Assessing Ship Emissions Reduction Strategies

Pacific Ports Clean Air Collaborative Conference
March 2018
San Pedro, California
Still Need to do More

2020 PM$_{2.5}$ Estimated Reduction from ECA

2020 Ozone Estimated Reduction from ECA
Ship Emissions 101

- **Ship Groups**
  - Container
  - Non-Container

- **Emissions Sources**
  - Propulsion engines
  - Auxiliary engines
  - Auxiliary boilers

- **Operational Modes**
  - Transit
  - Maneuvering
  - At-Berth
  - At-Anchorage
What are the Reduction Strategies?

- **Ship-Based Technologies**
  - ✔ Engine & boiler technologies – exhaust gas recirculation, de-rating, IMO Tier 3, etc.
  - ✔ After-treatment – scrubbers, SCRs, etc.
  - ✔ Energy – alternative fuels, shore power, etc.

- **Non-Ship Based Technologies**
  - ✔ Barge-based after-treatment technologies
  - ✔ Land-based after-treatment technologies

- **Efficiency-Based**
  - ✔ Operational efficiencies – VSR, reduced time at-berth or anchorage, larger cleaner ships, etc.
Efficiency Improvements

Containership & Noncontainership Arrivals

<table>
<thead>
<tr>
<th>Year</th>
<th>Containerships</th>
<th>Non-Containerships</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>1,479</td>
<td>1,037</td>
<td>2,516</td>
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<tr>
<td>2006</td>
<td>1,632</td>
<td>1,075</td>
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<td>2007</td>
<td>1,577</td>
<td>951</td>
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<td>2008</td>
<td>1,459</td>
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<td>2009</td>
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<td>655</td>
<td>1,910</td>
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<tr>
<td>2010</td>
<td>1,355</td>
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<td>2011</td>
<td>1,376</td>
<td>696</td>
<td>1,972</td>
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<td>2012</td>
<td>1,370</td>
<td>598</td>
<td>1,968</td>
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<td>2013</td>
<td>1,465</td>
<td>568</td>
<td>1,933</td>
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<tr>
<td>2014</td>
<td>1,413</td>
<td>549</td>
<td>1,962</td>
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<tr>
<td>2015</td>
<td>1,146</td>
<td>628</td>
<td>1,774</td>
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<tr>
<td>2016</td>
<td>1,251</td>
<td>614</td>
<td>1,865</td>
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</tbody>
</table>
Efficiency Improvements

Average Container Ship Call Density, teus/call

- 2005: 5,061
- 2006: 5,190
- 2007: 5,298
- 2008: 5,380
- 2009: 4,981
- 2010: 5,780
- 2011: 5,771
- 2012: 5,896
- 2013: 5,378
- 2014: 5,902
- 2015: 7,121
- 2016: 7,080
What are we Currently Doing?

- **Transit Emissions Reduction Strategies**
  - Fuel: CARB/ECA - 0.1% or Alt fuel (LNG)
  - Engines: IMO Tier 3
  - Speed: Vessel Speed Reduction (VSR)
  - Incentive programs: Environmental Ship Index (ESI)/Green ship program

- **At-Berth Emissions Reduction Strategies**
  - Fuel: CARB/ECA - 0.1% or Alt fuel (LNG)
  - Engines: IMO Tier 3
  - Shore power
  - Incentives

- **Fleet Efficiency Improvements**
  - Maersk TAP Project
Containership NOx Trends

2005-2016 Containership NOx Emissions by Mode, tons

- Transit
- Maneuvering
- Berth
- Anchorage
Non-Containership NOx Trends

2005-2016 Non-Containership NOx Emissions by Mode, tons

- Transit
- Maneuvering
- Berth
- Anchorage
Containership DPM Trends

2005-2016 Containership DPM Emissions by Mode, tons

- Transit
- Maneuvering
- Berth
- Anchorage
Non-Containership DPM Trends

2005-2016 Non-Containership DPM Emissions by Mode, tons

- Transit
- Maneuvering
- Berth
- Anchorage
How do we get to the Next Level?

- Transit Emissions Reduction Strategies
  - Ship-based strategies – cleaner engines, scrubbers, fuel, other?

- At-Berth Emissions Reduction Strategies
  - Shore & barge-based systems

- Fleet Efficiency Improvements
  - Optimization of operations
Scrubber 101

- Dry Scrubbers
- Wet Scrubber Types
  - Open Loop
  - Closed Loop
  - Hybrid
- Emissions Reduced
  - SOx 98% PM 80% NOx 5%
- Emissions Controlled
  - Transit (all)
  - At-Berth & At-Anchorage
- Projected Scrubber Penetration
  - IMO 2020 Global Fuel Cap
  - IMO MEPC 70/INF.6
    - 3.8k by 2020
    - Max 3k ships could be retrofitted annually
Scrubber 101

### Strengths
- IMO 2020 Global Fuel Cap will increase installations
- Significant PM & SOx reductions
- Reduces transit, at-berth, & at-anchorage emissions
- No extra at-berth infrastructure needs
- Operationally unobtrusive once installed

### Limitations
- No significant NOx reductions
- Waste stream disposal
- High retrofit costs per ship
- Not cost effective for smaller ships
- High uncertainty on number of ships calling each year equipped with scrubbers
- Might need CARB verification of emissions reduction levels
Barge-Based Capture Systems 101

- Barge-Based Systems
  - AMECS - ACTI
  - METS-1 - CAEM
- Emissions Reduced
  - NOx 72-80%
  - PM 76-86%
- Emissions Controlled
  - At-Berth (one to two engines)
- Projected Penetration
  - Currently two systems
  - Third company coming
Barge-Based Capture Systems 101

**Strengths**
- Certified alternative to CARB shorepower regulation
- 72-86% reductions for NOx & PM
- Does not require ship-board infrastructure
- Could apply to most vessel types
- No extra at-berth infrastructure needs
- Potentially able to reduce anchorage emissions

**Limitations**
- Only reduces at-berth auxiliary engine emissions
- Barge systems very expensive
- Potential operational & navigation limitations
- Safety issues with some vessel types
- Only CARB verified for specific range of containerships
- Will need CARB verification for each vessel class
- Limited industry acceptance
- Labor intensive
- Vessels cannot bunker
- Waste stream disposal
Shorepower 101

- **Emissions Reduced**
  - All pollutants reduced to zero at ship while plugged in
  - Total GHG reduction depends on grid makeup

- **Emissions Controlled**
  - At-Berth (all engines)
  - Does not control auxiliary boiler emissions

- **Projected Penetration**
  - CARB shorepower rule
  - 2018 – 80% of regulated fleets (container, reefer, & cruise)
Shorepower 101

Strengths

- CARB shorepower regulation
- Zero emissions at ship when plugged in
- International standards
- Once infrastructure is in place, generally easy to operate
- Shore-side infrastructure has long life
- Ships can bunker while connected

Limitations

- Only reduces at-berth auxiliary engine emissions
- Most expensive reduction strategy ranging: $0.75-$2M/ship & $7-$29M/berth
- Requires a high number of ships to be retrofitted
- Only mandated in CA
- Vault locations limits where ships can berth
- Not cost effective for non-liner services (tramp/spot)
- Stranded assets syndrome
- Does reduce emissions during connect/disconnect
- Moderate labor required
- Expensive onboard maintenance
Summary & Conclusions

- No ‘Silver Bullet’
  - Solution based on numerous variables – Which emissions? Which mode(s)? Which emission sources? Ship-based or non-ship-based?

- Currently implementing the most rigorous ship measures at any port

- Ultimately best solution is for new clean IMO Tier 3 fleet
  - We don’t think this will happen until the late 2030s to mid 2040s
Looking forward – What can we do until the fleet is turned over?

- Continue current measures including VSR, shorepower, fuel switching, ESI, etc.
- Optimize operational efficiencies both ship and terminal side.
- From a port perspective, land-based capture systems where applicable would be better solution than barge-based.
- Barge-based systems good for plugging holes when shorepower or land-based systems are not available.
- Track scrubber & other (SCR, engine and scrubber mods) after treatment technology uptake.