Vessel design and efficiency — A decision-support tool for energy systems, energy consumption, lifecycle emissions and cost analysis

UK National Clean Maritime Research Hub

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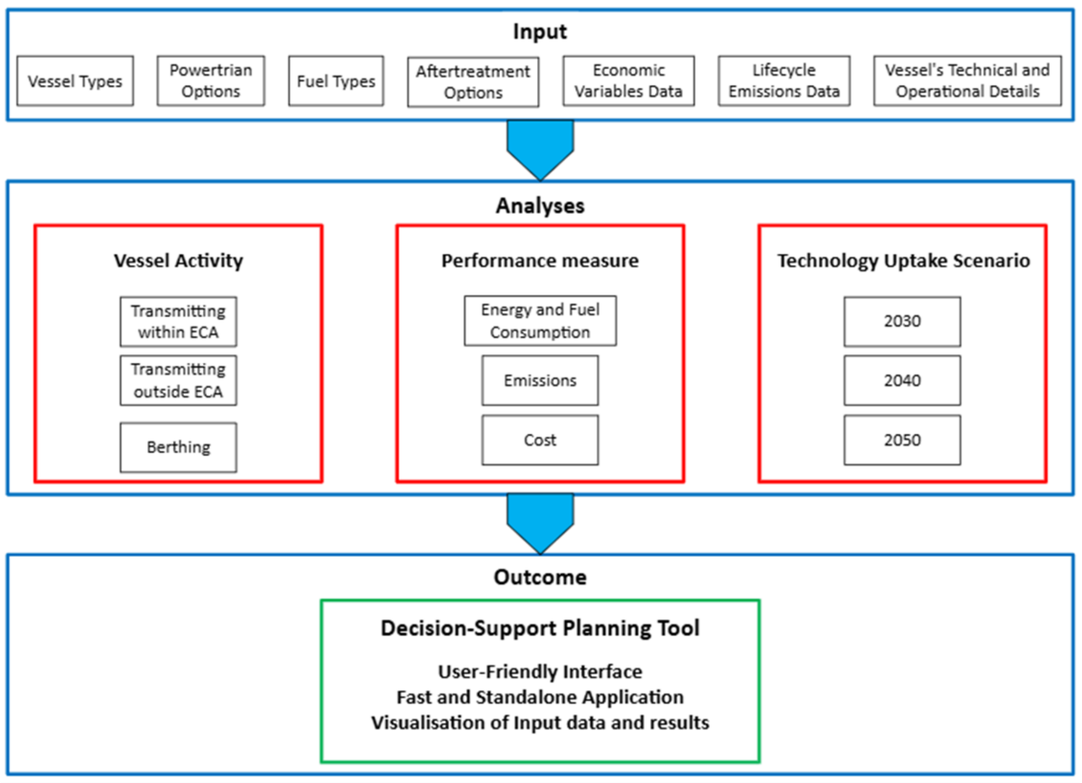
Background

- Decarbonising the maritime sector requires re-evaluating the entire industry.
- This work package will create an integrated decision-making application to assess vessels' decarbonisation options.
- Energy consumption, cost, and lifecycle emissions will be evaluated across various scenarios spanning the 2030, 2040, and 2050 timescales.

Conceptual design of the tool



Methods

Real-world data collection and analysis → Model set-up and validation → Simulation of ships' performance – using different fuels (renewable fuels) compared to the original fossil fuels → Outcome evaluation and interpretation

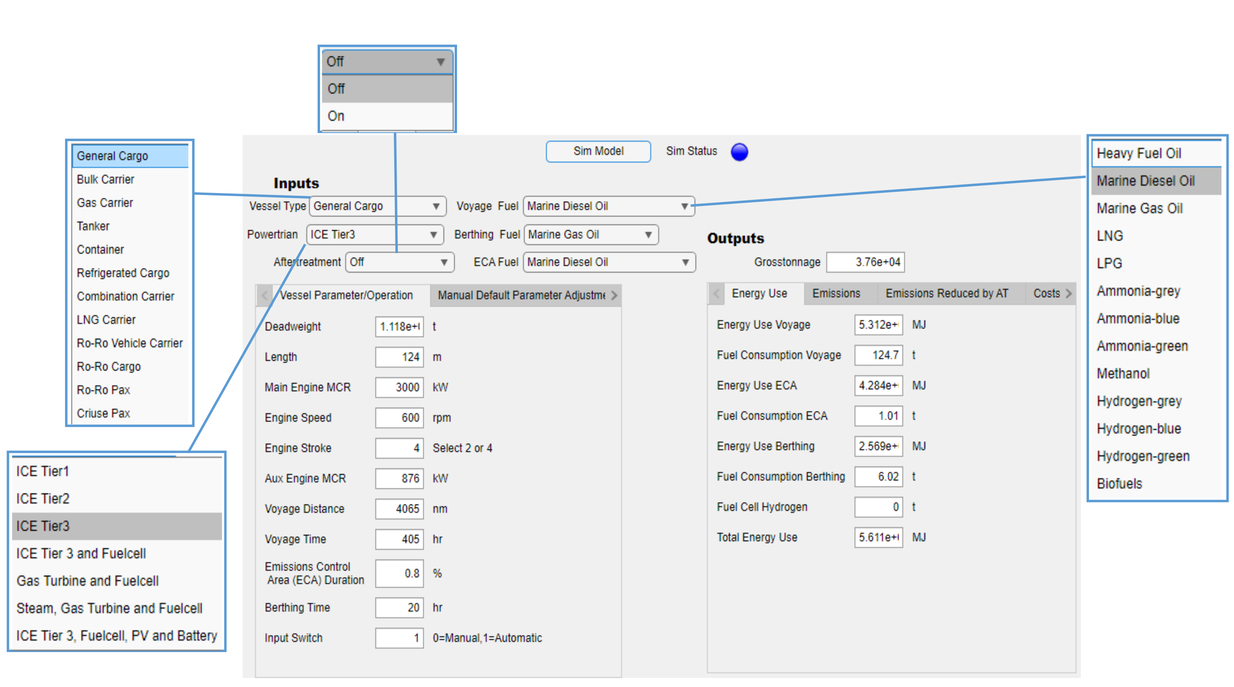
1. Real-world data collection and analysis
   - 69 Ships (Container & General Cargo)
   - 212 Voyage Records
     - ➢ 68 Annual Voyages (for 68 ships)
     - ➢ 144 Short Voyages (for 69 ships)

2. Model set-up and validation

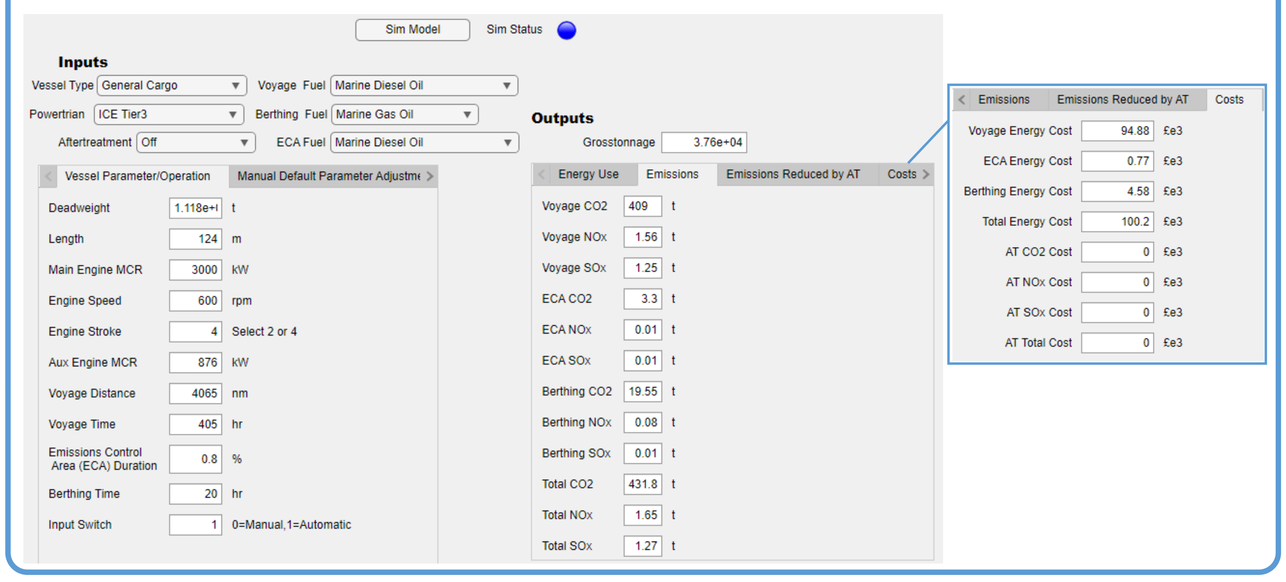
The energy consumption is derived from the ship's speed-power curve relationship.

Current tool capabilities

The tool estimates energy consumption using the ship's speed-power curve and incorporates emissions and fuel costs across 12 vessel types and eight fuel options. It accounts for both voyage phases (open sea and Emission Control Areas) and berthing. Aftertreatment systems, cost impacts, and alternative powertrain technologies are also included.



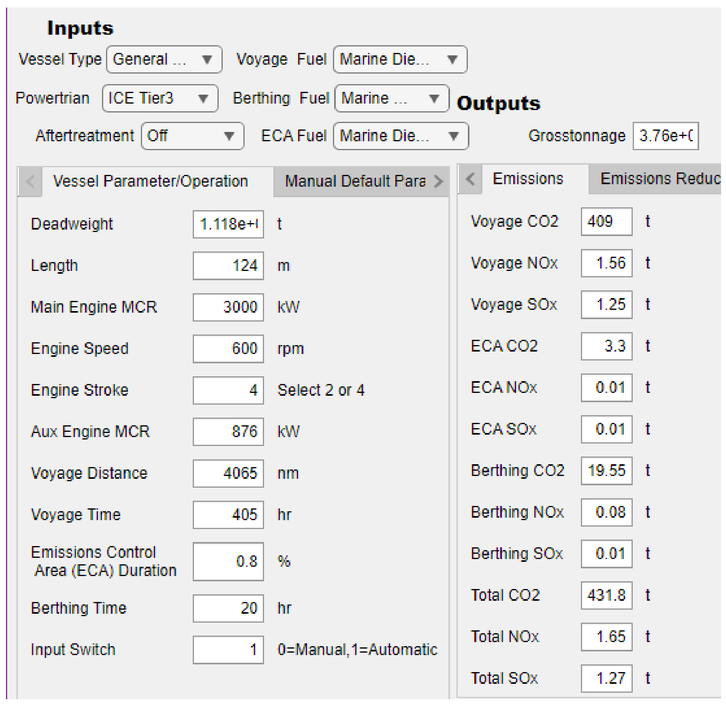
Current tool capabilities (continued)



Preliminary Results

Validation of the model:

• Preliminary results comparing the voyage of a general cargo vessel covering 4065 nautical miles in 405 hours of travel time, with an additional 20 hours spent at berth. These results are compared with those using alternative fuel types.



During berthing and voyage, burning marine gas oil and marine diesel oil, respectively.	Real data	Simulation result
Total energy use (GJ)	-	5611
Fuel consumption (tonnes)	132.8	131.73
CO2 (tonnes)	418.93	431.8*
NOx (tonnes)	-	1.65
SOx (tonnes)	-	1.27
Energy cost (£1000)	-	100.2

IMO Tier 3 Engine
* Lifecycle emissions considered in simulation

Simulation of ships' performance using ammonia and hydrogen:

• Preliminary results comparing the voyage of a general cargo vessel covering 4065 nautical miles in 405 hours of travel time, with an additional 20 hours spent at berth. These results are compared with those using alternative fuel types.

	Simulation	Simulation	Simulation
Fuel type	(Berthing: Marine gas oil. Voyage: Marine diesel oil)	(Berthing: Grey Ammonia*. Voyage: Grey Ammonia *)	(Berthing: Green Hydrogen. Voyage: Green Hydrogen)
Total energy use (GJ)	5611	6061	5821
Fuel consumption (tonnes)	131.73	325.8	48.5
CO2 (tonnes)	431.8	782.1	1.76
NOx (tonnes)	1.65	16.14	2.12
SOx (tonnes)	1.27	-	-
Energy cost (£1000)	100.2	183.1	242.6

* Grey Ammonia produced from Steam Methane Reforming and Haber-Bosch

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