NREL
NATIONAL RENEWABLE ENERGY LABORATORY





Medium-Duty Plug-in Electric Delivery Truck Fleet Evaluation

Robert Prohaska, Adam Ragatz, Mike Simpson, Kenneth Kelly

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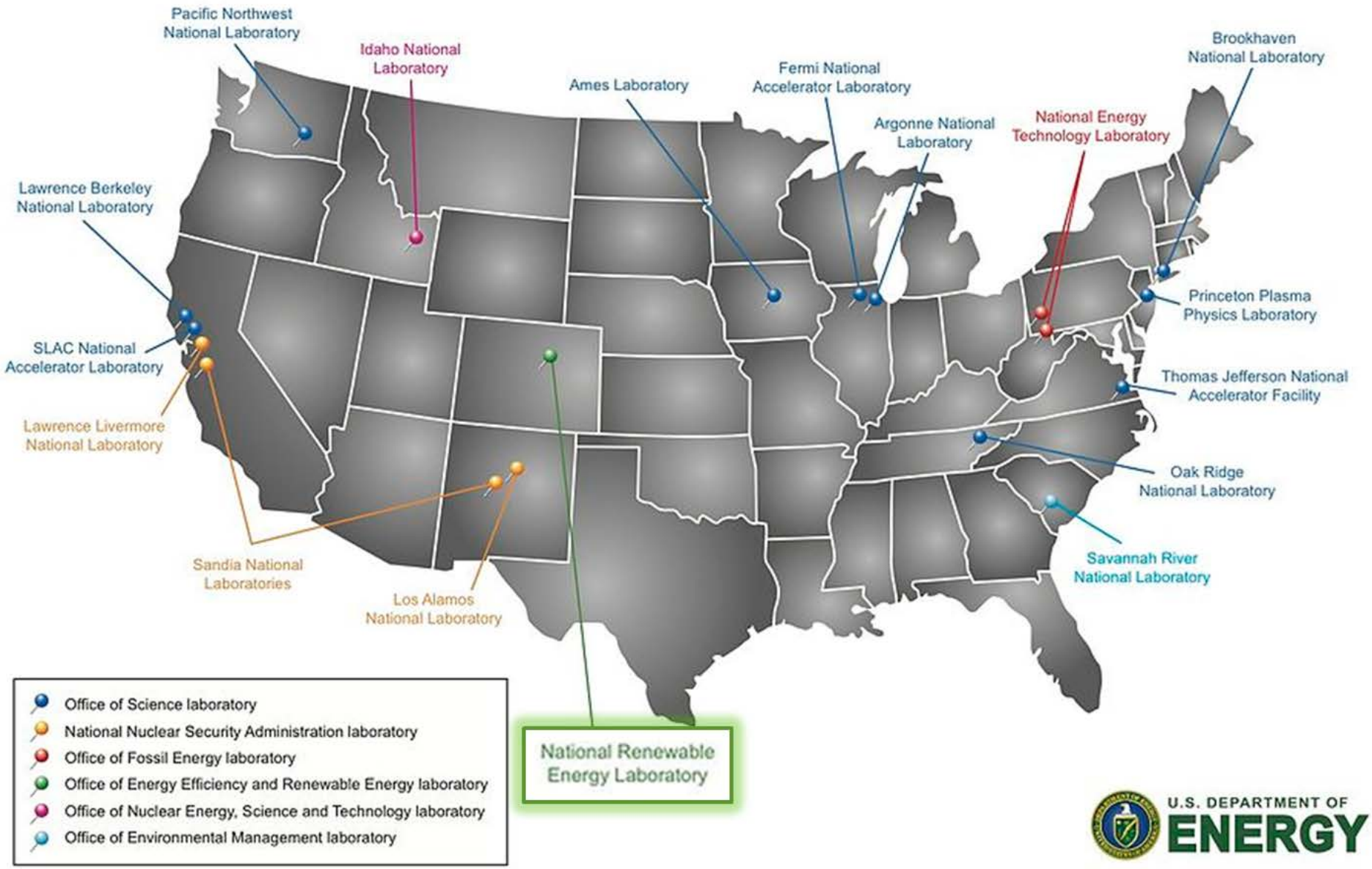
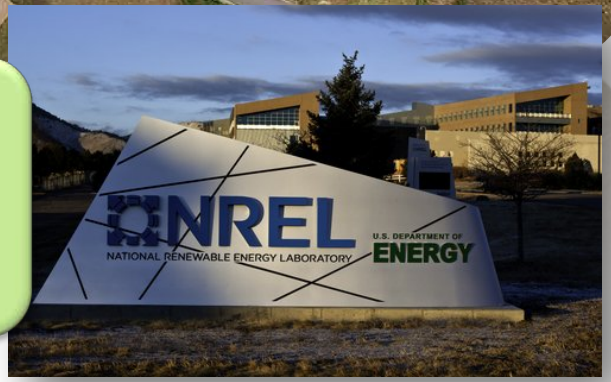
US Department of Energy National Labs



U.S. DEPARTMENT OF ENERGY

National Renewable Energy Lab - Golden, CO

- **NREL is the only lab solely dedicated to energy efficiency and renewable energy.**
- **NREL's campus is designed as a living laboratory with multiple LEED Platinum buildings onsite.**



Photos: Dennis Schroeder / NREL

NREL Transportation RD&D Activities & Applications

Vehicle Thermal Management
Integrated Thermal Management
Climate Control/Idle Reduction
Advanced HVAC

Vehicle Deployment/Clean Cities
Guidance & Information for Fleet Decision Makers & Policy Makers
Technical Assistance
Online Data, Tools, Analysis

Vehicle Systems Modeling and Simulation
Connected and Automated Vehicles
Vehicle Systems Analysis

Regulatory Support
EPAct Compliance
Data & Policy Analysis
Technical Integration
Fleet Assistance

Infrastructure
Vehicle-to-Grid Integration
Integration with Renewables
Charging Equipment & Controls
Fueling Stations & Equipment
Roadway Electrification
Automation

Advanced Combustion/Fuels
Advanced Petroleum and Biofuels
Combustion/Emissions Measurements
Vehicle & Engine Testing

Vehicle and Fleet Testing
MD/HD Dynamometer Testing
MDV & HDV Testing/Analysis
Drive Cycle Analysis/Field Evaluations
Technology Performance Comparisons
Data Collection, Storage, & Analysis
Analysis & Optimization Tools

Advanced Power Electronics and Electric Motors
Thermal Management
Thermal Stress and Reliability

Advanced Energy Storage
Development, Testing, Analysis
Thermal Characterization/Management
Life/Abuse Testing/Modeling
Computer-Aided Engineering
Electrode Material Development

Illustration by NREL

NREL Field Data, Testing, and Analysis Tools

Data from field evaluations helps populate FleetDNA database

DOE fleet tools (DRIVE, FASTSim, AFleet, etc.) used to analyze and investigate impacts – data used to validate and improve tools

Published information and data used by fleets, industry, DOE and other research programs, and other agencies

Collect Lab and Field Data

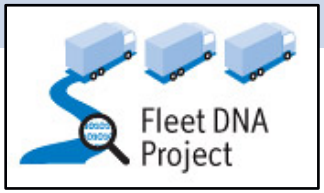
Capture, Store and Analyze

Laboratory Testing

Explore & Optimize

Communicate & Inform

Identify Barriers, New R&D Opportunities, Validate Efforts



Partnership with Fleets and Technology Providers = Relevant Results & Optimized Solutions for Real World Applications

Photos: Dennis Schroeder / NREL

Frito-Lay North America

- 269 Electric Delivery Trucks
- 208 CNG trucks
- Member of the National Clean Fleet Partnership (NCFP) since 2011
  - The NCFP provides fleets with resources, expertise, and support to incorporate alternative fuels and fuel-saving measures into their operations.

"At Frito-Lay, our goal is to be the most fuel-efficient fleet in the country."
- Mike O'Connell, Director, Frito-Lay Fleet Capability

http://www.fritolay.com/purpose/fleet-sustainability

Smith Newton Electric Delivery Vehicle

- *Project Objective: Evaluate and compare real world, in-use performance of Smith Electric delivery vehicles to conventional diesels.*

Photo: Robert Prohaska / NREL

- Smith Newton Specifications
  - Class 6 vehicles
  - 80-kWh $LiFePO_4$ battery
  - Motor power: 150 kW (peak) | 80 kW (continuous)
  - Top Speed: 80 kph (50 mph)
  - Charging standard: J1772

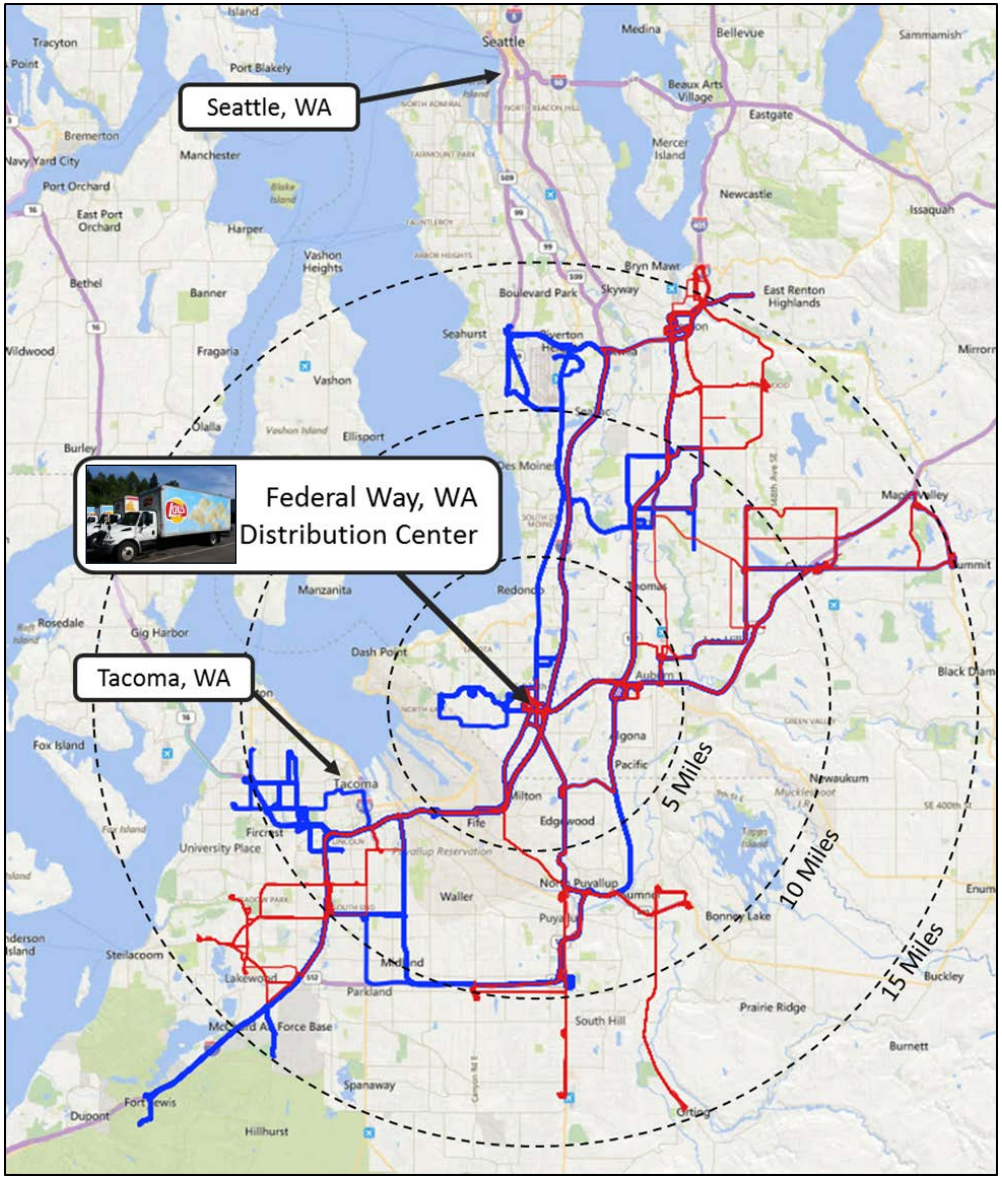
Data Collection

- Electric Vehicles
  - Data collected via onboard telematics as part of American Recovery and Reinvestment Act grant funding requirements
- Diesel Vehicles
  - Data loggers with GPS installed to collect SAE J1708/OBD CAN messages

Photos: Adam Ragatz / NREL

Operating Location

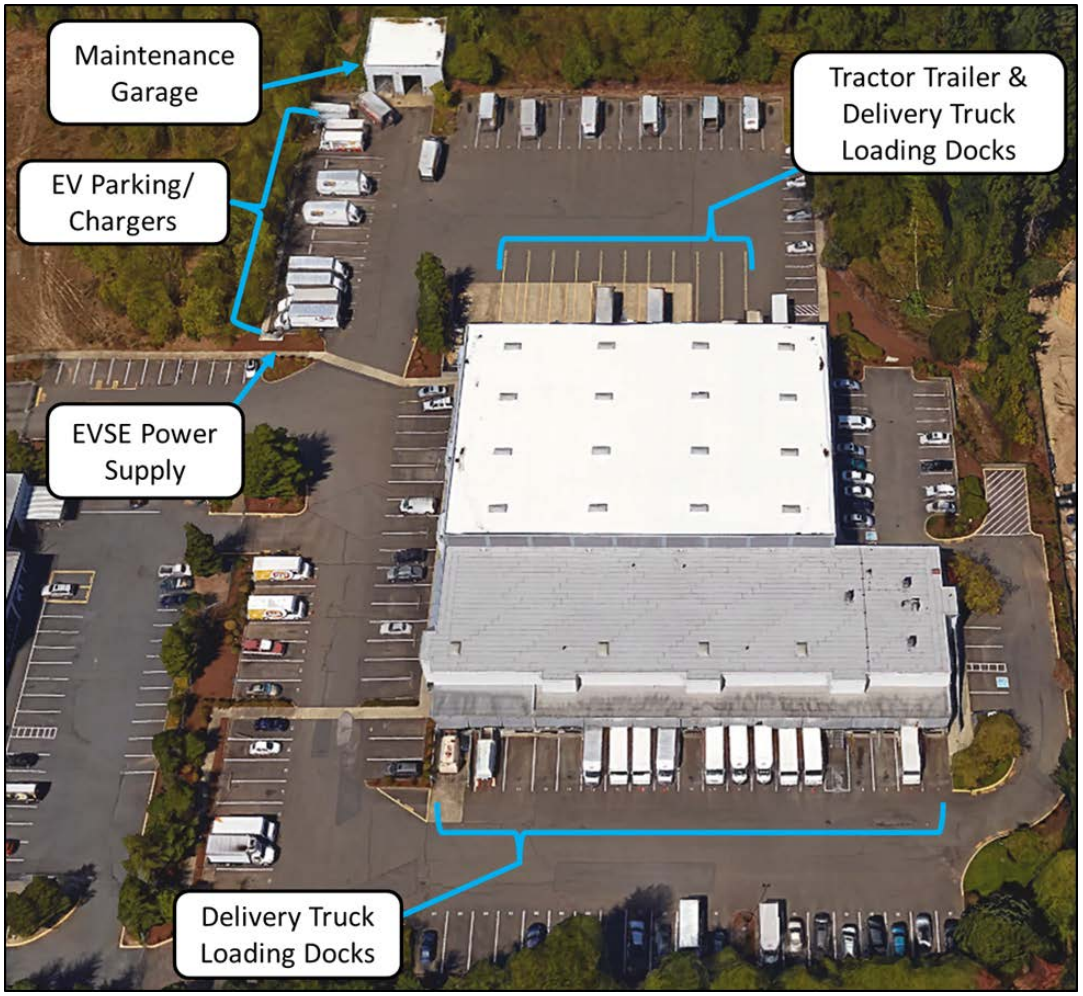
- Facility located Northeast of Tacoma, WA
- Sample route traces show EVs (red) and diesels (blue) cover the same region
- Drivers service customer accounts by filling orders and stocking store shelves



Federal Way, WA Frito-Lay Facility

- Warehouse and distribution center
- Services Tacoma, WA area
- Onsite charging with 10 chargers

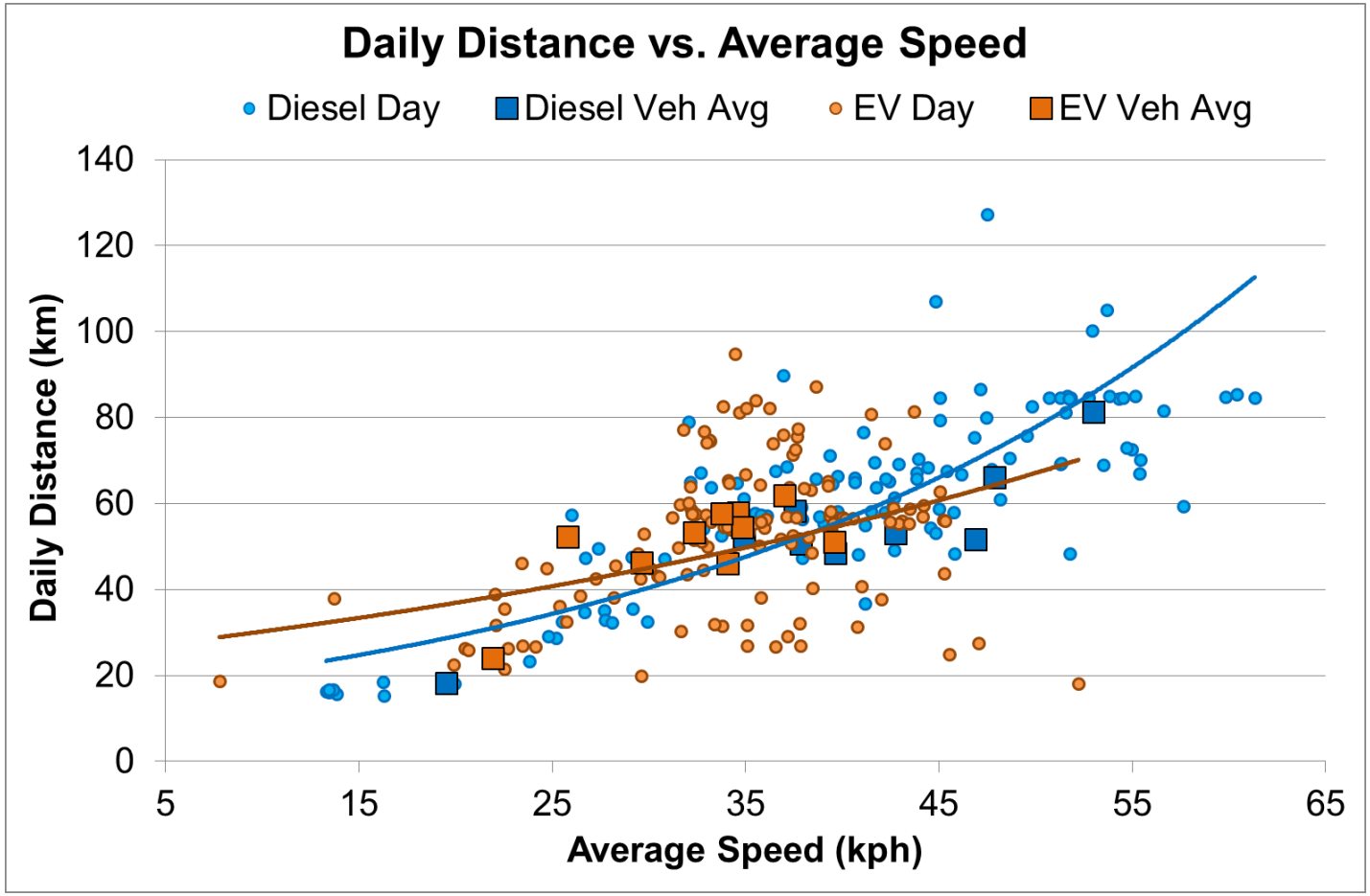
Photo: NREL 29589



Source: Google Earth

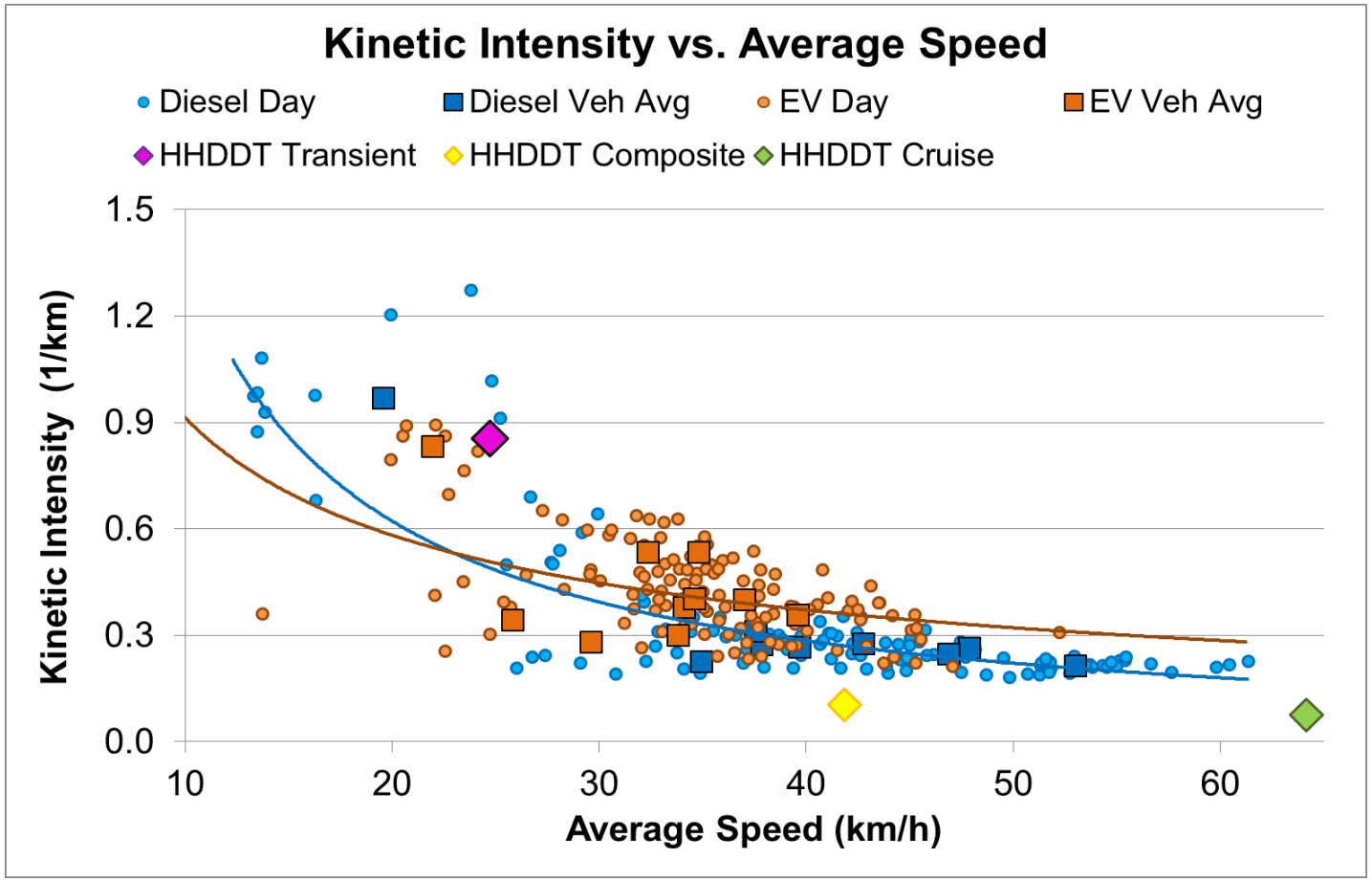
Driving Kinematics

Parameter	Electric Vehicles	Diesel Vehicles
Average Daily Distance	52.3 [km]	61.52 [km]
Average Speed	34.6 [km/hr]	40.5 [km/hr]



Driving Kinematics

Parameter	Electric Vehicles	Diesel Vehicles
Average Kinetic Intensity	0.44 [1/km]	0.34 [1/km]
Average Speed	34.6 [km/hr]	40.5 [km/hr]



HHDDT: Heavy Heavy-Duty Diesel Truck

Drive Cycle Statistics

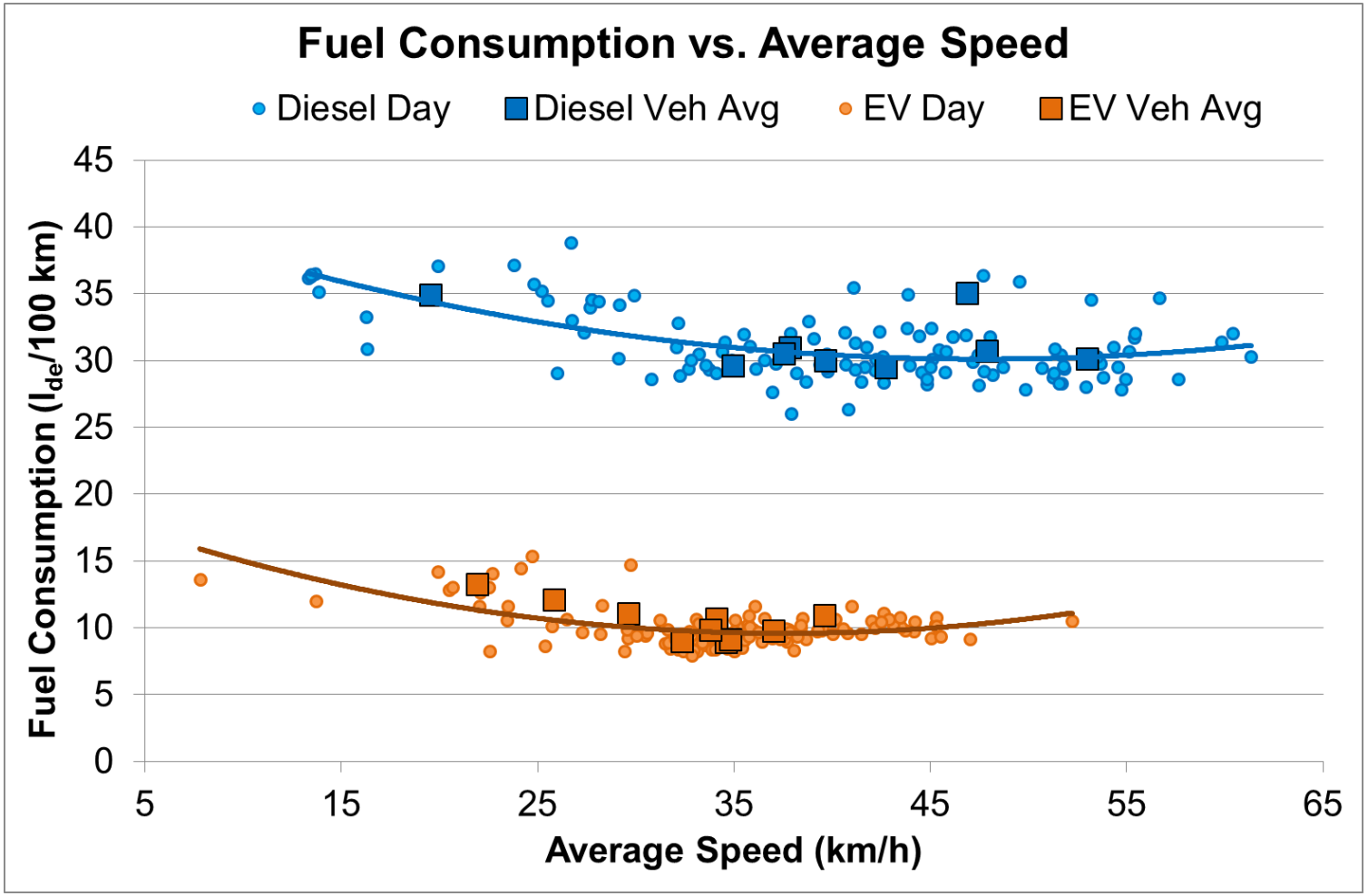
Daily Averages	Diesels	σ	EVs	σ
Average Driving Time (hours)	1.51	0.31	1.54	0.45
Average Total Distance (km)	61.52	20.54	52.31	16.74
Average Speed (km/h)	40.52	11.01	34.57	6.80
Average Fuel Consumed (L)	18.82	5.98	N/A	N/A
Average Energy Consumed (kWh)	187.24[a]	N/A	45.66	13.12
Energy Consumed per km (kWh/km)	3.07[a]	0.25	0.87	0.12
Average Fuel Economy (km/L_{de})	3.24	0.25	10.24[b]	1.21
Avg. Fuel Consumption (L_{de}/100 km)	30.84	2.54	9.77[b]	1.39
Average Number of Stops /day	44.25	13.74	43.28	14.47
Average Number of Stops/km	0.72	0.67	0.83	0.86
Average Kinetic Intensity (1 / km)	0.34	0.23	0.44	0.14

[a] 9.9477 kWh/L of diesel fuel [37.656 kWh / gallon of diesel fuel]

[b] Assumes 90% charger/inverter net efficiency

- EVs and diesels are operated very similarly EVs are driven slightly less distance on average
- EVs demonstrated over 3 times the average fuel economy

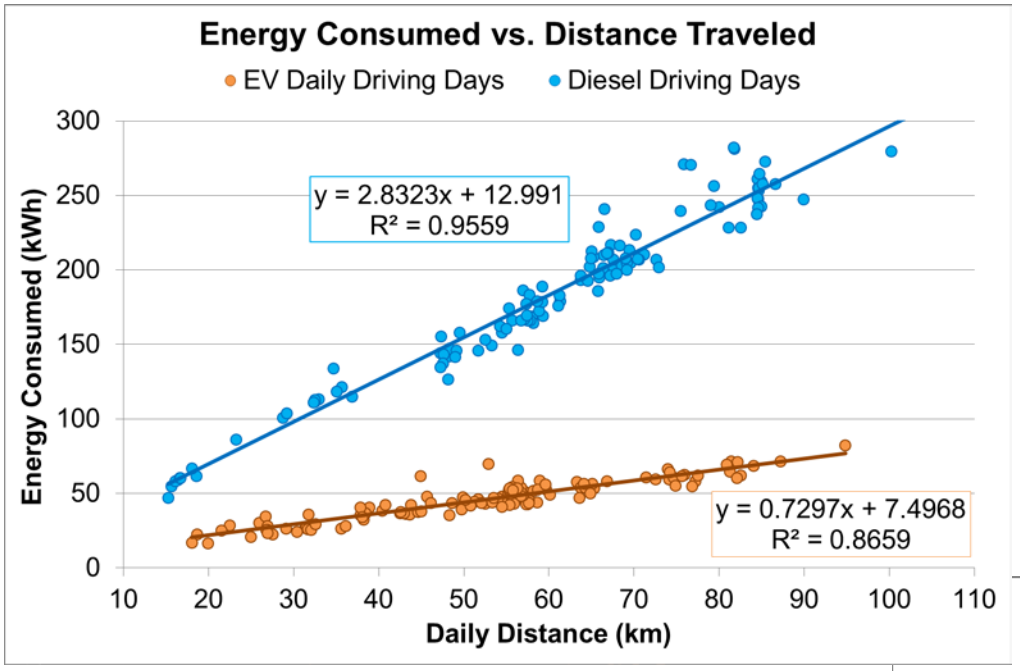
Fuel and Energy Consumption



- EVs consume less than 1/3 the equivalent[a] amount of energy as the diesels

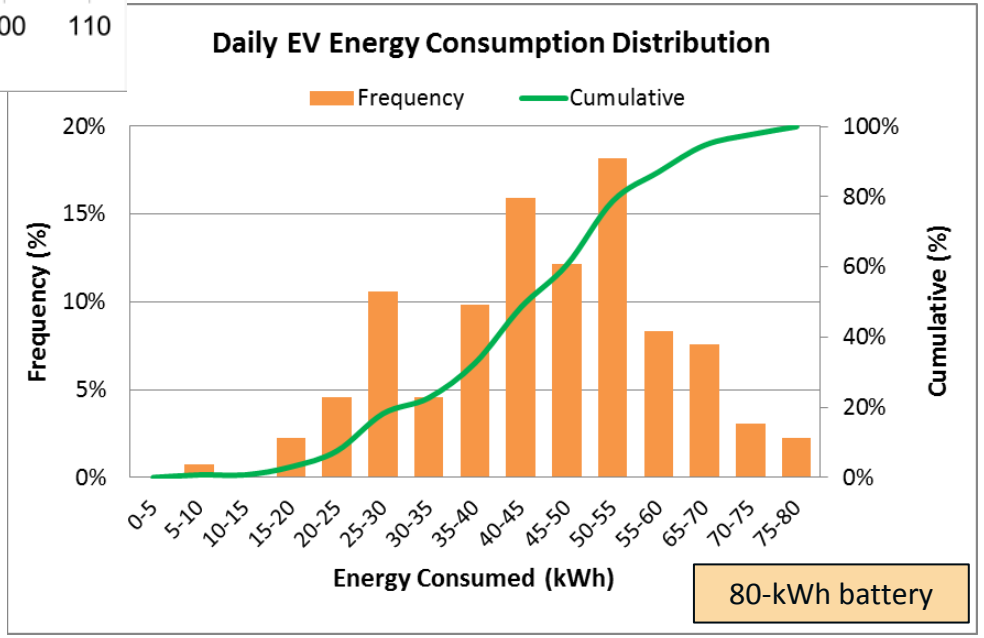
[a] 9.9477 kWh/L of diesel fuel [37.656 kWh / gallon of diesel fuel]

Daily Energy Consumption

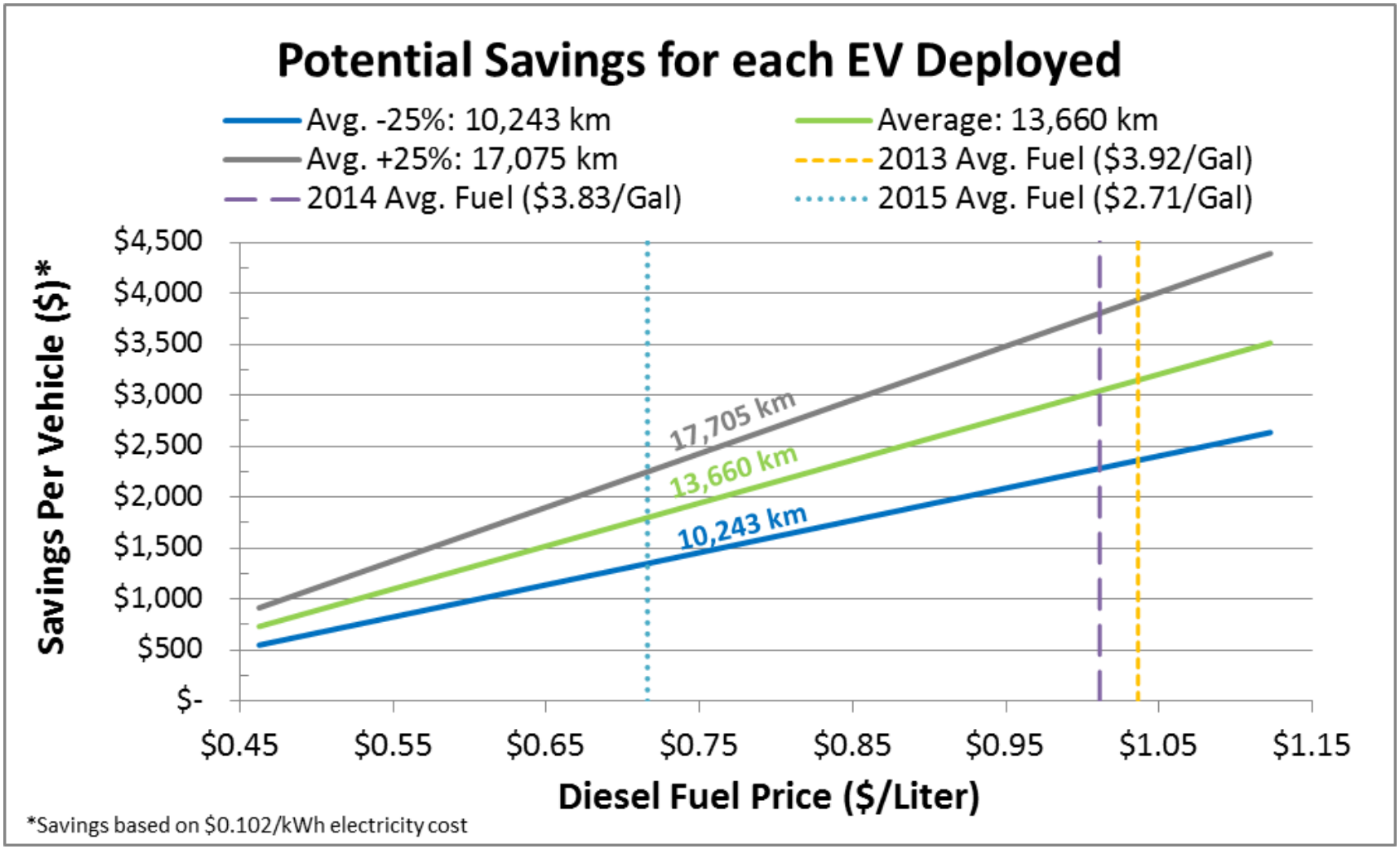


- Energy consumption (and savings) directly proportional to distance traveled

- Opportunity for additional savings by deploying EVs to longer routes



EV Cost Savings – Energy Only



- Cost savings based on energy efficiency only using Federal Way, WA average electricity cost of $0.102/kWh.

Summary

- EVs demonstrated over 3x improvement of diesel equivalent fuel economy over conventional diesels in Frito-Lay's Federal Way, WA fleet
- Overall energy consumption is highly dependent on drive cycle dynamics, operation, and environment
- Peak demand charging and infrastructure requirements are a key aspect to a successful deployment

For more information:
http://www.nrel.gov/transportation/fleettest_electric_frito.html

Project Partners:

- **Frito Lay N.A.**
- **Smith Electric Vehicles**
- **Chateau Energy Solutions**
- **U.S. Department of Energy**

Thank You

Robert Prohaska
Robert.Prohaska@NREL.gov
http://www.nrel.gov/transportation/fleettest.html

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Appendix

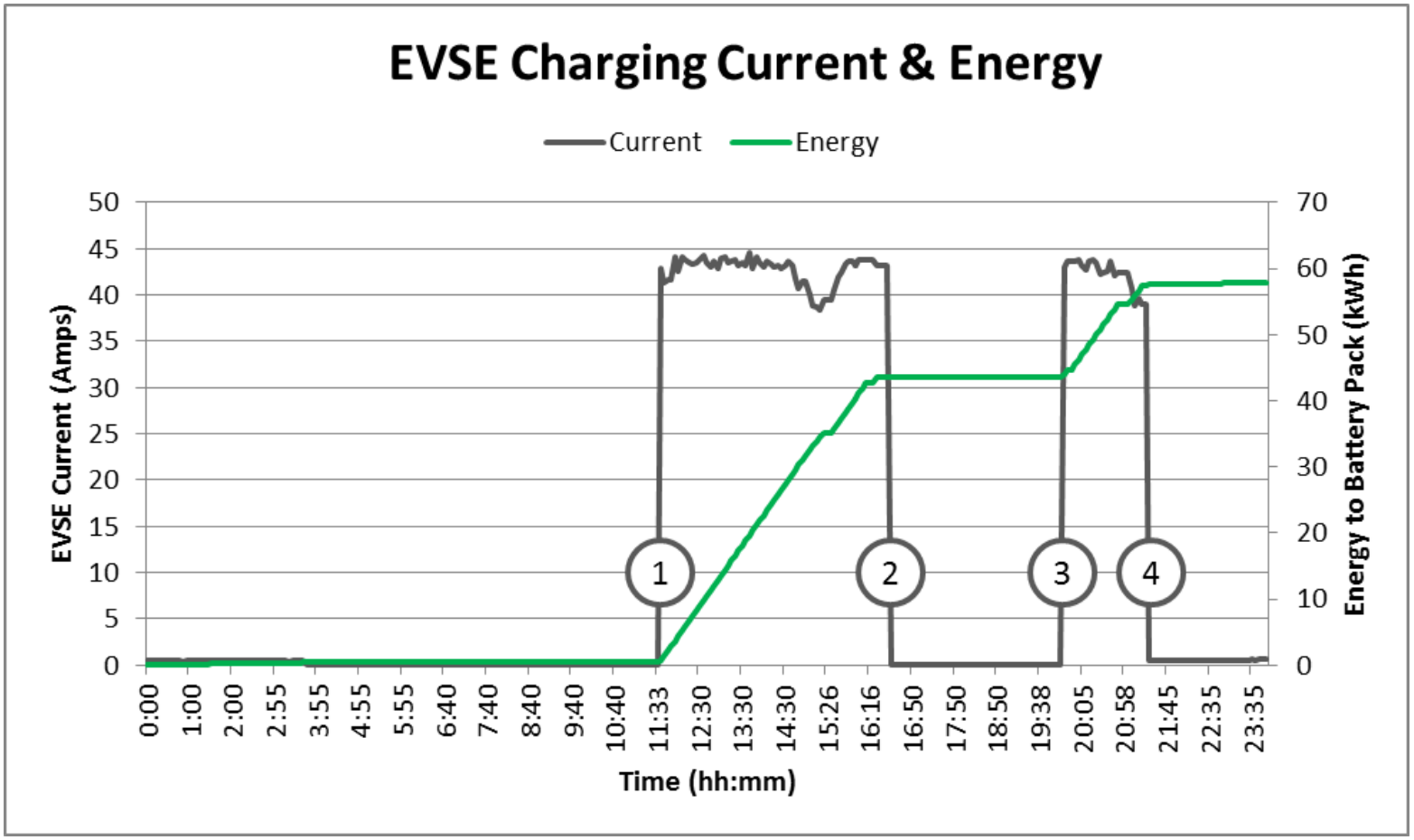
Smith EV Newton Vehicle Cost

Smith Newton 80 kWh	Conventional	Incremental	NY Voucher
$151,442	$64,651	$86,791	$60,000

https://truck-vip.ny.gov/NYSEV-VIF-vehicle-list.php

http://www.cmap.illinois.gov/documents/10180/316900/Change_Requests_082114.pdf/31d5a4c7-a419-4c97-8a0e-7e7547fe5e18

EVSE Charging Example



1: Plug in at end of shift | **2:** Unplug to load truck

3: Plug in after loading | **4:** 100% SOC, Charging stopped

Thank You

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