Marine Emissions Reduction Opportunities

Cross Sound Ferry Repowering

January 20, 2009
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Today’s Agenda

- The need for emissions reduction
- Marine vessel emissions
- Marine emissions reduction options
  - Retrofit
  - Repower
- Marine emissions reduction programs
  - PANYNJ
  - Cross Sound Ferry Repower
Need for Emissions Reductions

NY-NJ-CT-LI Nonattainment Area

- Must reduce both NO\textsubscript{x} and PM to achieve attainment with NAAQS
- Particular concern with diesel PM due to significant negative health effects
  - Asthma
  - Premature mortality
Why Focus on Marine Emissions?

NEXT 20 YRS:

Stricter Standards for onroad trucks and nonroad equipment will produce significant reductions as the fleets turn over.

Marine & locomotive sectors will dominate remaining diesel PM sources.
Types of Marine Vessels

Ocean-Going Vessels (Cruise Ships, Tankers, Cargo)
- Very large, unique diesel engines, 10,000 – 100,000 hp
- Burn heavy, residual “bunker fuel”
- *No emissions retrofit options exist for these vessels*

Coastal Vessels (Tugs, Ferries, Fishing/Work Boats)
- Use locomotive or large construction-type diesel engines, 500 – 4000 hp
- Typically burn #2 distillate fuel
- Can operate for 5,000 hrs per year or more, and burn more than 500,000 gallons of fuel annually
- Many in-use vessels have unregulated, Tier 0 engines
- *Both retrofit and repowering options exist for these vessels*
### Marine Vessel Emissions Inventory

#### New York Harbor

<table>
<thead>
<tr>
<th>VESSEL TYPE</th>
<th>Number</th>
<th>Annual Emissions (tons)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>NOx</td>
<td>PM</td>
</tr>
<tr>
<td>Ocean-going</td>
<td>1,425</td>
<td>4,139</td>
<td>234</td>
<td></td>
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<tr>
<td>Coastal Vessels</td>
<td></td>
<td>Ferries</td>
<td>1,484</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tug Boats</td>
<td>5,024</td>
<td>191</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excursion Vessels</td>
<td>871</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Government</td>
<td>168</td>
<td>5</td>
</tr>
</tbody>
</table>

Coastal vessels are less numerous but have greater effect on local air quality because they are generally captive to a region.
Emissions Reduction Opportunities

Coastal Marine Vessels

- Many vessels with older, unregulated engines but significant remaining life
- Significant contributor to diesel emissions inventory in port cities (i.e. NYC)
  - Individual vessels are significant sources (High HP, high load factor, high annual usage)
  - Captive to a specific region
- Cost-effective reduction options are available
  - Repower and/or DOC retrofit
- Improved fuel economy of new engines (repower) provides significant CO$_2$/GHG co-benefits

Coastal vessels are some of the most effective and cost-effective targets for NO$_x$ and PM reduction efforts
Cost Effective Emissions Reductions

TO REDUCE ~4 ANNUAL TONS OF PM:

- Repower 1 3000 HP marine vessel: $950,000
- Retrofit 20 switcher locomotives with DOC: $1,000,000
- Retrofit 100 - 200 construction engines with DPF: $1,000,000+
- Retrofit 200 - 400 onroad trucks with DPF: $1,700,000+

A marine engine repower will also reduce NOx and CO2 significantly, while the other approaches do not.
Coastal Marine Vessels

PM Retrofit Options

- Passive DPFs are generally not commercially available for marine engines
  - Active DPFs are available, but have mostly been installed in Europe, in conjunction with SCR
- DOCs are becoming available for marine engines, though there have been relatively few installations to date
  - A DOC will reduce PM by 25% and VOC by 25%
  - A DOC for a 3000 hp marine engine will cost approximately $50,000
Coastal Marine Vessels

Changing EPA Emission Standards

Current availability of cleaner Tier 2 engines opens up an opportunity to achieve significant emissions reductions by repowering older vessels.

<table>
<thead>
<tr>
<th>New Engine Standard</th>
<th>First Applied (Model Year)</th>
<th>Emissions Limits (g/kwh)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unregulated</td>
<td>Prior to 2004</td>
<td>~20.0</td>
<td>~0.70</td>
</tr>
<tr>
<td>EPA Tier 1 (IMO)</td>
<td>2004</td>
<td>11.5</td>
<td>~.50</td>
</tr>
<tr>
<td>EPA Tier 2</td>
<td>2007</td>
<td>7.8</td>
<td>0.27</td>
</tr>
<tr>
<td>EPA Tier 3</td>
<td>2013</td>
<td>6.2</td>
<td>0.14</td>
</tr>
<tr>
<td>EPA Tier 4</td>
<td>2016</td>
<td>1.8</td>
<td>0.04</td>
</tr>
</tbody>
</table>
New Tier 2 vs. Older Marine Engines

Technical changes yield lower emissions

- Electronic fuel control (*lower NO\textsubscript{x} & PM; lower fuel consumption*)
- Better piston rings for lower lube oil consumption (*lower PM*)
- Improved turbocharger (*lower NO\textsubscript{x} and PM*)
- Improved charge-air cooling (*lower NO\textsubscript{x}*).

Tier 2 engines generally DO NOT use after-treatment. Adding a DOC to a repower yields even greater PM reductions.
Coastal Marine Vessels

Repowering

- Many in-use marine vessels have unregulated Tier 0 engines
- Cleaner, Tier 2-compliant engines are now available
  - 66% lower PM and VOC emissions than Tier 0
  - 25% lower NOx emissions than Tier 0
  - 8 – 12% lower fuel use than Tier 0
- Repowering a marine vessel with a new 3000 hp Tier 2 engine will cost approximately $1,000,000
- Annual fuel savings for a large tug will pay back repowering costs in 7 – 8 years
  - Many vessel owners will repower if given a 50% capital subsidy (4 year pay back on owner’s costs)
Coastal Marine Vessels

Repowering Process

Replacing engines

Acceptance tests

Destroying Old Engines
## Comparing Emissions Reduction Projects

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Reductions [tpy/unit]</th>
<th>Project Cost [$/unit]</th>
<th>NOx &amp; VOC Offset Value* [$/unit]</th>
<th>PM$_{2.5}$ Offset Cost [$/tpy]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vehicle Retrofit &amp; Repower Options</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marine Repower + DOC</td>
<td>1.26 27.0 2.0</td>
<td>$350,000 **</td>
<td>$290,000</td>
<td>$47,000</td>
</tr>
<tr>
<td>Marine Vessel DOC Retrofit</td>
<td>0.63 - 0.98</td>
<td>$50,000</td>
<td>$9,800</td>
<td>$64,000</td>
</tr>
<tr>
<td>LH Locomotive DOC Retrofit</td>
<td>0.29 - 0.65</td>
<td>$50,000</td>
<td>$6,500</td>
<td>$150,000</td>
</tr>
<tr>
<td>Switcher Loco DOC Retrofit</td>
<td>0.19 - 0.19</td>
<td>$50,000</td>
<td>$1,900</td>
<td>$250,000</td>
</tr>
<tr>
<td>Gen-set Switcher Loco</td>
<td>0.73 12.1 0.73</td>
<td>$825,000</td>
<td>$128,300</td>
<td>$950,000</td>
</tr>
<tr>
<td>Onroad Vehicle Retrofits</td>
<td>0.02 0.7 0.04</td>
<td>Up to $20,000</td>
<td>Up to $7,000</td>
<td>$0.3 - $29 mill</td>
</tr>
<tr>
<td>Construction Retrofits</td>
<td>0.04 - 0.04</td>
<td>Up to $25,000</td>
<td>Up to $5,000</td>
<td>$0.3 - $2.8 mill</td>
</tr>
<tr>
<td>Cruise Ship Shore Power</td>
<td>6.5 95.3 6.5</td>
<td>$8 - $16 mill</td>
<td>$1 million</td>
<td>$0.7 - $1.6 mill</td>
</tr>
<tr>
<td><strong>Idle Reduction Options</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switcher Locomotive</td>
<td>0.04 1.3 0.04</td>
<td>$20,000***</td>
<td>$13,400</td>
<td>$165,000</td>
</tr>
<tr>
<td>Sleeper Cab-equipped Truck</td>
<td>0.01 0.3 0.01</td>
<td>$5,000***</td>
<td>$3,100</td>
<td>$190,000</td>
</tr>
</tbody>
</table>

* Assumes that NOx and VOC offsets have a value of $10,000/tpy
** Assumes a capital cost subsidy high enough to provide vessel owner a 4-yr pay back based on annual fuel savings.
*** Assumes a capital cost subsidy high enough to provide vehicle owner a 1-yr pay back based on annual fuel savings.
The Port of NY & NJ is located in an ozone Non-Attainment Area

Dredging activities to deepen shipping channels will result in NOx emissions of ~100 tpy to ~700 tpy

NOx reductions are required to offset the dredging emissions

Desire to reduce emissions from sources geographically and chronologically coincident

PANYNJ has funded marine emissions reduction programs

- Staten Island Ferry Retrofit/Upgrade
- Commercial marine engine replacements
Staten Island Ferry

Alice Austen SCR Demo

- Proof of concept demonstration
- Retrofit Alice Austen with
  - Selective Catalytic Reduction (SCR)
  - Diesel Oxidation catalyst (DOC)
- Applied to two CAT 3516 main engines
- Requires urea reductant
  - 32% solution in water
- ~70% NOx reduction and 25% PM reduction
## Engine Upgrades

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Technology</th>
<th>NOx Reduction (tpy)</th>
<th>NOx Reduction (%)</th>
<th>PM Reduction (tpy)</th>
<th>PM Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barberi</td>
<td>Tier 1 upgrade</td>
<td>124</td>
<td>48%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Newhouse</td>
<td>Tier 1 upgrade</td>
<td>124</td>
<td>48%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Kennedy</td>
<td>Tier 1 upgrade w/ UL</td>
<td>96</td>
<td>42%</td>
<td>2.3</td>
<td>30%</td>
</tr>
<tr>
<td>Molinari</td>
<td>Tier 2 upgrade w/ UL</td>
<td>70</td>
<td>32%</td>
<td>4.0</td>
<td>44%</td>
</tr>
<tr>
<td>Marchi</td>
<td>Tier 2 upgrade w/ UL</td>
<td>70</td>
<td>32%</td>
<td>4.0</td>
<td>44%</td>
</tr>
<tr>
<td>Spirit of America</td>
<td>Tier 2 upgrade w/ UL</td>
<td>70</td>
<td>32%</td>
<td>4.0</td>
<td>44%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>554</strong></td>
<td></td>
<td><strong>14.3</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Completed**  **Planned**
## Marine Engine Replacement

### Tugs & Excursion Vessels

<table>
<thead>
<tr>
<th>Program</th>
<th>Number of Vessels</th>
<th>Annual NOx Reduction (ton)</th>
<th>Average Cost ($/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KVK Tugs</td>
<td>2</td>
<td>51</td>
<td>$1,620</td>
</tr>
<tr>
<td>TERP</td>
<td>3</td>
<td>171</td>
<td>$1,170</td>
</tr>
<tr>
<td>MVERP</td>
<td>8</td>
<td>177</td>
<td>$1,550</td>
</tr>
<tr>
<td>MVERP2</td>
<td>10±*</td>
<td>240±*</td>
<td>$1,400±*</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>23</strong></td>
<td><strong>643</strong></td>
<td><strong>$1,400</strong></td>
</tr>
</tbody>
</table>

* Currently projected totals; no awards have been made to date.

PANYNJ pays for up to 100% of new engine cost – owner pays for installation
Potential Marine Vessel Projects

MAJOR FERRY & TUG FLEETS IN THE NORTHEAST
Requirements for a Successful Project

WILLING PARTNER

Cross Sound Ferry

FUNDING

NYMTC?

VIABLE & COST EFFECTIVE TECHNOLOGY

Marine Repower
Cross Sound Ferry

Proposed Repower Project

- Repower up to three vessels with new Tier 2+ engines
  - Include DOC as part of repower
- Total cost - $8 million
  - Cross Sound Ferry to provide 50% of total cost
  - Need to find $1 million in grant funding for each vessel
- Will significantly reduce annual emissions
  - 202 tons NO$_x$
  - 12.0 tons PM
  - 2,700 tons CO$_2$
Cross Sound Ferry - Overview

- Passenger and vehicle ferry service between New London, CT and Orient Point, NY
  - Carry passenger cars and heavy commercial trucks
- Fleet consists of 8 vessels
  - 7 passenger and vehicle service ferries
  - 1 high-speed ferry
- Each one-way trip covers a distance of 16 miles and takes approximately 1 hour and 20 minutes
- Over 12,000 annual one-way trips
- Over 2 million gallons of diesel fuel used annually
Cross Sound Ferry Service
## Cross Sound Ferry Fleet

<table>
<thead>
<tr>
<th>VESSEL NAME</th>
<th>ENGINES</th>
<th>HP</th>
<th>CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CARS</td>
<td>PASS</td>
</tr>
<tr>
<td>MARY ELLEN</td>
<td>(2) Caterpillar 3516</td>
<td>1,550 each</td>
<td>85</td>
</tr>
<tr>
<td>SUSAN ANNE</td>
<td>(2) EMD 12-645E7B</td>
<td>2,300 each</td>
<td>80</td>
</tr>
<tr>
<td>CAPE HENLOPEN</td>
<td>(2) EMD 12-645E2</td>
<td>1,500 each</td>
<td>90</td>
</tr>
<tr>
<td>JOHN H</td>
<td>(2) EMD 12-645E2</td>
<td>1,500 each</td>
<td>120</td>
</tr>
<tr>
<td>NEW LONDON</td>
<td>(2) Cummins KTA38MZ</td>
<td>1,200 each</td>
<td>60</td>
</tr>
<tr>
<td>NORTH STAR</td>
<td>(2) Caterpillar D398</td>
<td>900 each</td>
<td>35</td>
</tr>
<tr>
<td>CARIBBEAN</td>
<td>(2) DDC 12-71</td>
<td>360 each</td>
<td>22</td>
</tr>
<tr>
<td>SEA JET</td>
<td>(2) Deutz 620</td>
<td>2,500 each</td>
<td>0</td>
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</tbody>
</table>

REPOWER CANDIDATES
CURRENTLY BEING REPOWERED
## Cross Sound Ferry

### Potential Repower Emissions Savings

<table>
<thead>
<tr>
<th>VESSEL</th>
<th>NOx (tons/year)</th>
<th>PM (tons/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current</td>
<td>After Repower</td>
</tr>
<tr>
<td>JOHN H</td>
<td>141</td>
<td>48</td>
</tr>
<tr>
<td>MARY ELLEN</td>
<td>58</td>
<td>31</td>
</tr>
<tr>
<td>SUSAN ANNE</td>
<td>58</td>
<td>31</td>
</tr>
<tr>
<td>CAPE HENLOOPEN</td>
<td>84</td>
<td>29</td>
</tr>
<tr>
<td>TOTAL</td>
<td>341</td>
<td>139</td>
</tr>
</tbody>
</table>
Cross Sound Ferry

Repower Cost Effectiveness - Example

Vessel Mary Ellen:

Replace:

(2) EMD 12645H engines
with
(2) GE 1250 engines

$1,500,000 engines
$ 50,000 DOCs
$250,000 installation
$200,000 Project Mgmnt
$2,000,000 TOTAL

Annual Emissions Reductions:
NOx = 93 tons
PM = 3.9 tons

Cost of Reductions:

Project Cost: $2 million
— Cost Share $1 million
REQUESTED FUNDING: $1 million
— Value of NOx* $930,000

COST OF PM REDUCED $ 70,000

$70,000 ÷ 2.9 tpy = $24,000/tpy PM

* Assuming a market value of $10,000/tpy for NOx
Cross Sound Ferry Repower

Reasons for NYMTC Support

- Enforceable, localized PM & NOx reductions
  - Repowered vessels will (can) not leave the region
- Manageable & cost effective
  - Large reductions from a small number of vehicles (similar to a stationary source)
  - Pay back to operator from fuel savings limits grant funding required to make a voluntary program work
- CSF supports CMAQ congestion mitigation goals
  - Reduced traffic through Manhattan to reach LI
- Not eligible for PANYNJ marine program funding
  - Not captive to NY Harbor
Contact M.J. Bradley & Associates

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