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EFFECT OF FUEL TYPE ON MARITIME TRANSPORTATION'S POLLUTION: AN EEOI APPLICATION

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Abstract

The globalizing world naturally causes an increase in transportation activities. Reasons such as technological developments, increasing demands and globalization bring acceleration in transportation and production activities. With the increase in the use of vehicles and machinery, there is an increase in the damage to the environment, especially due to the use of fossil fuels. The fact that the damage to the environment reaches irreparable levels necessitates taking precautions. Fossil fuels are the main cause of emissions from ships in maritime transport. Reducing the cruising speed of the ship, using the fuel type that causes less emission, increasing energy efficiency, and making a weather-dependent cruise plan are the solutions to reduce emissions. The EEOI method is a calculation method that allows ships that are currently on their way to work more efficiently while giving less damage to the environment. In this study, the CO_2 emissions of 30 ships are calculated with the EEOI method and compared with the fuel types used in the ships. In the study, it is seen that the preferred fuel type for ships is directly related to carbon emissions. It is recommended that new studies be renewed for different ship types in order to contribute to science.

Keywords ***:*** *Maritime Transportation, EEOI, Fuel Types, Green Logistics, Sustainability.*

JEL Classification ***:*** *Q56.*

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DENİZYOLU TAŞIMACILIĞINDA YAKIT TÜRÜNÜN KİRLİLİĞE ETKİSİ: EEIO UYGULAMASI

Öz

Küreselleşen dünya taşımacılık faaliyetlerinin de doğal olarak artmasına neden olmaktadır. Teknolojik gelişmeler, taleplerin artması, küreselleşme gibi nedenler taşımacılık ve üretim faaliyetlerinde hızlanmayı beraberinde getirmektedir. Araç ve makine kullanımının artışıyla beraber özellikle fosil yakıt kullanımından dolayı çevreye verilen zararda da artış görülmektedir. Çevreye verilen zararların telafi edilemeyecek boyutlara ulaşması önlem alınmasını zorunlu kılmaktadır. Denizyolu taşımacılığında gemilerden kaynaklanan emisyonların da ana sebebi fosil yakıtlardır. Geminin seyir hızının düşürülmesi, daha az emisyona sebep olan yakıt türünün kullanılması, enerji verimliliğinin arttırılması, hava durumuna bağlı seyir planının yapılması emisyonların azaltılması için yapılan çözüm önerileridir. EEOI yöntemi; hali hazırda seferlerine devam eden gemilerin çevreye daha az zarar verirken daha verimli çalışmalarını sağlayan bir hesaplama yöntemidir. Bu çalışmada 30 geminin CO_2 salınımı EEOI yöntemi ile hesaplanarak gemilerde kullanılan yakıt türleriyle karşılaştırılmaları yapılmaktadır. Yapılan çalışmada gemiler için tercih edilen yakıt türünün doğrudan karbon salınımı ile ilişkili olduğu görülmektedir. Çalışmanın neticesinde, bilime katkı sağlamak amacı ile yeni çalışmaların farklı gemi türleri için de yenilenmesi önerilmektedir.

Anahtar Kelimeler ***:*** *Denizyolu Taşımacılığı, EEOI, Yakıt Türleri, Yeşil Lojistik, Sürdürülebilirlik.*

JEL Sınıflandırmaları ***:*** *Q56.*

INTRODUCTION

Although the Kiyikoy-Saroz oil pipeline project in the Marmara Region was first accepted by the public in 2002, it later became the target of environmental groups and caused the project to be canceled (TEMA, 2022). The main factor that led to the consideration of the oil pipeline was the environment and human factor. In other words, while trying to protect the environment, the project was canceled due to another environmental issue. Although there were some political issues in the background of the issue, the environmental factor was an important factor in the construction and cancellation of the project. Liquid and gaseous fuels transported by tankers through the Bosphorus posed great dangers several times in the last quarter of the twentieth century and hit the shores. Both human life and aquatic life in the Marmara Sea are under threat. The issue of accidents and management requires intense work with laws and regulations, long-term plans (Kodak & Acarer, 2021). According to 2002 data, at the time of the project, a ship carrying fuel was passing by every 6 minutes on average. Apart from the accidents, there is a serious emission release due to the increased traffic in the strait even in normal traffic.

Transportation is among the sectors with the highest energy consumption needs. Between 1990 and 2016, it is seen that agriculture consumes 4%, non-energy use 7%, industry 32%, Transportation 25%, residential, commercial and institutional 32% energy consumption. Almost 90% of Turkey's energy needs are met from fossil fuels. It is known that the use of renewable energy sources is less than 13% (Republic of Turkey Ministry of Environment and Urbanization, 2018). In this report, which was prepared for Turkey's submission to the United Nations Framework Convention on Climate Change, energy consumption rates according to sectors were explained. It is also stated that there will be legal regulations in July 2022 in the adaptation process according to the Green Deal and the developing sustainability norms (Karatas, 2022).

Table 1. Greenhouse Gas Emissions by Transport Types.

Years	Total	Airway % of Total	Roadway % of Total	Railway % of Total	Seaway % of Total	Others % of Total
1990	100	3,4	91,9	2,7	1,9	0,1
1991	95	4,1	90,7	2,9	2,1	0,2
1992	98	4,2	90,5	2,6	2,4	0,2
1993	119	4,6	90,8	2,3	2,1	0,2
1994	114	5,8	89,5	2,5	2	0,2
1995	126	8,1	87,2	2,3	2,1	0,2
1996	134	8,4	87,2	2,2	1,9	0,3
1997	129	9,3	86,1	2,3	2	0,3
1998	122	10,1	85	2,3	2,2	0,4
1999	128	8,3	87,3	2,1	1,9	0,4
2000	135	8,5	87,3	2	1,7	0,5
2001	135	9,2	86,4	1,6	2,2	0,5
2002	134	6,9	88,5	1,7	2,3	0,6
2003	140	7,2	88,2	1,7	2,4	0,6
2004	156	11,6	83,5	1,5	2,9	0,6
2005	156	9,7	84,5	1,8	3,1	0,9
2006	168	9,9	84,5	1,7	3,2	0,7
2007	193	11,6	83,8	0,9	3,1	0,6
2008	179	10,8	84,2	1	3,2	0,7
2009	178	10,7	83,9	1	3,4	0,9
2010	168	6,3	88	1,1	3,7	0,9
2011	176	7,1	86,3	1,1	4,7	0,8
2012	232	6	90,01	0,8	2,6	0,6
2013	255	5,5	91,3	0,7	1,7	0,8
2014	273	5,6	91	0,8	1,8	0,8
2015	281	5,5	91,4	0,6	1,5	0,9
2016	303	5,2	92,4	0,5	1,2	0,8

Derivated from (TUİK, 2021)

When the comparative table is examined according to the transportation types; Although emissions tend to decrease in some years between 1990 and 2010, they generally continue to increase. Between 2010 and 2016, it is seen that the emission figures increased much more than other periods. It is also seen that the greenhouse gas emission is mostly caused by the highway in all years. In recent years, there has been an increase in greenhouse gas emissions from airlines. The increase in air transport remains much lower than the increase in road transport. Highway transports; It causes a large part of greenhouse gas emissions in the transportation sector. While maritime transport caused less emissions than rail transport until the beginning of the 2000's, an increase has been observed in emissions since 2001. It is seen that this increase is related to the fact that maritime transport is being used more intensively all over the world. Due to the frequency of preference in maritime transport, it causes environmental damage. In this study, emissions from ships and the issue of reducing emissions are examined.

I. EMISSIONS RELATED TO MARITIME TRANSPORTATION: LITERATURE REVIEW

In Turkey, as in the world, the increasing economic volume and the maritime transport related to it follow an increasing trend towards polluting nature (Küçük & Topçu, 2012). The resulting pollution threatens not only marine life, but also human health (Aygül & Baştuğ, 2020). In maritime transport, many factors such as in-port activities, ship activities, ship accidents cause environmental damage. Emissions from ships are mainly listed as carbon dioxide, nitrogen oxides, sulfur oxides, particulate substances, hydrocarbon, and carbon monoxide.

I.I. Carbon Dioxide (CO_2)

The carbon cycle does not cause environmental damage by completing its cycle in the processes in which it occurs naturally. In the world, especially after the industrial revolution, carbon dioxide formation has accelerated with the human factor apart from the natural cycle. Fossil fuels needed in

industrialization significantly increase carbon dioxide emissions. This increase causes the greenhouse effect and causes global warming. Since carbon emissions are higher than other emissions, it is known as the most harmful gas that causes the greenhouse effect. Today, the use of fossil fuels at high rates, especially in the transportation sector, causes carbon emissions to not decrease and is one of the reasons why the greenhouse effect cannot be stopped (Bıyık & Civelekoğlu, 2018). In this sense, all kinds of studies that can contribute to the reduction of current emissions seem to be worthwhile.

I.II. Nitrogen Oxides (NO_x)

Nitrogen oxides and nitrogen dioxides are among the harmful gases released by the combustion of nitrogen. It is known that there is approximately 80% nitrogen in the atmosphere, and it is a type of gas that has a large impact on environmental damage. It prolongs the residence time of carbon dioxide in the atmosphere (Özet & Büyükakıncı, 2020). NO_x component is known as the common name of all N_2O_2, NO_2 and NO molecules. It is known that it does not affect human health in the short term. In addition to having no effect in the short term, the accumulation of nitrogen oxides in the long term can cause permanent damage to the lungs, causing respiratory diseases and environmental damage. As in other types of transportation, the preferred engine types in maritime transportation reach high temperatures, causing nitrogen and oxygen to react and cause harmful gases (Haşimoğlu, İçingür, Öğüt, 2002). Nitrogen concentration is seen at high rates especially in areas where industrial activities take place.

I.III. Sulfur Oxides (SO_x)

Sulfur oxides are another type of harmful gas caused by fossil fuels. This type of gas, which is released by combustion, is released from the types of oil used in the engine and the sulfur in the fuels (Uyumaz, Boz, Yılmaz, Solmaz, Polat, 2017). Aygül and Baştuğ (2020) draw attention to the fact that ships cause almost 4% of the sulfur oxides caused by fossil fuels in their research. Sulfur oxides remaining in the atmosphere for approximately one and a half months cause environmental damage. The development and expansion of industries are highly effective in the release of this harmful gas. Sulfur oxides, which can hold in air for more than 1 month, can also react with water at the end of this period. As a result of mixing of water droplets in the clouds with NO_x harmful gases, it causes acidic rains. Acid rain also directly threatens human health. Increasing rates of respiratory diseases, especially in port cities, are also directly related to sulfur oxides. With the increase in industrialization, there is an increase in sulfur oxides.

I.IV. Particulate Substances (PS)

Particulate Subtances refers to solid and liquid substances that can remain in the air and are harmful to the environment. These items are; It is caused by fossil fuels and especially coal, which is still used frequently today. The high rates of coal use with the industrial revolution cause an increase in environmental damage. Coal use; Although it decreases with the widespread use of natural gas, especially in domestic use, it is still used today due to the cost advantage in terms of price performance (Çelik & Kırmacı, 2011). Particulate Substances, which is generally released due to the use of coal, harms the environment. Serious sanctions to be implemented by the competent authorities in this regard are of great importance for the protection of the planet.

I.V. HydroCarbon (HC)

As a hydrocarbon, methane is the general name of compounds such as natural gas. It is not a toxic gas by itself. It is released due to engine use and mixes with the atmosphere. The reaction of hydrocarbons mixed with the atmosphere with nitrogen oxides causes air pollution (Kelen, 2014). This compound, which causes fog, harms living things.

I.VI. Carbon Monoxide (CO)

Even though carbon monoxide gas is released for reasons such as forest fires, most of the carbon monoxide in the atmosphere is caused by vehicles. Carbon in fuels; If it does not have enough oxygen, it can be released by not burning enough (Zencirci & Işıklı, 2017). Carbon monoxide is found in urban areas with high vehicle density.

I.VII. Greenhouse (Gases) Effect

Gases such as carbon dioxide, methane gas, ozone, water vapor cause the greenhouse effect. Carbon dioxide is known as the gas that causes the most greenhouse effect because it keeps the heat in the atmosphere for a longer time. The condensation of the gases that cause the greenhouse effect in the atmosphere, especially with the industrialization and the increase in the use of fossil fuels, causes the heat to be retained and the world to warm up more than it should. The increase in temperature in the world causes climate crises (Özmen, 2009). Sea transportation is frequently preferred in global trade. Reasons such as volume size and low unit transportation costs play an important role in the preference of maritime transportation. In their research, Efecan and Gürgen (2019) mention that maritime transport constitutes more than 2% of the factors causing the greenhouse effect in the early 2010s, and that in case the world trade increases with the same acceleration, the greenhouse gases caused by maritime transport are expected to increase by two times. Table 2 lists the top 15 countries that cause the most carbon dioxide emissions in 2018.

Table 2. Countries by CO_2 Emissions (2018 in Metric Gigatons)

Rank Country	Total CO2 Emissions
1- China	10.06
2- America	5,41
3- India	2,65
4- Russia	1,71
5- Japan	1,16
6- Germany	0,75
7- Iran	0,72
8- South Korea	0,65
9- Saudi Arabia	0,62
10- Endonesia	0,61
11- Canada	0,56
12- Mexico	0,47
13- South Africa	0,46
14- Brasil	0,45
15- Turkiye	0,42

Reference: (Union of Concerned Scientists, 2020).

II. REDUCING EMISSIONS IN MARITIME TRANSPORTATION

Maritime transport, which constitutes a large part of world trade; As the preference density increases, methods such as speed increase, route change, volume increase are preferred in order to increase the activities and respond to the demand. Both the increase in demand and the methods used while responding to the demand cause an increase in emissions (Aygül & Baştuğ, 2020). The increase in emissions causes environmental damage. Due to the increase in emissions, the negative effects of ships on human health, air pollution and water pollution are revealed.

Air and water pollution directly or indirectly threatens human health. It is known that emissions originating from ships cause air pollution primarily due to gases. It is known that all processes require energy due to the use of machinery and energy is mostly provided by the use of fossil fuels. The use of fossil fuels is among the main causes of air pollution. When examining how human health is affected by air pollution, attention is drawn to the increase in respiratory tract diseases. In this sense, it is known to cause bronchitis, asthma and even lung cancer. In addition to respiratory diseases, emissions can also cause cardiovascular diseases and these diseases directly threaten human life. Emissions from ships directly damage all kinds of environments where water transport is carried out, such as the sea and ocean. These emissions cause water pollution. This pollution harms living things in their natural environment and indirectly threatens human health (Kruse, Santis, Eaton, Billings, 2018). When considered in general, all processes of maritime transport, such as the navigation of ships, the handling of materials, port activities, can cause air pollution.

When the green solutions in the literature for reducing emissions from ships are examined, it is seen that several frequently used solution methods are used. The most preferred of these solution methods is to reduce the cruising speed of the ships. Other frequently used solution methods are; preference of new fuel types, making a cruise plan depending on the weather conditions, and increasing energy efficiency. In this section, the green solution methods used in maritime transportation will be examined.

II.I. Reducing the Speed of Ship

The need for rapid trade, resulting from the imbalance of supply and demand in international trade, directly affects maritime transport, which is the most preferred mode of transport in the world. In line with the demands of world trade, transportation is expected to be carried out as soon as possible. In particular, the type and type of the material subject to transport are effective in terms of speed. On the other hand, the need to make more profit causes businesses to turn to economic methods. This orientation is one of the reasons for reducing the speed of maritime transport. It is known that one of the biggest cost items in terms of logistics enterprises is the fuels used in logistics vehicles. In maritime transport, on the other hand, as the speed increases, the resistance rate of the water will increase, so the need for energy also increases. Increasing energy demand creates more costs. The reduced energy requirement as a result of low-speed travel is directly effective in the reduction of CO_2 emissions (Topaloğlu, 2013). Reducing the speed causes a decrease in the resistance and a decrease in the energy requirement.

Sert and Bilgili (2019) draw attention to the fact that the demand intensity is high in their studies and that it may not be possible for businesses that continue their transportation activities on a scheduled basis to prefer speed reduction methods in line with customer satisfaction. In line with the study, it is mentioned that reducing the speed of transportation such as container transportation will also decrease customer satisfaction. Attention is drawn to the applicability of scheduled ships such as container transportation, as well as dry cargo ships that are less frequent and unscheduled and have lower costs. Reducing the cruising speed of the ship not only provides cost advantages to the enterprises, but also causes a decrease in CO_2 emissions as a natural return. Situations such as legal obligations and popular culture giving more importance to environmental issues cause businesses to give importance to this area, especially in recent years.

II.II. Increasing Energy Productivity

Reducing the need for fossil fuels on ships can also be achieved by increasing energy efficiency. There are some natural factors that negatively affect energy efficiency. One of these factors is adverse conditions caused by weather conditions. Especially unexpected harsh weather conditions increase the wind and wave speed, causing the ship to continue using more energy. In addition to the increase in the need for energy due to natural reasons, research also draws attention to the decrease in energy efficiency due to pollution. Pollutions on the ship; It can be formed by the attachment of living things such as seaweed and mussels to the surface of the ship. At the same time, the type of paint used on the ship, rusting or oxidation of the ship surface are examples of pollution on the ship. Contamination of the

propellers also reduces the energy efficiency of the ship. In case of a decrease in energy efficiency, the ship uses more energy and causes more fossil fuel to be used (Erat, 2014). In the case of increasing energy efficiency, more efficiency can be achieved with less fossil fuel use.

II.III. Planning According to the Weather Forecasting

In terms of weather-based planning, it is aimed to make the most efficient route planning while planning the routes of the ships. Depending on this planning; The weather between the departure and arrival point is examined. Examining the weather does not mean not making a trip in bad weather. Care is taken to ensure that there are weather conditions in which the employees and the ship will not be harmed. As a result of this planning, it is aimed to create the shortest possible route with the best weather conditions (Smart KR, 2013). The absence of short and compelling weather-related situations leads to energy efficiency. Ensuring energy efficiency leads to a decrease in fossil fuel use and a decrease in CO^2 emissions.

II.IV. Fuel Selection

With the realization of the industrial revolution, the increase in the use of machinery naturally causes an increase in the use of fuel. It is known that the damage to the environment increases due to the use of fossil fuels. Even if it is not motorized for the first time in the history of maritime transport; Many situations such as the industrial revolution, the change of consumption habits, the formation of fast consumption habits, and the globalization of the world constitute the necessity of maritime transport to keep up with the period.

The fact that fuels such as coal are cheap and rapid supply processes occur in case of vehicle use provide economic benefits to the parties. In addition to this benefit, the increasing use of fossil fuels also causes irreversible environmental problems. Situations such as the gradual increase of these problems and the endangerment of living things show the necessity of being more careful about the environment. In line with these indicators, businesses resort to alternative fuel use methods with the principles of legal obligation, social responsibility and environmental awareness.

Alternative fuel use; It ensures that the need for fossil fuels is minimized by converting it to electrical assisted methods as in vehicles. Reducing the use of fossil fuels is possible with the use of inexhaustible energy resources. Inexhaustible renewable energy sources; alternative methods such as solar energy, wind energy, wave energy, biomass energy. Even if the systems to be used to benefit from inexhaustible energy resources cause high costs at the beginning, they can provide benefits both environmentally and economically in the long run (Yiğit, 2018). The development of technology and the discovery of new systems provide environmental benefits.

III. STUDY ACCORDING TO THE FUEL TYPES

When studies on the effect of fuels used on ships on emission rates are examined, Winnes & Fridell (2009) compares HFO and MGO (marine gas oil) in their research. In this comparison, two fuel types were used on the same ship. No significant differences were found between the two fuel types, except for SO_x emissions. In the study of Topaloğlu (2013), in which emissions from ships are examined, CO_2 emission is emphasized, and the speed reduction method is used. Calculations are made with the EEDI calculation method. As a result of the speed reduction method, the speed reduction technique is not very efficient due to the generally low speed capacities of the bulk carriers; In general, it is determined that high tonnage ships release less CO_2 together with the speed reduction technique. Kılıç (2009) uses commercial ships in the Marmara Region to calculate emissions from ships in his study. NO_x, SO_2, CO_2, HC and PS have been calculated by buttom up and top-down methods, and it is seen

that the emission rates in comparison with previous years have increased much more than the increase rate in the number of passing ships.

III.I. Calculations

Research was conducted on 30 ships using the Research (Energy Efficiency Operational Indicator). The main purpose is the monitoring of the change in CO2 emissions in case of changing the fuel type with data from real ships. Fuel types and conversion factors are data provided by IMO. Table 3 shows the conversion coefficients according to the species. Cargo, Ro-Ro and bulk carriers are randomly selected and consist of ships that sail between 01.09.2021 and 30.09.2021.

$$EEOI = \frac{Realized\ CO2\ Emission}{Carrying\ out\ work}$$

$$EEOI = \frac{\sum_j FC_j \times C_{Carbon}}{\sum_j m_{Cargo_j} \times Dj}$$

Table 3. Conversion Coefficients According to the Species

Fuel Type	Reference	Carbon Q	C_F (t-CO_2/t-Fuel)
Diesel/Gas Oil	ISO 8217 Grades DMX through DMC	0.875	3.206000
Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	0.86	3.151040
Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	0.85	3.114400
Liquified Petroleum Gas (LPG)	Propane	0.819	3.000000
	Butane	0.827	3.030000
Liquified Natural Gas (LNG)		0.75	2.750000

Reference: (International Maritime Organization, 2009)

The fuel types used in the ships and the conversion factors used in the EEOI calculations of the fuel types are shown in the table.

III.II. Fuel Types and CO_2 Emission

In the calculations made using the EEOI method, the carbon emissions of the ships according to the fuel types are given in the table. Table 4, 5, and 6 (respectively for Roro, Bulker and Cargo Ships) show the comparison of fuel type and emission values according to the selected ship type.

Table 4. RoRo – Emissions Under Certain Weights for the Same Way - (EEOI multiplied by x100)

Type	Gross Tons	Dead Weight - DWT	Length Height (Meter)	Diesel	LFO	HFO	LPG PROPANE	LPG BUTANE	LNG
Roro1	34.215	15121	223.3 X 26	0,23	0,23	0,23	0,22	0,22	0,20
Roro2	33.960	13439	195,4 X 30,5	0,27	0,26	0,26	0,25	0,25	0,23
Roro3	33.313	24485	195,2 X 30,5	0,04	0,04	0,04	0,03	0,03	0,03
Roro4	33.816	14509	217,77 X 26,51	0,53	0,52	0,52	0,50	0,50	0,46
Roro5	33.652	20731	193,62 X 28	0,20	0,19	0,19	0,19	0,19	0,17
Roro6	33.816	14509	217,6 X 26,51	0,31	0,31	0,30	0,29	0,29	0,27
Roro7	32.841	10770	190,02 X 26,5	1,54	1,52	1,50	1,46	1,46	1,32
Roro8	33.690	13428	195,4 X 30,5	0,29	0,28	0,28	0,27	0,27	0,25
Roro9	25.000	12000	195,2 X 30,5	0,84	0,82	0,81	0,79	0,79	0,72
Roro10	32.843	10773	200,85 X 26,5	1,03	1,02	1,00	0,98	0,98	0,89
Average	**32.715**	**14976,5**		**0,53**	**0,52**	**0,51**	**0,50**	**0,50**	**0,45**

Derivated from (Millet, 2022).

Table 5. Bulker – Emissions Under Certain Weights for the Same Way - (EEOI multiplied by x100)

Type	Gross Tons	Dead Weight - DWT	Length Height (Meter)	DIESEL	LFO	HFO	LPG PROPANE	LPG BUTANE	LNG
Bulker1	204.014	398411	361,9 X 65,06	0,01	0,00	0,00	0,00	0,00	0,00
Bulker2	201.384	400314	360 X 61	0,01	0,01	0,01	0,01	0,01	0,01
Bulker3	195.199	388000	360,97 X 65,06	0,02	0,02	0,02	0,02	0,02	0,02
Bulker4	152.608	300660	340 X 55	0,02	0,02	0,02	0,02	0,02	0,01
Bulker5	151.058	297461	327 X 55	0,01	0,01	0,01	0,01	0,01	0,01
Bulker6	132.537	250877	329,95 X 57	0,01	0,01	0,01	0,01	0,01	0,01
Bulker7	116.396	229126	324,99 X 52.5	0,02	0,02	0,02	0,02	0,02	0,02
Bulker8	109.824	207999	299,87 X 49,05	0,33	0,32	0,32	0,30	0,31	0,28
Bulker9	13.069	1999	139,91 X 24	0,46	0,45	0,44	0,43	0,43	0,39
Bulker10	21.000	34050	200 X 24	0,07	0,07	0,07	0,07	0,07	0,06

Derivated From (Millet, 2022).

Table 6. Cargo – Emissions Under Certain Weights for the Same Way - (EEOI multiplied by x100)

Type	Gross Tons	Dead Weight - DWT	Length Height (Meter)	Diesel	LFO	HFO	LPG PROPANE	LPG BUTANE	LNG
Cargo1	45.320	66347	249,97 X 37,4	0,41	0,41	0,4	0,39	0,39	0,35
Cargo2	45.320	66347	249,97 X 37,4	0,07	0,07	0,07	0,07	0,07	0,06
Cargo3	48.000	55944	249,95 X 37,39	0,37	0,37	0,36	0,35	0,35	0,32
Cargo4	48.960	55937	249,98 X 37,41	0,14	0,13	0,13	0,13	0,13	0,12
Cargo5	47.380	67052	255,1 X 37,3	0,35	0,34	0,34	0,32	0,33	0,30
Cargo6	48.000	57882	254,87 X 37,4	0,23	0,23	0,22	0,21	0,22	0,20
Cargo7	21.300	30580	204,39 X 28,06	0,87	0,86	0,85	0,81	0,82	0,75
Cargo8	21.300	30573	204,44 X 28	0,33	0,32	0,32	0,31	0,31	0,28
Cargo9	20.450	28352	205,5 X 27,4	6,21	6,1	6,03	5,81	5,87	5,32
Cargo10	18.040	29266	194 X 28,2	0,31	0,30	0,30	0,29	0,29	0,26
Average	36.407	48.828		0,93	0,91	0,90	0,87	0,88	0,80

Derivated from (Millet, 2022)

In these calculations, the most advantageous ranking in terms of CO_2 emissions per unit metric distance for a cargo to be transported in the range of 20-25 tons is Bulker, Cargo and RoRo ships, but this situation is based on ship engine volume, technologies, etc. It is seen that it differs with factors such as (Dönmez, 2021). An important detail in this regard is the regular maintenance of ships, and it should be kept in mind that ship maintenance is delayed from time to time due to cost savings, and this can be prevented with control mechanisms to be established. It is clear that the authorized public institutions have serious duties in this regard.

Considering the average values for the selected 30 ships, in the transportation of 1 ton of cargo for a distance of 1 mile;

Diesel → 15,51 (g CO_2/t.miles)

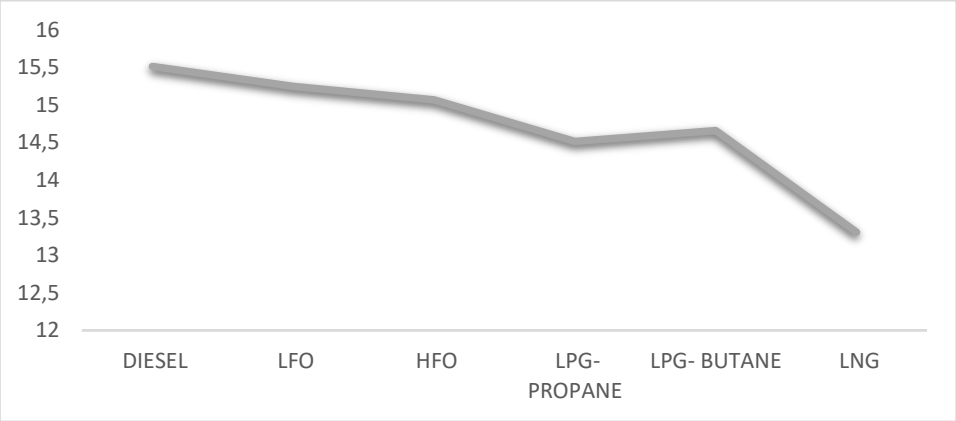
LFO → 15,25 (g CO_2/t.miles)

HFO → 15,07 (g CO_2/t.miles)

LPG-Propane → 15,52 (g CO_2/t.miles)

LPG-Butane →14,66 (g CO_2/t.miles)

LNG → 13,31 (g CO_2/t.miles) emissions have been calculated. Graph 1, gives the relations of the fuel type and CO_2 emissions.



Graph 1. Comparison of CO2 Emissions by Fuel Types

Reference: (Millet, 2022)

When the figure with the total value comparison is examined, it is seen that the lowest CO2 emission is achieved when the LNG fuel type is used. Diesel fuel type is seen as the fuel type that causes the most emissions. The CO2 emission difference between them is seen as 0.004 and 0.018 (g CO2/t.miles). In order to protect our world, which has no alternative, the authorities in this field should take more serious action and increase efforts not to pollute, on the one hand, and strive to clean up pollution on the other hand.

CONCLUSION

With the increase in the world's globalization and technological developments, transportation activities are also increasing. In line with the increase in demand in the world, there is a need to respond faster by using technological developments. The use of machinery in production processes is a necessity, and these tools also bring resource consumption. Although sources with lower carbon emissions such as electric vehicles and electric motors have been used recently, fossil fuel-based production and distribution resources have been used extensively, especially from the industrial revolution to the present. The main reason why the use of fossil fuel, especially coal, is frequently preferred all over the world is the low cost of this fuel and fuels. These fuel types, which provide cost advantages, directly threaten the environment, human and living health since the industrial revolution. Especially in recent years, these losses have increased and reached irreversible dimensions, making it necessary for countries, companies and people to take precautions.

Although maritime transport causes less emissions compared to other modes of transport, the fact that most of the world trade is carried out by sea in recent years causes an increase in emissions and therefore the damage to the environment. This increase in maritime transport may be due to in-port activities and ships. It directly threatens air, water and living life. In ports, harmful gases are released due to the use of vehicles and machinery. Emissions from ships can be released by the use of machinery, and causes such as ship accidents can harm the environment. Emissions from ships can be listed as CO_2, NO_x, SO_x, PS, HC, CO.

Some studies are carried out to prevent emissions from ships. Some of these studies are reducing the cruise speed of the ship, choosing the fuel type that causes less emission, finding ways to increase energy efficiency, and making a cruise planning based on weather conditions.

Data from 30 ships were used in this study. Of these, 10 are Ro-Ro ships, 10 are cargo ships and 10 are bulk carriers. It has been randomly selected from the one-month voyages of the ships dated September 2021. In the study, CO_2 emissions of 30 ships were investigated by using the EEOI method. In the study, it is seen that the choice of fuel has a direct effect on carbon emissions. It has been observed that the ships cause direct carbon emissions according to the fuel type, regardless of their gross tonnage and cruising distances.

Serious measures must be taken to slow down as much as possible the destruction of our planet, which we have borrowed from future generations. Every sector and institution should take much more action in this regard and be willing to do more than their part so that the future can be brighter. It should not be forgotten that none of us can be as good as all of us and all nations should cooperate and work in a serious synergy in this regard.

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