CLEAN FUELS PROGRAM ADVISORY GROUP MEETING

On-Road
Battery Electric Vehicle

SEPTEMBER 30, 2011

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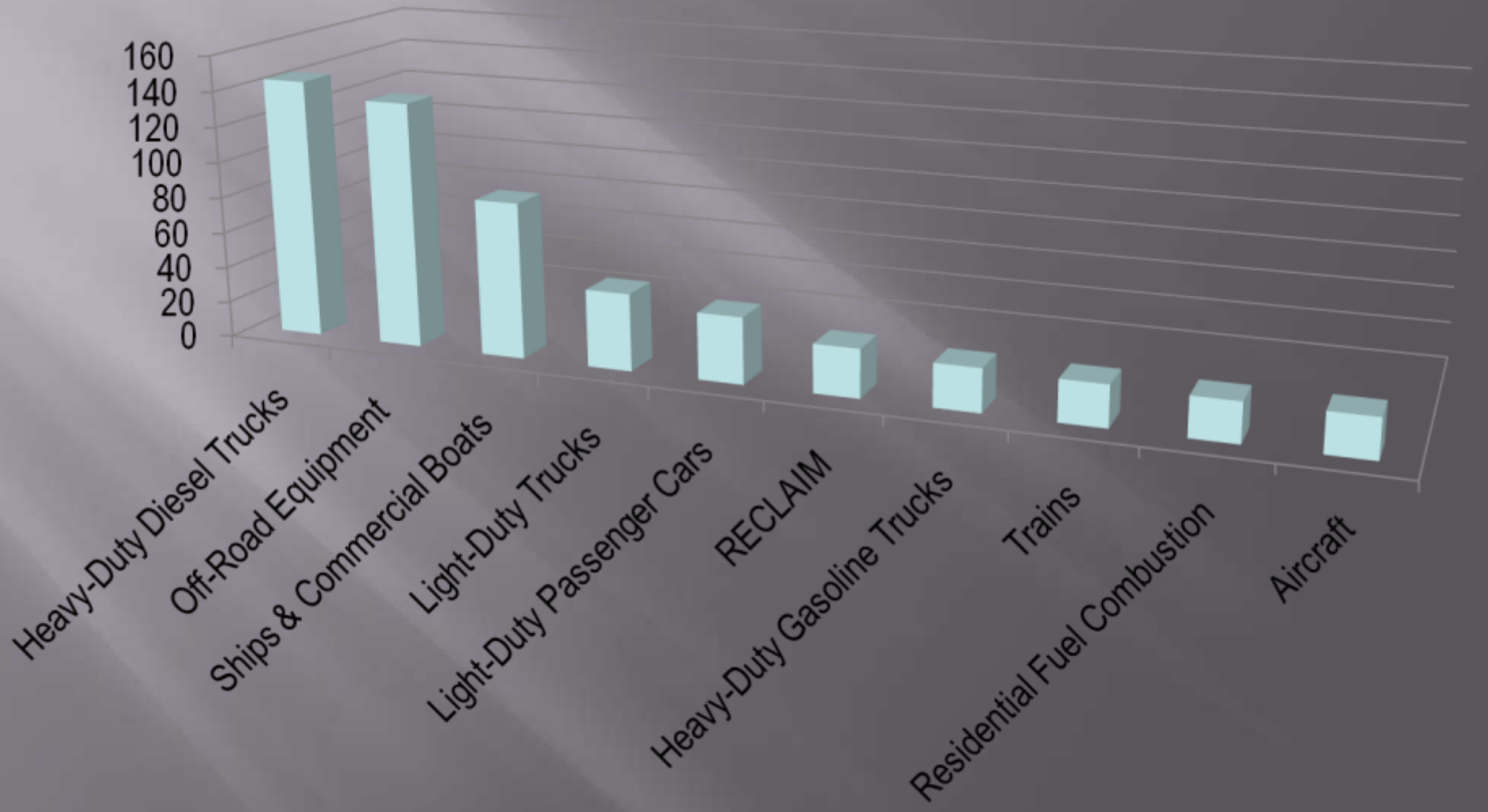
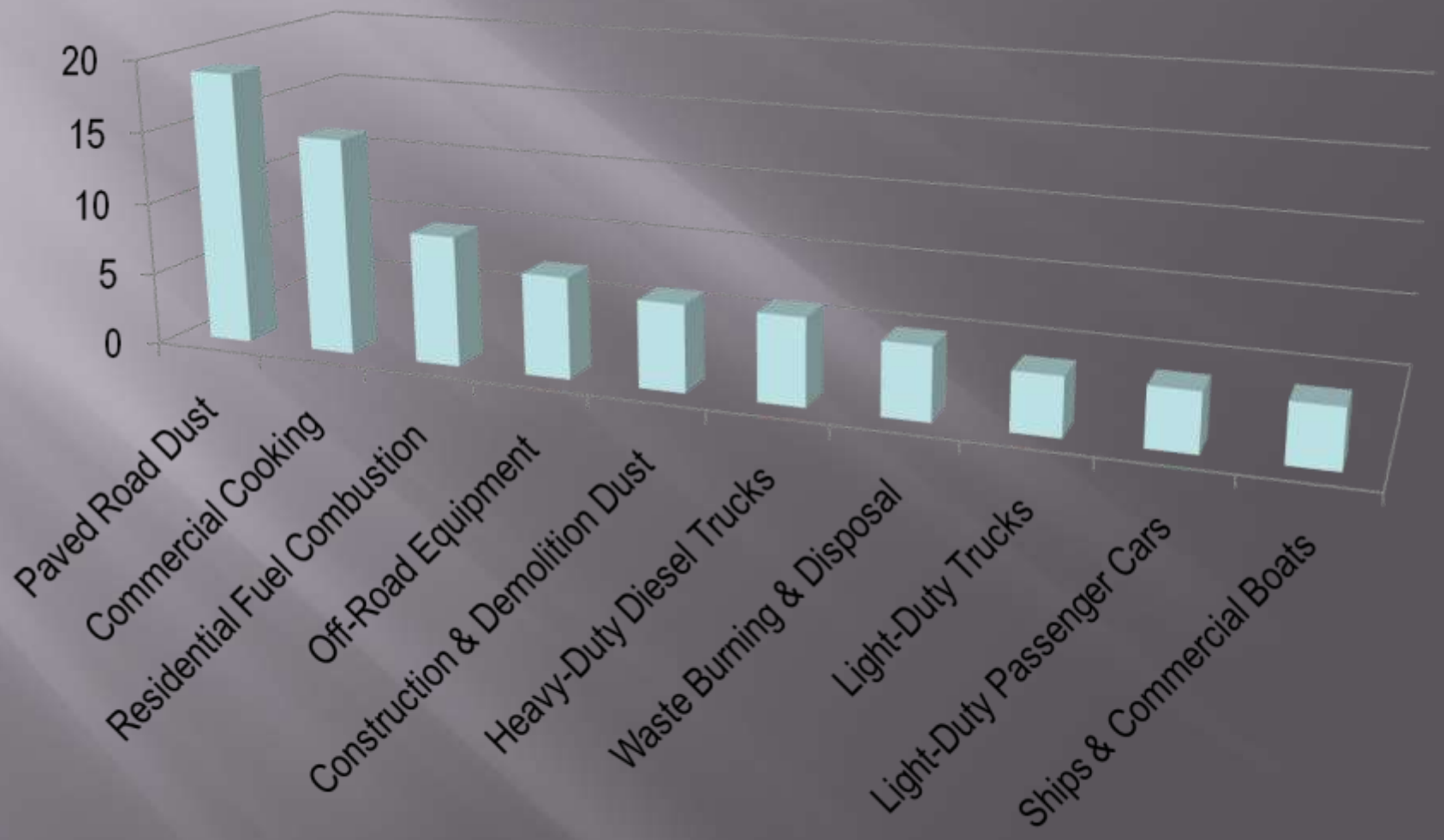
NOx Emissions (2014)
Top 10 Categories (tpd)



PM2.5 Emissions (2014)
Top 10 Categories (tpd)



Port Truck Emissions

Mode	Miles	Total 2009 Emissions (Tons)						
	VMT	PM_{10}	$PM_{2.5}$	DPM	NOx	SOx	CO	HC
On-Terminal	6,061,176	14	13	14	358	0	128	51
On-Road	233,791,284	101	93	101	3,880	5	949	157
Total	**239,852,460**	**115**	**196**	**115**	**4,238**	**5**	**1,077**	**208**

- *Emissions of criteria pollutants from heavy duty port trucks, L.A. area, 2009.*
- *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..*

Emission Reductions Estimates

Mode	Grams Per Mile (Per Truck)			Tons Per Year (Per Truck)		
	NOx	PM (Total)	GG (Total)	NOx	PM (Total)	GG (Total)
On-Terminal	53.63	6.13	4,084.01	1.77	0.20	134.93
On-Road	15.07	1.14	1,586.58	0.50	0.04	52.42
Total	**16.04**	**1.62**	**1,649.69**	**0.53**	**0.05**	**54.51**

These are reasonable estimates of emissions reductions that can be expected over the next several years through introduction of electric vehicles at various ports.

Electrification of Heavy Duty Truck Demonstration

- 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

Installation concept

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

TransPower EV Control System

INTEGRATED (ONBOARD) CHARGER

- Supplier: Joint development with EPC
- Power: 150 kW
- Voltage: 450V peak
- Current: 300A continuous/400A peak

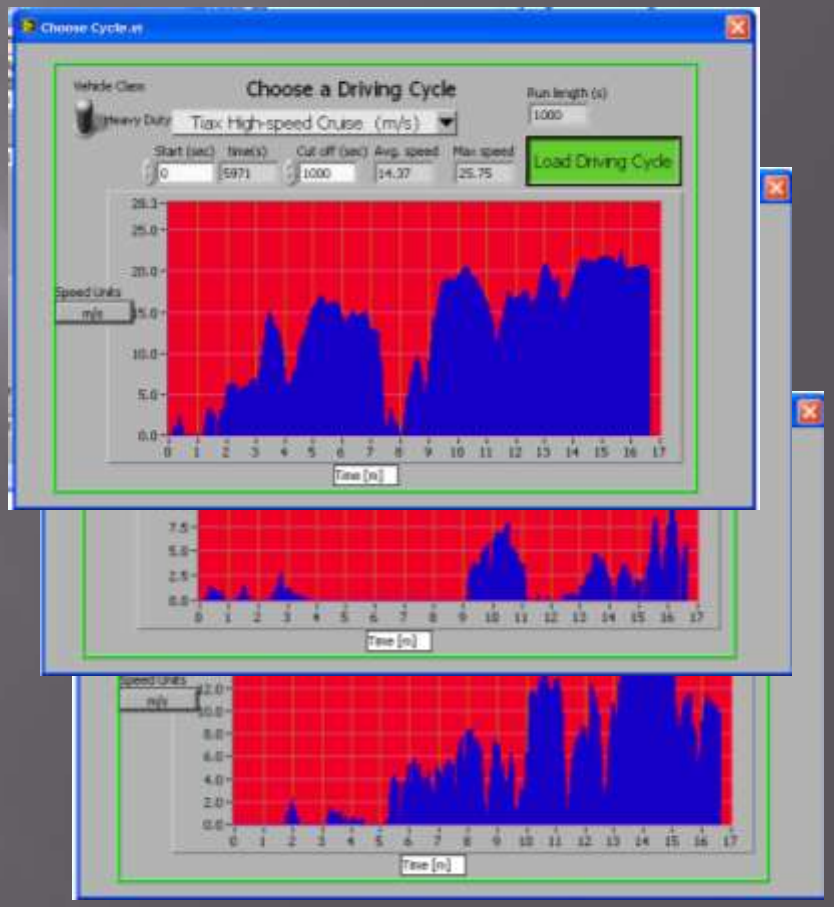
Battery Testing & Development

- 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

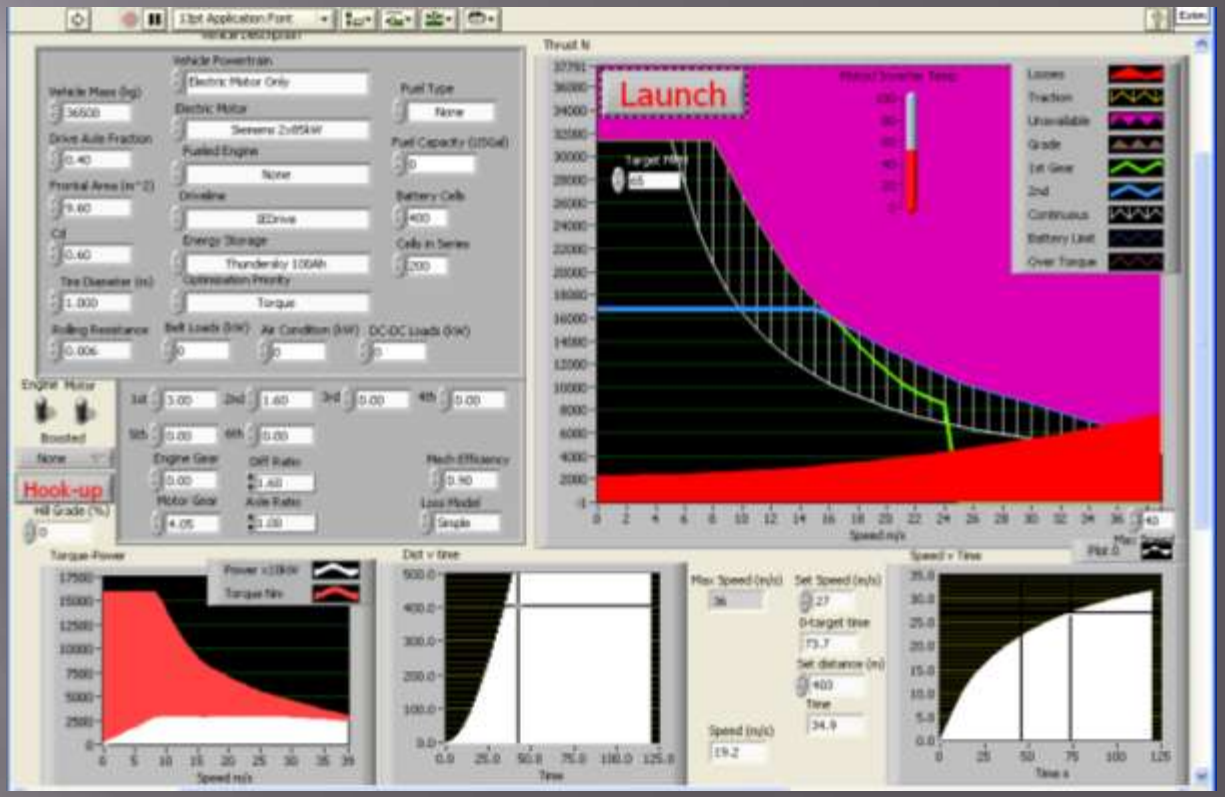
- Development of performance metrics
- End-User focused results
- Latest Drayage Drive-cycles

Port of Long Beach Drayage 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

Project Status

Project Status

Project Status Report

- 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

Source	Amount ($)	Percent (%)
TransPower	1,119,770	43
CEC	1,000,000	38
U.S. EPA	300,000	11
AQMD	196,505	8
Total	2,616,275	100