOL ESS to "2nd Use ESS" Experiments
- Provide data / results from on-road operation of motor and power electronics

Baseline Testing and Fleet Data Collection and Analysis of USPS eLLV

Overview

Timeline

- FY10 – Baseline and Dynamometer testing
- FY11 – Begin on road data collection and analysis (March 2011)
- FY12 – Complete on road data collection and analysis (March 2012)

Budget

- FY10 – $50,000
- FY11 – $325,000

Barriers

- Benchmark five conversion BEVs that utilize currently available ESS and power electronics
- Capture in use delivery data (vehicle, powertrain, and ESS data) from five BEVs
- USPS vehicle operational requirements differ from typical vehicles (route and driving patterns)

Partners

- USPS - LLV conversion lead
- Idaho National Lab - lead testing efforts
- ECOtality N. America - baseline testing
- Oak Ridge National Lab - dyno testing

Objective

- USPS commissioned five all-electric conversions of the Long Life Vehicle (eLLVs) to evaluate the feasibility of electric conversions
- U.S. DOE providing baseline testing and data collection / analysis in collaboration with USPS

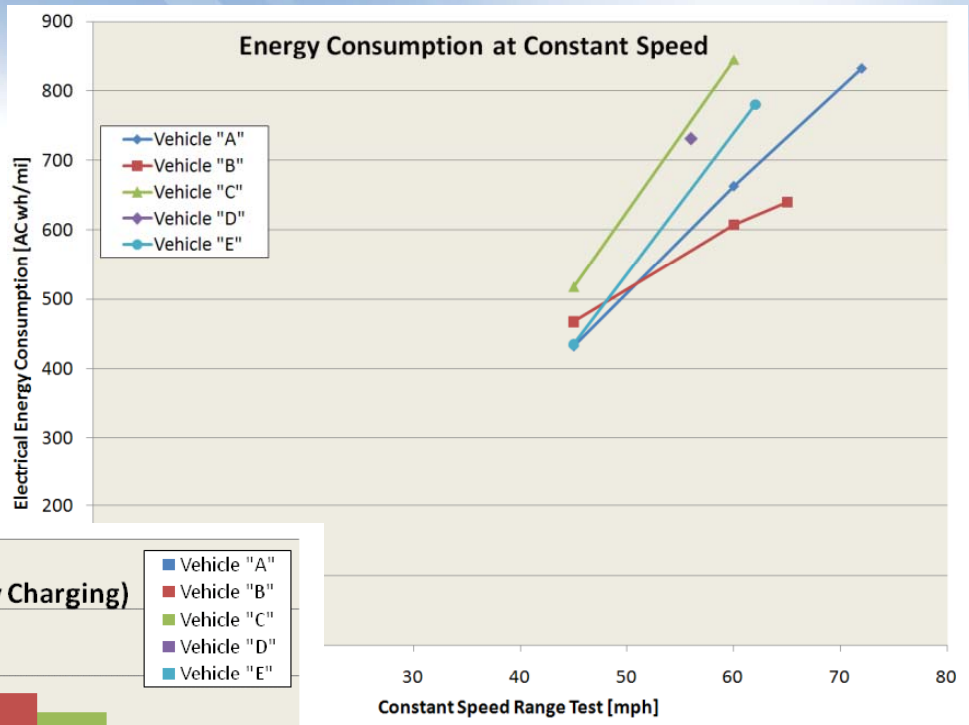
Approach

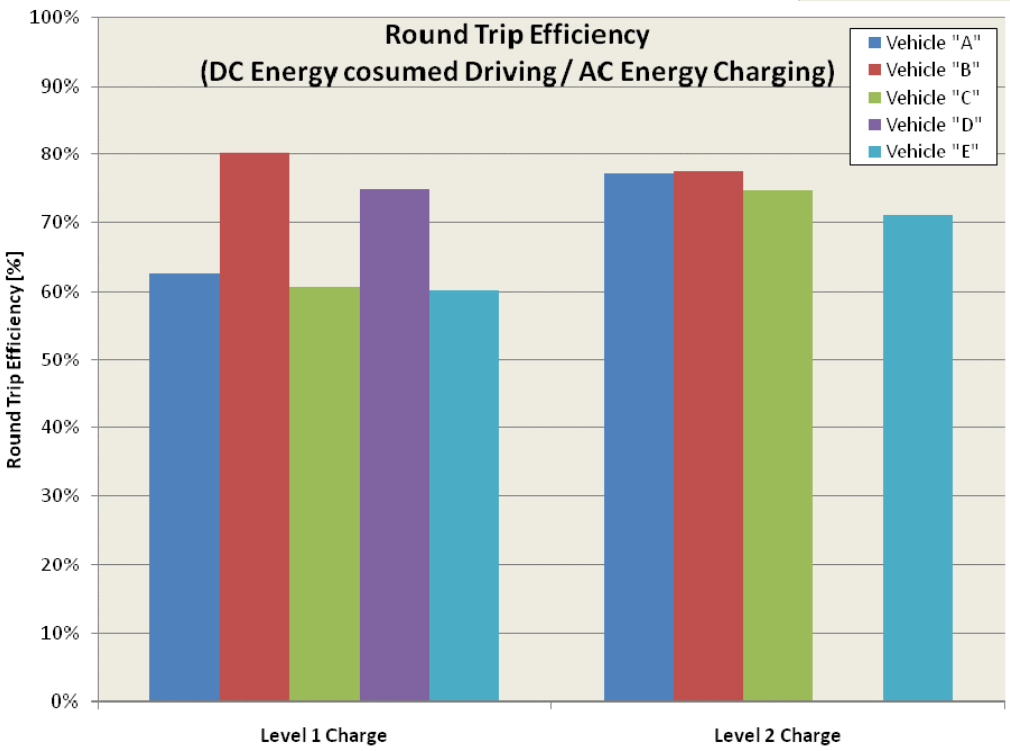
- AVTA Baseline testing
  - Acceleration, Braking, Driving Range, Charging Efficiency, USPS specific tests (delivery pattern driving), and Static measurements
  - Coastdown testing to determine road load for each vehicle
- Chassis Dynamometer testing (ORNL #VSS060)
- On road data collection
  - On board data logger w/ cellular modem data transfer
- Analyze on-road data through one year of USPS mail delivery service

Technical Accomplishments and Milestones

- Completed - Baseline testing for all five eLLV (Nov 2010)
- Completed - Dynamometer testing for all five eLLV (Feb 2011) (ORNL # VSS060)
- Completed - Fact Sheets summarizing the test results (March 2011)
- On board loggers installed and collecting / transmitting data
- Summarized results sent to USPS on a monthly basis from on road data (March 2011 – March 2012)
  - Energy consumption
  - Vehicle utilization
  - Operating conditions
  - Energy Storage System utilization

Technical Accomplishments (continued)





Technical Accomplishments (continued)

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

All-Electric Conversion of the USPS Long Life Vehicle (LLV)

Vehicle: USPS eLLV Conversion by *Autoport/AC Propulsion/University of Delaware*

Vehicle ID: 2204700
Seatbelt Positions: One (right hand drive)
Standard Features:
- Cabin Heat (gasoline fired heater)
- Power Steering (electro-hydraulic)
- Power Brakes (vacuum assist)
- Regenerative Braking
- Steel wheels

Additional Features:
- Vehicle-2-Grid Capable up to 80A

VEHICLE SPECIFICATIONS

BATTERY
Type: Li-Ion
Pack Locations: Underbody (inboard of frame rails)
Nominal System Voltage: 375 V
Rated Capacity (C/3): 60 Ah
Cooling Method: Forced air, conditioned with A/C (air to air exchanger)

POWERTRAIN
Motor Type: AC Induction
Number of Motors: One
Motor Cooling Type: Forced air
Drive Wheels: Rear Wheel Drive
Transmission: Fixed Gear Reduction

CHARGER
Location: Underhood
Charger Port: Driver's side, front quarter panel
Type: Conductive (J1772 connector)
Input Voltage(s): 120 or 240 VAC

CHASSIS
Aluminum Body on Steel Frame
Rear Suspension: Solid Axle with Leaf Springs
Front Suspension: Dual A-arm with Coil Springs

WEIGHTS
Design Curb Weight: 3250 lbs
Delivered Curb Weight: **3408 lbs**
Distribution F/R: 50.4/49.6%
GVWR: 4450 lbs
Max Payload: **842 lbs** + 200 lbs driver[1]
Performance Goal Payload: 1000 lbs + 200 lbs driver

DIMENSIONS
Wheelbase: 100.5 inches
Length: 176.5 inches
Width: 76 inches
Height: 85 inches

TIRES
Tire Mfg: Kumho
Tire Model: Solus KR2
Tire Size: P195/75R14
Tire Pressure F/R: 35/35 psi[2]

continued :

TATISTICS

50 mph (332 lbs payload)
c
c
71.4 kW
50 mph (1000 lbs payload)
c
c
80.3 kW
2.0 sec
) mph (332 lbs payload)
feet
) feet
) mph (1000 lbs payload)
feet
) feet
16 feet
alculated) (332 lbs payload)
%: 67.6 mph
%: 57.4 mph
5%
@ 50% SOC (332 lbs payload)
h

RANGE @ 45 mph[5,6] (332 lbs

C kWh
er: 14.4 kW
4 AC kWh @ 240 VAC
Wh/mile
Wh/mile

RANGE @ 60 mph[3,6] (332 lbs

C kWh
er: 23.0 kW
8 AC kWh @ 240 VAC
Wh/mile
Wh/mile

USPS DELIVERY 25 MILE CYCLE[4,5] (1000 lbs payload + 200 lbs driver)
Driving Distance: 25.0 miles
Energy Used: 18.2 DC kWh
Recharge Energy: 29.1 AC kWh @ 120 VAC
Efficiency: 727 DC Wh/mile
Efficiency: 1160 AC Wh/mile

DRIVING CYCLE RANGE (J1634)[6] (332 lbs payload)
Range per J1634: 54.4 miles
Energy Used: 18.7 DC kWh
Recharge Energy: 24.3 AC kWh @ 208 VAC
Efficiency (J1634): 446 AC Wh/mile
Efficiency UDDS: 318 DC Wh/mile
Efficiency HWFET: 385 DC Wh/mile

CHARGER LEVEL 1 (@120 VAC / 13A)
Time to Fully Recharge: 22 hours

CHARGER LEVEL 2 (@208 VAC / 18A)
Time to Fully Recharge: 6.5 hours

TEST NOTES:

1. Design Payload Value is 1000 lbs plus one 200 lbs driver (no passengers) given the original LLV GVWR of 4450 lbs.
2. Manufacturer recommended Tire Air Pressure
3. Test was terminated due to overheating.
4. At test termination, vehicle was still able to maintain the required drive schedule.
5. USPS Delivery Cycle: 8 miles city, 6 miles freeway, and 11 miles stop/go with 700 stops.
6. At test termination, vehicle was not able to maintain the required drive schedule.

Values in **Red** indicate the Performance Goal was not met.

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n by the electrical conversion components or materials.
opulsion.
SAE J2344 section 4.10 Mechanical Safety – to prevent
ced in "P" (PARK) or when the key is removed.
r automatically disconnect high voltage in case of a crash
a charges of at least 25 miles when loaded with 1000 lbs
ecified USPS drive cycle including 8 miles of city driv
les of delivery driving with 700 stops.
a 0 to 15 mph in 5 seconds, 0 to 50 mph in 22 seconds,
plete stop from 60 mph in 216 feet, 30 mph in 57 feet,
charger is capable of accepting input voltages of 110V
ervice. Charger input current is compatible with
ductors, terminals, contact blocks or devices of any type
exposed to 50 volts or greater.
als for service, operation, maintenance, and towing
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n Technology, Fleet Operations Program. Testing conduct-
performed by ECOtality North America and Oak Ridge
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f the U. S. Department of Energy.

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Renewable Energy

Collaboration

- Baseline Testing is conducted in collaboration with the USPS
- Dynamometer Testing is conducted by ORNL in collaboration with the USPS
- On road data collection and analysis is provided in collaboration with the USPS
- Fact Sheets are published on AVTA website
  - http://avt.inel.gov/

Future Work

- Data collection and analysis continues for a total of one year
  - March 2011 through March 2012
- On road data collection and analysis in collaboration with the USPS of six Medium Duty electric vehicles

Summary

- Five electric conversions of the USPS eLLVs are currently in use as part of USPS mail delivery service in the suburbs of Washington D.C. metro area

- Completed - Baseline testing for all five eLLVs
- Completed - Dynamometer testing for all five eLLVs (ORNL # VSS060)
- Completed - Fact Sheets summarizing the test results
- On board loggers installed and collecting / transmitting data
- Summarized results sent to USPS on a monthly basis from on road data
  - Energy consumption
  - Vehicle utilization
  - Operating conditions
  - Energy Storage System utilization

Acknowledgement

This work is supported by the

U.S. Department of Energy's Vehicle Technologies Program:

Pat Davis, Lee Slezak, and Dave Howell

Additional Information

http://avt.inl.gov or
http://www1.eere.energy.gov/vehiclesandfuels/avta/