PLUG-IN 2012

In-Use Performance Results of Medium Duty Electric Vehicles

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Background

- **The U.S. Department of Energy (DOE) and the American Recovery and Reinvestment Act (ARRA) is helping to deploy MD and HD vehicles and EVSEs:**
  - **Smith Electric Vehicles - Newton (500 vehicles)**
  - Navistar - eStar (up to 950 vehicles)
  - South Coast Air Quality Management District / EPRI – Utility bucket trucks and shuttle buses (~350 vehicles)
  - Cascade Sierra Solutions - sleeper cab trucks equipped with various anti-idle reduction devices and using electrified truckstops (50 sites and 5000 trucks)

- **The DOE Vehicle Technologies Program funded NREL to collect and analyze this data**
  - Goal is to monitor and report out on vehicle performance and energy utilization of deployed vehicles
  - Similar to light duty efforts by the INL AVTA programs
  - Provide useful data for additional R&D

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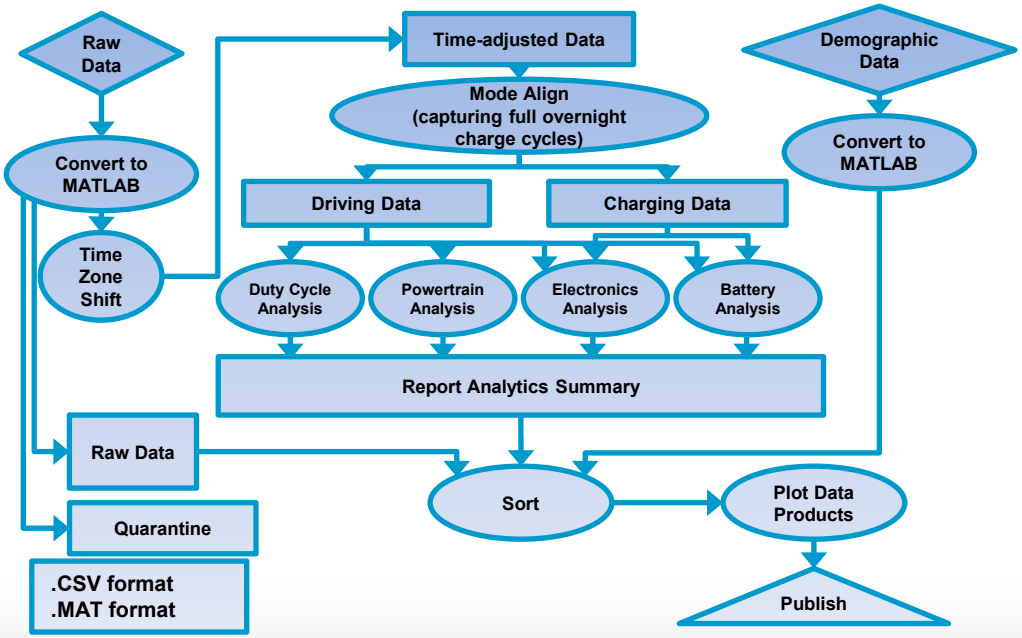
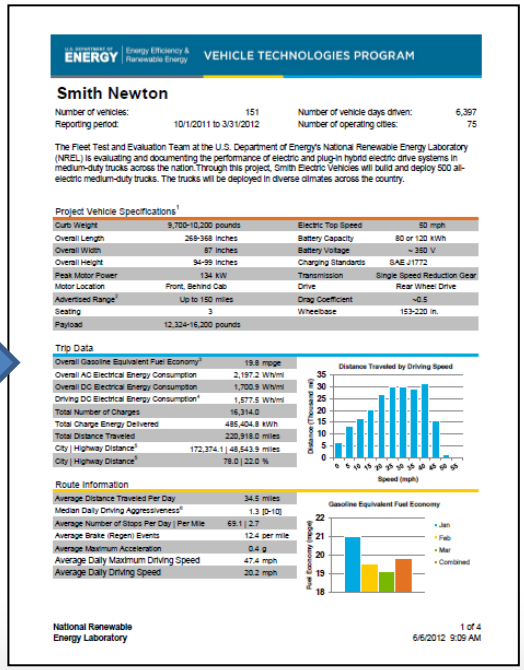
Background

Data collection and analysis plan:

- ~30 channels of 1hz data collected and stored at NREL (~300GB/month)
- Quarterly reports published on basic usage statistics





ENERGY | Energy Efficiency & Renewable Energy — VEHICLE TECHNOLOGIES PROGRAM

Smith Newton

Number of vehicles:	151	Number of vehicle days driven:	6,397
Reporting period:	10/1/2011 to 3/31/2012	Number of operating cities:	75

The Fleet Test and Evaluation Team at the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) is evaluating and documenting the performance of electric and plug-in hybrid electric drive systems in medium-duty trucks across the nation. Through this project, Smith Electric Vehicles will build and deploy 500 all-electric medium-duty trucks. The trucks will be deployed in diverse climates across the country.

Project Vehicle Specifications[1]

Curb Weight	9,700-10,200 pounds	Electric Top Speed	50 mph
Overall Length	269-368 inches	Battery Capacity	80 or 120 kWh
Overall Width	87 inches	Battery Voltage	~ 350 V
Overall Height	94-99 inches	Charging Standards	SAE J1772
Peak Motor Power	134 kW	Transmission	Single Speed Reduction Gear
Motor Location	Front, Behind Cab	Drive	Rear Wheel Drive
Advertised Range[2]	Up to 150 miles	Drag Coefficient	~0.5
Seating	3	Wheelbase	153-220 in.
Payload	12,324-16,200 pounds		

Trip Data

Overall Gasoline Equivalent Fuel Economy[3]	19.8 mpge
Overall AC Electrical Energy Consumption	2,197.2 Wh/mi
Overall DC Electrical Energy Consumption	1,700.9 Wh/mi
Driving DC Electrical Energy Consumption[4]	1,977.5 Wh/mi
Total Number of Charges	16,314.0
Total Charge Energy Delivered	485,404.8 kWh
Total Distance Traveled	220,918.0 miles
City | Highway Distance[5]	172,374.1 | 48,543.9 miles
City | Highway Distance[5]	78.0 | 22.0 %

Distance Traveled by Driving Speed

Route Information

Average Distance Traveled Per Day	34.5 miles
Median Daily Driving Aggressiveness[6]	1.3 [0-10]
Average Number of Stops Per Day | Per Mile	69.1 | 2.7
Average Brake (Regen) Events	12.4 per mile
Average Maximum Acceleration	0.4 g
Average Daily Maximum Driving Speed	47.4 mph
Average Daily Driving Speed	20.2 mph

Gasoline Equivalent Fuel Economy

National Renewable Energy Laboratory — 1 of 4 — 6/6/2012 9:09 AM

Quarterly and cumulative summary results are available on the NREL and DOE website:

http://www.nrel.gov/vehiclesandfuels/fleettest/

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Smith Electric Vehicles - Info

- 500 Newtons being deployed in U.S.
  - Manufactured in Kansas City, MO
  - $32 Million ARRA award
  - 100 mile electric range required (cycle dependent)
  - Deployment plans included 20 launch partners including:
    - Frito-Lay
    - Coca Cola (NY)
    - Kansas City Power and Light (MO)
    - AT&T (MO)
    - Staples (CA, OH)
    - PG&E (CA)

Curb Weight	9,700-10,200	pounds
Length	268-368	inches
Width	87	inches
Height	94-99	inches
Peak Motor Power	134	kW
Electric Range	Up to 150	miles
Seating	3	
Payload	12,324-16,200	pounds
Electric Top Speed	50	mph
Battery Capacity	**80** or 120	kWh
Battery Voltage	~350	V nominal
Charging Standards	J1772 or 3-phase	
Transmission	Single Speed Reduction Gear	
Drag Coefficient	~0.5	
Wheel Base	153 - 220	in.

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Smith Electric Vehicles – Data Collected

- First quarterly report covered Oct 2011-Dec 2011 (published)
- Next will cover January-March 2012 (published in July)
- Cumulative report will be published (July)

- Cumulative results to Date:

  - Reporting period: 10/1/2011 to 3/31/2012
  - Number of vehicles reporting: **151**
  - Number of vehicle days driven: 6,352
  - Number of miles recorded: 199,625 miles
  - Number of operating cities: 75

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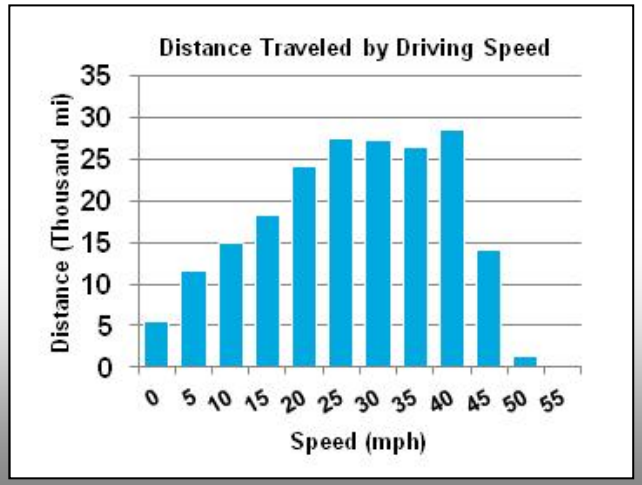
Smith Electric Vehicles – Route Info

Average Number of Stops (Per Day | Per Mile):	**68.4** | 2.7
Average Brake (Regen) Events (per mile):	12.3
Average Maximum Acceleration (g):	0.4
Average Daily Maximum Driving Speed (mph):	47.2
Average Daily Driving Speed (mph):	**20.3**
City | Highway Distance (miles):	155,531.5 | 44,094.8
City | Highway Distance %:	**79.1** | 22.4



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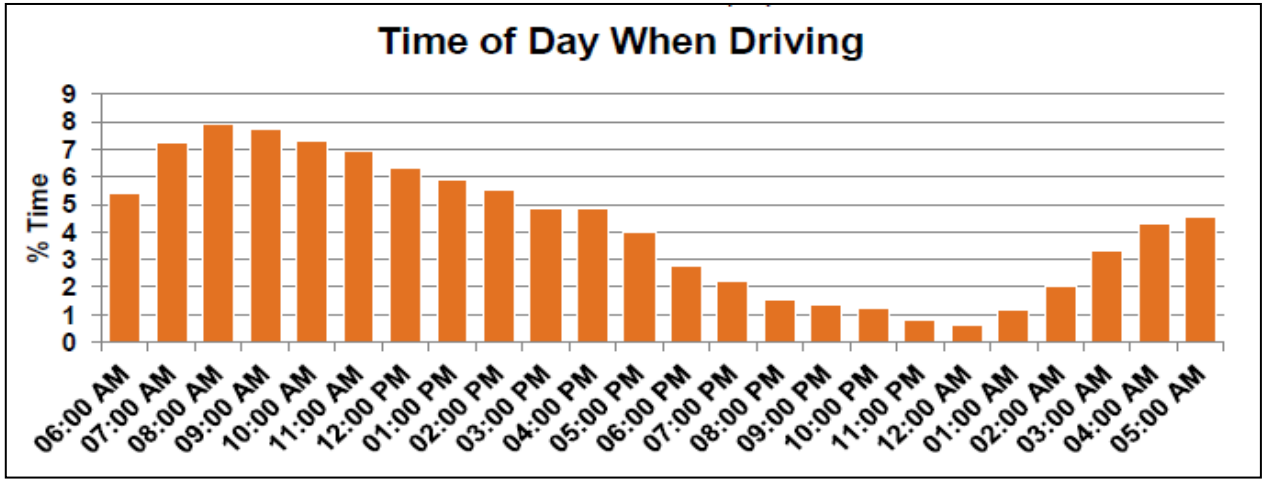
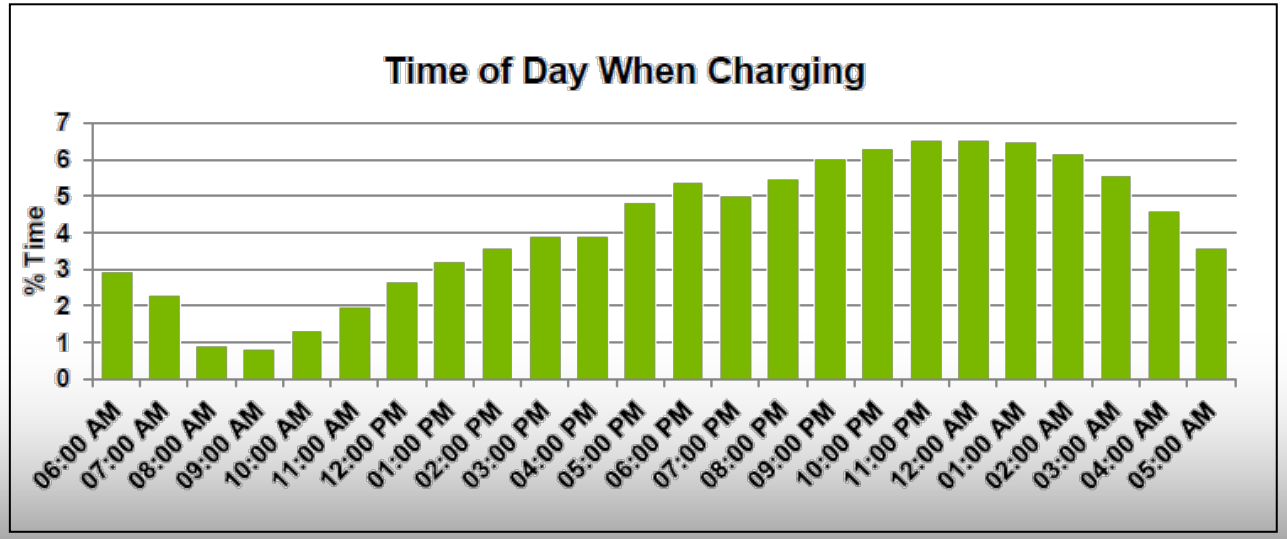
Smith Electric Vehicles – When Used





- Driving and charging patterns reflect typical commercial use
- 'when charging' is defined as time of day when plugged in

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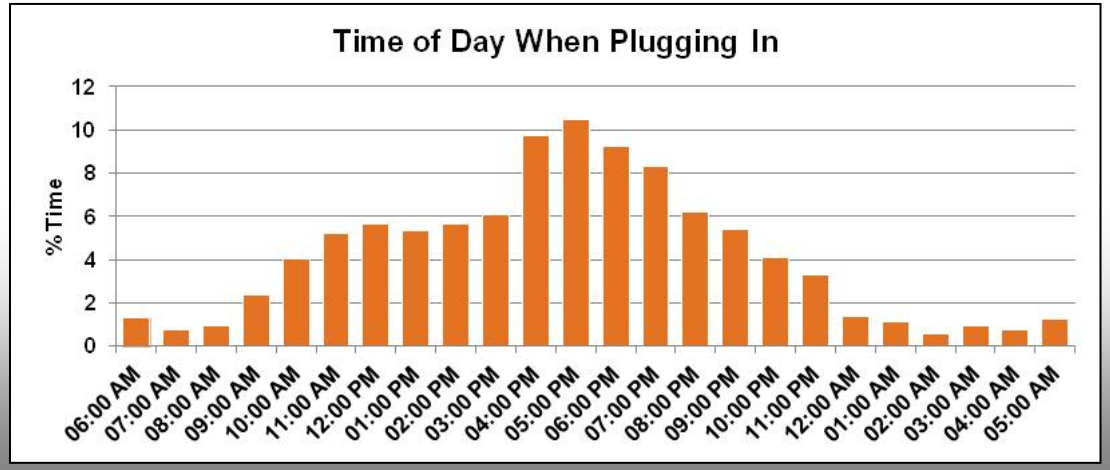
Smith Electric Vehicles – Overall Charging

Average Fleet Charging Events (per month):	2,475.2	
Average Fleet Charge Energy (per month):	72,886.5 kWh	
Average Vehicle Charging Frequency (per day):	2.3	
Average Per Vehicle Charge Energy (per day):	**67.7**	kWh
Average Energy Delivered (per charge):	**29.6**	kWh
Average Duration of Charge Event	7.5	hr
Average Distance Between Charges	**13.3**	miles



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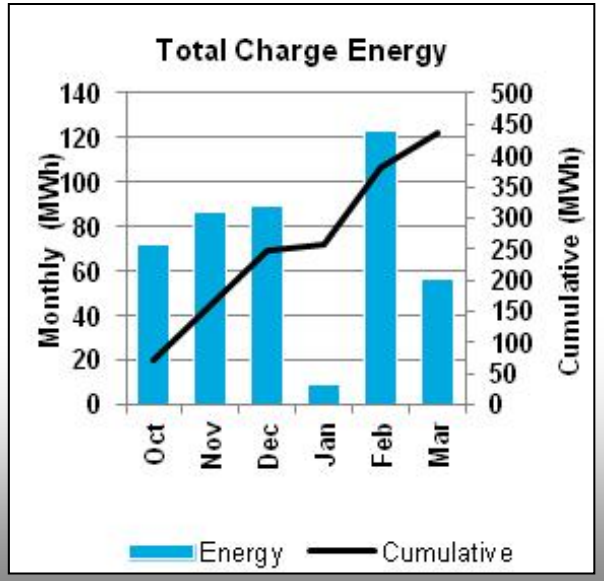
Smith Electric Vehicles – Overall Energy Use

Overall DC Electrical Energy Discharged:	1,732.7 Wh/mi
***Driving* DC Electrical Energy Consumption:**	1,594.3 Wh/mi
Total Number of Charges:	14,851.0
Total Charge Energy Delivered:	437,318.7 kWh
Overall Gasoline Equivalent Fuel Economy:	**19.4** mpge (based on EPA method of 33.7 kWh/gal)



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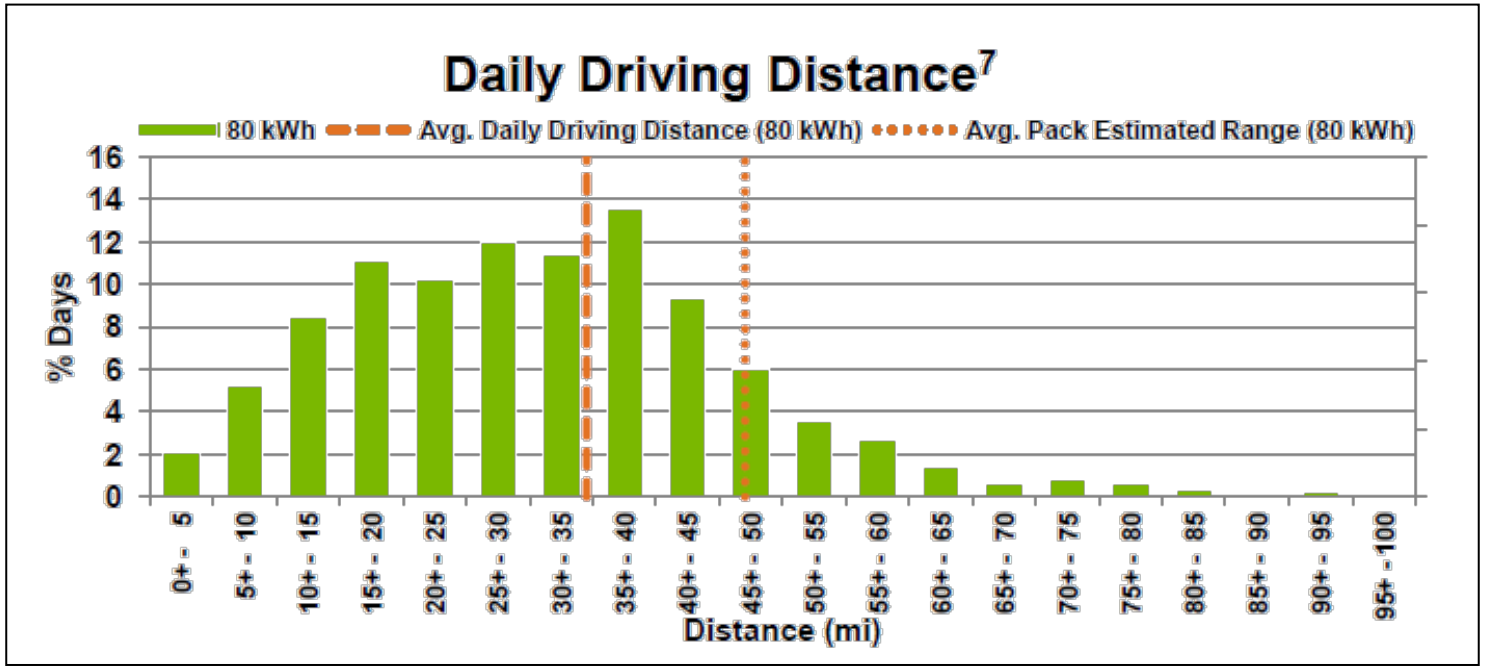
Smith Electric Vehicles – Distance and Range



- Average daily distance driven: 31 miles
- Route specific average range (w/idle): 46.2 miles
- Route specific average range (only moving): 50.2 miles

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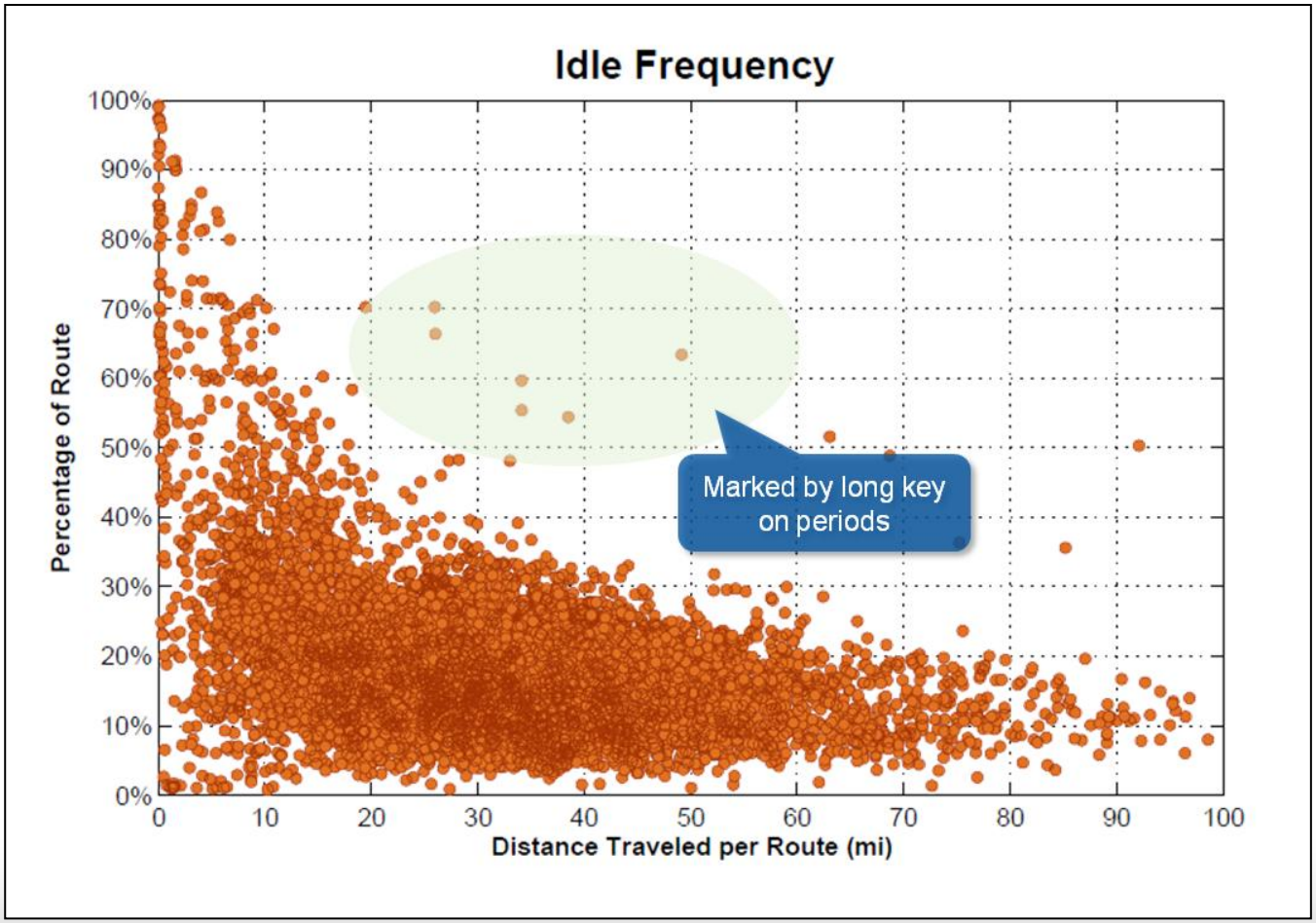
Smith Electric Vehicles – Distance and Idle



- **Looking into 'key on' time:**

  Will affect overall efficiency - (increases the Wh/mi and decreases overall range)

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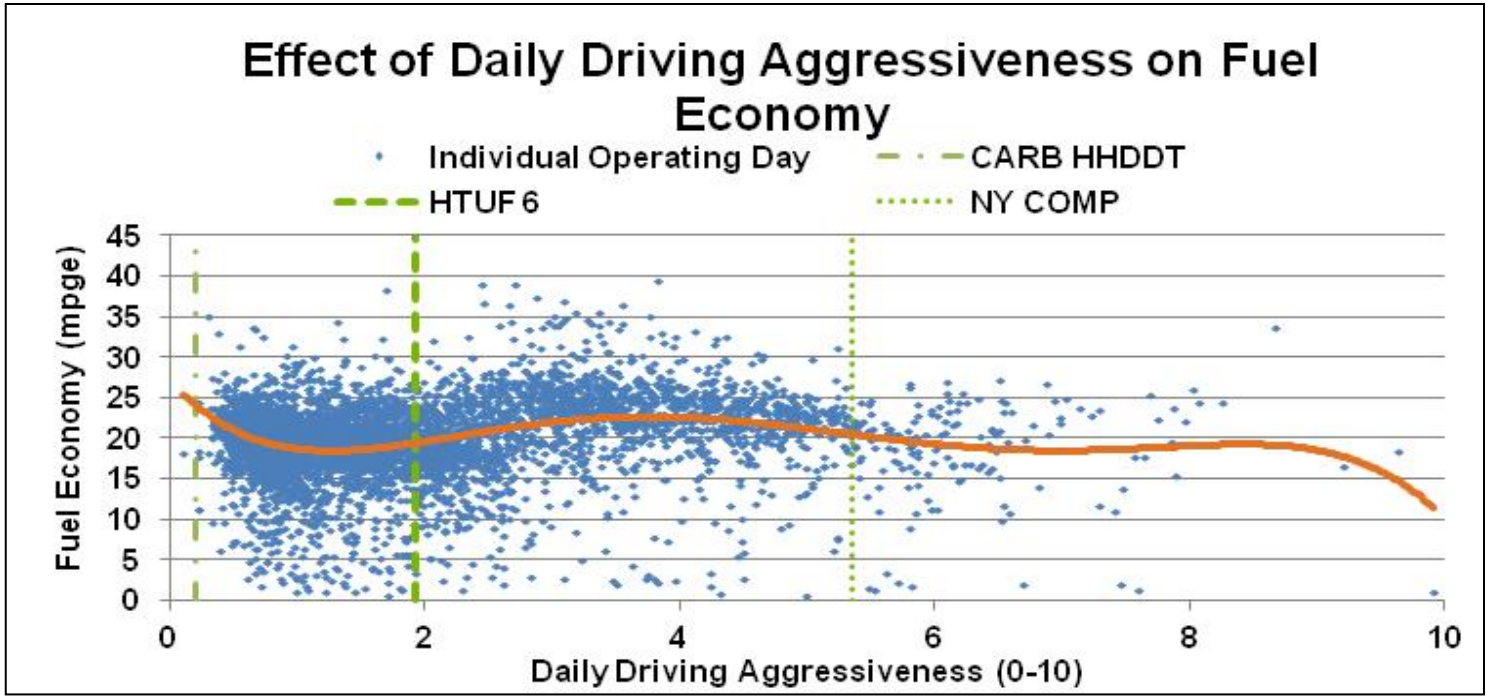
Smith Electric Vehicles – Efficiency vs Drive Cycle



- 'Fuel Economy' varies based on drive cycle
- Average driving style observed is somewhere between CARB HHDDT cycle and HTUF 6 Cycle
- Significant daily operations in more 'urban routes' approaching NY Composite Cycle

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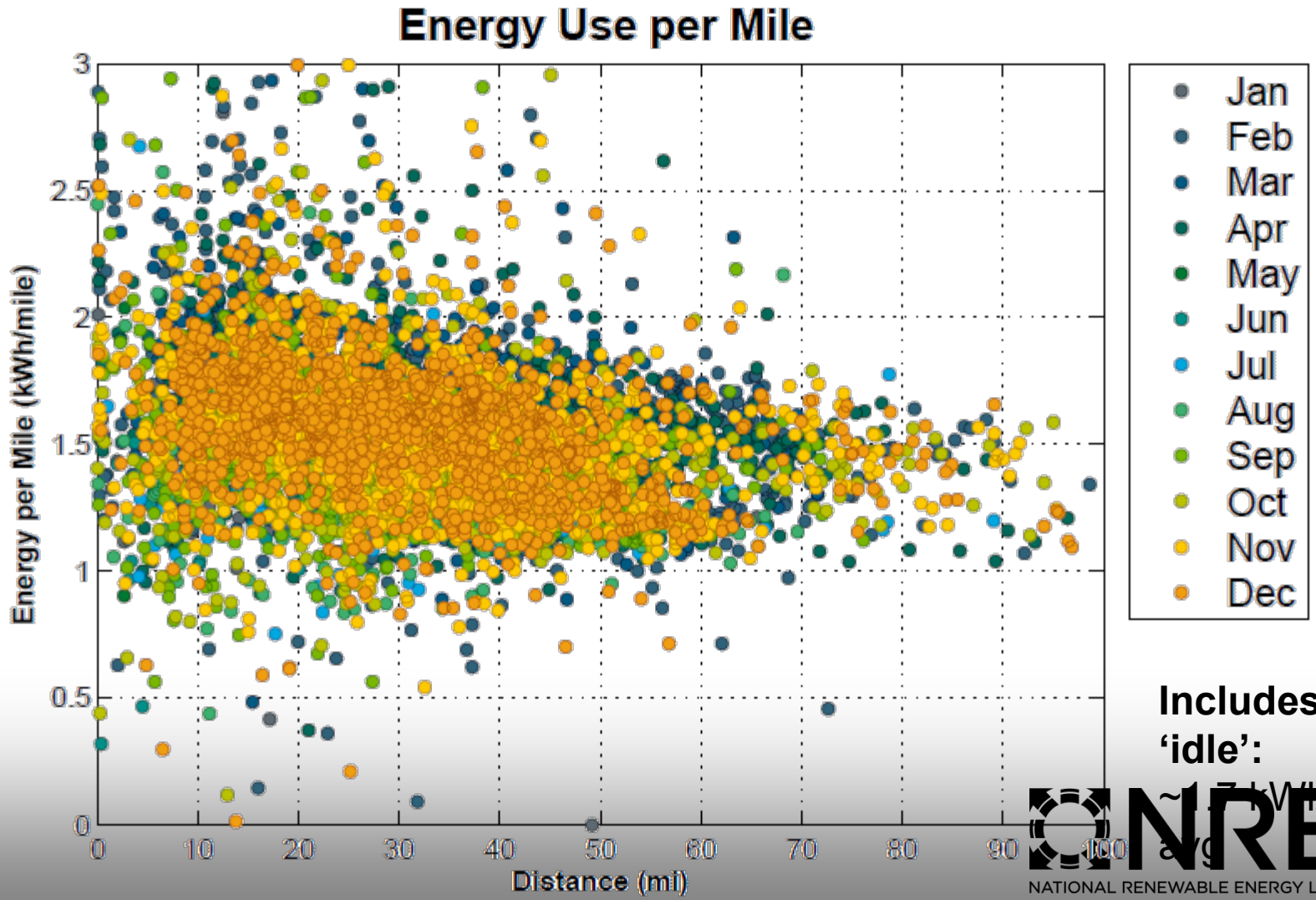
Smith Electric Vehicles – Avg Daily Energy Use



Includes 'idle':
~1.7 kWh/mi avg

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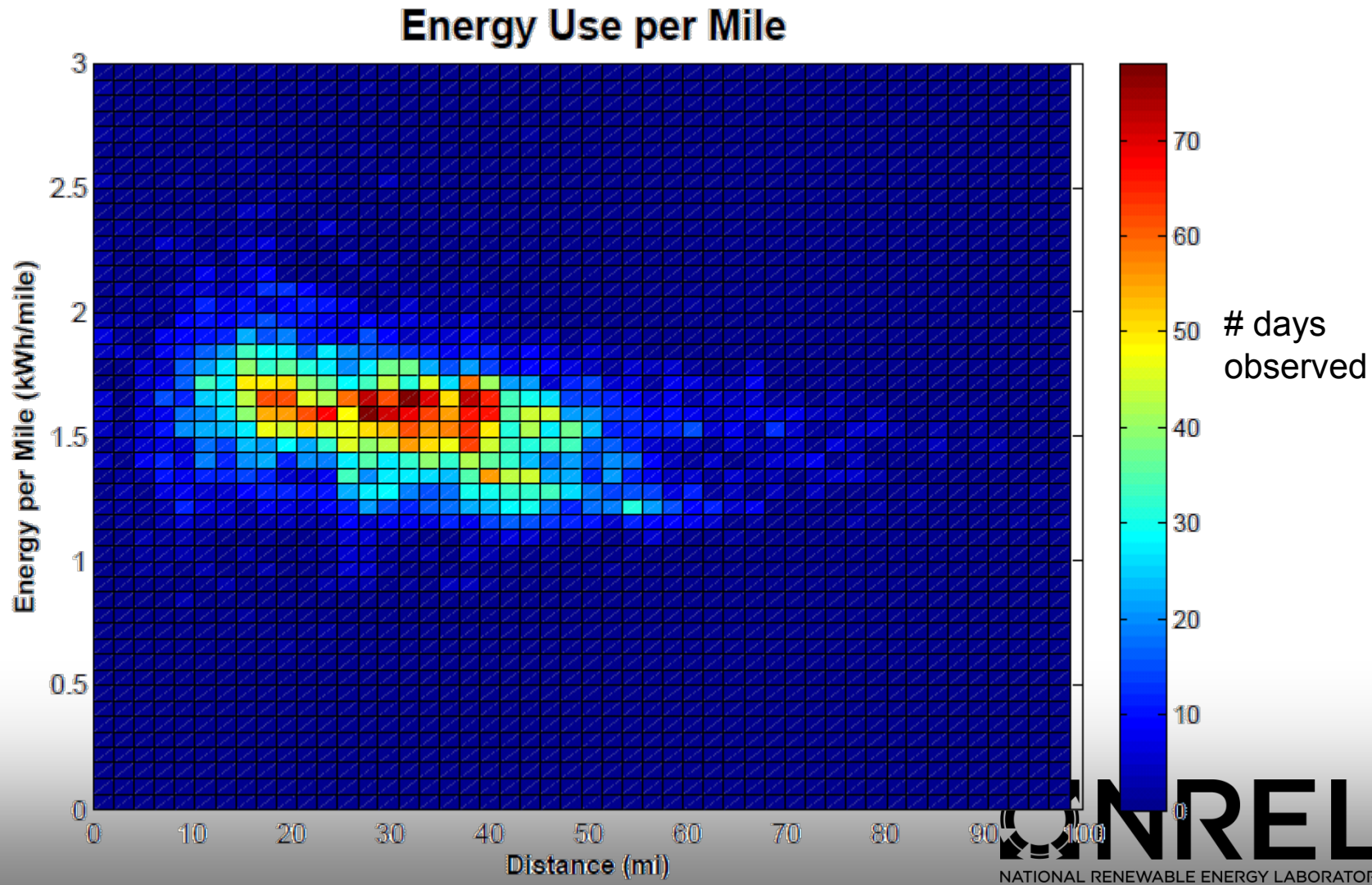
Smith Electric Vehicles – Avg Daily Energy Use



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Smith: Fuel Cost Comparison to Diesel

- What if compared to conventional vehicle?
- Modeled a diesel package delivery van and ran it on all the daily routes recorded for Smith vehicles

Conventional Vehicle Specifications	
Test Weight (lbs)	15,020
CD	0.7
FA (m^2)	7.8
RR	0.008
Engine Power (kW)	149

Conventional Vehicle	(Empty/Average/GVWR)
Curb Weight (lbs)	11,020
Payload Weight (lbs)	0/2,998/11,978
Total Weight (lbs)	11,020/14,019/22,998

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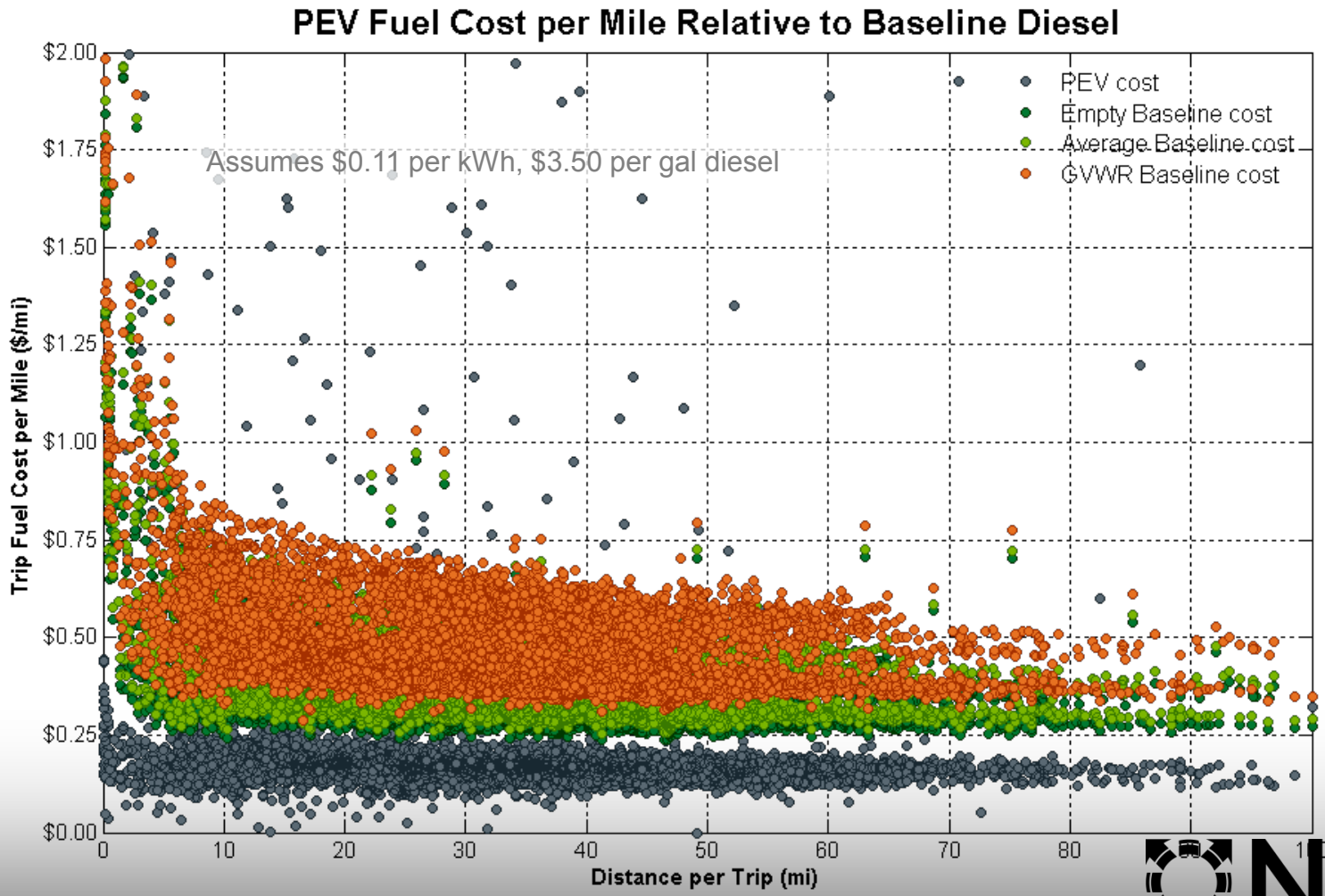
Smith: Fuel Cost Comparison w/Mass Sensitivity



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Next Steps

- Repeat process with additional data every quarter for Smith
  - Expect usage to change as vehicles are further implemented into service and adjusted based on performance
- Repeat process for Navistar eStar, AQMD shuttle buses and bucket trucks, and Cascade Sierra
- Continue to add additional analysis to explore:
  - Demand charge implications at commercial sites (smart charging / V2B / V2G)
  - Battery degradation vs drive/duty cycle, secondary use
  - Effects of environment on range
- Present and publish data on all projects into 2014

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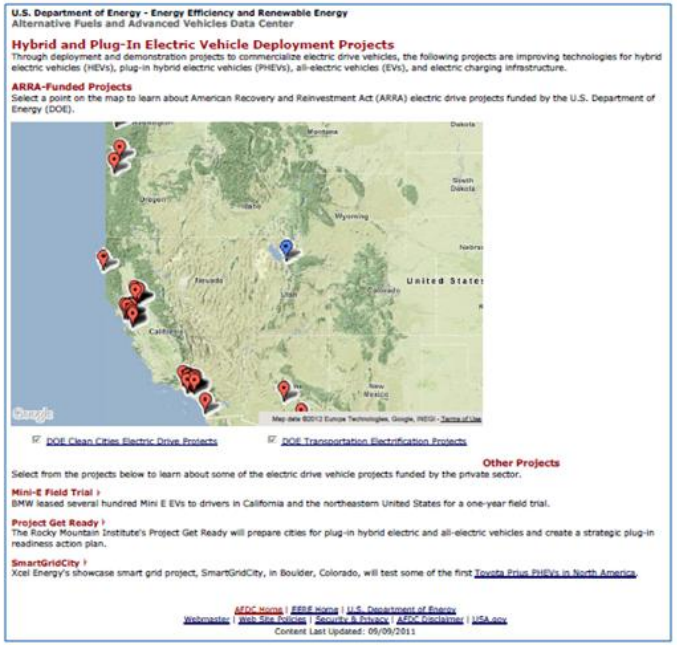
Thanks!

Acknowledgement:
This work is supported by the U.S. Department of Energy's EERE Vehicle Technologies Program

For More Information:
www.afdc.energy.gov


U.S. Department of Energy - Energy Efficiency and Renewable Energy
Alternative Fuels and Advanced Vehicles Data Center

Hybrid and Plug-In Electric Vehicle Deployment Projects

Through deployment and demonstration projects to commercialize electric drive vehicles, the following projects are improving technologies for hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), all-electric vehicles (EVs), and electric charging infrastructure.

ARRA-Funded Projects

Select a point on the map to learn about American Recovery and Reinvestment Act (ARRA) electric drive projects funded by the U.S. Department of Energy (DOE).

DOE Clean Cities Electric Drive Projects
DOE Transportation Electrification Projects

Other Projects

Select from the projects below to learn about some of the electric drive vehicle projects funded by the private sector.

Mini-E Field Trial ›
BMW leased several hundred Mini E EVs to drivers in California and the northeastern United States for a one-year field trial.

Project Get Ready ›
The Rocky Mountain Institute's Project Get Ready will prepare cities for plug-in hybrid electric and all-electric vehicles and create a strategic plug-in readiness action plan.

SmartGridCity ›
Xcel Energy's showcase smart grid project, SmartGridCity, in Boulder, Colorado, will test some of the first Toyota Prius PHEVs in North America.

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