International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 12, December-2016

Conversion Cost for the Diversion from Fuel Oil to Fuel Gas in Pioneer Ships

Farianto Fachruddin
Departement of Naval Architecture,
Engineering Faculty, Hasanuddin University
Makassar, Indonesia

Daeng Paroka
Departement of Naval Architecture,
Engineering Faculty, Hasanuddin University
Makassar, Indonesia

Syamsul Asri
Departement of Naval Architecture,
Engineering Faculty, Hasanuddin University
Makassar, Indonesia

Mohammad Rizal Firmansyah
Departement of Naval Architecture,
Engineering Faculty, Hasanuddin University
Makassar, Indonesia

***Abstract*—Sea transport plays significant role in the sea transportation sector. But some problems still prevent the operationalization of this sector to be efficient. One of the important problems is the increasing fuel oil cost which must be spent by the Indonesian government to subsidize the sea transportation for this sector. Implementation policy is needed for energy diversification to reduce the dependency on fuel oil by using an alternative efficient fuel. The use of fuel gas is one solution for energy diversification. This paper describes the result of a research on the cost analysis of fuel conversion from fuel oil to fuel gas on some pioneering ships. It shows that the conversion cost for pioneer ship is Rp. 10,270,000 per Ship Dead Weight Ton (DWT) or equal to Rp. 7,500,000 per ship main engine Horse Power (HP). The more ship main engine power and ship capacity, the more component and installation cost for fuel conversion will be. Some important factors need to be considered when implementing the ship fuel conversion are the fuel storage for fuel gas require more spaces in the ship compare to fuel oil. At the same time, the investment for fuel gas refilling installation is more expensive than fuel oil.**

Keywords—Pioneer ship, fuel conversion

I. INTRODUCTION

As the biggest archipelago country in the world as well as its location between two continents and two oceans, sea transport becomes a significant factor in Indonesian sea transportation sector. Regardless of the importance, some problems still exist to prevent the efficient operationalization in this sector.

One of the important problems is the increasing fuel oil cost which must be spent by the Indonesian government to subsidize the sea transportation for this sector. Implementation policy is needed for energy diversification to reduce the dependency on fuel oil by using an alternative efficient fuel. The use of gas fuel is one solution for energy diversification. Based on some researches, some advantages can be identified for using fuel gas to replace the fuel oil which are it has showed an efficient energy use as well as it is environmentally friendly and cheaper.

In transportation sector, the use of fuel gas to replace fuel oil has been initiated by the previous Indonesian government in 2012. In this current government, this policy is continued through fisherman welfare program by using fuel gas for saving 70% of fuel oil use. Other policy to support the previous policy includes the low gas pricing policy especially for fisherman boat. For bigger ships, it has been signed an agreement between a country owned gas company and some other shipping companies to use fuel gas for their ships. The use of fuel gas can save 40% of the use of fuel oil (Mulyatno et al., 2013, Prabaswara & Aryawan, 2013). Besides, some country owned ships which are called pioneer ships have been decided to use fuel gas instead of fuel oil as well.

Based on the above description, the discussion in this paper is divided into two steps. First, it justifies the technology for fuel conversion on pioneer ship and the second, the cost of fuel conversion from fuel oil to fuel gas on some pioneering ship is analyzed.

II. LITERATURE REVIEW

A. Potency of Indonesian natural gas

Mineral resources which have been explored and used to fulfill national energy need are still dominated by fuel oil. With the continuous used of these resources, the mineral reserves have been reduced significantly. Therefore, alternative energy resources are being used such as coal and gas. Indonesia has owns plenty of gas reserves. However, it has not been explored in full capacity. Potency of natural gas reserves of Indonesia which spread around the country has reached 170 TSCF with yearly production around 2.87 TSCF. With that composition, Indonesia owns gas reserves to production (R/P) for about 59 years. Besides, unlike fluctuate fuel oil price, natural gas price is more stable. The Indonesian natural gas potency and its production can be seen in Figure 1-4. (ESDM-SKK Migas, 2015).

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 12, December-2016

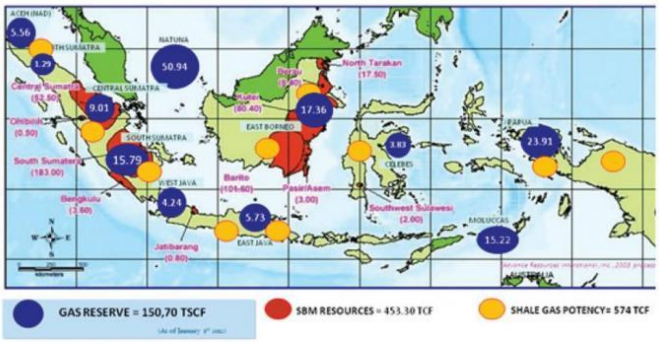

Figure 1. Indonesian gas reserve

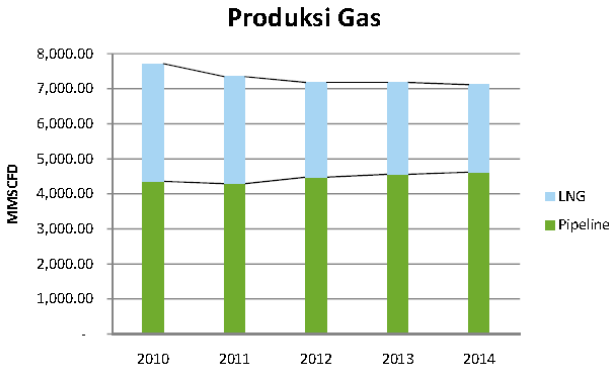

Figure 2. Indonesian gas production

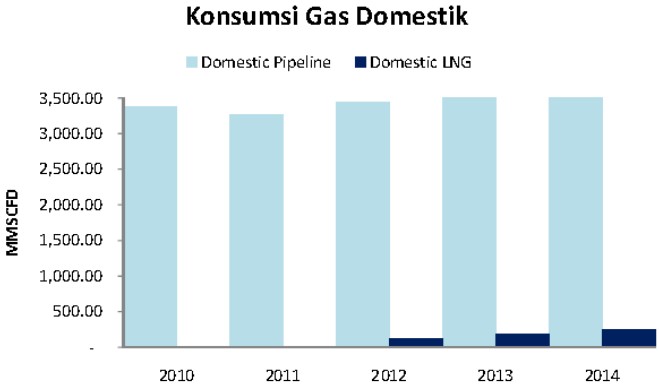

Figure 3. Indonesian domestically gas consumption

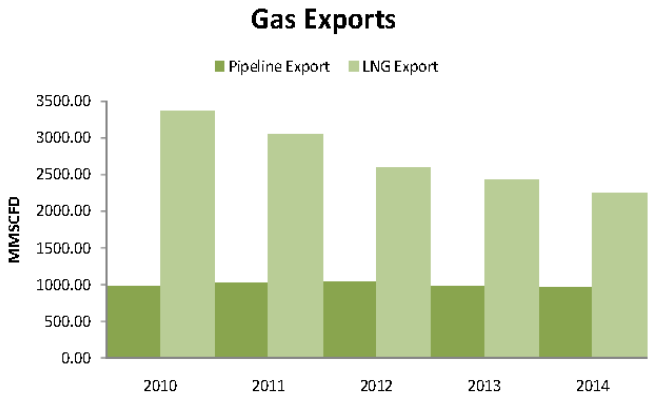

Figure 4. Indonesian gas export

The maximum exploration of Indonesian natural gas reserves is still facing some problems on the supporting tools and equipment. The main problem is in technology for gas handling and storage. It has been estimated that in 2025, the domestic gas need will reach 25% of the total national energy need. The need for the fuel gas will keep increase as its follow the Indonesian strategic plan for fuel diversification. One of the strategic programs is the conversion use of fuel oil to fuel gas especially for national sea transportation.

B. The use of fuel gas on ship.

Fuel gas on a ship has been used for the first time in 1964 for LNG carrier. Until 2000, the conversion from fuel oil to fuel gas has been applied to some limited small size ships such as Ferry and Yacht Ship (DNV-GL, 2013). Most of the ships use dual fuel (oil and gas). The first modern ship which is use fuel gas as its main fuel is Ferry Glutra Ship. It has capacities of 100 cars and 300 passengers and it's operated for the first time in February 2000. This ship has marked a new era of fuel conversion from fuel oil to fuel gas for commercial ships. Following this ship is 28 of fuel gas ships have been operated in the world while 12 other ships are under construction. The use of fuel oil on some ship types can be seen in Table 1.

Table-1 Number of ships using fuel natural gas

Ship Types	In Operation	On Order	Total
Ferry	16	4	20
SupplaY	6	5	11
Patrol	3	0	3
LNG	2	0	2
Ro-Ro	1	2	3
Bulk Carrier	0	1	1
Chemical Tanker	1	0	1
Total	29	12	41

Source: American Clean Skies Foundation (2012)

Most of the fuel gas ship type is Ferry ship, Supply vessel and Patrol vessel. The tendency of ships to use gas as their fuel is increasing. Based on 2014 data, total 50 fuel gas ships have been operated while 69 others are still under construction. It is predicted that until 2020, the number of fuel gas ship (not include gas carrier ship) is approximate 1000 ships. (DNV-GL, 2014). Figure 2 shows the current distribution of fuel gas ships including ships which are still under construction and under contract processing (DNV-GL, 2015).

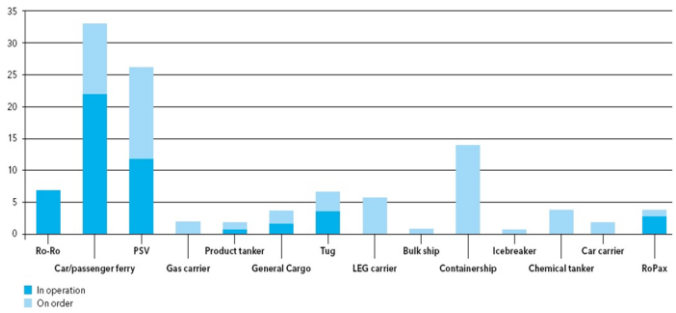

Figure 5. Fuel gas ship distribution in the world (source: DNV-GL/2015)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 12, December-2016

C. Benefits for using fuel gas.

Some benefits for using fuel gas compare to fuel oil can be described as follows:

- Reducing air pollution level. Pollutant level of NOx, SOx and CO2 as a result of gas combustion is lower than fuel oil.
- Engine maintenance and engine installation cost for fuel gas engine is lower than fuel oil.
- Reducing ship owner tax cost as well as other related cost for engine exhausts emission compensation.
- Reducing lubrication oil consumption.
- Reducing fuel consumption. Fuel gas engine is more efficient compared to diesel engine.
- Some components in diesel engine installation are not needed in fuel gas engine installation.
- Propulsion system installation is relatively simpler with cheaper operational and maintenance cost.

D. Some drawbacks for using fuel gas.

- One of the main disadvantages of using fuel gas on ship is the need for a bigger fuel gas tank if we compare with the fuel oil tank. As a consequence, volume for loading capacity is reduced.
- Besides, some additional equipment is needed following the installation of fuel gas engine such as installation for maintaining gas temperature condition and its pressure.

E. Method for gas storage

There are two methods for fuel gas storage at ship which are; high pressure compressed gas (CNG) and cryogenic liquid gas (LNG). Production, transportation and handling for LNG are more complex and expensive than CNG. On the other hand, the amount of gas that can be carried in the form of LNG is bigger than CNG for the same tank volume. Therefore, when determining gas storage method for fuel gas ship, cost and operationalization must be carefully considered such as the room availability, travel distance or ship operational time, the availability of gas refilling installation or gas bunker as well as time duration for gas conditioning to be fuel when it is about to deliver to engine. Based on the above consideration, it is more practical and advantageous for fuel gas ship to store its gas in the form of CNG.

III. CONVERSION STRATEGY

There are three possible alternative strategies that can be applied in the implementation policy of the fuel oil to fuel gas conversion for pioneer ship. First is by using kit converter, second is main engine modification and third by replacing or using specific main engine for natural gas. These strategy schemes are shown in Figure 6.

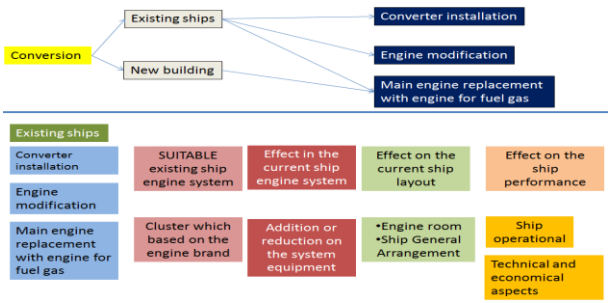

Figure 6 Scheme for conversion strategy from fuel oil to fuel gas for pioneer ship.

IV. PIONEERING SEA TRANSPORT

Indonesian pioneering transportation fleet can be grouped based on the ship loading capacities which are 200 DWT, 350 DWT, 500 DWT, 750 DWT, 1200 GT dan 2000 GT. Each capacity consist of some ships (sister ships). The number of ships for each capacity is shown in Table 2 below while in Table 3, the year of the pioneer ship was built for each capacity is shown.

Table- 2 Main dimension, capacity and engine power of pioneer ship

No.	Ship capacities	Number of ship	Length (m)	Breadth (m)	Draught (m)	Carrying capacity (person/ carg)	Engine power (HP)
1	200 DWT	4	36.60	8.00	2.40	114/100	2 x 600
2	350 DWT	6	47.00	8.60	2.65	234/143	2 x 620
3	500 DWT	16	51.80	9.00	3.20	250/240	2 x 640
4	750 DWT	8	58.00	10.20	3.20	265/400	2 x 825
5	1200 GT	11	62.80	12.00	2.70	400/50	2 x 1000
6	2000 GT	2	68.50	14.00	2.90	466/100	2 x 1400

Source: Ditjen Perhubungan Laut (2016)

Table- 3 the year of pioneer ship was built based on their capacities

No.	Year of building	Ship capacities (DWT/GT)						Number of ship
		200	350	500	750	1200	2000	
1	2003	-	3	3	2	-	-	8
2	2004	1	1	3	1	-	-	6
3	2005	-	-	2	-	-	-	2
4	2006	-	-	3	1	-	-	4
5	2007	-	-	-	1	-	-	1
6	2008	-	2	2	1	-	-	5
7	2009	-	-	-	-	-	-	-
8	2010	-	-	-	-	-	-	-
9	2011	-	-	2	1	3	-	6
10	2012	-	-	1	1	2	-	4
11	2013	3	-	-	-	6	2	11
	Total	4	6	16	8	11	2	47

Source: Ditjen Perhubungan Laut (2016)

As can be seen in Table 3, ship with 500 DWT capacities has been built with 16 ships. This is the biggest number of ships fleet to be built around the year while ship with the biggest capacity (2000 GT), only two of them have been built in the last year of the project. This project of building Indonesian pioneering ship started in 2003 until 2013.

Pioneer ships transport fleet were being built as Indonesian cargo and passenger transportation ship to serve remote and isolated area of Indonesian islands. Therefore, the ship loading capacities as well as the room for passenger accommodation are depending on the ship route for each destination. One example of the room layout for 500 DWT of pioneer ship can be seen in Figure 7. This ship has cargo carrying capacities for about 240 ton while for passengers, it can transport for about 250 passengers. The ship engine room is located in the ship stern after cargo room while passengers are located in the ship stem. The length of the engine room is 10.20 meter.

V. COST ESTIMATION FOR PIONER SHIP FUEL CONVERSION

Cost factor must be carefully considered when there are system changes or an addition to the supporting system of engine before the fuel conversion can be done. As a comparison, Table 4 shows cost estimation for engine fuel conversion which is based on the component cost as well as installation cost for BMW engine. Another example for fuel oil to fuel gas conversion on a container ship with 9.480 HP powering engine and engine made by MAN B&W can be detailed as follows:

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 12, December-2016

Conversion cost (for component and installation)	$ 4.380.000,-
Stell construction	$ 2.000.000,-
Design and classification	$ 500.000,-
Loss for not being operated (40 hari)	$ 680.000,-

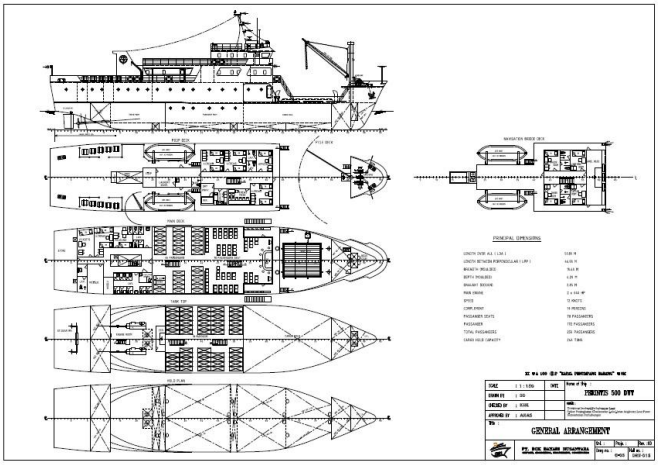

Figure- 7 General arrangement of 500DWT pioneer ship (Source: PT. DBN Shipyard)

Tabel- 4 Cost Estimation for fuel engine conversion which is based on component and installation cost.

Bore	Engine type	Indicative budget price [EUR]	
		Components	Installation
50	6S50ME / ME-C	825.000	300.000
	6S50MC / MC-C	1.800.000	500.000
60	6S60ME / ME-C	830.000	300.000
	6S60MC / MC-C	1.900.000	500.000
70	6S70ME / ME-C	870.000	300.000
	6S70MC / MC-C	1.960.000	500.000
80	6K80ME / ME-C	1.120.000	300.000
	6K80MC / MC-C	1.630.000	500.000
90	6S90ME / ME-C	1.060.000	300.000
	6S90MC / MC-C	1.750.000	500.000
98	12K98ME / ME-C	2.000.000	600.000
	12K98MC / MC-C	3.600.000	1.000.000

The bigger the engine power, the more component and installation cost will be. Fuel conversion system with engine replacement method especially for new shipbuilding will need more investment cost if we compare it with fuel oil engine. Cost component to be considered includes main engine cost, fuel system, ship construction and ship layout especially in the main engine room. Investment cost estimation for fuel conversion of the current pioneer ship which is based on the study by MAN-BMW can be seen in Table 5. In this table, the conversion cost estimation for pioneer ship is Rp. 10,270,000 per DWT or equal to Rp. 7,500,000 per HP.

Table - 5 Investment cost estimation value for pioneer ship fuel conversion

Ship capacities (DWT or GT)	200 DWT	350 DWT	500 DWT	750 DWT	1200 GT	2000 GT
Main engine power (HP)	600 HP	620 HP	640 HP	825 HP	1000 HP	1400 HP
Component and installation (Rp)	2,607,142,857	2,694,047,619	2,780,952,381	3,584,821,429	4,345,238,095	6,083,333,333
Stell construction (Rp)	1,190,476,190	1,230,158,730	1,269,841,270	1,636,904,762	1,984,126,984	2,777,777,778
Design and classification (Rp)	297,619,048	307,539,683	317,460,317	409,226,190	496,031,746	694,444,444
Loss for not operating (Rp)	404,761,905	418,253,968	431,746,032	556,547,619	674,603,175	944,444,444
Cost total (Rp)	4,500,000,000	4,650,000,000	4,800,000,000	6,187,500,000	7,500,000,000	10,500,000,000
Cost for retrofit per HP	7,500,000					
Cost for retrofit per DWT	10,270,000					

VI. CONCLUSION

Based on the above discussion, some conclusion can be drawn as follows:

- Technology for fuel conversion system from fuel oil to fuel gas is basically an engine retrofit system or fuel oil engine modification. There are two methods for fuel gas storage at ship which are; high pressure compressed gas (CNG) and cryogenic liquid gas (LNG). Ship main engine modification for fuel oil to fuel gas conversion will give significant benefit if the modified engine is relatively new. The conversion cost for relatively new engine will be more competitive if we compare with an investment cost for installing gas emission purification on an old ship main engine to fulfil maximum limit of exhaust gas emission.
- There are 3 types of technologies that can be used to utilized gas as the main fuel on bigger ship such as spark-ignited lean-burn, dual-fuel diesel pilot ignition with low-pressure gas injection and dual-fuel diesel pilot ignition with high-pressure gas injection.
- One important factor that needs to be carefully considered when converting fuel oil to fuel gas is the gas fuel storage requires more space than oil fuel gas storage. Besides, the cost for installing fuel gas refilling installation is more expensive than fuel oil.
- The bigger the ship main engine horse power (HP) and the ship capacities, the more component and installation cost for the fuel conversion will be.
- Cost average value for pioneer ship fuel conversion is Rp. 10,270,000 per DWT or equal to Rp. 7,500,000 per HP.

REFERENCES

[1] Imam Pujo Mulyatno et al, “Kajian Teknis Dan Ekonomis Penggunaan Dual Fuel System (Lpg-Solar) Pada Mesin Diesel Kapal Nelayan Tradisonal”, Jurnal KAPAL- Vol. 10, No.2 Juni 2013, Universitas Diponegoro;

[2] ESDM, “Potensi Dan Peluang Dan Investasi Sektor Energi Dan Sumber Daya Mineral” Kementerian ESDM, 2015;

[3] DNV-GL, “Latest Developments And Projects In The LNG Industry" Maritime In Focus–LNG As Ship Fuel: No. 01 2015, Hamburg Germany.

[4] ¬DNV-GL, “Status for LNG as Ship Fuel” Maritime In Focus–LNG As Ship Fuel: No. 01 2014, Hamburg Germany.

[5] ¬DNV-GL, “Vessel size development the last 50 years l” Maritime In Focus–LNG As Ship Fuel: No. 01 2013, Hamburg Germany.

[6] American Clean Skies Foundation (ACSF), “USA:GA, Cheseapeake Team Up to Speed Adoption of Gas as Transportation Fuel”, LNG World News, (2012).

[7] Ditjen Perhubungan Laut, “Rencana Strategis (Renstra) Kementerian Perhubungan 2015-2019”, Ditjen Perhubungan Laut, 2016.

[8] PT. Duta Bahari Nusantara, “Laporan Pembangunan Kapal Perintis 500 DWT”, PT. DBN Cirebon, 2015.