U.S.-Mexico Fuel Switching Demonstration on Ocean Going Vessels in the Gulf of Mexico and Implications for ECA

Angela Bandemehr
U.S. EPA
Office of Global Affairs and Policy

Karen Riggs, Battelle, Presenter

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Background

Contribution of shipping to PM2.5 concentrations (in $\mu$g/m3)

Project Partners

- Port of Houston Authority
- U.S. Maritime Administration
- Mexican Ministry of Environment/PEMEX
- Maersk Line/Hamburg Süd
- ICF, University of California at Riverside, and Battelle
Project Goals

- Demonstrate Switching to Low Sulfur Distillate Fuels in Gulf of Mexico
- Measure Emission Reductions
- Estimate Emission Reductions at Mexican Ports from Fuel Switching
- Estimate Health and Environmental Benefits from Fuel Switching
- Raise Awareness of upcoming Emission Control Area
North American Emission Control Area
Caribbean ECA
2020 Potential ECA PM$_{2.5}$ Reductions

Legend

- $\leq 0.01$ mg/m$^3$
- $> 0.01$ to $\leq 0.03$
- $> 0.03$ to $\leq 0.05$
- $> 0.05$ to $\leq 0.1$
- $> 0.1$ to $\leq 0.25$
- $> 0.25$ to $\leq 0.5$
- $> 0.5$ to $\leq 1.0$
- $> 1.0$ to $\leq 2.0$
- $> 2.0$ to $\leq 4.1$

outside 12km grids
2020 Potential Sulfur Deposition Reductions

Improvements in deposition for marine and terrestrial ecosystems
Project Design

- Demonstration of fuel switching on two ocean-going vessels of Maersk and Hamburg Süd
  - Fuel switched from high sulfur heavy fuel oil (>3.0% sulfur) to marine gas oil (<0.1% sulfur)
- Stack emission monitoring
- Modeling – Port emission inventories, air quality, loadings
Maersk Demonstration

- Maersk Roubaix
  - Container Ship – 1118 TEUs
  - 9.7 MW Propulsion Engine
  - Medium Speed Engine
- Switched from Bunker Fuel (3.3% Sulfur) to Distillate Fuel (0.14% Sulfur) 24 nm from shore at Port of Houston and Port of Progreso, Mexico
- Calculated Emission Reductions per call at Progreso
  - 27 kg NOx (7%)
  - 47 kg PM$_{2.5}$ (81%)
  - 479 kg SOx (88%)
  - 2% increase in operating costs
Hamburg Süd Demonstration

- **Cap San Lorenzo**
  - Container Ship – 3,739 TEUs
  - 28.8 MW Propulsion Engine
  - Slow Speed Engine
- Represents 40% of container ships and 20% of all ships calling on Veracruz and Altamira
- Stack emissions measured in port and at sea at Altamira, Veracruz and Houston
Observed Operational Findings

- No significant issues encountered
- No additional training needed for crew involved in this demonstration
- Cost and Availability of Low Sulfur Fuel
  - Additional cost for fuel switch represents less than 2% of voyage costs
  - Demonstration fuel available in U.S.
- Tank Size
  - Sufficient capacity to carry MGO for demonstration
- Fuel Switching Procedure
  - Boilers must be slowly turned down
  - Switch over took about an hour
Emission Sampling

- Measurements of in-use stack emissions and their reduction from fuel switching
  - MARPOL NOx Technical Code (NTC) and other protocols
  - Specific engine loads and transient operations, main and auxiliary engines

Pollutants measured
- NOx, CO, CO₂ continuously
- PM continuously and speciated PM (EC, OC) with discrete filter samples
- Measure SO₂ and calculate SOx from fuel measurements
Propulsion Engine Results – SO2

![Graph showing emission factors for different speeds and fuel types.]

- HFO (3.79% S)
- MGO (0.01% S)
Propulsion Engine Results – PM$_{2.5}$

- Emission Factor (g/kWh)
  - HFO (3.79% S)
  - MGO (0.01% S)
Fuel Switching Emissions
HFO -> MGO

HFO to MGO Fuel Switch (CASLO, 4/20/10 0540-0710)
Reductions from Fuel Switching in Port of Veracruz
With 24 nm Boundary

Emission Inventory based on 2005 activity data
Veracruz Emissions by Ship Type

<table>
<thead>
<tr>
<th>Ship Type</th>
<th>PM$_{2.5}$</th>
<th>Tanker</th>
<th>Auto Carrier</th>
<th>Bulk Carrier</th>
<th>General</th>
<th>Container</th>
</tr>
</thead>
<tbody>
<tr>
<td>RoRo</td>
<td>3%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reefer</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM$_{2.5}$</td>
<td></td>
<td></td>
<td>19%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| SOx        |            |        |              |              |         |           |
| RoRo       | 3%         |        |              |              |         |           |
| Reefer     | 0%         |        |              |              |         |           |
| SOx        |            |        |              |              |         |           |

| Container | 39%        | Bulk Carrier | 17%         | General       | 16%     | Container | 38%        |
|-----------|------------|--------------|-------------|--------------|---------|-----------|
| Tanker    |            |              |             |              |         |           |
| Auto Carrier |         |              |             |              |         |           |
| Bulk Carrier |         |              |             |              |         |           |
| General   |            |              |             |              |         |           |
| Container | 39%        |              |             |              |         |           |
Effect of Fuel Switching Zone Size for Port of Veracruz

- NOx: 4.8x
- PM2.5: 4.4x
- SOx: 4.3x

Emission Reductions (Metric Tonnes)
## Dispersion Modeling

**Estimated Annual Total Deposition of SO\(_2\) to Reefs in Veracruz**

<table>
<thead>
<tr>
<th>Reef</th>
<th>Area</th>
<th>Units</th>
<th>HFO</th>
<th>MGO</th>
<th>Difference</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reef Area 1</td>
<td>Area</td>
<td>m(^2)</td>
<td>283,474,477</td>
<td>0.19</td>
<td>0.01</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Total Annual SO(_2) Flux</td>
<td>g/m(^2)</td>
<td>53,000</td>
<td>1,900</td>
<td>52,000</td>
<td>96%</td>
</tr>
<tr>
<td>Reef Area 2</td>
<td>Area</td>
<td>m(^2)</td>
<td>57,673,276</td>
<td>0.0093</td>
<td>0.00081</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>Total Annual SO(_2) Flux</td>
<td>g/m(^2)</td>
<td>540</td>
<td>47</td>
<td>490</td>
<td>91%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>Total Annual SO(_2) Deposition</td>
<td>kg</td>
<td>54,000</td>
<td>2,000</td>
<td>52,000</td>
<td>96%</td>
</tr>
</tbody>
</table>
Raising Awareness

- Meetings and Workshops
  - Mexico City
  - Veracruz
  - U.S. Gulf States
- Aquarium Kiosk - Video
- Press Releases
- Web site
- Final Report

www.epa.gov/international/fuelswitch.html
Summary

- Fuel switching can significantly reduce PM and SOx emissions
- Fuel switching within 24 nm reduces annual emissions of PM by 78% and SOx by 87% at the Port of Veracruz
- Deposition of SOx on sensitive reefs around Veracruz reduced by 52 Metric Tonnes per year (96%)
- Final Report available at http://www.epa.gov/international/fuelswitch.html
Outcomes

- Awareness of North American ECA and implications for Mexico
- Initiating technical studies needed to determine impacts of an ECA on Mexican public health and environment, if Mexico were to adopt an ECA