2022 AQMP Mobile Source Working Group Meeting #1 – Ocean-Going Vessels

February 3, 2021

Cleaning The Air That We Breathe...
Agenda

1. Ocean Going Vessels Operations and Emissions – AQMD
2. Strategies for Reducing Emissions from Ocean Going Vessels - CARB
4. Pacific Rim Initiatives for Maritime Emission Reductions – AQMD
Agenda Item #1

Ocean-Going Vessels Operations and Emissions in South Coast AQMD
2019 OGV Calls by Vessel Type (3,791)

Sources: POLA/POLB 2019 Emission Inventories
Annual Containers Statistics

Million Twenty-Foot Equivalent Units (TEUs)

- POLA
- POLB


Values: 9.5, 9.6, 10.6, 11.8, 13.1, 14.2, 15.8, 15.7, 14.3, 14.1, 14.0, 14.1, 14.6, 15.2, 15.4, 15.6, 16.9, 17.5, 17.0, 17.3
Forecasted vs. Actual TEUs

Sources:
Mercator Report 2016
POLA/POLB TEU Statistics
OGV NOx Emissions Trend

Sources: POLA/POLB Emission Inventories
OGV Emissions by Vessel Type (2019)

**POLA Total:** 2,743 tons

**POLB Total:** 3,983 tons

Sources: POLA/POLB 2019 Emission Inventories
OGV Main Engine Tiers (2019)

POLA - Total Calls: 1,687

- Tier II: 29%
- Tier I: 59%
- No Tier: 5%
- Tier III: 0.5%

POLB - Total Calls: 2,104

- Tier II: 28%
- Tier I: 56%
- No Tier: 0.1%
- Tier III: 0.4%

Sources: POLA/POLB 2019 Emission Inventories
2019 OGV NOx Emissions (Two Ports Combined)

By Engine Type
- Aux Engine: 21%
- Aux Boiler: 30%
- Main Engine: 49%

By Operational Mode
- Transit: 56%
- Hotelling at-anchorage: 10%
- Hotelling at-berth: 26%
- Maneuvering: 8%

Total NOx: 6,726 tons

Sources: POLA/POLB 2019 Emission Inventories
Significant OGV emission reductions are needed for attainment of ozone standards.
New OGV Emissions category

• Fugitive VOC emissions from tankers carrying petroleum products
  • Crude oil, gasoline, jet kerosene, distillate oil, residual oil
• Draft emission estimates: 8 tons per day
• Emissions estimated based on:
  • Annual throughput data provided by California State Land Commission
  • U.S. EPA’s AP-42 emission factors for marine transit loss (Table 5.2-6)
  • Vessel transit duration based on the average anchorage time for non-chemical tankers in the POLA/POLB 2018 EIs
  • 85% non-methane hydrocarbon content assumed for crude oils and 100% for other products
  • Growth forecast based on oil cargo forecast in 2016 Mercator Report
OGV Existing Control Programs

• IMO/U.S. EPA
  • NOx Engine Standards; Fuel Requirements
    • Tier 3 engines for new vessels at Emission Control Areas

• California Air Resources Board
  • At-Berth Regulation
  • Low-Sulfur Fuel Regulation

• Ports of Los Angeles and Long Beach
  • Local incentive programs (e.g., vessel speed reduction)

• Shipping Lines
  • Energy efficiency improvements
2022 AQMP Overall Schedule

- Preliminary 2018 emissions inventory: January 2021
- Draft control measures: June/August 2021
- Release Draft AQMP: Late Fall 2021
- CARB Board Hearing: July 2022
- April 2021: Updated base and future emissions inventory
- June/August 2021: Carrying Capacity
- June 2022: South Coast AQMD Board Hearing
- August 3, 2022: 70 ppb Ozone SIP due to EPA

Mobile Source Working Groups
December 2020 – June/August 2021
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South Coast 2037 Draft Attainment Goal

More than 70% Reduction Needed to Meet 2037 Goals

Baseline

Carrying Capacity 2037

55-85 tpd

Carrying Capacity

SCAB NOx Emissions (tpd)

Stationary and Area
Cars/Light-Duty Trucks/SUVs/Motorcycles
Medium-Duty & Heavy-Duty Gas Trucks
Heavy-Duty Diesel Vehicles
Aircraft
Locomotives
Ocean Going Vessels
Commercial Harbor Craft
Recreational Boats
Off-Road Equipment and Vehicles

Baseline Carrying Capacity 2037

SCAB NOx Emissions (tpd)
Controlling Federal Sources is Critical to Achieving our Clean Air and Climate Targets

California-Regulated Sources: Cars, Trucks, & Equipment

Primarily Federally-Regulated Sources: Interstate Trucks, Planes, Trains, & Ships

Reductions from California Sources:
75% as of 2019
>85% by 2032

Emissions from Primarily Federally Regulated Sources Will Surpass California Source Emissions by 2030

Ocean Going Vessels (OGVs)

- Over 400 feet, 10,000 tons, large engine displacement
  - Auto, container, cruise, cargo, reefers, tankers, etc.
- Visit CA port or marine terminal complex at least once per year
- Significant source of emissions around the ports and coastal shipping lanes
  - Transiting
  - Maneuvering
  - Anchoring
  - At berth
Growing Importance of Marine Emissions

Statewide Mobile NOx Emissions by Source (Baseline)

Source: CEPAM 2019 Summer emissions; OGVs includes emissions up to 100 nautical miles
Distribution of Global Shipping Activity from Satellite Tracking in 2012

Source: ShipMap, developed by University College, London and Kiln; IMO GHG Study 2014.
OGV NOx Emission Contribution in South Coast

- OGV emissions (up to 100 nautical miles) make up 20% of mobile source NOx emission in 2037, up from 10% in 2017

Source: CEPAM 2019 Summer Emissions, with 2020 at-berth amendments
OGV NOx Emission Forecast by Mode

- Emissions for transit, anchorage, and maneuvering increasing
- At berth emissions decreasing due to shore-power requirements
  - Based on 2020 amendments
OGV Inventory Status

- At-Berth inventory updated in 2020
- Inventory updates for transit, maneuvering, anchorage in progress, based on Automatic Identification System (AIS) data
  - Improve base year accuracy and location specificity
  - Review growth forecast and future engine Tiers for visiting vessels
  - Review literature on emission factors for main/auxiliary engines and boilers
  - Draft Release: Summer 2021
OGV At Berth Regulation

• Every vessel visiting a regulated port/terminal must connect to shore power or alternative control technology

• Reduce emissions from auxiliary engines and some tanker boilers
  - No requirements for main engines or auxiliary engines while not at berth

• Amended rule in 2020:
  - Expansion of At Berth Rule to cover more vessel types and locations
  - Taking effect in 2023
OGV NOx Reductions in SC from 2020 Amendments to At Berth Regulation

- 3.6 tpd of NOx Reduction in 2031
- 2.8 tpd of NOx Reduction in 2037

NOx Emissions (tpd)

- Baseline
- 2020 Amendment to At-Berth
Emission Reductions: Tier 3 Vessels

• Tier 3 marine engines offer significant NOx reductions
Emission Reductions: Tier 3 Vessels

• Projections indicate Tier 3 will not likely arrive in significant numbers for California ports until 2030
  o Large increase in keels laid prior to Tier 3 standards, allowing continued manufacturing of vessels with Tier 2 engines
  o Newer vessels generally used on European-Asian routes, later coming to Asian-American routes
Emission Reductions: Retrofit Technologies

• **Water in Fuel (WiF) Emulsion**
  - Emulsifies the fuel with fresh water prior to combustion
  - 10% - 40% NOx reductions compared to Tier 1
  - May cause incomplete combustion and could increase PM emissions

• **Exhaust Gas Recirculation (EGR)**
  - Recirculates part of cleaned exhaust gas back into engine chamber
  - 10% - 40% NOx reductions compared to Tier 1
  - May result in additional unburned HC, PM, CO2 emissions, and slight increase in fuel usage

• **Selective Catalytic Reduction (SCR)**
  - Treats exhaust gases and passes the treated exhaust over a catalyst
  - ≥ 80% NOx reductions compared to Tier 1 (comparable to Tier 3)

Source: CARB, Draft Technology Assessment: Ocean-Going Vessels
Emission Reductions: Marine Tier 4 Standards

- Would require working with US EPA and IMO on new standards
- Marine tech assessment set a goal of an additional 70% reductions in NOx beyond Tier 3 standards, or 1 gram of NOx per kw-hr
- Scrubber (after-treatment of SOx and PM) manufacturers have claimed PM reductions of 30 to 85 percent
GHG Reductions: IMO Targets

- At least 50% reduction of annual GHG emissions compared to 2008 level by 2050 (requires approximately 85% CO2 reduction per ship)
2020 Mobile Source Strategy (MSS)

- Address transit, anchorage, and maneuvering emissions
  - Replace Tier 0/1/2 visits with Tier 3 (or retrofitted Tier 2 visits that achieve similar reductions) by 2031
  - Introduce Tier 4 marine standards in 2028
Potential Measures to Consider

- Explore CA state regulatory authority to require cleaner vessel visits
- Work between CARB and U.S. EPA on requirements for visiting vessels
- Incentive programs and possible partnerships with Pacific ports
- Vessel speed reduction programs
- Working with US EPA and IMO for marine Tier 4 standard
COVID-19 Impacts

- Container activity initially down by ~30% in spring, but rebounded ~30% above 2019 level in the fourth quarter of 2020, driven by consumer demands.
- Cruises stopped sailing in April 2020; no firm date of resumption yet.
- Auto carrier visits down 50-75% between Feb-May 2020 compared to 2019.
- Refinery crude imports down ~20% in 2020 compared to 2019.
Questions, Comments, Feedback

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2022 AQMP Mobile Source Working Group
Ocean Going Vessels (Meeting #1)

Current Marine Diesel Engine Emission Requirements

Wednesday, February 3, 2021, 1:30 p.m.

Presentation by:
Michael J. Samulski, LMAC Director
Assessment and Standards Division
EPA Office of Transportation and Air Quality
Summary

• EPA’s Coordinated Strategy to reduce OGV engine emissions
  • Standards
    • Clean Air Act
    • MARPOL Annex VI (ECA and Global)
  • Compliance and Enforcement

• Ongoing International Maritime Organization (IMO) Activity
EPA’s Coordinated OGV Strategy

• Set out in EPA’s C3 Marine Rule (75 FR 22896, 4/30/10)
  • Combination of national and international action to address emissions from all ships that affect US air quality
  • Result: emission reductions from all OGVs that operate in US waters

Clean Air Act (CAA) program
• Engines of any size installed on a US ship, no matter where it is operated
• Fuel sold in the United States, no matter where it is used

MARPOL Annex VI program
• Engines >130 kW installed on any ship
• Fuel used on any ship
• Limits depend on whether the ship is operating inside or outside an Emission Control Area (ECA)
U.S. Emission Control Areas

North American ECA
US Caribbean Sea Area ECA
## OGV Engine and Fuel Standards

<table>
<thead>
<tr>
<th>Program</th>
<th>Engines</th>
<th>Fuels</th>
<th>Applicability</th>
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</table>
| **CAA**         | Engines >30 l/cyl displ  
• 80% NOx reduction from Tier I  
• HC and CO caps  
• PM measurement  

Engines <30 l/cyl displ  
• EPA Tier 4 limits* | C3 vessels  
• 1,000 ppm S – fuel used inside ECAs  
• 5,000 ppm S – fuel used outside ECAs | Engines installed on US vessels  
Fuel sold in US |
| 40 CFR 1042     |                                                                          |                                           |
| 40 CFR 80       |                                                                          |                                           |
| **Annex VI - ECA** | Engines >130 kW  
Tier III: 80% reduction NOx from Tier I | 1,000 ppm S limit | All OGV operated in ECAs |
| 40 CFR 1043     |                                                                          |                                           |
| 40 CFR 80       |                                                                          |                                           |
| **Annex VI - Global** | Engines >130 kW  
Tier II: 20% NOx reduction from Tier I | 5,000 ppm S limit | All OGV operated outside ECAs |
| 40 CFR 1043     |                                                                          |                                           |
| 40 CFR 80       |                                                                          |                                           |

*Auxiliary engines on US-flag C3 vessels can comply with either CAA Tier 4 or Annex VI Tier III (to simplify foreign port state control inspections)*
• EPA’s CAA and Annex VI both have engine remanufacture programs
  • They cover different engines, focus on different pollutants

• CAA: 40 CFR 1042, Subpart I
  • Engines >600 kW, built from 1973 through Tier 2
  • Applies at time of remanufacture, if a certified reman kit is available
    • Replace all cylinder liners, either all at once or over a 5-year period
  • 25% reduction in PM
    • Kits subject to a cost cap of $45K/ton PM

• MARPOL Annex VI: Regulation 13.7
  • Engines >5,000 kW and > 90 l/cyl displacement, built 1990-1999
  • Applies at time of vessel survey (renewal or intermediate) if there is an approved method available
  • Tier I NOx limits
Compliance and Enforcement

- **Engines**
  - EPA has sole authority to certify engines: Certificate of Conformity (CoC), Engine International Air Pollution Prevention (EIAPP) Certificate
  - Compliance and enforcement
    - Engine and vessel manufacturers: EPA (OECA)
    - Vessel compliance: USCG with EPA assistance

- **Fuels**
  - Fuel providers: EPA (OECA)
  - Vessel compliance: USCG with EPA assistance
Transition to Tier III NOx

• OGV turnover to Tier III is slow
  • Only applies to ships that operate in ECAs
  • Applicability is based on keel lay date
  • Long service lives

• Very few vessels built beginning 2016 have Tier III engines
  • Originally, Tier III was meant to be retroactive, applying to engines on any vessel built beginning 2016 regardless of when a NOx ECA is designated
  • 2014 amendment changed this: Tier III effective date now tied to ECA designation date
  • NOx ECAs for Baltic and North Sea apply to 2021 and later vessels

• IMO’s Marine Environment Protection Committee is focused on climate change regulations and is not currently working on additional NOx limits
IMO GHG Activities

• Initial IMO GHG strategy adopted in 2018; 3 parts

1. More stringent Energy Efficiency Design Index for new ships
   • Pulled ahead Phase 3 EEDI (30-50% improvement from baseline)
   • Currently considering new Phase 4 EEDI
   • Result: new ships have less total power

2. Reduce CO2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008
   • Design index (EEXI) for existing ships in EEDI categories
   • Carbon Intensity Indicator for all ships >5,000 GT
   • Amendments approved in November 2020, expected to be adopted in June 2021 – would be effective April 2023
   • Main compliance measure is expected to be speed reduction

\[
EEDI = \frac{P \cdot SFC \cdot C_f}{DWT \cdot V_{ref}}
\]
IMO GHG Activities (cont.)

3. Peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 whilst pursuing efforts towards phasing them out as called for in the Vision as a point on a pathway of CO2 emissions reduction consistent with the Paris Agreement temperature goals

• Committee will soon begin considering medium- and long-term measures to achieve this goal
• Some technologies to achieve long-term goal have potential to reduce criteria pollutants (e.g., hydrogen)
• In addition to the Initial IMO GHG strategy, there are 3 other important GHG actions:

  • 4th IMO GHG study
    • Estimates 10% increase in OGV GHG emissions from 2012 to 2018 (2.9% of global anthropogenic emissions)
    • Over the same time period, the study estimates a 2.5% and 4.0% increase in NOx and PM2.5, respectively

  • IMO Fuel Consumption Database
    • Ships >5,000 GT report annual fuel consumption, operating data
    • Use this data to inform future energy efficiency requirements, as part of a 3-step program

  • Ship Energy Efficiency Management Plan
    • Ships to develop plan to evaluate, track, improve energy efficiency
    • SEEMP is mandatory; current amendments will require approval and SEEMP will be enforceable
Questions?

Wednesday, February 3, 2021, 1:30 p.m.

Presentation by:
Michael J. Samulski, LMAC Director
Assessment and Standards Division
EPA Office of Transportation and Air Quality
Pacific Rim Initiative for Maritime Emission Reductions — PRIMER —

a Multi-Regional Clean Vessel Incentive Framework

2022 AQMP OGV Working Group (02/03/2021)
PRIMER Concept

- Trans-Pacific partnerships of multiple port regions around the Pacific Rim
- Coordinated efforts to incentivize cleaner ocean-going vessels (OGV) on shared routes

PRIMER’s Main Focus: Transit Emissions

OGV NOx Emissions Inventory for South Coast AQMD (2016 SIP - out to 100 nautical miles)*

(*Adjusted by CARB’s At-Berth Amendment Estimates)
Emissions Occur While Ships Transit Nearshore

Note: Lighter colors denote faster speeds.
Source: EERA Analysis of the 2016 Marine Cadastre data for the South Coast AQMD.
OGV NOx Reduction Pathways for Transit Emissions

**IMO Tier III Technologies**
- Mandatory for newbuilds operating in NOx ECAs
- Certified & market ready (current options: SCR, EGR, and Otto Cycle LNG)
- Large capital investment
- Retrofit technically possible in some cases

**Tier II+ Retrofit Technologies**
- Technologies developed (e.g., water in fuel emulsion)
- Verification needed
- Lower capital investment and potentially more cost-effective than Tier III
- Voluntary: currently no market demand

**Efficiency Measures**
- Voluntary or required by IMO for newbuilds; potential new requirements for in-use fleets
- Reduce fuel consumption, thus GHG and potentially NOx emissions
- Certain measures may increase NOx emission rate (g/kWh)
- Could be more difficult to track and verify NOx reductions
Few Tier III Ships Have Been Deployed to the Transpacific Trade Lane

* OGVs with pre-2000 keels may be subject to Tier I requirements if a retrofit kit is commercially available and suitable for the vessel’s engine and other specs.

Source: South Coast AQMD staff analysis of the IHS-Seaweb data.
Still Few Tier III in the Global Fleet of Transoceanic Container Ships

Serving local/regional routes or as feeder vessels in Asia

Suitable for transoceanic services*

* Including 4 Iran-flagged container ships that may not be Tier III. The remaining 9 ships belong to two groups of sister ships, and some—if not all—of the ships from each group have visited one or more U.S. ports since maiden voyage. Additional newly constructed Tier III ships have come in service in CY 2020.

Source: South Coast AQMD staff analysis of the IHS-Seaweb data.
NOx Emission Source Categories in Ports of LA/LB (2019)

Heavy Duty Vehicles 20%
Locomotives 12%
Harbor Craft 11%
Cargo Handling Equipment 5%
Ocean Going Vessels 53%
Container Ship 27%
Tanker 12%
Cruise 6%
Others 7%

OGV share was 38% in 2005

Note: OGV emissions reported by the Ports of Long Beach and Los Angeles consisted mostly of emissions from vessel movements within the 40 nautical mile arc from Point Fermin whereas California’s State Implementation Plan inventory includes OGV emissions within 100 nautical miles from the coast. Data sources: Ports of Long Beach and Los Angeles.
Opportunity: Transpacific Containerized Cargo Movement

Note: Frequent callers are defined for analytical purposes as ocean-going vessels making 5 or more calls per year at POLA, POLB, or El Segundo, and 5 or more calls in the same year at one or more of the large-scale East and Southeast Asian ports.
Source: South Coast AQMD staff analysis of the IHS Seaweb data.
Transpacific Frequent Caller Container Ships in 2019

Note: Frequent callers are defined for analytical purposes as ocean-going vessels making 5 or more calls per year at POLA/LB, and 5 or more calls in the same year at one or more of the large-scale East and Southeast Asian ports. Source: South Coast AQMD staff analysis of the IHS-Seaweb data.
PRIMER: Transpacific Partnerships for Cleaner OGVs

• Partner with local/regional authorities to coordinate individual programs to attract cleaner OGVs on shared routes
  • Harmonize programs requirements in overlapping areas
  • Voluntary incentive-based programs: monetary or non-monetary
  • Incentives provided on a per-port-call basis – most suitable for non-captive OGV fleet

• Each port’s individual program is then leveraged to encourage changes in shipping behavior
  • Deployment of existing and new Tier III OGVs to shared routes
  • Encourage construction of Tier III vessels on pre-2016 keels
  • Encourage retrofits of existing vessels to be cleaner than Tier II
Retrofit Technologies are Key

• Slow fleet turnover to Tier III
• Significant NOx reductions possible through retrofits
  • Tier I/II to Tier II+/III: 10-80%
  • Developed but require demonstration, validation, and emission reduction verification
  • Retrofit priority: optimizing abatement performance for nearshore operations
• Can contribute to advancing NOx control technology development for low-to-zero carbon fuels in ICE applications
• Suitable retrofit technologies should have minimal dis-benefits in GHG and directly emitted PM
• OGV tech demo at South Coast AQMD
  • Water in Fuel Emulsion: launched in 2020, in partnership with MAN, MSC, Ports of Los Angeles and Long Beach
  • Other retrofit and emissions testing/monitoring projects under active discussion
Optimizing Per-Port-Call Incentive

• Optimal level of per-port-call incentive depends on:
  • *Cost of technology*: capital investment + operating and maintenance expenditures
  • *Payback period*: length of time to reach break-even point of technology investment
  • *Port calls*: total calls made across all partnering port regions within the payback period

• Draft estimates derived to entice adoption of cleaner technology by OGVs frequently calling Pacific Rim ports
  • Much more cost-effective than stationary source emission controls
  • Currently refining assumptions and data inputs – will share finalized study results
PRIMER’s Current Status in a Nutshell

Engagement with Asia
- Ongoing discussions with officials in China and various Chinese port regions
- Expanding engagement with officials in Japan and South Korea
- Promoting PRIMER at high-level policy forums in Asia

Technical analysis to support program development
- Researching ship deployment and movement patterns
- Finalizing incentive optimization analysis
- Preparing a PRIMER policy paper

Industry partnerships
- Partnering with engine manufacturers, shipping lines, ports and other stakeholders in demonstrating OGV retrofit technology
- Continuing discussions with vessel operators to seek feedback for PRIMER
PRIMER
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