Advanced Engineering Days

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Energy efficiency in ports with a green port perspective: A conceptual framework

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Cite this study: Demir, E., Satır, T., Doğan-Sağlamtimur, N., & Çalışkan, U. Y. (2022). Energy efficiency in ports with a green port perspective: A conceptual framework. 2nd Advanced Engineering Days, 103-106.

Keywords
Green port
Energy efficiency
Sustainable energy
Maritime transportation

Abstract

The importance of ports has continued to increase day by day, because trade can be done faster and efficiently. The fact that the ports are located at such an important point and the increasing transaction volume, and the development of environmentally sensitive systems bring along an inevitable process of change. At this point, with increasing awareness, the concept of green port has been developed. Green port aims (i) to minimize the negative effects on the environment and ecosystem while the ports continue their activities, (ii) to use energy resources efficiently and effectively while meeting energy needs and having the least impact on the ecosystem. The equipment that maintains port operations, port equipment and ships berthing in the port are energy-consuming elements. The aim of this study is to analyze the energy efficiency in ports with a green port perspective by using the literature review method. In this context, the energy efficiency practices of two of the leading ports in Europe were examined. As a result, because of the qualitative analysis, it has been determined that the studies of the ports for energy efficiency have reached an important point and an approach compatible with the green port principles has been exhibited.

Introduction

With the consequences of climate change and increasing awareness, the concepts of decarbonization and energy efficiency, which have become more popular in recent years, make green transformation a necessity in ports. To express the concept of "green port" in the literature, green transformation in ports is addressed. It is a policy to include environmentally friendly methods in the port's activities and operations, thus increasing efficiency and minimizing the negative effects on the environment and ecosystem [1]. The term green harbor was first announced at the United Nations (UN) climate conference in 2009, in other words, at the Copenhagen summit (COP15). At the conference, the importance and necessity of reducing emissions originating from ports and ships was emphasized [2]. In this context, it is seen that energy efficiency and green port principles and policies in ports are directly related. In short, it is possible to say what are the criteria that a port with a green port perspective should consider, as waste management, sustainability, water, air and energy management and sustainable port activities [3]. In the maritime sector, it is stated that the emission generation amount of ports is approximately 3%. Although it can be considered low for the port sector in maritime, it is seen that it is significant when the greenhouse gas (GHG) emission rates are taken into account [4]. If we need to list the motivation and importance of decarbonization studies in ports as following [5]: (i) Compliance with international regulations of International Maritime Organization (IMO) and decarbonisation regulations, (ii) ensuring green port practices and contributing to sustainability in ports, (iii) within the scope of harmonization with the UN sustainable development goals, target 13, climate change mitigation and target 7, implementation of renewable energy use targets, (iv) contributing to the expansion of the corporate social responsibility vision of the ports and achieving cooperation and harmony

with the stakeholders, (v) reducing greenhouse gas emissions from port operations, (vi) contribution to the corporate image of ports with the green port concept and reduction in energy costs.

Decarbonization and Energy Efficiency Applications in Ports

Alternative fuels and their use

It is possible to obtain the energy needs of the equipment used to maintain the activities in the ports from different fuel sources such as liquefied natural gas (LNG), hydrogen, biomethanol and biofuel obtained by recycling wastes and biomass, which are expressed as alternative energy sources. Considering the use of LNG in ports, it is used in port internal operations and activities as well as being used to power the ships in the port [6]. With the use of LNG, a significant decrease in NO_x and SO_2 emissions, and a 25% reduction in CO_2 emissions can be achieved [7]. Hydrogen is not a natural energy source, and other energy sources are needed to ensure its production. At this point, it is important to reach hydrogen energy by choosing and using renewable energy sources [8]. If it is produced through renewable energy sources, it is possible to reduce the amount of greenhouse gas emissions by preferring hydrogen energy in ports. Although the use of biomass and biofuels in ports is very new, special equipment and hardware are required for generation and use these kinds of energy. High investment costs and requiring complex production tools are seen as another difficulty [6].

Renewable energy resources and their use in ports

Renewable energy sources in ports are the general expression of preferred energy production sources due to their positive contribution for reducing greenhouse gas emissions. It is possible to express renewable energy sources as wind, solar, wave and geothermal energy [9]. Solar energy is expressed as the radiant energy emerging from fusion process in the solar core. It is a clean and renewable energy source that can meet the amount of energy needed by the world with approximately 3.9x1026 W of power emitted by the sun. Photovoltaic (PV) solar modules have technology used to convert solar energy to electrical energy [10]. Solar energy is proposed as an energy system used in ports to reduce carbon emissions [11]. Radiation originating from the sun heats the earth at different rates. Due to warming difference, changes occur in the temperature, humidity balance and pressure of the air. All these changes cause air movements and these air movements create winds. Wind energy is the name given to the use of these changes in air movements as energy. Approximately 2% of the solar energy reaching the earth's surface is converted into wind energy. The high initial investment cost for using wind energy as an energy source and the low-capacity factor and the variability of energy production can be expressed as disadvantages. Despite to all these disadvantages, the advantages of wind energy are [12]: (i) Being an environmentally friendly and renewable energy source, (ii) no possibility of extinction or increase in price over time, (iii) low maintenance costs of the system, (iv) its technology is relatively simple to implement and operate, (v) the establishment of the facility in the short term. The oceans, which cover 71% of the world, provide opportunities for wave energy. Wave energy is recognized as one of the most promising methods among renewable energy sources. It is estimated that wave energy produces a maximum of 2000 TWh and at least 1 TWh annually [13]. Geothermal resources have thermal energy stored in trapped steam and water from the Earth's interior [14]. In geothermal energy, the power of heat is used to generate electricity. Antwerp and Hamburg Ports, which are European Union (EU) ports, generate energy from geothermal sources located close to the surface [4]. As GHG emissions cause concerns on a global scale, the interest in renewable energy sources for energy production and transportation sectors is increasing day by day. Promoting and using renewable energy are key factors in tackling climate change [15].

Alternative power systems used in ports

Although the sources of pollution in the ports are very diverse, the ships in the port are responsible for a large part of the air emissions of the ports. The new system that can be used instead of the fuel generators used by the ships for their energy needs during berthing and waiting at the port is expressed as “cold ironing”. It is expressed as the transportation of energy to the ships through the systems installed in the port, instead of meeting the energy needs from the auxiliary engines of the ships waiting at the pier [16]. Cold ironing can be expressed in different ways as land power supply, shore-to-ship power supply and shore-to-shore power supply. Currently, it is seen as the most effective way to reduce emissions from ships waiting in ports. The cold ironing power system basically consists of three parts. These are port power system, port-ship power system and ship power system [17].

It is possible to say that the shore power supply system allows feasibility to be made in the short term and all the necessary components have been available for many years. The biggest obstacle to the usability of the system is incompatibility between port and ship connection points. While it does not pose a problem for ships that follow the same route all the time, it is not suitable for ships operating between ports on different routes. This lack of standardization has been overcome with the standards developed by Institute of Electrical and Electronics

Engineers (IEEE). In addition, the low cost of adapting the system to newly built ships can be considered as an advantage. However, the high initial investment cost of the system in ports is seen as a disadvantage [18].

Use of Renewable Energy in European Ports

Within the scope of the study, two ports operating in Europe were examined. These ports are the Port of Rotterdam located in the Netherlands and the Port of Antwerp operating in Belgium.

Port of Rotterdam

The Port of Rotterdam is the largest port in Europe with a size of 105 square kilometers and 40 kilometers [19]. Due to its hinterland network connected to the Central European region, the Port of Rotterdam hosting approximately 30 thousand ships/year is the busiest port in Europe [20]. It has been observed that the use of wind energy is used quite actively. The Port of Rotterdam can generate wind energy with a power capacity of approximately 200 MW. Increasing the capacity by 150 MW is among the plans of this port. Another renewable energy usage area of the port is biomass. It is planned to provide hydrogen energy with biofuels, which is an important step in reducing emissions. The most important renewable energy work of the port is the generation of hydrogen energy, which is expressed as "green hydrogen", from renewable environmentally friendly energy sources. With this vision, the port continues its projects to realize its 2025 targets. It has also been seen that the port has been very successful in energy production using solar energy [21].

Port of Antwerp

The Port of Antwerp is the second largest port in Europe. It is seen that emissions will be reduced until 2050 and aimed to continue its activities as a more sustainable port. Energy transition studies with a greener port perspective gain importance and actions are taken in this direction. By using solar energy as an energy source in the port, it produces heat, which is expressed as green heat, and uses it for heat processes. Another renewable energy source used by this port is biomass energy. In addition, more than 200 MW of energy can be produced annually with wind energy at the port. Port continues its new projects with its partnerships. One of the most important of these, the 'power-to-methanol' project, aims to reduce its CO_2 emissions by at least 8000 tons. In addition to all these works, the port's work on generating energy with hydrogen continues [22].

Conclusion

With climate change and increasing awareness, it is seen that the use of renewable energy in ports and the transition to alternative fuels are started to be realized by the ports. It is found that the ports are given importance in the transition from carbon-intensive sources to renewable sources, because of their targets of being more sustainable and efficiency in terms of cost. As seen in the ports of Rotterdam and Antwerp, which are the two ports given as examples in this study, it was seen that the use of solar energy is heavily utilized in the transition to renewable resources in the ports. In addition, it is seen that investments are made to meet the energy needs by using wind energy. The replacement of port equipment with electrical energy-operated equipment provides a significant reduction in emissions originating from the port. In this context, all steps taken by ports to reduce fossil fuel emissions are considered important.

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