Dynamometer Testing of USPS EV Conversions

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Overview

- **Timeline**
  - Project start date: Nov. 2010
  - Project end date: May 2011
  - 100% complete
- **Barriers**
  - Unique vehicle mission, drive cycle
  - Standardized test development
  - Charging infrastructure
  - Vehicle readiness
- **Budget**
  - New project, FY10 funding
  - FY10 funding: $ 200 k
  - USPS Provided Vehicles
  - FY11 (current) funding: $0k project completed
- **Partners**
  - Oak Ridge National Laboratory
  - Idaho National Laboratory VSS033
  - United States Postal Service
  - Ecotality NA

Objectives

- **Perform benchmark dynamometer testing on USPS Electric Vehicle Conversions**
- **Quantify vehicle performance using both “standardized” test methods and project specific test methods.**
- **Characterize vehicle performance in various driving modes**

Vehicle Technology Program (VTP) - Relevance

- **VTP Multi-Year Program Plan (2 key goals from VSST Subprogram)**
  - **Demonstrate market readiness of grid-connected vehicle technologies by 2015.**
  - **Support the laboratory and field evaluations of large-scale demonstration fleets of advanced commercial and passenger PHEVs and EVs.**

- **Barriers**
  - **Public acceptance of electric drive as central vehicle choice**
    - **Government to show leadership in usage of advanced vehicle technologies**
  - **Battery cost and durability**
    - **Though not directly evaluated in this program, right sizing components for mission design is critical – consumer behavior and understanding**

Background USPS Fleet - Relevance

Largest non-military fleet in the world*

- **Range of 'Road' vehicles T3 to Windstar to Class 8**
- **Various Technology Applications**

  Air, Rail, and Marine & 44K Alternative fuel vehicles

  Bio- ,LNG, CNG, Electric Vehicles
- **Huge fleet operation costs/logistics**

  Fuel used in 2010 – 650 Million gallons (street, highway and air)

  Cost of fuel impact – 1 cent/gallon increase ~$6.5M

  2008 record prices ($4.11/gallon) – increase equates to $31M/month**

  Driven distance in 2010 – 4+ million miles per day

* *"Electrification of Delivery Vehicles"*, U.S. Postal Service, Office of Inspector General, DA-WP-09-001, August, 2009.

** Steve Masse, VP USPS Finance and Planning

USPS Electric Vehicle History* - Relevance

- **Previous electric vehicles**

Cleveland, Ohio, 1899
22 miles route 2 ½ hr previously powered by horse taking 6 hrs.

Cupertino, California, 1978.
Used thru 1982, Cupertino converted its entire 30 vehicle fleet.

- **2000-2003 Ford Based EV**

  500 EV Ranger based delivery vehicles

  Predominantly in California, few in Washington D.C, and NY

  Replaced with Gasoline Windstars when Ford ended their EV program

* www.usps.com/postalhistory/_pdf/ElectricVehicles.pdf

Long Life Vehicle (LLV)

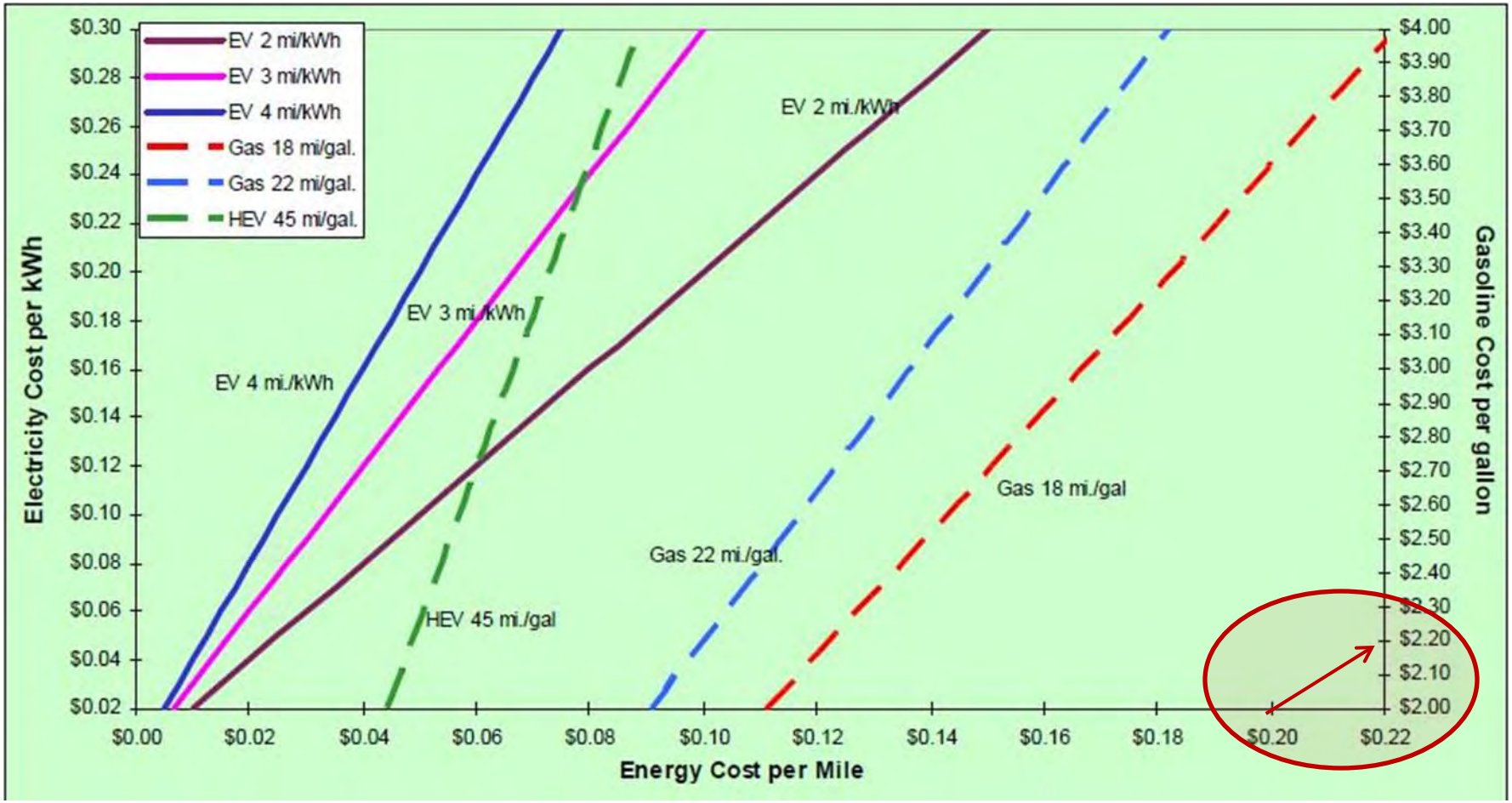
Grumman Aluminum body
Modified Chevrolet S-10 Chassis
4 cylinder 2.5 and 2.2L 3spd Auto
Rear Wheel Drive

142,000 Vehicles in service
EPA Rated at 18 MPG

'Real' mail delivery MPG*≈ 10 MPG

* *"Electrification of Delivery Vehicles"*, U.S. Postal Service, Office of Inspector General, DA-WP-09-001, August, 2009.

Opportunities to Meet VTP Goals - Relevance



"Real" Mail Delivery Driving

* Modified chart; original chart source: http://avt.inel.gov/pdf/fsev/costs.pdf

USPS EV Conversion Project - Relevance

United States Postal Service (USPS)

- **Key Vehicle Requirements -**
  - **Project Management - First article acceptance, infrastructure, field test and evaluation**
  - **Vehicle Conversions meet numerous FMVSS and SAE EV safety specifications**
  - **USPS Basic requirements for EV LLV**
    - **0 – 15 mph within 5 seconds**
    - **0 – 55 mph within 35 seconds**
    - **110V recharge @ 15 amps**
    - **25 mile range over described route**
    - **Maintain 1000 lb cargo carrying capacity**
    - **Heater/Power steering – no Manual shifting**
    - **Maintain 40 foot turning radius**

5 Awards – Convert a vehicle (provided by USPS), 1 year evaluation

Idaho National Laboratory (INL)

- **PI - Jim Francfort and Richard "Barney" Carlson**
  - **Field data collection and analysis (VSS033)**

Ecotality – Vehicle Prep, baseline test and vehicle characterization

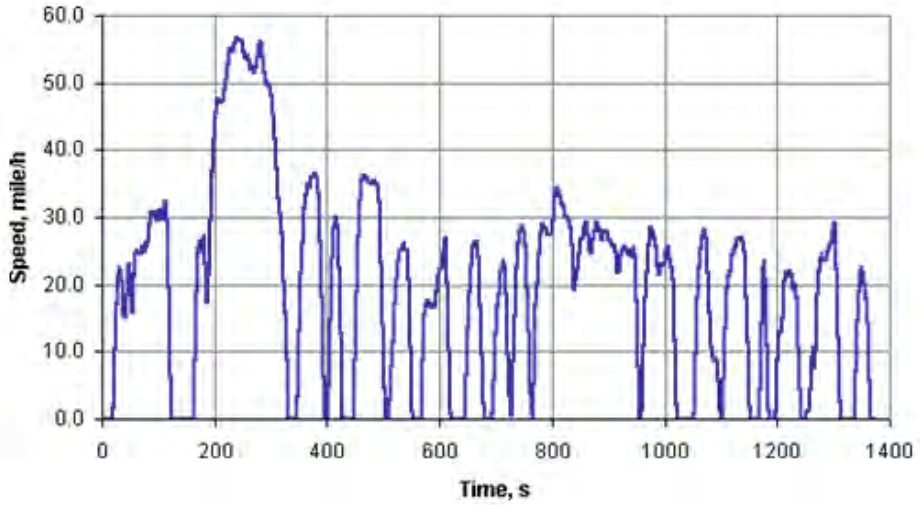
Approach

- **Test Procedure development and selection (INL & USPS)**
  - **SAE original J1634:**

    Electric Vehicle Energy Consumption and Range Test Procedure
  - **Develop USPS "worst-case" Delivery cycle based on 'bin' data**
- **Vehicle track characterization (INL & Ecotality NA)**
  - **Perform vehicle coast down testing**
  - **Establish vehicles meet minimum performance criteria and instrument:**
    - **Performance**
    - **Energy consumption, charging requirements**
    - **Emissions**
- **Conduct Dynamometer Testing (ORNL)**
  - **Utilize AC motoring chassis dyno and instrumentation to capture energy usage data**
- **Compare and Validate (INL and ORNL)**
  - **Field usage data with dyno results**

Test Procedure - Strategy

- **J1634 type testing**
  - **based on the Federal Emission Test Procedure using the Urban Dynamometer Driving Schedule (UDDS) and the Highway Fuel Economy Driving Schedule (HFEDS**
  - **Complete usable ESS capacity used in transient drive cycles**



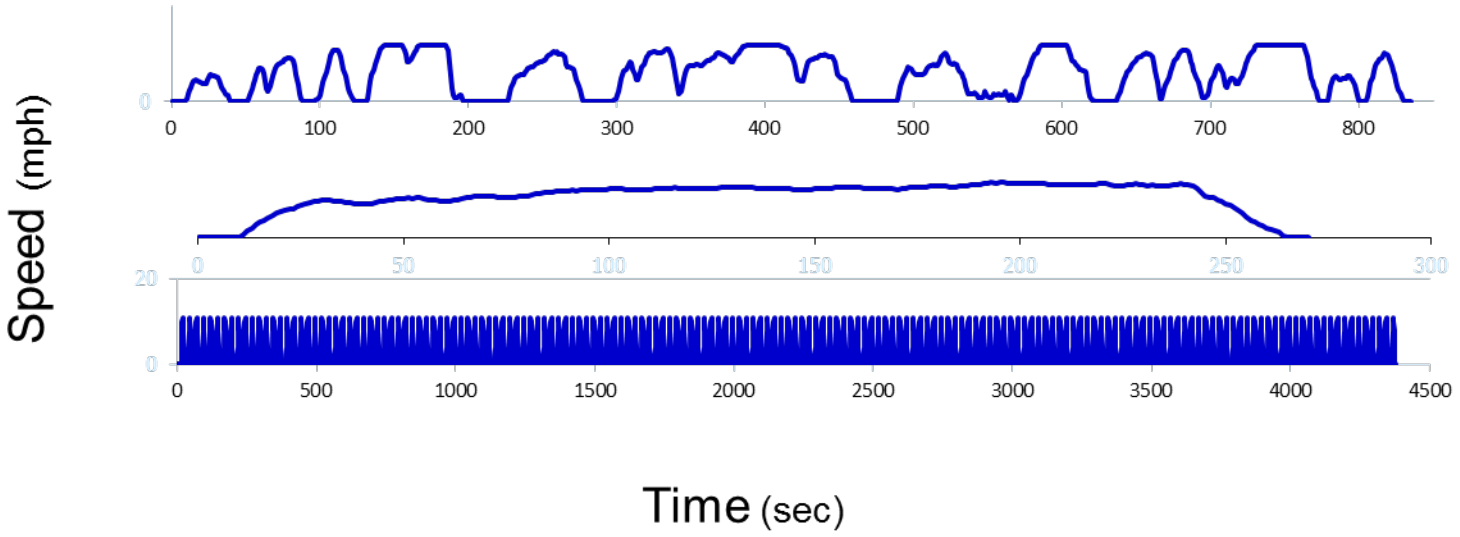
- **C/3 Range Testing**
  - **Based on vehicle battery rated capacity**
  - **Steady state cruise at speed determined**
  - **Complete usable ESS capacity used in three one hour drives**

- **USPS Simulated Delivery Cycle (worst case scenario) – next slides**

Test Procedure Development - Approach

USPS Delivery cycle (worst case)

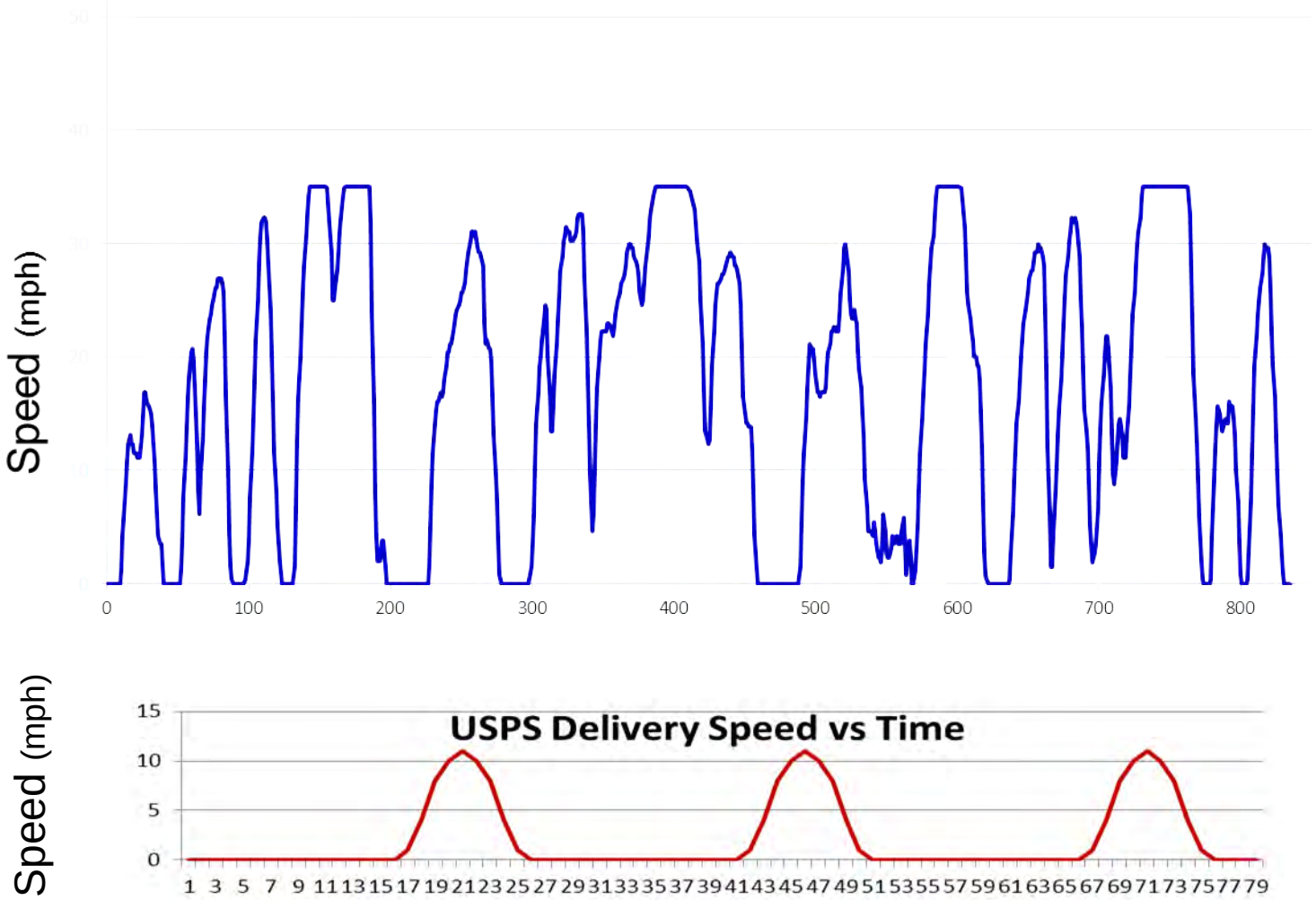
Cycle Name	Distance (mi)	Top speed (mph)	Number of stops	Time [sec]
City	3.96	35	11	835
Freeway	3.07	55	1	270
Delivery #1	2.77	11	175	4380
Delivery #2	2.77	11	175	4380
Lunch	0	0	0	1800
Delivery #3	2.77	11	175	4380
Delivery #4	2.77	11	175	4380
Freeway	3.07	55	1	270
City	3.96	35	11	835
total:	**25.14**		**724**	**21530** seconds
				5.98 hours



OAK RIDGE National Laboratory

Test Procedure Development - Approach

- **USPS Delivery cycle (worst case)**



Milestones - Progress

- **Milestone #1, February 28, 2011:**
  - **Benchmark testing on all 5 EV conversion vehicles completed**
  - **Final vehicle leaves for USPS Engineering**

AOP Project Objective:
The purpose of this task is benchmark up to five (5) United States Post Office delivery vehicles that have been converted to operate as battery electric vehicles (BEV). This task was funded late in FY2010, and benchmarking dynamometer work will be carried out in FY2011.

Vehicle Architecture Summary

	Vehicle A	Vehicle B	Vehicle C	Vehicle D	Vehicle E
FWD or RWD	RWD	RWD	RWD	**FWD**	RWD
Drive system	DC Brushless	AC Induction	DC Brushless	DC Brushless	DC Brushless
ESS type	Li-Ion liquid cooled	Li-Ion, air cooled with A/C	$LiFePO_4$ prismatic cells - air cooled	$Na\text{-}NiCl_2$ battery (hot) +500°F	Li-Ion liquid cooled
Rated capacity [DC kWh]	13.3	23.2	19.5	55.7	21.4
Voltage [V]	333	374.4	345	371	267
Capacity [Ah]	40	62	56.5	150	80
Curb Weight (lbs)	3310 lbs	3408 lbs	3598 lbs	4366 lbs	3500 lbs
Additional features	Solar panels on roof	Vehicle-2-Grid (up to 80A)	-	4 wheel disc brakes	-

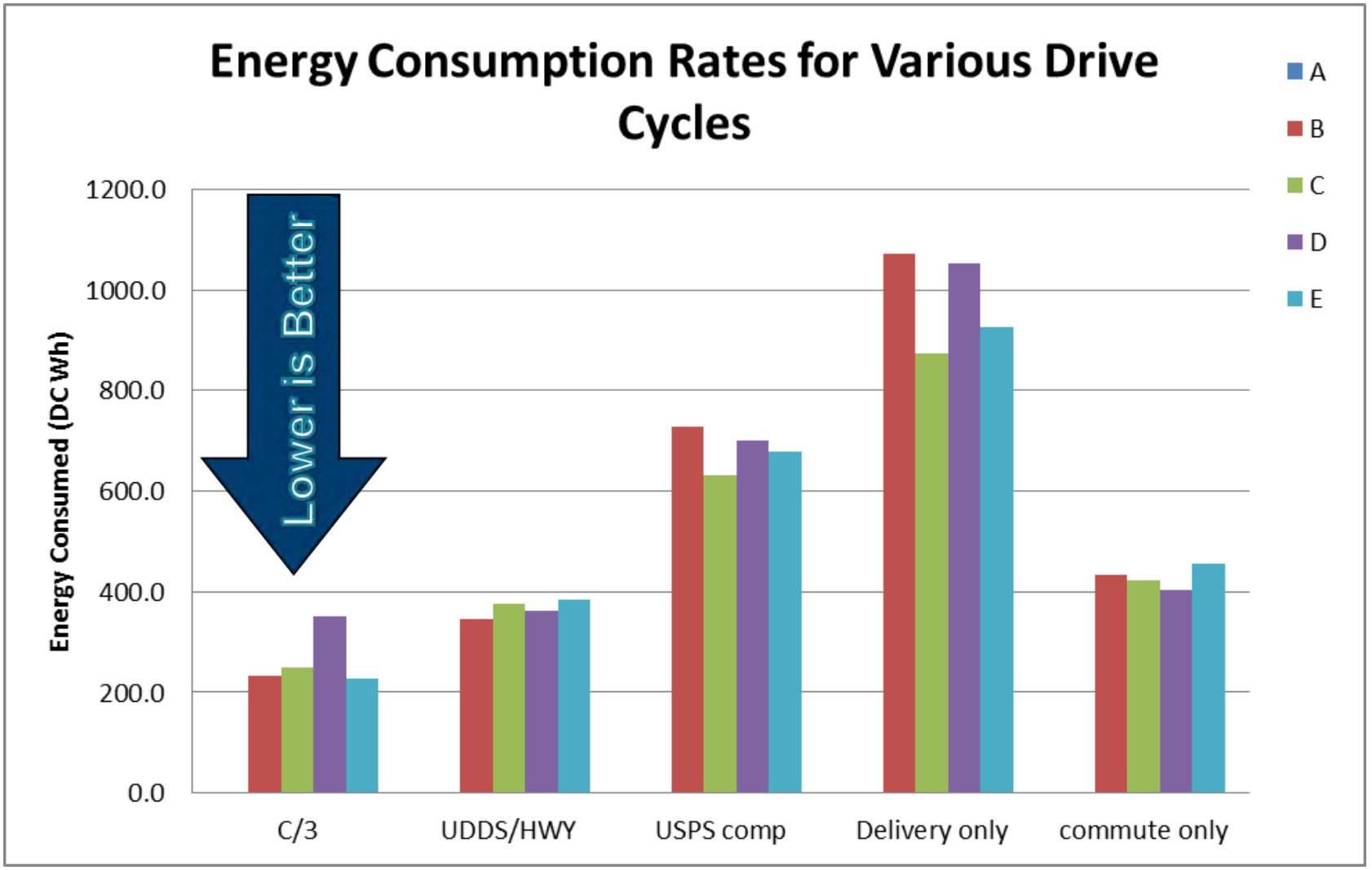
Vehicle Test Results Summary

	Vehicle A	Vehicle B	Vehicle C	Vehicle D	Vehicle E
Curb Weight (lbs)	3310 lbs	3408 lbs	3598 lbs	4366 lbs	3500 lbs
USPS Composite Test Efficiency (AC Wh/mile)	**	1160	842	1217	939
UDDS / HWY (J1634) Efficiency (AC Wh/mile)	**	446	503	599	506
C/3 Range Efficiency (AC Wh/mile)	**	284	328	508	311
Level1 USPS Recharge Time	**	22 hours	14 hours	40 hours*	17 hours

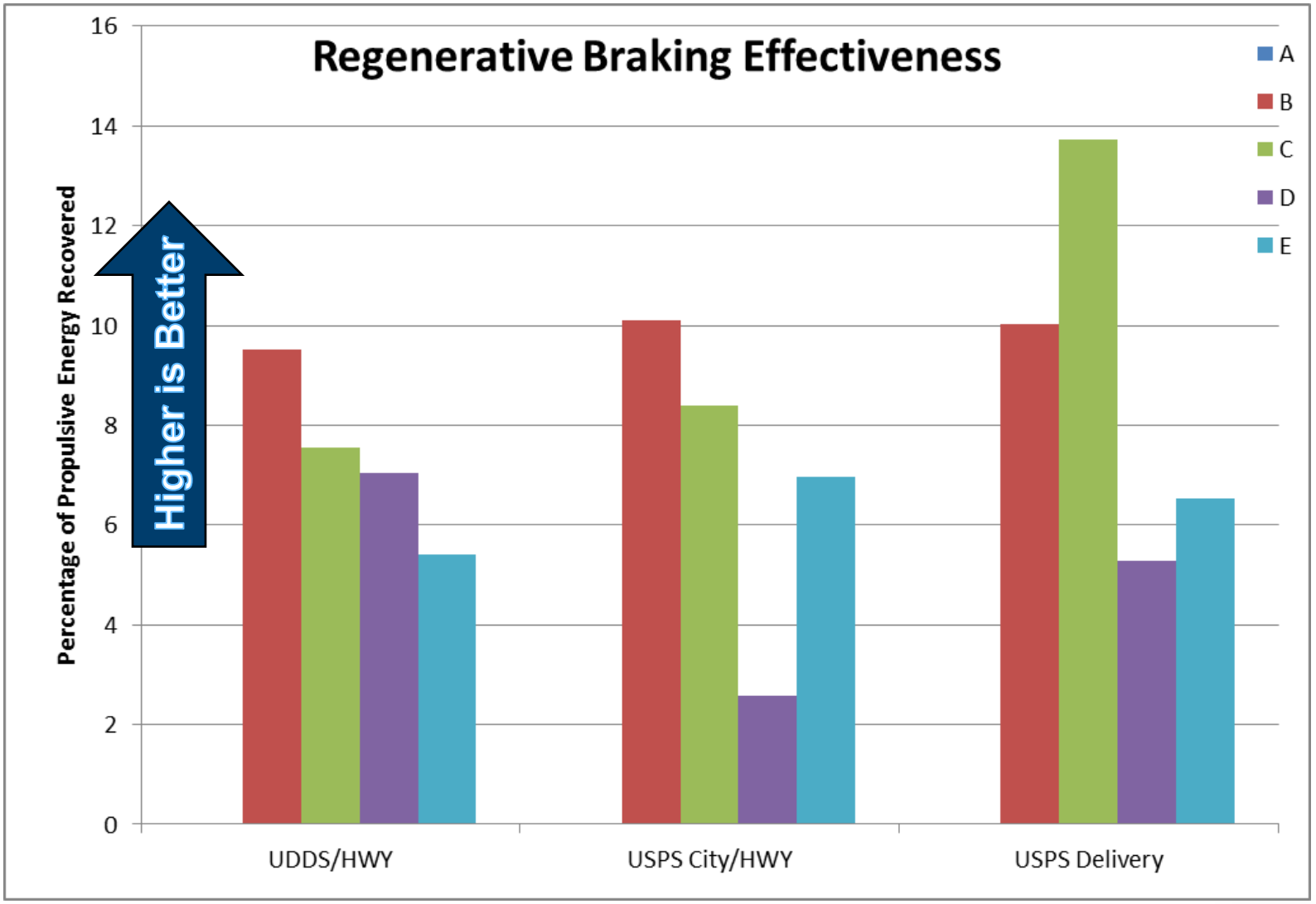
* Duration of charge due to ESS and USPS requirements

** Testing complete and data supplied to Program management, under review with Supplier

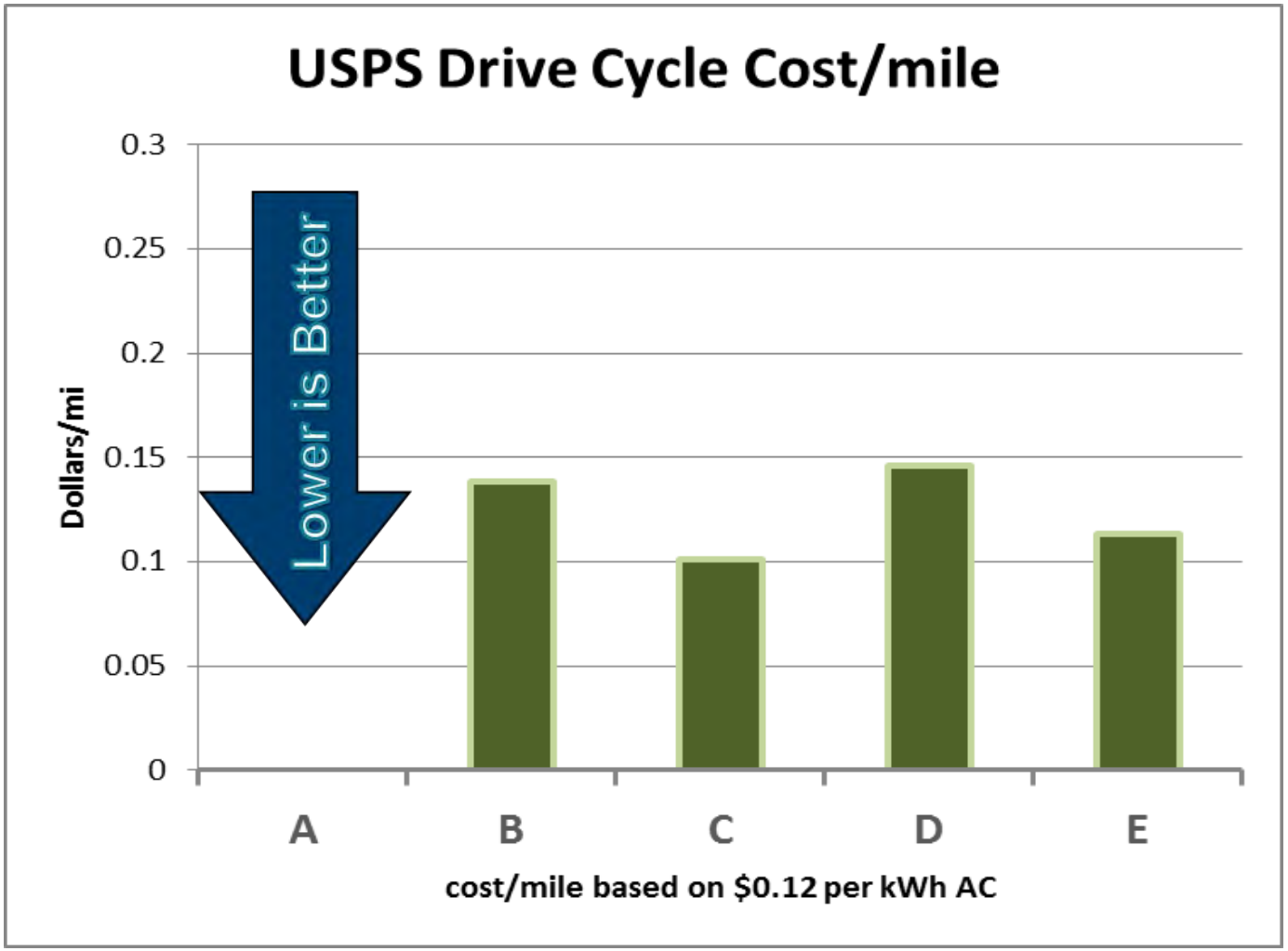
Vehicle Graphical Comparison - Progress



Vehicle Testing Summary - Progress



Vehicle Summary - Progress



A stable fuel/energy price, which for the tested EV architectures, yields significant fuel savings over the current LLVs, though conversion cost are high

Accomplishments – Vehicle and Data Sharing

- **Transfer of vehicles to ORNL for testing in route to USPS field deployment**
- **Evaluated using new project specific drive cycle (worst case scenario)**
- **Quantified vehicle initial vehicle performance using “standardized” tests**
- **Summarized vehicle information for field data comparison and future test procedure modifications**

Collaboration and Coordination with Other Institutions

United States Postal Service (USPS)

- **Vehicle Engineering and Evaluation – Han Dinh, Joseph McGrath and J. Smith**
- **Overall Program Management**
  - **Field deployment**
  - **Statement of Work**
    - **Key Vehicle Requirements - Performance, safety, charging**
    - **First article testing, Infrastructure, Overall test and Evaluation**

Idaho National Laboratory (INL)

- **Project Management**
- **PI - Jim Francfort and Richard "Barney" Carlson**
  - **Vehicle preparation and project leads**
  - **Field data collection and analysis (VSS033)**

Ecotality - baseline test and vehicle characterization

Summary

- **Benchmark dynamometer testing was performed on five USPS Electric Vehicle Conversions at Oak Ridge National Laboratory**
- **ORNL used “standardized” test methods and specific program test methods to quantify vehicle performance and report to INL (Lead Project Lab).**
- **Analysis was performed on vehicle test results to identify areas of interest in various driving modes**

Future Work

- **Obtain in-use delivery drive cycle information and access test drive cycle impacts**
- **Establish baseline vehicle model to identify architecture sensitivity to drive cycle**
- **Use vehicle modeling to identify maximum regeneration possible from vehicles**

Acknowledgements and Contacts

DOE Vehicle Technologies Program:

- ***Lee Slezak, Vehicle Systems Manager***

Oak Ridge National Laboratory (ORNL)

- ***David E. Smith, Advanced Vehicle Systems Program Manager***

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INL Investigators:

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USPS Vehicle Engineering and Evaluation

- ***Han Dinh and Joseph McGrath***