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Energy and Operating Costs of Methanol Fuel on A 4000 DWT Oil Chemical Tanker

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ABSTRACT

The International Maritime Organization (IMO) has introduced regulations that the shipping industry must reduce Greenhouse Gas Emissions by at least 50% by 2050 compared to 2008. At the same time, the IMO predicts that global shipping emissions will increase by 250% by 2050. Therefore, the Shipping Industry must fix this problem by reducing carbon emissions. Methanol Fuel is an alternative fuel for ships that is cost-effective, low-emission, environmentally friendly, and renewable. Methanol can reduce SOx emissions by up to 99%, NOx emissions by up to 60%, and Special Particulates by up to 95%. The purpose of this study is to make adjustments to the methanol-fueled main engine, calculate energy, operating costs, main engine retrofit prices, and return periods on the Oil Chemical Tanker 4000 DWT ship with the method of Round-Trip Shipping with Route Variations, Composition, and Fuel Prices. From the discussion of this study, it can be concluded that the calculation of energy and operating costs of Heavy Fuel Oil (HFO) and methanol is influenced by the amount of fuel used during the voyage, in addition to the results of the calculation of energy, operating costs, and retrofit prices on the Oil Chemical Tanker 4000 DWT (Deadweight Tonnage) ship with a voyage on the American route of 3,467,320 MJ, Rp. 1,565,684,341.-, and a 2.4-year return period, the European route of 3,137,099 MJ, Rp. 1,352,844,897.-, and 2.8 years of return period, and Asia Pacific routes of 3,274,914 MJ, Rp. 1,069,629,506.-, and 3.5 years of return period, as well as the price of the main engine retrofit, which reached Rp. 7,574,435,035.-. These findings offer valuable insights for shipping companies to make informed decisions about fuel selection and retrofit investments, potentially leading to significant cost savings and a reduced environmental footprint. Furthermore, the study provides a strategic foundation for complying with IMO regulations and achieving long-term sustainability goals in the maritime industry.

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INTRODUCTION

Over the past five years, governments around the world, environmental groups and the IMO have been working to minimize harmful emissions such as sulfur oxides (SOx), nitrogen oxides (NOx), carbon dioxide (CO2) and other special particulates that can cause the greenhouse effect and can cause global warming in accordance with some IMO regulations. Harmful emissions emitted by marine transportation, such as nitrogen oxides (NOx), sulfur oxides (SO_2) (Zannis et al. 2022), and carbon dioxide (CO2), contribute to acid rainfall as well as negatively impact the health and marine ecosystems. Diesel is a fuel that is known to produce higher levels of harmful emissions compared to other fuels such as gasoline. In the maritime sector, efforts to reduce harmful gas emissions are by applying emission reduction methods such as using low-VOC paints, using equipment without harmful gas emissions for heating and drying processes, and considering the use of fuels with lower nitrogen content (Elishav et al. 2020) (Agarwal & Rauthan 2019) (Cui et al. 2024).

The International Maritime Organization (IMO) has published guidelines for ships to reduce emissions, such as MARPOL Annex VI and *Energy Efficiency Design Index* (EEDI), which regulates emission levels. MARPOL Annex VI regulations 13 and 14 cover sulfur oxide (SOx) and nitrogen oxide (NOx) emissions using the concept of emission control areas (ECAs). From the perspective of emissions regulations, ships must control sulfur oxide (SOx) and nitrogen oxide (NOx) levels and prohibit the emission of ozone-depleting substances (DPS). Therefore, once a ship enters the emission control area, its emission level must be in accordance with the limits set by the IMO. Despite all the efforts that have been made, ocean transportation still produces about 940 million tons of CO2 annually, accounting for about 2.5% of total global greenhouse gas emissions (Zhang et al. 2024).

Currently, many ships use *heavy fuel oil (*HFO), especially large ships such as containers and tankers. This is because HFO provides high energy efficiency with low operating costs. It is undeniable that *heavy fuel oil* (HFO) is one of the petroleum fractions that has a very complex structure. Its history shows that HFO has long been used as an economical fuel source (Schüppel & Gräbner 2024). However, HFO has poor emission quality because it contains high sulfur content and other dirty particles, which leads to the emission of sulfur oxide (SOx), nitrogen oxides (NOx), and other particles that have a negative impact on human health and the environment. HFO combustion is a challenge due to its high viscosity and the presence of high molecular weight components. This causes combustion efficiency to decrease and increases the emission of various pollutants such as CO, CO2, NOx, SOx, and hydrocarbons (HC) (Shahnazari et al. 2023). This condition encourages the Shipping Industry to convert conventional fuels (HFO or MDO) into fuels that provide better emission results. In addition to the emission factor, another factor that encourages shipping to replace fuel is the availability of fuel in the world that has begun to run out. To overcome the problems associated with the direct combustion of HFO, the oil can be converted into syngas through the gasification process (Yin et al. 2022; AlAbbad et al. 2024). An example of syngas itself is Methanol.

Methanol is a safe and cost-effective alternative fuel. With the increasing demand for cleaner ship fuels, Methanol is a promising alternative fuel for ships as it can help the shipping industry meet increasingly stringent emissions regulations. According to (Liu et al. 2024), Methanol has high combustion efficiency, low viscosity, is easy to decompose, and produces clean emissions. The use of methanol is more advantageous than fossil fuels due to its lower pollution emissions (Tian et al. 2022). This is one of the promising solutions where methanol can be used as a fuel because it is an easily available raw material and produces less pollution than fossil fuels which can significantly reduce the emission of sulfur oxide (SOx), nitrogen oxides (NOx) and other particles. reported that currently Methanol is produced with natural gas feedstocks, but can be produced from very large feedstocks such as coal, biomass and most interestingly from CO(Rachow, Loest, & Bramastha, 2018)$_2$. If future technologies can make Methanol from CO2 more effective, it will make the world more sustainable because CO2 is one of the main causes of global warming. In comparison, if the Maritime Industry is likened to a country, then this Industry will be a contributor to CO(Methanex, 2023)$_{2,}$ the 6th largest (after Brazil and Germany). Until now, Methanol Research continues to be carried out to determine the impact on ships and their shipping lanes. (Balcombe, et al., 2019).

Research by (Bayraktar, Yuksel & Pamik 2023) regarding the impact of ship diesel engines on the environment and the economy. It is concluded that machines that use methanol can reduce carbon dioxide (CO_2) emissions, and economically, it can be estimated that the Energy Return Period (PBP) can be reduced to 4.44 years for a scenario similar to the possible development of methanol production and distribution technologies by 2050. This is because Methanol, also known as CH3OH, has a high octane level, a fast combustion rate, is soluble in water, and provides a clean, sulfur-free combustion (Chen 2021). Methanol itself is a type of material that is easy to store on ships. Methanol can be liquid at room temperature and pressure and can be stored easily on a vessel using a conventional fuel tank with little adjustment (Zincir & Deniz 2021). In addition to the impact of methanol on ships, it also has an impact on shipping routes. According to, there are three options for the article *Methanol bunkering* for OCT Vessels with a ship speed of 13.5 knots on American, European, and Asia-Pacific routes. According to the ship's route, methanol facilities to choose from are in Trinidad (Americas), Egypt (Europe), and Japan (Asia Pacific). The large amount of methanol traded on the Americas, Europe, and Asia-Pacific routes in metric tons is experiencing a growing demand for methanol every year. This can result in an increase in the amount of state revenue from methanol production. Methanol has proven to be a technically adequate option, and there are no major obstacles visible in its supply chain. While there are several current economic headwinds, the potential can be addressed by increasing environmental targets for the shipping industry

(Methanex, 2023)(*Methanol Institute*, 2023)(Svanberg et al., 2018). There is a research gap in previous research where there has been no case study of Oil Chemical Tanker ships whose fuel will be converted using methanol for shipping in the Americas, Europe, and Asia Pacific.

The purpose of this study is to analyze Methanol energy, fuel energy consumption, operating costs, retrofit prices, and payback periods on the 4000 DWT Oil Chemical Tanker Ship. This study offers a novel approach by focusing on the integration of Methanol as an alternative fuel in maritime operations, addressing the gap in current research regarding its economic feasibility and environmental impact for medium-sized vessels. By providing detailed cost-benefit analysis and long-term operational projections, this research contributes to the development of more sustainable shipping practices and informs policymaking in maritime fuel alternatives.

METHODS

Methanol is a clear, colorless liquid that is soluble in water and can decompose naturally. Methanol, also known as methyl alcohol, is the simplest type of alcohol, coming in the form of a colorless clear liquid with a distinctive aroma and as one of the most beneficial chemical compounds (Dalena et al. 2018). Table 1 shows the details of the properties and characteristics of Methanol.

Table 1. Methanol Characteristics

Molecular Weight	32.04 g/mol
Density Energy	19.7 kJ/kg
Carbon Content (Natural Gas)	37.49
Sulfur Content	0
Specific Gravity (20/20 ºC)	0.7910 – 0793
Freezing point	-97.8 ºC
Boiling point	64.6 ºC
Flash Point (Closed State, 1 atm.)	12 ºC
Critical Temperature	239.4 ºC
Critical Pressure	80.48 bar
Adiabatic Flame Temperature (1 bar)	1980 ºC
Combustion Temperature	450 ºC
Explosive Limits in Air	6 % - 36 %
Solubility: Methanol in Water/Water in Methanol	100 % / 100 %
Octane Value	109
Cetane Value	< 5
HFO Equivalent Volume	2.54 times
Density	798 kg/m3

Energy calculation refers to the process of measuring energy consumption or production in various systems. The calculation method used involves comparing the energy produced by HFO (Marine Fuel Oil) and MGO (Marine Gas Oil) fuels during normal operation with the energy required in dual fuel operations, i.e., Methanol and MGO. Therefore, the total energy generated by the ship during normal operation can be calculated by the following formula:

$$E = C\ x\ NCV \quad (1)$$

Where E is Energy [MJoule], C is Fuel Consumption [ton], and NCV is the Net Calorific Value in [MJoule/Ton].

From the previous calculation, it is necessary to calculate the amount of fuel that needs to be carried by the ship for one round trip voyage on a certain route. It is expressed in units of mass (tons). To accommodate the fuel in the tank, it needs to be converted to volume units (m^3). Therefore, the amount of mass must be converted to volume (m^3) using the following formula:

$$V = \frac{C}{\rho} \quad (2)$$

Where, V is the volume [m^3], C is the fuel

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consumption/fuel mass [tons], and ρ is the fuel density [tons/m³].

The total cost incurred to obtain the fuel used by a system or engine is the consumption of fuel costs. In a power generation operation, the biggest cost incurred is the cost of fuel consumption. Factors influencing the increase in fuel consumption include increased water load and displacement, propeller design, hull roughness, and worse weather conditions. Cost consumption can be calculated using the following formula:

$$FC = (C + 5\%) \cdot FP \quad (3)$$

Where FC is the cost of fuel [rupiah], C is the fuel consumption/fuel mass [ton], and FP is the fuel price [rupiah per ton].

The Payback Period is the time it takes to recover the capital of the cost of retrofitting the ship's main engine from the use of conventional fuel to methanol fuel. Variations in fuel consumption at various engine load levels (from 50% maximum to 85% minimum) can reduce the payback period from 6 years to 4 years, according to the LCCA (Taghavifar & Perera 2023). The Payback Period can be calculated with the formula, as follows:

$$Payback\ Period = \frac{Initial\ Investment}{Net\ Cash\ Flow} \quad (4)$$

Where the initial investment is the total cost of retrofitting the main engine [rupiah] and the net cash flow is the total cost of double fuel [rupiah].

To calculate energy and operating costs on the Ship *Oil Chemical Tanker* 4000 DWT. Data is needed to plan the ship's fuel. This ship does not yet exist and is still in the process of design. . The data in question is data on the main size of the ship, the specifications of the ship's auxiliary engines, and the general arrangement of the ship contained in tables 2 - 4 and figure 1 (Rachow, Loest, & Bramastha, 2018)

Relying on secondary data may present limitations, such as outdated or incomplete information and potential biases that may not align with the specific conditions of the 4000 DWT Oil Chemical Tanker. Future validation approaches could involve primary data collection through real-world testing or simulations, as well as comparative studies using multiple fuel types in various operational contexts to strengthen the findings.

Table 2. Vessel main size data

Ship name	Doris Tanker	Units
Type	Oil Chemical Tanker	
LWL	102.96	m
LPP	99	m
Beam	15.8	m
Depth	8.4	m
Draft	6.336	m
Cb	0.62	
Vs	13.5	Knots
Voyage Endurance	± 5	Push
GT	3352	
DWT	4000	DWT
Payload	3880.7	Ton

Table 3. Main machine specifications

Specification	Details	Units
Type	MAN B&W 7S26MC6	
Power	2800	Kw
Velocity	250	Rpm
SFOCHFO	179	g/kWh
SFOCMeOH	260.9	g/kWh
SFOCMGO	8.95	g/kWh
Quantity	1	Piece

Table 4. Specification of auxiliary machine

Specifications	Detail	Units
Type	MAN 6L16/24	
Power	660	Kw
Gen. Power	627	Kw

Velocity	1200	Rpm
SFOCMGO	195	g/kWh

Quantity	2	Piece

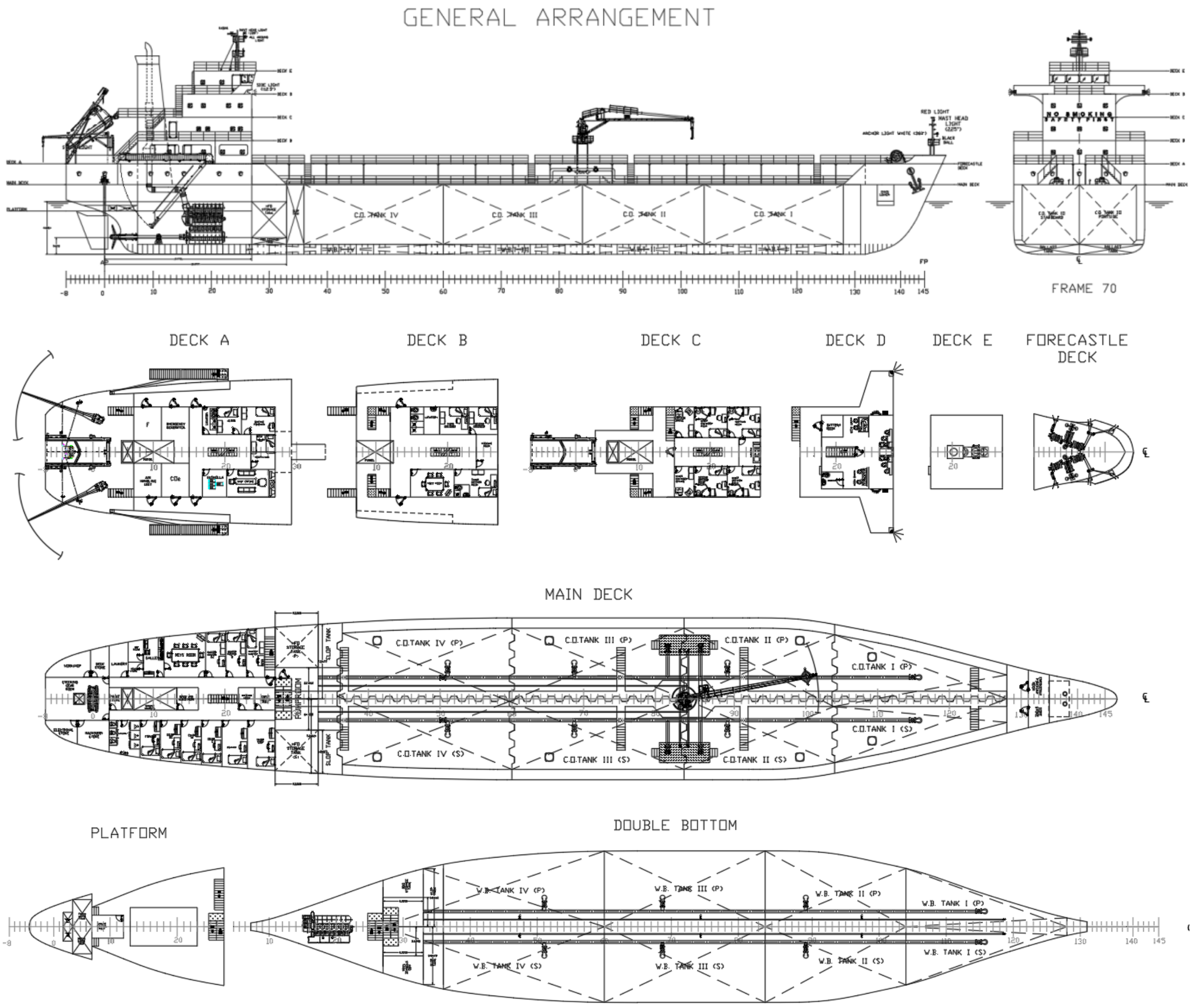

Fig 1. General arrangement Oil Chemical Tanker

RESULTS AND DISCUSSION

Methanol will replace the fuel for OCT Vessels. This calculation still uses the same round trip and the same mode of operation on all routes. Therefore, methanol must cover all the energy produced by the previous fuels, HFO and MGO.

Figures 2, 3, and 4. show graphical images of Methanol and MGO Energy calculations on the North American route, graphical images of Methanol and MGO energy calculations on the European route, and graphical images of Methanol and MGO energy calculations on the Asia Pacific route.

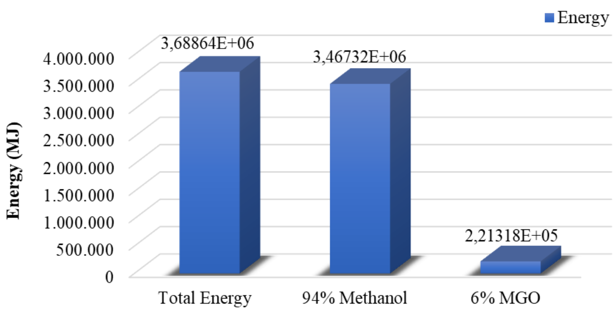

Figure 2. Energy calculation chart of Methanol and

MGO (North America)

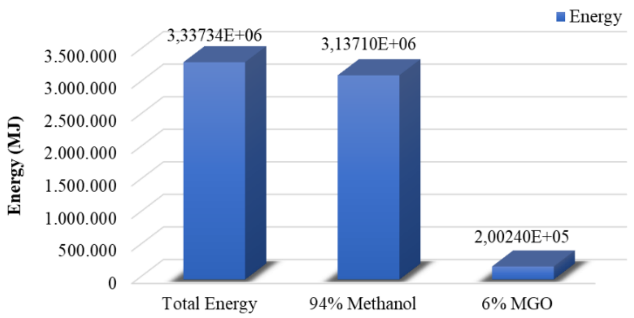

Fig 3. Energy calculation chart of Methanol and MGO (Europe)

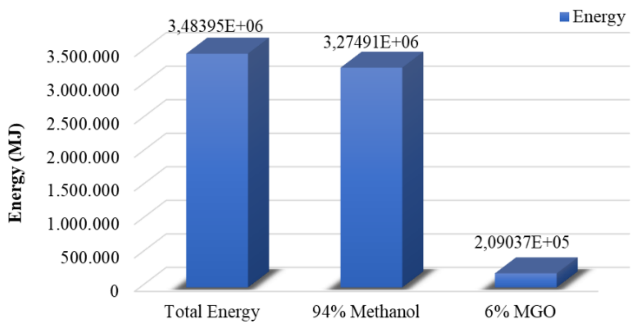

Fig 4. Energy calculation chart of Methanol and MGO (Asia-Pacific)

Since methanol is a low cetane number fuel and requires pilot fuel for ignition, pilot fuel should be injected at cycle TDC, and Methanol will be injected on the ongoing combustion of pilot fuel. The amount of pilot fuel is 5 - 8% of the blended fuel (Methanol Institute, 2023). In this calculation, the amount of pilot fuel taken is 6%. Therefore, methanol covers 94% of the energy, and the remaining 6% is covered by pilot fuel.

From the fuel consumption calculations, it can be concluded that to produce the same amount of energy required for a round trip cruise of the American route, the OCT ship requires 173.37 tons of methanol and 5.18 tons of MGO. As for the round-trip voyage of the European route, the OCT ship requires 156.85 tons of methanol and 4.69 tons of MGO. For round-trip voyages on Asia Pacific routes, OCT ships require 163.75 tons of methanol and 4.90 tons of MGO. This indicates that the weight of fuel in the dual-fuel operating mode is almost 2 - 3 times greater than the normal operating mode.

The HFO tank used to store HFO in the normal operating mode will be converted into a methanol tank. This is done because methanol does not require a special tank to store it, but with a note: if the tank capacity of the ship filled with methanol is not enough, the capacity of the methanol tank. At the same time, the MGO tank will remain filled with MGO in dual-fuel operation mode.

In dual-fuel mode operation, the vessel will be operated using Methanol and MGO as fuel. The fuel consumption of methanol spent on the American route is 173.37 tons, and MGO is 5.18 tons. On the European route of 156.85 tons and MGO of 4.69 tons. And on the Asia Pacific route of 163.75 tons and MGO of 4.9 tons. Similar to the normal operating mode, there is some safe margin of fuel availability in the amount of 5% in the bunkering process.

According to the round trip America route, the OCT Vessel is sailing from Trinidad towards the USA, and the planned ports for methanol bunkering are at *Port of Lisas*, Trinidad, and at *Georgia Ports Authority*, USA. The *Georgia Ports Authority* port is the closest destination port and already has Methanol bunkering facilities on the Trinidad - United States journey with Methanol production locations in Trinidad (American Continent).

While on the return trip on the European route, the OCT Ship sailed from Egypt to Spain, and the planned ports for bunkering methanol are at *Damietta Port Authority*, Egypt, and at the *Port of Barcelona*, Spain. *Port of Barcelona* is the closest destination port and already has Methanol bunkering facilities on the Egypt - Spain trip with

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Methanol production locations in Egypt (African Continent).

The last leg of the Asia Pacific route, the OCT, sailed from Hong Kong to Japan, and the planned ports for methanol bunkering were at *Container Terminal West*, Hong Kong, and at *Kanazawa Port*, Japan. *Kanazawa Port* is the closest destination port and already has Methanol bunkering facilities on the Hong Kong - Japan voyage with a Methanol production site in New Zealand (Australian Continent) as the *Methanex* production site in Asia is only in New Zealand. The Hong Kong section only has the *Methanex* Official Office, not the Methanol production site. Methanol prices differ greatly in the Americas, Europe, and Asia Pacific. Therefore, there will be some comparisons on fuel costs when bunkering in Trinidad and the USA (Americas), Egypt and Spain (Europe), and Hong Kong & Japan (Asia). For MGO prices, refer to the average global MGO price (Iqbal, 2017).

The summary cost comparison of normal operation and dual fuel mode for each trip going to the American route is IDR 782,419,233 compared to IDR 1,565,684,341. While the cost comparison on the European route is IDR 707,903,115 to IDR 1,352,844,897. The cost comparison on the Asia Pacific route is IDR 738,951,498 to IDR 1,069,629,506. In dual fuel mode, fuel costs are 1.7 - 2 times greater than in normal operating mode.

In normal operating mode, the OCT Vessel spends IDR 782,419,233 for bunkering HFO and MGO for the voyage going to the American route. On the European route, in normal operating mode, the OCT Ship spent IDR 707,903,115. And on the Asia Pacific route, in normal operating mode, the OCT Ship costs IDR 738,951,498. While in dual fuel mode, for the American route, the OCT Ship spends IDR 1,565,684,341 if bunkering methanol in the Americas. On the European route, in dual fuel operating mode, the OCT ship spent IDR 1,352,844,897. And on the Asia Pacific route, in dual-fuel operation mode, the OCT ship costs IDR 1,069,629,506.

It can be stated that the fuel cost in the dual-fuel operating mode is 2.1 times greater than the normal operating mode on the American route. On the European route, the dual fuel cost is 1.91 times greater than the normal operating mode. And on the Asia Pacific route, the dual fuel cost is 1.45 times greater than the normal operating mode.

Figure 5. shows a comparison chart of the total cost of Methanol and HFO on the North American, European, and Asia Pacific routes.

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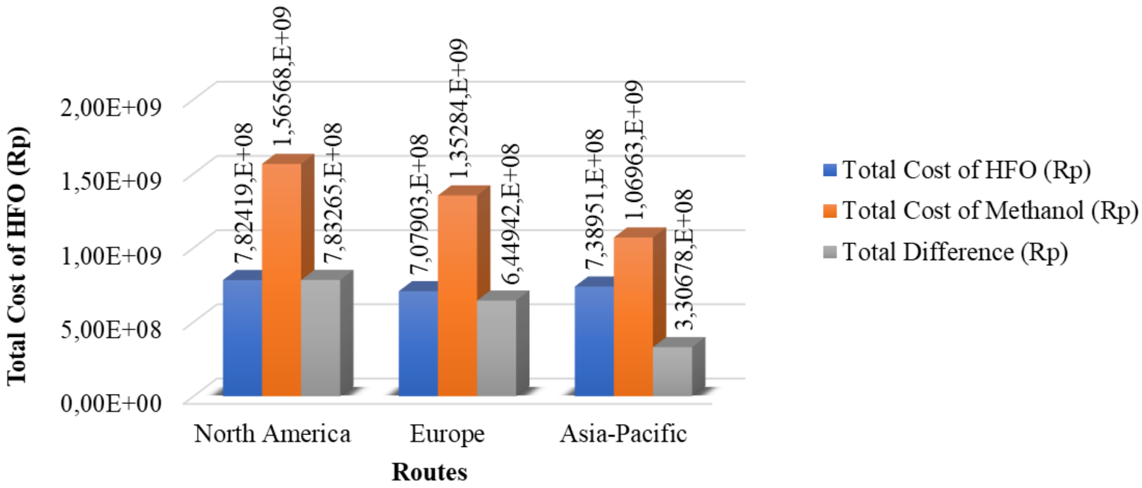

Figure 5. Comparison chart of total cost of Methanol and HFO for each route

The fuel cost comparison above is a simulation of the 4000 DWT Oil Chemical Tanker voyage based on the location of Methanex Production Sites and bunkering Facilities available at several points in the world. The route selection chosen is in the Americas, Europe, and Asia Pacific. It should be emphasized that this cost comparison refers to the fuel cost in May 2023. Fuel costs may be higher or lower on subsequent trips due to fluctuations in fuel prices (HFO, MGO, and Methanol).

The available retrofit cost data comes from the conversion of the 24-MW ro-pax ferry Stena Germanica. The conversion cost for the engines is IDR 212,182,100,000, and the total project cost is IDR 359,077,400,000. Includes onshore methanol storage and methanol bunkering infrastructure. The retrofit of the Stena Germanica and associated infrastructure requires new technical solutions, safety assessments, and adaptation of rules and regulations. Costs are expected to be lower in the next retrofit project, it has been estimated that the next retrofit costs will be 30 - 40% significantly lower for the Stena Germanica conversion (FCBI Energy, 2015).

Other retrofit cost data comes from the conversion of a 6.5 MW Sleipnir vessel. This vessel was studied by Heerema on retrofitting Sleipnir for methanol, with a total CAPEX investment cost of IDR 104,805,512,240, resulting in an OPEX estimate of IDR 3,362 per kWh over 25 lifetime periods. The overall system has an on-board efficiency of 43%. A total of 4,100 m^3 of liquid methanol under ambient pressure must be stored to meet the operational profile requirements for the hotel load. Sleipnir has approximately 8,000 m^3 of storage space for LNG and 11,000 m^3 for MGO (Sustainable Ships, 2023).

According to the *Energy FCBI* Methanol as a Vessel Fuel Report, the cost of retrofitting engines from diesel fuel to dual fuel (methanol and diesel) is estimated at IDR 4,080,425 - 5,712,595/kW for large engines (10 - 25 MW). MAN has also converted an engine with 10 MW, and the resulting conversion cost was IDR 4,406,859.

According to *Sustainable Ships*, with the title *The State of Methanol as Marine Fuel 2023* (Sustainable Ships, 2023), said that the cost of retrofitting engines from diesel fuel to dual fuel (methanol and diesel) is estimated at IDR 8,739,167.33 for the *Stena Germanica* ship engine (24 MW), IDR 10,480,551.22 for the *Sleipnir* ship engine (6.5 MW), and IDR 4,401,831.51 for the *Newbuild Example* ship engine (10 MW).

Although the cost is given for every kW, it may not apply to larger engine sizes as additional installations are required inside the vessel. Therefore, there is a limit to the size of vessels that can be converted cost-effectively (FCBI Energy, 2015).

The OCT vessel is planned to have 1 set of main engines (MAN B&W S26MC6 2,800 kW) and 2 sets of MAN 6L16/24 Generators of 660 kW each. The engines will be converted to methanol-fueled engines. In terms of main engine power, the OCT has a relatively small main engine (2.8 MW). Estimates from *FCBI Energy*, MAN, and *Sustainable Ships* apply to the OCT Ship. In this study, the retrofit cost is defined by assuming that the retrofit cost and engine size correlation is using the Regression Method, which uses the Linear method. The estimated cost of retrofitting the main engine of the OCT Ship is IDR 662,841. 64/kW. The main engine power of the OCT ship is 2,800 kW, so the total retrofit cost for the main engine of the 4000 DWT Oil Chemical Tanker ship is ± IDR 1,855,953,791.98. This cost does not include the cost of retrofitting auxiliary engines.

The OCT vessel has 2 MAN 6L16/24 generator sets of 660 kW each. According to MAN's retrofit cost estimate, the cost is IDR 4,332,182.76/kW. The total retrofit cost for the 2 generators on the OCT Ship is ± IDR 5,718,481,243.2. The overall total estimated methanol retrofit cost for the OCT Ship is ± IDR 7,574,435,035.18. According to the IMO (*International Maritime Organization*) 2016 book *entitled Methanol As Marine Fuel: Environmental Benefits, Technology Readiness, And Economic Feasibility* (IMO, 2016), IMO conducted a payback period scenario on the use of methanol fuel on newbuilding ships and retrofitted ships.

IMO exemplifies the ship used as a ro-ro ship with a main engine of 24,000 kW and tank capacity for a 3-day voyage. The scenario of this Ro-Ro ship, if built new, will reach a total of IDR 83,777,349,969, and if retrofitted, it will cost a total of IDR 157,082,531,193. Then, the calculation for the payback period is based on the assumption of time spent in the Emission Control Area as part of the entire sailing time and the corresponding fuel consumption. The more fuel the vessel consumes in the Emission Control Area, the greater the opportunity to save money by purchasing cheaper fuel.

Two MGO price scenarios were used to estimate payback times for methanol fuel systems versus switching to MGO. The high price scenario assumes a price close to the mid-2014 Rotterdam MGO price (IDR 9,688,000/ton). The low price scenario assumes the MGO price is close to the mid-2015 Rotterdam MGO price (IDR 5,850,000/ton). A payback time calculation of choosing HFO with a scrubber versus a fuel switch to MGO is also performed for comparison.

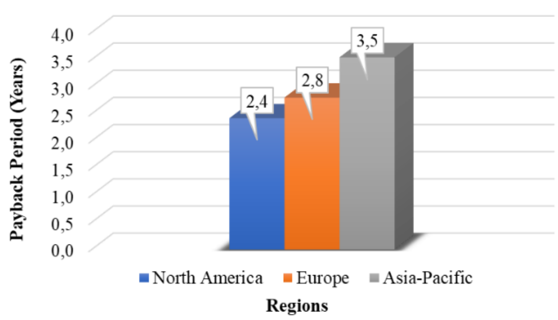

Fig 6. Payback period chart of main engine retrofit cost of *Oil Chemical Tanker* ship 4000 DWT

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Figure 6 shows a graph of the payback period of the main engine retrofit cost on the 4000 DWT Oil Chemical Tanker. Therefore, currently, the price of methanol in the Americas and Europe is more expensive than HFO globally. Whereas Methanol prices in Asia Pacific and Global are lower than MGO globally. So the fuel cost in dual fuel operation is greater than normal operation on the American and European routes. But not necessarily greater on Asia Pacific routes. The longer payback period in the Asia-Pacific region may be due to higher retrofit costs or lower operational cost savings compared to North America and Europe. Although methanol prices in Asia-Pacific are generally lower than MGO, other economic factors such as financing, subsidies, and port infrastructure could also influence the overall payback period.

Returning to the summary of fuel cost results on Normal Operations and Dual fuel Operations shows that there are no cost savings on all routes that have been simulated. The comparison of HFO and Methanol fuel costs is 1.7 - 2 times greater than Normal Operation.

However, according to the reference from the IMO book, the payback period can be realized with the combination of high MGO prices as it is today. Judging from Figure X, it shows that the simulated payback period of the 4000 DWT Oil Chemical Tanker is a good result under 3 - 4 years, referring to the IMO book.

Another way to get income and achieve a payback period for OCT Vessels is from chartering vessels, round trips with different routes, or someone buying OCT vessels at a price higher than the Retrofit Cost and the cost of traveling all Routes, which is estimated to touch the figure of ± IDR 10,000,000,000.

Revenue from chartering or travel cannot be calculated because there is no complete data planning on operational expenses for ships such as crew costs, port fees, insurance on ships, classification and maintenance bureau fees, purchase of goods on board, use of consumable materials, partial change of seawater tanks to MGO tanks, this 4000 DWT Oil Chemical Tanker ship has not been built and has not yet operated, and others because there is no journal with complete calculations.

CONCLUSION

The results of the analysis of energy and operating costs of HFO and methanol on the 4000 DWT Oil Chemical Tanker are as follows: (i) The HFO energy required for the voyage of the America, Europe, and Asia Pacific routes is 2,778,653 MJ, 2,514,019 MJ, and 2,624,400 MJ, respectively, (ii) The methanol energy required for the voyage of the America, Europe, and Asia Pacific routes is 3,467,320 MJ, 3,137,099 MJ, and 3,274,914 MJ, respectively, (iii) The total operating costs with HFO and MGO fuels for the America, Europe, and Asia Pacific routes are IDR. 782,419,233, IDR 707,903,115, and IDR 738,951,498, (iv) Total operating costs with methanol and MGO fuels for the Americas, Europe, and Asia Pacific routes are IDR 1,565,684,341, IDR 1,352,844,897, and IDR 1,069,629,506, (v) Total retrofit costs for Oil Chemical Tanker 4000 DWT vessels are IDR 7,574,435,035, and (vi) The payback period of retrofit cost and methanol fuel operating cost is 2.4 years for American route, 2.8 years for European route, and 3.5 years for Asia Pacific route.

The energy calculation results of HFO and methanol are based on and influenced by the energy density according to the characteristics of these compounds, their NCV (Net Calorific

Value) values, and the amount of fuel used during the voyage. The results of the calculation of HFO and methanol operating costs are based on and influenced by the amount of fuel used during the voyage, fuel price fluctuations, global fuel availability, and other costs associated with operations, such as crew costs, maintenance costs, and so on. The calculation of the payback period of the retrofit cost is influenced by the total retrofit cost divided by the total cost of the trip using methanol.

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