UK Ship Emissions Inventory

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Introduction

- Objectives
- Methodology
- Data Sources
- Refinements
- Uncertainties

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Aims and Objectives

- Quantification of emissions
- Pollutants:
  - $\text{SO}_2$
  - $\text{NO}_x$
  - $\text{PM}_{2.5}$ & $\text{PM}_{10}$
  - VOCs
  - $\text{CO}_2$
- Fuel consumption
- Geographical Distribution of emissions (5 x 5 km$^2$)
Aims and Objectives

Outputs

- Emissions reported by;
  - fuel type
  - vessel type (i.e. cargo & passenger)
  - flag type
  - movement type
  - ~ 12 nm zone

- Total emission estimates disaggregated by grid cells
Methodology

- **Bottom-Up Approach**
  - Activity Based

- **Top-Down Approach**
  - Unknown destinations
  - Smaller vessels
Methodology

- **Vessels**: Power of ME & AE engines (kW)
- **Routes**: In 5x5 grid cells
- **Moves**: Provided by LMIU database
- **Distance**: Traveled by Vessels at Sea
- **Speed**: of vessel per Vessel Type
- **Time**:
  - at sea
  - OR
  - in Port
- **Load Factors**: ME & AE engines Load factor & Operational time
- **Effective kW**: Power of ME & AE engines
- **Energy (kWh)**: Output by Vessels
- **Fuel Type**: by fuel and engine
- **Emissions (g)**: By grid cells
- **Emission factors (g/kWh)**: by fuel & engine type

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Methodology
Fuel Type

- Fuel Type based on
  - Engine
  - Vessel type
  - Location

- At Berth projections – MGO for vessels (exception passenger vessels)
Methodology
Emission projections

- Forecasting future emissions on the basis of historical data and best future estimates does lead to high uncertainty
- Growth rates of 2%, 3% and 4% applied to future emission forecasts

Global indices for seaborne trade, ship energy/fuel demand, installed power (Corbett et al., 2007)
Data Sources

- Movements Database
- Characteristics Database
- Emission Factors
- Routes
Data Sources
Movements Database

- **Provided by Lloyd's Marine Intelligence Unit (LMIU)**
  - "aims to cover all merchant vessels over 100gt engaged in international trade"

- **Lloyd’s MIU extracted transits**
  - Between ports in the area;
  - From / to ports inside the area to / from ports outside the area; and
  - Through the area without calling at a port in the area

- **Information extracted**
  - Arrival/Departure Port;
  - Arrival/Departure Dates and where available Arrival/Departure Times; and
  - Port/Place details including: Port Name, Country, Latitude/Longitude
Data Sources
Characteristics Database

- Provided by Lloyd's MIU
- **Vessel Characteristics**
  - Vessel Type
  - Flag type
  - Service Speed
  - Vessel size
- **Engine Characteristics**
  - Main Engine (ME) & Auxiliary Engine (AE) kW Power
  - Engine Speed (RPM)
Data Sources
Emission Factors

- Originally Developed by IVL
  - Based on Monitoring Data and Literature Survey
  - Presented as 15 Engine Type / Fuel Type Combinations
  - At Sea / Manoeuvring / At Berth
  - NO$_x$ / SO$_2$ / CO$_2$ / HC / PM
  - Load factors for ME and AE operation

- Updated for Policy Scenarios and Future Years
  - Sulphur Content of Marine Fuels Directive (SO$_2$ & PM)
  - MARPOL Annex VI Regulations (NOx, SO$_2$ & PM)
Data Sources
Route Network

- **AtoBviaC Plc**
  - Provided BP Shipping Marine Distance Tables
  - Routes respect all mandatory & recommended traffic separation schemes

- **Created using a GIS Based Methodology**
  - Shortest Straight Line Route (Avoiding Land)
  - Routes take into account passing places when possible
Refinements
Managing Incomplete Data

- Characteristics Data
- Movements Data
Refinements
Managing Incomplete Data

- LMIU Characteristics Data
  - Assumptions and Vessel Profiling to Account for Missing Data
    - Vessel speed
    - ME & AE Power
    - Engine speed
Refinements
Managing Incomplete Data

- LMIU Movements Data
  - Automatic Identification System (AIS) (Passenger)
  - Time of Arrival & Departure
  - Assumptions made for estimating emissions from missing / problematic movements (e.g. movements from and to the same port)
Areas of Uncertainty

- Accuracy and coverage of data
- Assumptions employed
- Uncertainty at All Stages
Conclusions

• Emission estimates for UK waters
• Approach – Bottom up
  – Emissions estimated based on:
    • Vessel movements; and
    • Vessel / Engine characteristics
UK Ship Emissions Inventory

Thank you