Heavy-Duty Technology and Fuels Assessment: Overview

December 18, 2014

California Environmental Protection Agency
Air Resources Board

Outline

- Background
- Zero and Near-Zero Emission Technologies
- Maximizing Efficiencies
- Preliminary Observations and Next Steps

California's Mobile Source Programs Have Been Effective

- 90% reduction in on-road and off-road NOx and PM standards since 2000
- 70% reduction in diesel PM at largest ports
- 50 to 70% reduction in diesel PM at highest risk railyards

More Reductions Needed

- Additional 90% reduction in NOx
  - A more stringent ozone standard will be even more challenging
- Continued diesel PM reductions to protect public health
- 80% reduction in GHG needed throughout state for 2050 climate goals

Planning for Air Quality and Climate Targets

- Requires reductions across all sectors
- Focus on advanced technologies, cleaner fuels, increased efficiencies
- Support key planning efforts underway
  - State Implementation Plans (SIPs)
  - Scoping Plan
  - California's integrated freight planning
  - Funding Plans
  - Governor's ZEV Action Plan

Purpose of Technology Assessment

- Inform policy decisions that support technology development and use
- Assess emerging technologies and fuels
  - Trucks and buses, locomotives
  - Marine, cargo handling equipment
  - Airport sources
  - Fuels

Process and Schedule

- Partnership with air districts
- Literature review and stakeholder meetings
- Solicited comments at Sept. workshops
- Overview document will be released for comment
- Sector specific reports will be released for comment as completed in 2015
- Technology assessments updated periodically

Technology Assessment Elements

- Sector overview
- Technology description
- Technology development status
- Current capital costs, projected costs at widespread deployment (if available)
- Emissions reduction potential
- Deployment opportunities and challenges

Types of Technologies Evaluated

- Battery and fuel cell electric propulsion
- Combustion engines
- Hybrids
- Vehicle / engine / vessel efficiency
- Automation and communication
- Fuels

Comparing Technologies

- Tailpipe emissions
  - Important for regional pollutants: NOx, PM
- Well to wheels emissions
  - Tailpipe emissions (vehicle and fuel efficiency)
  - Upstream emissions (fuel production and distribution)
  - Important for global pollutants: GHG

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Zero Emission Technologies

- Commercially available in some applications
- Feasible in many applications
- On-going work needed
  - Reduce upfront cost
  - Develop fueling infrastructure
  - Extend range
- Lower fuel and maintenance costs
- Need to continue demonstrations and incentives

Commercially Available

Electric forklift

Electric gantry cranes

Airport electric baggage tug

Early Commercialization

Fuel cell electric transit bus

Fuel cell lift trucks

Electric plug-in transport refrigerator

Battery electric transit bus

Demonstration

Battery electric and fuel cell drayage trucks

Electric or Fuel cell delivery van

School bus with V2G capability

Battery electric switcher locomotive

Hybrids and Other Zero Emission Enabling Technologies

- Pathway technologies
  - Hybrids providing zero emission miles
  - Electric propulsion with range extender
  - Help commercialize ZEV components
- Other technologies
  - Electrify accessories while parked, at berth
  - Smaller engines that increase efficiency
  - Mild hybrids that electrify auxiliary systems

Example Hybrid Applications

Hybrid electric van with pure electric range

Diesel electric hybrid ferry with solar & wind assist

Locomotive battery or fuel cell tender

Technologies that Reduce Main Engine Use

Aircraft Taxi Assist

Jet Bridge Ground Power for Aircraft

TRU Power at Distribution Centers

Vessel Shore Power

Example Near-Zero Emission: Trucks

- Characteristics
  - Diesel or natural gas combustion
  - Certified to lower NOx standards
  - Use renewable / low carbon fuels
- Status
  - Research and development
  - Lower NOx natural gas available in 1-4 years
  - Fueling infrastructure may be needed

Reducing Emissions from Current Technology

- Enhanced emissions standards / testing requirements for on and off-road
  - Achieve lowest emissions in-use
  - Provide durability protections and robust warranty
  - Inspection and maintenance programs
- New opportunities for rail, marine, and off-road engines with aftertreatment

Transition to Low or No Carbon Fuels

- Bio and Renewable fuels are important
  - Being demonstrated and expanded
  - Provide immediate reductions
- Power to gas and vehicle to grid integration potentially transformative
  - Store excess renewable energy until needed
  - Can feed energy to grid during peak demand
  - Fuel zero and near-zero vehicles

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Current Technologies: Maximizing Efficiencies

- 40% or more GHG reductions possible in some sectors
- Drivetrain and hybridization
- Engine technologies
- Vehicle technologies

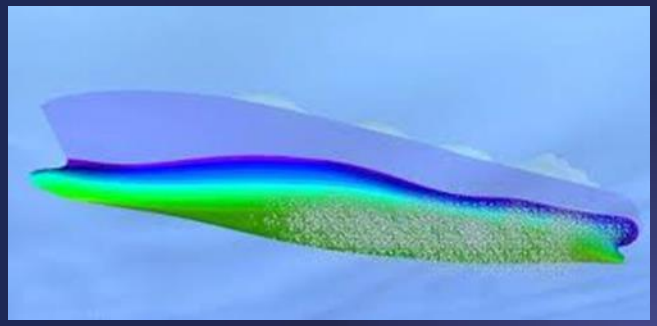
Cummins/Peterbilt Super Truck

Improving Truck Efficiencies

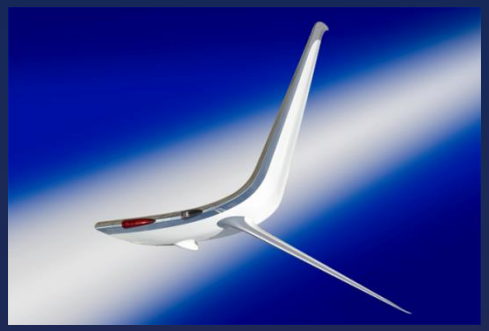
- Engine
  - Downspeeding / downsizing
  - Waste heat recovery
  - Combustion optimization / advanced catalyst
- Hybrid and drivetrain
  - Advanced transmissions
  - Hybridization and energy recapture
- Vehicle technologies
  - Aerodynamics and low rolling resistance tires

Improving Ship Efficiencies

- Engine
  - Combustion optimization
  - Liquefied natural gas
  - Exhaust heat recovery
- Vehicle technologies
  - Hull and propeller design
  - Low friction coatings
  - Hull air lubrication



Reducing Aircraft Emissions



- Engine
  - Improved turbofans
  - Improved combustors
  - Open rotor designs
- Aircraft design
  - Weight reduction
  - Aerodynamics: winglets, skin technologies
- Fuel cell auxiliary power units
- Biofuels

Improving Efficiencies through Technology

- Potential benefits
  - Efficient trips and routes
  - Smoother driving cycles
  - Improved safety
  - Safety enables lighter vehicles, smaller engines
  - Significant potential emission reductions
- Terminal automation
- Platooning
- Vehicle to vehicle / infrastructure communication

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Preliminary Observations

- Many promising zero and near-zero emission technologies
  - Pathway technologies encourage commercialization
- Major vehicle, engine, and operational efficiency improvements are possible
- Renewable fuels provide deep GHG reductions

Developing New Strategies to Reduce Emissions

- Incentives
  - Support technology demonstrations
  - Reduce upfront capital costs
- Regulations
  - Create market certainty
  - Accelerate technology development and deployment
- Multi-sector and multi-fuel planning is necessary

Next Steps

- Draft overview report will be released for public comment
  - Report: http://www.arb.ca.gov/msprog/tech/report.htm
  - Comments: http://www.arb.ca.gov/lispub/comm/bclist.php
- Sector-specific draft documents will be released first quarter 2015 for public comment
- Complete assessments in 2015, will be used for key planning efforts