

# TEAMS

## What the Hull is Really Happening?

*Total Fuel Cycle Energy and Emissions from Marine Vessels*

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# Overview

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2. What is “Well-to-Hull” Analysis?
3. TEAMS Model & Algorithm
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# Background

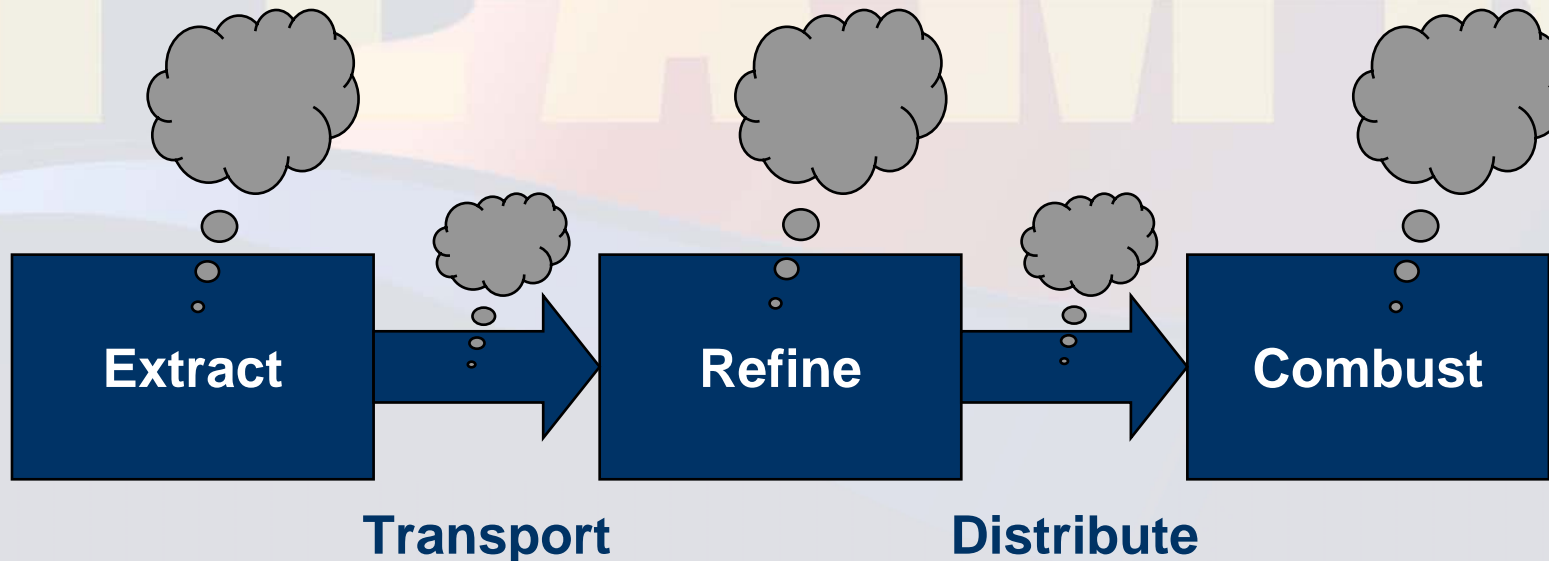
- Marine vessels are a significant source of air pollution
- Marine transportation services are expanding
- Emerging interest in alternative fuels for ships
- Past studies examined only “end-of-pipe” with no analysis of total fuel-cycle emissions
- Need tools to help understand energy and emissions from total fuel cycle for non-automobile transportation

# Research Goal

- To develop a modeling tool useable by analysts and decision makers to evaluate total fuel-cycle (TFC) emissions from marine transportation
- Tool must allow for use on a wide variety of marine vessels
- Tool must capture emissions along the entire fuel pathway
  - *Well-to-Hull Analysis (contrary to Well-to-Wheels)*

# Well-to-Hull Analysis (W2H)

W2H Analysis accounts for energy consumption and emissions along the entire fuel cycle of a given fuel



# The TEAMS Model

- **TEAMS: Total Energy and Emissions Analysis for Marine Systems Model**
- **Applies a variation of the ANL GREET fuel-cycle algorithm, which has been peer-reviewed and widely accepted as the TFC “gold-standard”**
- **Calculates TFC Btu/trip energy use and grams/trip emissions for vessels**
- **Considers combustion and non-combustion events in all upstream and downstream stages**

# The TEAMS Algorithm

$$EM_{cm,i} = \left( \sum_j \sum_k EF_{i,j,k} \times EC_{j,k} \right)$$

**Where:**

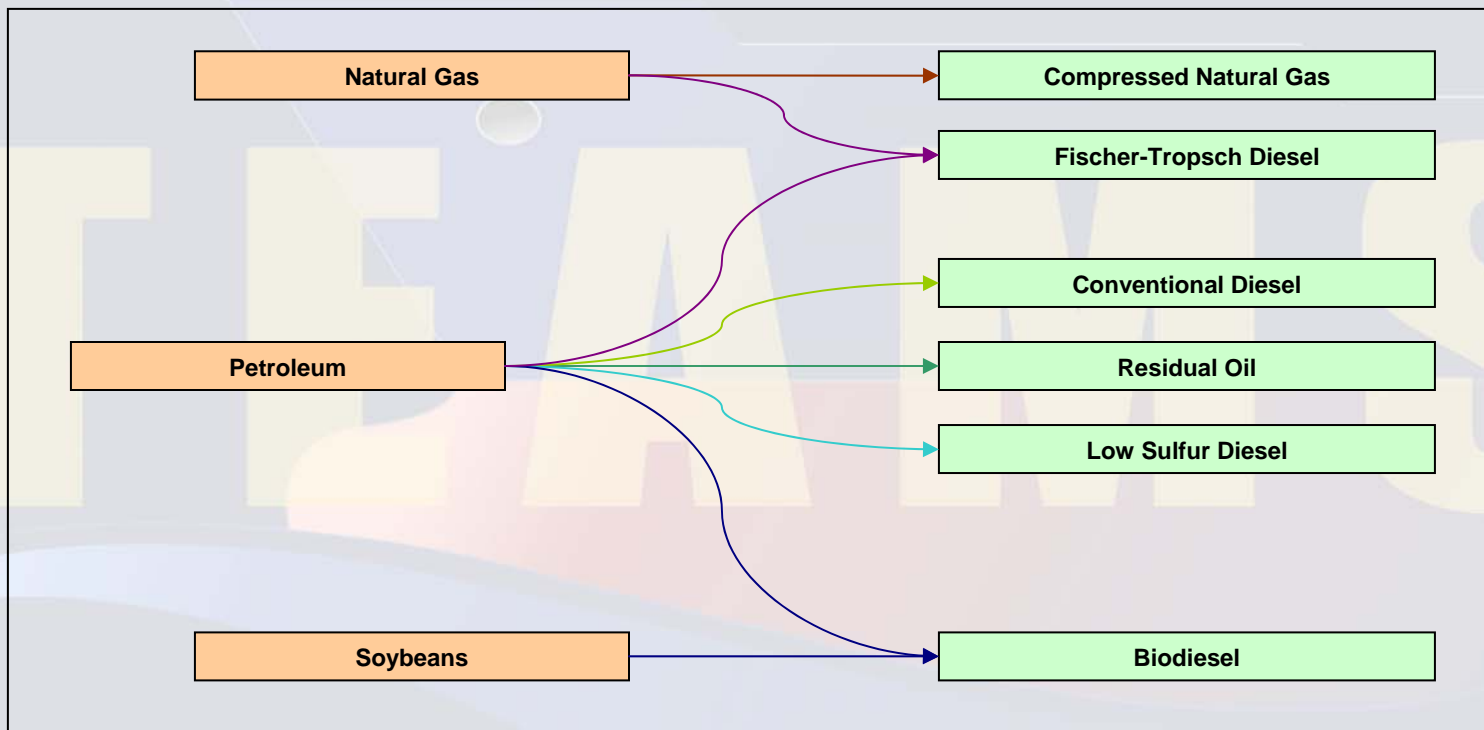
$EM_{cm,i}$  = Emissions of pollutant  $i$

$EF_{i,j,k}$  = Emission factor of pollutant  $i$  for process fuel  $j$  with combustion technology  $k$

$EC_{j,k}$  = Consumption of process fuel  $j$  with combustion technology  $k$

# TEAMS Pathways & Emissions

Pathways included:



## ▪ Emissions calculated:

### • Major greenhouse gases:

- CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub>

### • Criteria pollutants:

- VOCs, CO, NO<sub>x</sub>, PM<sub>10</sub> and SO<sub>x</sub>

# The TEAMS Model, cont.

- “Tool” that is geared towards analysts
- Does not run itself, but instead allows for a wide range of user inputs
  - *Example inputs:*
    - Refining efficiencies
    - Transportation distances
    - Vessel HP
    - Trip distance and time
    - Engine efficiency using each fuel type
    - Auxiliary fuel options
- The model will provide detailed output for the simulated vessel operating on each of the six fuel types

# Demonstration

A stylized graphic of a ship's hull and superstructure. The hull is a dark red-to-maroon gradient, and the superstructure is a dark blue gradient. The ship is positioned behind the 'TEAMS' text. The background is a dark blue gradient with a white wavy line at the bottom representing water.

# TEAMS

# General Results

## GHG Emissions

- **Residual oil and biodiesel**
  - 90% of total GHG emissions occur during operation
  - 10% during upstream
- **Conventional diesel, NG, FTD & LSD**
  - 80% occur during operation

## Total Energy Consumption

- **Residual oil**
  - 90% consumed during operation
- **NG**
  - 85% consumed during operation
- **CD, LSD, BD**
  - 80% consumed during operation
- **FTD**
  - 60% during operation (40% upstream!)
- **Also Significant:**
  - **Net energy consumption per trip  $\approx$  20 MBtu for all fuels**  
(except, FTD  $\approx$  30 MBtu)
  - **Biodiesel uses 15% less petroleum than conventional diesel**  
(even though B20 blend)

# Implications and Next Steps

- **TEAMS allows users to account for total fuel-cycle energy use and emissions for marine transportation**
- **Results can be incorporated into DOE, EPA, and other environmental modeling activities**
  - *Land-side v. water-side analyses*
- **Results can be used to help construct GHG emissions inventories**
- **Application for overall impacts on freight movement**
- **Further work will involve expanding case studies and integrating TEAMS with federal and state regulatory analyses**

# Availability

- TEAMS can be downloaded for free from the project website:

**[www.rit.edu/~teams](http://www.rit.edu/~teams)**

- On the website you will also find:
  - *Detailed User Guide*
  - *Presentations*
  - *Contact Information*