

# Optimization of Reefer Plug on Ferry to Support Cold Logistic System

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**ABSTRACT:-** Reefer Plug is an important plug-in electrical technology that supports frozen truck operations on ships, especially to maintain the quality of sensitive goods such as frozen food and pharmaceuticals during sea travel. However, the implementation of reefer plug in Indonesia faces various challenges, including inadequate infrastructure, high investment costs, and regulations that still need to be refined. The main questions that arise are how Reefer Plug can meet the high power needs of frozen trucks, the technical, economic, and environmental impacts of its use compared to fossil fuel generators, and what strategies can be applied to optimize this technology. This study aims to analyze the technical benefits, economic impacts, and environmental sustainability of Reefer Plug, as well as provide strategic recommendations for improving its operational efficiency. The method used is a case study on the operation of Reefer Plug on the biggest ferry company in Indonesia Ferry ship with an analysis of regulations and modern logistics market needs. The results of the study show that Reefer Plug can increase energy efficiency by up to 40%, reduce carbon emissions by up to 30%, and reduce operational risks due to ODOL vehicles.

**KEYWORDS:-** Reefer Plug, Frozen Truck, Refrigerated Logistics, Energy Efficiency

## I. INTRODUCTION

Reefer Plug is an important technology in the refrigerated logistics supply chain on board ships. This technology provides a stable electrical connection for refrigerated vehicles such as frozen trucks, which dominate power requirements during sea voyages. Rodrigue and Notteboom (2022) explain that the Reefer Plug system allows vehicles to maintain optimal temperatures [1], which is very important for maintaining the quality of goods such as frozen food and pharmaceuticals.

In Indonesia, the operation of Reefer Plugs on ships is supported by regulations such as PM 25 of 2015, which regulates operational safety standards for maritime transportation, including the operation of refrigerated vehicles. In addition, PM 60 of 2021 encourages the adoption of environmentally friendly technologies to support national strategic areas. With the projected growth of the cold chain logistics market reaching USD 12.59 billion in 2031 [2], Reefer Plugs are an important part of a sustainable logistics strategy.

Cold supply chain management is a critical element in ensuring the quality of perishable goods is maintained during the distribution process [3]. As part of the cold supply chain, Reefer Plug functions to maintain the required temperature in refrigerated vehicles. Research shows that implementing effective cold chain management, such as maintaining low temperatures throughout the distribution process, can reduce logistics costs while improving the quality of service to end consumers. This supports the role of Reefer Plug in ferry operations in Indonesia, especially for sensitive goods such as frozen food products and pharmaceuticals.

The Reefer Plug system is not only designed to support refrigerated vehicles, but can also help reduce the pressure caused by ODOL vehicles on marine transportation infrastructure. ODOL is known to cause road damage and increase infrastructure maintenance costs by up to IDR 43 trillion per year [4]. In the context of refrigerated logistics, the use of Reefer Plug can reduce the need for internal vehicle power, thereby reducing the risk of accidents and damage to the ship's deck during sea voyages.

In the period 2003 to 2009, 24 ferry/Ro-Ro accidents were recorded in Indonesia, consisting of 25% sinking incidents, 25% fires, and 29% grounding [5]. Most of these accidents were caused by weather factors (34%), followed by human factors (27%), and technical factors [5]. This shows the need to improve the safety system on board ferries, including the integration of technology such as Reefer Plug to reduce operational risks due to over dimension over load (ODOL) vehicles that can affect ship stability.

This study is designed to answer three main questions related to the implementation of Reefer Plug on board ships: first, how can Reefer Plug support the high power needs of refrigerated vehicles, especially frozen trucks, during sea voyages? Second, what are the technical, economic, and environmental impacts of using Reefer Plug compared to fossil fuel generators? Finally, what strategies can be taken to overcome infrastructure challenges, investment costs, and regulations in optimizing the use of Reefer Plug on ships?

The objectives of this study are: to analyze the technical benefits of Reefer Plug in supporting frozen truck operations on ships, to examine the economic and environmental impacts of using Reefer Plug as a refrigerated logistics solution and to propose strategic recommendations in improving the operational efficiency of Reefer Plug on ferries with a focus on regulatory support and market needs.

## **II. METHODOLOGY**

This case study focuses on the operation of Reefer Plug on a ship owned by PT. ASDP Indonesia Ferry. Rodrigue and Notteboom (2022) explain that Reefer Plug has a primary function to ensure power stability in refrigerated vehicles during sea voyages [1]. This study evaluates the specific power requirements for frozen trucks and the challenges that arise in their management.

The research data is combined with regulatory analysis such as PM 25 of 2015, which regulates ship safety standards, and PM 60 of 2021, which encourages the development of clean energy in the maritime transportation sector. Considering the increasing projection of the refrigerated logistics market, this study provides a practical evaluation of the use of Reefer Plug on ferry ships.

The case study approach at PT. ASDP Indonesia Ferry considers the challenges of ODOL vehicles in marine logistics operations. With the analysis of regulations such as PM 25 of 2015, this study highlights the importance of integrating Reefer Plug with vehicle weight monitoring system to reduce ODOL violations during shipping [6].

## **III. LITERATURE REVIEW**

Related literature is used to provide operational context for Reefer Plug on board vessels. Rodrigue and Notteboom (2022) highlight the importance of this technology in the global supply chain [1], while Williamsson (2022) highlights the energy efficiency and carbon emission reduction of Reefer Plug compared to fossil fuel generators [7].

Regulation PM 25 of 2015 is the basis for assessing the suitability of this technology with operational safety standards in Indonesia. In addition, the market projection of USD 12.59 billion in 2031 Electrical Plugin Implementation Plan provides an overview of the strategic relevance of Reefer Plug adoption to meet modern logistics demands [2].

Previous studies have shown that technologies such as Weigh-in-Motion (WIM) are effective in identifying vehicles that violate load limits [6]. Integration of this technology with Reefer Plug can provide a comprehensive solution to manage ODOL risks and improve the energy efficiency of refrigerated vehicles [4].

## **IV. RESULTS AND DISCUSSIONS**

### **Technical and Economic Benefits of Reefer Plug**

Reefer Plug provides a technical solution for the high power requirements of refrigerated vehicles such as frozen trucks. Rodrigue and Notteboom (2022) show that Reefer Plug is able to maintain the stability of the temperature of goods during sea travel [1], while reducing the risk of operational disruption. This system also supports energy efficiency of up to 40% and is able to reduce carbon emissions by up to 30% compared to fossil fuel generators [7].

Fuel efficiency is one of the main advantages of using Reefer Plug compared to fossil fuel generators. Based on a study by Williamsson (2022), the use of Reefer Plug can reduce fuel consumption by up to 40%, a significant achievement in the context of logistics operations [7]. In addition, reducing fuel consumption not only reduces operational costs but also reduces carbon emissions produced during sea travel. The implementation of Reefer Plug provides an energy-efficient solution that supports the sustainability agenda, especially in the growing refrigerated logistics sector. This is very relevant in facing global challenges related to climate change and the shift towards clean energy.

The result and discussion could be combined in one section, or separated into two sections, namely: Results, and Discussions. This section should be the longest section of the paper, could consist of some sub-sections. The result section provides the findings of this study. The discussion section provides the Authors engagement between the findings this study and of other related studies, other related phenomena, other related issue (supported by strong references from other related studies or other media).

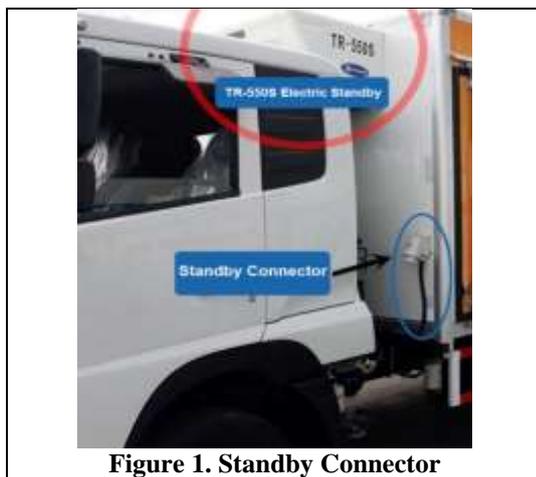
Reefer Plug technology has a significant impact on improving safety aspects on ferries, especially in addressing the risks posed by overloaded vehicles (Over Dimension Over Load/ODOL). ODOL vehicles not only increase the risk of accidents due to excessive loads on the ship's deck, but also reduce the stability of the ship during the voyage. By using Reefer Plug, the engines of refrigerated vehicles such as frozen trucks can be turned off during the voyage, thereby reducing vibrations and the risk of fire that are often associated with engines that are constantly running. Reefer Plug also reduces the need for excessive power on the ship because the vehicles are no longer using their internal resources. This impact contributes directly to improving ship safety and reducing pressure on ship infrastructure. Regulations such as PM 60 of 2021 provide incentives to

adopt this technology, especially in national strategic areas. With the refrigerated logistics market continuing to grow, Reefer Plug has the potential to improve ship operational efficiency while supporting environmental sustainability.

Power factor is an important technical aspect in the use of Reefer Plug, especially in reducing power losses in inductive loads such as compressors. Previous research at PT. Pelindo IV showed that the installation of a capacitor bank can increase the efficiency of electrical power in Reefer Plugs by up to 27.04% [8], while significantly reducing reactive power consumption. These findings indicate that technical optimization through power management can improve the performance of Reefer Plugs in supporting the operational needs of refrigerated vehicles during sea voyages. Reefer Plugs play an important role in improving the operational efficiency of refrigerated logistics. With energy management optimization, Reefer Plugs can reduce power consumption during operations, thereby extending the life of the device and reducing maintenance needs. This is relevant to support the delivery of refrigerated goods that require stable electrical power, especially during sea voyages. This efficiency not only reduces operational costs but also supports energy sustainability in the logistics sector [9].

Reefer Plug not only improves energy efficiency but also helps ship operators identify ODOL vehicles before boarding the ship [4]. With this system, operators can optimize the use of ship capacity and ensure stability during the voyage [6].

Reefer Plug has the potential to reduce the risk of accidents due to ODOL vehicles carrying excessive loads on the ship's deck, which often causes disturbances in stability and safety of the voyage [5]. Data shows that poor cargo management can increase the risk of ship accidents by more than 30%, in bad weather conditions and maneuvering in narrow waters such as the Bali Strait and Lombok Strait [5].



**Figure 1. Standby Connector**



**Figure 2. Pin Connector**

### **Regulatory and Market Support**

Regulation PM 25 of 2015 sets out relevant operational safety standards for the management of Reefer Plugs on ships, including the use of safe and stable power. On the other hand, PM 60 of 2021 provides support for the development of environmentally friendly technologies that are relevant to modern logistics needs.

The implementation of Reefer Plugs also requires stronger support from government regulations. Regulation PM 25 of 2015, which regulates maritime transportation safety standards, can be expanded to include the use of Reefer Plugs as an operational standard for refrigerated vehicles on ships. In addition, incentives such as electricity subsidies or tax reductions for ferry operators who adopt this technology can accelerate implementation in the field. Strong regulatory support will not only encourage the adoption of Reefer Plugs but also increase the competitiveness of refrigerated logistics services in Indonesia.

The projection of the refrigerated logistics market reaching USD 12.59 billion, Electrical Plugin Implementation Plan shows a great opportunity to expand the use of Reefer Plugs on Indonesian ships [2]. With the dominant use by frozen trucks, investment in Reefer Plug infrastructure can have a positive impact on the efficiency and sustainability of inter-island logistics.

The adoption of e-monitoring technology for Reefer Plug has been proven to increase the effectiveness of reefer container management. With this system, the temperature of the cargo can be monitored in real-time, ensuring that goods remain in optimal condition at all times. A case study at the Makassar Container Terminal recorded an increase in average revenue after the implementation of this system, from IDR 823 million to IDR 954 million per month [10]. This shows that technological innovation not only improves operational efficiency but also provides significant economic added value.

Regulations PM 25 of 2015 and PM 60 of 2021 have provided a legal basis for improving the safety of maritime transportation [6]. However, the implementation of this policy requires additional incentives such as electricity subsidies and tax reductions for ship operators using Reefer Plug to support sustainable logistics [4].

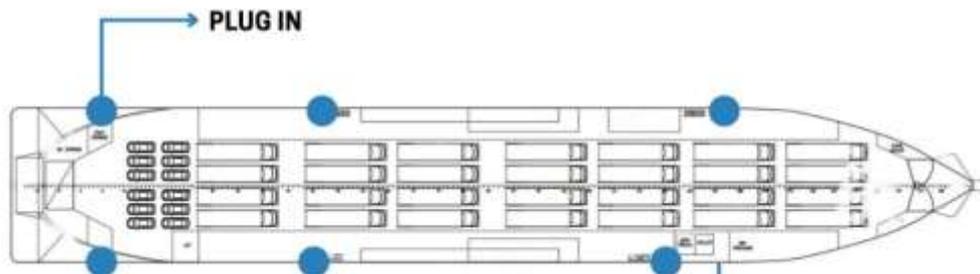
Safety regulations such as PM 25 of 2015 need to be strengthened by adding ODOL vehicle handling components through weight monitoring technology integrated with Reefer Plug. This step will not only reduce the pressure on ship infrastructure but also increase user confidence in safer ferry services [5].

### Strategy for Reefer Plug Optimization

Optimizing the use of Reefer Plugs on ferries requires improving supporting infrastructure designed to support this system effectively. The installation of adequate Reefer Plug units on ships and ports must be accompanied by the development of a reliable power distribution system. In addition, the use of e-monitoring technology can ensure that the temperature of refrigerated vehicles remains stable during sea voyages [11]. This system allows real-time temperature monitoring, so that the risk of damage to goods can be minimized, as has been implemented in several container terminals in Indonesia [12].

Close collaboration between the government, ferry operators, and the logistics industry is needed to overcome the constraints of initial investment costs. The government can provide incentives in the form of subsidies or tax reductions for ferry operators who adopt environmentally friendly technologies such as Reefer Plugs [13]. On the other hand, logistics operators can be involved in sharing investment costs to ensure the sustainability of this project [14]. Strong collaboration among stakeholders will accelerate the implementation of this technology in the field.

Supportive regulations and policies are also key factors in optimizing Reefer Plugs. Existing regulations, such as PM 25 of 2015 concerning maritime transportation safety, can be updated to regulate the use of Reefer Plugs as an operational standard on ferries [15]. This policy not only reduces the risk of fire due to running vehicle engines but also improves overall operational safety [16]. In addition, new regulations can include mandatory training programs for ship operators and crews on the safe and efficient operation of Reefer Plugs.



**Figure 3. Electrical Plug-in on board to support refrigerated logistics in the Ferry Industry**



**Figure 3. Flow Process Plug In Ferry**

## V. CONCLUSIONS

Reefer Plug on ships offers a significant solution to support refrigerated logistics transportation in Indonesia. This technology not only improves energy efficiency but also supports environmental sustainability by reducing carbon emissions by up to 30%.

The use of Reefer Plug in refrigerated logistics provides significant competitive advantages for operators. With high energy efficiency and reliability, Reefer Plug enables logistics companies to offer quality services at lower operating costs. This is a major attraction for customers looking for energy-efficient and environmentally friendly refrigerated logistics solution [9]. This improvement strengthens Reefer Plug's position as a key technology in the modern logistics industry.

National regulatory support and the potential of the refrigerated logistics market provide a strategic basis for accelerating the adoption of this technology. By addressing infrastructure challenges and investment costs, Reefer Plug can be a major solution to meet modern logistics needs.

Competitiveness of logistics services is an important factor in the development of Reefer Plug on ferry vessels. Research has identified that shipping costs, service reliability, and company credibility are the main determinants of competitiveness in refrigerated transportation [17]. By implementing Reefer Plug, companies can improve service reliability and meet quality standards expected by customers. This shows that Reefer Plug technology has the potential to strengthen the market position of refrigerated logistics operators in Indonesia.

Optimizing Reefer Plugs requires not only investment in electrical infrastructure but also training for ship crews. This training should include efficient operation of the Reefer Plug system and emergency scenario simulations to ensure safety during shipping. In addition, further research on the integration of Reefer Plugs with renewable energy technologies, such as solar panels or batteries, can provide long-term solutions for energy efficiency and fuel consumption reduction. The combination of cutting-edge technology and trained human support will increase the success of implementing Reefer Plugs as a modern logistics solution.

Reefer Plugs not only provide technical and economic solutions for refrigerated logistics, but also support ODOL reduction policies which are a major challenge in maritime transportation[6]. With strong regulatory support and cross-sector collaboration, this technology can strengthen operational efficiency and sustainability of national logistics.

With the increasing incidence of ferry accidents caused by human, technical, and weather factors, technologies such as Reefer Plugs can be a risk mitigation solution. The implementation of Reefer Plug, together with stricter regulations, has the potential to reduce accident rates by up to 30%, thereby supporting the safety and operational efficiency of refrigerated logistics in Indonesia [5].

Training and education for ship crews and logistics operators are top priorities in supporting Reefer Plug implementation. Research shows that adequate safety training can significantly reduce the risk of accidents [18]. These training programs need to include emergency simulations to help crews deal with worst-case scenarios, such as fires on board, so that they can act quickly and effectively in critical situations [5].

Economic and environmental analyses need to be conducted to evaluate the long-term impacts of Reefer Plug use. A study comparing the operating costs of fossil fuel generators with the Reefer Plug system can provide a clear picture of its economic benefits [13]. The results of this analysis can be used to convince stakeholders about the importance of adopting this technology, not only as an energy solution but also as a real step towards more sustainable transportation [14].

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