

CASE STUDY IDENTIFICATION SHEET

This document has been developed 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 analyzing case studies that exemplify best practices for behavioral change among operators aimed at reducing the environmental impact of port operations.

The primary objective of this activity is to collect, document, and analyze concrete examples of technological, managerial, or behavioral 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).

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1. GENERAL INFORMATION

A. Continuous monitoring of emissions during operations

Practice 6: Continuous monitoring of emissions during operations

Description: Implement monitoring systems to track emissions of CO₂, SO₂, and other pollutants, using advanced technologies to collect accurate data.

B. Specific goals

The implementation of Continuous Emission Monitoring Systems (CEMS) on tugboats to reduce CO₂, SO₂, and NO_x emissions and ensure compliance with environmental regulations.

2. CONTEXT AND DESCRIPTION

A. Description of the practice

Tugboats play a crucial role in maritime transport. However, their diesel engines contribute to the emission of harmful substances such as carbon dioxide (CO₂), sulfur dioxide (SO₂), and other pollutants that negatively impact the environment and human health. Given the increasingly strict international environmental standards and national regulations, such as the Air Pollution Control Program for the period 2020–2029, it is essential to implement advanced emission monitoring systems on tugboats. These systems enable continuous monitoring and analysis of CO₂, SO₂, NO_x, and other harmful emissions, allowing for better control and reduction of environmental impact.

Several technologies can be used for emission monitoring on tugboats. Continuous Emission Monitoring Systems (CEMS) are standard systems that provide real-time measurement of exhaust gas emissions from ship engines. These systems use sensors to detect and quantify the concentrations of CO₂, SO₂, NO_x, and other gases. The data is collected in real-time, enabling immediate analysis and response in case of exceeding the permitted limits.

Recent innovations include the use of drones equipped with sensors for monitoring ship emissions. An example of this practice is a pilot project in the Port of Barcelona, where drones are used to monitor pollutant emissions and potential spills from ships. These drones can detect SO₂ and NO_x levels and identify potential violations of environmental regulations. Additionally, mathematical models can be used to estimate emissions based on operational data, taking into account engine characteristics, fuel consumption, and operating conditions, allowing for emission estimation even when direct measurement is not available.

B. Driving factor behind the adoption of the green practice

The main driving factor behind the adoption of emission monitoring systems on tugboats is compliance with environmental regulations. Stricter international and national standards, such as the MARPOL Convention and the Air Pollution Control Program (2020–2029), require shipping companies to monitor and reduce CO₂, SO₂, and NO_x emissions.

By implementing advanced monitoring technologies, such as Continuous Emission Monitoring Systems (CEMS), drones with sensors, and mathematical models, operators can ensure compliance with regulations, avoid legal penalties, and contribute to environmental protection.

Additionally, reducing emissions enhances the company's reputation and supports global efforts in combating climate change.

3. IMPLEMENTATION

A. Description of the adopted practice

The first step in implementing an emission monitoring system is a detailed assessment of the current state of the tugboat, including the engine type and age, current emissions and fuel consumption, and existing monitoring systems. This assessment helps identify key areas for improvement and adapt the monitoring system to the specific needs of the vessel.

Based on the assessment, the most suitable emission monitoring technology should be selected. For tugboats operating near the coast and in ports, CEMS systems may be ideal due to their precision and continuous monitoring capability. In cases where installing CEMS is technically or financially unfeasible, emission estimation models combined with periodic measurements can be used.

Steps for Implementing an Emission Monitoring System:

- Assessment of the current state – Reviewing the technical characteristics of the tugboat, current emission levels, and integration possibilities for new systems.
- Installation of sensors and equipment – Connecting the monitoring system with ship systems and ensuring proper sensor calibration for accurate measurement.
- Testing and system adjustments – Verifying the system's functionality in real operational conditions and making necessary adjustments based on initial data.
- Crew training – Ensuring that the crew can use the system, interpret data, and respond appropriately if emissions exceed allowed limits.
- Regular maintenance and continuous monitoring – Maintaining sensor accuracy and data reliability over time.

B. Technologies used

After selecting the technology, the emission monitoring system should be integrated with existing ship systems. This includes installing sensors, establishing communication channels for data transmission, and implementing software solutions for analysis and reporting.

c. Competencies required

It is crucial to provide adequate crew training to understand system functionality, interpret collected data, and take action in case of excessive emissions. Continuous emission monitoring allows for the early detection of deviations and the implementation of corrective measures. The collected data should be regularly analyzed and compared with regulatory limits, and reporting systems must be established in compliance with national laws and international conventions such as MARPOL.

Regular maintenance of the monitoring system is essential to ensure long-term functionality and data accuracy.

4. CONCLUSIONS

The implementation of CO₂, SO₂, and NO_x emission monitoring systems on tugboats represents a significant step toward reducing the negative impact of maritime transport on the environment. By utilizing advanced technologies for accurate data collection, ship operators can ensure compliance with regulations and contribute to global efforts to reduce air pollution.

Through a combination of cutting-edge technology, crew education, and continuous monitoring, tugboats can become part of the solution in the global fight against climate change, while maintaining their essential role in maritime logistics and safety.

1. GENERAL INFORMATION

A. Regular maintenance of tugboat engines

Practice 15: Regular maintenance of tugboat engines

Description: Regularly perform maintenance and calibration of engines to ensure they operate efficiently, reducing emissions and fuel consumption.

B. Specific goals

Implement regular maintenance and calibration of tugboat engines to optimize fuel consumption, reduce harmful gas emissions, and ensure compliance with international environmental regulations such as MARPOL Annex VI and the IAPP certificate.

2. CONTEXT AND DESCRIPTION

A. Description of the practice

Regular maintenance and calibration of tugboat engines are crucial for ensuring their efficient operation, reducing emissions, and optimizing fuel consumption. Compliance with international regulations, such as MARPOL Annex VI, the Engine Technical File (ETF), and the International Air Pollution Prevention Certificate (IAPP), requires continuous monitoring and maintenance of engines to prevent excessive emissions of pollutants and ensure the longevity of the vessel. In addition to environmental benefits, proper engine maintenance significantly reduces operational costs, increases vessel reliability, and lowers the risk of failures that can lead to expensive repairs and delays in tugboat operations.

B. Driving factor behind the adoption of the green practice

The main driver behind the adoption of regular maintenance and calibration of tugboat engines is compliance with environmental regulations and cost optimization. International standards, such as MARPOL Annex VI and the IAPP certificate, require continuous monitoring and maintenance of engines to reduce CO₂, NO_x, and SO₂ emissions and ensure the environmental acceptability of the vessel. At the same time, proper maintenance and calibration reduce fuel consumption, increase engine reliability, and lower operational costs. By using digital monitoring systems and predictive analytics, operators can prevent costly failures, ensure engine longevity, and avoid legal sanctions, thus achieving long-term economic and environmental sustainability.

3. IMPLEMENTATION

A. Description of the adopted practice

Key maintenance activities include monitoring and analyzing engine performance using advanced sensor systems, analyzing parameters such as exhaust gas temperature, cylinder pressure, and the air-fuel ratio, and comparing actual performance with data from the Engine Technical File (ETF) to detect deviations. The implementation of digital engine monitoring systems enables automatic logging of key data and its analysis through advanced algorithms. This enables predictive maintenance, reducing the need for emergency repairs and increasing engine reliability.

Regular calibration and adjustment of engine components involve calibrating fuel injection and adjusting turbocharger operation to reduce fuel consumption and emissions, checking and adjusting combustion control systems, and regularly replacing and cleaning filters, nozzles, and other engine components. In addition to these basic activities, exhaust gas analysis is recommended to ensure that the engine operates within specified norms. The use of advanced diagnostic tools can help identify faults before they cause more serious issues.

The Air Pollution Prevention Certificate (IAPP) certifies that the vessel meets international emission standards. Maintenance and calibration documentation must be updated and available during inspections, and the use of exhaust gas filtration and purification systems contributes to maintaining the certificate. Regular inspections by authorized bodies ensure that vessels comply with strict environmental standards. Improper maintenance or lack of documentation can result in the loss of certification and financial penalties, as well as operational restrictions.

The benefits of regular maintenance and calibration include reducing operational costs through optimal fuel consumption, reducing CO₂, NO_x, and SO₂ emissions in accordance with international standards, extending engine life, and reducing the need for expensive repairs, increasing the safety and reliability of tugboat operations, avoiding legal issues and fines by complying with international regulations, and improving the company's image through responsible environmental practices.

B. Technologies used

MARPOL Annex VI sets the maximum allowable emissions of NO_x, SO₂, and CO₂ and requires the maintenance and documentation of engine technical parameters. Regular servicing and repairs must be recorded in the ETF to demonstrate compliance with regulations, and it is also recommended to implement systems for optimizing fuel consumption and reducing harmful emissions. Tugboats exceeding certain emission thresholds must be equipped with emission control systems, such as SCR catalysts and scrubbers, to remain within permitted limits. Maintaining these systems is crucial for their long-term efficiency.

c. Competencies required

For effective regular maintenance and calibration, it is recommended to develop a detailed maintenance plan with predefined service and inspection intervals, implement a digital data monitoring system with automatic logging of engine performance, train the crew to recognize potential issues, regularly analyze fuel with an emphasis on using high-quality fuels that can significantly reduce harmful emissions, and collaborate with certified service providers to ensure that all engine interventions are carried out according to manufacturer and regulatory standards.

4. CONCLUSIONS

Regular maintenance and calibration of tugboat engines are essential for reducing emissions, improving efficiency, and ensuring compliance with MARPOL Annex VI and the IAPP certificate. The implementation of modern technologies for monitoring and analyzing engines enables fuel consumption optimization and extends equipment lifespan, which contributes to ecologically sustainable and cost-effective operations in the long term. Systematic and precise maintenance reduces operational costs, increases engine reliability, and ensures regulatory compliance. The

digitalization of maintenance processes and the use of predictive analytics further contribute to optimizing performance, reducing emissions, and maintaining high levels of safety on vessels.