NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Sustainable Technologies: Finding Success the Second Time Around

Kevin Walkowicz
National Renewable Energy Laboratory

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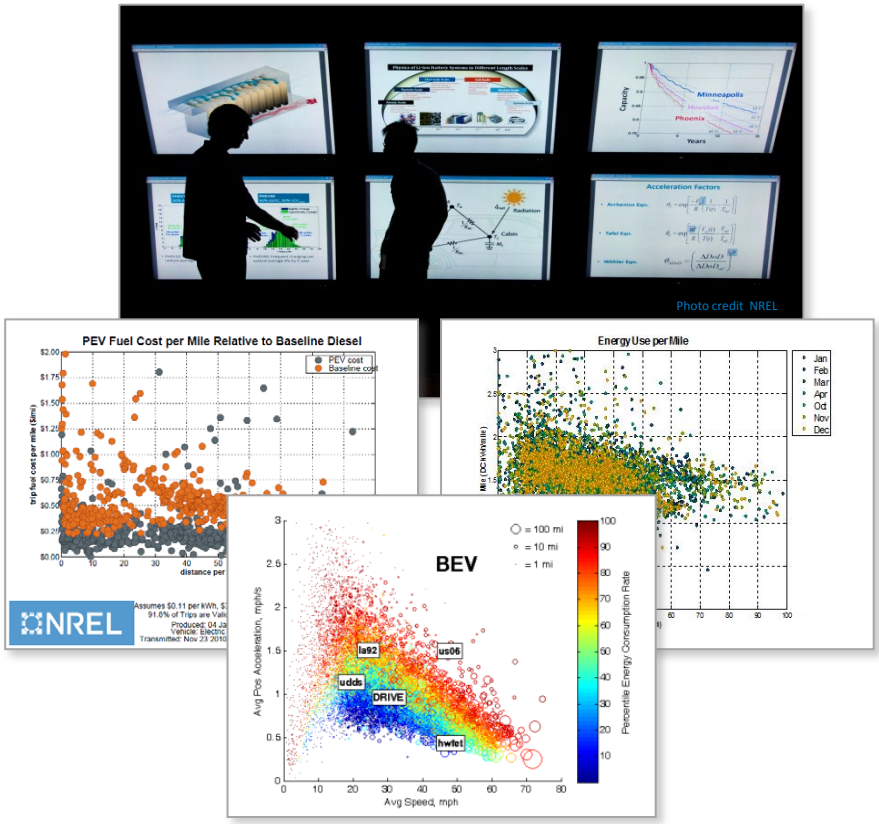
Lessons Learned: Applying Knowledge in Next Generation



Buy it. Then try it.

Evaluations of newly deployed technology are useful if you use the lessons learned

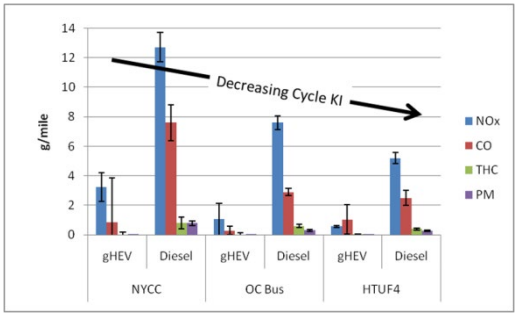
Optimize it.

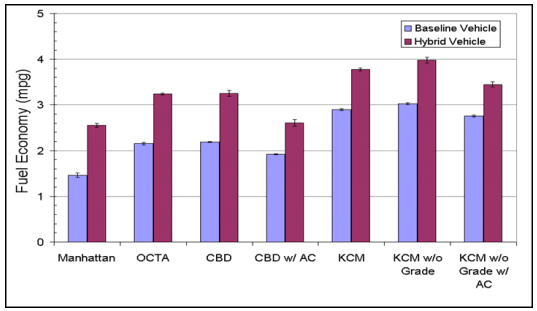
Good data, tools, and techniques for development of next generation, optimized systems

Optimal Deployment 2nd Time Around

Re-establish your goals/objectives:

- GHG Reduction
- **Criteria Pollutants (i.e., NO_x)**
- Petroleum Use Reduction
- Alt Fuel Credits
- **Total Operational Cost Savings**
- Low Carbon Fuel Use
- Electrification Incentives
- **Idle Reduction, etc.?**



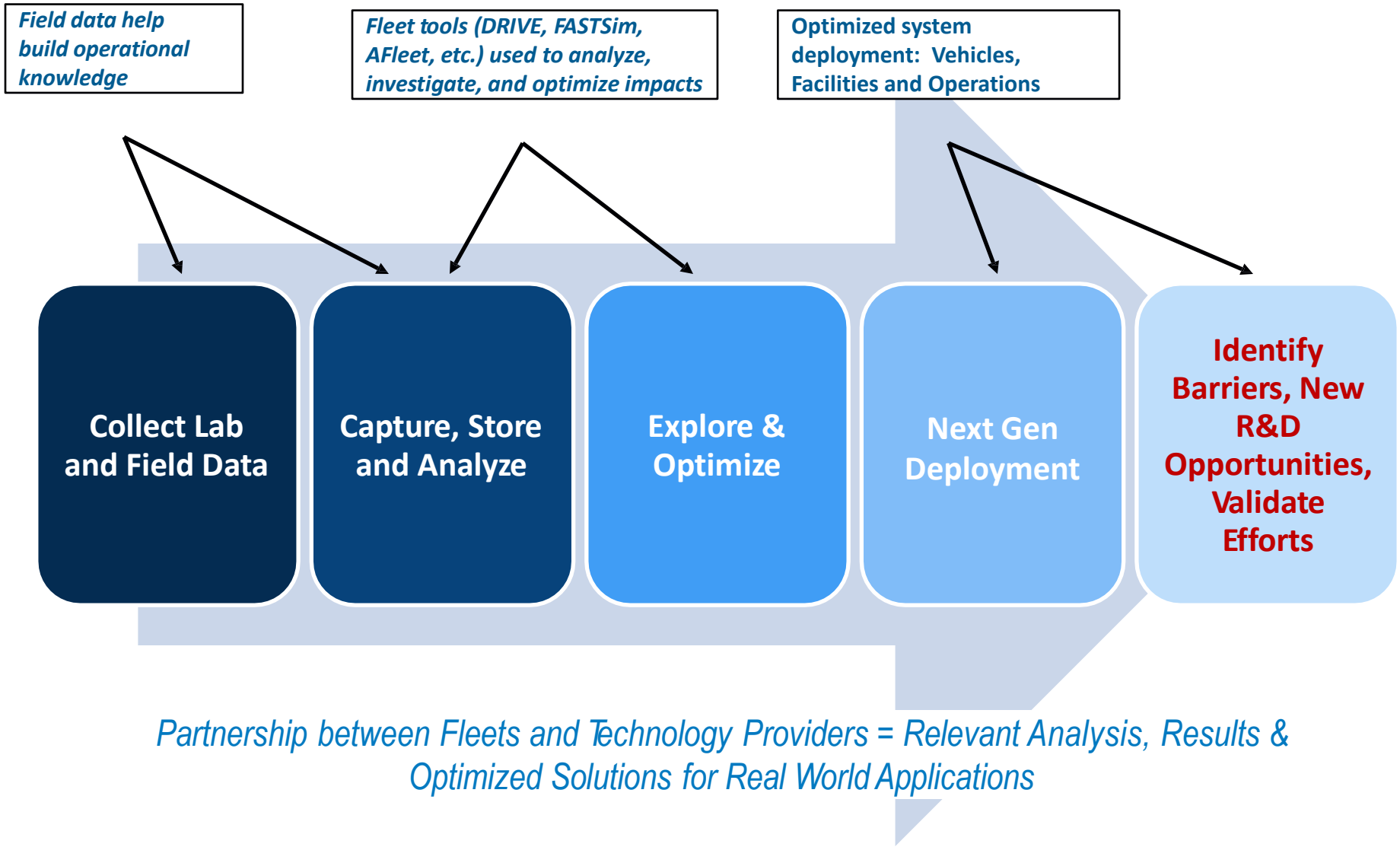


Sometimes:

Success might mean negative consequences in non-objectives

Re-assess and adjust

Field Data & Analysis Tools: Process for Improving the Deployment



Partnership between Fleets and Technology Providers = Relevant Analysis, Results & Optimized Solutions for Real World Applications

Fleet Evaluations Provide Lessons for Next Iteration

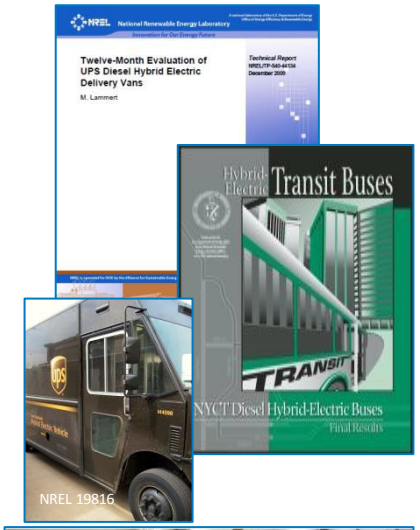
Background:

Medium-duty (MD) and heavy-duty (HD) testing, aggregated data, and detailed analysis have resulted in:

- **3rd party unbiased data:** Provides data that would not normally be shared by industry in an aggregated and detailed manner

- Over 6 million miles of advanced technology **MD and HD truck data have been collected, documented, and analyzed** on over 300 different vehicles since 2002

- **Guiding R&D** for new technology development and identifying new opportunities for next generation deployments – where are the areas for improvement?



2nd Time Around Examples from NREL's Field Testing

- **Vehicle Placement** – Optimizing vehicle vs. route
- **Tuning** – Understanding duty cycle and fine tuning
- **New Features** – Adding new features to optimize
- **Integrated Operations** –Vehicle demands vs. facility
- **Battery State of Charge (SOC) Control** – Understanding duty cycle vs. battery use

Improvement: Vehicle Placement

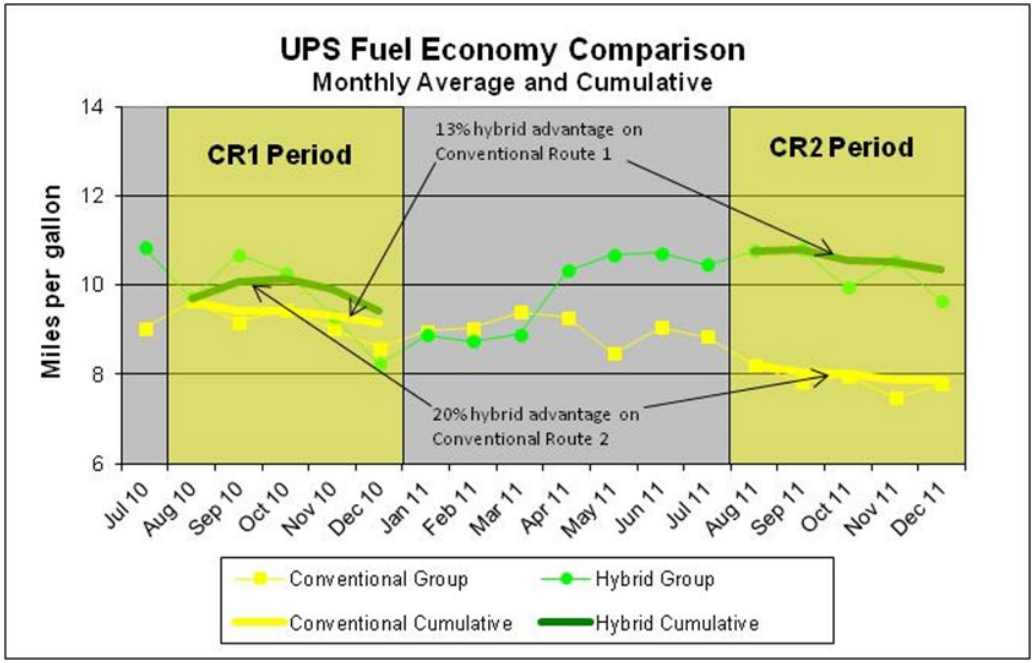
UPS Hybrid Electric Package Delivery Placement

- UPS has deployed hybrid electric vehicle (HEV) delivery vans in multiple locations around the United States and has learned to maximize success in its fleet by optimizing location / usage

- In its "2nd Gen" deployment, UPS placed HEVs in more "urban" drive cycles (higher "kinetically intense" routes) and maximized HEV advantage. NREL documented this improvement in a study in 2012 with its Minneapolis, MN fleet

- Optimized placement resulted in higher gal/day/vehicle savings over other route options

CR1 = routes where non-hybrids were placed
CR2 = routes where hybrids were placed
NREL study showed the "switch" between the two groups, which maximized hybrid advantage (20% vs. 13%) if HEVs were placed in CR1 routes

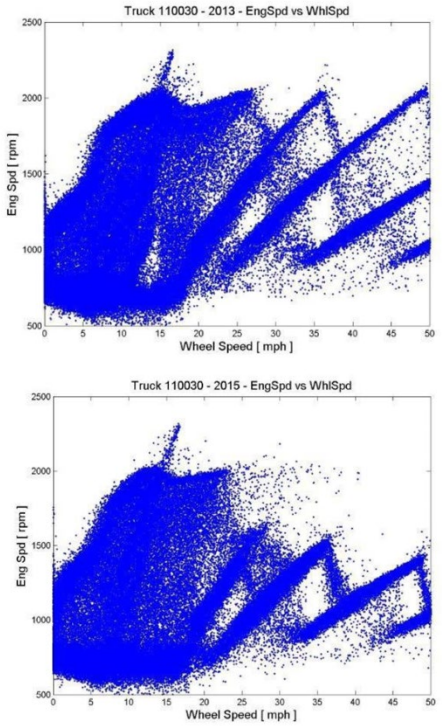


Full Report: http://www.nrel.gov/docs/fy12osti/55658.pdf

Improvement: Tuning

City of Indianapolis Transmission Tuning

- City of Indianapolis deployed 50 side-loader refuse trucks and roll-off recycling trucks
- Used drive cycle analysis techniques to investigate new powertrain options and determined that new transmission calibrations could drastically improve fuel economy while maintaining operational performance
- 11 % fuel economy improvement for roll-off recycler trucks by applying an improved calibration and a reduced road speed limit change
- 5.6 % side-loader fuel economy improvement by applying a new calibration including “Dynamic Shift Sensing” and “Neutral at Stop”
- 50 truck improvement = $250k / yr



	2013	2015	Change
Fuel Economy [mpg]	1.93	2.09	+8% *
KI [1/mi]	2.18	2.15	-1%

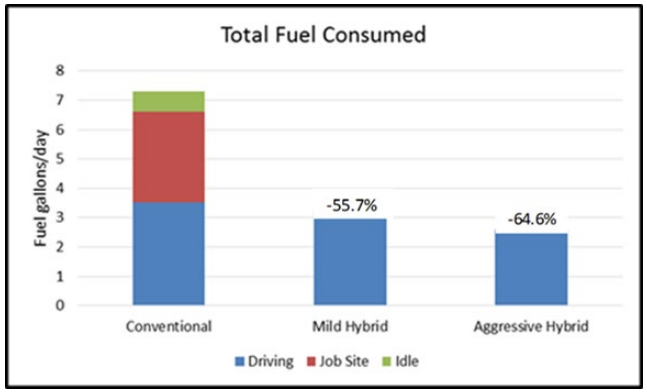
KI = kinetic intensity

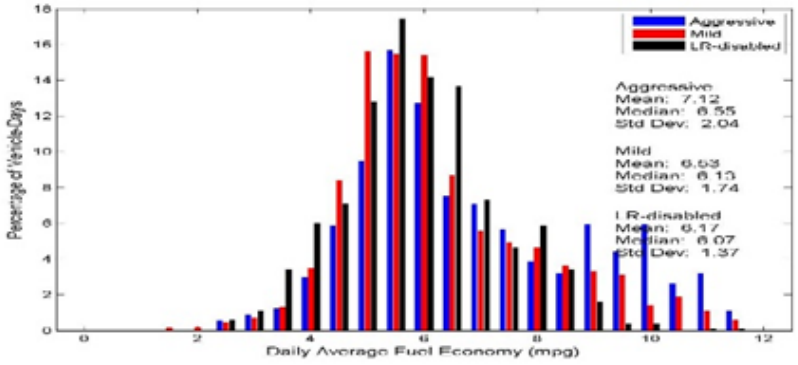
Improvement: Same Hardware, New Features

Odyne's Next Generation Energy Management System

- Odyne has delivered over 150 plug-in (charge depleting) hybrid electric systems for work trucks – some as part of the American Recovery and Reinvestment Act (ARRA)
- Customer use has been observed and measured and used to develop new control features
- The plug-in HEV system is capable of propelling the vehicle to and from the job-site or providing job-site electrification of PTO loads (or both)
- How to optimize where the energy is use is being explored – i.e., where and when use the stored energy. Battery size vs. driving calibration vs. duty cycle

Two calibrations have been developed (Mild and Aggressive) to optimize route vs. job-site battery use

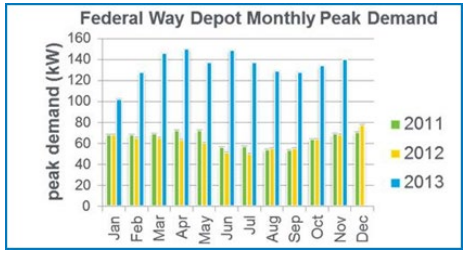




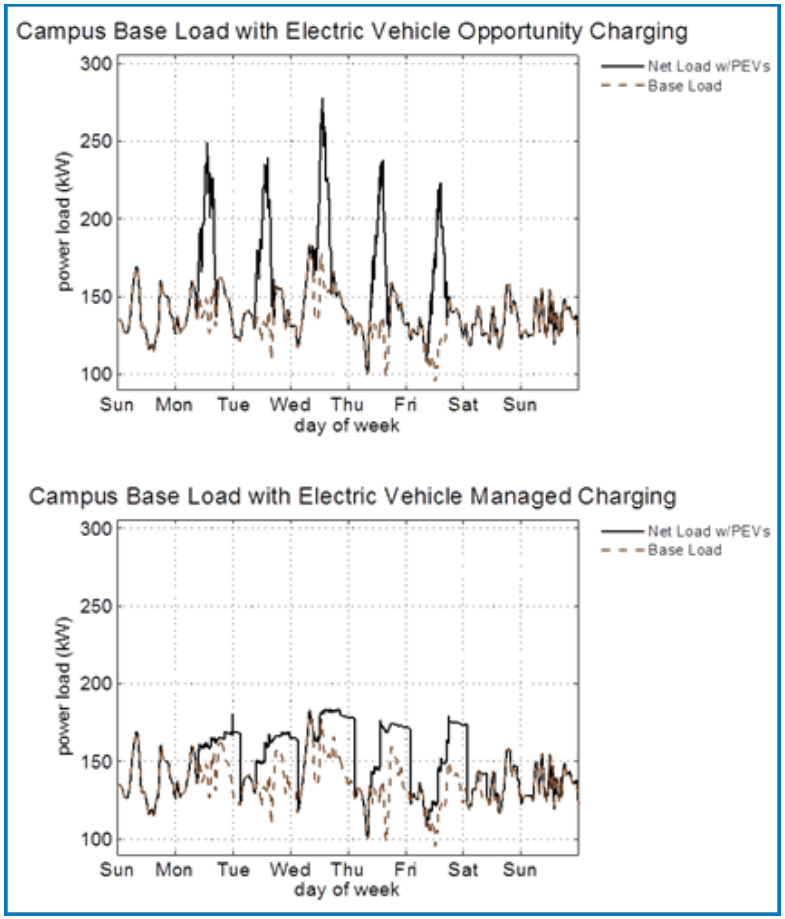
Improvement: Integrated Operations

EVs and Facility Management: Intelligent Charge Control

- Frito-Lay has deployed fully electric delivery trucks to its facilities.
- Demand charges can be as high as 30%–50% of a facility's utility cost (based on highest 15 mins) depending on location and rate structure
- EV charging strategies have been identified as a possible way to minimize facility cost and maximize vehicle utilization
- Understanding charging patterns of vehicles and energy demands of a facility can lead to an optimized charge strategy for a fleet of EVs



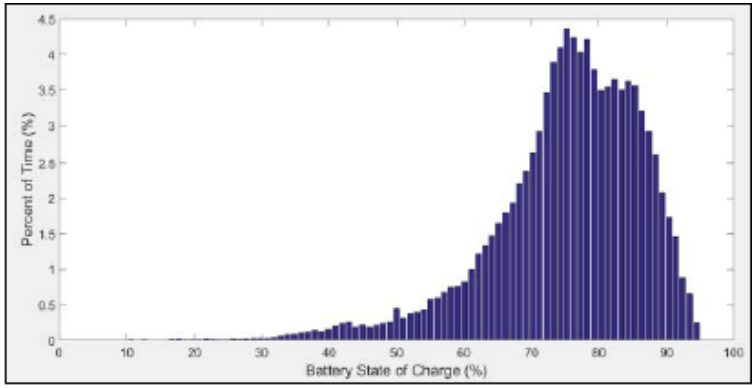
A strategy to manage EV charging could reduce facility demand charges by 20%

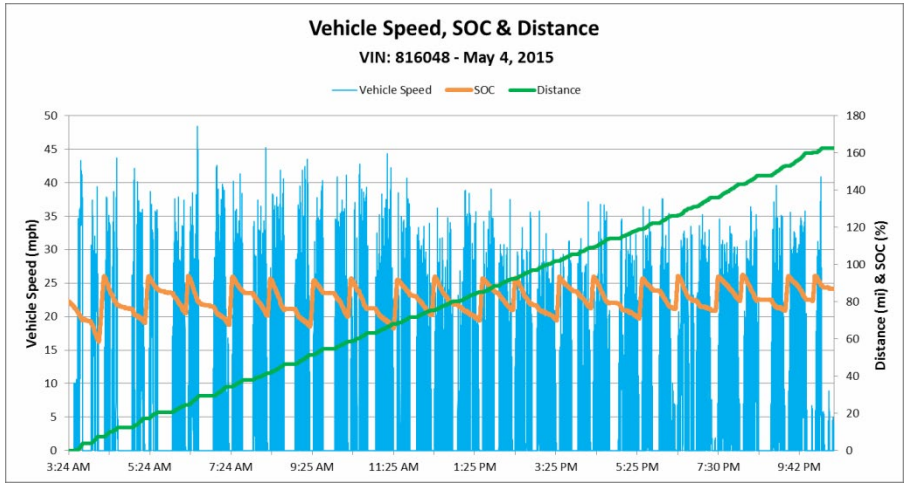


Improvement: Battery SOC Control

Foothill Transit EV Optimization

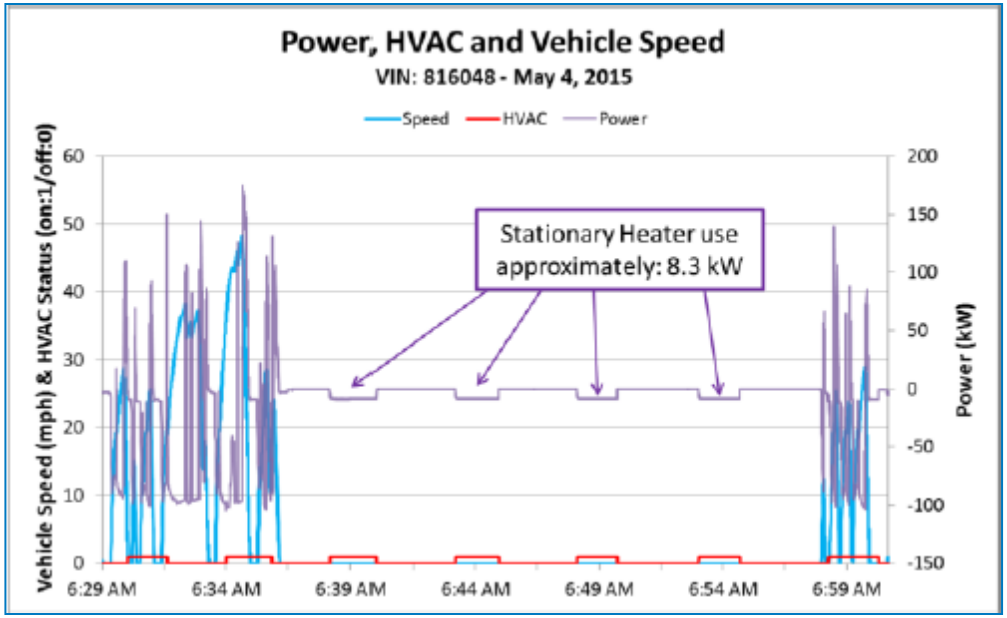
- Foothill Transit in California has installed a DC fast charger to charge a fully electric transit bus while on route, minimizing battery size and reducing bus cost
- Battery SOC (along with other factors) has an effect on battery life
- Changes can be made to enable bus operation while maximizing battery life
- 75.4% of the time it is between 60%–90% SOC
- Opportunities for charge strategy change to prolong life of battery?

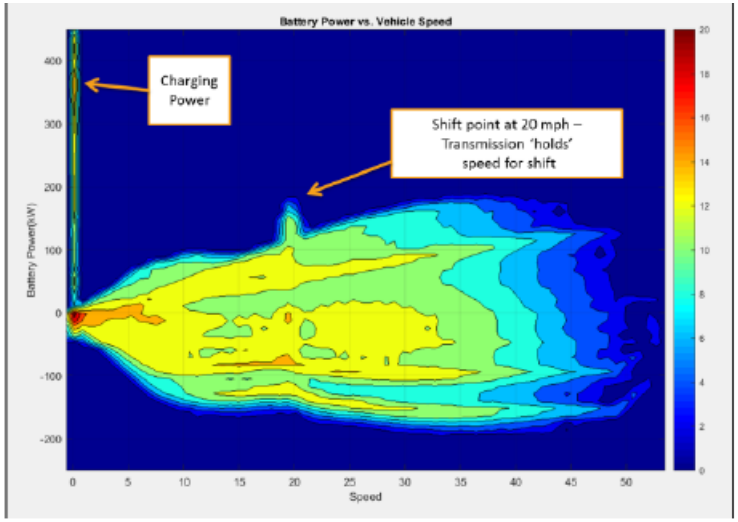




In Process: Foothill EV Bus Project

Using power and HVAC analysis to look for next gen improvements?





Auxiliary load analysis: Power impacts of HVAC, can system be improved?

Controls Calibration: Understanding at what vehicle speed the power is being used; shows charge, regen and depletion characteristics, could possibly "tune" for better efficiency

Special Thanks To:

- The U.S. Department of Energy's Vehicle Technologies Office & the Vehicle Systems Program
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- Foothill Transit
- City of Indianapolis
- Odyne Systems, LLC
- Frito-Lay North America

Questions?

Kevin.walkowicz@nrel.gov