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# TECHNICAL ANALYSIS OF THE USE OF SHORE CONNECTION SERVICES AT TANKER DOCKS

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***Abstract***
*The implementation of shore connection services at tanker docks is a critical advancement towards reducing the environmental impact of maritime operations. This technical analysis evaluates the effectiveness, efficiency, and economic implications of using shore power connections for tankers during docking periods. The study involves a comprehensive assessment of the infrastructure requirements, installation processes, and operational protocols associated with shore connection services. By utilizing shore power, tankers can shut down their auxiliary engines while docked, significantly reducing emissions of CO2, NOx, and particulate matter. Data collected from multiple tanker docks equipped with shore connection systems reveal substantial reductions in fuel consumption and operational costs. Additionally, the analysis highlights the technical challenges encountered, such as compatibility issues between ship and port electrical systems, and proposes solutions to enhance interoperability. The economic evaluation indicates that while initial installation costs are high, the long-term benefits in terms of reduced fuel expenditure and compliance with stringent environmental regulations justify the investment. The study concludes that shore connection services represent a viable and sustainable solution for the maritime industry, promoting cleaner port environments and contributing to the global effort to mitigate climate change. Further research is recommended to optimize system designs and expand the adoption of this technology across different types of ports and vessels.*



***Keywords:***
*Shore connections; tanker ship; energy efficiency; greenhouse gas emissions; port infrastructure.*

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## 1. Introduction

In recent decades, the maritime industry has come under increasing pressure to reduce the environmental impact of ship operations [1]. One of the main issues is the greenhouse gas emissions and other air pollutants produced by ships [2], especially when docked at ports [3]. Tankers, with their large size and significant fuel consumption, are a major contributor to this [4]. The use of fossil fuel-based generators to provide electricity when ships are at dock is a source of emissions that needs to be addressed [5]. In this context, shore connection services [6], or often called cold ironing, emerge as a potential solution [7]. This technology allows ships to turn off their engines and switch to using electricity from land [8], which is usually cleaner and more efficient [9].

Implementing shore connections at tanker docks is not only about reducing emissions, but is also related to increasing operational efficiency and reducing long-term operational costs [10]. By utilizing energy sources from land [11], ships can reduce the use of expensive and inefficient fossil fuels [12], and reduce the need for engine maintenance [13]. However, the transition to a shore connection system faces various technical and economic challenges [14]. Implementation of this system requires substantial infrastructure investment at the port, as well as technical adjustments to the tanker for compatibility with the onshore electrical system [15]. In addition, international technical standards need to be widely adopted to ensure system interoperability and security.

This research aims to analyze the technical aspects of using shore connection services at tanker docks. Through a descriptive analysis approach, this research will identify optimal system configurations, evaluate integration with port infrastructure [16], and examine existing challenges and opportunities [17]. Data will be collected through field observations [18], interviews with port operators [19], and a review of relevant literature [20]. It is hoped that the research results will provide comprehensive insight into the advantages and obstacles in implementing shore connections, as well as practical recommendations for increasing the adoption of this technology [21]. Thus, this research contributes to global efforts to achieve more sustainable and environmentally friendly maritime operations.

## 2. Method

This research uses a qualitative descriptive approach to analyze the technical aspects of using shore connection services at tanker docks. The descriptive method was chosen because it allows researchers to observe and describe phenomena in detail, without intervention or manipulation of variables. Data was collected through several techniques, including field observations, in-depth interviews with port operators and tanker crews, and literature reviews. Field observations were carried out at several major ports that have implemented or are currently testing shore connection systems [22]. It provides a first-hand overview of the technical configurations used, challenges faced during implementation, and solutions that have been implemented as seen in Figure 1. In-depth interviews were conducted with various stakeholders, including port managers, technicians, and ship crew, to gain a comprehensive perspective on system operations and their practical experiences.

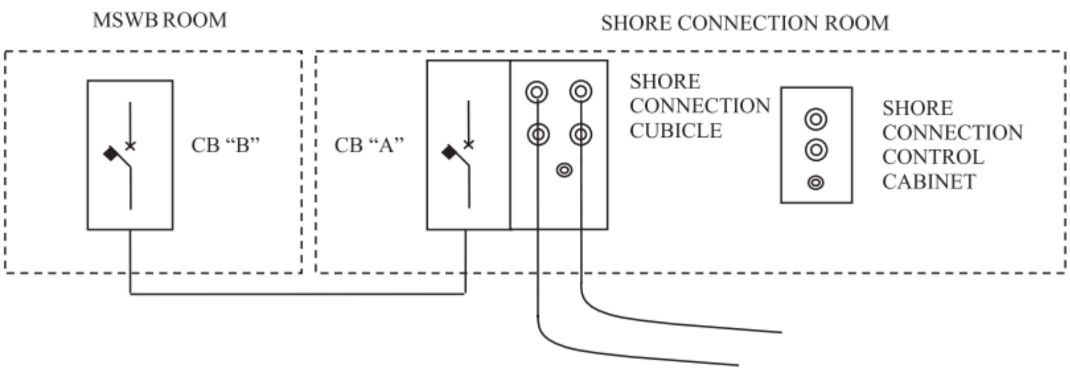


Figure 1. Simple block diagram of shore connection services at a tanker berth.

The literature review includes case studies, previous research papers, and technical documents related to shore connections. This literature is analyzed to understand the latest developments in shore connection technology, applicable international standards, and best practices that have been identified in various ports throughout the world. The data collected was then analyzed using the thematic analysis method to identify main patterns and themes related to the use of shore connections. The results of this analysis are used to develop practical recommendations that can help ports and ship operators adopt this technology more effectively [23]. This research also considers economic aspects, by analyzing the initial investment costs and long-term benefits of using shore connections, as well as the impact on reducing emissions and operational efficiency of tanker ships [24]. Thus, this research method is designed to provide a comprehensive understanding of the potential and challenges of using shore connection services, as well as their contribution to the sustainability of the maritime industry.

## 3. Result and Discussion

### *Implementation of Shore Connection at Main Ports*

This research looks at the implementation of shore connections at several major ports that have adopted this technology, such as the Port of Rotterdam, the Port of Singapore, and the Port of Los Angeles. Observation results show that the technical configuration of shore connections at each port varies according to operational needs and available electricity capacity [25]. In the Port of Rotterdam, for example, the shore connection system uses high-voltage electrical connections (6.6 kV to 11 kV) which allows large tankers to meet their power needs without the need to use fossil fuel generators as seen in Figure 2. Meanwhile, the Port of Los Angeles is adopting a more flexible approach by providing low and high-voltage options, allowing vessels with varying technical specifications to use shore connection facilities.

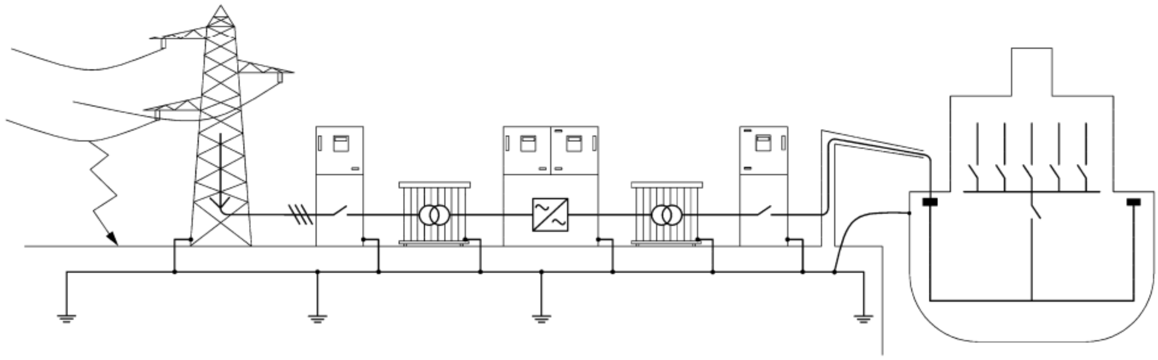

Figure 2. Port with system power supply via primary line 6.6 kV to 11 kV with single phase fault at delivery point.

Interviews with port operators and technicians revealed that one of the main challenges in implementing shore connections is technical adjustments to tankers. Older tankers often require significant modifications to their electrical systems to be compatible with shore connections. Additionally, international standardization is a critical issue, with the need to harmonize safety and operational protocols for compatibility between ports [26]. However, despite technical challenges and high initial investment, the long-term benefits derived from emissions reductions and operational efficiencies were consistently recognized by all stakeholders interviewed.

***Energy Efficiency and Emission Reduction***

Data from observations and interviews show that the use of shore connections significantly reduces fuel consumption and pollutant emissions from anchored tankers. For example, at the Port of Singapore, the implementation of shore connections on several large tankers has shown a reduction in fuel consumption of up to 30% during the berthing period. This reduction not only reduces operational costs, but also reduces $CO_2$, $N_{ox}$, and SOx emissions which are major contributors to air pollution and climate change [27]. A case study at the Port of Los Angeles also showed similar results, with a reduction in $CO_2$ emissions of up to 40% compared to ships using diesel-fueled generators during anchorage.

Economic analysis reveals that although the initial investment costs for shore connection infrastructure are quite high, the long-term savings in fuel costs and engine maintenance costs can offset this investment. For example, in the Port of Rotterdam, estimates show that the port could reach a break-even point within 5-7 years after implementing shore connections, with the potential for significant operational savings thereafter [28]. In addition, government incentives and increasingly stringent environmental regulations provide additional encouragement for ports and ship operators to adopt this technology.

***Operational Challenges and Solutions***

This research also identifies several operational challenges faced in implementing shore connections. One of the main challenges is the technical compatibility between ships and port infrastructure. Older tankers often require significant modifications to integrate shore connection systems, including electrical system upgrades and installation of additional equipment. This creates additional costs and operational downtime that ship operators need to take into account. In addition, differences in technical standards between countries and ports are an obstacle to wider implementation as seen in Figure 3. For example, different electrical voltages and frequencies in various ports require ships to have more flexible adaptability.

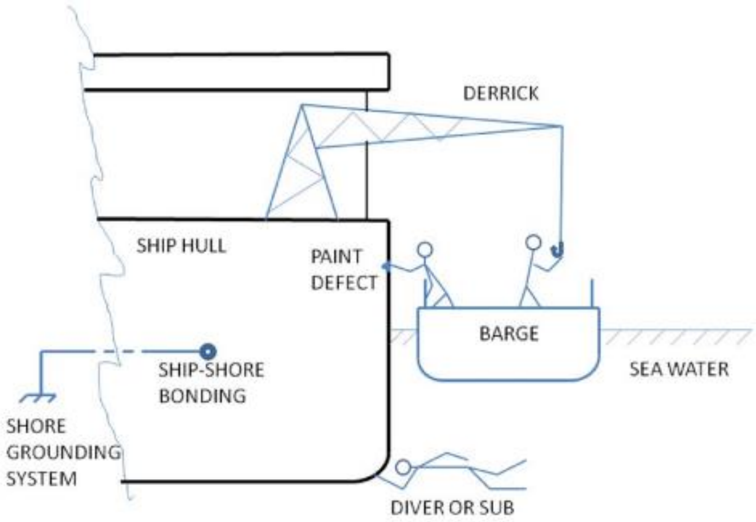


Figure 3. The dock running the Shore Connection Service at the Tanker Pier is moored alongside.

To overcome these challenges, several solutions have been identified. First, the development of international technical standards that can be applied globally is essential to ensure operational compatibility and security. The *International Maritime Organization* (IMO) and *International Electrotechnical Commission* (IEC) are working on this standardization, but implementation and widespread adoption still take time. Second, ports can offer financial incentives to ships that invest in upgrading their electrical systems. This incentive can take the form of a reduction in port fees or a direct subsidy for the installation of shore connection equipment. Third, ports and ship operators can work together on training programs to improve the technical skills of ship crew and port technicians in operating and maintaining shore connection systems.

***Future Potential and Recommendations***

Based on the results and analysis carried out, the use of shore connections has great potential to improve sustainability and operational efficiency in the maritime industry, especially for tankers. To maximize this potential, several strategic recommendations are proposed. First, ports must continue to invest in shore connection infrastructure and ensure the availability of this service for various types of vessels. Second, collaboration between ports, ship operators, and international regulatory bodies needs to be improved to accelerate the development and adoption of uniform technical standards [29]. Third, financial incentives and supporting regulations need to be expanded to encourage more ship operators to adopt shore connection technology [30]. Governments can play an important role in this by offering subsidies, tax breaks, or other incentives to ports and ship operators that invest in green technologies. Fourth, research and development must continue to be encouraged to increase efficiency and reduce the costs of implementing shore connections. New technologies such as automation systems and smart grids can provide innovative solutions to existing operational challenges.

By implementing these recommendations, the maritime industry can more quickly transition to cleaner and more efficient operations, making a significant contribution to reducing global emissions and protecting the marine environment. This research shows that despite technical and economic challenges, the long-term benefits of using shore connections far outweigh the initial costs, making them a worthwhile investment for a more sustainable future for the shipping industry.

## 4. Conclusion

In summary, this research examines the technical aspects of using shore connection services at tanker berths, with a focus on implementation, energy efficiency, emission reduction, operational challenges and potential solutions. The study results show that shore connection is an effective solution for reducing fuel consumption and pollutant emissions, as well as increasing the operational efficiency of anchored tankers. Implementation of this technology in major ports, such as Rotterdam, Singapore and Los Angeles, has proven significant environmental and economic benefits. However, challenges such as high initial investment costs, the need for technical adjustments to vessels, and differences in international standards need to be overcome. Recommendations to address these challenges include developing global technical standards, providing financial incentives, and increasing collaboration between ports, ship operators, and regulatory agencies. This research confirms that shore connections are a worthwhile investment for a more sustainable future for the maritime industry, and with the right support, this technology can be widely adopted to achieve cleaner and more efficient shipping operations..

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