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A Study on CO_2 Emissions of a Small-Scale Port

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Abstract: The European Green Deal, which was signed in 2021, has adopted a target of achieving a 90% reduction in emissions from European ports by the year 2050. In order to meet this target and comply with international carbon footprint standards, the International Maritime Organization (IMO) has developed a "net zero" strategy, the implementation of which is recommended by ports. In this study, Scope 1 and Scope 2 carbon emissions of Zonguldak Port, one of the important ports in the Western Black Sea, were determined according to fuel, natural gas and electricity data obtained from the port. Furthermore, an evaluation was conducted on the potential differences in carbon emissions that that will be able to occured in case of electrification and alternative fuel use, which are recognised stand out as decarbonisation strategies for ports. The obtained results indicated that 89% of Scope 1 emissions at the Zonguldak Port are attributable to diesel fuel consumption. As calculations, total carbon emission of port have emerged from using 55% diesel fuel, 39% electricity and 6% natural gas. When evaluating the use of different fuel alternatives for CHEs, a ranking of electricity > diesel > LNG was obtained based on $kgCO_2$ emissions. However, this ranking depends entirely on the emission factors used in the calculations. Consequently, the primary source of carbon emissions in relatively small-scale ports such as Zonguldak port is fuel utilised in CHE. In order to plan sustainable decarbonization strategies in ports, port management should have a detailed data inventory on energy supply and use.

Keywords: Carbon footprint; Port emission; Cargo handling equipments; Net zero.

INTRODUCTION

In recent years, in order to reduce greenhouse gas (GHG) emissions, which are the most important cause of climate change, national and international strategies have been developed and many procedures have been prepared for implementation of these strategies. At the United Nations Paris climate change conference held in 2015 with the participation of approximately two hundred countries, an international agreement has been made that set targets to reduce global greenhouse gas emissions. The emission limitations that were agreed to reduce greenhouse gas emissions such as CO_2 and SO_x in this agreement have to establish low-carbon policies and solutions for all types of activities the governments that signed the agreement (Yang et al.2019). As a result of this, all activities with environmental impact and GHG emission potential are expected to produce and implement solutions to achieve environmental sustainability and carbon-neutral targets (InnoEnergy 2022).

Transportation is one of the major activities that cause GHG emissions (Song 2024). A large portion of global trade is carried out by maritime transportation (Elkafas and Seddiek 2024). 80% of global trade volume and 70% of global trade value are carried out through ports, which are the heart of maritime transportation (UNCTD 2023). Ports provide terminal and transfer services for the delivery of cargo coming from inland and to be transferred by sea to ships or for the transportation of products coming to the port by ships to land transfer vehicles and their transportation to inland areas. Ports can be used not only in transportation activities but also as energy platforms that can provide energy production, supply and terminal services (Notteboom et al. 2022). Large ports may involve energy production or import and export, and in this respect, ports can provide energy support to energy-intensive industries. Depending on their place in the energy supply chain, they may be close to energy production sites upstream and close to energy distribution (consumption) markets downstream.

Maritime transport accounts for 3% of global greenhouse gas emissions (UNCTD 2023). 24% of CO_2 emissions (InnoEnergy, 2022) and 13% of CO_{2eq} emissions (IMO 2021; Zhang et al.2017) of global transportation are also generated by maritime transport. According to IMO data, total global shipping emissions in 2012 were 938 million tonnes of CO_2 and GHG 961 million tonnes of CO_{2eq}, with international shipping emissions of 796 million tonnes of CO_2 and 816 million tonnes of CO_{2eq} (Wang et al. 2013). Although sea transport accounts for a large portion of emissions in the maritime sector, emissions from ports are also reasonably significant. So these emissions can cause adverse health effects and environmental problems in coastal settlements in near ports (Notteboom et al. 2022). For this reason, ports also have taken their place among the decarbonisation target strategies in international environmental agreements in recent years. The 2021 EU green deal have been targeted 90% emission reduction for European port cities by 2050. To meet this target, the IMO adopted "net zero" strategy for implementing in ports in 2023. "Net zero" concept refers to a state of equilibrium in which the total amount of GHG in the atmosphere is not increased by human activities (IMO,2021). Within the scope of the IMO net zero target, it is foreseen that international maritime transport emissions will be reduced to relation 2008 CO_2 emissions, 40% of by 2030 and 70% of by 2050 respectively (Song 2024).

Ports that provide coastal services such as loading/unloading, accommodation, fuel or energy support to ships, passenger in/out and customs procedure are one of the vital parts of maritime activities. To be able adopt and implement of ports to the net zero emission strategy has been presented a certification programme referring to "green port". Green ports are ports operated in accordance with strategies that environmental sustainability, low emissions and low energy use. Green port or sustainable port certification is an important quality indicator for modern ports. (Lam and Li 2019). Therefore, all stakeholders operating in the port area should support and cooperate for success of the green port certification studies (Ignaccolo et al.2018).

Within the scope of this study, firstly, literature information about determining the carbon footprint and port emission inventory used in determining the GHG emission potential in ports and developing emission reduction strategies is given. Then, emission calculation method in ports and current alternative approaches regarding decarbonisation are defined. With the help of the information obtained, Zonguldak TTK Port, a small-scale port on the Black Sea coast of Turkey, is defined and emission calculation is made.

CO_2 EMISSIONS IN THE PORTS

The Corporate Carbon Footprint (CFO) defined within the scope of the ISO 14064-1 standard expresses an organization's contribution to global GHG emissions. Emissions that emerged from the organization's are grouped under three scope headings depending on to be or not be under organization control of the emission source (Song 2024);

Scope 1; Direct emissions generated from sources in the under control of the organization

Scope 2; Indirect emissions emerged during production of purchased energy consumed by the organization

Scope 3; All other indirect emissions occurring in the organization's value chains.

Carbon footprint calculation and reporting is an important indicator used in determining the environmental impacts of maritime activities and port operations, as in all organizations, and in creating sustainability strategies (Jalkanen et al. 2016; Carballo et al. 2012).

Carbon footprint calculation limits for port shore and field services should include only emission sources under the control of the port method. Activities under the control of the port management are generally cargo handling services, logistics services, accommodation services for ships arriving at the port. In addition, electricity is used for management offices, lighting, heating and cooling. Emission factors of the identified emission sources can be obtained from open access sources such as IPCC, DEFRA, EPA (GGR 2024; EPA 2025a).

Emission inventory in the port

In regions where the port industry is rapidly developing, it has been observed that air pollutant emissions have increased significantly (Notteboom et al. 2022). A significant portion of the emissions occurring in the port area originate from the auxiliary engines used by ships during their manoeuvres while approaching and leaving the berth at the sea-port interface (Bacalia et al. 2020) and from the auxiliary engines used to provide the energy required to meet the needs of the personnel on the ships waiting at the berth. Such emissions are the responsibility of maritime activities rather than the port operator (Hall 2010). In the port-land interface, there are also emissions generated outside the port area by transportation vehicles and personnel transportation vehicles that take or unload their cargo from the port. However, since these emissions are not directly sourced from the port, they may not be included in the emissions of the port operator (InnoEnergy 2022). Carbon emissions under the responsibility of the port operator mostly consist of direct and indirect carbon emissions originating from fuel or electrical energy consumed during port field services (Yun et al. 2018; Oksaş 2023).

The port capacity, service type (terminal, transit, ro-ro, energy production/distribution etc.), shore and field activities (dock cranes, ship energy support, cargo handling equipment and dock marine vehicles etc.) and the decision-making and control authority (ownership and responsibility) of the port management on emission tools are the factors that should be taken into account in the formation of the emission inventory of port operations. When determining the carbon footprint of ports, emission sources in ports are classified as follows (Table 1) (Song 2024).

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Table 1. Classification of port emission sources according to the scopes specified in the standard (Song 2024)

Port emission sources	Source Description
Scope 1 Direct sources	It refers to all resources like this, all vehicles, buildings, cargo handling equipment, etc. used within the port. In addition, generators, natural gas heating, etc. other processes that cause direct emissions with the consumption of different fuels. All of these must be responsible of the port authority.
Scope 2 Indirect sources	Includes electricity purchased for port authority buildings, charging stations, air conditioners, lighting and all operations that use electricity. Tenants' power and energy purchases are not included.
Scope 3 Other indirect sources	It includes emission sources that are not under the control of the port operator.

If the port emission inventory is determined using the activity-based method and the actual data of the port, more reliable results can be obtained. The success rate of the emission reduction strategies prepared taking account in these results is higher. However, it may not be possible to determine the actual values of some emission data due to port infrastructure or operational problems. In this case, approximate results can be obtained by using literature values related to similar emission sources (substitution method). Although the use of actual data in calculations is the priority, a hybrid calculation method using literature values instead of missing data may also be appropriate. Pollutant emissions can be calculated using [Eq 1] (WPCI 2010).

$$Emissions\left(^{kg\ CO_2}/_{yr}\right) = fuel\left(^{L}/_{yr}\right) or\ energy\left(^{kWh}/_{yr}\right) consumption\ x\ Emission\ Factor \quad [Eq.1]$$

Emission from purchased electricity in the port

As in all businesses, ports are also indirectly responsible for the emissions generated at the place where electricity is produced, due to the electricity purchased. Ports can be use electricity in operational buildings, lighting of open areas, operation or charging of cargo handling equipment, refrigerators, shore supports including cold ironing or charging of ship working by electricity (Holzapfel et al. 2024). ISO standards on product carbon footprint (ISO 14067) state that in addition to direct emissions, all indirect emissions related to electricity production and consumption should also be taken into account (ISO 2006a; ISO 2006b; ISO 2019). The environmental impacts of purchased electricity vary depending on the energy production technology. For example, energy production with renewable energy sources (RES) has a lower environmental impact potential than energy production with fossil fuels (Wernet et al. 2016). Therefore, the emission factor used for GHG calculations of purchased electricity is selected according to the electricity generation technology (EC 2021).

Explanation in the ISO 14064-18 (the Annex E), "emissions from electricity purchased and consumed by the organization shall be measured by the organization using the location-based approach by applying the emission factor that best characterizes the relevant network, i.e. the dedicated transmission line, local, regional or national network average emission factor" (ISO 2006a; WRI 2015). The emission factor of purchased electricity is determined from the average emission data calculated from the last year consumption data of the relevant network. In the calculations, electricity bills and technical specification data of cargo handling equipment (CHE) such as electric dock cranes, field cranes and forklifts can be used (Archana et al. 2020). Annual energy consumption of electric equipment can be calculated by determining its technical specifications and operating hours (Yang et al. 2019; Oksaş 2023). In case detailed information about the equipment cannot be obtained, electricity consumption in the bills other than the energy used for lighting and air conditioning can be attributed to the equipment. In ports that do not have detailed data on annual electricity consumption, emissions from purchased electricity can be determined as a general approach by multiplying the total electricity usage amount of the port by the national electricity grid emission factor (NGEF) [Eq.2] Although definitive results cannot be reached with this calculation, it can be accepted as a preliminary evaluation (Zhang et al. 2017).

$$Purchased\ Electricity\ Emission\left(^{kgCO_{2eq}}/_{yr}\right) = Electricity\ consumption\left(^{kWh}/_{yr}\right) x\ NGEF\left(^{kgCO_{2eq}}/_{kWh}\right) \quad [Eq.2]$$

Emissions from cargo handling equipment

Many CHEs with different technical features such as quay cranes, field cranes, stackers, terminal trucks and forklifts can be used in the coastal services of ports and in the port area (Zhang et al. 2017;20]. CHEs can be electric or can run on gasoline, diesel or an alternative fuel type, CHEs depend on used energy type, can produce more emissions than other emission sources in the port area (Notteboom et al. 2022). It is preferred to calculate its emissions using the technical properties and annual activity data of each CHE in the port to produce sustainable emission minimization strategies. However, since port administrations usually do not registered the necessary data for this calculation method, detailed emission calculations are usually not possible. In this condition, calculations can be made based on fuel consumption to provide a general information about the emission amounts of CHEs in the port. Emission calculations were made using the equations [Eq.3-6] in the IPCC 1996 Guidelines and assuming complete combustion of fuel. The emissions factors has been given as 74,100 kg/TJ of CO_2 for diesel and 56,100 kg/TJ for LNG in the IPCC 2006. CO_2 equivalent (eq) emissions are calculated using global warming potentials (GWP). GWP describes the emission impact that could occur over a 100-year time horizon and is updated periodically with IPCC assessment reports. In this study, GWPs of 27 and 273 were used for CH_4 and N_2O, respectively (GHG, 2024).

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$$E_{CO_2}\,(kgCO_2) = consumed\ fuel\ (TJ)\,x\ emission\ factor\ \left({}^{kgCO_2}/_{TJ}\right) \quad \text{[Eq.3]}$$

$$E_{CH_4}(kgCO_2eq) = consumed\ fuel\ (TJ)x\ emission\ factor\ \left({}^{kg}/_{TJ}\right)x\ GWP\ for\ CH_4 \quad \text{[Eq.4]}$$

$$E_{N_2O}(kgCO_2eq) = consumed\ fuel\ (TJ)x\ emission\ factor\ \left({}^{kg}/_{TJ}\right)x\ GWP\ for\ N_2O \quad \text{[Eq.5]}$$

$$GHG\ emission\ (kgCO_2eq) = E_{CO2} + E_{CH_4} + E_{N_2O} \quad \text{[Eq.6]}$$

DECARBONISATION STRATEGIES IN THE PORTS

There are many solution proposals regarding the reduction of GHG emissions from activities under the responsibility of the port authority (Bierkan and Seter 2019; Iris and Lam 2019; Song 2024). In order to create decarbonisation strategies, port management should have at least one year of highly accurate detailed data on port activities. Only in this way can the contribution of existing each of emission sources to total port emission be determined and their change or renewal in a way that supports emission reduction be planned.

Electrification is a prominent solution proposal in decarbonisation of ports. Firstly, electrification of light duty vehicles and equipment in the port can be implement. If there is an infrastructure including renewable energy sources such as solar energy, wind energy, wave energy in the port area, in this case electrification of equipment requiring high energy can also feasible (Iris and Lam 2019). The majority of cargo handling equipment used in the port uses diesel fuel. In order to reduce fuel-related GHG emissions, low-carbon fuels such as HVO, LNG, lignin, ethanol and hydrogen can be used in cargo handling equipment. This process can involve changing or technically converting equipment (Budiyanto et al.2021: Woo et al. 2018). Another suggestion for emission reduction is energy saving; for example, using high-performance LED lamps for lighting in the port area and buildings, and implementing heating/cooling energy saving policy for offices (Tsai et al. 2018).

Implementing the proposed solutions for decarbonisation (or net zero) in the port area requires significant costs. Therefore, when planning the decarbonisation strategy, the port's energy supply alternatives, infrastructure features and technical and technological change opportunities required for existing equipment should be taken into account. For example; If there are opportunities that will provide renewable energy (wind, wave or solar energy, etc.) within the port, a plan can be made for the electrification of all CHE. Nevertheless, also shouldn't forget that the placement of vehicle charging points within the port for the electrification of CHE require a significant infrastructure investment. In conditions where electrification is not possible or only partially applicable, it may be planned to reduce emissions by using alternative fuels in port vehicles. In this case, technical changes must be made to existing equipment or equipment suitable for the fuel to be used must be purchased.

DETERMINATION OF THE EMISSION INVENTORY OF ZONGULDAK TTK PORT

Zonguldak Port is a located within the borders of Zonguldak province at the northern part of Turkey. This port has an important role in industrial and commercial relations between Türkiye and the other countries bordering the Black Sea (Fig.1). The port, which has connections via railway and road, serves as an entry/exit gate under the responsibility of Zonguldak customs. Port services are provided to Ro-Ro ships carrying vehicles and passengers mostly between Zonguldak and Ukrainian ports, and to cargo ships engaged in cabotage and international transportation. Zonguldak TTK Port also has a strategic importance in the country's economy in terms of providing logistics services to Karabük iron and steel industry, one of Turkey's important industrial enterprises. The port area is 400 000 m^2, of which 90 000 m^2 is effectively used for cargo handling. according to statistical data of 2023, 11 million tons of cargo have handled in the Zonguldak TTK port (Türklim 2024). There are a total of 3 docks in Zonguldak TTK Port where Ro-Ro and Cargo/Freight ships can berth. A large part of the quay is used for coal import and export, which is the most intensive activity of the port. The part of the quay used for coal cargo activities is connected to the railway. Thus coal coming to port can easily transferred to the factory by rail.

It has not been possible to conduct activity-based emission assessment as relation with equipment since cargo handling equipment at the port is rented on an as-needed basis. therefore, GHG emissions was calculated over from consumed energy data in the port. Energy sources in the port are fuel and electricity used for CHEs, electricity and natural gas used in buildings and electricity used for field lighting. Data of fuel, electricity and natural gas bill information was obtained through interviews with the port management (Table 6). Emission factors required for calculating carbon emissions were taken from documents published by IPCC (IPCC 2006) and EPA (EPA 2025).

Table 6. Energy provided for the Port at 2024

Energy sources	Amount consumed	Energy (TJ)*
Electricity (kWh)	523 021	1.883
Diesel fuel (L)	113 216	3.458
Natural gases (m3)	16 145	0.618

*Energy units conversion; 1 kWh=3.6x10^{-6} TJ, diesel 1L=38.3x10^{-6} TJ, Natural gas 1 m^3 = 38,63.10^{-6} TJ

Although it is not possible to reach definitive conclusions with the proposed calculation method, it can be accepted as a preliminary assessment regarding the determination of the problems. Sustainable emission reduction strategies planning for the port depend on determination in detail of data in relation with emissions resources at the ports. Therefore, it is very important that the port administrations record all the necessary records for calculation of emission in a data inventory.

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Figure 1. Zonguldak TTK port (TTK 2025)

RESULTS

CO_2 Emissions from Diesel Fuel and Natural Gas Consumed in the Port (Scope 1)

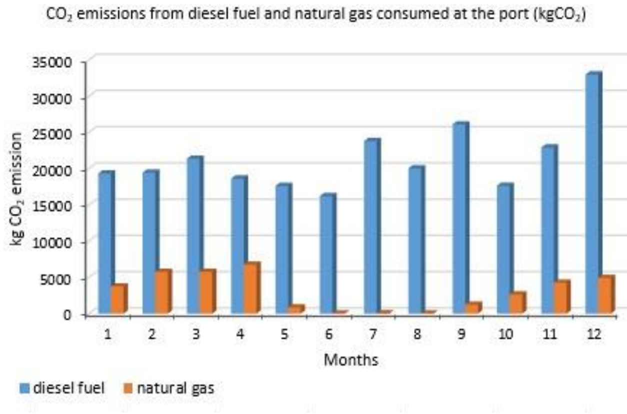
Diesel fuel is used in the most part of CHE's in the Port. As the amount of cargo served at the port increases, the load intensity of the port equipment also increases. As a result of this, the diesel fuel consumed raise at the same rate. According to information received from the Port Authority, diesel fuel is purchased as needed at non-periodic intervals several times a year. Therefore, emission calculations had been made assuming that all fuel purchased between two fuel purchases is consumed. Natural gas is only used for heating purposes at the port. Diesel fuel and natural gas usage data and emission values calculated from equation 5. has presented at Table 7.

Scope 1 emissions in the port are due to diesel fuel used in equipment and natural gas used for heating. Emissions from diesel fuel were calculated as 259288 (88%) $kgCO_2eq$/year, while emissions from natural gas were calculated as 34793 (12%) $kgCO_2eq$/year.

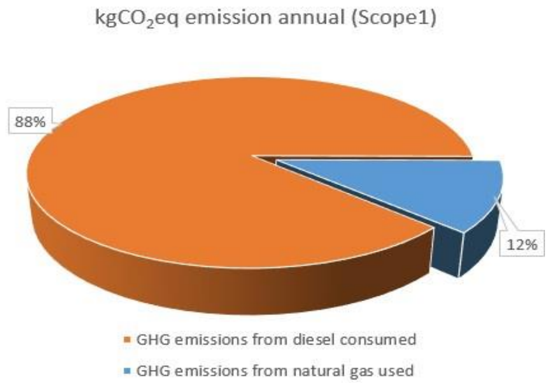
Table 7. The data of natural gas (NG) and diesel fuel consumed in the port and emission values ($kgCO_2$) calculated from these data.

Months	The data of diesel fuel			The data of natural gas (NG)		
	L	TJ	$kgCO_2$	m^3	TJ	$kgCO_2$
Jan.	6818	0,2610	19344	2577	0,0987	5538
Feb.	6860	0,2627	19464	2195	0,0841	4717
Mar.	7533	0,2884	21373	1224	0,0469	2630
Apr.	6572	0,2516	18645	1429	0,0547	3071
May.	6213	0,2379	17627	429	0,0164	922
June	5714	0,2188	16214	11	0,0004	24
July	8393	0,3214	23813	6	0,0002	13
Aug.	7063	0,2704	20040	0	0	0
Sept.	9203	0,3524	26112	350	0,0134	752
Oct.	6216	0,2380	17638	2284	0,0875	4908
Nov.	8080	0,3094	22926	2712	0,1039	5828
Dec.	11633	0,4454	33006	2928	0,1122	6292

Emission Factors; E_{NG}=56 100 $kgCO_2$/TJ, E_{diesel}=74 100 $kgCO_2$/TJ (IPCC2006)



(a)



(b)

Figure 2. Scope 1 emissions from the use of diesel fuel and natural gas in the port; (a) as kg CO_2 emission (b) percentage distribution of kg CO_2 emission from the port in 2024

CO_2 Emissions from Electricity Purchased in the Port (Scope 2)

Electricity purchased at the port is used in buildings, field lighting and electric shore cranes. GHG emissions from electricity consumption at the port had been calculated monthly electricity bill data multiplied by National power grid emission factor (0.44 kg CO_2eq /kWh for Türkiye) (TEUVETN 2024) (Fig.3.).

$$CO_2\ Emissions\ (kg) = Energy(kWh)x\ NGEF\left({}^{kg}/_{kWh}\right) \quad [Eq\ 7.]$$

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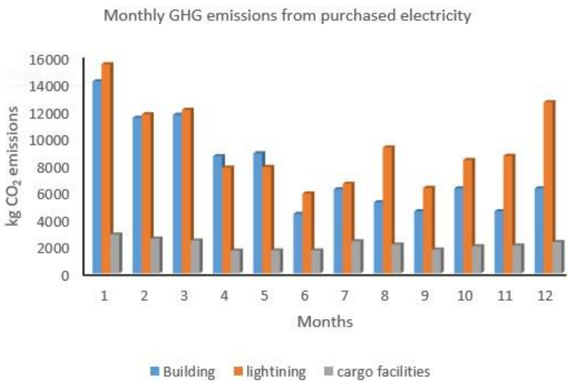
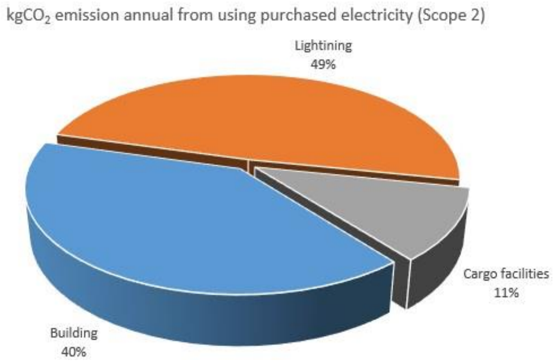


(a)



(b)

Figure 3. a) Monthly GHG emission from purchased electricity, b) Percentage distribution rate of annual emission of purchased electricity according to using aims.

Electricity consumption in the port causes a total of 209669 kgCO_2 emissions as annual. Due to 89% of the electricity consumed in the port is used in buildings and field lighting, electricity consumption is high in the winter months when the days are short.

The Carbon Footprint of the Port

Contribution as percentage of diesel fuel, natural gas and purchased electricity to total CO_2 emission at Zonguldak TTK port has calculated and given in Fig.4.

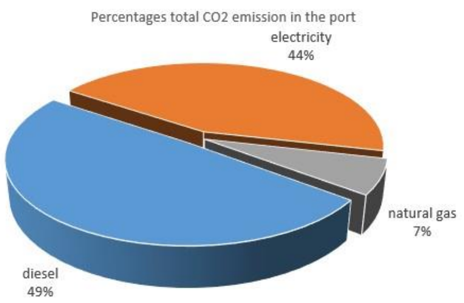


Figure 4. Percentage distribution of CO_2 emissions in the port depend on its sources

The port's CO_2 emissions is consist of diesel fuel used in cargo handling equipment, purchased electricity and natural gas use, its rates are %49, %44 and%7, respectively. According to 2024 data, the total kgCO_2 emissions of Zonguldak TTK port is 521023 kgCO_2. This is a similar result to previous studies (Zhang et al. 2017; Ballaster et al. 2020).

Use of LNG or Electricity Instead of Diesel to Reduce CO_2 Emissions in the Port

Some studies prospect that using liquefied natural gas LNG or electricity instead of diesel fuel in ports may reduce CO_2 emissions (CINEA 2023). In this section, the changes that may occur in CO_2 emissions in case of using LNG or electricity instead of diesel fuel in Zonguldak TTK Port were calculated. LNG (in TJ) and electricity (in kWh) corresponding to the energy of diesel fuel used in the port multiplied with their relevant emission factor as respectively 56100 (IPCC,2006) and 0,44 (TEUVETN, 2024). In this way, kgCO_2 emissions will be able to generate in case using these alternative fuel has been estimated.

When alternative energy sources were used instead of diesel fuel for CHEs in the port, likely changes in kgCO_2 emissions from both only CHEs and total the port were presented in Fig.5.

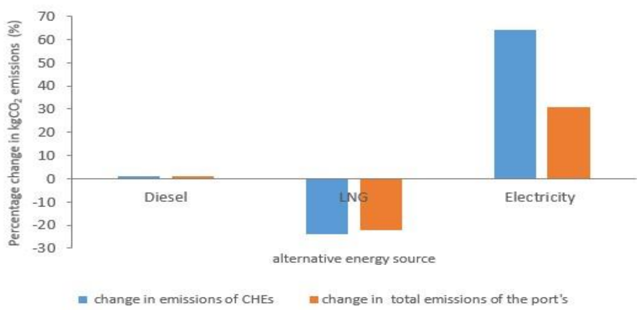


Figure 5. As assumed alternative energy sources were used instead of diesel fuel for CHEs in the port, percentage likely change of compared to diesel fuel use of kgCO_2 emissions from both the port and only CHE's.

The impact of alternative fuel use in motor vehicles on CO_2 emissions depends on numerous factors. In addition to activities such as fuel supply, processing, transportation, and storage, many factors such as fuel density and vehicle technical specifications can affect CO_2 emissions. Therefore, the use of LNG or other fuels in vehicles requires comprehensive research. However, obtaining the necessary data to determine the impact of all factors is quite difficult. In this study, likely CO_2 emissions were calculated for LNG that has energy content equivalent with diesel fuel consumed for CHEs at the port. These calculations indicate that using LNG as a fuel in CHEs could reduce CO_2 emissions from CHEs by 24% and total CO_2 emissions at the port by 22%

Based on this result, while LNG use appears advantageous, there are many more factors to consider before making the

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right decision. Converting or replacing diesel-fueled vehicles with LNG requires high costs. However, because LNG-fueled vehicles can operate for longer periods (CINEA 2023), this cost can be neglected in long-term service. Some studies have shown that using LNG instead of diesel fuel has little effect in reducing CO_2 emissions (SütheÖ) and even causes more emissions than diesel fuel when considering LNG's life cycle (Howarth 2024).

Electrification of port equipment is one of the suggested alternatives for decarbonization of ports (Wang et al. 2023). According to the calculations made by assuming that the energy required for CHEs in Zonguldak TTK Port is provided by the grid electricity, the kgCO_2 emission of the port increases by 31%. The reason for this result is that Turkey's national electricity grid emission factor (0.44 kgCO2/kWh) is high.

Electrification is regardable option for the net zero target in the port when electricity can be obtained from renewable sources at or near the port (Elkafas and Seddiek 2024), otherwise the expected benefits may not be achieved. Implementation of the chosen strategy for reducing CO_2 emissions requires significant infrastructure investments in the port as well as a high cost that includes modification or renewal of CHEs. Therefore, before deciding to use alternative energy sources, the port's opportunities to provide energy with low CO_2 emissions should be evaluated in detail.

Conflict of Interest

There are no conflicts of interest declared by the authors.

CONCLUSION

Large container ports need to produce and implement decarbonization strategies for green port certification, which is an international environmental quality indicator. Therefore, there are generally studies in the literature on large cargo terminals with very high GHG emission values (Zhang et al. 2017; Oksaş 2023). However, small-scale national ports such as Zonguldak TTK port, which do not have a planned capacity increase but continue to operate, do not develop decarbonization strategies to obtain the green port certificate. Therefore, since no renewal and improvement work is carried out in such ports, the amount of CO_2 emissions will not change for many years and may even increase. When the total emissions of many small-scale ports without an emission reduction strategy are taken into account, it can be estimated that they contribute significantly to global carbon emissions.

Since a process targeting economic and environmental sustainability has not been planned in small-scale ports, there are still no regular and detailed data records for calculating the carbon footprint. Therefore, it is not possible to reach carbon footprint results based on the emission source with calculation methods using fuel consumption, natural gas and electricity usage invoice information and to use the obtained data to create decarbonization strategies. Nevertheless, an effective preliminary assessment can be made regarding the emission status and problems in small-scale ports thanks to invoice information (Zhang et al. 2017). It is important for port administrations to record the necessary data in order to clearly determine the emissions originating from ports.

In this study, emissions were calculated by considering the emission sources in Zonguldak TTK port, which is an example of a small-scale port. Results obtained showed how remarkable such ports are within the scope of global carbon footprint reduction strategies. Although it is not preferred to implement comprehensive emission reduction strategies in such small port operations, this study suggested that decarbonization targets should be taken as a basis at least in the purchase-sale, maintenance, replacement and transformation of diesel-fueled vehicles in the port area. In order to plan sustainable decarbonization strategies in ports, port management should have a detailed data inventory on energy supply and use.

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