

CASE STUDY IDENTIFICATION SHEET

Practice 8: Implementation of eco-friendly propulsion systems

This document has been developed by **Piri Reis University (PRU)** as part of the activities under Task 3.2 of the “GREENPORT Alliances” project, for which MAR.TE. S.c.ar.l. serves as the responsible entity. Task 3.2 focuses on identifying and analysing case studies that exemplify best practices for behavioural change among operators aimed at reducing the environmental impact of port operations.

The primary objective of this activity is to collect, document, and analyse concrete examples of technological, managerial, or behavioural innovation that have proven effective in contributing to the environmental, economic, and social sustainability of the port services sector. Through a structured selection and evaluation process, the document highlights the specific features of each case study and assesses their performance against key environmental and economic impact indicators.

The information gathered will be integrated into the overall framework of the GREENPORT Alliances project to promote the dissemination of sustainable solutions and the development of curricula for: a. higher education students (future personnel); b. current professionals (professional training); c. educators (train-the-trainer courses).

Table of Contents

1. General information	2
2. Context and description	2
3. Implementation	3
4. Collected data.....	4
5. Economic and environmental analysis (<i>If the information is accessible</i>).....	5
6. Conclusions.....	7
7. Annexes.....	8

1. GENERAL INFORMATION

A. Case study title

Technological Solution – Implementation of Eco-Friendly Propulsion Systems for Tugboats in Ports

B. Green practice implemented:

Practice 8: Implementation of eco-friendly propulsion systems

Description: Investing in green technologies such as hybrid propulsion systems, electric engines, and other innovations to reduce environmental impact. Adoption of hybrid and fully electric propulsion systems for tugboats

C. Specific goals

Reduce emissions, improve fuel efficiency, and enhance sustainability in port operations

D. Direct impact of the practice

Significant reduction in CO2 emissions, lower fuel consumption, and reduced noise pollution

E. Place of implementation

Port of Los Angeles/USA

F. Start and end date or duration of the pilot project

Initiated in 2019, ongoing expansion

2. CONTEXT AND DESCRIPTION

A. Description of the practice

The Port of Los Angeles introduced eco-friendly propulsion systems in tugboats, integrating battery-electric and hybrid technology to decrease reliance on fossil fuels.

B. Driving factor behind the adoption of the green practice

Need for reducing the environmental impact of port operations and complying with stricter emissions regulations. The primary driving factor behind the adoption of eco-friendly propulsion systems in tugboats at the Port of Los Angeles was the need to reduce harmful emissions. Ocean-going vessels and commercial harbour craft are responsible for a significant portion of particulate matter and nitrogen oxide emissions at the port. By integrating battery-electric and hybrid technology, the port aims to decrease reliance on fossil fuels and improve air quality, aligning with broader environmental goals and regulations.

C. Stakeholders involved

Port authorities, tugboat operators, environmental agencies, technology providers involved in the process. Several key stakeholders are involved in the adoption of eco-friendly propulsion systems in tugboats at the Port of Los Angeles:

1. **Port of Los Angeles:** The port authorities are leading the initiative, providing infrastructure and support for the integration of new technologies
2. **California Energy Commission (CEC):** The CEC funds and supports research and development projects, including the Hydrogen Zero-Emission Tugboat Project
3. **Crowley Marine Services:** This company is involved in the construction and operation of the hybrid and battery-electric tugboats
4. **ABB Marine & Ports:** They provide the necessary technology and equipment for the propulsion systems
5. **Ballard Power:** This company supplies fuel cell technology for the hydrogen-powered tugboats
6. **Environmental Agencies:** Organizations like the California Air Resources Board (CARB) set regulations and standards for emissions, ensuring the new technologies meet environmental goals

These stakeholders collaborated to reduce emissions, improve air quality, and promote sustainable practices at the port. It's collective effort to drive innovation and environmental responsibility.

There were also several incentives for exceeding environmental regulations at the Port of Los Angeles:

1. **Green Ship Incentive Program:** This program rewards vessels that meet or exceed Tier II and Tier III emission standards with rebates of up to \$6,000 per visit
2. **Vessel Speed Reduction Program:** Ships that comply with this program, which aims to reduce speeds to protect marine life and improve air quality, enjoy reduced port fees
3. **California Energy Commission (CEC) Grants:** The CEC provides funding for projects that demonstrate significant emission reductions, such as the Hydrogen Zero-Emission Tugboat Project
4. **Environmental Ship Index (ESI):** Ports like Los Angeles offer discounts on harbor dues for vessels with high ESI scores, incentivizing reduced emissions

These incentives not only help reduce operational costs but also promote sustainable practices and enhance the port's reputation as a leader in environmental stewardship.

3. IMPLEMENTATION

A. Description of the adopted practice

Deployment of hybrid-electric and fully electric tugboats to assist in vessel manoeuvring within the port. The Port of Los Angeles has adopted several eco-friendly practices for tugboats to reduce emissions and reliance on fossil fuels:

1. **Battery-Electric Propulsion:** Tugboats are equipped with large batteries that can be recharged using shore power connections. This allows the tugboats to operate with zero emissions during most of their operations
2. **Hybrid Propulsion Systems:** These systems combine battery-electric power with traditional diesel engines, which are used only as a backup or in emergencies. This significantly reduces fuel consumption and emissions
3. **Hydrogen Fuel Cells:** Some tugboats are being equipped with hydrogen fuel cells, which produce electricity through a chemical reaction between hydrogen and oxygen, emitting only water vapor as a by-product
4. **Biofuels:** In the short term, biofuel blends are being used to reduce diesel dependency. These fuels are cleaner alternatives to traditional diesel and help lower emissions
5. **Infrastructure Development:** The port is developing the necessary infrastructure to support these new technologies, including charging stations for battery-electric tugboats and facilities for hydrogen fuel storage and refuelling

These practices are part of a broader effort to improve air quality and promote sustainability at the port.

B. Technologies used (if applicable)

Battery-electric propulsion, diesel-electric hybrid systems, energy recovery systems

C. Competencies required

Expertise in electric propulsion maintenance, energy management, and sustainable maritime operations

4. COLLECTED DATA

Before and after the implementation of eco-friendly propulsion systems in tugboats at the Port of Los Angeles, several types of data were collected to assess the impact and effectiveness of the new technologies:

Before Implementation:

High fuel consumption, elevated greenhouse gas emissions, increased noise pollution

1. **Emission Levels:** Baseline data on emissions of particulate matter (PM) and nitrogen oxides (NOx) from traditional diesel-powered tugboats
2. **Fuel Consumption:** Data on the amount of diesel fuel consumed by the tugboats during their operations
3. **Operational Efficiency:** Information on the operational efficiency and performance of the existing tugboats
4. **Air Quality:** General air quality measurements in and around the port area

After Implementation:

Reduction in fuel usage by up to 30%, lower emissions, and quieter port operations

1. **Emission Reductions:** Measurements of emissions from the new battery-electric, hybrid, and hydrogen fuel cell tugboats to compare with baseline data
2. **Fuel Savings:** Data on the reduction in diesel fuel consumption due to the use of battery-electric and hybrid systems
3. **Performance Metrics:** Evaluation of the operational efficiency and performance of the new tugboats, including any improvements or challenges
4. **Air Quality Improvements:** Updated air quality measurements to assess the impact of reduced emissions on the local environment

These data points help stakeholders understand the benefits and challenges of adopting green technologies and guide future decisions on expanding such practices.

5. ECONOMIC AND ENVIRONMENTAL ANALYSIS (IF THE INFORMATION IS ACCESSIBLE)

A. Initial investment required

High initial cost for acquiring and retrofitting tugboats with eco-friendly propulsion systems technology

B. Key savings or economic impact

The adoption of eco-friendly propulsion systems in tugboats at the Port of Los Angeles has led to several key savings and economic impacts:

Key Savings:

1. **Fuel Cost Reduction:** The use of battery-electric and hybrid systems significantly reduces the reliance on diesel fuel, leading to substantial savings in fuel costs
2. **Maintenance Savings:** Electric and hybrid propulsion systems generally require less maintenance compared to traditional diesel engines, resulting in lower maintenance costs

3. **Emission Reduction Incentives:** The port benefits from various incentives and rebates for reducing emissions, such as the Green Ship Incentive Program, which offers financial rewards for meeting specific emission standards

Economic Impact:

1. **Job Creation:** The development and maintenance of new technologies have created jobs in the fields of engineering, manufacturing, and environmental science
2. **Increased Competitiveness:** By adopting green technologies, the Port of Los Angeles enhances its reputation as a leader in sustainability, attracting more business and investment
3. **Long-Term Savings:** Although the initial investment in eco-friendly technologies can be high, the long-term savings from reduced fuel and maintenance costs, along with emission-related incentives, contribute to a positive economic impact

These savings and economic benefits highlight the importance of sustainable practices in the maritime industry. It's a win-win for both the environment and the economy!

C. Contribution to environmental goals

Significant reduction in carbon footprint, compliance with green port initiatives, and improved air quality.

The adoption of eco-friendly propulsion systems in tugboats at the Port of Los Angeles significantly contributes to several environmental goals:

1. **Reduction in Emissions:** By using battery-electric, hybrid, and hydrogen fuel cell technologies, the port has significantly reduced emissions of particulate matter (PM) and nitrogen oxides (NOx), which are major pollutants from traditional diesel engines
2. **Improved Air Quality:** The reduction in harmful emissions directly contributes to better air quality in and around the port area, benefiting the health of local communities and ecosystems
3. **Decreased Greenhouse Gas Emissions:** The shift to cleaner propulsion systems helps lower the port's overall carbon footprint, aligning with global efforts to combat climate change
4. **Promotion of Renewable Energy:** The use of renewable energy sources, such as hydrogen and electricity from renewable sources, supports the transition away from fossil fuels
5. **Compliance with Regulations:** The port's initiatives help meet stringent environmental regulations and standards set by agencies like the California Air Resources Board (CARB), ensuring sustainable operations

The eco-friendly propulsion systems in tugboats at the Port of Los Angeles are designed to meet several specific regulations:

1. **California Air Resources Board (CARB) Regulations:** These regulations require significant reductions in emissions from commercial harbor craft. The new propulsion systems help meet CARB's stringent standards for particulate matter (PM) and nitrogen oxides (NOx) emissions
2. **Clean Air Action Plan (CAAP):** The Port of Los Angeles, in collaboration with the Port of Long Beach, developed the CAAP to reduce air pollution and health risks. The adoption of battery-electric, hybrid, and hydrogen fuel cell technologies aligns with the goals of this plan
3. **Zero-Emission Vessel (ZEV) Requirements:** CARB's Zero-Emission Vessel regulations mandate that new and newly acquired vessels, including tugboats, must be capable of operating with a minimum of 30% zero emissions by the end of 2025
4. **Environmental Protection Agency (EPA) Standards:** The propulsion systems also comply with EPA's marine engine emission standards, which aim to reduce air pollution from marine vessels

These regulations ensure that the port's operations are environmentally sustainable and contribute to improved air quality and public health.

6. CONCLUSION

The implementation of eco-friendly propulsion systems has demonstrated strong environmental benefits and cost savings over time. There are plans to introduce additional hybrid and fully electric tugboats across other major ports. Further investment in renewable energy sources and charging infrastructure to support full electrification of port operations is also under consideration.

Electric tugboats have provided several valuable lessons for the maritime industry:

- a. **Environmental Impact:** Electric tugboats significantly reduce carbon emissions compared to their diesel counterparts. For instance, the eWolf, the first electric tug in the U.S., is expected to cut 3,100 metric tons of CO₂ over ten years
- b. **Operational Costs:** The operational costs of electric tugs are lower. The Port of Auckland's electric tug, Sparky, has operational costs approximately 50% lower than diesel tugs
- c. **Maintenance:** Electric tugs have lower maintenance costs due to fewer moving parts and the absence of diesel engines
- d. **Energy Storage and Charging:** Ensuring adequate battery capacity and efficient charging infrastructure is crucial. Sparky's design included maximizing shore charging power to 1500 kW to meet demanding shipping schedules
- e. **Training and Adaptation:** New training programs are necessary for crews and engineers to operate and maintain electric tugs, as the technology and systems differ from traditional diesel tugs

- f. **Design and Integration Challenges:** Integrating various systems and ensuring the physical capabilities of electric tugs match those of diesel tugs posed significant challenges

These lessons highlight the potential benefits and challenges of transitioning to electric tugboats, paving the way for more sustainable maritime operations.

Casting Towards a Sustainable Horizon

The quest for sustainable maritime solutions doesn't anchor on electric power. The teams continue to evolve design enhancements aiming for elongated battery power and negligible emissions. Innovations like replacing generator sets with batteries illuminate a path where tugs can harness electricity shoreside and reserve diesel for open water.

The challenge is a monetary one as well. Diesel maintenance savings do not fully compensate for the capital cost of batteries. Nonetheless, with federal regulations moving in favour of green innovations, grants and funding might soon tip the scales, paving the way for even more eco-friendlier vessels to move into production.

Riding the Tide of Energy Alternatives

The marine industry hasn't placed its hopes on electric power alone. Other fuels—methanol, hydrogen, and ammonia—are on the radar, but they still require elaborate experimentation. For now, renewable diesel appears most worthy, capable of cutting carbon emissions by 75%.

Despite the promising advances in technology, the tides of change flow slowly. The industry's venerable vessels, with lifespans stretching to half a century, won't retire their diesel engines overnight. We're witnessing a balancing act, a pursuit of progress tinged with practicalities of cost and feasibility.

The following proposal is devised for a structured training concept document and detailed curricula for skilling and upskilling port pilots and tugboat operators, focusing on the implementation of eco-friendly propulsion systems.

Training Concept Document

1. Introduction

The maritime industry is transitioning towards eco-friendly propulsion systems to reduce greenhouse gas emissions and comply with international environmental regulations. This training program aims to equip port pilots and tugboat operators with the necessary skills and knowledge to operate and maintain these advanced systems efficiently.

2. Objectives

- **Skilling:** Provide foundational knowledge and practical skills for new port pilots and tugboat operators.
- **Upskilling:** Enhance the competencies of existing personnel to adapt to eco-friendly propulsion technologies.

- **Compliance:** Ensure adherence to international standards and regulations, such as the International Maritime Organization (IMO) guidelines.

3. Target Audience

- **Port Pilots:** Responsible for navigating ships through congested and challenging waters.
- **Tugboat Operators:** Assist in manoeuvring ships in ports and harbours.

4. Training Modules

The training program shall be divided into several modules, each focusing on different aspects of eco-friendly propulsion systems and their operation.

Proposed Curricula

Module 1: Introduction to Eco-Friendly Propulsion Systems

- **Overview of Propulsion Systems:** Traditional vs. eco-friendly systems.
- **Types of Eco-Friendly Propulsion:** Electric, hybrid, wind-assisted, and smart propulsion systems
- **Benefits and Challenges:** Environmental impact, fuel efficiency, and operational considerations.

Module 2: Regulatory Framework and Compliance

- **International Regulations:** IMO guidelines, MARPOL Annex VI, and other relevant regulations
- **National and Local Regulations:** Specific requirements for different regions.
- **Compliance Strategies:** Best practices for ensuring regulatory adherence.

Module 3: Technical Training on Eco-Friendly Propulsion Systems

- **System Components:** Detailed study of engines, batteries, fuel cells, and other components.
- **Operation and Maintenance:** Procedures for operating and maintaining eco-friendly propulsion systems.
- **Troubleshooting and Repairs:** Common issues and their solutions.

Module 4: Simulator-Based Training

- **Simulation Exercises:** Realistic scenarios for hands-on practice.
- **Performance Assessment:** Evaluating proficiency in operating eco-friendly propulsion systems

Module 5: Safety and Emergency Procedures

- **Safety Protocols:** Ensuring safe operation of eco-friendly propulsion systems.
- **Emergency Response:** Handling emergencies related to propulsion system failures.

Module 6: Environmental Impact and Sustainability

- **Environmental Awareness:** Understanding the environmental benefits of eco-friendly propulsion.
- **Sustainability Practices:** Implementing sustainable practices in daily operations.

Module 7: Advanced Navigation and Manoeuvring Techniques

- **Navigation Skills:** Enhancing navigation skills using eco-friendly propulsion systems.
- **Manoeuvring in Ports and Harbours:** Techniques for efficient and safe manoeuvring.

Module 8: Continuous Learning and Development

- **Ongoing Training:** Regular updates and refresher courses.
- **Professional Development:** Opportunities for further education and certification.

Module 9: Case Studies on Eco-Friendly Propulsion Systems

Case Study 1: Green Ports Initiative

- **Overview:** This case study examines the sustainability initiatives undertaken by the Ports of Rotterdam, Long Beach, and Yokohama.
- **Details:** These ports have integrated technologies like hydrogen production, zero-emission equipment, and eco-friendly dredging to minimize their environmental impact
- **Learning Outcomes:** Understanding the implementation of sustainable practices in port management and their benefits.

Case Study 2: Electric and Hybrid Tugboats

- **Overview:** This case study explores the adoption of electric and hybrid propulsion systems in the tugboat industry.
- **Details:** Tugboats with electric or hybrid propulsion systems have been built to reduce emissions and improve sustainability. For example, **Sanmar Shipyards** and Damen Shipyards have delivered several electric and hybrid tugs, such as the all-electric harbour tug, Sparky
- **Learning Outcomes:** Gaining insights into the design, operation, and benefits of electric and hybrid tugboats.

Case Study 3: Pilotage Skills with Eco-Friendly Propulsion

- **Overview:** This case study focuses on the training and adaptation of pilotage skills for eco-friendly propulsion systems.
- **Details:** The study highlights the need for pilots to adapt their navigation and manoeuvring techniques when operating vessels with eco-friendly propulsion systems. This includes understanding the unique handling characteristics and operational procedures of these systems
- **Learning Outcomes:** Enhancing pilotage skills to ensure safe and efficient navigation with eco-friendly propulsion systems.

Integration into Curriculum

- **Module 1:** Introduction to Eco-Friendly Propulsion Systems
 - Include a brief overview of the case studies to provide real-world context.
- **Module 3:** Technical Training on Eco-Friendly Propulsion Systems
 - Discuss the technical aspects and outcomes of the case studies.
- **Module 6:** Environmental Impact and Sustainability
 - Highlight the environmental benefits observed in the case studies.
- **Module 8:** Continuous Learning and Development
 - Encourage ongoing study and analysis of similar case studies to stay updated with industry advancements.

These case studies will provide practical examples and insights into the implementation of eco-friendly propulsion systems in various maritime contexts.

Learning Outcomes

The following are the learning outcomes for the entire training course on skilling and upskilling port pilots and tugboat operators in view of implementing eco-friendly propulsion systems. These learning outcomes will ensure that participants are well-equipped to handle the transition to eco-friendly propulsion systems, contributing to a more sustainable maritime industry.

By the end of this training program, participants will be able to:

1. **Understand Eco-Friendly Propulsion Systems:**
 - Differentiate between traditional and eco-friendly propulsion systems.
 - Identify various types of eco-friendly propulsion technologies, such as electric, hybrid, wind-assisted, and smart propulsion systems.
 - Recognize the environmental and operational benefits of eco-friendly propulsion systems.
 -
2. **Comply with Regulatory Frameworks:**
 - Understand international regulations, including IMO guidelines and MARPOL Annex VI.
 - Identify national and local regulations relevant to eco-friendly propulsion systems.
 - Implement compliance strategies to adhere to regulatory requirements.
 -
3. **Operate and Maintain Eco-Friendly Propulsion Systems:**
 - Describe the components and functioning of eco-friendly propulsion systems.
 - Perform routine operations and maintenance of these systems.
 - Troubleshoot and resolve common issues related to eco-friendly propulsion systems.
 -
4. **Apply Practical Skills through Simulation:**
 - Engage in realistic simulation exercises to practice operating eco-friendly propulsion systems.
 - Assess performance and improve proficiency through hands-on practice.

-
- 5. **Ensure Safety and Emergency Preparedness:**
 - Follow safety protocols for the operation of eco-friendly propulsion systems.
 - Respond effectively to emergencies related to propulsion system failures.
- 6. **Promote Environmental Sustainability:**
 - Understand the environmental impact of eco-friendly propulsion systems.
 - Implement sustainable practices in daily operations to minimize environmental footprint.
-
- 7. **Enhance Navigation and Manoeuvring Skills:**
 - Improve navigation skills using eco-friendly propulsion systems.
 - Apply advanced manoeuvring techniques in ports and harbours.
-
- 8. **Analyse Real-World Case Studies:**
 - Examine case studies of eco-friendly propulsion systems in ports, tugboats, and pilotage.
 - Draw practical insights and lessons from real-world implementations.
-
- 9. **Commit to Continuous Learning and Development:**
 - Participate in ongoing training and refresher courses to stay updated with industry advancements.
 - Pursue further education and certification opportunities for professional development.
-
- 10. **Achieve Certification:**
 - Successfully complete written exams, practical tests, and simulator evaluations.
 - Obtain certification upon meeting the course requirements.

7. ANNEXES

This case study is based on the Port of Los Angeles introduction to eco-friendly propulsion systems in tugboats, integrating battery-electric and hybrid technology to decrease reliance on fossil fuels. Several ports worldwide have initiated projects to implement eco-friendly propulsion systems for tugboats, aiming to reduce emissions and enhance sustainability in maritime operations. Here are some notable examples:

1. Port of Busan: Hybrid-Electric Tugboat "Meta 7"

In Busan, South Korea, the Port of Busan introduced the "Meta 7," a hybrid-electric tugboat equipped with Kongsberg Maritime's propulsion system. This vessel utilizes battery power during transit operations, significantly reducing emissions and improving air quality in the port area. The

integration of battery power has also led to lower fuel consumption and reduced maintenance requirements.

2. E3 Tug Project: Port of Rotterdam

The E3 Tug Project is a collaborative R&D initiative involving Smit International, Damen Shipyards Gorinchem, and Alewijnse Marine Technology, spearheaded by the Port of Rotterdam. The project's goal is to develop energy-efficient and environmentally friendly tugboats by analysing operational patterns and integrating advanced propulsion systems.

3. Ammonia-Powered Tugboat on the Hudson River

A pioneering project in the United States saw a 67-year-old diesel-powered tugboat retrofitted to run on ammonia, a carbon-free fuel. Developed by the start-up Amogy, this vessel operates on technology that splits ammonia into hydrogen and nitrogen to power fuel cells, emitting primarily water and nitrogen. This initiative represents a significant step toward zero-emissions maritime propulsion.

These projects exemplify the maritime industry's commitment to adopting innovative, eco-friendly propulsion technologies to promote sustainable port operations.



References

1. Hayton, M. (2023). Marine Electrification is the Future: A Tugboat Case Study. In: Li, Y., Hu, Y., Rigo, P., Lefler, F.E., Zhao, G. (eds) Proceedings of PIANC Smart Rivers 2022. PIANC 2022. Lecture Notes in Civil Engineering, vol 264. Springer, Singapore. https://doi.org/10.1007/978-981-19-6138-0_77
2. Tugboats Powered by Ammonia, <https://apnews.com/article/ammonia-fuel-diesel-amogy-shipping-60beccfb8894c79ddc624026fbf0a8e5>

3. Electric Propulsion Solutions for Tugboats, <https://medha.com/electric-propulsion-solution-for-tugboats/>
4. A Green Solution to BUSAN Port, https://www.kongsberg.com/maritime/feature_articles/2025/2/a-green-solution-for-busan-port/
5. **Techno-economic investigation of alternative propulsion systems for tugboats**, [Istanbul Technical University](#), *Student thesis: Master's thesis*, <https://research.itu.edu.tr/en/studentTheses/techno-economic-investigation-of-alternative-propulsion-systems-f/>
6. **Optimization of Tugboat Propulsion System Configurations: A Holistic 2 Life Cycle Assessment Case Study** Haibin Wang, Peilin Zhou, Yibo Liang, Byongug Jeong, Ana Mesbahi, https://strathprints.strath.ac.uk/71632/1/Wang_etal_JCP_2020_Optimization_of_tugboat_propulsion_system_configurations
7. First Environmentally Friendly Next-Generation Electric Propulsion Ship System in Japan System integration enabling to reduce CO2 emissions by 30%, https://www.ihi.co.jp/en/technology/techinfo/contents_no/1201051_13586.html
8. Challenges and Triumphs: Electrifying the Future of Tugboat Design, <https://pepmobile.org/electrifying-the-future-of-tugboat-design/>
9. The benefits of electric tugboats - TT Club, <https://www.ttclub.com/news-and-resources/case-studies/case-studies-new/case-study-the-benefits-of-electric-tug-boats/>
10. [The Hydrogen Zero-Emission Tugboat Project Final Project Report](#)
11. [New zero-emissions tug could be tested in the ports of LA, Long Beach](#)
12. [New zero-emissions tug could be tested in the ports of LA, Long Beach](#)
13. [The Hydrogen Zero-Emission Tugboat Project Final Project Report](#)
14. [Tug Industry Embraces Electric Propulsion for Sustainable Future](#)
15. [New zero-emissions tug could be tested in the ports of LA, Long Beach](#)
16. [The Hydrogen Zero-Emission Tugboat Project Final Project Report](#)
17. [The Hydrogen Zero-Emission Tugboat Project Final Project Report.](#)
18. [New zero-emissions tug could be tested in the ports of LA, Long Beach](#)
19. [LA Waterfront](#)
20. [15 Port Rebates and Incentives Every Shipowner Should Know About](#)
21. [The Hydrogen Zero-Emission Tugboat Project Final Project Report](#)
22. [Sustainable Technologies and Green Ports – Maritime Education](#)

23. Tug Industry Embraces Electric Propulsion for Sustainable Future

24. MINIMAL project reaches experimental stage on the road to reduce ...