CLEAN FUELS PROGRAM ADVISORY GROUP MEETING

On-Road Battery Electric Vehicle

SEPTEMBER 30, 2011

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Technology Advancement Office
PM2.5 Emissions (2014)
Top 10 Categories (tpd)
# Port Truck Emissions

<table>
<thead>
<tr>
<th>Mode</th>
<th>Miles</th>
<th>Total 2009 Emissions (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VMT</td>
<td>PM&lt;sub&gt;10&lt;/sub&gt;</td>
</tr>
<tr>
<td>On-Terminal</td>
<td>6,061,176</td>
<td>14</td>
</tr>
<tr>
<td>On-Road</td>
<td>233,791,284</td>
<td>101</td>
</tr>
<tr>
<td>Total</td>
<td>239,852,460</td>
<td>115</td>
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</tbody>
</table>

- According to EMFAC data there are 52,0000 heavy duty Class 8 trucks operating in the South Coast Basin approximately 16,000 operating at the Ports..
These are reasonable estimates of emissions reductions that can be expected over the next several years through introduction of electric vehicles at various ports.
A zero-emission battery-electric drive system will be installed by TransPower into two Class 8 truck tractors.

The trucks will be placed into service moving containers at the Ports and intermodal facilities.

Demonstrate 100 mile round trip range.

Project will be springboard for rapid commercialization of a modular electric drive system.
Battery Electric Drive System

Replaces engine and transmission in any Class 8 truck model

Value Proposition:

- Less Expensive to Own and Operate
  - Affordable price
  - Eliminates fuel use
  - Reduces brake wear

- Zero Emissions
  - Government subsidies and tax breaks
  - Improved customer acceptance
  - Enabled by major advances and cost reductions in lithium battery technology
**MAIN DRIVE MOTOR**
- Supplier: Quantum
- Power: 100 kW continuous/150 kW peak
- Torque: 320 Nm continuous/650 Nm peak
- Size/weight: 91 kg/405 mm O.D. x 360 mm

**INVERTER**
- Supplier: Quantum
- Power: 120 kW continuous/165 kW peak
- Voltage: 375V continuous/450V peak
- Current: 300A continuous/400A peak

**BATTERY SUBSYSTEM**
- Supplier: Elite Power Solutions
- Capacity: 300 kWh
- Voltage: 384V nominal
- Chemistry: Lithium iron phosphate

**INTEGRATED (ONBOARD) CHARGER**
- Supplier: Joint development with EPC
- Power: 150 kW
- Voltage: 450V peak
- Current: 300A continuous/400A peak
Battery Testing & Development

- Cell Acceptance testing at 3+ “C”
- 77V module testing at 3+ “C” using ABC 150
- 77V module testing in small EV for 20-50 cycles 80%DOD
- Model-based Simulation
- Examine “as delivered” variability
- Examine balancing rate effectiveness of BMS options
- Verify claimed evolution of cell impedance
Engineering, Testing & Development

- Development of performance metrics
- End-User focused results
- Latest Drayage Drive-cycles
Engineering, Testing & Development

- Energy Use
- Battery management
- Gearing
- Context driven controls
- Fault Tolerance
- Component Impact assessment

Existing Proprietary Simulation Interface
Demonstration

• Ideal duty cycle for electrification
  – 1/3 of trips are <50 miles round trip
  – Low average speed, extended idle times
  – Large accessible market: 16,000 trucks operating at Los Angeles/Long Beach ports

• Expected benefits
  – Eliminate tailpipe emissions
  – Improve health of local residents and workers
  – Reduce dependence on fossil fuels
  – Reduce noise
  – Improve driver comfort
  – Local “green job” creation
  – Create springboard for introduction of electric trucks into other markets
Drive Train Component Selection, Sourcing And Procurement Continues

Battery Testing And Sub System Development is Progressing

Power Electronics Supplier Progresses in Design Of Inverter Charger

Working Prototype Scheduled For October
# Project Cost

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount ($)</th>
<th>Percent (%)</th>
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</thead>
<tbody>
<tr>
<td>TransPower</td>
<td>1,119,770</td>
<td>43</td>
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<tr>
<td>CEC</td>
<td>1,000,000</td>
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<td>U.S. EPA</td>
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<td>AQMD</td>
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<tr>
<td>Total</td>
<td>2,616,275</td>
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