Technology Assessments Underway
ARB, working with air districts

- Air Quality Plans (SIPs)
- AB32 Scoping Plan
- Freight Strategy
- Technology Assessment
Build on What Others Have Done

• Technology assessments
• Freight system description/logistics
• Operational strategies
• Research and testing
• Demonstration/pilot projects
• Fuels availability and demand
• Emissions inventories

Collaborate Moving Forward

• Reach out to:
  • Technology providers
  • Industry
  • National labs
  • NGOs
  • Local, State, federal government
• Collaborate with partners
  • SCAQMD, BAAQMD, SJVAPCD
  • CEC, CalTrans
Technology Assessment Sectors

- Trucks
- Transport Refrigeration Units
- Rail
- Ocean Going Vessels
- Commercial Harbor Craft
- Cargo Handling Equipment
- Aviation
- Ground Support Equipment
- Fuels

Technology Assessment Elements

- Technology description
- Readiness - current development status
- Fueling needs, strengths and limitations, key performance parameters
- Cost and new vehicle emission levels (per vehicle)
- Next steps to demonstrate and deploy technology, fill knowledge gaps
- Sector summary - technology highlights, set the stage for Freight Strategy and SIPs
## Technology Assessment Schedule

<table>
<thead>
<tr>
<th>Activity</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review literature, discuss with technology providers, meet with stakeholders</td>
<td>Spring 2014 – On</td>
</tr>
<tr>
<td>Technology assessment workshops</td>
<td>August 2014</td>
</tr>
<tr>
<td>Technology assessment document</td>
<td>October 2014</td>
</tr>
</tbody>
</table>

## Trucks (On-Road Heavy-Duty)
Understanding the Trucking Sector

- Large variability in configurations and driving cycles
- Short vs. long haul
- Captive vs. national fleets
- National purchasing patterns
- Technology development timeframes

Truck Technology Categories

- Advanced combustion
- Engine and vehicle efficiencies
- In-use
- Hybrids
- Zero tailpipe
- TRUs
Truck Technology Categories

- Advanced combustion
- Engine and vehicle efficiencies
- In-use
- Hybrids
- Zero tailpipe
- TRUs

Advanced Combustion Technologies - Diesel

- Advanced aftertreatment
- NOx adsorbers
- Exhaust thermal management
- Improved SCR
- Engine optimization/enhanced certification
- Electrification of accessories
Advanced Combustion Technologies - Natural Gas

- Advanced aftertreatment
  - 3 way catalyst with cooled EGR
  - SCR
  - Lean NOx traps
- Engine optimization
  - Dedicated EGR
  - Advanced fuel delivery
  - Improved sensors

Truck Technology Categories

- Advanced combustion
  - Engine and vehicle efficiencies
  - In-use
  - Hybrids
  - Zero tailpipe
  - TRUs
Advanced Powerplants, Drivetrain Optimization

- Engine technologies
  - Multiple on-board engines/microturbine engines/camless engines
  - Engine downspeeding/engine downsizing
  - Variable valve actuation/cylinder deactivation
  - Advanced combustion cycles
  - Free piston engines or alternators
  - Advanced transmissions
  - Advanced cycle-specific electronic controls

Truck and Trailer Efficiency

- Aerodynamics
- Lightweighting
- Vehicle speed limiters
- Tires
  - auto-inflate
  - low-rolling resistance
- Auxiliary load reduction
- Improved AC/idle reduction/auxiliary electrification
Truck Technology Categories

- Advanced combustion
- Engine and vehicle efficiencies
- In-use
- Hybrids
- Zero tailpipe
- TRUs

In-Use Emissions / Maintenance / Reduced Deterioration

- Need for enhanced Heavy-Duty Inspection and Maintenance Program
- Goals – ensure fleets have preventive maintenance/ID and repair high emitters
Truck Technology Categories

- Advanced combustion
- Engine and vehicle efficiencies
- In-use
  - Hybrids
- Zero tailpipe
- TRUs

Hybrid Electric Trucks

- Understanding hybrid sector
- Types of hybrids
- Hybrid electric vehicle demonstration projects
- Need for systems integration
- Key next steps for development and deployment
Truck Technology Categories

- Advanced combustion
- Engine and vehicle efficiencies
- In-use
- Hybrids
  - Zero tailpipe
- TRUs

Battery Electric Trucks

- Battery technologies
- Battery charging technologies
- Battery electric vehicle demos to date
- Range/applicability for vocations
- Key next steps for development and deployment
Fuel Cell Trucks

- Fuel cell technology
- Fuel cell demos to date
- Potential vocational applications
- Hydrogen production and vehicle fueling infrastructure
- Key next steps for development and deployment

Truck Technology Categories

- Advanced combustion
- Engine and vehicle efficiencies
- In-use
- Hybrids
- Zero tailpipe
- TRUs
Transport Refrigeration Units

- Understanding TRUs – for trucks, trailers, rail
- Technologies
  - Fuel cells
  - Electric - plug-in, battery, solar/battery
  - Alternative fuels
  - Energy efficiency improvements – insulated van, operational changes
  - Advanced combustion
  - Reduced deterioration
  - Tier 5 for less than 25 hp off-road
Rail Technology Assessment
Overview

- North American rail operations
- U.S. freight locomotive fuel and fuel infrastructure
- U.S. diesel-electric freight locomotives
- California freight rail operations
- Historical locomotive technology development
- Advanced locomotive technologies
- Key performance parameters and technology assessment

Rail Technology Assessment
Advanced Locomotive Technologies

- Tier 4 diesel-electric
- Tier 4+ aftertreatment diesel-electric
- Natural gas
- Battery hybrid
  - battery augmented
  - tender car
- Catenary Electric
- Fuel cell technologies
- Advanced train/locomotive propulsion systems
Ocean-Going Vessels

- Engine and engine support technologies
- Aftertreatment
- Lower emission diesel and alternative fuels
- Shoreside technologies
  - Shore power, emission control
- Alternative supplemental power
  - Wind, fuel cells, battery
- Vessel efficiency improvements
- Maintenance/reduced deterioration

Commercial Harbor Craft

- Lower emission diesel and alternative fuels
- Hybrids
- Battery electric
- Lower emission diesel
- Shore power
- Vessel efficiency improvements
- Aftertreatment retrofit
Cargo Handling Equipment

- Lower emission alternative fuels
- Hybrids
  - Electric hybrid, hydraulic hybrid, diesel or alt fuel
- Electric
  - Battery electric, direct grid connection, or wayside power
- Lower emission diesel
- Efficiency improvements
  - Terminal automation, automated queuing, idle reduction

Aviation
Airplanes & Ground Support Equipment

- Understanding the Sector
  - Airport logistics
  - Types of aircraft and activity
  - Airplane operation and logistics
  - Ground Support Equipment (GSE) characteristics
  - Other airport related emission sources
  - Passenger, air cargo
Airplanes and Airports

- Aircraft technologies
  - Structural, aerodynamic, material
- Engine technologies
  - Material, design
- Alternative fuels
  - Bio-derived, hydrogen, aviation gas replacements
- Operational changes
  - Ground strategies - APU, taxi process
  - Flight path optimization

Ground Support Equipment

- Engine technologies
- Hybrids
- Electric
- Other advanced equipment
Fuels Assessment

Fuels Assessment – Overview

- Fuel demand across heavy-duty sectors
- Fuel supply of conventional and alternative fuels
- Alternative fuel distribution systems
- Alternative fuel techno-economic analysis
- Well-to-wheel emission factors
- Natural gas leakage sensitivity study
Fuels Assessment – Well-to-Wheels Basics

• Historically tailpipe and fuel production and distribution emissions controlled separately
• Now looking at them together and considering the full lifecycle
• Well-to-tank emissions includes fuel extraction, refining, and distribution (and analogous for production of electricity and biofuels)
• Tank-to-wheel emissions include tailpipe and fugitive emissions
• Well-to-wheel is the full lifecycle

Fuels Assessment – Well-to-Wheel Emission Factors

• New California specific analysis
• Criteria emissions from fuel production
  • Using CA facility inventory emissions
  • GREET 2013 for non-CA facility processes
  • Will specify which processes are in-state
• Greenhouse gas emissions
  • Using ARB LCFS carbon intensity values
  • Will specify which processes are in-state for AB 32 inventory
Fuels Assessment - Supply & Distribution

- Long-term fuels outlook
  - Alternative fuel supply potential
  - Industry trends, feedstock options, etc
  - Aligned with LCFS regulation update
- Alternative fuel distribution networks
  - Utilizing existing fuel network for alternative fuels
  - Identifying key upgrades of existing or creation of alternative fuels distribution system
  - Challenges associated with the roll-out of alternative fuel distribution systems

Cross Sector Topics
Funding and Financing

- Sustainable Freight Strategy will begin looking at funding and financing issues
- Leveraging federal funding
- Public/private partnerships
- Market mechanisms
- Incentive funding for vehicle and fuels pilot and demonstration projects

Advanced Technology Incentive Funding

- **AB 118 funding** through 2023
  - ARB AQIP ~$20-$25 million for mobile source technology advancement
  - CEC Program ~$100 million for vehicles, alternative and renewable fuels
- **Cap-and-Trade Auction Proceeds proposed FY 2014-15** allocation for low carbon transportation
  - $120 for light-duty ZEV/plug-in hybrid rebates and pilots
  - $30 million for hybrid and zero-emission truck and bus vouchers and pilots
  - $50 million for advanced technology freight demonstrations
Using the Technology Assessments

- Technology assessment document will include all sectors and address overarching issues
- Technology assessments will inform the Sustainable Freight Strategy and SIP development
- These documents together will help us address broader policy questions

Broader Questions

- Role of natural gas?
  - Potentially lower tail-pipe emissions, but methane leakage GHG issue
- Low-carbon biofuels in-state production?
  - GHG emission reductions, but if produced in-state, adds facility & agricultural NOx emissions
- Pace of technology rollout?
  - Scenarios to highlight when technology may be needed
Broader Questions

• Technology/fuel mixes?
  • Which technology/fuel mixes will get us to our air quality and public health goals?

• Actionable next steps?
  • What actions can ARB and our partners could take now to start us on the path?

• Funding/financing?
  • What is the most strategic use of state incentive funds, and what other funding/financing is available?

Broader Questions

• Defining zero?
  • How do we define zero – power plant equivalent emissions?

• Biofuels availability?
  • What is the projected availability of renewable fuels and how does that impact our technology options?
Contacts

- Trucks: Kim Heroy-Rogalski (kheroyro@arb.ca.gov)
- Locomotives: Nicole Dolney (ndolney@arb.ca.gov)
- Ocean-going vessels:
  - Peggy Taricco (ptaricco@arb.ca.gov)
  - Paul Milkey (pmilkey@arb.ca.gov)
- Commercial harbor craft:
  - Randall Pasek, SCAQMD (rpasek@aqmd.gov)
  - Cherie Rainforth, ARB (crainfor@arb.ca.gov)

Contacts (continued)

- Cargo Handling Equipment:
  - Cherie Rainforth (crainfor@arb.ca.gov)
- Aviation & GSE:
  - Dave Salardino (dsalardi@arb.ca.gov)
- Fuels:
  - Roxana Bekemohammadi (rbekemoh@arb.ca.gov)
  - Joshua Cunningham (jcunning@arb.ca.gov)
- Coordination: Renee Littaua (rlittaua@arb.ca.gov)
- Policy: Todd Sax (tsax@arb.ca.gov)