Development of a CO₂ Model for Competing Cargo Routes Analysis

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Purpose of the Model

To provide a method for the Panamá Canal Authority to compare CO₂ emissions for cargo transiting the Panamá Canal versus the same cargo using competing routes. Identifies the “greenest route”.

“The complex network of global cargo ship movements” Pablo Kaluza, Andrea Kölzsch, Michael T. Gastner and Bernd Blasius, J. Royal Society: Interface
GHG emissions from shipping primarily stem from fuel consumption – making CO$_2$ the most prominent GHG associated with movement of cargo on oceangoing vessels.

The vast majority of CO$_2$ from the shipping industry is a result of international shipping.

Growth of global commerce requires implementing a variety of reduction techniques to reduce/eliminate CO$_2$ emissions.

The model was constructed to enhance and interact with a dynamic financial route analysis model (PCRCAM).

Endeavor Program Management, Novix S.A., Drewry Shipping Consultants and Cardno TEC worked as a team to develop the CO$_2$ Model of Emissions from Transportation Sector (CO$_2$METS).

3rd Party review and validation by Norfolk Southern Corp.
CO$_2$METS Data Inputs

Emission Sources

Maritime

Ports

Panamá Canal

Inland Transportation (North America)

Rail

Barge

Truck
Primary Data Inputs

Maritime Data Source for Emissions

- Containers
- Dry Bulk
- Reefer
- Liquid Bulk
- Car Carrier

217 Ports

316 cargo/port combinations

Panamá Canal Route Competitiveness Analysis Model (PCRCAM)

Vessel Fuel Consumption

Fuel Consumption

Mobile Source Type

7 World Regions

Primary Data Inputs

Panamá Canal Route Competitiveness Analysis Model (PCRCAM)
Fuel consumption evaluated using data from PCRCAM as well as user inputs
Port Inputs to the CO$_2$METS

- **316 Port/Cargo Combinations**
- **Calculated Port Size**: Small, Medium, Large
- **21 Aggregate Ports**
- **Cargo Handling Equipment**: Power Rating, Duration
- **Port Tugboats**: Power Rating, Duration
- **Cold Ironing**: Duration, Load
- **PCRCAM**
- **7 World Regions**
Panamá Canal Inputs to CO$_2$METS

- Panamá Canal
  - Liquid Bulk Pipeline
  - Canal Tugboats
    - Current Operations
      - Power Rating
      - Duration
    - New Operations
      - Power Rating
      - Duration
  - Canal Electricity Consumption
Intermodal Inputs to CO$_2$METS

- Inland Transportation
  (North America)

  - Rail
    - Distance
    - Freight Cars
    - Intermodal
    - Tonnage

  - Barge
    - Power Rating
    - Distance
    - Specific Route

  - Truck
    - Power Rating
    - Distance

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Inland Waterway Transport Inputs to CO₂ METS

Trip time
- # days from PCRCAM

Geographic factor
- accounts for the changes in load capacity for tug due to geographic constraints - lower Mississippi, 1 tug can tow 40 barges; upper (MN area), 1 tug can tow 9 barges. Specific route based.

Weighted average of barge capacities in the U.S. in tonnes
- 1516.6

Fuel consumption in tonnes/day as function of gross tonnage
- 5.6511 +0.01048*GRT
Truck Transport Inputs to CO$_2$METS

- Trucks assumed to carry 2 TEU at a time
- 8 is the average number of CEU per truck
- EF is for the Heavy Duty Diesel Truck, from MOVES 2010, a USEPA modeling tool
- Empty miles are included in the calculation

CO$_2$ (kg/TEU) = Distance Traveled $\times$ EF$_{fuel}$

CO$_2$ (kg/CEU) = Distance Traveled $\times$ EF$_{fuel}$/8

EF = 1414 g/mi
### Rail Inputs to CO$_2$METS

Class I Annual Reports to Surface Transportation Board
- Average net tons per railcar
- Quantity of Railcars
- Average fuel economy – eastern railroads & western railroads
- Intermodal fuel consumption

Distance traveled in miles – from PC*MILER Rail©

<table>
<thead>
<tr>
<th>Line No.</th>
<th>Kind of locomotive service</th>
<th>Diesel oil (gallons)</th>
<th>Line No.</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Freight</td>
<td>330,685,939</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Passenger</td>
<td>10,815,977</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Yard switching</td>
<td>121,699,350</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>TOTAL</td>
<td>1,063,201,286</td>
<td>4</td>
</tr>
</tbody>
</table>
Data Sources

All data sources obtained in public domain
- Accepted international or national standards
- Widely vetted and recognized
- Ensures consistency within countries or industry communities
- Examples: IPCC Guidelines, Transportation Energy Data Book, DOE

Documentation required by legal requirements
- Documents must meet standards set by government
- Ensures consistency in reporting
- Examples: MSDS and Rail Class I Annual Reports
Example Outputs from CO$_2$METS

NE Asia/Columbus via Panamá Canal (kg CO$_2$/TEU)

% Contribution to Total Emissions

- OGVs: 82%
- Port Activities: 0%
- Canal: 2%
- Inland: 16%
Example Outputs from CO$_2$METS

**ASIA - Atlanta**

- CO2 Emissions (kg/TEU)

<table>
<thead>
<tr>
<th>Location</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suez</td>
<td>2000 kg</td>
</tr>
<tr>
<td>Intermodal</td>
<td>1500 kg</td>
</tr>
<tr>
<td>Current Panama - 5K TEU</td>
<td>1200 kg</td>
</tr>
<tr>
<td>Expanded Panama - 8k TEU</td>
<td>1000 kg</td>
</tr>
<tr>
<td>Expanded Panama - 10k TEU</td>
<td>800 kg</td>
</tr>
</tbody>
</table>
Further Application of CO$_2$METS

- Can be used by ports, shippers, rail
- Identify green routes for any sector
- Readily refined to capture specific requirements (example: regional focus vs global)
- Green route selection can be used with green product promotion
- Combined with the financial competitive analysis model, provides user a comprehensive and dynamic tool for market analysis and forecasting.
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