

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

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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**



Voyage Distance 4065 n	im	Bertning CO2 19.55 I	
Voyage Time 405 h	ır	Berthing NOx 0.08 t	
Emissions Control Area (ECA) Duration	6	Berthing SOx 0.01 t	
Berthing Time 20 h	ır	Total CO2 431.8 t	
Input Switch 1 0	)=Manual,1=Automatic	Total NOx 1.65 t	
		Total SOx 1.27 t	

## **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.

Inputs						
Vessel Type General	. 🔻 Voya	ige Fuel Marine Die				
Powertrian ICE Tier3  Berthing Fuel Marine  Outputs						
Aftertreatment Off	<b>v</b> E	CA Fuel Marine Die	Grosst	onnage 3.76e+(		
< Vessel Parameter/0	Operation	Manual Default Para >	< Emissions	Emissions Redu		
Deadweight	1.118e+I	t	Voyage CO2	409 t		
Length	124	m	Voyage NOx	1.56 t		
Main Engine MCR	3000	kW	Voyage SOx	1.25 t		
Engine Speed	600	rpm	ECA CO2	3.3 t		
Engine Stroke	4	Select 2 or 4	ECA NOX	0.01 t		

	During berthing and voyage, burning marine gas oil and marine diesel oil, respectively.	Real data	Simulation result
uc	Total energy use (GJ)	_	5611
	Fuel consumption (tonnes)	132.8	131.73
	CO2 (tonnes)	418.93	431.8*
	NOx (tonnes)	_	1 65

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

2. Model set-up and validation

the ship's speed-power curve

relationship.

The energy consumption is derived from

- 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)

## **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.



ingine MCR 876 kW	ECASOX 0.01 t			
a Dictanco	Berthing CO2 19 55 t	SOx (tonnes)	-	1.27
ge Time 405 hr	Berthing NOx 0.08 t	Energy cost (£1000)	-	100.2
sions Control	Berthing SOx 0.01 t			
(ECA) Duration		IMO Tier 3 Engine		
ing Time 20 hr	Iotal CO2 431.8 t	* Lifervale emissions considered		
Switch 1 0-Manual 1-Automati	Total NOx 1.65 t			
Switch	Total SOv 1.27 t	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	
* Grev Ammonia produced from Steam Methane Reforming and Haber-Bosch				

	Refrigerated Cargo				
	Combination Carrier	Vessel Parameter/Operation	Manual Default Parameter Adjustme >	< Energy Use Emissions Emissions Reduced by AT Costs >	Ammonia-grey
	LNG Carrier	Deadweight 1.118e-	-I t	Energy Use Voyage 5.312e+ MJ	Ammonia-blue
	Ro-Ro Vehicle Carrier	Longth 12		Fuel Consumption Voyage 124.7 t	Ammonia-gree
	Ro-Ro Cargo		+ 111		Methanol
	Ro-Ro Pax	Main Engine MCR 300	D KW	Energy Use ECA 4.284e+ MJ	Hvdrogen-grev
	Criuse Pax	Engine Speed 60	0 rpm	Fuel Consumption ECA 1.01 t	Hydrogen-blue
_		Engine Stroke	4 Select 2 or 4	Energy Use Berthing 2.569e+ MJ	Hydrogen-gree
IC	E Tier1	Aux Engine MCR 87	6 kW	Fuel Consumption Berthing 6.02 t	Diofuele
IC	E Tier2	Vevere Distance	E nm		Biolueis
IC	E Tier3	Voyage Distance 400			
IC	E Tier 3 and Fuelcell	Voyage Time 40	5 hr	Total Energy Use 5.611e+I MJ	
G	as Turbine and Fuelcell	Emissions Control Area (ECA) Duration	8 %		
01	oom, Gos Turbino and Eucleall	Berthing Time			
0	E Ties 2. Evelocity DV and Detters				
IC	E Tier 3, Fueicell, PV and Battery	Input Switch	1 0=Manual,1=Automatic		

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