

Zero Emission Drayage Truck Demonstration (ZECT I)



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Overview

Timeline

- Project start date: Oct. 2012
- Project end date: Sept. 2017

Budget

- Total project cost: \$9,374,641
 - ✓ DOE share: \$4,169,000 (45%)
 - \$2,437,754 expended
 - ✓ Cost share: \$5,205,641 (55%)

Barriers & Targets

- Evaluate market viability
- Promote market acceptance
- Data collection and analysis

Partners

- SCAQMD
- TransPower
- U.S. Hybrid
- NREL
- TTSI & other fleets



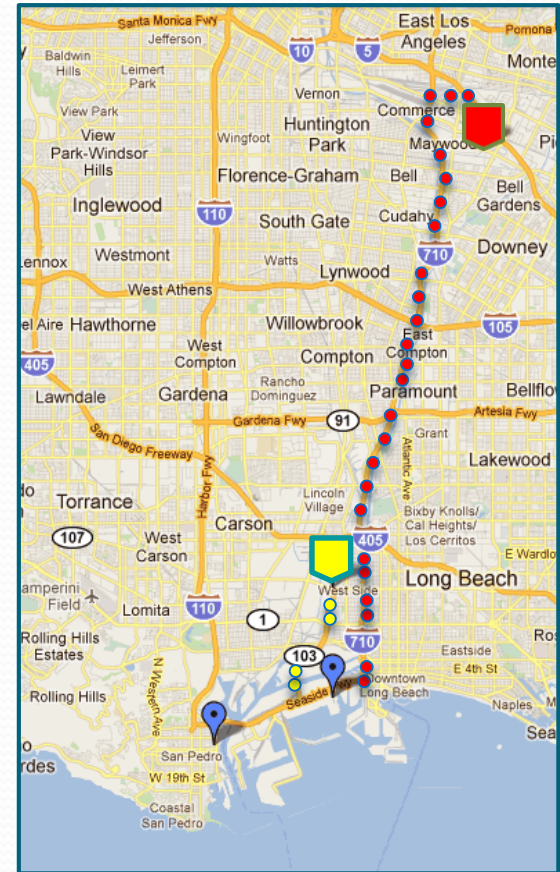
Objectives

- Demonstrate zero emission capable heavy-duty truck technologies in real world drayage operations
- Promote market acceptance through demonstration with fleet partners
- Collect and analyze performance and operational data



Project Approach/Scope

- Develop 11 Class 8 electric drayage trucks consisting of:
 - Six battery electric trucks (BETs):
TransPower (4), US Hybrid (2)
 - Five plug-in hybrid electric trucks (PHETs):
TransPower (2), US Hybrid (3)
- At least one truck from each technology tested on chassis dynamometer to validate vehicle performance
- Up to two years of demonstration in port drayage service with fleet partners
- Collect and analyze performance and operational data against baseline trucks



Demonstration Technologies

	BET		PHET	
Manufacturer	TransPower	US Hybrid	TransPower	US Hybrid
No. of Trucks	4	2	2	3
Chassis	International Prostar	International Prostar	International Prostar	Peterbilt 384
Traction Motor	Dual Motor 300 kW	Induction Motor 320 kW	Dual Motor 300 kW	PM Motor 223 kW
Transmission	Automated Manual	Direct Drive	Automated Manual	Automatic
APU	N/A	N/A	Ford 3.7L CNG	Cummins 8.9L LNG
Battery/Storage Capacity	215 kWh	240 kWh	115 kWh/ 60 DGE	80 kWh/ 82 DGE
Charger	On-board ICU 70 kW	On-board 60 kW	On-board ICU 70 kW	On-board 20 kW
Recharge/Refuel Time	3-4 hrs	4 hrs	2 hrs/ 10-15 min	4 hrs/ 10-15 min
Range	70-100 miles	70-100 miles	200+ miles/ 30 AER miles	250+ miles/ 30 AER miles

Technical Accomplishments and Progress

BETs - TransPower

- Completed all four Electric Drayage Demonstration trucks (EDDs)
- Three EDDs currently deployed in drayage service
 - EDD2 (TTSI), EDD3 (Cal Cartage), EDD4 (NRT)
 - Near dock and local operations within 20-mile radius from port terminals
 - Positive feedback on quiet and smooth operations with comparable power and torque
 - Improvement needed on operating range and tractor weight
- EDD1 to be upgraded with new battery cells and BMS
 - 60% higher energy density
 - 311 kWh in the same system weight as for 215 kWh battery pack
 - 120-150 miles in operating range



EDDs



KAM Battery Module

Data Collection & Analysis

TransPower BETs

- 1/15 through 3/16
- EDD 2, 3 & 4
- 209 days of operation
- 9,440 miles traveled
- More local operations

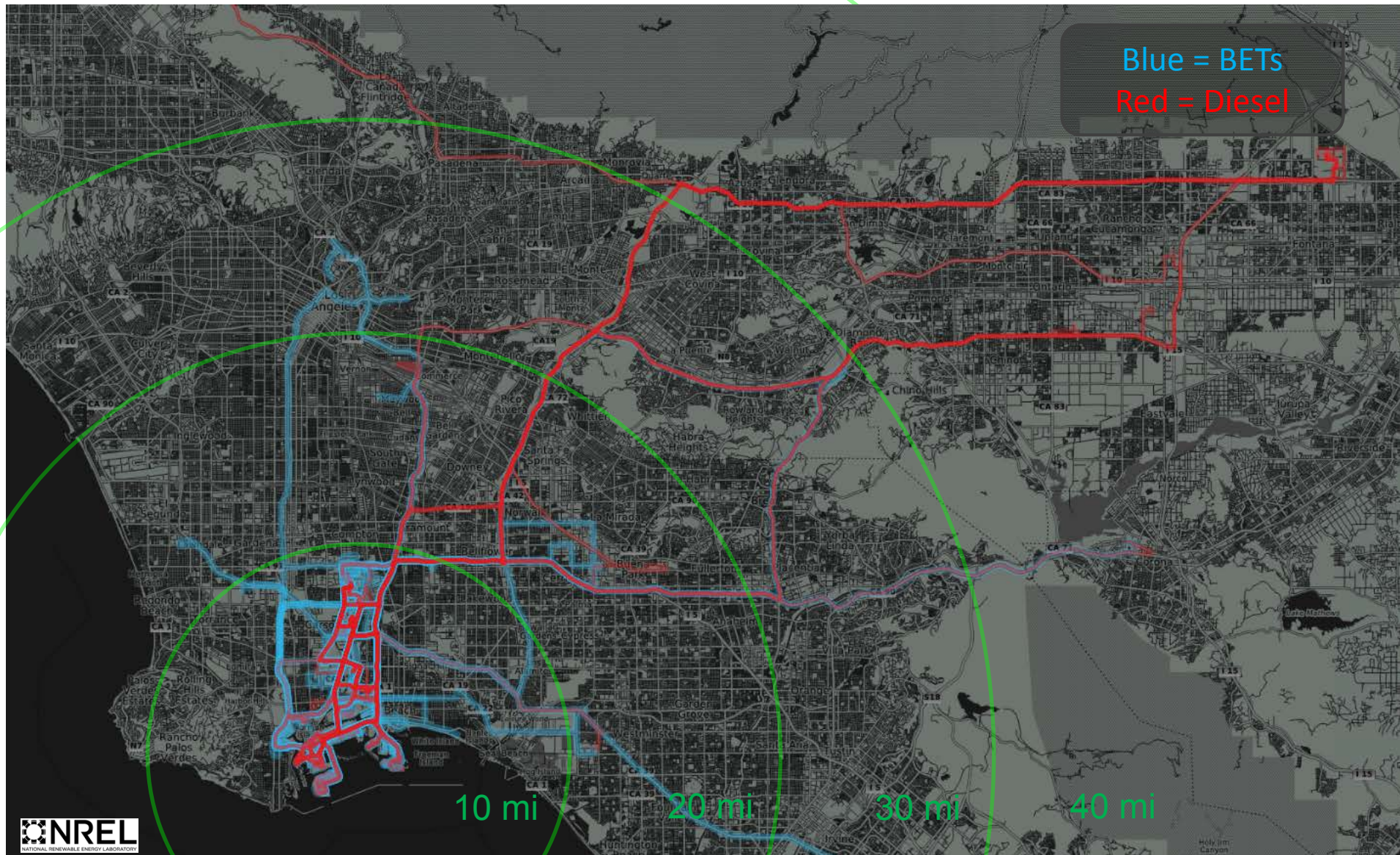


Baseline Trucks

- 10/14 through 2/15
- Two diesel trucks (2013 Mack)
- 166 days of operation
- 23,590 miles traveled
- More regional operations

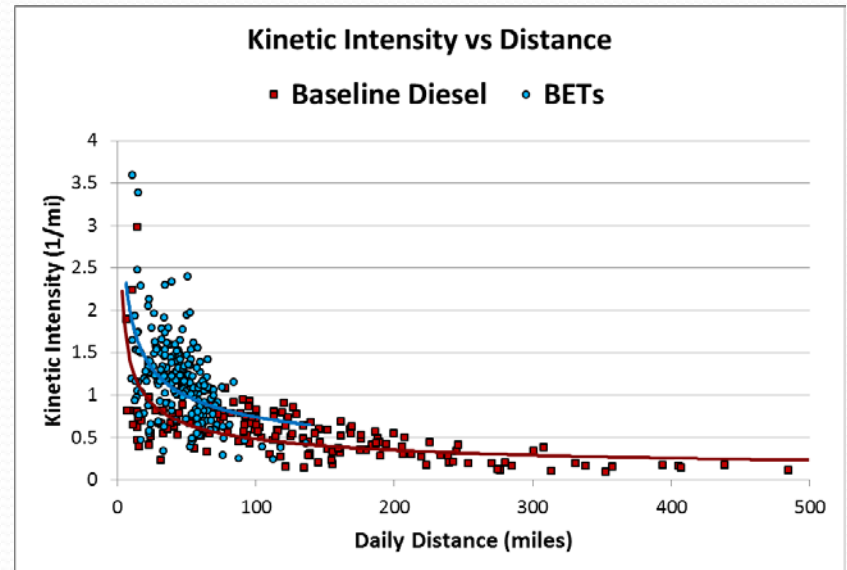
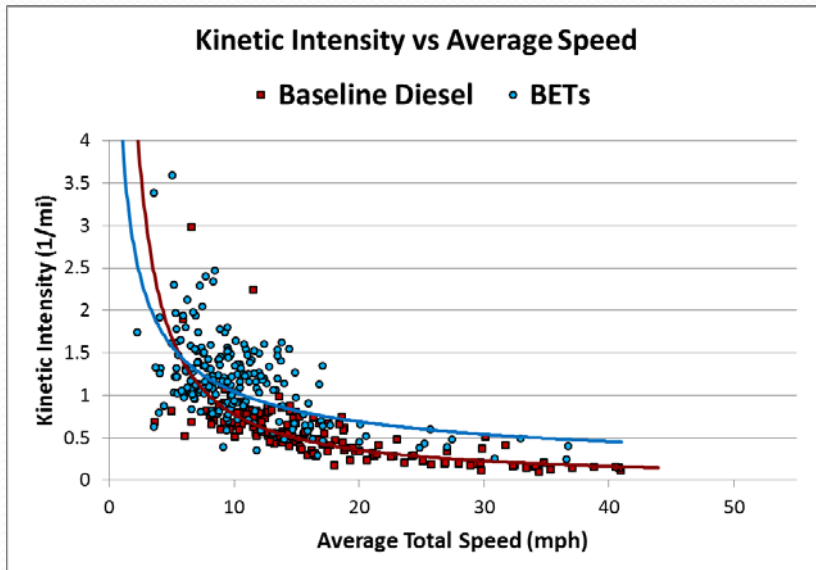
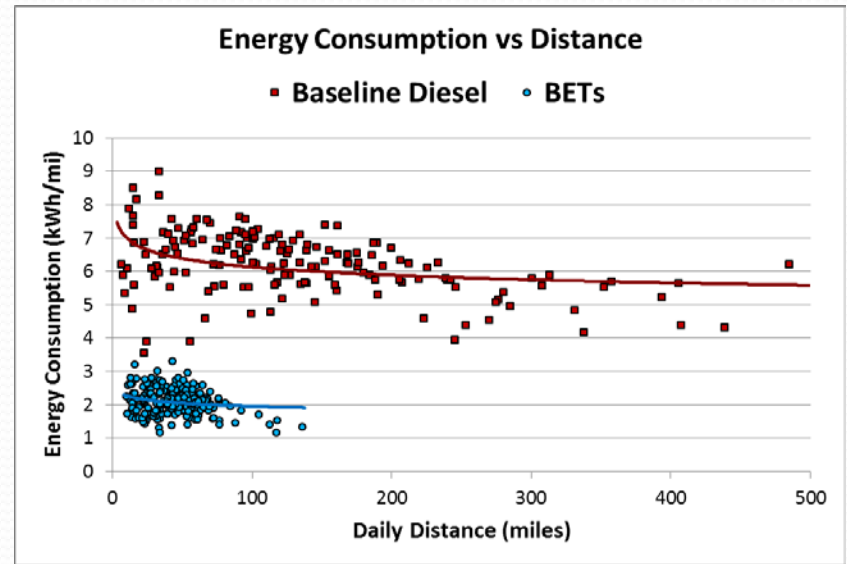
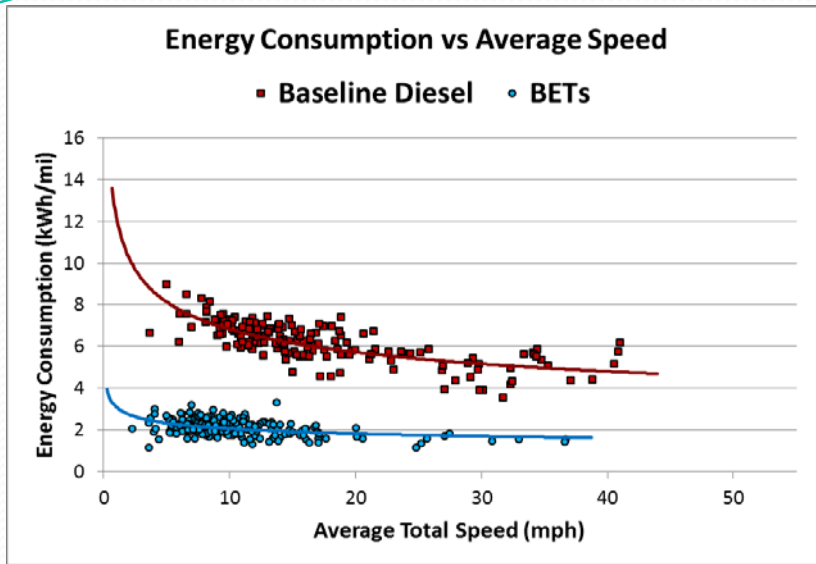


BET vs Baseline Diesel Drayage Routes



Average Daily Use

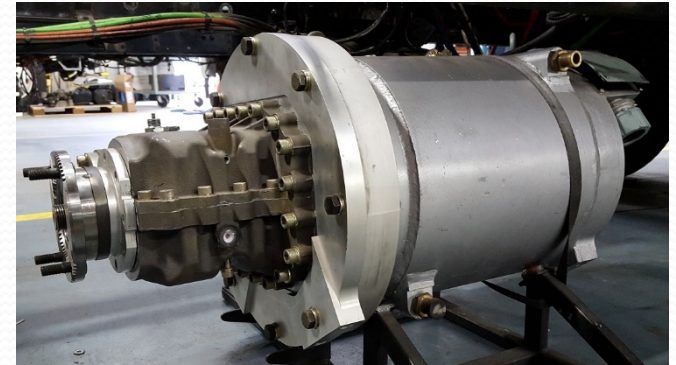
	BETs	Baseline Diesel
Operation Time	4.9 hrs	8.1 hrs
Idle Time	2.6 hrs	3.3 hrs
Distance	45 miles	142 miles
Trailer Distance	26 miles	N/A
Average Total Speed	10.4 mph	17.0 mph
Average Driving Speed	20.1 mph	27.3 mph
Fuel Consumption	2.1 kWh/mi (18.6 MPGde)	6.2 kWh/mi (6.2 mpg)
Regen Energy	0.37 kWh/mi	N/A
Ending SOC	54%	N/A
Kinetic Intensity	1.18	0.57



Technical Accomplishments and Progress

BETs – US Hybrid

- Completed first BET in 9/15
 - Developed and integrated on-board charger
 - Modified drive train to direct drive (cost & weight benefits)
- Chassis dyno testing at UC Riverside in 10/15
 - DTP and UDDS Cycles with 70,000 lbs. GCWR
 - Preliminary results show 2.2 to 2.8 kWh/mi (DTP) & 3.0 kWh/mi (UDDS)
- On-road testing including Vincent Thomas Bridge (7% grade) with a fully loaded container
- In discussion with TTSI for deployment in drayage service



EDU320 Assembly

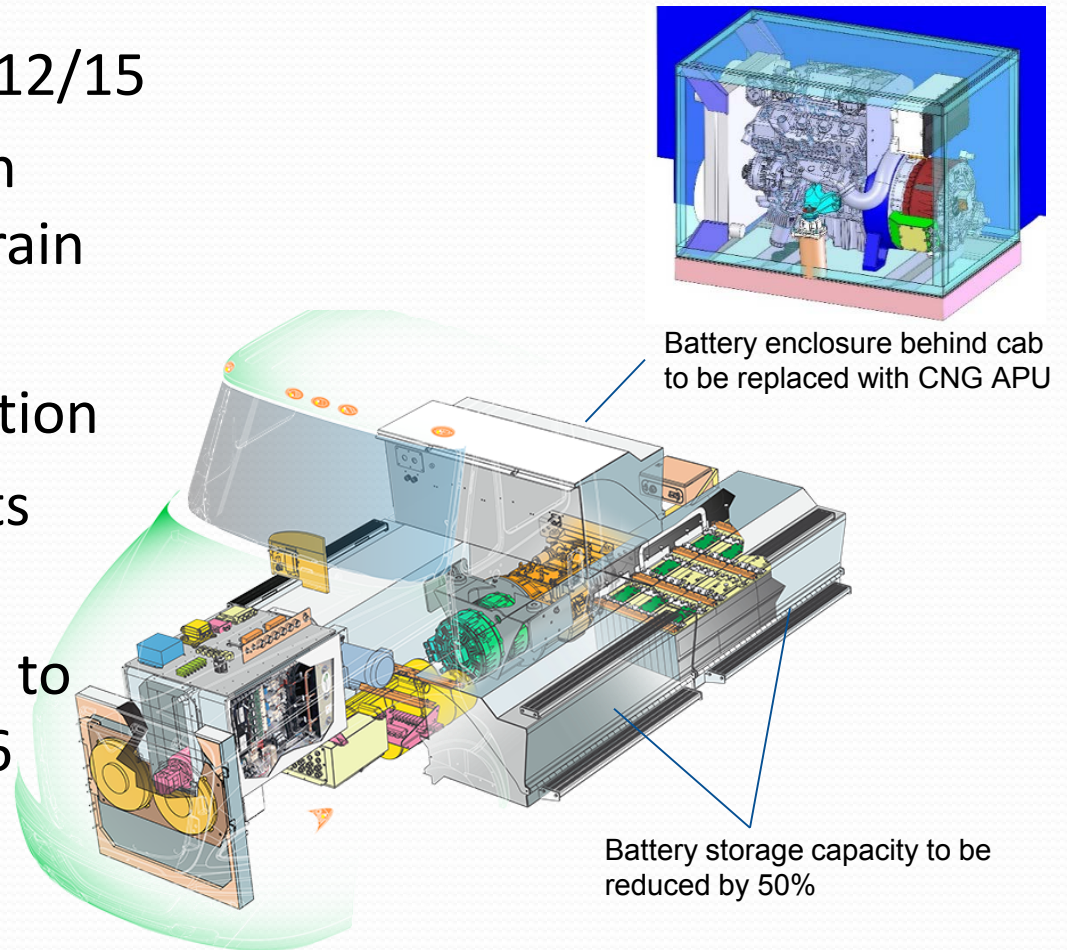


US Hybrid BET on UCR Dynamometer

Technical Accomplishments and Progress

PHETs - TransPower

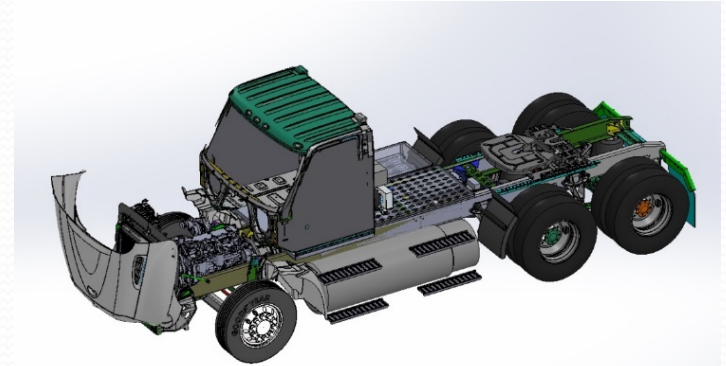
- Contract executed in 12/15
- Vehicle/system design based on EDD drive train
- Engine test cell for calibration and validation
- Long lead components ordered
- First PHET integration to be completed by 9/16



Technical Accomplishments and Progress

PHETs – US Hybrid

- Contract executed in 11/15
- System design completed, leveraging CEC-funded PHET project
- Simulation and validation of subsystems and components
- Procurement and fabrication of subsystems in process
- First PHET to be completed by 6/16



US Hybrid PHET CAD Model



TTSI Truck for Conversion

Proposed Future Work

- Remainder of FY 15-16
 - BETs
 - US Hybrid to deploy both BETs
 - TransPower to re-deploy upgraded EDD1
 - PHETs
 - US Hybrid to complete first LNG PHET
 - The LNG PHET to be chassis dyno tested at UCR
 - TransPower to complete first CNG PHET
- FY 16-17
 - US Hybrid and TransPower to deploy first PHETs by Q1
 - Complete and deploy remaining PHETs by Q2

Response to Reviewer Comments

- What mechanisms are in place to capture operational issues for each truck type, including performance anomalies, that can potentially dissuade fleet operators from acquiring the technology?

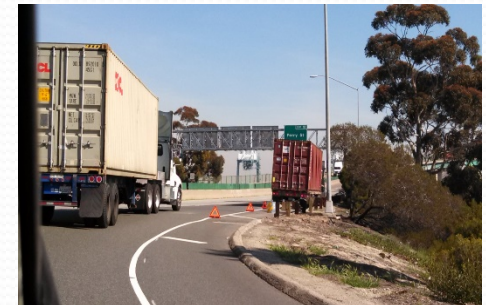
Response: Vehicle integrators monitor and record such issues and anomalies for product improvement. Also, fleet operators are surveyed for feedback on their experience and recommendations.

- Vehicle integrators, TransPower and US Hybrid, should play a larger role to provide adequate support during the deployment phase given that the demonstration vehicles are essentially pre-commercial prototypes.

Response: Both TransPower and US Hybrid are directly engaged with fleet partners to provide proper training in operations and maintenance, as well as to promptly resolve technical issues and glitches during deployment.

Collaboration and Coordination

- TransPower and US Hybrid each to develop Class 8 BETs and PHETs for demonstration in drayage service
- University of California, Riverside to perform chassis dynamometer testing to validate the performance of demonstration vehicles
- TTSI and other fleet partners to deploy demonstration vehicles in drayage service for up to two years
- TTSI is also providing two baseline diesel trucks
- NREL to analyze vehicle performance and operations data during demonstration



Summary

Objective/Relevance

- Demonstrate zero-emission capable drayage trucks in real world drayage service to promote market acceptance and analyze performance and cost data

Approach

- Develop a total of eleven demonstration trucks consisting of:
 - Six BETs: TransPower (4), US Hybrid (2)
 - Five NG PHETs: TransPower (2), US Hybrid (3)
- Chassis dynamometer testing to validate vehicle performance
- Up to two years of demonstration in drayage service
- Two baseline diesel trucks for comparison analysis
- Collect and analyze performance and operational data

Summary (Continued)

Technical Accomplishments

- TransPower completed all four BETs (EDD1 – EDD4)
- EDD2, 3 and 4 currently deployed with fleet partners
- US Hybrid completed first BET
- TransPower and US Hybrid each completed system design for PHETs

Future Work

- US Hybrid to complete second BET by 4/16
- TransPower to re-deploy upgraded EDD1 by 9/16
- TransPower and US Hybrid each to complete first PHET by 9/16