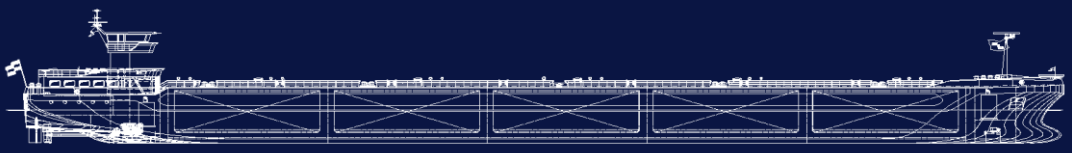


Decarbonizer Premium Report

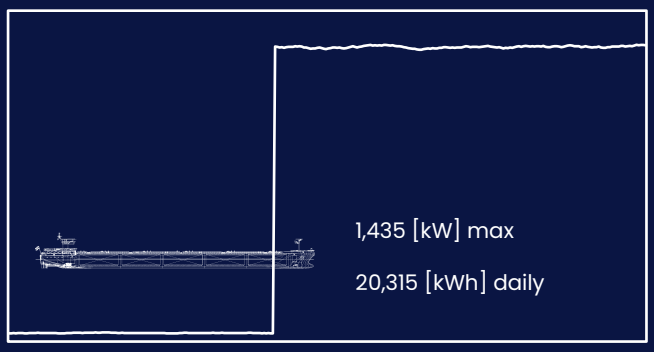
A techno-economic emission reduction guide for Skoon Skipper

Client	**vincent**
Date	**2023-09-18**
Source	**Sustainable Ships**

EXECUTIVE SUMMARY

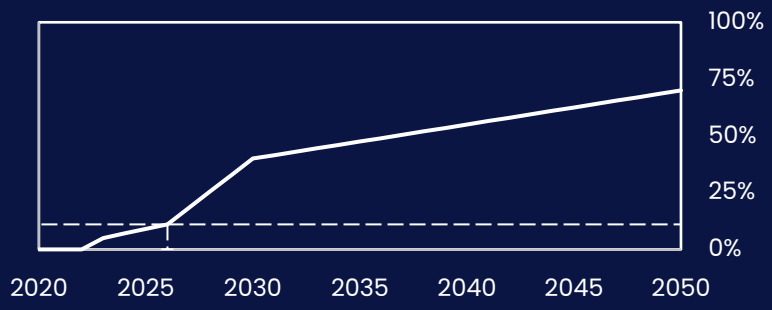
The purpose of this document is to provide vincent with guidance and insights on maritime sustainability of Skoon Skipper. This report elaborates on your operational profile, applicable rules and regulations and on your preferred carbon reduction measures and costs.

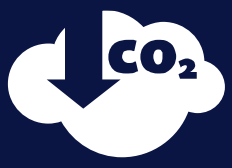
Operational Profile



Fuel	3,914	[l/day]
CO2	11,169	[kg/day]
ETS	€ 0	[€/day]
OPEX	€ 3,732	[€/day]
CII	Not Applicable	
EEXI	Not Applicable	

Rules and Regulations





2026
Year

11%
Reduction

Decarbonization Measures	CO_2 Red.	CAPEX	Dayrate*	Payback [yrs]
Shore Battery	3%	€ 0	+ € 1	-
-				
-				

* The difference in daily costs after implementation of measure. A negative dayrate means your OPEX is reduced and you will save money.

	CO_2 Red.	CAPEX	OPEX [daily]	Payback [yrs]
Current situation	0%	€ 0	€ 3,732	-
Future Skoon Skipper	**3%**	**€ 0**	**€ 3,733**	**-**

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About Report

Legislation is uncertain

Legislation, rules and regulations or politics in general are vague by nature. In contrast to the engineer's worldview, there is and will always remain uncertainty over upcoming rules and regulations due to 'the political process'. Additionally, the engineering performed for retrofitting is uncertain as well, as it is subject to significantly varying parameters and assumptions.

Our solution to this conundrum is twofold. First, we provide you with a free to use helpdesk, that can help you clarify and answer questions even after this report has been delivered. You can ask any question related to maritime sustainability by clicking on the 'contact helpdesk' button on the top of the page.

Secondly, we provide you with a model, not a solution. Our tools are fully customizable to your vessel and provide you with the option to easily change input parameters when new information is provided. In other words, you can use the Decarbonizer tool as a sensitivity analysis for your vessel, in which you can easily determine what works for you and what does not.

Class is exempt

Class rules and regulations from either DNV, Lloyds or other classification bureaus are excluded in the upcoming rules and regulations section because these are technical of nature. They are included in the cost breakdowns as lump-sum estimates that you can easily customize.

Liability Disclaimer

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1.0 OPERATIONAL PROFILE SKOON SKIPPER

1.1 Vessel and operational properties

Property	Value	Unit
Ship name	Skoon Skipper	
Ship type	Inland Waterways General Cargo	
Fuel type main	MDO	
Main engine name	Main Engine	
Installed power kw	1760	[kW]
Main engine type	2-Stroke	175 [g/kWh]
Main engine speed	Low	
Aux engine name	Aux Engine	
Aux power kw	176	[kW]
Aux engine type	4-Stroke	
Aux engine speed	High	[kW]
Year built	2020	[years]
GT	5,000	[-]
Deadweight	5,000	[mT]
Cargo capacity	5,000	[m3]
Propulsion type	Direct Drive	
Cruising speed	12	[knts]
Fuel tank capacity main	1,000	[m3]
Length	100	[m]
Beam	30	[m]
Displacement	5,000	[mT]
Fuel price MDO	€ 0.80	[€/liter]
Electricty price Shore_Battery	€ 0.39	[€/kWh]
No fuel change	-	

Operational profile		
Idle / Moored	41%	151 days per year
Sailing	59%	214 days per year
Working	0%	0 days per year

1.2 Current OPEX per operational profile

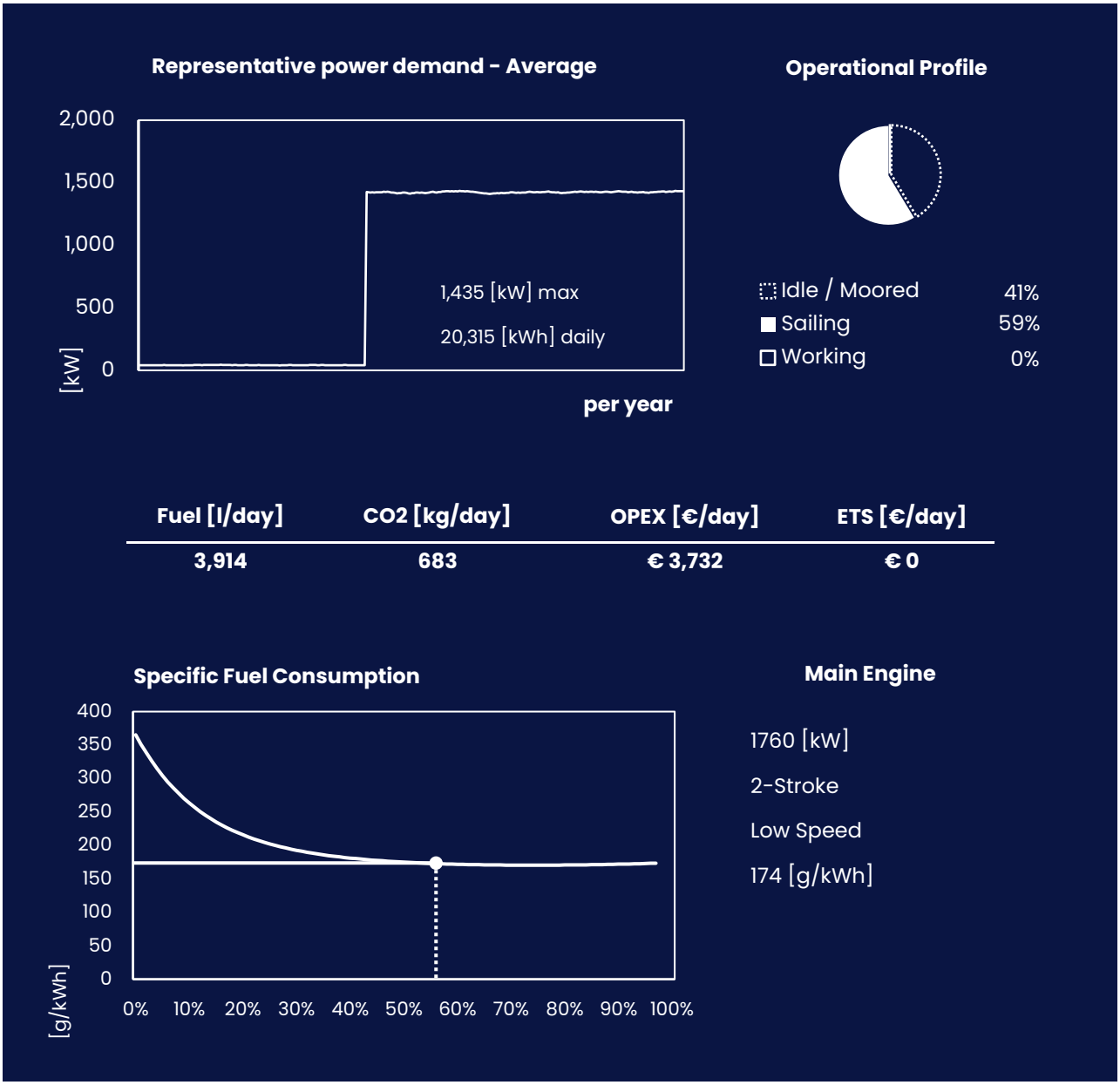
		Idle / Moored 151 [days/year]	Sailing 214 [days/year]	Working 0 [days/year]	Average per [day]
Max Power	[kW]	44	1,435	-	1,435
Average Power	[kW]	41	1,415	-	846
Energy Required	[kWh]	983	33,956	-	20,315
Fuel Consumption	[liter]	239	6,508	-	3,914
Engine Hours	[hrs]	24	24	-	24

CO2 Emissions	[kg]	683	18,569	-	11,169
NOx Emissions	[kg]	€ 11.69	€ 317.86	-	€ 191.20
SOx Emissions	[kg]	€ 0.46	€ 12.45	-	€ 7.49
PM Emissions	[kg]	€ 0.20	€ 5.50	-	€ 3.31
CH4 Emissions	[kg]	€ 0.01	€ 0.29	-	€ 0.17

Fuel	[€]	€ 191	€ 5,206	-	€ 3,132
Lease / Rental	[€]	€ 0	€ 0	-	€ 0
Engine Maintenance	[€]	€ 480	€ 480	-	€ 480
Spares / Consumables	[€]	€ 48	€ 48	-	€ 48
ETS Costs	[€]	€ 0	€ 0	-	€ 0
Coating	[€]	€ 72	€ 72	-	€ 72

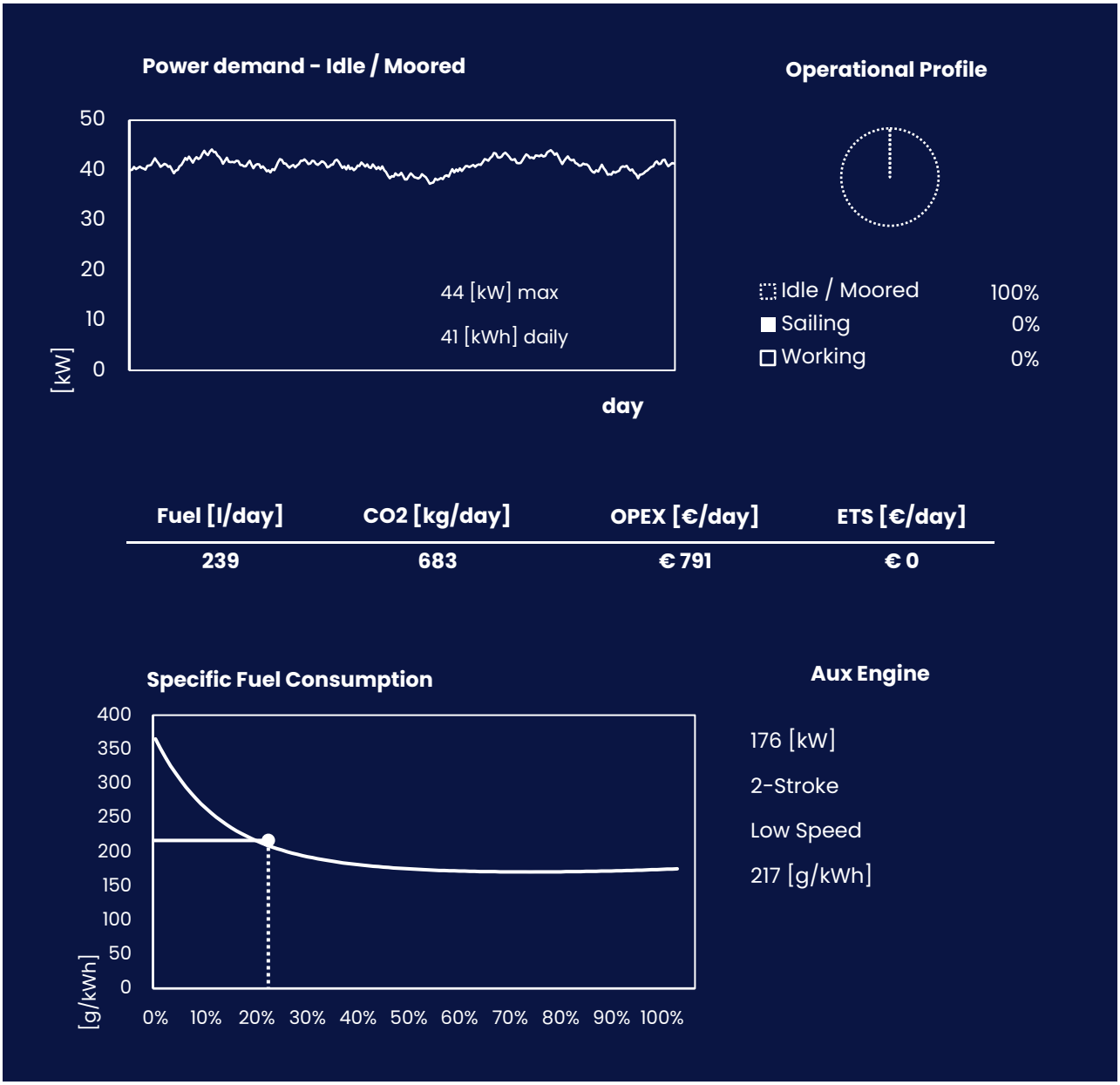
OPEX	**daily**	**€ 791**	**€ 5,806**	**-**	**€ 3,732**
	yearly	**€ 288,861**	**€ 2,119,272**	**-**	**€ 1,362,033**

1.3 Average – Yearly



The estimated operational profile of Skoon Skipperwhen operational modes are combined (i.e. idle/moored, sailing and working). For example, a vessel can be moored for 25% of the year and sailing for 75% of the year, which results in a combined power demand representing vessel operations. This can be viewed as 'yearly combined profile". OPEX includes ETS. the ETS component is shown for additional reference.

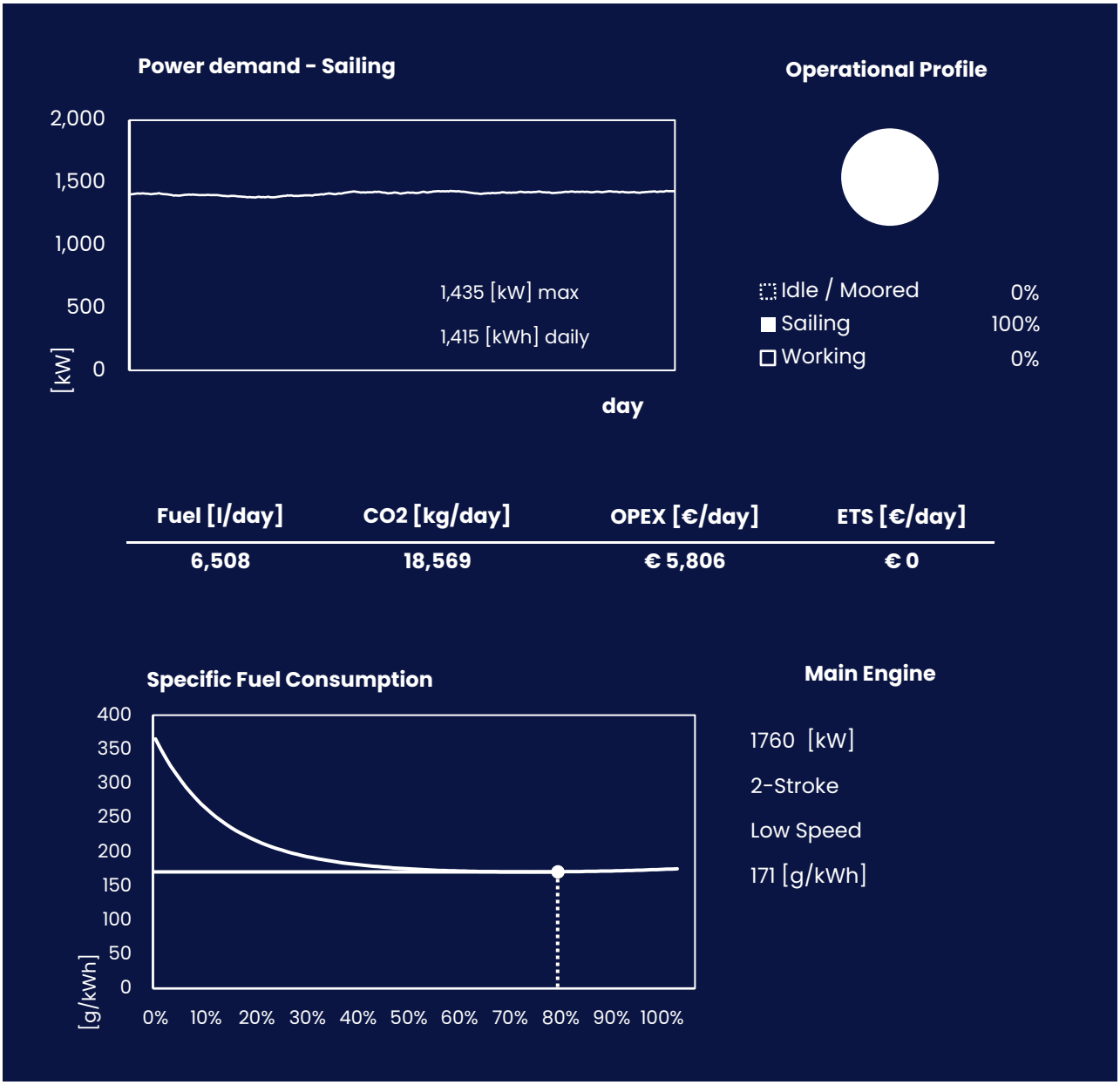
1.4 Idle/Moored – Daily



Fuel [l/day]	CO2 [kg/day]	OPEX [€/day]	ETS [€/day]
239	683	€ 791	€ 0

The estimated idle / moored power profile, main fuel and cost parameters for Skoon Skipper. OPEX includes ETS, the ETS component is shown for additional reference.

1.5 Sailing – Daily



The estimated sailing power profile, main fuel and cost parameters for Skoon Skipper. OPEX includes ETS, the ETS component is shown for additional reference.

1.6 Working – Daily

Not applicable

2.0 KEY UPCOMING RULES AND REGULATIONS FOR SKOON SKIPPER

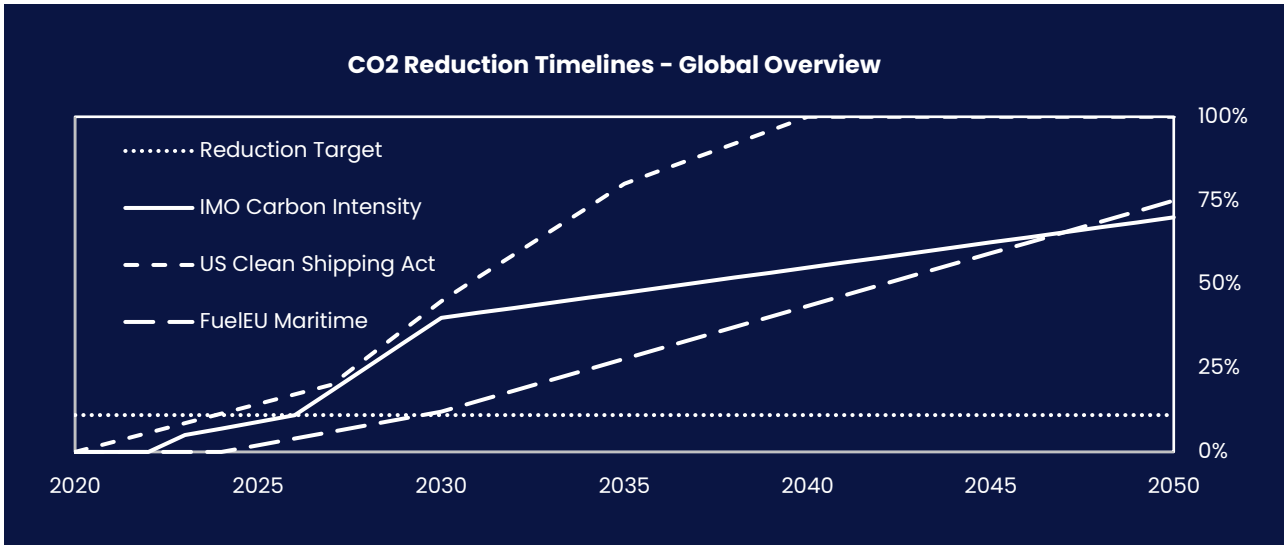


Figure 5. CO2 reduction timelines for key organizations around the world.

Key takeaways	
For 2026 a CO2 reduction of 11% is required	Key regulatory frameworks for maritime sustainability include IMO and EU, of which IMO is more stringent at the moment and EU probably after 2030. In addition, the US Clean Shipping Act requires all vessels to be fully zero emission by 2040. Client requirements have not yet been incorporated.
Electrification is excluded	Electric vessels 'pass' all rules and regulations that have been identified. It is therefore highly recommended to pursue a course of electrification of your vessel where possible to ensure smooth sailing in the future.
Shore power is mandatory	Shore power will become fully mandatory in EU and US by 2030, as per FuelEU and US clean shipping act and this trend in expected to be tightened while at berth. Shore power in the Netherlands is more attractive for operators due to HBE.
Carbon tax & fossil is expensive	Shipping industry will be incorporated into EU ETS from 2025 onwards. With the current price of €0 per mT CO2, that would equate to a surtax of roughly €0 per mT of fuel.

Key rules and regulations for Skoon Skipper		
Regulation	**Organization**	**Impact / Restraint**
PAS	Netherlands	-80% NOx
HBE	Netherlands	Get € 0.04-0.20 kWh
UK ETS	UK	£ 252763 per year
EU ETS	EU	€ 0 per year
ECA Norway	IMO	0.1% SOx max
Global Sulphur Limit	IMO	0.5% SOx max
ECA North Sea	IMO	0.1% SOx max
ECA Mediterranean	IMO	0.1% SOx max
IMO Carbon Price	IMO	Unknown
Ørsted	Ørsted	-100% CO2 2040
Repsol	Repsol	-100% CO2 2040
Equinor	Equinor	-100% CO2 2050
Shell	Shell	-100% CO2 2050
BP	BP	-100% CO2 2050
Total	Total	-100% CO2 2050

CII / EEXI / EU ETS		
CII	**EEXI**	**EU ETS [year]**
Not Applicable	Not Applicable	€ 0

Purchase the **premium Rules and Regulations report** for an overview on all rules and regulations on sustainability. This includes regulations imposed by energy majors, shipping companies and ports around the world that might affect your operations. It is accompanied by a one-hour consult to clarify all your questions. Click below fore more information.

Learn more

3.0 CARBON REDUCTION MEASURES & COSTS

3.1 All carbon reduction measures

Below is an overview of several key carbon reduction measures. Δ-OPEX represent the difference between current OPEX and OPEX when measures is implement. OPEX of carbon reduction measures include fuel, ETS and maintenance costs. All costs are indicative. No rights or claims can be made based on this analysis.

Measure	CO_2 Reduction	CAPEX	Dayrate	Payback [yrs]
Shore Power	3%	€ 31,224	- € 175	-
Shore Battery	**3%**	**€ 0**	**+ € 01**	**-**
Solar PV	7%	€ 382,500	- € 193	5
Wind Power	11%	€ 810,000	- € 317	7
Hull Coating	18%	€ 234,000	- € 383	2
Battery Hybrid	3%	€ 2,320,972	- € 58	109
Biofuels	47%	€ 5,000	+ € 1,206	-
Ammonia	97%	€ 1,285,691	+ € 2,856	-
Methanol	90%	€ 823,936	+ € 2,455	-
Hydrogen	97%	€ 12,833,955	+ € 11,547	-
Full Electric	97%	€ 7,905,044	- € 1,020	21

Current situation	**0%**	**€ 0**	**€ 3,732**	**-**
After measures	**3%**	**€ 0**	**€ 3,733**	**-**
Target reduction	**11%**			

3.2 Selected measures for Skoon Skipper

The below carbon reduction measures have been applied to Skoon Skipper. Click on the links below the figures to learn more, or contact the helpdesk to clarify any questions.

Selected carbon reduction measures		
Shore Power	Prevent Measure	Change Measure
	None Chosen	None Chosen
Shore Battery	-	-

3.3 CII / EEXI / EU ETS

Below is an overview of current and future CII, EEXI and EU ETS. Future means after implementation of carbon reduction measures. More details and calculations are provided in Appendix I.

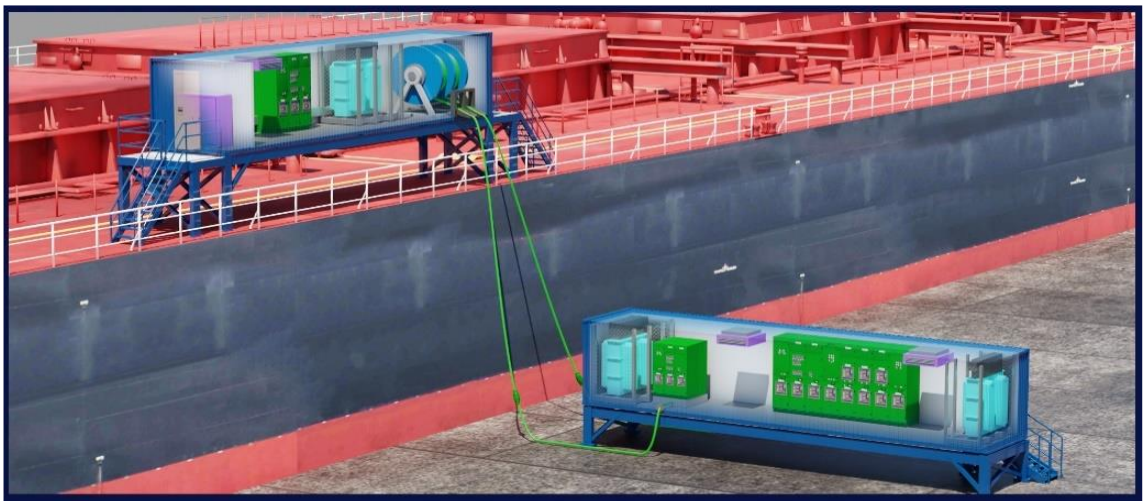
CII / EEXI / EU ETS			
	CII	EEXI	EU ETS
Current	Not Applicable	Not Applicable	€ 0
Future	Not Applicable	Not Applicable	€ 0

3.4 Technical Details Shore Battery

Shore battery is the use of a battery container - assumed to be placed either on deck, on board or on the quayside - to provide power while idle or moored. This is particularly useful when no onshore infrastructure is avilable, but shore power is still required. The amount of days the vessel needs to be power is 0.5. This will lead to a battery capacity and cost of approximately 522 kWh and € 351,798, assuming SoC as stated. Costs generally include inverters, safety systems, FAT and more. See CAPEX section of the report for details.

Parameter	Value	Unit
Electricity Consumption	836	[kWh/day]
Average Power	35	[kW]
Rated power for system	176	[kW]
Days powered by battery ('operation')	0.5	[days]
Energy required per operation	418	[kWh/ops]
Max. charge level (SoC high)	100%	
Max. discharge level (SoC low)	20%	
Resulting battery capacity	522	[kWh]
Energy density battery	2	[MWh/20 ft]
20ft Containers required per operation	0.3	[container]
Ship operating Voltage	440	[V]
Ship operating frequency	50	[Hz]
Converter Required?	Yes	
Transformer Required?	Yes	
Switchboard spare breaker available?	Yes	
Battery/cell purchase price per kWh	€ 500	[€/kWh]
Switchboard equipment purchase price per kW	€ 100	[€/kW]
Power equipment purchase price per kW	€ 150	[€/kW]
Fire suppression system price per kW	€ 50	[€/kW]
Shore power availability w.r.t. idle/moored time	100%	

Learn more about Shore Battery



Shore battery is the use of a battery to power your vessel while moored. It can be placed on the quayside or on deck. It is particularly useful for ports where no infrastructure is available

Shore batteries can be hired when there is only temporary need of shore power
Commercially available batteries can provide up to 2 [MWh] of power in a 20ft container

Inside a battery container

Shore battery for inland vessels

3.5 Technical Details Prevent Measure n.a.

None chosen

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3.6 Technical Details Change Measure n.a.

None chosen

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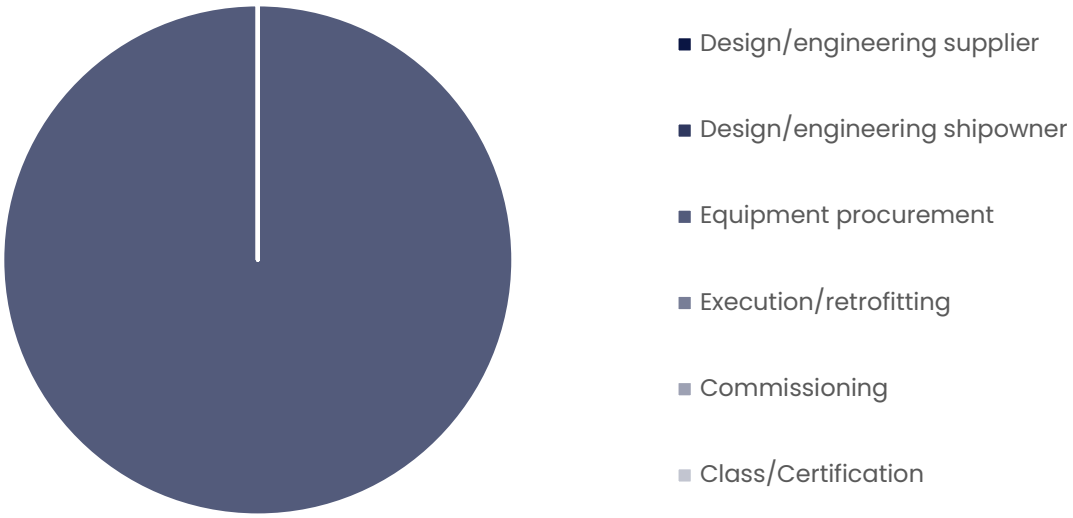
3.7 CAPEX Breakdown Shore Battery

	Time [hours]	Costs
Design/engineering supplier	140	€ 0
Design/engineering shipowner	160	€ 0
Equipment procurement	-	€ 351,798
Execution/retrofitting	364	€ 0
Commissioning	280	€ 0
Class/Certification	28	€ 0
Total	**24 fte weeks**	**€ 351,798**



	Total Time [hrs]*			Total Cost
	972.16		Total Estimated for Project	€ 351,798

Shore Battery Costs

	Time [hrs]	Units	Parameter	Price per hour/unit	Total Cost
Design/engineering supplier	**140**				**€ 0**
Electrical engineering for switchboard and breaker modifications	40		EUR/hr	€ 0	€ 0
Electrical engineering for shore connection panels	20		EUR/hr	€ 0	€ 0
Electrical engineering for PMS modifications	40		EUR/hr	€ 0	€ 0
Short circuit and selectivity study for shore connections	40		EUR/hr	€ 0	€ 0
Design/engineering shipowner	**160**				**€ 0**
Misscalenous engineering	40		EUR/hr	€ 0	€ 0
Engineering for cable routing at location	40		EUR/hr	€ 0	€ 0
Mechanical engineering for shore connection changes	80		EUR/hr	€ 0	€ 0
Equipment procurement	**0**				**€ 351,798**
Battery system		1	EUR	€ 261,169	€ 261,169
Switchboard modifications*		0	EUR	€ 17,600	€ 0
(HV) Breakers Set		0	EUR	€ 1,760	€ 0
Converter (if needed)		1	EUR	€ 26,400	€ 26,400
Transformer (if needed)		1	EUR	€ 26,400	€ 26,400
Harmonic filters		1	EUR	€ 1,760	€ 1,760
Foundation/containment for battery system		1	EUR	€ 704	€ 704
Fire suppresion system		1	EUR	€ 8,800	€ 8,800
Shore connection panel/housing		1	EUR	€ 704	€ 704
(HV) Cabling [meters]		50	per [m]	€ 150	€ 7,500
Cable trays		50	per [m]	€ 30	€ 1,500
FAT testing of equipment (Factory Acceptance Test)		1	lot	€ 2,108	€ 2,108
Power management system modifications		1	lot	€ 2,108	€ 2,108
Spare parts		1	lot	€ 4,215	€ 4,215
Consumables on-board, general supplies, paint, electrodes etc.		1	lot	€ 4,215	€ 4,215
Rental tools		1	lot	€ 4,215	€ 4,215
Execution/retrofitting	**364**				**€ 0**
Creating means of access for safe working location	8		EUR/hr	€ 0	€ 0
Cleaning/removing obstructions from working locations	8		EUR/hr	€ 0	€ 0
Installation/removal of scaffolding on working locations	0		EUR/hr	€ 0	€ 0
Installation/Implementation of switchboard/breaker modifications	40		EUR/hr	€ 0	€ 0
Implementation of power management modifications	20		EUR/hr	€ 0	€ 0
Installation of bulkhead penetrations for cable routing	40		EUR/hr	€ 0	€ 0
Installation of cable trays to complete routing	40		EUR/hr	€ 0	€ 0
Installation of foundations for battery	8		EUR/hr	€ 0	€ 0
Installation of connection panels	40		EUR/hr	€ 0	€ 0
Pulling, fastening and terminating of cables	80		EUR/hr	€ 0	€ 0
Painting/coating of equipment	40		EUR/hr	€ 0	€ 0
Non-destructive testing of structures (if installed)	40		EUR/hr	€ 0	€ 0
Commissioning	**280**				**€ 0**
Testing of cable from switchboard to the shore connection panels	40		EUR/hr	€ 0	€ 0
Testing of shore connection in switchboard	40		EUR/hr	€ 0	€ 0
Testing of power management system modifications	40		EUR/hr	€ 0	€ 0
Testing of change over from vessel to shore power and back	40		EUR/hr	€ 0	€ 0
Training and familiarising of crew	120		EUR/hr	€ 0	€ 0
Class/Certification	**28.16**				**€ 0**
Approval costs of drawings/calculations	97		EUR/hr	€ 0	€ 0
Surveyor attendence for fabrication/installation incl. travel expense	14.08		EUR/hr	€ 0	€ 0
Permitting for E-house, cabling etc. (if needed)	0		EUR/hr	€ 0	€ 0
(Writing) Operational manuals and procedures	14.08		EUR/hr	€ 0	€ 0

All numbers are indicative. Ask your supplier for fixed numbers.

It is assumed transportation costs for all equipment is included in the pricing.

3.8 CAPEX Breakdown Prevent Measure n.a.

None chosen

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3.9 CAPEX Breakdown Change Fuel n.a.

None chosen

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3.10 Future OPEX Breakdown Skoon Skipper

The below table shows the current and future OPEX breakdown for Skoon Skipper, based on the representative daily operational profile. Depreciation of equipment has not been taken into account (neither for existing or newly purchased equipment).

		Current	Future
Max Power	[kW]	1,435	1,435
Average Power	[kW]	846	844
Energy Required	[kWh]	20,315	20,254
Fuel Consumption	[liter]	3,914	3,815
Engine Hours	[hrs]	24	14

Fuel	[€]	€ 3,132	€ 3,187
Lease / Rental	[€]	€ 0	€ 163
Engine Maintenance	[€]	€ 480	€ 282
Spares / Consumables	[€]	€ 48	€ 29
ETS Costs	[€]	€ 0	€ 0
Coating	[€]	€ 72	€ 72

OPEX	**daily**	**€ 3,732**	**€ 3,733**
	yearly	**€ 1,362,033**	**€ 1,362,522**

3.11 Potential suppliers

The below partners can assist in implementing the proposed measures on-board your vessel. You can contact them directly, or contact the helpdesk for further guidance. In case you prefer to work with (local) partners on your own, feel free to use this report as a guideline for their input.

Preferred Suppliers		
Technology	**Supplier**	**Contact**
Shore Battery	Skoon	**pepijnreesink@skoon.world**
-	-	
-	-	

Other Suppliers		
Technology	**Supplier**	**Contact**
Shore Battery	EST-Floattech	**w.vander.pennen@est-floattech.com**

4.0 APPENDIX I – ASSUMPTIONS AND CALCULATIONS

4.1 Input values and assumptions

Parameter	Value	Unit
Fuel Price	€ 0.80	[€/liter]
ETS	€ 0	[€/mT]
Engine Maintenance Costs	€ 20	[€/hr]
Spares / Consumables Costs	€ 2	[€/hr]
Parasitic Load Engine	15%	[-]
(Engineering) Hour External	€ 0	[€]
(Engineering) Hour Internal	€ 0	[€]
Depreciation Time	10	[years]
Annual (Fuel) Price Increase	1.03	[-]

MDO density	0.89	[kg/l]
CO2 Emission Factor MDO	3.206	[kg/kg]
NOx Emission Factor MDO	0.05488	[kg/kg]
SOx Emission Factor MDO	0.00215	[kg/kg]
PM Emission Factor MDO	0.00095	[kg/kg]
CH4 Emission Factor MDO	0.00005	[kg/kg]

Fuel after change	-	[-]
Fuel density after change measures	0.89	[kg/liter]
Fuel price after change measure	€ 0.80	[€/liter]
Shore-side kWh price	€ 0.35	[€/kWh]
CO2 Emission Factor	3.206	[kg/kg]
Nox Emission Factor	0.05488	[kg/kg]
Sox Emission Factor	0.00215	[kg/kg]
PM Emission Factor	0.00095	[kg/kg]
CH4 Emission Factor	0.00005	[kg/kg]

4.2 CII Calculation

Skoon Skipper CII Scores	2023	2024	2025	2026
Baseline	n.a.	n.a.	n.a.	n.a.
After reduction measures	n.a.	n.a.	n.a.	n.a.

CII Input Values		
Operational Mode	Yearly average	
CO2 Emissions	4,076,827,838	[g/year]
Capacity	n.a.	[mT]
Distance Sailed	61,632	[nm/year]
a		for Reference line
c		for Reference line
CII ref	n.a.	Reference line
Required CII 2023	n.a.	5% reduction
Required CII 2024	n.a.	7% reduction
Required CII 2025	n.a.	9% reduction
Required CII 2026	n.a.	11% reduction
Attained Current CII	n.a.	Baseline
Attained CII	n.a.	After modifications

Learn more about CII

CII Scores per Technology	2023	2024	2025	2026
Shore Power	n.a.	n.a.	n.a.	n.a.
Shore Battery	**n.a.**	**n.a.**	**n.a.**	**n.a.**
Solar PV	n.a.	n.a.	n.a.	n.a.
Wind Power	n.a.	n.a.	n.a.	n.a.
Hull Coating	n.a.	n.a.	n.a.	n.a.
Battery Hybrid	n.a.	n.a.	n.a.	n.a.
Biofuels	n.a.	n.a.	n.a.	n.a.
Ammonia	n.a.	n.a.	n.a.	n.a.
Methanol	n.a.	n.a.	n.a.	n.a.
Hydrogen	n.a.	n.a.	n.a.	n.a.
Full Electric	n.a.	n.a.	n.a.	n.a.

4.3 EEXI Calculation

$$\text{EEXI} = \frac{CO2\ emissions}{Transportation\ work}$$

$$\text{EEXI} = \frac{Main\ engine\ emissions + Auxiliary\ engine\ emissions + (PTI - Innovative\ electrical\ energy\ technologies) - Innovative\ propulsion\ energy\ technologies}{Capacity * Reference\ speed * Reduction\ factors}$$

$$\text{EEXI} = \frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} C_{ME(i)} SFC_{ME(i)}\right) + \left(P_{AE} C_{AE} SFC_{AE}\right) + \left(\left(\prod_{j=1}^{n} f_j \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} P_{AEeff(i)}\right) C_{FAE} SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} P_{eff(i)} C_{FME} SFC_{ME}\right)}{Capacity\ V_{ref}\ f_i f_c f_l f_w f_m}$$

EEXI Input values		
Ship Type	d_Waterways_General_Cargo_	
Operational Mode	Sailing	
CO2 Emissions	773,705	[gram/hour]
Capacity	5,000	[mT]
Reference Speed	12	[knts]
fi	n.a.	
fc	n.a.	
fl	n.a.	
fw	n.a.	
fm	n.a.	
Reduction factor	n.a.	

EEXI	**Not Applicable**	**[gram/mT mile]**
EEXI After	**Not Applicable**	**[gram/mT mile]**
EEXI Required	**Not Applicable**	**[gram/mT mile]**

Learn more about EEXI

4.4 EU ETS Calculation

Yearly ETS Costs	2024	2025	2026	2027
Current	€ 0	€ 0	€ 0	€ 0
Shore Power	€ 0	€ 0	€ 0	€ 0
Shore Battery	**€ 0**	**€ 0**	**€ 0**	**€ 0**
Solar PV	€ 0	€ 0	€ 0	€ 0
Wind Power	€ 0	€ 0	€ 0	€ 0
Hull Coating	€ 0	€ 0	€ 0	€ 0
Battery Hybrid	€ 0	€ 0	€ 0	€ 0
Biofuels	€ 0	€ 0	€ 0	€ 0
Ammonia	€ 0	€ 0	€ 0	€ 0
Methanol	€ 0	€ 0	€ 0	€ 0
Hydrogen	€ 0	€ 0	€ 0	€ 0
Full Electric	€ 0	€ 0	€ 0	€ 0
Yearly Gains	**€ 0**	**€ 0**	**€ 0**	**€ 0**

Year	% Phase-in
2024	0%
2025	40%
2026	70%
2027	100%

Learn more about EU ETS

5.0 APPENDIX II - CASE STUDIES SIMILAR TO SKOON SKIPPER

Here are several case studies similar to your vessel type, as well as more references on potentially interesting technologies and regulations from the Sustainable Ships site. Click on the stories' title to learn more.

Inland vessel + solar PV

Hydrogen inland vessel

Methanol as marine fuel

Regulations for maritime sustainability