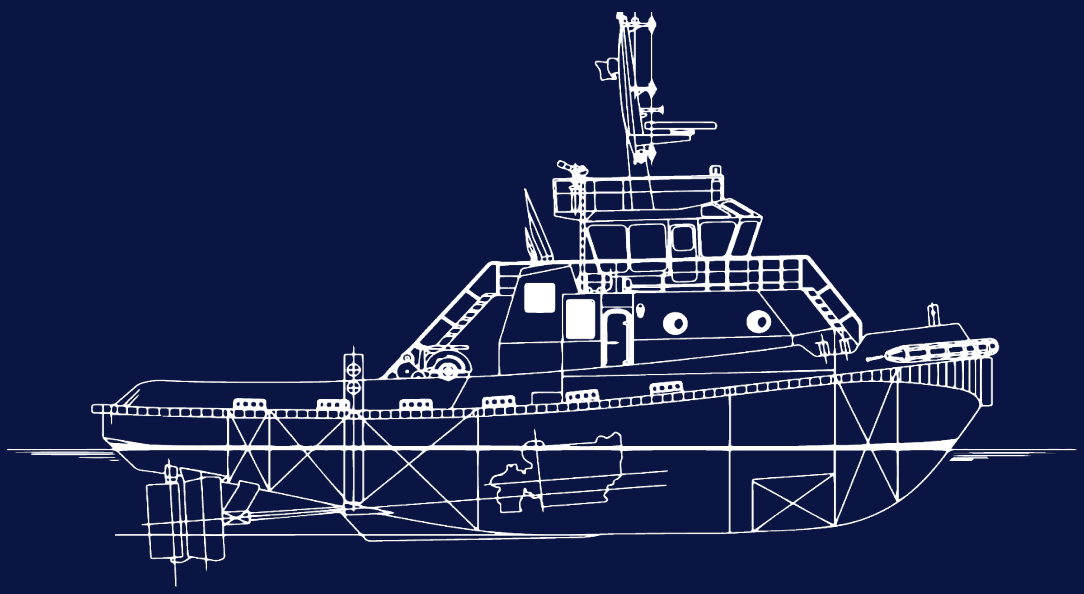


Decarbonizer Premium Report

A guide on upcoming rules and regulations on maritime sustainability

+ measures to reduce carbon emissions for Sparky McSparkspark

Client Name	**Electric Tugs**
Date	**2023-05-18**
Source	**Sustainable Ships**

EXECUTIVE SUMMARY

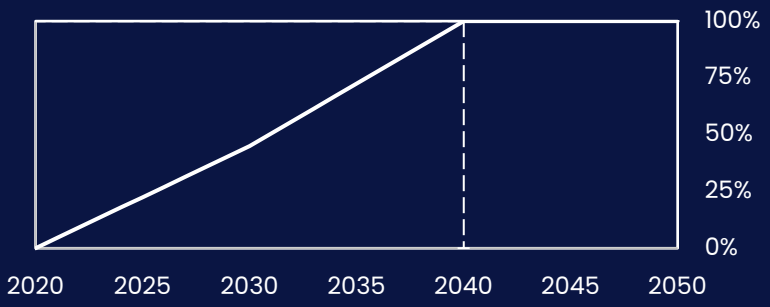
The purpose of this document is to provide Electric Tugs with guidance and insights on maritime sustainability of Sparky McSparkspark. This report elaborates on your operational profile, applicable rules and regulations and finally on carbon reduction measures and costs.

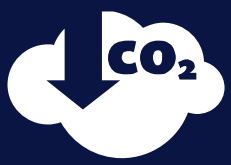
Operational Profile

day/year

Fuel	2,052	[l/day]
CO2	5,854	[kg/day]
ETS	€ 498	[€/day]
OPEX	€ 2,626	[€/day]
CII	Not Applicable	
EEXI	Not Applicable	

Rules and Regulations





2040
Target Date

100%
Reduction

Decarbonization Measures	CO_2	CAPEX	Δ-OPEX [daily]	Payback [days]
-				
-				
Full_Electric	100%	€ 5,916,663	-€ 1,675	**3532**

	CO_2	CAPEX	OPEX [daily]	Payback [days]
Current situation	0%	€ 0	€ 2,626	-
Future Sparky McSparkspark	**-100%**	**€ 5,916,663**	**€ 951**	**3,532**

A negative Δ-OPEX means you will pay less than your current OPEX

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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

Sustainable Ships will not be held responsible for any damages that could arise from using the information provided in this report or on its platform. View all terms and conditions here.

1.0 OPERATIONAL PROFILE SPARKY MCSPARKSPARK

1.1 Vessel and operational properties

Parameter	Value	Unit
Ship name	Sparky McSparkspark	
Ship type	Port / Coastal	
Fuel type	MDO	
Main Engines	Main Engines	
Installed Power	3804	[kW]
Engine Type	4-Stroke	226 [g/kWh]
Engine Speed	High	
Aux Engines	Aux Engines	
Aux Power	100	[kW]
Aux. Engine Type	4-Stroke	
Aux. Engine Speed	High	[kW]
Year built	2023	[years]
Ship age	0	[years]
Lifetime from today	25	[years]
Target Date	2048	
Gross Tonnage	100	[-]
Deadweight	50	[mT]
Cargo capacity	50	[m3]
Area	Europe	
Propulsion Type	Diesel-electric	
Cruising speed	13	[knts]
Fuel Tank Capacity	78	[m3]
Length overall	23	[m]
Extreme Beam	12.03	[m]
Hull Roughness	Smooth	

Parameter		
Idle / Moored	82%	301 days per year
Sailing	2%	7 days per year
Working	16%	57 days per year

1.2 Current OPEX Sparky McSparkspark

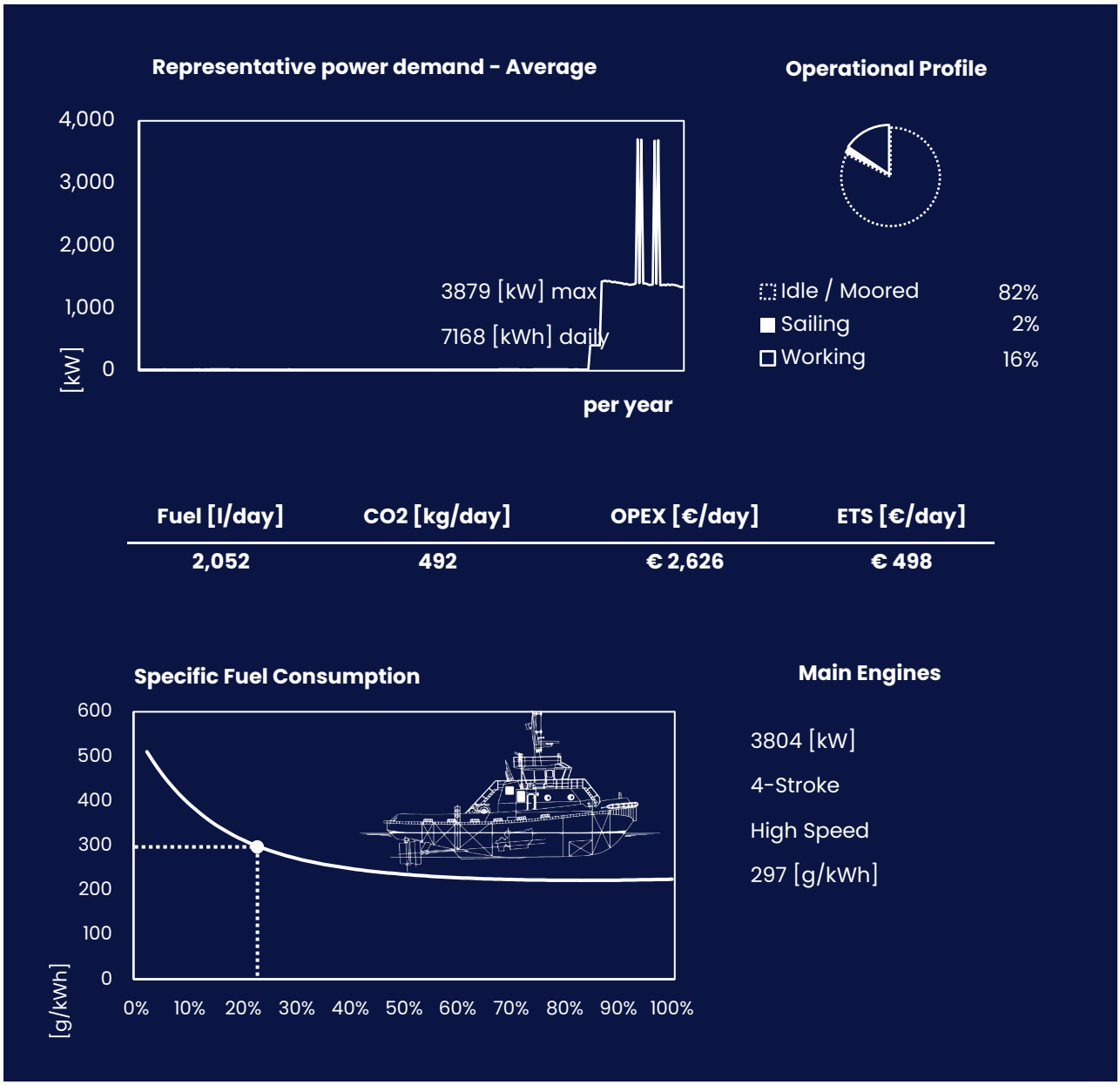
		Idle / Moored 301 [days/year]	Sailing 7 [days/year]	Working 57 [days/year]	Average per [day]
Max Power	[kW]	22	408	3,879	3,879
Average Power	[kW]	20	402	1,755	299
Energy Required	[kWh]	492	9,647	42,123	7,168
Fuel Consumption	[liter]	172	4,247	11,705	2,052
Engine Hours	[hrs]	24	24	24	24

CO2 Emissions	[kg]	492	12,117	33,400	5,854
NOx Emissions	[kg]	8	207	572	100
SOx Emissions	[kg]	0	8	22	4
PM Emissions	[kg]	0	4	10	2
CH4 Emissions	[kg]	0	0	1	0

Fuel	[€]	€ 134	€ 3,312	€ 9,130	€ 1,600
Lease / Rental	[€]	€ 0	€ 0	€ 0	€ 0
Engine Maintenance	[€]	€ 480	€ 480	€ 480	€ 480
Spares / Consumables	[€]	€ 48	€ 48	€ 48	€ 48
ETS Costs	[€]	€ 42	€ 1,030	€ 2,839	€ 498
Coating	[€]	€ 0	€ 0	€ 0	€ 0

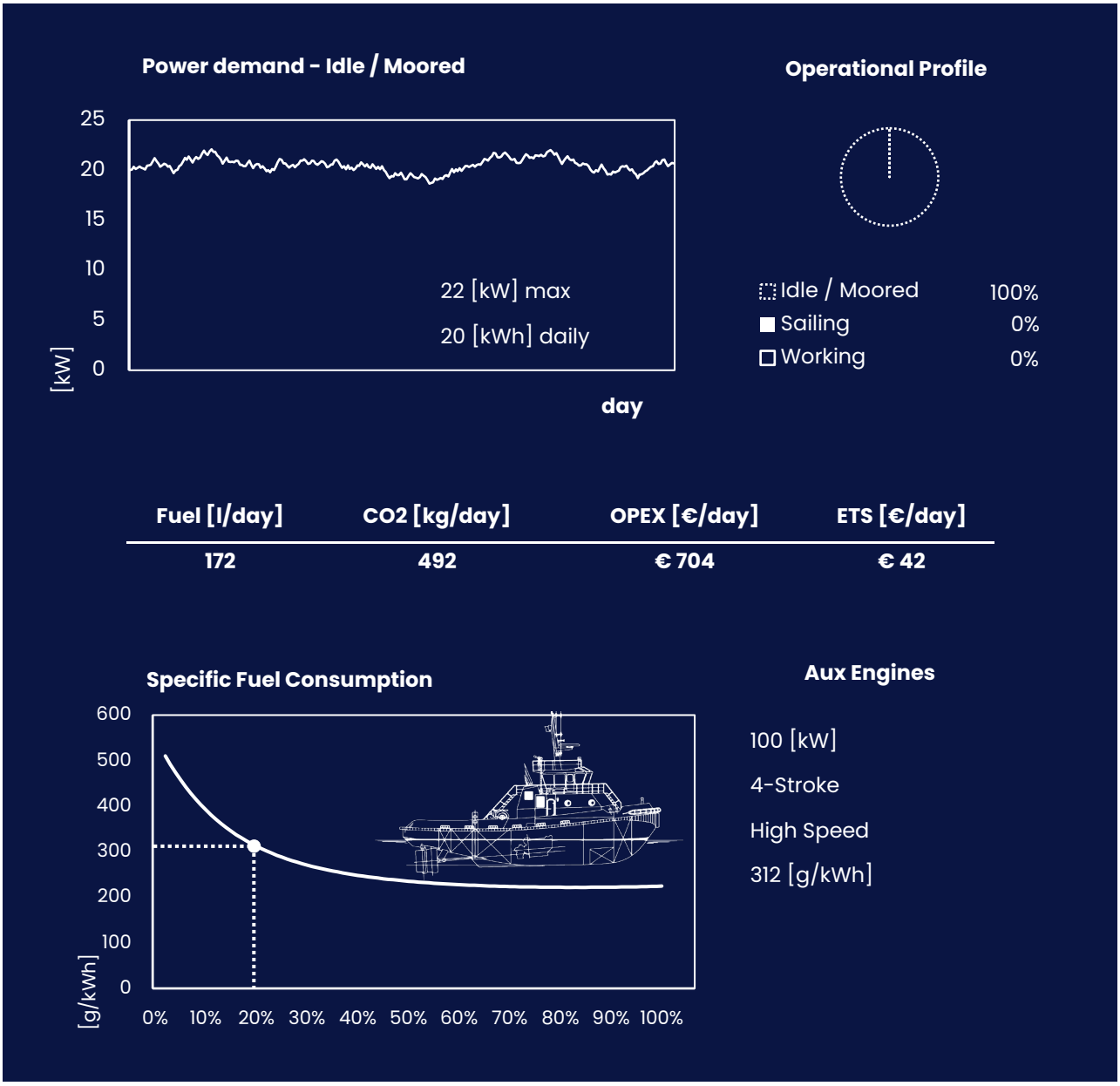
OPEX	**daily**	**€ 704**	**€ 4,870**	**€ 12,497**	**€ 2,626**
	yearly	**€ 257,071**	**€ 1,777,703**	**€ 4,561,493**	**€ 958,431**

1.3 Combination – Yearly



The estimated operational profile of Sparky McSparksparkwhen 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".

1.4 Idle/Moored – Daily



Fuel [l/day]	CO2 [kg/day]	OPEX [€/day]	ETS [€/day]
172	492	€ 704	€ 42

Aux Engines

100 [kW]

4-Stroke

High Speed

312 [g/kWh]

1.5 Sailing – Daily

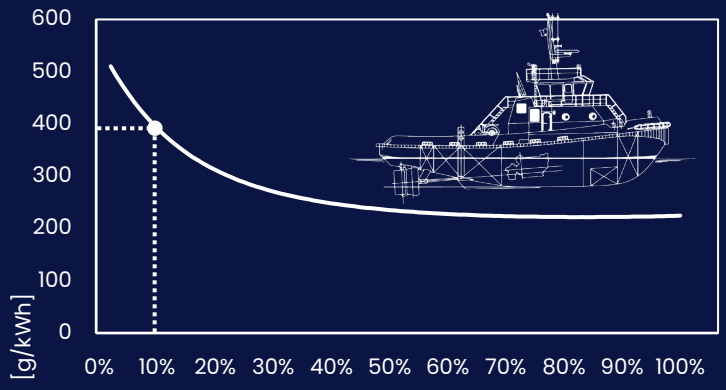
Power demand - Sailing

Operational Profile

Idle / Moored	0%
Sailing	100%
Working	0%

Fuel [l/day]	CO2 [kg/day]	OPEX [€/day]	ETS [€/day]
4,247	12,117	€ 4,870	€ 1,030

Specific Fuel Consumption



Main Engines

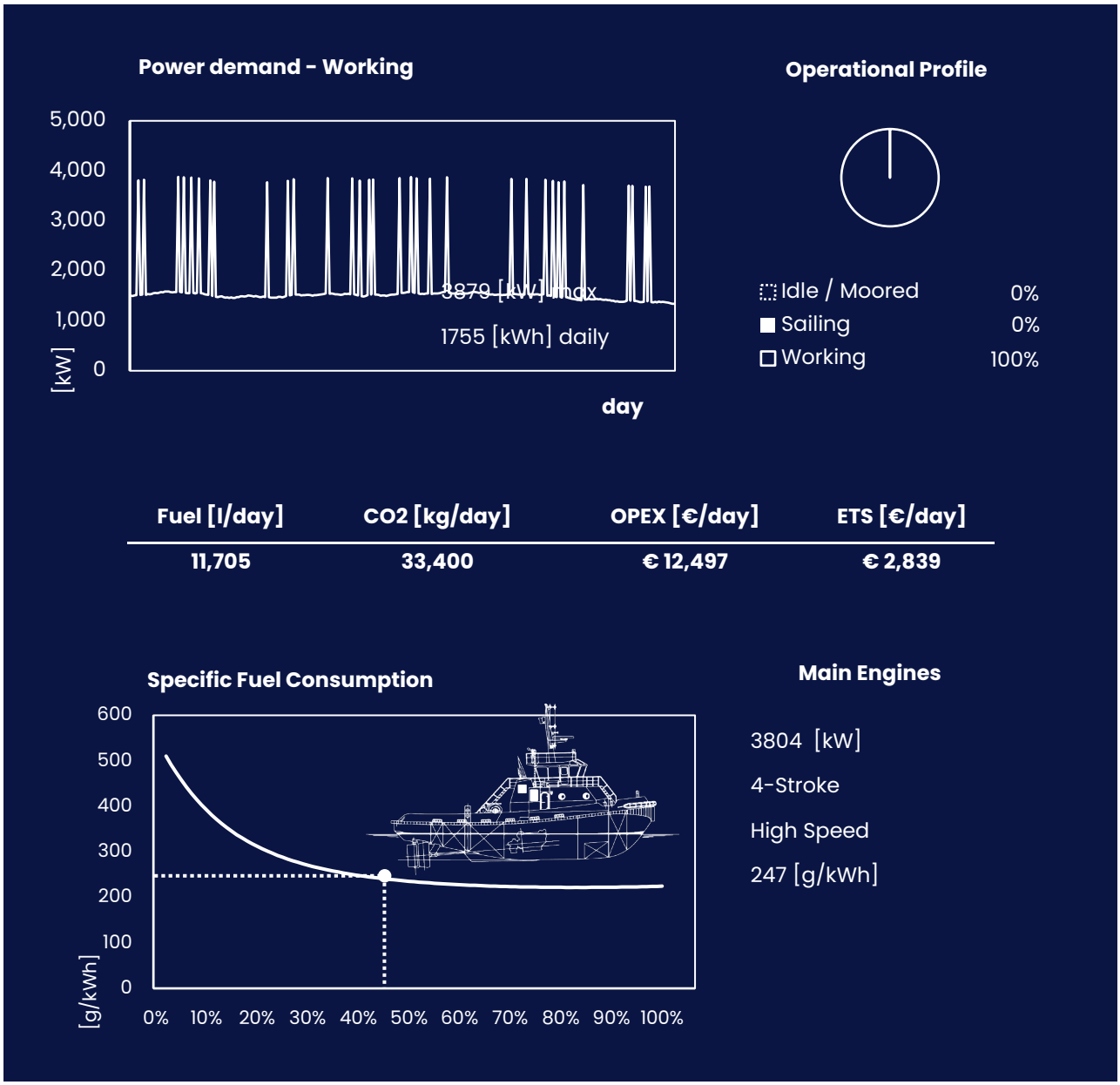
3804 [kW]

4-Stroke

High Speed

392 [g/kWh]

1.6 Working – Daily



Fuel [l/day]	CO2 [kg/day]	OPEX [€/day]	ETS [€/day]
11,705	33,400	€ 12,497	€ 2,839

Main Engines

3804 [kW]

4-Stroke

High Speed

247 [g/kWh]

'Working' is defined as an operational mode in which the vessel operates on its main engines and experiences peaks in power demand. This can be the case for offshore working vessels when on DP or operating cranes.

2.0 KEY UPCOMING RULES AND REGULATIONS FOR SPARKY MCSPARKSPARK

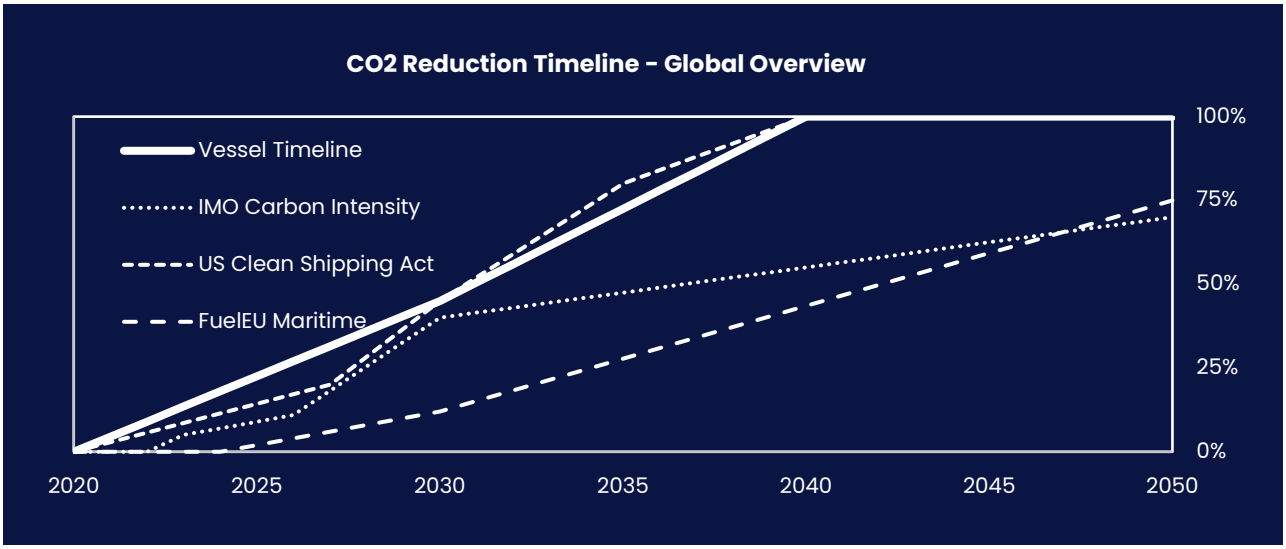


Figure 5. CO2 reduction timelines for key organizations around the world.

Key takeaways	
For 2048 a CO2 reduction of 100% 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 €85 per mT CO2, that would equate to a surtax of roughly €255 per mT of fuel.

Key rules and regulations for Sparky McSparkspark				
Rule/Reg	**Organization**	**In Effect**	**Area**	**Impact / Restraint**
PAS	Netherlands	2021	Europe	-80% NOx
HBE	Netherlands	2022	Europe	Get € 0.04-0.20 kWh
ECA Norway	IMO	2019	Europe	0.1% SOx max
Global Sulphur Limit	IMO	2020	Global	0.5% SOx max
ECA North Sea	IMO	2021	Europe	0.1% SOx max
ECA Mediterranean	IMO	2025	Europe	0.1% SOx max
IMO Carbon Price	IMO	2026	Global	Unknown
Ørsted	Ørsted	2040	Europe	-100% CO2 2040
Repsol	Repsol	2040	Global	-100% CO2 2040
Equinor	Equinor	2050	Europe	-100% CO2 2050
Shell	Shell	2050	Global	-100% CO2 2050
BP	BP	2050	Global	-100% CO2 2050
Total	Total	2050	Global	-100% CO2 2050
Eni	Eni	2050	Global	-100% CO2 2050
Maersk	Maersk	2035	Global	-100% CO2 2035

CII / EEXI / EU ETS		
CII	**EEXI**	**EU ETS [year]**
Not Applicable	Not Applicable	€ 181,618

Purchase the **premium Rules and Regulations report** for only €399 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	CAPEX	Δ-OPEX [daily]	Payback [days]
Shore_Power	-7%	€ 201,000	-€ 459	438
Shore_Battery	-7%	€ 418,377	-€ 459	912
Solar_PV	-3%	€ 52,251	-€ 58	896
Wind_Power	n.a.	-	n.a.	n.a.
Hull_Coating	n.a.	-	n.a.	n.a.
Battery_Hybrid	n.a.	-	-	-
Biofuels	-79%	€ 80,880	€ 329	-
Ammonia	-100%	€ 2,821,407	€ 137	-
Methanol	-95%	€ 1,897,856	€ 19	-
Hydrogen	-100%	€ 9,117,121	€ 2,665	-
Full_Electric	**-100%**	**€ 5,916,663**	**-€ 1,675**	**3,532**
Carbon_Capture	n.a.	-	-	-

Current situation	**0%**	**€ 0**	**€ 2,626**	**-**
After measures	**-100%**	**€ 5,916,663**	**€ 951**	**3,532**

Target reduction **-100%** Estimate based on vessel end-of-life

3.2 Selected measures for Sparky McSparkspark

The below carbon reduction measures have been applied to Sparky McSparkspark Click on the buttons 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	
-	-	Full_Electric

3.3 CII / EEXI / EU ETS

Below is an overview of CII, EEXI and EU ETS before and after implementation of carbon reduction measures. Elaboration on the calculation of CII, EEXI and EU ETS are provided in Appendix I.

CII / EEXI / EU ETS			
	CII	**EEXI**	**EU ETS**
Current	Not Applicable	Not Applicable	€ 181,618
After	Not Applicable	Not Applicable	€ 0

3.4 Technical Details -

None chosen

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3.5 Technical Details Prevent Measure n.a.

None chosen

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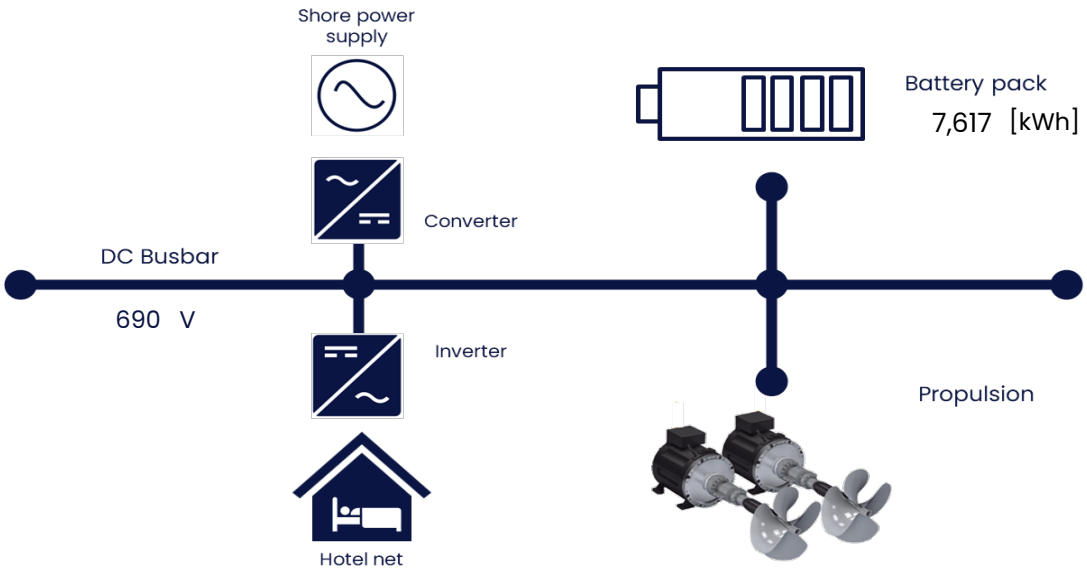
3.6 Technical Details Change Measure Full_Electric

This measure implies fully electrifying the vessel by using batteries to power the vessel. It is highly restrictive in terms of operations for most vessels, as the energy density of battery packs is not enough for weeks of autonomy at see. This measure is thus usually reserved for ships operating for shorter periods of time, hours to a day at most, and returning to a fixed location afterwards. Most commonly available battery types for maritime use are NMC and LFP, of which LFP is safest.

Conversion of a vessel to full electric is highly intrusive, as the entire engine room, electrical system and/or propulsion needs to be refitted. It is commonly only reserved for diesel-electric vessels, and from an economic viewpoint recommended for newbuilt only.

Other	Value	Unit
Shore power ready?	No	-
Shore battery installed?	No	-
Days powered by battery ("trip")	1.0	[days]
Nominal Power for trip	254	[kW]
Energy consumption per trip	6093	[kWh/day]
Energy density battery	2.5	[mWh/20ft container]
Minimum volume required per day	81	[m3/day]
20ft Containers required per day	2.4	[20ft container/day]
20ft Containers required total journey	2.4	[20ft container]
Volume required total	81	[m3]
Current fuel tank capacity	78	[m3]
Capacity increase	4%	-
Distance battery to engine room / SWB	50	[m]
Operating Voltage	690	[V]
Operating frequency	DC	[Hz]
Number of phases	1	-
Converter Required?	Yes	-
Transformer Required?	Yes	-
Switchboard spare breaker available?	No	-
Switchboard Vendor/Type	-	-

Learn more about Full_Electric



Sparky - Full Electric Tug

Damen's first all-electric harbour tug, the RSD-E Tug 2513, is a high-powered tug with 70-tonnes bollard pull, capable of manoeuvring even the largest vessels. It can undertake two or more assignments before being recharged, which takes just two hours. The battery pack size is 2,800 kWh, resulting an approximately 1,400 kW of charging power required. The battery pack is design for the vessel's 30 year lifetime.

Learn more

Inside The World's First Electric Cargo Ship

Dubbed 'the Tesla of the seas' this fully-electrified, fully-autonomous cargo ship is already making waves. The Yara Birkeland has a 7MWh battery, charged by Norwegian hydro power. She can carry a little over 100 containers. The ship cost about 25 million dollars, about three times a "conventional ship price", but will nonetheless cut OPEX for Yara by 90%.

Learn more

3.7 CAPEX Breakdown -

None chosen

None chosen

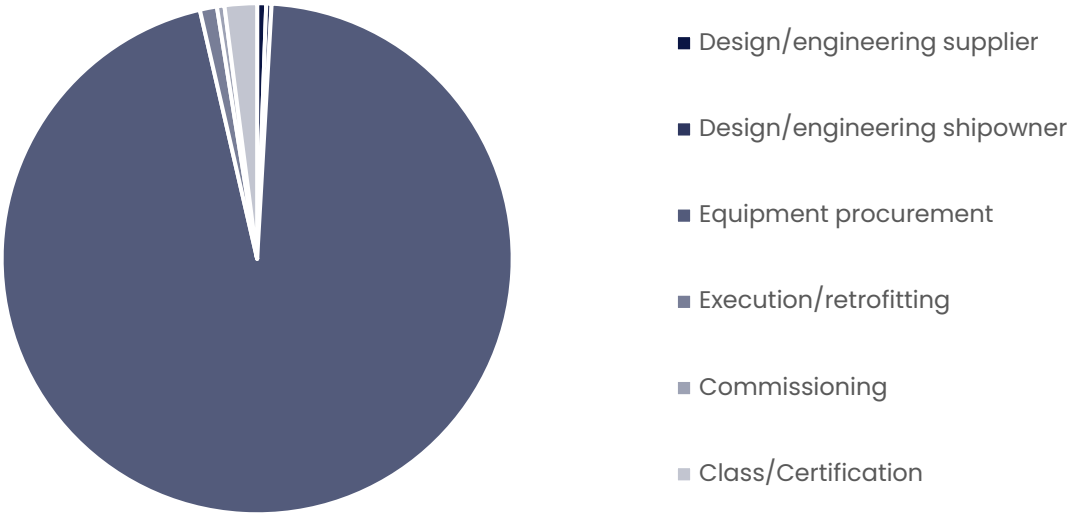
3.8 CAPEX Breakdown Prevent Measure n.a.

None chosen

None chosen

3.9 CAPEX Breakdown Change Fuel Full_Electric

	Time [hours]	Costs
Design/engineering supplier	280	€ 33,600
Design/engineering shipowner	200	€ 20,000
Equipment procurement	0	€ 5,649,819
Execution/retrofitting	640	€ 64,000
Commissioning	280	€ 28,000
Class/Certification	609	€ 121,244
Total	**50 fte weeks**	**€ 5,916,663**



	Time [hrs]	Units	Parameter	Price per hour/unit	Total Cost
Design/engineering supplier	**280**				**€ 33,600**
Electrical engineering for switchboard and breaker modifications	80		EUR/hr	€ 120	€ 9,600
Electrical engineering for electric interfaces and cabling	40		EUR/hr	€ 120	€ 4,800
Electrical engineering for PMS modifications	80		EUR/hr	€ 120	€ 9,600
Short circuit and selectivity study	80		EUR/hr	€ 120	€ 9,600
Design/engineering shipowner	**200**				**€ 20,000**
Misscalenous engineering	40		EUR/hr	€ 100	€ 4,000
Engineering for cable routing at location	40		EUR/hr	€ 100	€ 4,000
Mechanical engineering for battery installation	120		EUR/hr	€ 100	€ 12,000
Equipment procurement	**0**	**1**			**€ 5,649,819**
Battery system		1	EUR	€ 3,808,262	€ 3,808,262
Switchboard modifications*		1	EUR	€ 323,340	€ 323,340
(HV) Breakers Set		1	EUR	€ 32,334	€ 32,334
Converter		1	EUR	€ 485,010	€ 485,010
Transformer		1	EUR	€ 485,010	€ 485,010
Harmonic filters		1	EUR	€ 32,334	€ 32,334
Foundation/containment for battery system		1	EUR	€ 3,808	€ 3,808
Fire suppresion system		1	EUR	€ 152,330	€ 152,330
Shore connection panel/housing/interface		1	EUR	€ 12,934	€ 12,934
(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	€ 38,182	€ 38,182
Power management system modifications		1	LOT	€ 38,182	€ 38,182
Spare parts		1	LOT	€ 76,364	€ 76,364
Consumables on-board, general supplies, paint, electrodes etc.		1	LOT	€ 76,364	€ 76,364
Rental tools		1	LOT	€ 76,364	€ 76,364
Execution/retrofitting	**640**				**€ 64,000**
Creating means of access for safe working location	80		EUR/hr	€ 100	€ 8,000
Cleaning/removing obstructions from working locations	40		EUR/hr	€ 100	€ 4,000
Installation/removal of scaffolding on working locations	40		EUR/hr	€ 100	€ 4,000
Installation/Implementation of switchboard/breaker modifications	80		EUR/hr	€ 100	€ 8,000
Implementation of power management modifications	80		EUR/hr	€ 100	€ 8,000
Installation of bulkhead penetrations for cable routing	40		EUR/hr	€ 100	€ 4,000
Installation of cable trays to complete routing	40		EUR/hr	€ 100	€ 4,000
Installation of foundations for battery	80		EUR/hr	€ 100	€ 8,000
Installation of battery system	40		EUR/hr	€ 100	€ 4,000
Pulling, fastening and terminating of cables	40		EUR/hr	€ 100	€ 4,000
Painting/coating of equipment	40		EUR/hr	€ 100	€ 4,000
Non-destructive testing of structures (if installed)	40		EUR/hr	€ 100	€ 4,000
Commissioning	**280**				**€ 28,000**
Testing of battery system	40		EUR/hr	€ 100	€ 4,000
Testing of switchboard	40		EUR/hr	€ 100	€ 4,000
Testing of power management system modifications	40		EUR/hr	€ 100	€ 4,000
Testing of safety systems	40		EUR/hr	€ 100	€ 4,000
Training and familiarising of crew	120		EUR/hr	€ 100	€ 12,000
Class/Certification	**608.64**				**€ 121,244**
Approval costs of drawings/calculations	401.728		EUR/hr	€ 120	€ 48,207
Surveyor attendence for fabrication/installation incl. travel expense	304.32		EUR/hr	€ 120	€ 36,518
(Writing) Operational manuals and procedures	304.32		EUR/hr	€ 120	€ 36,518

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

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

3.10 Future OPEX Breakdown Sparky McSparkspark

The below table shows the current and future OPEX breakdown for Sparky McSparkspark, based on the representative daily operational profile. Depreciation of equipment has not been taken into account (neither for existing or newly purchased equipment). Rental of equipment will be made available soon.

		Current	Future
Max Power	[kW]	3,879	1,492
Average Power	[kW]	299	254
Energy Required	[kWh]	7,168	6,093
Fuel Consumption	[liter]	2,052	0
Engine Hours	[hrs]	24	0

Fuel	[€]	€ 1,600	€ 914
Lease / Rental	[€]	€ 0	€ 0
Engine Maintenance	[€]	€ 480	€ 18
Spares / Consumables	[€]	€ 48	€ 18
ETS Costs	[€]	€ 498	€ 0
Coating	[€]	€ 0	€ 0

OPEX	**daily**	**€ 2,626**	**€ 951**
	yearly	**€ 958,431**	**€ 346,948**
			-64%

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**
-	-	
-	-	
Full_Electric	Skoon	pepijnreesink@skoon.world

Other Suppliers		
Technology	**Supplier**	**Contact**
Full_Electric	EST-Floattech	w.vander.pennen@est-floattech.com
Full_Electric	Corvus Energy	
Full_Electric	AYK Energy	
Full_Electric	Kongsberg Maritime	
Full_Electric	Spear Power Systems	
Full_Electric	Praxis Automation Technology	
Full_Electric	Zero Emission Services	
Full_Electric	Energy Storage Solutions	
Full_Electric	Freudenberg Battery Power System	
Full_Electric	Siemens Energy	

4.0 APPENDIX I – ASSUMPTIONS AND CALCULATIONS

4.1 Input values and assumptions

Parameter	Value	Unit
Fuel Price	€ 0.78	[€/l]
ETS	€ 85	[€/mT]
Engine Maintenance Costs	€ 20	[€/hr]
Spares / Consumables Costs	€ 2	[€/hr]
Parasitic Load Engine	15%	[-]
(Engineering) Hour External	€ 120	[€]
(Engineering) Hour Internal	€ 100	[€]
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	Full_Electric	[-]
Fuel density after change measures	0	[kg/liter]
Fuel price after change measure	€ 0.15	[€/liter]
Shore-side kWh price	€ 0.35	[€/kWh]
CO2 Emission Factor	0	[kg/kWh]
Nox Emission Factor	0	[kg/kWh]
Sox Emission Factor	0	[kg/kWh]
PM Emission Factor	0	[kg/kWh]
CH4 Emission Factor	0	[kg/kWh]

4.2 CII Calculation

Sparky McSparkspark 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	Combined	
CO2 Emissions	2,136,687,117	[g/year]
Capacity	n.a.	[mT]
Distance Sailed	2,184	[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.
Carbon_Capture	n.a.	n.a.	n.a.	n.a.

4.3 EEXI Calculation

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

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

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

EEXI Input values		
Ship Type	Port / Coastal	
Operational Mode	Sailing	
CO2 Emissions	504,890	[gram/hour]
Capacity	50	[mT]
Reference Speed	13	[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	€ 72,647	€ 127,133	€ 181,618
Shore_Power	€ 0	€ 67,613	€ 118,322	€ 169,031
Shore_Battery	€ 0	€ 67,613	€ 118,322	€ 169,031
Solar_PV	€ 0	€ 70,528	€ 123,424	€ 176,320
Wind_Power	€ 0	€ 71,915	€ 125,852	€ 179,788
Hull_Coating	€ 0	€ 72,334	€ 126,584	€ 180,834
Battery_Hybrid	n.a.	n.a.	n.a.	n.a.
Biofuels	€ 0	€ 15,207	€ 26,612	€ 38,018
Ammonia	€ 0	€ 0	€ 0	€ 0
Methanol	€ 0	€ 3,965	€ 6,939	€ 9,913
Hydrogen	€ 0	€ 0	€ 0	€ 0
Full_Electric	**€ 0**	**€ 0**	**€ 0**	**€ 0**
Yearly Gains	**€ 0**	**-€ 72,647**	**-€ 127,133**	**-€ 181,618**

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

Learn more about EU ETS

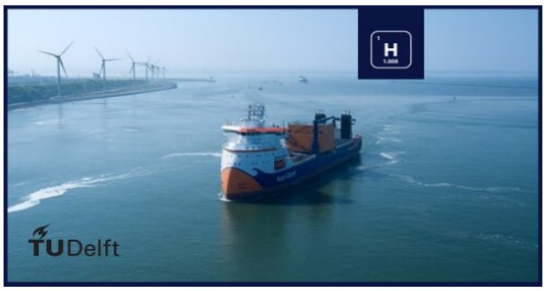
5.0 APPENDIX II - CASE STUDIES SIMILAR TO SPARKY MCSPARKSPARK

This section is under development. In the future, case studies similar to your vessel type will be taken from sustainable-ships.org/stories as reference. Feel free to browse or contact the helpdesk for more stories!

4/30/21

Hydrogen Powered Propulsion for an Offshore Crane Vessel

This thesis performs a technical, economical and environmental feasibility study of three dense hydrogen carriers as a fuel to power the largest semi-submersible offshore crane vessel in the world – Heerema's Sleipnir.



3/12/21

Methanol Hybrid Offshore Working Vessels

This thesis by J.M. Rozendaal at van Oord focuses on the technical, environmental and economic impact of a methanol hybrid power plant design for new-build offshore working vessels. Its conclusion is that a methanol solution has a CO2 reduction potential up to 99% and a CO2 price of 78 euro per ton CO2 reduction.