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ADVANTAGES AND DISADVANTAGES OF USING ELECTRIC TUGBOATS

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Abstract ***:*** The International Maritime Organization (IMO) has implemented rules aiming to halve emissions by 2050 within the maritime industry. Greenport is a port initiative emphasizing environmental sustainability, striving for minimal emissions across all operations and activities. The integration of electric tugboats into maritime operations has garnered significant attention as the maritime industry seeks to address environmental concerns and transition towards sustainable practices. This paper explores the multifaceted advantages and disadvantages associated with the adoption of electric propulsion technology in tugboats. One of the primary advantages of electric tugboats lies in their potential to significantly reduce emissions and environmental impact compared to conventional diesel-powered vessels. By utilizing electric propulsion systems, tugboats can operate with zero emissions at the point of use, thereby mitigating air and water pollution in port areas and surrounding communities. This environmental benefit aligns with global efforts to combat climate change and improve air quality, making electric tugboats an attractive option for ports and shipping companies aiming to reduce their carbon footprint. The adoption of electric tugboats also presents several challenges and considerations. One of the primary challenges is the upfront cost associated with purchasing electric tugboats and establishing the necessary charging infrastructure. While electric tugboats may offer long-term cost savings through reduced fuel and maintenance expenses, the initial investment required for electric propulsion systems and charging infrastructure can be substantial, posing a barrier to adoption for some operators.

The adoption of electric tugboats presents both opportunities and challenges for the maritime industry. While electric propulsion technology offers significant environmental and operational benefits, stakeholders must carefully evaluate the advantages and disadvantages to make informed decisions regarding the integration of electric tugboats into their fleets. By addressing challenges such as upfront costs, infrastructure requirements, and technological limitations, the maritime industry can harness the potential of electric propulsion technology to drive sustainable innovation and achieve long-term environmental and economic goals.

Key words : Advantages, CO_2 emissions, electric tugboat, Methatug, Sparky, Zeetug.

1. INTRODUCTION

The In recent years, the maritime industry has been increasingly focused on sustainability and reducing its environmental impact. As part of this broader effort, there has been growing interest in the adoption of electric propulsion technology for tugboats, with the aim of minimizing emissions and promoting greener operations. This analysis aims to deepen understanding regarding the opportunities and challenges associated with electric tugboats. By offering insights, we intend to assist decision-makers in the maritime industry to make informed choices that are in line with their sustainability goals, operational requirements, and strategic objectives. However, the decision to transition to electric tugboats involves weighing the advantages and disadvantages associated with this innovative propulsion system.

As per a recent study by Transport & Environment (T&E) [1], Rotterdam emerges as the foremost European port in terms of traffic volume, responsible for nearly 14 million tons of CO_2 emissions annually. Consequently, it holds the title of being the largest industrial polluter in Europe (Fig.1, Fig.2) [1].

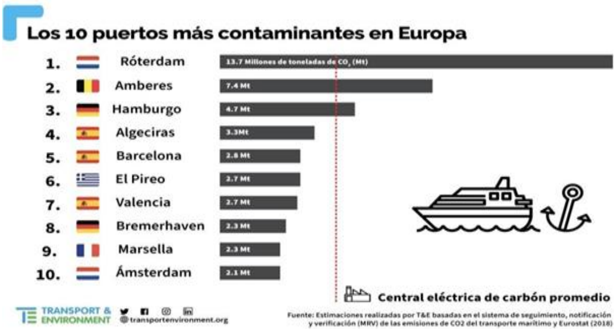

Figure 1 Contaminated ports in Europe [1]

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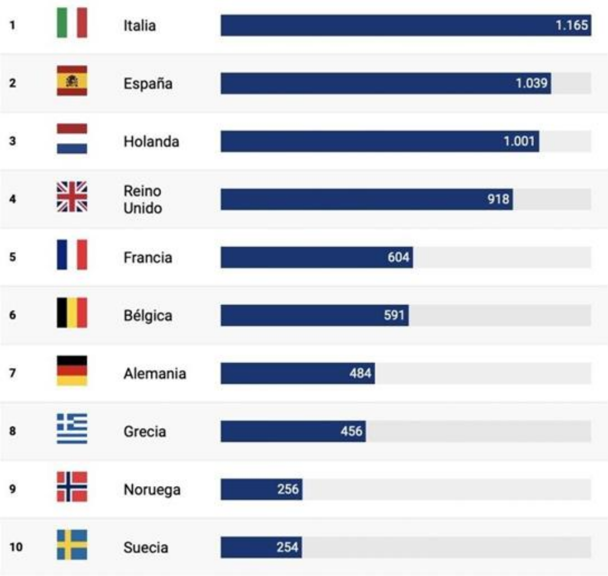

Figure 2 Ranking by country of CO_2 emissions from port activities [1]

While the broader shipping industry faces increasing pressure to decarbonize due to factors like regulations, customer demands, and societal expectations, certain segments of the supply chain, such as tugboat services, are frequently disregarded.

In various industries, the need to reduce carbon emissions and awareness of climate change has led to an increasing focus on sustainability. “ Ports have become a prime target for implementing innovative solutions to reduce their carbon footprint “[2]. More sustainable measures were applied in this context: European Union standards, renewable energies and electrification, logistics optimization and waste management, green infrastructure and design (Fig. 3)[2].

Figure 3 Green infrastructure and design in ports [2]

Currently, more than 21,000 tugboats are in operation worldwide, releasing 40 million tonnes of CO_2 annually.[3] ” In parallel, the trend of combating climate change in the world is to focus on reducing emissions policies. In 2030, it is aimed to reduce human-induced CO_2 emissions by 45% compared to 2010 and to reach net zero emissions by 2050 (IPCC, 1996). Perhaps the most important of the measures taken for this purpose is to reduce the sulphur content in ship bunkers to 0.5% by 2020 (IMO, 2020)”(Fig. 4)[4].

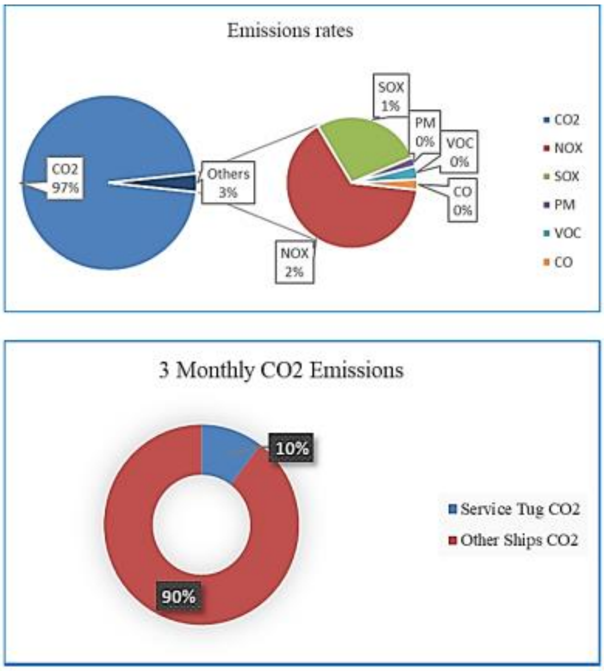

Figure 4 Ship emissions rate [4]

While some may consider this insignificant as it comprises only 4% of total shipping emissions, it's a significant issue. To put it into perspective, it equals the emissions of over 7 million cars each year. It's evident that there's a chance to transition the maritime towage sector to decarbonize..

2. WHAT PROGRESS HAS BEEN MADE SO FAR IN ADDRESSING THIS ISSUE?

Starting January 2025, tugboats exceeding 400 gross tonnage (GT) that operate offshore and fall within the specified criteria will be subject to the EU-MRV. This scheme necessitates the measurement, reporting, and verification of emissions for vessels operating within the European Union [2]. From 2027, the tugboats exceeding 400 GT will be subject to the Emissions Trading System (ETS) scheme. Not only does this mean monitoring, reporting, and verifying their vessels’ emissions, they also need to purchase and surrender emission allowances (EUAs) equivalent to their vessel’s emissions. [2]

2.1 Ports of Auckland, New Zealand

Ports of Auckland – New Zealand’s primary port – now has the world’s first full-size, ship-handling electric tugboat. Named Sparky, the e-tug is expected to save approximately 465 tonnes of CO_2 in diesel emissions annually. [5]

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Sparky's 80 battery racks accommodate 2,240 batteries, providing a total power capacity of 2,784 kWh, enabling up to four shipping manoeuvres on a single charge, equivalent to approximately three to four hours of operation. It takes around two hours to recharge. For safety measures, Sparky is equipped with two 1000 kW backup generator sets, reserved solely for emergency situations (Fig. 5)[5].

Figure 5 Sparky e-tug [5]

Additionally, Sparky boasts a 70-ton bollard pull, matching the strength of the port's most powerful diesel tug, which typically consumes 120 litres of diesel per hour.

2.2 *Port of Antwerp*

The Port of Antwerp-Bruges unveiled a global first: the Methatug. This tugboat, powered by methanol, forms a crucial component of the port's fleet greening initiative, marking a significant milestone in the journey towards achieving a climate-neutral port by 2050. Funding for the project comes from the European research program Horizon 2020 and is a key element of the FASTWATER project, designed to showcase the viability of methanol as a sustainable fuel for the shipping industry (Fig. 6).[6], [7]

Figure 6 Methatug [6]

The Methatug forms part of the European FASTWATER initiative, funded by the European research and innovation program Horizon 2020. [9]

This project aims to showcase the viability of methanol as a sustainable fuel for the shipping industry. Alongside the Port of Antwerp-Bruges, various partners from the FASTWATER consortium are involved, including the Swedish ship design agency ScandiNAOS, Belgian engine manufacturer ABC, German company Heinzmann responsible for methanol injectors, Ghent University overseeing the emission monitoring program, and Canadian methanol supplier Methanex during the trials.[9]

Another example is the all electric tugboat ZEETUG45, constructed with azimuth stern drive propulsion (Fig. 7).[10]

Figure 7 ZEETUG45 has met the sea![10]

2.3 *Port of Hamburg*

“ Port of Hamburg is located in Hamburg. It is known as Germany’s ” Gate to the World” and the largest seaport by volume in the country”. [11]

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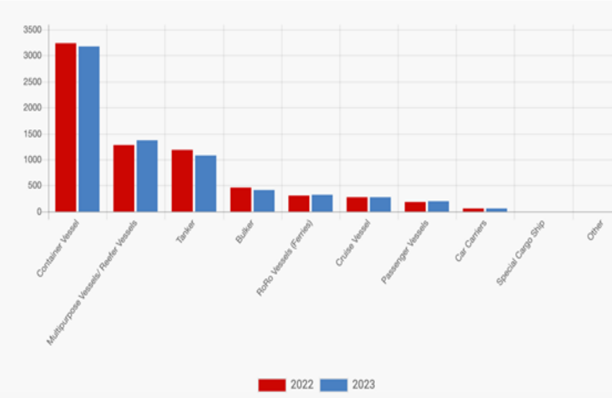

Figure 8 Number of vessels calls, in the last two years [12]

"The Port of Hamburg handled 8 million Twenty-foot Equivalent Units (TEUs) in 2023" (Fig. 8)[12]

3. FACTORS INFLUENCING CO_2 EMISSIONS

Several factors influence the CO2 emissions of ships, such as the size of the ship, the distance travelled, the type of fuel that she is using, the carbon intensity indicator (CII).

- *Which types of fuels are the vessels using*?

The environmental effects, cost, availability, and suitability for various marine engines differ among the fuels that are used. Selecting the appropriate fuel depends on factors like regulatory standards, fuel costs, technological progress, and environmental concerns.

- *What is carbon intensity indicator (CII)*?

The carbon intensity indicator serves as a crucial tool in monitoring and controlling greenhouse gas emissions across diverse industries, such as shipping. It plays a vital role in climate change mitigation efforts and the shift towards more sustainable practices. Within the maritime sector, the carbon intensity indicator is frequently employed to gauge the volume of CO_2 emissions generated for each unit of cargo conveyed, distance covered, or similar pertinent criteria (Table 1).[13]

Table 1. Types of tugboats and their functions [13]

No.crt.	Type of tugboat	Definition
1.	HARBOUR TUGBOATS	Harbour tugs move ships and barges at ports and harbours in restricted locations by taking advantages of their tiny size and mobility.
2.	TERMINAL TUGBOATS	Same as harbour but specialized in haul enormous cargo ships.
3.	ESCORT TUGBOATS	Mainly work on tankers and cruise ships for escorting crowded areas
4.	OCEAN OR SEAGOING TUGBOATS	Towing massive boats and construction equipment over long distance and open seas.
5.	SALVAGE TUGBOATS	These tugboats are equipped and trained for salvage and rescue operations. They combat, reflate stranded boats, and carry underwater repair and salvage equipment.
6.	ANCHOR-HANDLING TUGS/ SUPPLY TUGBOATS	These tugboats play a vital role in placing heavy ships and oil rigs in the ocean from the harbour. They also stabilize oil rig ships.
7.	RIVER TUGBOATS	These tugboats are small and shallow draft to handle barges and push boats unconfined waterways.
8.	ICEBREAKIN G TUGBOATS	These tugboats sail and clear frozen rivers using strengthened hulls to keep the rigs steady.

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4. ADVANTAGES OF USING E-TUGS

1. *Environmental Benefits*: Electric tugboats produce no emissions during operation, contributing to reduced air and water pollution compared to traditional diesel-powered tugboats, thereby aiding in environmental conservation efforts.[14]
2. *Cost Efficiency*: Electric tugboats generally incur lower operating expenses than their diesel counterparts due to reduced maintenance requirements, fewer moving components, and the potential for cheaper and more stable electricity prices compared to diesel fuel.[13]
3. *Enhanced Energy Efficiency*: Electric propulsion systems typically boast higher energy efficiency levels than diesel engines, resulting in decreased energy consumption and lower fuel expenses.[15]
4. *Noise Reduction*: Electric tugboats operate with less noise than diesel-powered alternatives, leading to quieter port environments and less disruption to marine ecosystems.[16]
5. *Health Benefits*: By eliminating emissions, electric tugboats contribute to improved air quality, benefiting the health and well-being of workers in ports and nearby communities.[17]
6. *Long-term Cost Savings*: Although the initial investment in electric tugboats may be higher than conventional diesel models, the long-term savings from reduced fuel and maintenance costs can outweigh the initial expense.[13]
7. *Operational Flexibility*: Electric tugboats can operate in sensitive areas such as nature reserves or near populated areas where emissions regulations are strict or noise pollution must be minimized.[13]
8. *Potential for Energy Storage*: Electric tugboats can leverage advancements in energy storage technology, such as high-capacity batteries, to store energy during off-peak times or from renewable sources, enhancing operational efficiency and reducing reliance on grid power.[18]
9. *Market Differentiation*: Ports and shipping companies that pioneer the adoption of electric tugboats can gain a competitive edge by positioning themselves as leaders in sustainability and innovation, attracting environmentally conscious customers and partners.[19]
10. *Resilience to Fuel Price Volatility*: Electric tugboats are less susceptible to fluctuations in fuel prices, providing stability and predictability in operating costs, which can be advantageous during periods of fuel price volatility.[20]
11. *Regulatory Incentives*: Governments and regulatory bodies may offer incentives, subsidies, or tax breaks to encourage the adoption of electric propulsion technology, further enhancing the economic viability of electric tugboats.[21]

Advantages are presented in table 2:

Table 2. Advantages

No.crt.	Operational Advantages	Operational Flexibility Potential for Energy Storage
1.	Rational Advantages	Environmental Benefits Health Benefits Market Differentiation Noise Reduction
2	Economic Advantages	Cost Efficiency Long-term Cost Savings Resilience to Fuel Price Volatility Enhanced Energy Efficiency Regulatory Incentives

5. DISAVANTAGES OF USING E-TUGS

1. *Limited Range*: Electric tugboats may have limited range compared to diesel-powered vessels due to the capacity and weight of onboard batteries. This can restrict their operational flexibility, especially for long-distance towing or extended operations without recharging.[20]

2. *Initial Cost*: The upfront cost of purchasing electric tugboats, including the necessary infrastructure for charging or battery replacement, can be higher than traditional diesel-powered tugboats. This initial investment may deter some operators from adopting electric propulsion systems.[13]

3. *Charging Time*: Charging electric tugboats can take significantly longer than refueling diesel-powered vessels, leading to potential downtime and reduced productivity during charging cycles. Rapid charging solutions may mitigate this issue but could require substantial investment in infrastructure and equipment.[13]

4. *Weight and Space Constraints*: Batteries required for electric propulsion systems can be heavy and bulky, impacting vessel stability, maneuverability, and cargo capacity. Designing tugboats to accommodate large battery banks while maintaining performance characteristics can be challenging.[16]

5. *Limited Power Density*: Current battery technology may not offer the same power density as conventional fuels, limiting the maximum power output and acceleration of electric tugboats compared to diesel-

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powered counterparts, particularly in demanding towing scenarios.[23]

6. *Dependence on Electricity Grid*: Electric tugboats rely on a stable and reliable electricity supply, which may be subject to disruptions, grid outages, or fluctuations in energy prices. This dependency introduces risks related to energy security and operational resilience. [13]

7. *Regulatory Uncertainty*: Regulatory frameworks governing electric propulsion in maritime applications may still be evolving, leading to uncertainty regarding compliance requirements, safety standards, and liability considerations for operators deploying electric tugboats. [13]

8. *Infrastructure Requirements*: Implementing electric tugboats necessitates significant investment in charging infrastructure, including the installation of charging stations, grid upgrades, and possibly new power distribution systems in ports. This infrastructure investment can be costly and time-consuming. [24]

9. *Limited Power Output*: Electric propulsion systems may have lower power output compared to conventional diesel engines, particularly in high-demand situations such as towing heavy loads or maneuvering large vessels. This limitation can affect the performance and operational capabilities of electric tugboats.[25]

10. *Cold Weather Performance*: Batteries used in electric tugboats may experience reduced performance and efficiency in cold weather conditions, impacting overall vessel operation and reliability, especially in regions with harsh winter climates. [26]

11. *Limited Availability of Electric Models*: The availability of electric tugboats may be limited compared to traditional diesel-powered vessels, making it challenging for operators to find suitable electric alternatives that meet their specific operational requirements and preferences. [13]

12. *Transition Challenges*: Transitioning from diesel to electric tugboats may involve challenges such as retraining personnel, adapting to new operating procedures, and integrating electric vessels into existing fleets and workflows. These transitional challenges can add complexity and uncertainty to the adoption process. [27]

Disavantages are presented in Table 3:

Table 3. Disavantages

No.crt.	Operational Disadvantages	Limited Range Cold Weather Performance Charging Time Weight and Space Constraints Limited Power Density Limited Power Output
1.	Rational Disadvantages	Limited Availability of Electric Models Transition Challenges Dependence on Electricity Grid Regulatory Uncertainty
2	Economic Disadvantages	Initial Cost Infrastructure Requirements

Several ports implemented or are in the process of implementing the e-tugs as part of their efforts to reduce emissions. Some examples around the world are: Port of Los Angeles, Port of Auckland, Port of San Francisco, Port Vancouver, Port of Singapore. And in Europe we have: Port of Hamburg, Port of Amsterdam, Port of Gothenburg, Port of Valencia, Port of Oslo, Port of Antwerp (Table 4).

Table 4. Port-producer

PORT	*PRODUCER*	*ARTICLE*
Port of Auckland	DAMEN	https://www.damen.com/insights-center/news/damen-s-first-all-electric-tug-sparky-delivered-to-ports-of-auckland
Port of Hamburg	Fairplay Towage Group	https://safety4sea.com/hydrogen-fuelled-tugboats-to-be-deployed-in-the-port-of-hamburg/
Port of Antwerp	DAMEN	https://www.offshore-energy.biz/europes-1st-all-electric-tug-on-the-horizon-as-part-of-port-of-antwerp-bruges-tug-renewal-deal-with-damen/

DAMEN is the principal producer of e-tugs that supplies ports around the world and also in Europe, our interest zone.

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Port of Hamburg	Fairplay Towage Group	https://safety4sea.com/hydrogen-fuelled-tugboats-to-be-deployed-in-the-port-of-hamburg/
Port of Antwerp	DAMEN	https://www.offshore-energy.biz/europes-1st-all-electric-tug-on-the-horizon-as-part-of-port-of-antwerp-bruges-tug-renewal-deal-with-damen/

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5. CONCLUSIONS

Electric tugboats reduce air pollution, fuel consumption, and noise. Hybrid tugs reduce emissions by 30-60% compared to conventional tugboats. Fully electric tugboats produce zero emissions during voyages.

Electric tugboats contribute to marine conservation objectives. The marine species' ability will be better to communicate, reproduce and find food.

Also for crew will be better to work, because electrifying tugboats reduces noises.

The battery' designers will create more space for crew and equipment.

E-tugs offer an opportunity to reduce the environmental impacts in marine industry.

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