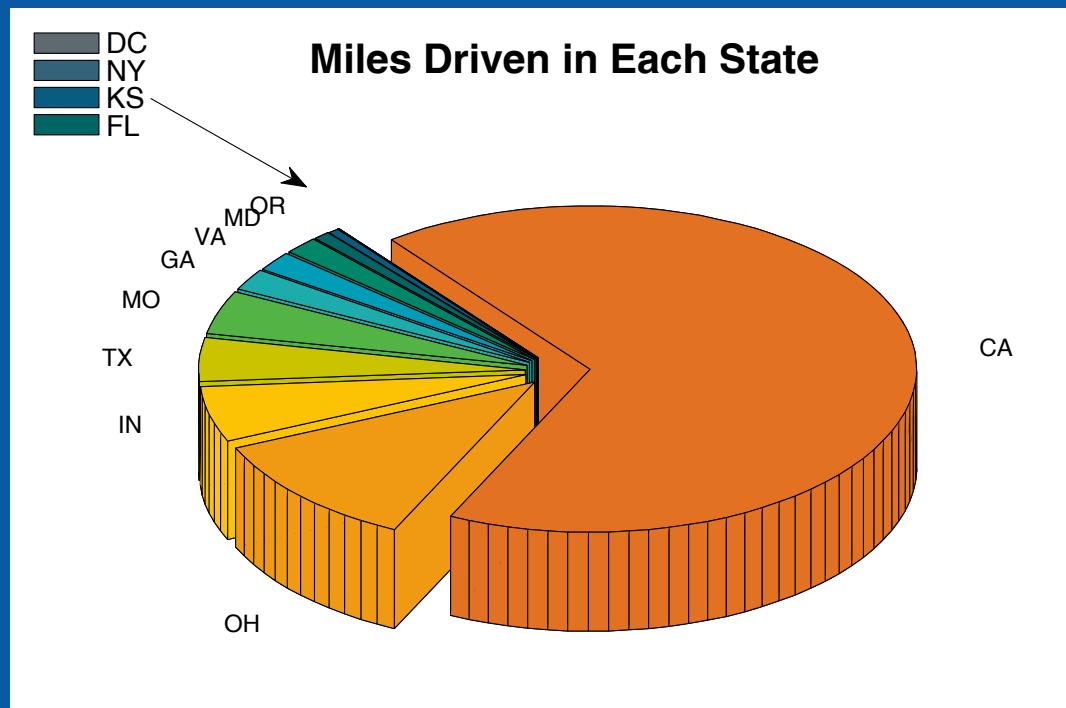


MD PHEV/EV ARRA Project Data Collection and Reporting



Led by:
Kevin Walkowicz

With support from:
Laurie Ramroth
Adam Duran
Ben Rosen

NREL/PR-5400-53878

10 January 2012

- ARRA funds helped deploy vehicles and EVSEs
 - Four awards total:
 - Smith
 - Navistar
 - SCAQMD/EPRI
 - Cascade Sierra Solutions
- DOE's Vehicle Technologies Program (VTP) funded NREL to collect and analyze commercial fleet deployment data
 - Part of Advanced Vehicle Testing Activity (AVTA)
 - Planned under VSST Activity, FY10-12
 - Monitoring performance and energy utilization
 - Reporting effort similar to INL AVTA LD programs

~500 Newtons throughout U.S.

- Manufactured in Kansas City, MO
- \$32 Million ARRA award
- 100 mile electric range (cycle dependent)
- 26 channels of 1hz data to be logged and delivered to NREL for analysis
- Deployment plans included 20 launch partners

Smith Newton Data Parameters

1	Timestamp
2	Operating Mode
3	GPS Speed
4	Accelerator Pedal Position
5	Brake Pedal Position
6	Battery Current
7	Battery Voltage
8	Battery State of Charge
9	Minimum Cell Voltage
10	Maximum Cell Voltage
11	Balancing State Module 1
12	Balancing State Module 2
13	Balancing State Module 3
14	Balancing State Module 4
15	AC Current
16	AC Voltage
17	GPS Latitude
18	GPS Longitude
19	GPS Altitude
20	Minimum Battery Temperature
21	Maximum Battery Temperature
22	Motor Temperature
23	Power Electronics Temperature
24	Motor Speed
25	Heater State
26	Auxiliary Battery Voltage

Up to 950 EVs throughout U.S.

- Manufactured in Elkhart, IN
- \$39.2 million ARRA award
- 100 mile range (cycle dependent)
- 12,100 lb GVWR (class 3)
- 32 channels of 1hz data being logged and delivered to NREL for analysis

Navistar eStar Data Parameters

1	Timestamp
2	GPS Latitude
3	GPS Longitude
4	GPS Altitude
5	Ambient Temperature
6	Auxiliary Battery Voltage
7	Odometer
8	Operating Mode
9	Vehicle Speed
10	Accelerator Pedal Position
11	Brake Pedal Position
12	Battery Current
13	Battery Voltage
14	Battery State of Charge
15	Battery Discharge Energy
16	Battery Charge Energy
17	Battery Cell Voltage Minimum
18	Battery Cell Voltage Maximum
19	AC On
20	AC Current
21	AC Voltage
22	AC Power Factor
23	AC Charge Energy
24	AC Discharge Energy
25	Battery Bulk Temperature
26	Minimum Battery Cell Temperature
27	Maximum Battery Cell Temperature
29	Charger Temperature
29	Heater State
30	Shifter Position
31	Transmission Gear

Vehicles to be deployed across the US:

F-550 based PHEV utility “Trouble Truck”
application + an E-450 based Shuttle Bus

- EPRI is the primary partner
- \$45.4 million ARRA award
- ~40 channels of 1 hz data proposed for logging
and delivery to NREL/DOE
- Charge depleting range is cycle dependent



Shorepower Truck
Electrification Project

- Expecting 50 sites w/25 connections per site to report eventually
- Up to 5000 trucks to utilize system
- Capture vehicle electrification data and truckstop pedestal data
- Monitor and report usage patterns



- Raw data sent securely to NREL
- Agreements for 3-year storage of proprietary data
- ~25-40 parameters protected

Unilateral (IN) Non-Disclosure Agreement

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NON-DISCLOSURE AGREEMENT
("Agreement")

This Agreement is entered into by and between the Alliance for Sustainable Energy, LLC ("Alliance"), the Manager and Operator of the National Renewable Energy Laboratory ("NREL") under Prime Contract No. DE-AC36-08GC2B308 for the U.S. Department of Energy (the "DOE"), located at 1617 Cole Boulevard, Golden, CO, 80401 and Smith Electric Vehicles US Corp and its affiliates ("Disclosing Party"), whose place of business is located at 12200 N.W. Ambassador Drive, suite 326, Kansas City, MO 64103. Both parties are hereinafter referred to individually as the "Party," and collectively as the "Parties". The effective date ("Effective Date") of this Agreement shall be the signature date of the last of the Parties to sign this Agreement. For the purpose of this Agreement, the terms NREL and Alliance are interchangeable except where the circumstances dictate otherwise.

1. PURPOSE

a. Disclosing Party wishes to provide to NREL, for a period of thirty six (36) months, and NREL wishes to obtain access to Disclosing Party's information related to electric vehicle performance data regarding operation of Disclosing Party's vehicles while in service or in testing situations, which the Disclosing Party considers PROPRIETARY INFORMATION, including the following: Medium Duty Electric Vehicle (EV) Delivery Truck Data, vehicle performance data, an example of which is provided in Appendix A, for Disclosing Party's ~ 500 EV delivery vehicles being demonstrated. Disclosing Party is furnishing PROPRIETARY INFORMATION to NREL for the purpose of evaluation of a geographically deployed fleet of electric delivery vehicles utilized across different logistic applications.

b. As used herein, PROPRIETARY INFORMATION means information which (i) embodies trade secrets as defined under 18 U.S.C. §1839 or (ii) commercial or financial information which is privileged or confidential under the Freedom of Information Act (5 U.S.C. §552(b)(4)), either of which is developed at private expense outside this Agreement and which is marked as PROPRIETARY INFORMATION.

2. PROPRIETARY INFORMATION

a. Alliance agrees to use PROPRIETARY INFORMATION only for the purpose(s) set forth in Paragraph 1.a. above. NREL will treat all PROPRIETARY INFORMATION disclosed to NREL by Disclosing Party, whether such original disclosure is written or oral, as confidential and proprietary. However, oral disclosure of information (i.e., information expressed by spoken words) to NREL by Disclosing Party shall be considered PROPRIETARY INFORMATION only upon being identified as such at the time of disclosure, reduced to writing, and a copy of it provided by Disclosing Party to NREL within thirty (30) days of the oral disclosure. NREL will not disclose PROPRIETARY INFORMATION to any third party for a period of three (3) years from the effective date of this Agreement. All written PROPRIETARY INFORMATION provided to Alliance hereunder is subject to inspection by DOE employees upon reasonable notice and shall be protected against further disclosure by DOE employees under 18 U.S.C. §1905.

b. All PROPRIETARY INFORMATION provided will be identified and marked by Disclosing Party as "PROPRIETARY INFORMATION" at the time it is conveyed to NREL except as noted in Paragraph 2.a. above.

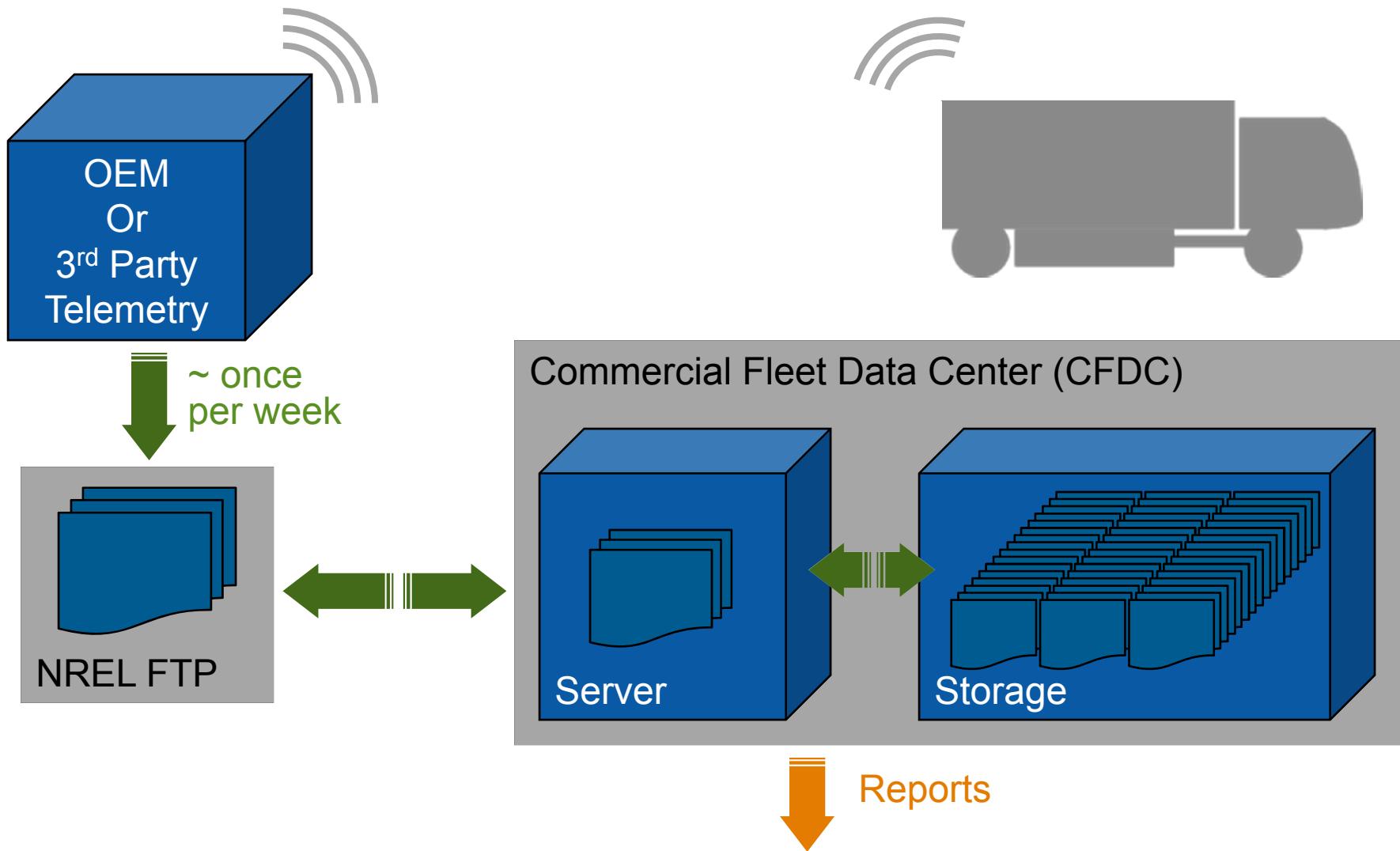
c. NREL agrees that access to PROPRIETARY INFORMATION will be provided only to NREL's employees, agents and independent contractors who are required to have access specifically related to the purpose(s) permitted herein and to DOE for auditing and inspection purposes only. NREL further agrees that it will inform individuals having access to PROPRIETARY INFORMATION of the confidential nature of the PROPRIETARY INFORMATION and restrictions on its publication, disclosure and use. NREL will inform individuals having access to such

NDA APPENDIX A

Parameter	Units	Acquisition Frequency	Comments
Vehicle ID	NA	NA	Remote Device ID Links to Vehicle
Timestamp	YY/MM/DD HH/MM/SS	<= 1Hz*	None
Odometer	km	<= 1Hz*	Product of Vehicle Speed and Time in drive mode**
Operation state	4 states	<= 1Hz*	0 = standby, 1 = charge, 2 = drive, 3 = error
Vehicle speed	mph	<= 1Hz*	None
Accelerator pedal position	Volts	<= 1Hz*	None
Brake pedal position or force	Volts	<= 1Hz*	None
Battery current	Amps	<= 1Hz*	None
Battery voltage	Volts	<= 1Hz*	None
Battery pack SOC	%	<= 1Hz*	None
Battery pack DC discharge energy	Watts	<= 1Hz*	Product of Battery Current and Voltage in drive mode**
Battery pack DC charge energy	Watts	<= 1Hz*	Product of Battery Current and Voltage in charge mode**
Battery pack min cell voltage	mV	<= 1Hz*	None
Battery pack max cell voltage	mV	<= 1Hz*	None
Battery pack balance mode state	2 states	<= 1Hz*	0 = No balancing between modules, 1 = Balancing between modules
AC current	Amps	<= 1Hz*	None
AC voltage	Volts	<= 1Hz*	None
GPS latitude	Degrees	<= 1Hz*	None
GPS longitude	Degrees	<= 1Hz*	None
GPS altitude	Meters above sea level	<= 1Hz*	None
Battery pack min cell temperature	Deg C	<= 1Hz*	None
Battery pack max cell temperature	Deg C	<= 1Hz*	None
Motor temperature	Deg C	<= 1Hz*	None
Power electronics temperature	Deg C	<= 1Hz*	None
Motor speed	RPM	<= 1Hz*	None
Heater state	On/Off	<= 1Hz*	None
Heater power consumption	Watts	constant	Used to calculate energy consumption when 'on' according to state
Auxiliary 12V battery voltage (24V)	Volts	<= 1Hz*	None

*All samples on "data change" of value and not greater than 1Hz

**NREL to calculate



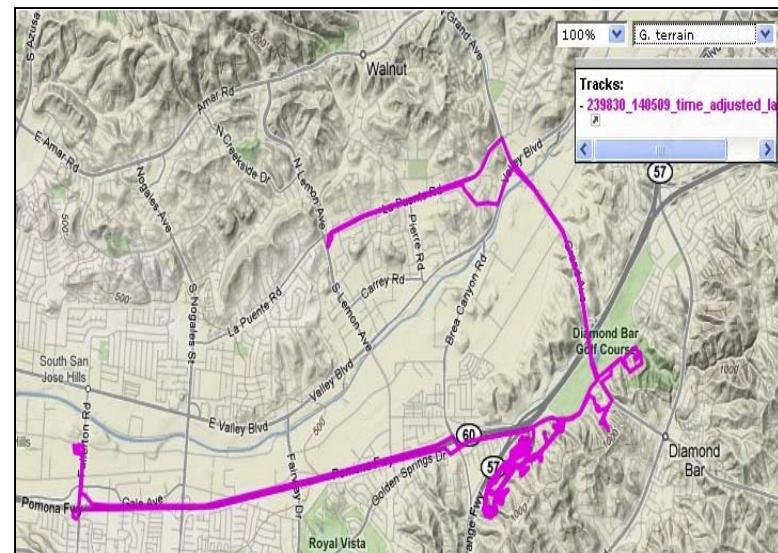
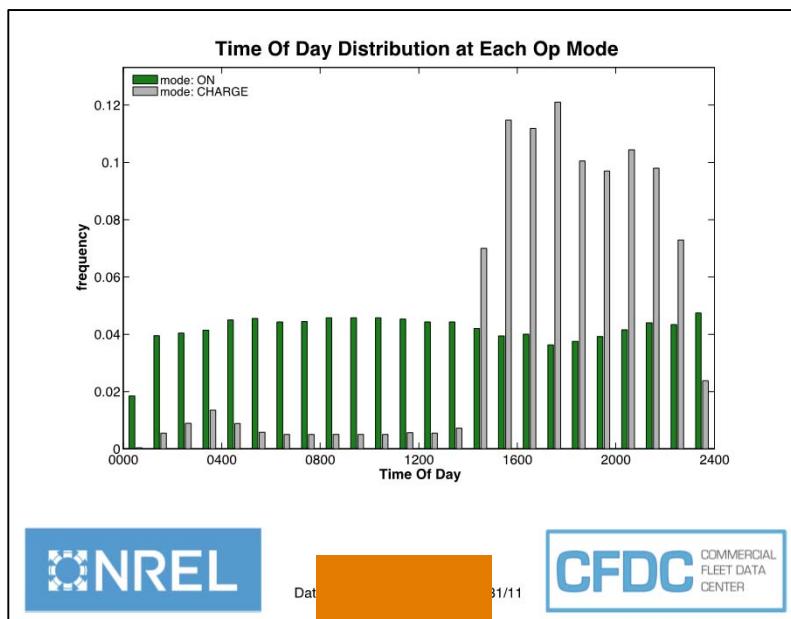
- Planning to collect over 300 GB/month (peak)
 - Three secure FTP sites set up and running to receive data
- Commercial Fleet Data Server (CFDS) currently operating
- Tape Backup
 - 2 Storage Arrays
 - ✓ Up to 25 TB data
 - HP DL360 G7
 - ✓ 6-core, 2.66 GHz

Filter, Analyze, Characterize and Store

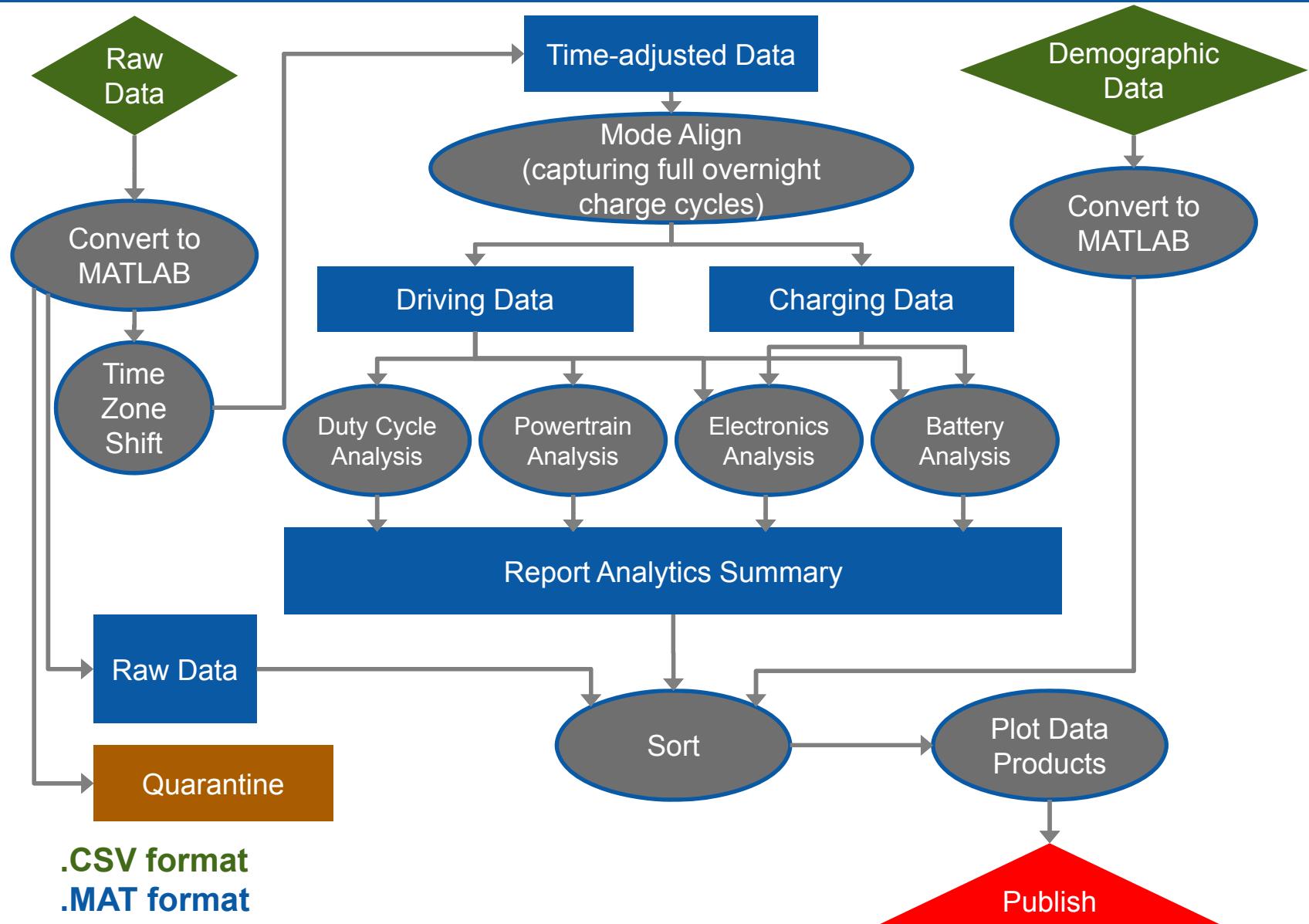
- DRIVE (drive cycle tool) Calculates over 200 unique driving statistics (Appendix A)
- Fleet Analysis Toolkit has unique algorithms developed for each set of variables from mfg.
 - Requires significant effort to understand each fleet

Visualize

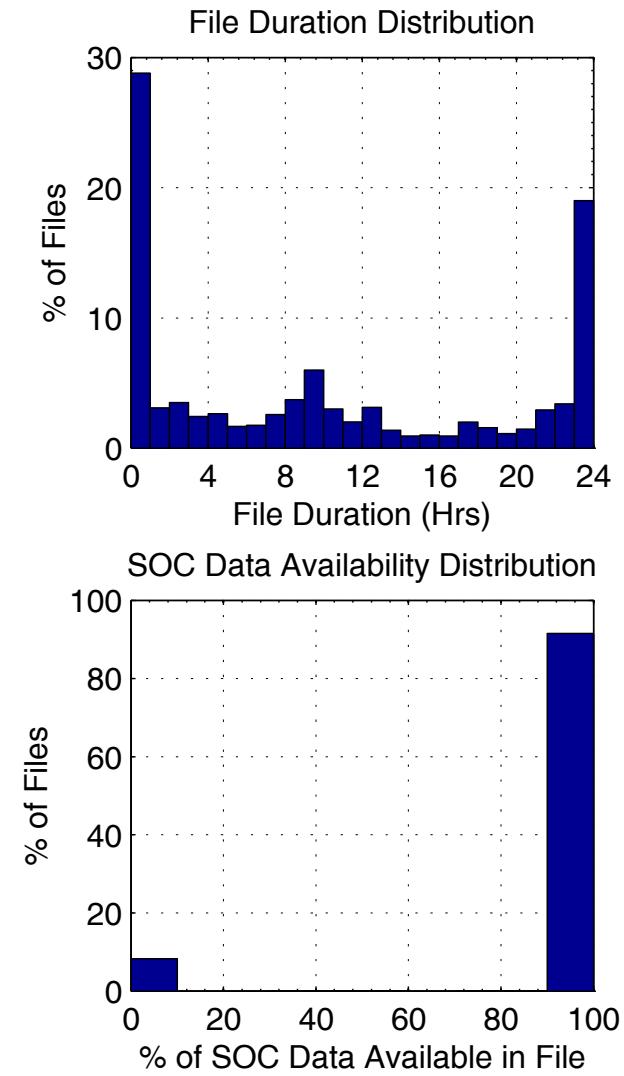
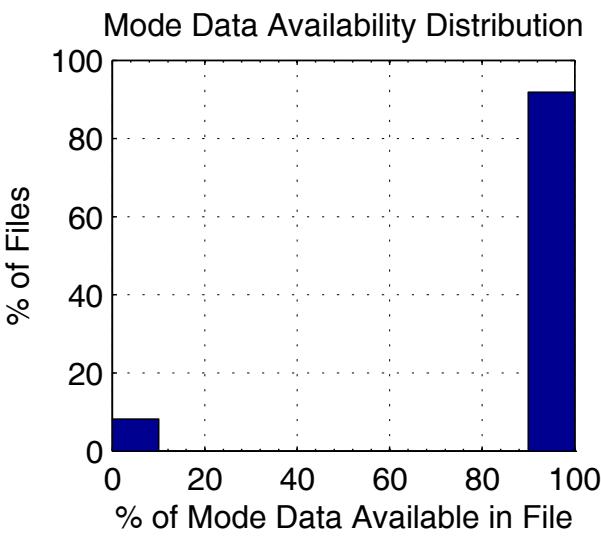
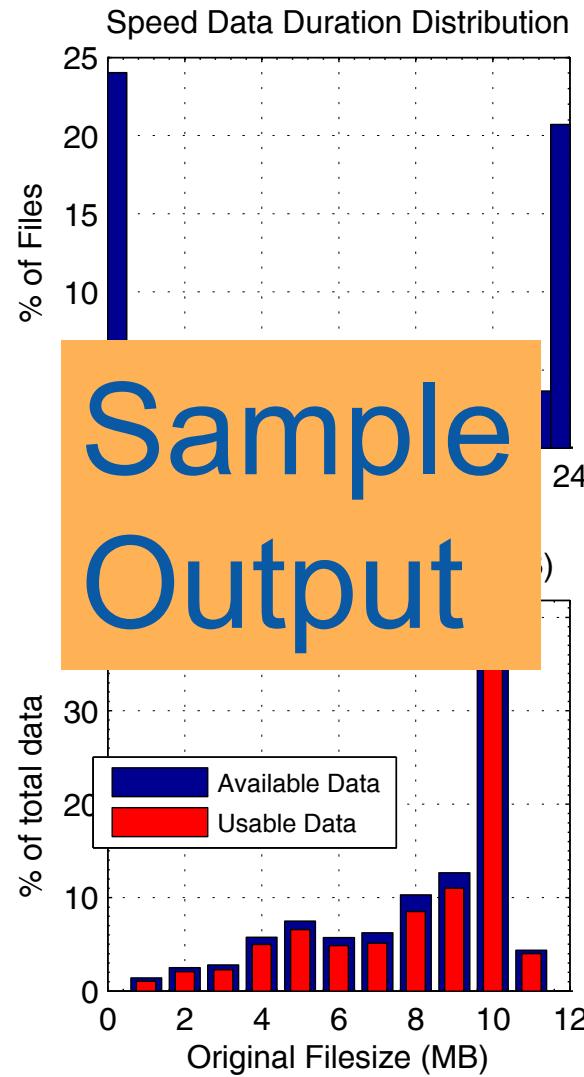
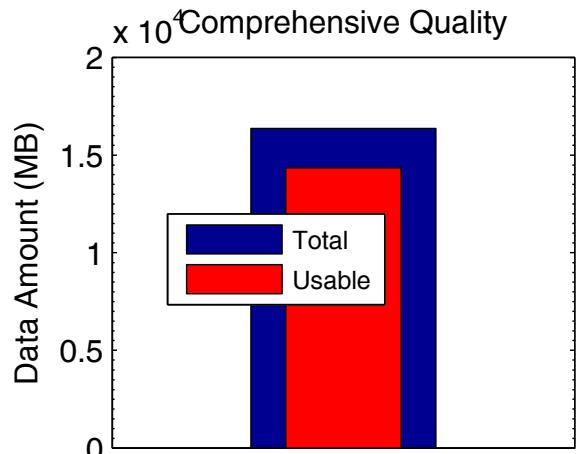
- Displays graphs, tables, and histograms of data
- Automated production / common templates



Multi-Step Analysis



- Each file is checked for “usability” using a proprietary in-house process with a ‘quarantine’ function
- All quarantined files will be revisited and re-examined in coordination with the OEM to attempt to recover or interpret the data via alternative methods.
- *Raw data is never deleted...* only moved between quarantined and valid locations
- Empty data records (with no value logged) within each file are also marked “unusable.”



1	Time in Service	Total days of valid data
2	Vehicle Range	Miles traveled per trip
3	Fuel Efficiency	DC energy out of the battery with respect to total miles traveled (Wh/mi)
4	Battery Pack & Cell Voltage	Average voltages at pack and cell levels
5	Battery Degradation	Average voltages for fleet each 1000 miles (or 1000 cycles)
6	Battery Soak Temperatures	Time spent parked at various temperatures
7	Time Spent Charging	Total hours spent charging per vehicle per mile traveled
8	Arriving/Departing SOC	Binned SOC % recorded when plugging-in and unplugging
9	Battery Resting SOC	Time spent at each range of SOC
10	Charging Time of Day	Local time when plugging-in
11	Powertrain Efficiency	Compare road-load demand (assuming various GVWs) to DC power out
12	Charging Efficiency	Total AC energy in (from the charging cord) vs. total DC energy out (to the motor)
13	Duty Cycle Impacts to Range	Variation in energy efficiency (Wh/mi) with respect to Kinetic Intensity
14	Idling Statistics	Idle time (key-on zero speed) and power demand during Idle
15	Drive Temperatures	Trip duration at various ambient temperatures
16	Drivetrain Temperatures	Motor/power electronics temperatures at various DC power levels
17	Air Conditioner Energy Impacts	Fuel efficiencies with air conditioner on and off and duration in each mode
18	Charging Location	Map of locations where vehicle charge (with bubbles sized proportional to duration)
19	Effective Vehicle Range	Estimate total range availability using fuel efficiency and SOC usage windows
20	Voltage Transients	Second-by-second deviations in pack voltage
21	Energy Cost Savings	Estimate electricity cost by location with respect to diesel equivalent cost and more to come...

PRODUCT

Quarterly Data Published

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

VEHICLE TECHNOLOGIES PROGRAM

Number of vehicles:	127	Number of vehicle days driven:	6154
Reporting period:	7/1/2011 to 11/30/2011	Number of Operating Cities:	67

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. The trucks will be deployed in diverse climates across the country.

Vehicle Specifications

Curb Weight	16,535-26,455 pounds	Battery Capacity	80 or 120 kWh
Length	225.6 - 285.6 inches	Battery Voltage	~350 V
Width	79.2 inches	Battery Warranty	Unconfirmed
Height	78 - 79.2 inches	Charging Standards	J1772
Peak Motor Power	120 kW	Transmission	Single Speed Reduction Gear
Motor Location	Front, Behind Cab	Drive	Rear Wheel Drive

Electric Range	100 miles	Drag Coefficient	0.5
Seating	3	Wheel Base	153 - 197 in.
Payload	16,000 pounds	Current Market Position	Unconfirmed
Electric Top Speed	50 mph	U.S. Debut	2008

Trip Data

Overall Gasoline Equivalent Fuel Economy:	10.4 mpg
Overall AC Electrical Energy Consumption:	xxxx Wh/mi
Overall DC Electrical Energy Consumption:	xxxx Wh/mi
Driving DC Electrical Energy Consumption:	xxxx Wh/mi
Total Number of Trips:	6049
Total Distance Traveled:	300,100.8 miles
City / Highway Trips:	97.1 2.9 %
City / Highway Distance:	280,778.7 39,324.1 miles
Note: city distance is considered <35mph, highway >35mph in these studies	

Route Information

Average Trip Aggressiveness	1.7 [0-10]
Average Number of Stops	61.7 per Trip
Average Number of Stops	4.2 per mi
Average Brake (Regen) Events	6.5 per mi
Average Maximum Acceleration	0.4 g's
Average Maximum Driving Speed	44.1 mph
Average Driving Speed	10.9 mph

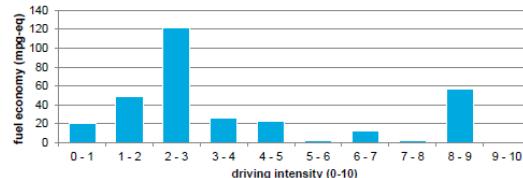
National Renewable
Energy Laboratory

1 of 3
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Quarterly Data Published

VEHICLE TECHNOLOGIES PROGRAM

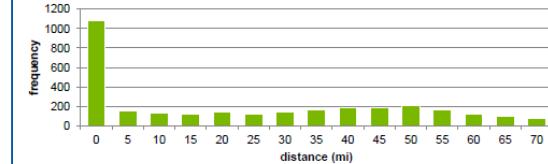
Effect of Driving Intensity on Fuel Economy



Time of Day When Driving



Distance Between Recharges

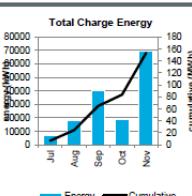


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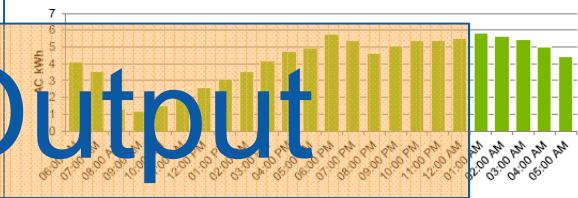
VEHICLE TECHNOLOGIES PROGRAM

Plug-in Charging

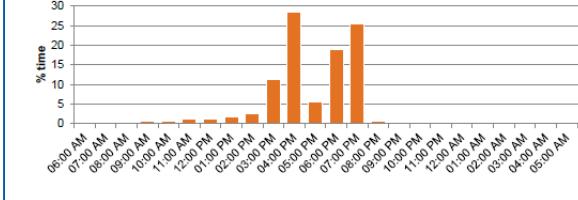
Average Charging Frequency	893.2 per month
Average Charging Frequency per Vehicle	0.7 per day each
Average Distance Between Charges	67.2 miles
Average Trips Between Charges	1.4 -
Average Duration of Charge	12.6 h/event
Average Charge Energy Delivered	34.3 kWh/event
Average Charge Energy per Vehicle	30848 kWh/month
Total Number of Charges	4466 events
Total Charge Energy	153240.2 kWh



Time of Day When Charging



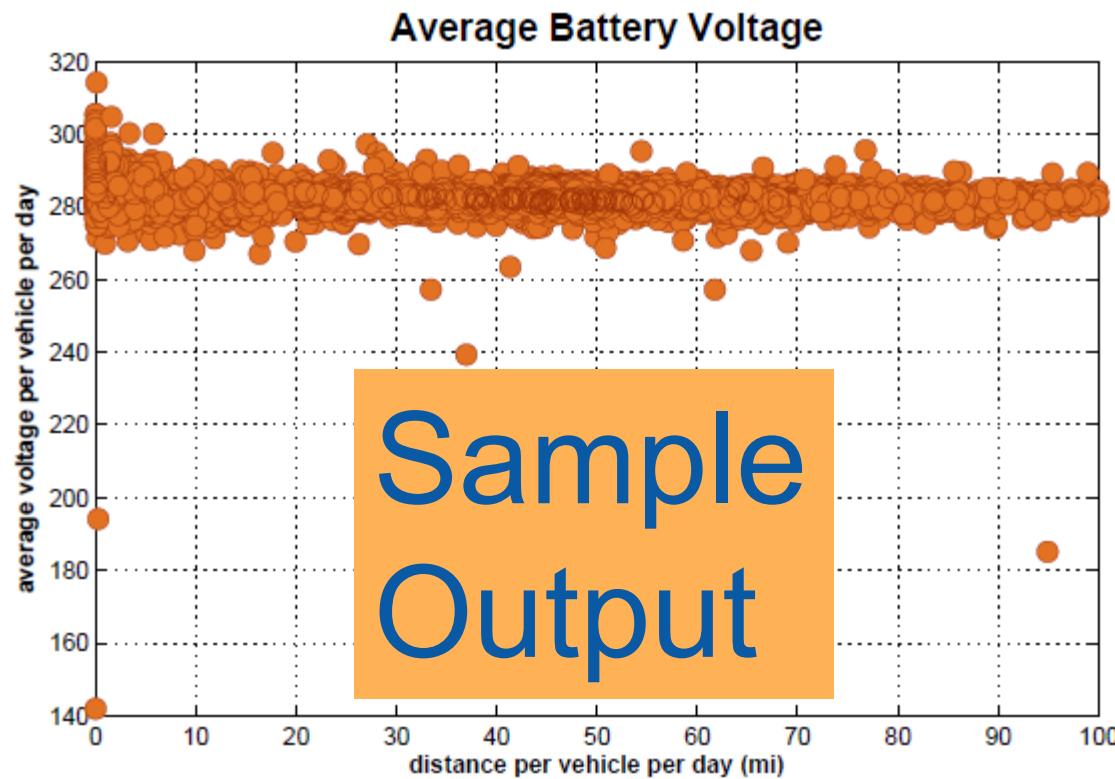
Time of Day When Plugging In



National Renewable
Energy Laboratory

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3-4 Page Quarterly Reports Include: vehicle background, trip/route data, equivalent mpg, driving styles, drive and charge metrics

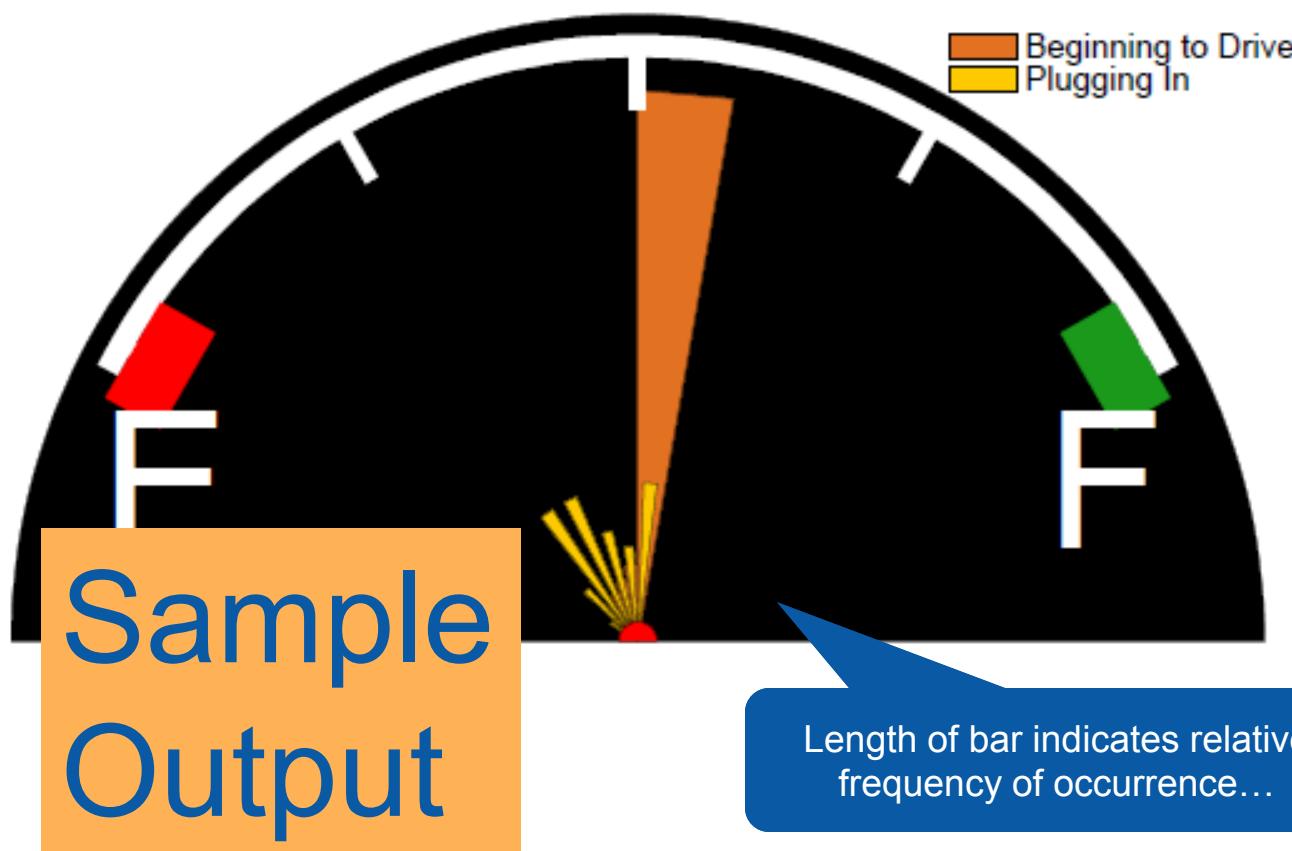


Time Stamp and
Data Description

95.5% of Trips are Valid and Included
Produced: 04 Jan 2012
Vehicle: Electric Vehicle
Transmitted: Nov 23 2010 to Nov 30, 2011

CFDC COMMERCIAL
FLEET DATA
CENTER

Vehicle State of Charge at the Start of Each Route

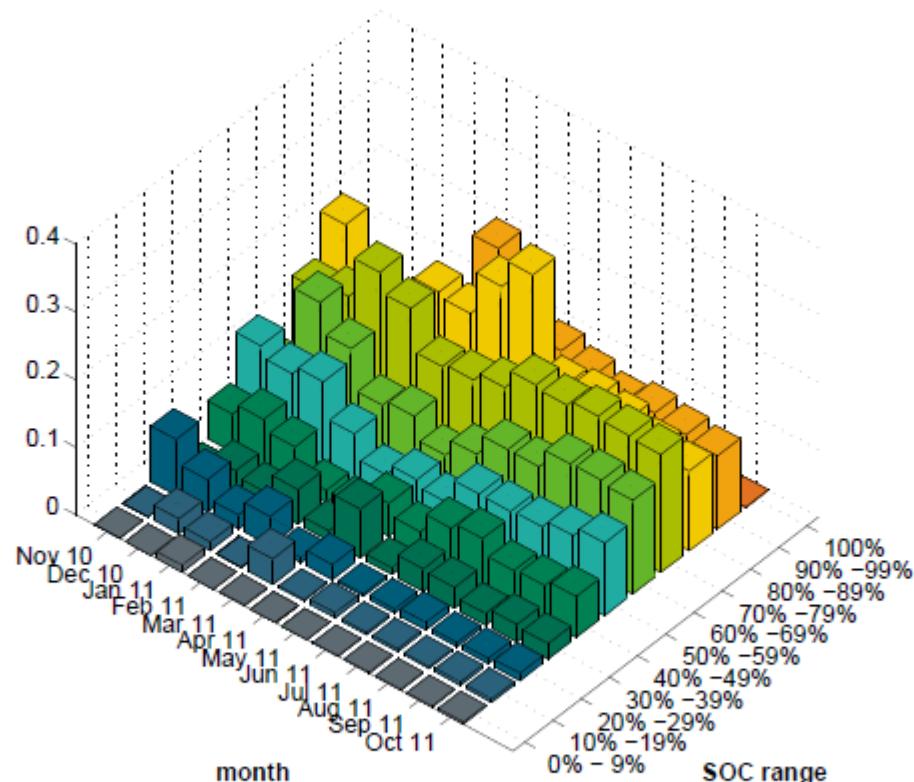


Produced: 04 Jan 2012
Vehicle: Electric Vehicle
Transmitted: Nov 23 2010 to Nov 30, 2011



Sample Output

Amount of Time at Each SOC Level

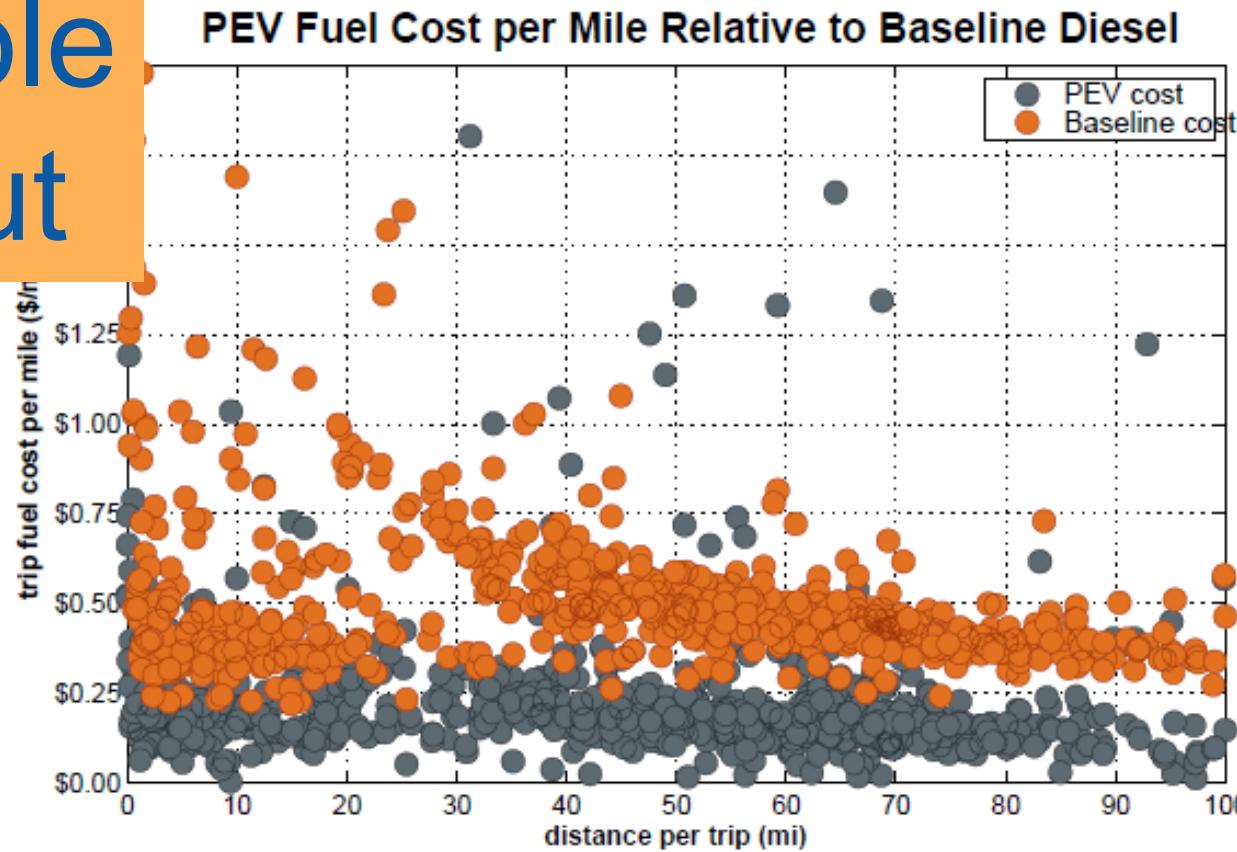


Produced: 04 Jan 2012
Vehicle: Electric Vehicle
Transmitted: Nov 23 2010 to Nov 30, 2011



COMMERCIAL
FLEET DATA
CENTER

Sample Output



Assumes \$0.11 per kWh, \$3.50 per gal diesel
91.8% of Trips are Valid and Included
Produced: 04 Jan 2012
Vehicle: Electric Vehicle
Transmitted: Nov 23 2010 to Nov 30, 2011

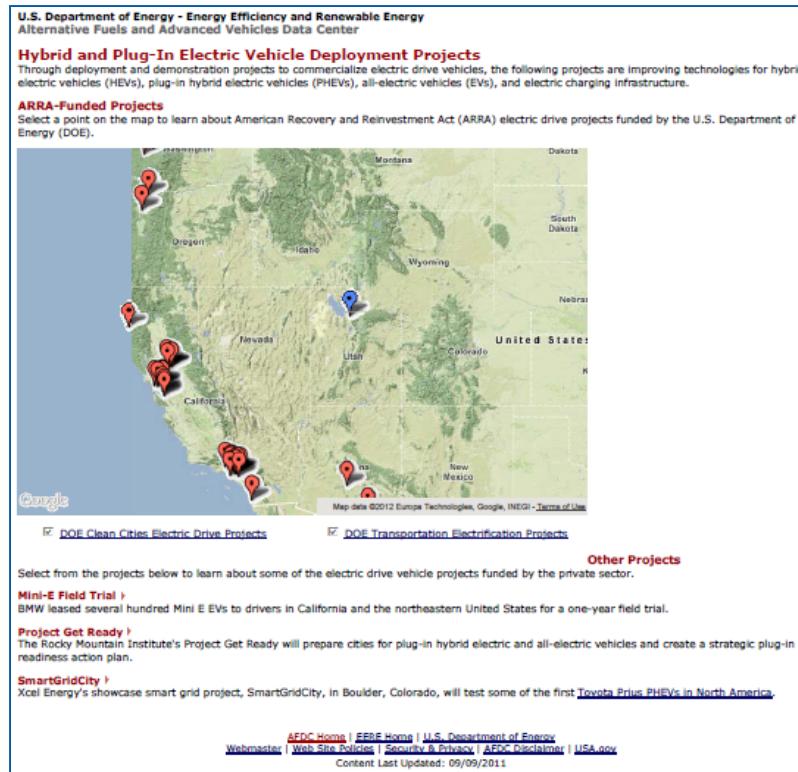


- As of Dec 2011, approximately 122 Navistar e-Star vehicles delivered and reporting data
 - As of Dec 2011, approximately 169 Smith EV's delivered and reporting data
 - Cascade Sierra currently has multiple Shorepower TSE sites operational and over 2000 trucks enrolled and operating in program
 - AQMD 'trouble trucks' and shuttle buses will be delivered in Q3 2012
-
- 1st quarterly Report on Smith Vehicles will be published in Jan 2012
 - 1st quarterly Report on Navistar Vehicles will be published in Feb 2012
 - 1st quarterly Report on Cascade Sierra will be published in March-April 2012
 - AQMD 'trouble trucks' and shuttle buses 1st quarterly report will be published in late 2012

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



Contact: Kevin.Walkowicz@nrel.gov