ELKON

Canadian Ferry Association Conference

Life Cycle Management of Marine Assets

elkon
electric system integrator
a member of the SCHOTTEL Group

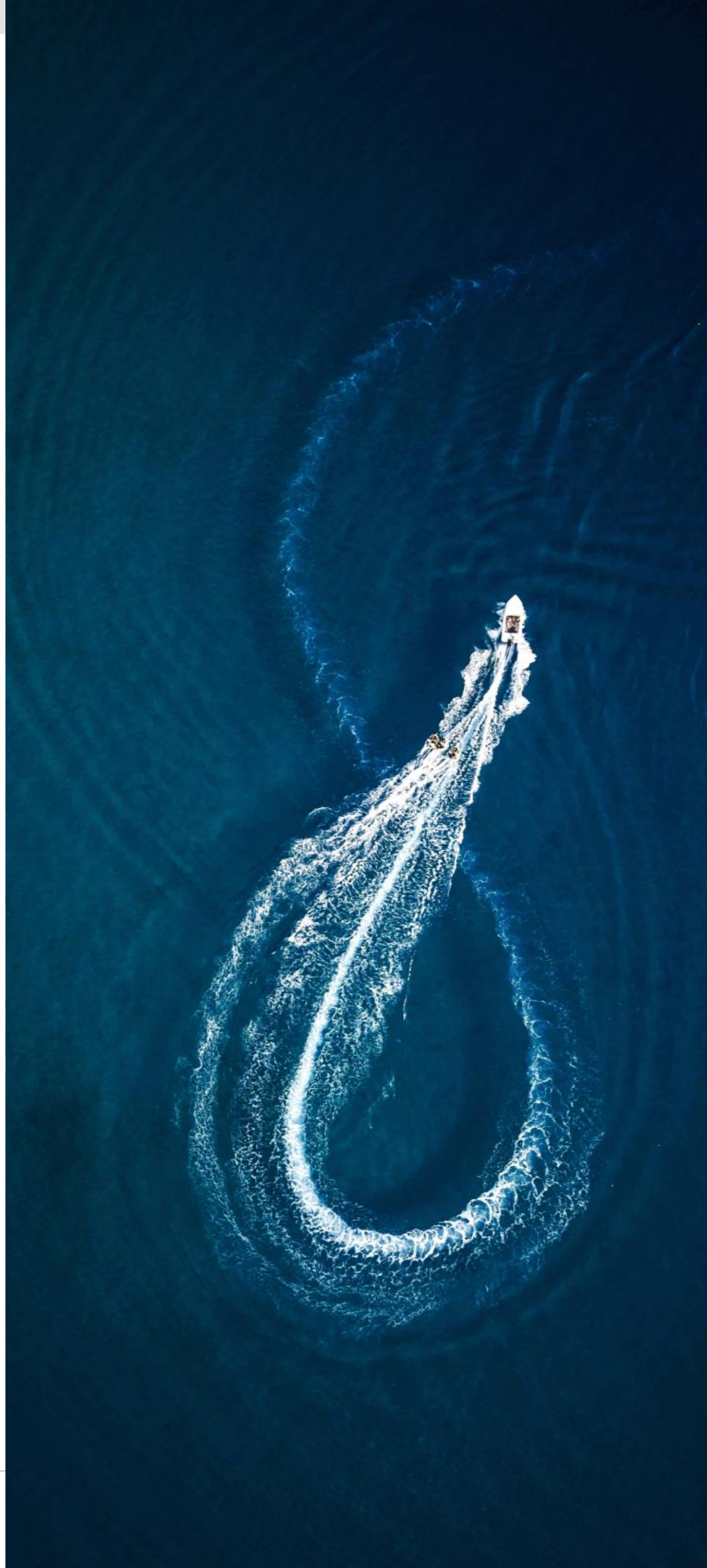
01

ABOUT ELKON

Elkon

Founded in 1980, **Elkon** stands out as one of Turkey's leading integrators of marine electrical systems.As an engineering company, Elkon employs a team of over 450 people, including 100 electrical engineers. Since 2022, As part of the **SCHOTTEL Group**, Elkon combines global reliability with local expertise to deliver sustainable maritime solutions.

Our core values include drawing strength from knowledge and our roots, mutual solidarity, technological leadership, sensitivity to the sea, fair and transparent governance, and commitment to the principle of equality.

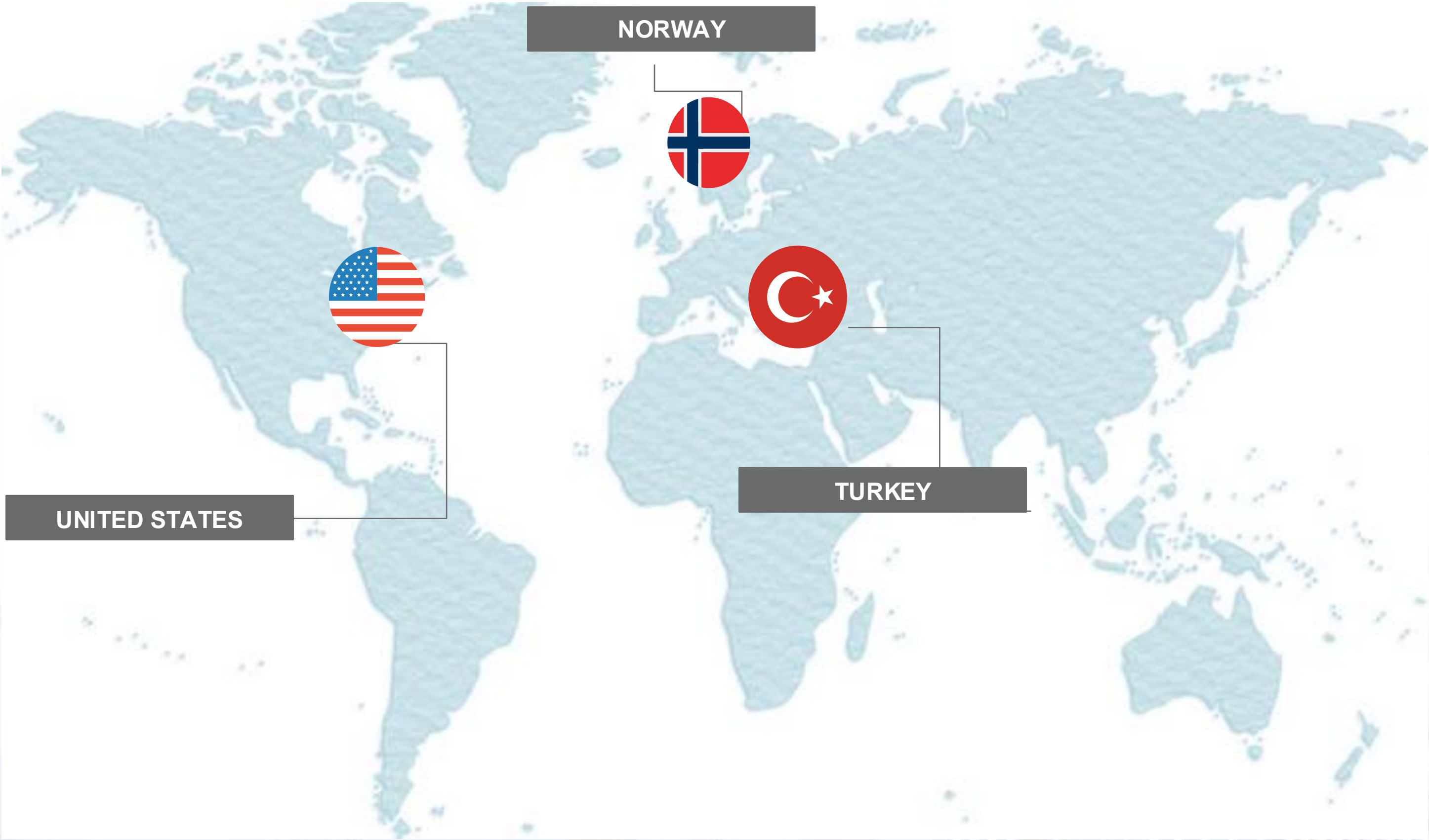


OFFICES

Turkey, Norway, United States

TURKEY

Our headquarters is located in Turkey, and through our offices in the United States and Norway, we provide global-scale support for after-sales services and project management. This structure enables us to offer solutions tailored to local needs while ensuring the continuity and efficiency of our international operations.



02

REFERENCES

REFERENCES

Ro-Ro & Ferries Study Case

NB 1092 - 1093
Ro-Ro & Ferries

EOLIE NB 54
Ro-Ro & Ferries

NB 1100 - 1101
Ro-Ro & Ferries

NB 44 Svelvik
Ro-Ro & Ferries

NB 52 Victoria of Wight
Ro-Ro & Ferries

Two Hybrid Ferries Seaspan
Ro-Ro & Ferries

NB 1080-1081-1082
Ro-Ro & Ferries

NB 179-180 Seaspan
Ro-Ro & Ferries

Gloppefjord & Eidsfjord
Ro-Ro & Ferries

REFERENCES

Ro-Ro & Ferries Study Case

REFERENCES

Ferry Case Studies

SEFINE - ELOIE NB 54	
NAME	ELOIE NB 54
Type	Diesel & LNG Hybrid Ro-Pax Ferry
Owner	Caronte & Tourist of Italy
Designer	Naos Ship and Boat Design
Delivery Date	2023
Principal Particulars	110m * 19.5m * 4.9m
Hybrid System Configuration	Diesel & LNG Hybrid
ESS Capacity	994 kWh

REFERENCES

Ferry Case Studies SEFINE - ELOIE NB 54

SEFINE - NEREA NB 54

SEFINE - NEREA NB 44

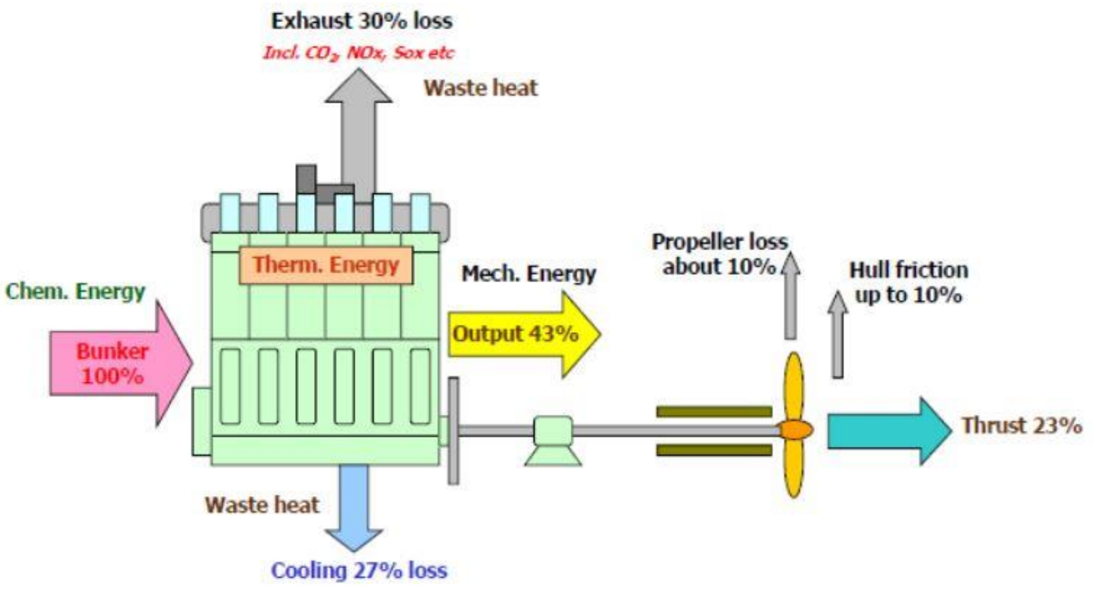
03

COMPARATIVE ANALYSIS OF CONVENTIONAL VS. ELECTRICALLY PROPELLED VESSELS ENERGY FLOW

COMPARATIVE ANALYSIS OF CONVENTIONAL VS. ELECTRICALLY PROPELLED VESSELS ENERGY FLOW

Case Studies

Energy Flow On Board For Propulsion Of Conventional Vessel*



* WMU-IMO, 2013: Training course on Energy Efficient Operation of Ships

Energy Flow On Board For Propulsion Electric Propulsion Vessel**

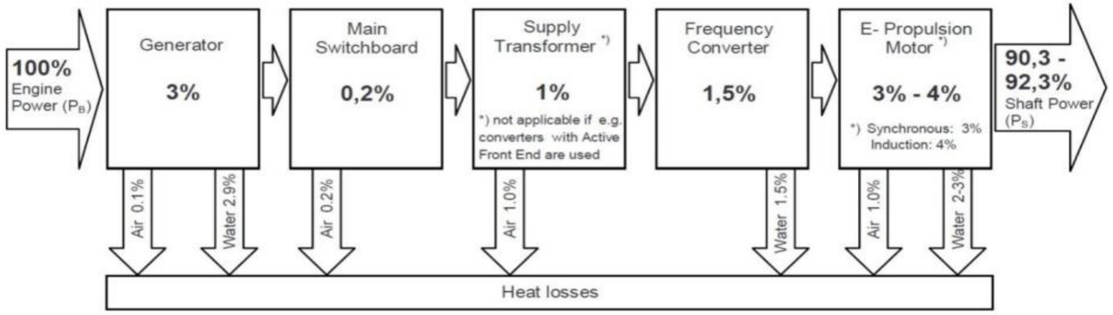


Figure 44 Drive train losses in Diesel-electric drive train with Diesel generator powered energy source, (MAN, Diesel electric drives - Guideline).

** EU funded E-Ferry Project Prototype and full-scale demonstration of next-generation 100% electrically powered ferry for passengers and vehicles
Deliverable number: (D.7.5)

SOME EXAMPLES OF LIFE CYCLE ASSESSMENTS OF ELECTRIFIED VESSELS

Evaluating the economic performance of a pure electric and diesel vessel: *the case of E-ferry in Denmark.*

Evaluating the Economic Performance of a Pure Electric and Diesel Vessel: The Case of E-ferry in Denmark

Annie Kortsari[a], Lambros Mitropoulos[a], Trine Heinemann[b], Henrik Mikkelsen[c], Georgia Aifadoupoulou[a]

Europe is an extremely ferry-intensive area, with two main markets – the Northern Europe and the Baltic, and the Mediterranean; while EU ferries account for 35 % of the world fleet. This research presents the E-ferry, the first pure electric ferry for medium range routes and likely the largest battery pack ever installed in an electric vessel, and evaluates its economic performance compared to an electric-diesel and a diesel vessel. Three E-ferry schemes are used in the evaluation: E-ferry prototype, E-ferry prototype excluding the development costs, and Series 3 E-ferry, for which we assume an increased production level. The evaluation focuses on the construction and operation costs of the vessels by utilizing real-world data that were collected during the evaluation period of the E-ferry, and complemented with data provided by the ferry operator. The evaluation shows that while the E-ferry construction cost is higher compared to the other two technologies, it contributes significantly to energy demand reduction. The E-ferry achieves cost parity with the diesel-based engine vessels between 5.2 and 3.6 years when considering different E-ferry and energy schemes, showing the potential to promote sustainable ferry operations in short and medium range ferry connections.

KEY WORDS
~ Pure electric ferry
~ Economic assessment
~ Diesel
~ Hybrid
~ Lifecycle cost

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doi: 10.7225/toms.v11.n01.008

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1. INTRODUCTION

Maritime transport emits around 940 million tonnes of carbon dioxide (CO_2) annually and is responsible for about 2.5 % of global greenhouse gas (GHG) emissions, while shipping emissions accounted for around 13 % of the overall EU GHG emissions from the transport sector in 2015 (IMO 2015). Maritime shipping uses about 11 % of the transportation sector's petroleum (i.e., 5 million barrels per day), resulting in 1 Gt CO_2 emissions annually (IEA 2013). Moreover, maritime air pollutants affect the inhabitants of coastal and harbor areas; the European maritime sulphur dioxide (SO_2) and nitrogen oxide (NO_x) emissions have been forecasted to surpass corresponding pollutants by land-based activities by 2030 (EC 2005). Moreover, maritime shipping's sheer volume and rapid growth makes it a major consumer of energy and source of carbon and air-polluting emissions.

Table 6.
Summary of construction and operation costs in 2020€ per vessel.

	E-ferry prototype	E-ferry series 3	LMG-50.1	M/F Marstal
(a) E-Ferry plan				
Cost of ferry	16,662,000	13,250,000	13,000,000	12,856,000
Cost of shore charging system	2,452,000	2,345,000	n/a	n/a
Cost excluding development costs	18,493,000	n/a	n/a	n/a
Cost including auto mooring for 2 harbors	19,640,000	16,742,000	14,147,000	n/a
Operation costs/year (5 trips/day - 360 days/year)	1,714,000	1,714,000	2,256,000	2,690,000
(b) Grid transformer ownership plan				
	E-ferry prototype	E-ferry series 3	LMG-50.1	M/F Marstal
Cost of ferry	16,662,000	13,250,000	13,000,000	12,856,000
Cost of shore charging system	2,452,000	1,858,000	n/a	n/a
Cost excluding development costs	18,493,000	n/a	n/a	n/a
Cost including auto mooring for 2 harbors	19,640,000	16,742,000	14,147,000	n/a
Operation costs/year (5 trips/day - 360 days/year)	1,714,000	1,671,000	2,256,000	2,690,000

"The E-ferry achieves cost parity with the diesel-based engine vessels between 5.2 and 6.6 years when considering different E-ferry and energy schemes, showing the potential to promote sustainable ferry operations in short and medium range ferry connections."

SOME EXAMPLES OF LIFE CYCLE ASSESSMENTS OF ELECTRIFIED VESSELS

Life Cycle Analysis and Total Cost of Ownership Comparison of Conventional and Electric Inland Ferries.

Life Cycle Analysis and Total Cost of Ownership Comparison of Conventional and Electric Inland Ferries

25 Pages • Posted: 9 May 2025

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Troy Hawkins
Argonne National Laboratory

Abstract

Electrifying inland marine vessels is one strategy to reduce emissions from the maritime sector. Several battery-powered ferries have been conceptualized and developed to demonstrate the opportunities for waterway electric ferries. Such studies often analyze the life cycle environmental and cost impacts of these vessels; however, the simplistic assumptions most studies make about battery capacity and life can lead to underestimation of the environmental and cost impacts of electric marine vessels. This study uses a detailed approach to electric ferry battery design, accounting for the battery's life, space occupancy, cost, and technical considerations. A detailed comparative life cycle and total cost of ownership assessment of a conceptualized electric ferry operating in the Washington State Ferry system was performed against the conventional ferry with an internal combustion engine operated on ultra-low sulfur fuel oil. The life cycle assessment indicated that electrifying a ferry reduces carbon footprint, particulate matter, and nitrogen oxide emissions compared to a conventional ferry. However, the electric ferry had higher sulfur oxide emissions than the conventional ferry due to nickel, cobalt, and manganese-based lithium-ion batteries, which use nickel sulfate as a raw material. The economic analysis showed that electric ferries are likely to have a 14-35% higher total cost of ownership than conventional ferries unless interest rates are low. Overall, electric ferries can be a practical step towards inland marine emissions reduction, provided sufficient economic incentives, more energy-dense, sustainable and cheaper batteries & more research into alleviating the significant power demand on electricity grids.

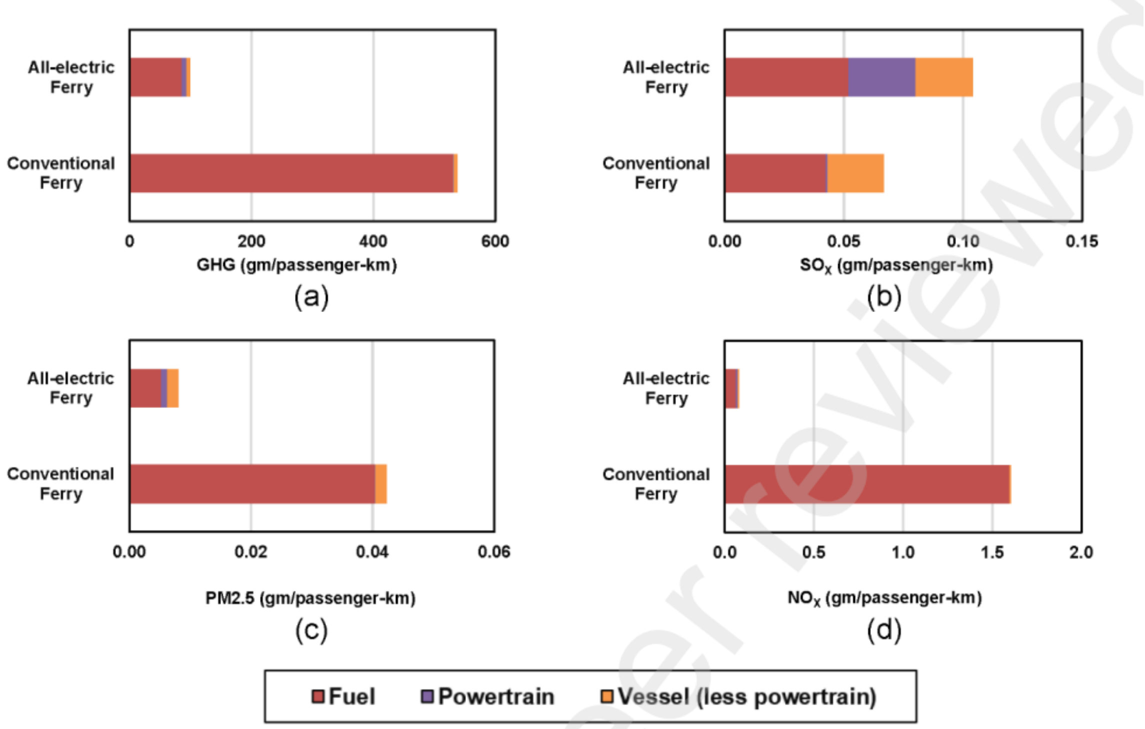

Figure 5. The total life cycle (a) greenhouse gas emissions, (b) SO_x emissions, (c) PM2.5, and (d) NO_x emissions per passenger -km for all-electric and conventional ferries. The total life cycle emissions include the emissions from fuel/electricity , powertrain and the rest of the vessel apart from the powertrain.

- "A detailed comparative life cycle and total cost of ownership assessment of a conceptualized electric ferry operating in the Washington State Ferry system was performed against the conventional ferry with an internal combustion engine operated on ultra-low sulfur fuel oil.«
- "The life cycle assessment indicated that electrifying a ferry **reduces carbon footprint**, particulate matter, nitrogen oxides, and greenhouse gas emissions compared to the conventional ferry.«
- "However, the electric ferry had **higher sulfur** oxide emissions than the conventional ferry due to nickel, cobalt, and manganese-based lithium-ion batteries, which use nickel sulfate as raw material.«
- "The economic analysis showed that electric ferries are likely to **have a 15-35% higher total cost of ownership** than conventional ferries unless interest rates are low."

SOME EXAMPLES OF LIFE CYCLE ASSESSMENTS OF ELECTRIFIED VESSELS

Life cycle analysis and cost assessment of a battery powered ferry. Decarbonizing City Water Traffic: ***Case of Comparing Electric and Diesel-Powered Ferries.***

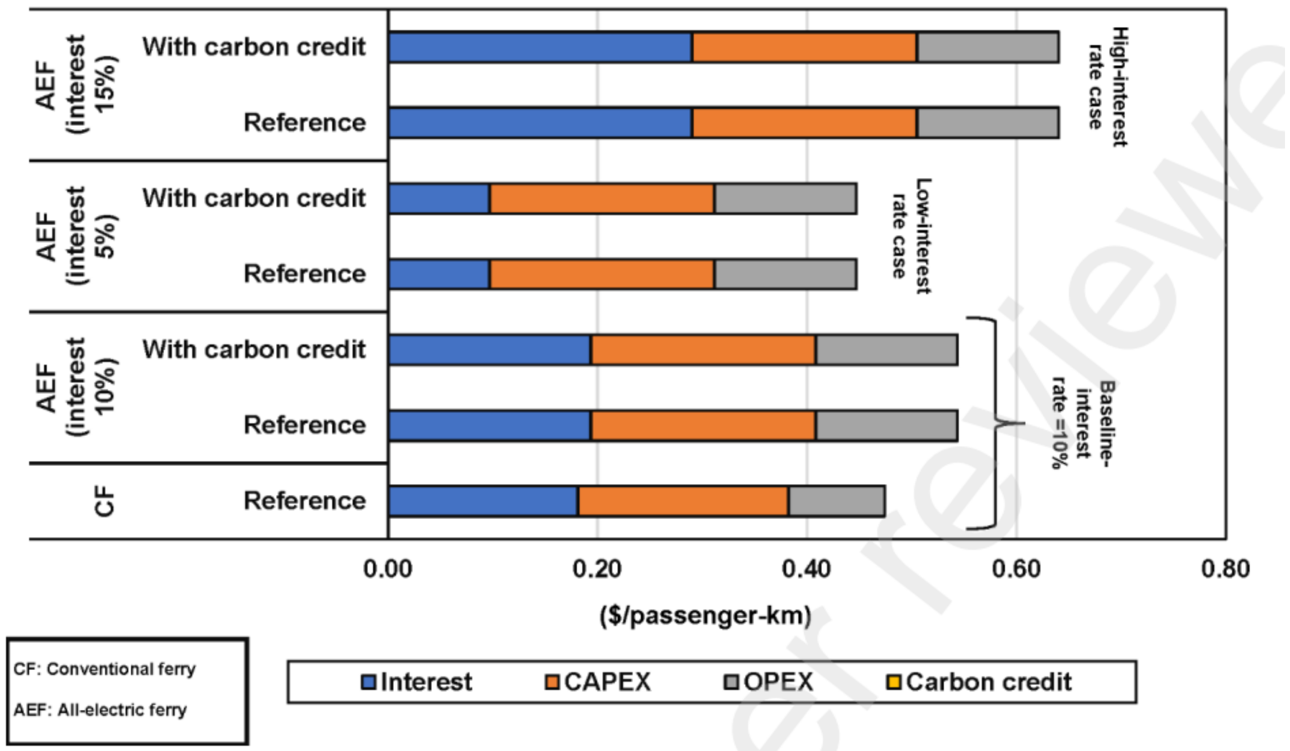

Figure 8. The life cycle cost of a conventional ferry compared to an all-electric ferry with interest rates of 5%, 10%, and 15%. All the values are in 2023 USD.

- A detailed comparative life cycle analysis and total cost of ownership assessment of a conceptualized electric ferry operating in the Washington State Ferry system was performed against the conventional ferry with an internal combustion engine operated on **ultra-low sulfur fuel oil.**
- The life cycle assessment indicated that electrifying a ferry **reduces carbon footprint,** particulate matter, nitrogen oxides, and greenhouse gas emissions compared to the conventional ferry.
- However, the electric ferry had **higher sulfur oxide emissions** than the conventional ferry due to nickel, cobalt, and manganese-based lithium-ion batteries, which use nickel sulfate as raw material.
- The economic analysis showed that electric ferries are likely to have a **15–35% higher total cost** of ownership than conventional ferries unless interest rates are low.

SOME EXAMPLES OF LIFE CYCLE ASSESSMENTS OF ELECTRIFIED VESSELS

Life cycle analysis and cost assessment of a battery powered ferry.

Contents lists available at ScienceDirect
Ocean Engineering
journal homepage: www.elsevier.com/locate/oceaneng

Life cycle analysis and cost assessment of a battery powered ferry

Haibin Wang [a,*], Evangelos Boulougouris [a], Gerasimos Theotokatos [a], Peilin Zhou [a,b], Alexandros Priftis [a], Guangyu Shi [a]

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[b] Faculty of Marine Science and Technology, Harbin Institute of Technology, Weihai, 264209, China

ARTICLE INFO

Keywords:
Battery-powered ferry
Life cycle analysis
Environmental-economic assessment
Electric vehicles
Shipping decarbonisation

sustainability

MDPI

Article

Decarbonizing City Water Traffic: Case of Comparing Electric and Diesel-Powered Ferries

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* Correspondence: riina.otsason@taltech.ee

Abstract: The maritime sector aims to achieve carbon neutrality by 2050. Consequently, shipping companies are investigating efficient and optimal ways to minimize greenhouse gas emissions. One of these measures includes vessels that operate on alternative non-carbon fuels. In this study, we compared a diesel-fuelled catamaran's greenhouse gas (GHG) emissions and its fully electric sister vessel, which operates on the same line. This study showed that the GHG emissions of the electric vessel were only 25% of those of its diesel-powered sister vessel. However, this figure highly depends on the source of electricity in the operating country. In this case, the energy cost of the fully electric vessel was 31% cheaper than the cost of diesel energy and the payback time without possible subsidy for replacing a diesel ferry with an electric one would be 17 years and 6 months. We also showed that the additional energy from solar panels sufficiently covers several application options for consumers even in winter, when there is low solar energy production. This study brings more insight into the academic literature on decreasing maritime CO_2 emissions from city water traffic. Regarding its managerial implications, our study findings can be used when shipping companies evaluate options for reducing their emissions. The results of this study show that using fully electric vessels has major benefits not only concerning carbon emissions but also financially.

- The results show that using grid mix electricity in 2019 reduces life-cycle greenhouse gases by about **30% and life-cycle costs by 15%** compared to conventional power systems.
- "Compared a diesel-fuelled catamaran's greenhouse gas (GHG) emissions and its fully electric sister vessel, which operates on the same line. This study showed that the GHG emissions of the electric vessel were only **25% of those of its diesel-powered sister vessel.**
- ""Fully electric vessel was **31% cheaper** than the cost of diesel energy and the payback time would be 17 years and 6 months.
- ""The results of this study show that using fully electric vessels has major benefits not only concerning **carbon emissions but also financially."**

SOME EXAMPLES OF LIFE CYCLE ASSESSMENTS OF ELECTRIFIED VESSELS

Towards green marine propulsion: comparative lifecycle evaluation of LPG and battery-electric systems for small vessels.

J.K. Kim et al.

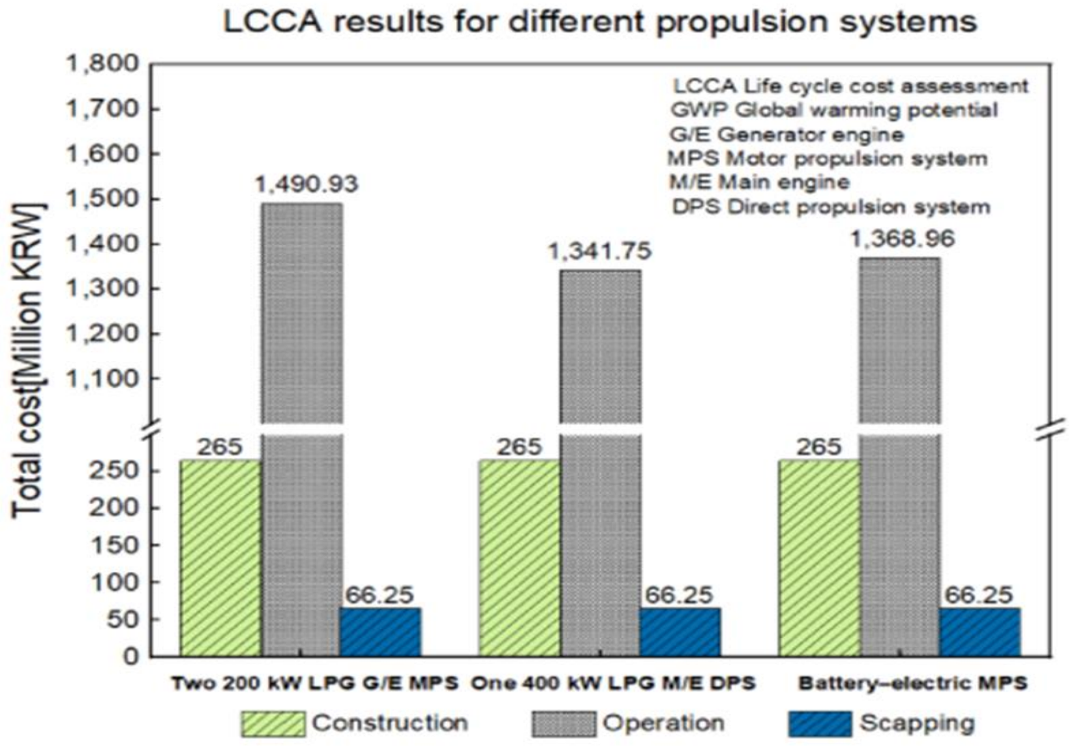
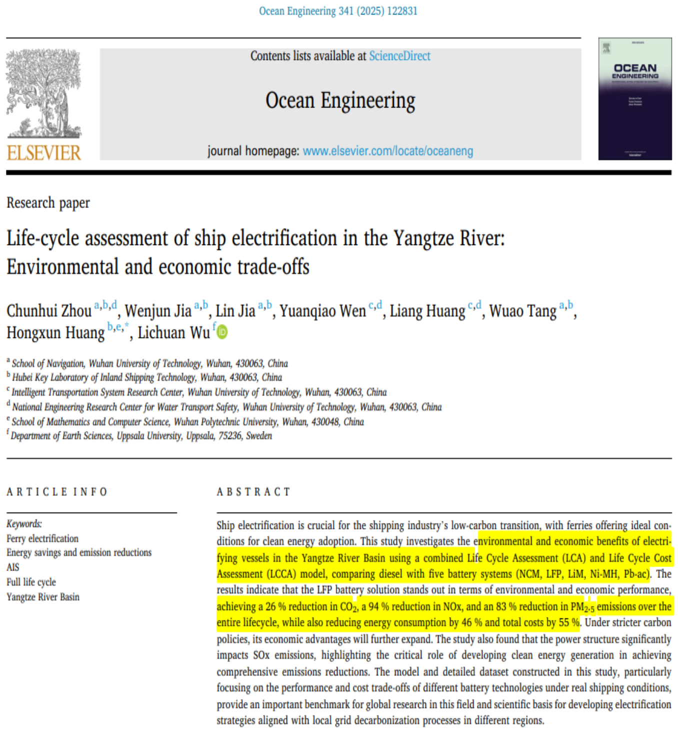


Fig. 8. Results of LCCA.

- **Total Cost Breakdown (in million KRW):**
- **Two 200 kW LPG G/E MPS**
  - Construction: 408.61
  - Operation: 1044.32
  - Scrapping: 38.00
  - Total: 1490.93
- **One 400 kW LPG M/E DPS**
  - Construction: 379.75
  - Operation: 961.99
  - Scrapping: 0.00
  - Total: 1341.75
- **Battery-electric MPS**
  - Construction: 408.61
  - Operation: 960.35
  - Scrapping: 0.00Total: 1368.96

SOME EXAMPLES OF LIFE CYCLE ASSESSMENTS OF ELECTRIFIED VESSELS

Life-cycle assessment of ship electrification in the Yangtze River: Environmental and economic trade-offs.



Ocean Engineering 341 (2025) 122831

Contents lists available at ScienceDirect

Ocean Engineering

journal homepage: www.elsevier.com/locate/oceaneng

ELSEVIER

Research paper

Life-cycle assessment of ship electrification in the Yangtze River: Environmental and economic trade-offs

Chunhui Zhou [a,b,d], Wenjun Jia [a,b], Lin Jia [a,b], Yuanqiao Wen [c,d], Liang Huang [c,d], Wuao Tang [a,b], Hongxun Huang [b,e,*], Lichuan Wu [f]

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[b] Hubei Key Laboratory of Inland Shipping Technology, Wuhan, 430063, China
[c] Intelligent Transportation System Research Center, Wuhan University of Technology, Wuhan, 430063, China
[d] National Engineering Research Center for Water Transport Safety, Wuhan University of Technology, Wuhan, 430063, China
[e] School of Mathematics and Computer Science, Wuhan Polytechnic University, Wuhan, 430048, China
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ARTICLE INFO

Keywords:
Ferry electrification
Energy savings and emission reductions
AIS
Full life cycle
Yangtze River Basin

ABSTRACT

Ship electrification is crucial for the shipping industry's low-carbon transition, with ferries offering ideal conditions for clean energy adoption. This study investigates the environmental and economic benefits of electrifying vessels in the Yangtze River Basin using a combined Life Cycle Assessment (LCA) and Life Cycle Cost Assessment (LCCA) model, comparing diesel with five battery systems (NCM, LFP, LiM, Ni-MH, Pb-ac). The results indicate that the LFP battery solution stands out in terms of environmental and economic performance, achieving a 26 % reduction in CO_2, a 94 % reduction in NOx, and an 83 % reduction in $PM_{2.5}$ emissions over the entire lifecycle, while also reducing energy consumption by 46 % and total costs by 55 %. Under stricter carbon policies, its economic advantages will further expand. The study also found that the power structure significantly impacts SOx emissions, highlighting the critical role of developing clean energy generation in achieving comprehensive emissions reductions. The model and detailed dataset constructed in this study, particularly focusing on the performance and cost trade-offs of different battery technologies under real shipping conditions, provide an important benchmark for global research in this field and scientific basis for developing electrification strategies aligned with local grid decarbonization processes in different regions.

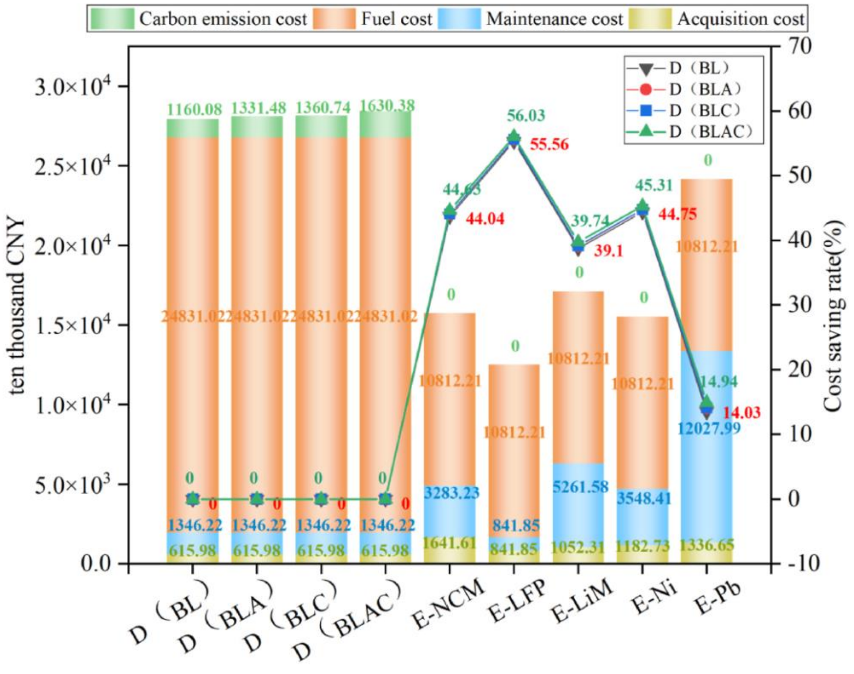


Fig. 16. Comparative LCCA of the ferry fleet.

- Environmental and economic benefits of electrifying vessels in the Yangtze River Basin
- Combined Life Cycle Assessment (LCA) and Life Cycle Cost Assessment (LCCA) model
- Five battery systems (NCM, LFP, LIM, NIMH, and PbAc)
- LFP battery solution stands out in terms of environmental and economic performance
- Achieves a 26.4% to 99.4% reduction in NOx and a 45.3% to 98.5% reduction in PM10 emissions over the entire lifecycle
- **Reduces energy** consumption by 46% to 54%

SOME EXAMPLES OF LIFE CYCLE ASSESSMENTS OF ELECTRIFIED VESSELS

Life-cycle assessment and life-cycle cost assessment of lithium-ion batteries for passenger ferry.

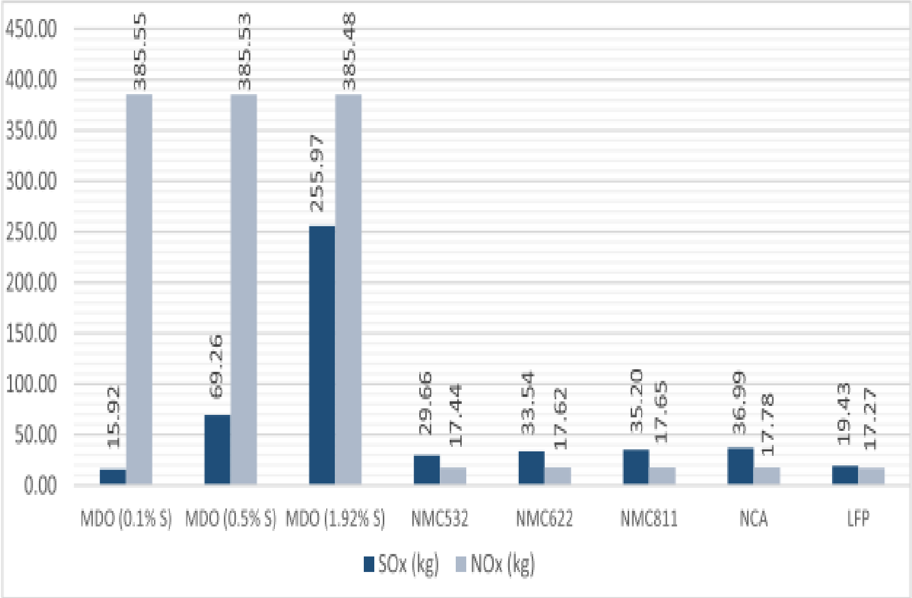
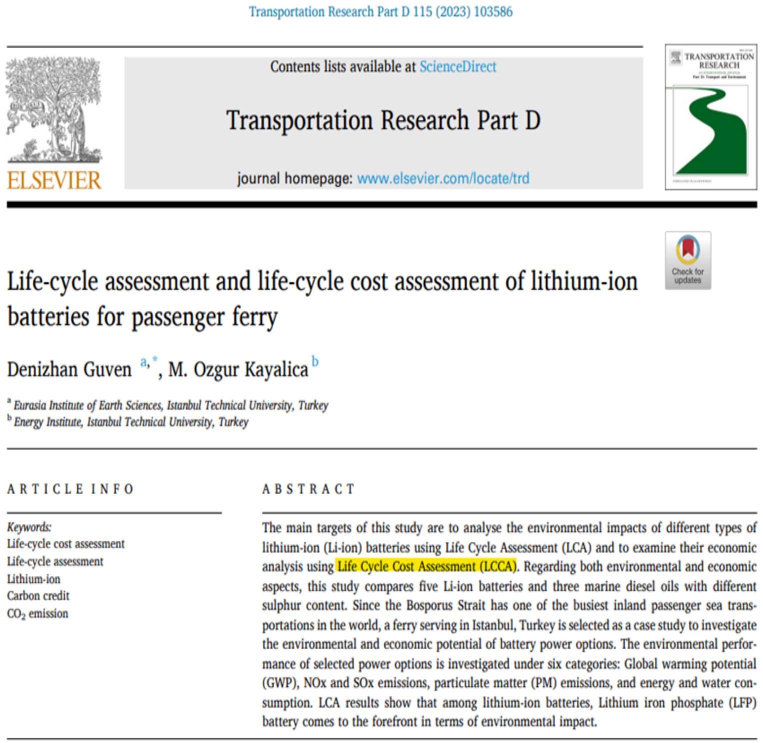


Fig. 11. SOx and NOx emissions of battery-powered and diesel-powered propulsion system.



Transportation Research Part D 115 (2023) 103586

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

Life-cycle assessment and life-cycle cost assessment of lithium-ion batteries for passenger ferry

Denizhan Guven [a,*], M. Ozgur Kayalica [b]

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ARTICLE INFO

Keywords:
Life-cycle cost assessment
Life-cycle assessment
Lithium-ion
Carbon credit
CO_2 emission

ABSTRACT

The main targets of this study are to analyse the environmental impacts of different types of lithium-ion (Li-ion) batteries using Life Cycle Assessment (LCA) and to examine their economic analysis using Life Cycle Cost Assessment (LCCA). Regarding both environmental and economic aspects, this study compares five Li-ion batteries and three marine diesel oils with different sulphur content. Since the Bosporus Strait has one of the busiest inland passenger sea transportations in the world, a ferry serving in Istanbul, Turkey is selected as a case study to investigate the environmental and economic potential of battery power options. The environmental performance of selected power options is investigated under six categories: Global warming potential (GWP), NOx and SOx emissions, particulate matter (PM) emissions, and energy and water consumption. LCA results show that among lithium-ion batteries, Lithium iron phosphate (LFP) battery comes to the forefront in terms of environmental impact.

Study Results:

- **Diesel fuels** produce significantly higher **NOx emissions** (~385 kg) regardless of sulfur content.
- **SOx emissions** increase with sulfur content in diesel fuels.
- **Battery systems** produce **much lower NOx emissions** (~17 kg) and **varying SOx emissions** depending on battery chemistry.
- Among battery types, **LFP** has the **lowest SOx and NOx emissions**.

Title: Life-cycle assessment and life-cycle cost assessment of lithium-ion batteries for passenger ferryAuthors: Denizhan Guven, M. Ozgur KayalicaPublished in: Transportation Research Part D

SOME EXAMPLES OF LIFE CYCLE ASSESSMENTS OF ELECTRIFIED VESSELS

Life-cycle assessment and life-cycle cost assessment of lithium-ion batteries for passenger ferry.

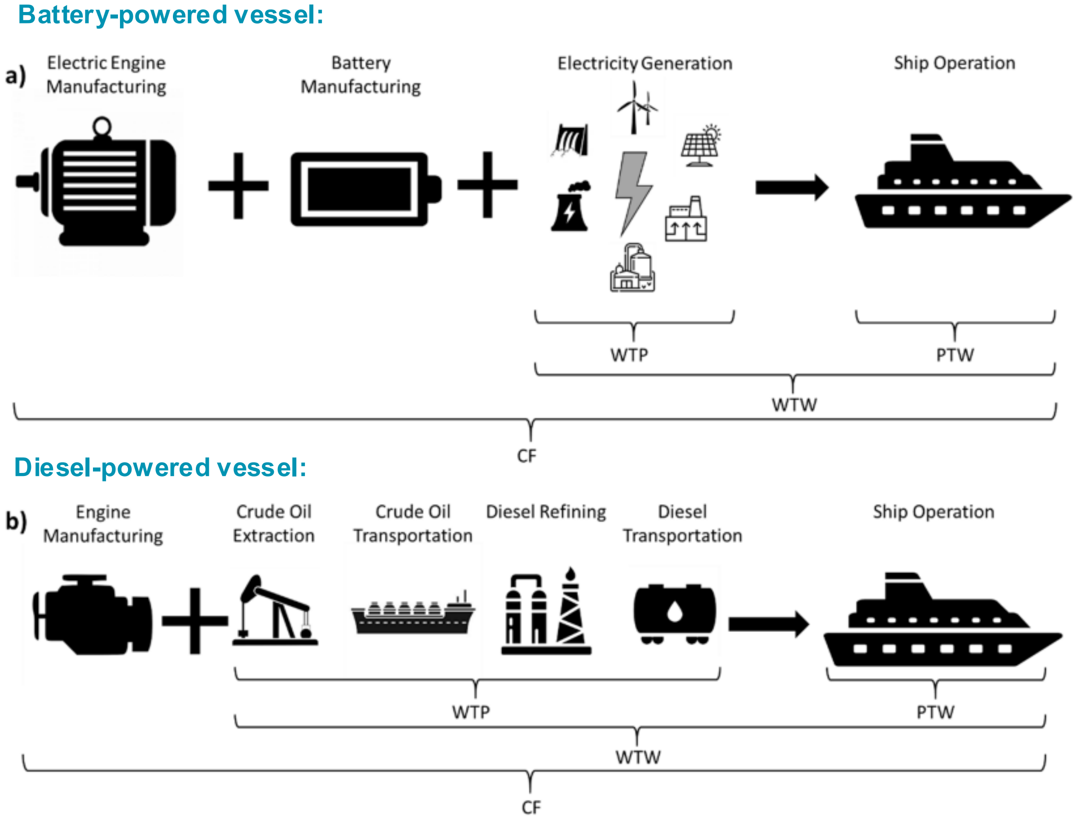


Fig. 3. Scope of LCA for a) battery-powered b) diesel-powered vessel.

Title: Life-cycle assessment and life-cycle cost assessment of lithium-ion batteries for passenger ferryAuthors: Denizhan Guven, M. Ozgur KayalicaPublished in: Transportation Research Part D

Study Focus:

•Evaluates the environmental and economic performance of different lithium-ion battery types for a passenger ferry operating in Istanbul.

•Compares five Li-ion battery types with three marine diesel oils of varying sulfur content.

Environmental Impact Categories Assessed:

•Global Warming Potential (GWP)

•NOx and SOx emissions

•Particulate Matter (PM) emissions

•Energy consumption

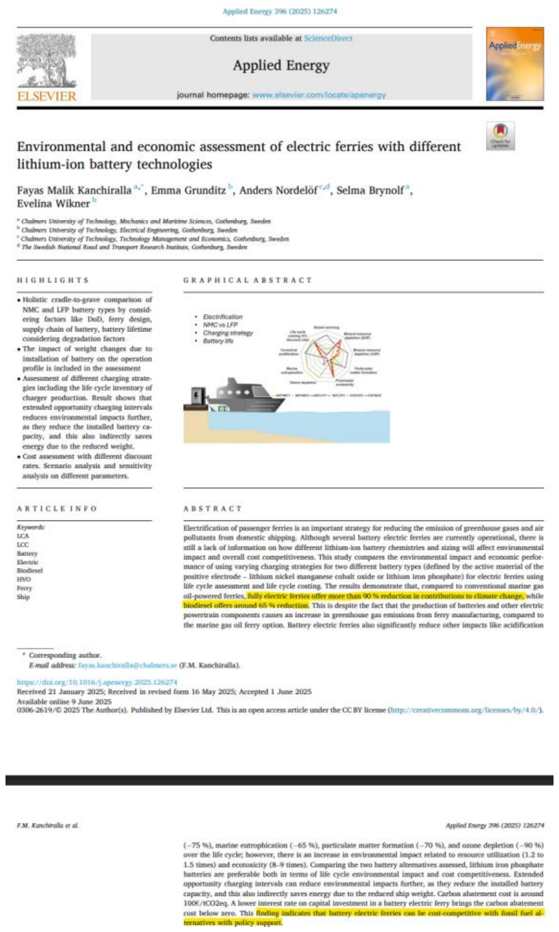
•Water consumption

Key Finding:

•**Lithium Iron Phosphate (LFP)** battery shows the best environmental performance among the battery types.

SOME EXAMPLES OF LIFE CYCLE ASSESSMENTS OF ELECTRIFIED VESSELS

Environmental and economic assessment of electric ferries with different lithium-ion battery technologies.



Applied Energy 396 (2025) 126274

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Environmental and economic assessment of electric ferries with different lithium-ion battery technologies

Fayas Malik Kanchiralla [a,*], Emma Grunditz [b], Anders Nordelöf [c,d], Selma Brynolf [a], Evelina Wikner [b]

[a] Chalmers University of Technology, Mechanics and Maritime Sciences, Gothenburg, Sweden
[b] Chalmers University of Technology, Electrical Engineering, Gothenburg, Sweden
[c] Chalmers University of Technology, Technology Management and Economics, Gothenburg, Sweden
[d] The Swedish National Road and Transport Research Institute, Gothenburg, Sweden

HIGHLIGHTS

- Holistic cradle-to-grave comparison of NMC and LFP battery types by considering factors like DoD, ferry design, supply chain of battery, battery lifetime considering degradation factors
- The impact of weight changes due to installation of battery on the operation profile is included in the assessment
- Assessment of different charging strategies including the life cycle inventory of charger production. Result shows that extended opportunity charging intervals reduces environmental impacts further, as they reduce the installed battery capacity, and this also indirectly saves energy due to the reduced weight.
- Cost assessment with different discount rates. Scenario analysis and sensitivity analysis on different parameters.

GRAPHICAL ABSTRACT

- Electrification
- NMC vs LFP
- Charging strategy
- Battery life

ARTICLE INFO

Keywords:
LCA
LCC
Battery
Electric
Biodiesel
HVO
Ferry
Ship

ABSTRACT

Electrification of passenger ferries is an important strategy for reducing the emission of greenhouse gases and air pollutants from domestic shipping. Although several battery electric ferries are currently operational, there is still a lack of information on how different lithium-ion battery chemistries and sizing will affect environmental impact and overall cost competitiveness. This study compares the environmental impact and economic performance of using varying charging strategies for two different battery types (defined by the active material of the positive electrode – lithium nickel manganese cobalt oxide or lithium iron phosphate) for electric ferries using life cycle assessment and life cycle costing. The results demonstrate that, compared to conventional marine gas oil-powered ferries, fully electric ferries offer more than 90 % reduction in contributions to climate change, while biodiesel offers around 65 % reduction. This is despite the fact that the production of batteries and other electric powertrain components causes an increase in greenhouse gas emissions from ferry manufacturing, compared to the marine gas oil ferry option. Battery electric ferries also significantly reduce other impacts like acidification

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Available online 9 June 2025

(−75 %), marine eutrophication (−65 %), particulate matter formation (−70 %), and ozone depletion (−90 %) over the life cycle; however, there is an increase in environmental impact related to resource utilization (1.2 to 1.5 times) and ecotoxicity (8–9 times). Comparing the two battery alternatives assessed, lithium iron phosphate batteries are preferable both in terms of life cycle environmental impact and cost competitiveness. Extended opportunity charging intervals can reduce environmental impacts further, as they reduce the installed battery capacity, and this also indirectly saves energy due to the reduced ship weight. Carbon abatement cost is around 100€/tCO2eq. A lower interest rate on capital investment in a battery electric ferry brings the carbon abatement cost below zero. This finding indicates that battery electric ferries can be cost-competitive with fossil fuel alternatives with policy support.

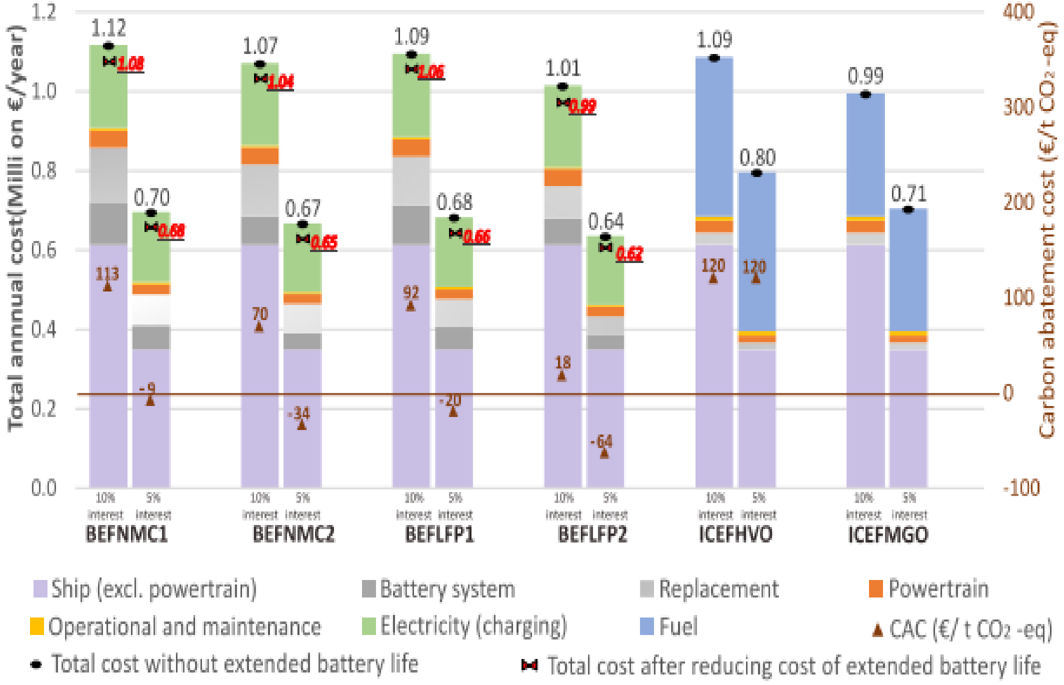

Fig. 8. LCC results for the six cases assessed for the functional unit annual operation of the ferry.

- **Holistic life-cycle comparison** of various Li-ion battery types for coastal and inland ferries.
- **Battery type selection** significantly affects both environmental and economic performance.
- **Full lifecycle evaluation** is essential when assessing powertrain options for electric ferries.
- **Certain battery types** show clear advantages in reducing greenhouse gas emissions and lowering costs.
- **Seasonal variability** and **sensitivity analysis** were conducted on different parameters.

SOME EXAMPLES OF LIFE CYCLE ASSESSMENTS OF ELECTRIFIED VESSELS

Ebdg New Vehicle Ferry M/V Woods Hole Equivalent Hybrid Propulsion Study

Table 4: Martha's Vineyard Full Vessel Capital Cost Summary

OPTION	DESCRIPTION	COST
1	Diesel Mechanical	$ 53,602,000
2	Berth Battery	$ 58,496,000
3	Peak Shave	$ 60,114,000
4	50% Battery	$ 60,690,000
5	All Electric	$ 61,461,000
6	Plug-In Hybrid	$ 60,636,000

Table 5: Nantucket Full Vessel Capital Cost Summary

OPTION	DESCRIPTION	COST
1	Diesel Mechanical	$ 53,602,000
2	Berth Battery	$ 58,551,000
3	Peak Shave	$ 59,793,000
4	50% Battery	$ 60,091,000

Cost estimations for both the vessel construction cost and propulsion options were sought by a third-party as a method of vetting EBDG calculations. The values found by the third-party were in line and within reasonable margins from EBDG values [5].

The operating costs over a 20-year period, in 2022 dollars, are shown in Table 6 and Table 7. Additional details of the operating cost calculation are provided in Appendix B.

Table 6: Martha's Vineyard 20-Year Operating Cost Summary

OPTION	DESCRIPTION	COST
1	Diesel Mechanical	$ 29,866,000
2	Berth Battery	$ 29,524,000
3	Peak Shave	$ 31,798,000
4	50% Battery	$ 32,358,000
5	All Electric	$ 33,864,000
6	Plug-In Hybrid	$ 32,115,000

Table 7: Nantucket 20-Year Operating Cost Summary

OPTION	DESCRIPTION	COST
1	Diesel Mechanical	$28,002,000
2	Berth Battery	$27,983,000
3	Peak Shave	$ 29,346,000
4	50% Battery	$ 30,142,000

Elliott Bay Design Group

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3/27/2023

NEW VEHICLE FERRY
M/V WOODS HOLE EQUIVALENT

Hybrid Propulsion Study

Prepared for: Steamship Authority |Falmouth, MA

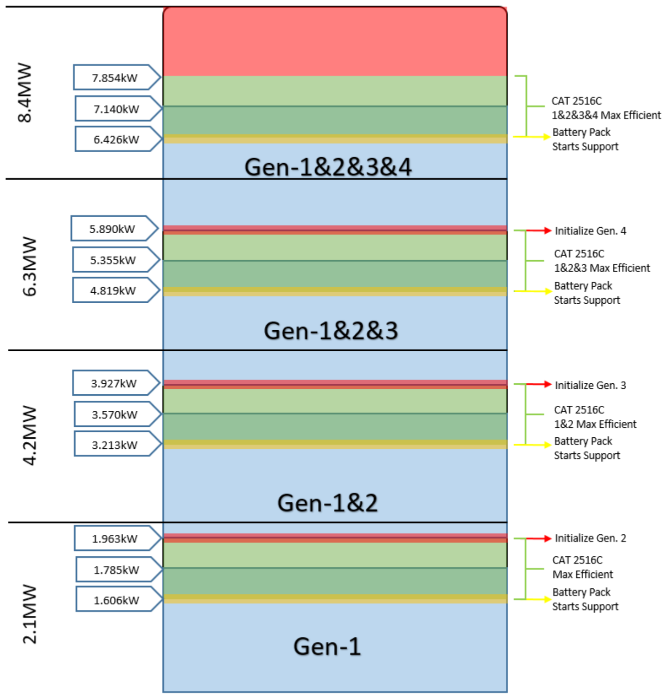
Ref: 21051-894-7 Rev. B March 27, 2023

- **Seasonal variability** and **sensitivity analysis** were conducted on different parameters.

03

NEMOSHIP EU FUNDED PROJECT: ELKON OPERATIONAL MODES ON AHTS TYPE OF DEMO VESSEL

Case Study: Elkon actively contributes to EU-funded projects, validating its technology on international platforms.



Fuel Consumption of 2100kW Generator	Standby	Continuous
100% load with fan – L/hr	505.8	427.9
75% load with fan – L/hr	393.9	338.3
50% load with fan – L/hr	284.2	238.3
25% load with fan – L/hr	164.3	144.1

Fuel Consumption CAT3516C

03

NEMOSHIP EU FUNDED PROJECT: ELKON OPERATIONAL MODES ON AHTS TYPE OF DEMO VESSEL

Case Study

NEMOSHIP
344 followers
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🚢 NEMOSHIP enters a new hands-on phase! 🔋

We're excited to share a major milestone in the European NEMOSHIP project: the installation of the modular battery energy storage system has begun on board Solstad's vessel.
Following the preparation of the vessel and the analysis of historical operational data, the first equipment has now been loaded.

📊 A real-time data logger will soon be used to monitor system performance under real operating conditions.

This is a significant step forward in the decarbonization of maritime transport!

📷 Check out some early photos from the installation phase below.

#NEMOSHIP #EnergyStorage #Solstad #EnergyTransition #EUProjects

40 3 reposts

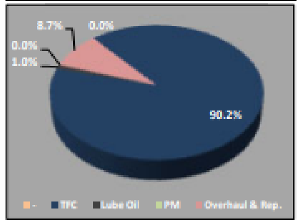
SOME EXAMPLES OF LIFE CYCLE ASSESSMENTS OF ELECTRIFIED VESSELS

Lorem ipsum

Cat® | EPA Tier 4 | 3516E | Diesel - High Spd.

LIFE CYCLE RESULTS - PER VESSEL

Owning Costs (CAPEX)	$0
Total Fluid Cons. (TFC) Costs	$27,508,507
Diesel	$27,508,507
DEF	$0
Gas	$0
Lube Oil Costs	$313,200
Lube Oil Consumption	$60,000
Lube Oil Changes	$253,200
Preventative Maint. (PM) Costs	$0
Parts	$0
Labor	$0
Overhaul & Repair Costs	$2,660,000
Parts	$1,950,000
Labor	$710,000
Residual Value	$0
Total Cost of Ownership (TCO)	$30,481,707



Cost/bhp-hr (Life Cycle Avg.)	$0.400
Cost/Hour (Life Cycle Avg.)	$508.0
Cost/Month (Life Cycle Avg.)	$127,007
Cost/Year (Life Cycle Avg.)	$1,524,085

(Results include configured inflations)

Owning Costs (CAPEX) - PER VESSEL					
Engine Related	DEF / SCR Related	Gas Related	Other CAPEX	Total Initial Investment	Redidual Value
$0	$0	$0	$0	$0	$0

Life Cycle Year	Total Fluid Consumption (TFC) Costs - PER VESSEL				Engine Lube Oil Costs - PER VESSEL			Preventative Maint. (PM) Costs - PER VESSEL			Overhaul & Repair Costs - PER VESSEL			TOTALS - PER VESSEL	
	Diesel	DEF	Gas	Total Fluid Cons. (TFC)	Lube Oil Cons.	Lube Oil Changes	Total Lube Oil	PM Parts	PM Labor	Total PM	Overhaul & Repair Parts	Overhaul & Repair Labor	Total Overhaul & Repair	Per Year	Aggregated
1	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$1,391,085
2	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$2,782,171
3	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$4,173,256
4	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$250,000	$90,000	$340,000	$1,731,085	$5,904,341
5	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$7,295,427
6	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$8,686,512
7	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$10,077,597
8	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$600,000	$220,000	$820,000	$2,211,085	$12,288,683
9	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$13,679,768
10	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$15,070,854
11	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$16,461,939
12	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$250,000	$90,000	$340,000	$1,731,085	$18,193,024
13	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$19,584,110
14	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$20,975,195
15	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$22,366,280
16	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$600,000	$220,000	$820,000	$2,211,085	$24,577,366
17	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$25,968,451
18	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$27,359,536
19	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$0	$0	$0	$1,391,085	$28,750,622
20	$1,375,425	$0	$0	$1,375,425	$3,000	$12,660	$15,660	$0	$0	$0	$250,000	$90,000	$340,000	$1,731,085	$30,481,707
	$27,508,507	$0	$0	$27,508,507	$60,000	$253,200	$313,200	$0	$0	$0	$1,950,000	$710,000	$2,660,000	$30,481,707	$30,481,707

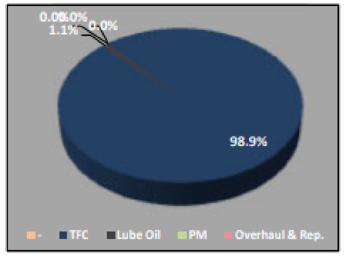
SOME EXAMPLES OF LIFE CYCLE ASSESSMENTS OF ELECTRIFIED VESSELS

Lorem ipsum

Cat® | EPA Tier 4 | 3516E | Diesel - High Spd.

LIFE CYCLE RESULTS - PER VESSEL

Owning Costs (CAPEX)	**$0**
Total Fluid Cons. (TFC) Costs	**$4,584,751**
Diesel	$4,584,751
DEF	$0
Gas	$0
Lube Oil Costs	**$52,200**
Lube Oil Consumption	$10,000
Lube Oil Changes	$42,200
Preventative Maint. (PM) Costs	**$0**
Parts	$0
Labor	$0
Overhaul & Repair Costs	**$0**
Parts	$0
Labor	$0
Residual Value	**$0**
Total Cost of Ownership (TCO)	**$4,636,951**



Cost/bhp-hr (Life Cycle Avg.)	$0.365
Cost/Hour (Life Cycle Avg.)	$463.7
Cost/Month (Life Cycle Avg.)	$19,321
Cost/Year (Life Cycle Avg.)	$231,848

(Results include configured inflations)

Owning Costs (CAPEX) - PER VESSEL					
Engine Related	DEF / SCR Related	Gas Related	Other CAPEX	Total Initial Investment	Redidual Value
$0	$0	$0	$0	$0	$0

Life Cycle Year	Total Fluid Consumption (TFC) Costs - PER VESSEL				Engine Lube Oil Costs - PER VESSEL			Preventative Maint. (PM) Costs - PER VESSEL			Overhaul & Repair Costs - PER VESSEL			TOTALS - PER VESSEL	
	Diesel	DEF	Gas	Total Fluid Cons. (TFC)	Lube Oil Cons.	Lube Oil Changes	Total Lube Oil	PM Parts	PM Labor	Total PM	Overhaul & Repair Parts	Overhaul & Repair Labor	Total Overhaul & Repair	Per Year	Aggregated
1	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$231,848
2	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$463,695
3	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$695,543
4	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$927,390
5	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$1,159,238
6	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$1,391,085
7	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$1,622,933
8	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$1,854,780
9	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$2,086,628
10	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$2,318,476
11	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$2,550,323
12	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$2,782,171
13	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$3,014,018
14	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$3,245,866
15	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$3,477,713
16	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$3,709,561
17	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$3,941,409
18	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$4,173,256
19	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$4,405,104
20	$229,238	$0	$0	$229,238	$500	$2,110	$2,610	$0	$0	$0	$0	$0	$0	$231,848	$4,636,951
	$4,584,751	$0	$0	**$4,584,751**	$10,000	$42,200	**$52,200**	$0	$0	$0	$0	$0	$0	$4,636,951	**$4,636,951**

KEY FINDINGS

Comparative Insights into Ferry Electrification and Lifecycle Economics

- Life Cycle Assessment may differ according to the vessel type, operation region, operation modes, equipment, battery and time.
- Electrification of vessels create emission reduction, little bit higher CAPEX, on the other hand lower OPEX (including emission reduction, carbon tax, incentives and fuel consumption)
- Conventional vessels are analyzed but electrified vessels data are in collection and time dependent so far.
- Each vessel and their operation is unique, and their benefits can only be revealed in close cooperation with the optimum usage of the vessel.

Additional Key Points to Include

- Life Cycle Cost Assessment (LCCA) results vary significantly depending on propulsion type, battery chemistry, and vessel-specific operational data.
- Battery-powered vessels show substantial reductions in NOx, SOx, and PM emissions compared to diesel-powered vessels.
- Electrification leads to higher initial capital expenditure (CAPEX), but long-term operational expenditure (OPEX) is lower due to reduced fuel consumption, maintenance, and potential carbon tax savings.
- Environmental performance of battery systems is highly dependent on the electricity mix and battery material sourcing.
- LFP batteries consistently demonstrate favorable environmental and economic performance across multiple studies.
- Real-world data collection for electrified vessels is ongoing and time-dependent, requiring continuous monitoring and validation.
- Seasonal variability and operational patterns significantly influence the environmental and economic outcomes of electrification.
- Comparative studies show that each vessel requires a tailored approach; benefits of electrification are maximized through optimized usage and close cooperation between technical and operational teams.

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ELKON

Earl Johnson,
Project Engineering Manager

Thank you

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electric system integrator
a member of the SCHOTTEL Group