Zero-Emission Drayage Truck Demonstration (ZECT I)

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South Coast Air Quality Management District
2015 DOE Vehicle Technologies Annual Merit Review
June 11, 2015

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South Coast Air Quality Management District
Overview

Timeline
- Project start date: Oct. 2012
- Project end date: Sept. 2015*
  * To be extended to Sept. 2017

Budget
- Total project cost: $9,251,003
  ✓ DOE share: $4,169,000 (45%)
    $1,268,335 expended
  ✓ Cost share: $5,082,003 (55%)

Barriers & Targets
- Promote market acceptance
- Data collection and analysis

Partners
- Project Lead – SCAQMD
- TransPower
- U.S. Hybrid
- NREL
- TTSI
- SA Recycling
Objective/Relevance

- Demonstrate zero-emission heavy-duty truck technologies in real world drayage operations
- Promote market acceptance through demonstration with fleet partners
- Collect and analyze data on performance and O&M costs
Project Approach/Scope

- Initially to develop 13 Class 8 zero-emission drayage trucks consisting of:
  - Nine BETs - Balqon (3), TransPower (4), US Hybrid (2)
  - Four fuel cell range extenders by Vision Motors
- Balqon and Vision have dropped out
  - CNG PHEVs to be added
- Chassis dynamometer testing to validate and optimize vehicle performance
- Two-year demonstration in port drayage service with fleet partners (TTSI, SA Recycling)
- NREL to collect and analyze performance and O&M cost data against baseline trucks
## Demonstration Technologies

<table>
<thead>
<tr>
<th></th>
<th>TransPower</th>
<th>US Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Architecture</strong></td>
<td>BEV</td>
<td>BEV</td>
</tr>
<tr>
<td><strong>Traction Motor</strong></td>
<td>Dual Motor (300 kW Total)</td>
<td>Dual Motor (320 kW Total)</td>
</tr>
<tr>
<td><strong>Transmission</strong></td>
<td>Automated Manual</td>
<td>Automated Manual</td>
</tr>
<tr>
<td><strong>Battery</strong></td>
<td>215/269 kWh LiFePO$_4$</td>
<td>314 kWh Li-ion</td>
</tr>
<tr>
<td><strong>Charger</strong></td>
<td>On-board Two 150kW/70 kW ICUs</td>
<td>Off-board 120 kW</td>
</tr>
<tr>
<td><strong>Recharge Time</strong></td>
<td>3-4 hrs (70 kW ICU)</td>
<td>3 hrs</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>70-100 miles</td>
<td>100 miles</td>
</tr>
</tbody>
</table>

* CNG PHEVs with 30-40 miles AER and 150-200 miles in operating range to be added.
Technical Accomplishments

TransPower – EDD1

- Completed in 4/14
- Extensively road tested with over 3,000 accumulated miles
- Deployed with SA Recycling in 11/14
  - Heavy cargos (scrap metals)
  - Valuable lessons on real world operations and challenges
  - Limited operations due to issues with battery cells and BMS
  - 325 miles (303 miles w/trailer)
  - Averaging 2.4 kWh/mi efficiency
Technical Accomplishments
TransPower – EDD2

- **System Improvements**
  - More reliable battery cells
  - Improved battery pack design
  - New BMS

- **Chassis dyno testing at UCR**
  - DTP and UDDS Cycles
  - 2.06 - 2.42 kWh/mile (72,000 lbs)
  - 7% grade simulation

- **Deployed with TTSI in late 1/15**
  - More typical drayage service
  - Port gate access & queuing up
  - Reliable operations with positive feedback from drivers
Technical Accomplishments
TransPower-EDD3 & EDD4

**EDD3**
- Completed in 12/14
- Delivered to TTSI in late 3/15
- Deployment in 4/15

**EDD4**
- Completed in 2/15
- Undergoing on-road testing
- To be deployed by 5/15
- Reduced recurring labor hours for truck assembly from 4,200 hrs to 1,000 hrs
Technical Accomplishments
US Hybrid

- Both trucks in assembly
- First truck to be completed in 6/15
- Chassis dyno testing in 7/15
- First truck deployment in 9/15
- Second truck to be deployed by 11/15
Data Collection & Analysis

**EDD2**
- 1/15 through 3/15
- 26 days of operation
- 1120 miles traveled (680 miles with trailer)
- More local operations

**Baseline Trucks**
- 10/14 through 1/15
- Two diesel trucks
- Mack® 2013 – 12.8L
- 149 days of operation
- 22,660 miles traveled
EDD2 Sample Routes
## Median Daily Use

<table>
<thead>
<tr>
<th></th>
<th>EDD2</th>
<th>Baseline Trucks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation Time</td>
<td>3.7 hrs</td>
<td>7.9 hrs</td>
</tr>
<tr>
<td>Idle Time</td>
<td>1.2 hrs</td>
<td>2.6 hrs</td>
</tr>
<tr>
<td>Distance</td>
<td>39.8 miles</td>
<td>124 miles</td>
</tr>
<tr>
<td>Trailer Distance</td>
<td>21.6 miles</td>
<td></td>
</tr>
<tr>
<td>Average Speed</td>
<td>11.8 mph</td>
<td>16.5 mph</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>2.0 kWh/mi</td>
<td>6.2 mpg</td>
</tr>
<tr>
<td>Ending SOC</td>
<td>68.1%</td>
<td></td>
</tr>
<tr>
<td>Kinetic Intensity</td>
<td>1.3</td>
<td>0.7</td>
</tr>
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Responses to FY2014 Reviewer Comments

- Several reviewers commented that the project won’t be able to collect two years worth of demonstration data by September 2015.
  
  Response: We are in discussion with DOE to extend the project term to September 2017.

- One reviewer would like to see “fuel cell trucks go head to head with electric trucks.” This would help narrow down the field for commercialization in the future.
  
  Response: 2014 ZECT demonstration project (ZECT II) includes several fuel cell electric trucks and hybrid electric trucks for demonstration in drayage service, providing a valuable opportunity to evaluate a wide range of zero-emission capable technologies between the two projects.
Collaboration and Coordination

- TransPower and US Hybrid each to develop battery electric drayage trucks for demonstration
- University of California, Riverside to perform chassis dynamometer testing to validate the performance of demonstration vehicles
- TTSI and SA Recycling to deploy demonstration vehicles in drayage service for two years
- TTSI is also providing two baseline diesel trucks
- NREL to analyze vehicle performance and O&M cost data during demonstration
Proposed Future Work

- **Remainder of FY 15**
  - TransPower to deploy EDD4 by May
  - US Hybrid to complete first demo truck by June
  - Chassis dynamometer testing for US Hybrid truck in July
  - US Hybrid to deploy first demo truck by September
  - Amend agreement with DOE to add CNG PHEVs and extend the project term to September 2017

- **FY 16**
  - US Hybrid to deploy second demo truck by Q1
  - Continue field demonstration
  - Deploy first CNG PHEV for demonstration by Q1 (if included)
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 demonstration drayage trucks based on
  - Two types of BEVs (TransPower, US Hybrid)
  - CNG PHEVs to be added
- UCR to perform chassis dynamometer testing to validate vehicle performance
- Two-year demonstration in drayage service with TTSI, SA Recycling and other participating fleets
- Two baseline diesel trucks for comparison analysis
- NREL to collect and analyze performance and cost data
Summary (2)

Technical Accomplishments

- TransPower completed all four demo trucks
- TransPower deployed EDD1 with SA Recycling in 11/14
- EDD2 and EDD3 deployed with TTSI in 1/15 and 4/15 respectively
- EDD2 was chassis dyno tested at UCR in 10/14
- NREL is collecting and analyzing performance data
- US Hybrid completed system design and is working on vehicle integrations for both demo trucks

Future Work

- TransPower to deploy EDD4 in 5/15
- US Hybrid to complete first demo truck in 6/15 with a deployment plan in 9/15
- Second US Hybrid truck to be deployed in 11/15
- Amend agreement to add CNG PHEVs with 30-40 miles AER and 150-200 miles of operating range