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by M tirtana Siregar

Submission date: 11-Feb-2024 08:00PM (UTC+0700)
Submission ID: 2291685383
File name: for_turnitin.docx (6.8M)
Word count: 2930
Character count: 15574

Available *online* at : http://jurnal.poltekapp.ac.id/
Jurnal Manajemen Industri dan Logistik
| ISSN (Print) 2622-528X | ISSN (Online) 2598-5795 |

Logistic Management

GREEN ENERGY DEVELOPMENT STRATEGY TOWARDS GREEN LOGISTICS: CASE STUDY AT PT. PELABUHAN INDONESIA III (PERSERO) BENOA BALI

ARTICLE INFORMATION

Article history:

Received: February 00, 00
Revised: March 00, 00
Accepted: April 00, 00

Keywords:
Green Energy
Green Logistic
Strategy
Benoa Port

ABSTRACT

Management of Benoa Port under PT. Pelabuhan Indonesia III (Persero), is currently in a development program with the Bali Maritime Tourism Hub (BMTH) concept. The development of green energy at ports is a major part of the implementation of greenhouse gas (GHG), it will have an impact on the implementation of green logistics. The green energy development strategy includes the sea side and the land side. In this research, we conducted a case study regarding the development of green energy towards green logistics. This transition will have an impact on managerial and operational effectiveness. This research aims to create a strategy for developing the use of green energy towards green logistics at Benoa Port. The research methodology used is based on literature studies and field studies to then create a strategy development scheme that will be implemented. The results of the research conclude that the sea side and land side strategies can be applied to Benoa Port, the initial development strategy that has the greatest potential to be implemented is wind energy and solar energy on the land side to support the implementation of green logistics in fulfilling the Port area's electrical energy.

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INTRODUCTION

The port sector is currently an important center for the development of maritime transportation, logistics, passenger services, tourism, a world trade center and as a link between various countries in the world. A report from the United Nations Conference on Trade and Development (UNCTAD) in 2021 stated that more than 80% of the volume of international goods trade is carried out via sea transportation routes and developing countries have a higher share [1], however high energy consumption and pollution occur due to Increasing port production and trade volumes have made the environmental impact on seas and ports even greater. Pollution and port operations will not only damage the natural ecological balance and the surrounding environment, but also have a negative impact on climate change. The port sector is ideal and plays an important role in developing a green and sustainable energy transition for a better future [2]. Ports in their operations require large energy requirements, so how can they manage this energy efficiently or can use alternative fuels [3]. Port classification in Indonesia is divided into two groups; 1) Managed ports and 2) non-managed ports, with the main objective being to serve the entire process of sea transportation activities, the difference is related to the facilities at non-managed ports which are not as complete as the facilities at managed ports.

Ports are nodes in complex trade and logistics networks that include shipping companies, shipping companies, terminal operators, and other parties [4]. The port sector is composed of various stakeholders and varies in characteristics and needs, for example, it includes public and private entities, for-profit or non-profit purposes, geographic conditions, large and small organizations, and more [5]. Furthermore, this sector is characterized by a variety of activities, such as transportation, logistics, large-scale manufacturing, etc. [6]. Port authorities recognize that environmental and social performance is fundamental in dealing with the community and environment in which the port is located because they can also provide a competitive advantage. As customers increasingly emphasize the value of sustainable and environmentally friendly supply chains, initiatives are needed to improve port sustainability, especially in the green energy sector to support the creation of environmentally friendly green logistics services.

Benoa Harbor is a business entity owned by the Government of the Republic of Indonesia through PT. Port Indonesia III (Persero). The status of Benoa Port is an International Port, with an area of the eastern pier (P=290 m; I= 20 m; D= -10 m LWS), southern pier (P= 205.8 m; I = 21.3 m; D= - 8 m LWS) and fishing pier (P= 406 m; I= 8 m; D= -3 m LWS). Building facilities consist of: 1) International passenger terminal 1,300 m2; 2) Domestic passenger terminal 1,383 m2; 3) Warehouse 1,856 m2 and 4) Stacking yard 1.5 Ha. Shipping channel with a channel length of 3.9 nautical miles, a channel width of 1,500 m and a channel depth of -9-13 m LWS with a terminal area of 1,530 m2. Currently Benoa Harbor is in the development process with work that has been completed and is still ongoing with the following information:

Table 1. Development of Benoa Harbor

Work	Year
Melastik Area Development	2019-2020
Construction of Retaining Wall and Revetment	2020-2022
City Forest Development	2022-2024
Jetty Construction	2020-2026
Construction of Storage Tanks	2021-2026
Pond Dredging	2020-2025
Extension of East Pier (Cruise) 160 m	2021-2022
Fishery Zone Development	2023-2028

The development of Benoa Port is currently being carried out to increase operational capacity, but not so much towards developing green energy towards green logistics. The concept of environmentally friendly port development has been put forward in the port industry. An environmentally friendly port is a sustainable port that provides a balance between environmental and economic benefits. The environmentally friendly port development strategy involves many aspects including reducing harmful gas emissions from ports and ships, which is also the most prominent factor [7]. More than 90% of ports are close to urban areas so they have a pollution impact and result in a risk of decreased health for people living in these areas [8] On the other hand, several studies discussing the use of renewable energy and smart power grids in ports, show that it cannot only improve the environmental performance of the port system but also save economic costs [9]. The development of logistics has greatly promoted the rapid growth of global trade and trade globalization has continuously increased the demands for international and domestic logistics. However, negative externalities of logistics have long been recognized. For instance, carbon dioxide emissions, noise pollution, resource waste, infrastructure failure and traffic congestion are generated from freight transportation and operating equipment [10].

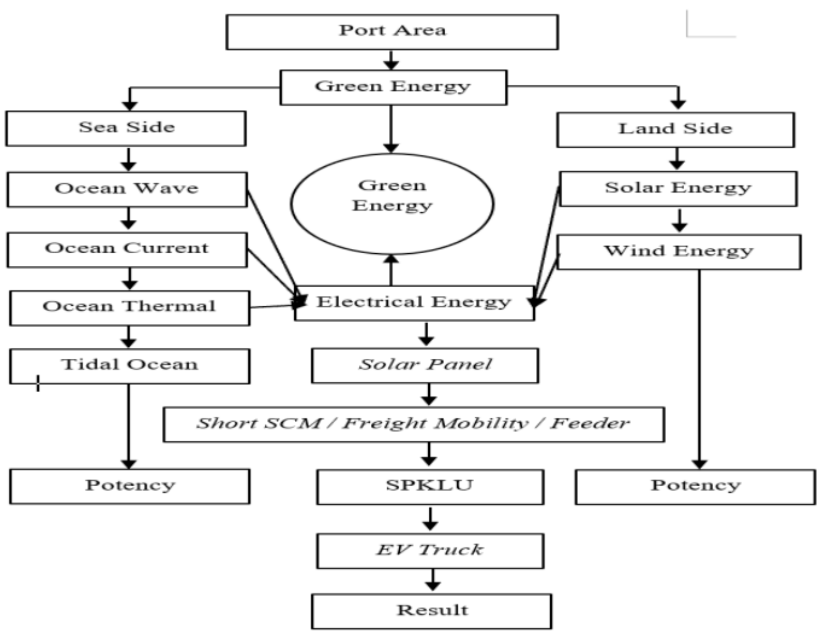
Ports have different energy needs such as electrical energy, natural gas, heat/cooling energy, and conventional fuels or renewable fuels such as hydrogen, ammonia, biofuel, etc. Energy needs are adjusted to the types of activities carried out at the port, such as loading and unloading of cargo and shipping, providing electrical power for docked ships, and providing various port facilities and infrastructure as services for commercial operators and passengers. The increasing demand for energy needs in port areas, coupled with demands to reduce pollutant emissions, has encouraged the development of new renewable energy systems that can provide various forms of energy using sustainable sources [9]. There is a lot of literature regarding energy efficiency and new renewable energy-based systems in port areas, including design, optimization, and operation strategies. State-of-the-art technologies and management strategies to save energy and reduce environmental impacts are reviewed in detail and comprehensively [11].

The combination of various renewable energy sources can provide major benefits for ports also in terms of the environmental impact of docked ships. Yigit and Acarkan 2018 [12], studied several scenarios for harnessing solar and wind energy through electricity supply and energy storage systems at the coast. They developed MATLAB models to assess the environmental and economic performance of proposed energy management methods for ports located in Brazil, the UK, Turkey, and Japan. The main results show that CO2 emissions in Brazil can be reduced by 90% while port costs in Turkey are reduced by 58%. Benoa Port has a very strategic position in implementing the new, renewable/green energy transition process, the potential for green energy to support green logistics at Benoa Port, including from the water side, namely marine energy in the form of wave energy, tidal energy, ocean current energy., and marine thermal energy, while from the land side, namely solar energy (solar cells) and wind energy. The aim of this research is to create a strategy for implementing green energy at Benoa Port to support the creation of green logistics.

RESEARCH METHOD

The author carried out this research activity using literacy study data collection techniques as well as data sources with secondary data types. The discussion in this research can be described qualitatively based on the results of data processing that has been previously collected. Literature review methodology allows researchers to implement rigorous and reliable analysis of scientific sources [13], [14]. Some scientific review methods exist as literature-based reviews, using a framework as a methodology, theory-based, reviews aimed at theory development, hybrid types, and bibliometric analysis. Considering the research gaps, the author considers that the analysis was carried out using a literature review. The research methodology was adopted from Arena et al. (2018) [15] and adapted to conditions at Benoa Harbor.

Figure 1. Research Methodology Scheme



RESULT AND DISCUSSION

In the strategy scheme for developing green energy towards green logistics at Benoa Port, it can be explained as follows:

1.1 Ocean Side

From the sea side, looking at all the potential of green energy that can be applied, some of these energies are as follows:

1.1.1 Ocean Wave Energy

Is kinetic energy by utilizing differences in sea wave height by converting energy into electrical energy through wave indicators, namely wavelength, wave height and time of sea waves which are used as energy in rotating turbines and generators to produce electrical energy. There are five wave energy technologies that have been applied as electrical energy generators, namely Cockerall rafts, Kayser rigid tubes, salter floats and Masuda tubes [16].

Figure 2. Ocean Wave Energy

1.1.2 Ocean Current Energy

The way ocean current energy works through power plants has the same characteristics as wind power plants which utilize the rotation of a windmill to drive a generator to produce electrical energy. The minimum ocean current speed reaches 2 m/s, with the ideal ocean current speed being 2.5 m/s [16].

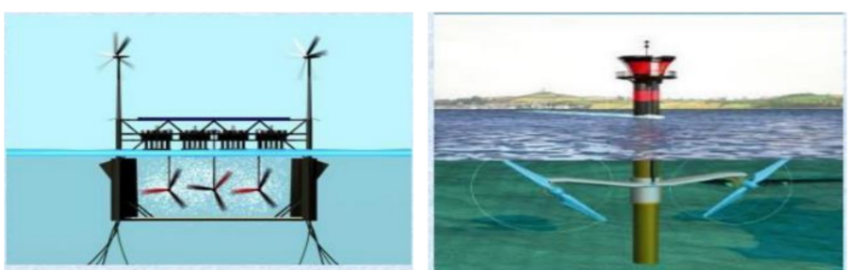


Figure 3. Ocean Current Energy

1.1.3 Ocean Thermal Energy

It is a power plant that utilizes the temperature difference between surface sea water and deep-sea water, with a minimum temperature difference reaching 20 ^{0} C [16].

1.1.4 Tidal Energy

It is kinetic energy from utilizing differences in tidal and low tide heights, the working principle is the same as hydroelectric power plants (PLTA) [16].

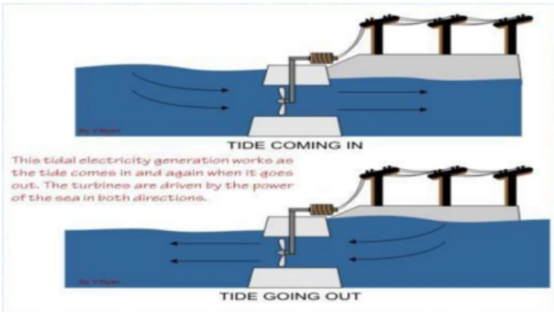


Figure 4. Tidal Energy

1.1.5 Potency

Looking at the geographical conditions of Benoa Harbor according to Figure 5, the potential for implementing green energy from the sea side by utilizing all the energy produced is very possible to be implemented. The indicators for ocean waves, ocean currents, ocean heat and tides have been met by Benoa Harbor, the calculation process in the form of a *feasibility study* must be carried out first.

Figure 5 Application of Green Energy on the Sea Side

 http://dx.doi.org/10.30998/jmil.vxix.xxxx

1.2 Land Side

The application of green energy on the land side has advantages over the sea side, because the implementation process is easier to implement. Below is a further explanation regarding green energy on the land side.

1.2.1 Solar Energy

Currently, solar energy is very popular in society. Indonesia as a tropical country has advantages in utilizing solar energy. To find out how big the potential for solar energy is in Indonesia, you can see the following graph (Figure 6). The graph shows that Denpasar and Gorontalo are the two cities with the highest value, namely 4.1 kWh/kWp. This value is obtained from a comparison of kWh/kWp using SAM software with the assumption that the panel used is the *Polycrystalline type* with a slope angle of 100, total *losses* from the system are 14%, and the average capacity factor is 15.4%. [14].

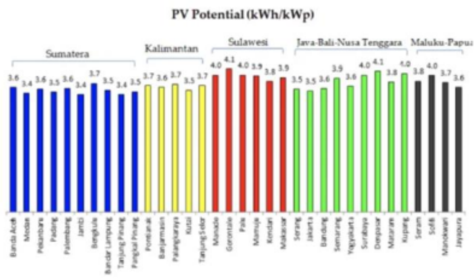


Figure 6. Potential of Solar Panels in Indonesia (kWh/kWp)

Research regarding the potential for solar energy in Bali was also carried out by a research institute called IESR (Institute *for Essential Services Reform)*. The research carried out was by simulating the installation of solar panels on several buildings in Bali. As a result, installing solar panels on 46 government buildings was able to produce 7.8 MWp of energy [17]. If you look at the light intensity in the Bali area of 4.3 - 7.5 kWh/m^{2}, if it is assumed that the *irradiance value* is 6000 W/m ^{2} in the Benoa Harbor area then the *photovoltaic efficiency value* is 10% - 15% obtained for every m ^{2} of PV = 6000 x 10% = 600 W/m^{2}.

The construction of solar panels can be carried out on buildings/rooftops in the Benoa Harbor area, *Solar Ground,* and vehicle parking areas. The current process of loading and unloading and delivering passengers uses conventional vehicles which causes pollution conditions around the port to increase. The following is the scheme for building solar panels in the Benoa Harbor rooftop position and installing solar panels in the solar ground position and parking roof at the logistics center as shown in Figure 7 and Figure 8.

Figure 7. Installation of Solar Panels on the Rooftop

Figure 8. Installation of Solar Ground and Parking Roof at the Logistics Center

The energy produced from solar panels is then stored in batteries. To support green logistics at logistics activity centers such as loading and unloading processes, shipping and passenger movement, electric vehicles can be used. Solar energy-based SPKLU (figure 9) can be built as an electric vehicle charging center.

Figure 9. Solar Energy Based SPKLU [18]

Currently, the use of electric trucks to support short distance *supply chain management processes has been carried out, several electric truck products, namely e-canters from PT.* Krama Yudha Tiga Berlian Motor and Hino Dutro Z EV from PT. Hino Motor Sales Indonesia (figure 10) is very supportive of achieving green logistics because it does not produce exhaust emissions.

Figure 10. ***Electric Truck***

The concept of using electric trucks in short-distance SCM logistics transportation at Benoa Port can be made into a scheme by adopting *Electric Trucks: Keeping Shelves Stocked in a Net Zero World (Australian Trucking Association)* as shown in figure 11.

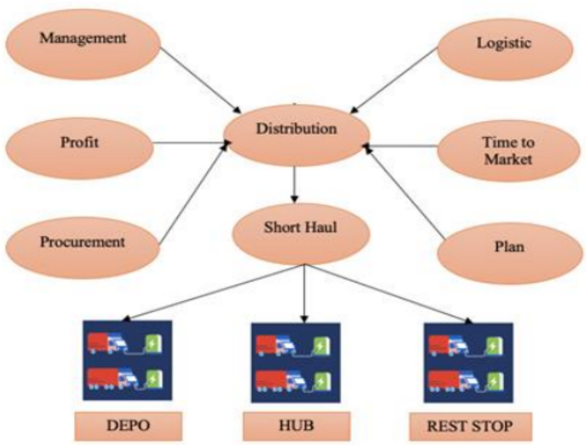


Figure 11. Concept of Using Electric Trucks in Short Distance SCM Logistics Transportation at Benoa Port

1.2.2 Wind Energy

It is a very flexible renewable energy. A wind power plant is a power plant that uses wind as an energy source to produce electrical energy. Wind power plants convert wind power into electrical energy using a wind turbine. A wind turbine is a device that functions to convert kinetic energy into mechanical energy in the form of rotation of the rotor and generator shaft to produce electrical energy. The motion energy originating from the wind will be transmitted into motion force and torque on the generator shaft which then produces electrical energy. A wind turbine is a driving machine whose driving energy comes from the wind. The basic working principle of a wind turbine is to convert wind motion energy into rotational energy in the turbine, then the turbine rotation is used to rotate the generator, which will ultimately produce electricity (figure 12).

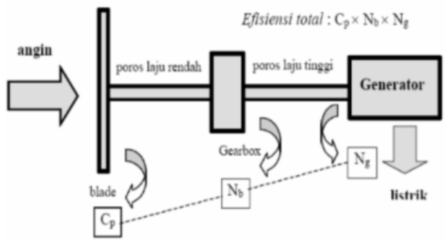


Figure 12. Working principle of a wind turbine

In the Benoa Harbor area the average wind speed is 18 km/h. The characteristics of wind that can be utilized in PLTB are wind that flows laminarly (flows regularly) with a speed of between 4 m/s to 25 m/s, so that the average wind speed is 18 km/h or the same as 5 m/s., PLTB can be implemented. PLTB can be built on the *port side of the area* as shown in Figure 13.

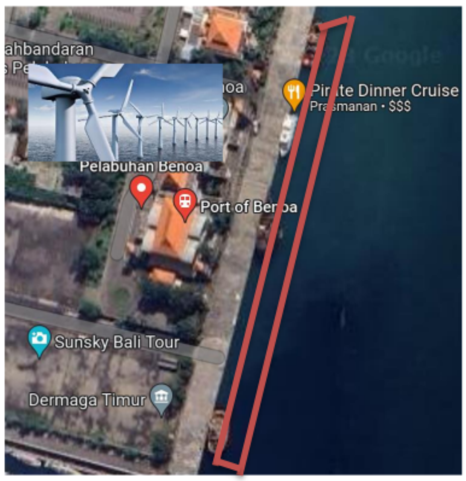


Figure 13. PLTB on *the Port Area Side*

1.2.3 Potency

Looking at the geographical conditions of Benoa Harbor, there is potential for implementing green energy from the land side by utilizing the electrical energy produced to be implemented. The indicators for solar energy and wind energy have been met by Benoa Port, a more in-depth calculation process needs to be carried out to ensure feasibility.

The strategy design that has been presented above will later be submitted to Benoa Port Management as support for the Benoa Port development program, especially in the use of green energy to support the creation of green logistics. The above also supports the results of research conducted by Giovanna et. al 2023 [16]; Giuseppe et. al 2019 [14]; Andrzej Montwiłł 2019 [19]; Ke Du et. al 2019 [20]; Chengying Hua et.al 2019 [21]; Annamaria et.al 2023 [22]; Davide Pivetta et.al 2023 [23], Syahrir, DM [24], Furqon, et.al [25] who have conducted research related to the application of green energy to support green logistics in the port area.

CONCLUSION

The application of green energy in ports is currently a top priority in reducing dependence on conventional energy use. Benoa Port is one of the ports that has enormous potential to apply green energy to support the achievement of green logistics. The strategy for implementing green energy at Benoa Port to support the creation of green logistics is carried out on the sea and land sides. On the sea side by utilizing the energy of ocean waves, ocean currents, ocean heat and tides, on the land side by utilizing solar energy and wind energy, the above strategy as a first step in determining the most feasible green energy can be applied by considering further studies. with the main goal of achieving green logistics.

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