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Energy Diversification Indonesian Railways

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Abstract

This study aims to find alternative energy in substitution high speed diesel (HSD) in the railway by measuring the economic, supply chain, and liquefied natural gas (LNG) optimization especially in Java. The economic analysis using the feasibility of investment method in LNG locomotive, supply chain analysis to simulate infrastructure of transportation and distribution LNG to identify internal and external factors affecting. The economic analysis result showed fuel saving costs up to 36%, the NPV is positive, and the IRR higher than the discount rate so the investment is feasible to held that will bring benefits for country's revenues from using dual fuel in LNG locomotive. Supply chain analysis provide two simulation models of LNG distribution for railway that suitable to be applied in Java Island, the source of LNG coming from outside Java Island using existing LNG plant and the source of LNG coming from inside Java Island using mini LNG plant.

Penelitian ini bertujuan untuk mengetahui keekonomian, supply chain, dan optimasi liquefied natural gas (LNG) sebagai opsi energi alternatif dalam mensubstitusi high speed diesel (HSD) di kereta api khususnya di Pulau Jawa. Analisis keekonomian menggunakan metode kelayakan investasi pada lokomotif LNG, analisis supply chain mensimulasikan infrastruktur transportasi dan distribusi LNG dengan mengidentifikasi faktor eksternal dan internal yang mempengaruhi. Hasil analisis keekonomian menunjukkan penghematan bahan bakar hingga 36%,

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NPV yang bernilai positif, dan IRR yang lebih besar dari nilai discount rate sehingga investasi ini layak untuk dilakukan yang akan mendatangkan keuntungan bagi pendapatan negara dari penggunaan bahan bakar dual fuel di lokomotif LNG. Analisis supply chain menghasilkan dua model simulasi distribusi LNG ke kereta api yang cocok untuk diaplikasikan di Pulau Jawa yaitu sumber LNG yang berasal dari Luar Pulau Jawa menggunakan eksisting LNG Plant dan sumber LNG yang berasal dari domestik/dalam Pulau Jawa dengan mini LNG plant.

Introduction

Indonesia is often referred to as a country rich in natural resources. If the terms of the diversity of energy resources, but this time as the biggest importer of crude oil and fuel oil (BBM).

This shows that the wealth of natural resources in Indonesia has not been used optimally which may result in vulnerability to resilience and energy security. Indonesia until today still rely on fossil fuels, especially petroleum in the fulfillment of its energy consumption.

Reliance on fossil fuels in the country is still high at 96% (48% oil, 18% gas and 30% coal). The primary energy supply is still dominated by oil includes crude oil and fuel oil (BBM). Almost 98% most of the petroleum products consumed by the transportation sector.

Data backup oil and gas Indonesia beginning in 2014 amounted to 7374 billion barrels. Remaining proven reserves of 3624 billion barrels and potential reserves of around 3,750 billion barrels. While the number of total oil production in 2013 was 292.05 billion barrels (Ministry of Energy and Mineral Resources, 2014).

Currently the petroleum needs of about 1.2 million barrels per day, while oil production below 1 million barrels per day, resulting in Indonesia became a net importer of petroleum. Import dependency ratio has reached 37% in 2013 and expected to increase in the future.

The government has issued various policies to reduce fuel usage by diversifying energy by increasing the use of fuel gas (Compressed Natural Gas (CNG)) in the transport sector (Law No. 30, 2007; ESDM, 2014; Presidential Decree 5, 2006).

Dependence on petroleum with the target the use of petroleum fell from 51% to less than 20% and enlarge the role of natural gas to more than 30% in the energy mix in 2025. About 99% more than the total energy consumption of the transport sector is still filled with fuel.

Natural gas is the third main type of primary energy in Indonesia, as petroleum and coal, with a share of approximately 22% (without biomass). Natural gas is an energy resource potential is quite high in Indonesia.

Natural gas reserves at the beginning of 2014 amounted to 149.3 trillion standard cubic feet (TSCF), with proven reserves of around 100.26 TSCF while potential reserves ranging from 49.04 TSCF. While the number of total gas production of 2.9 TSCF during 2013 (Ministry of Energy, 2014). So, assuming relatively constant production, natural gas can meet the needs of Indonesia until about 34 years into the future.

Selection of gas as an option fuel oil constituted by a variety of considerations, namely the abundance of natural gas reserves, cheap, clean and friendly to the environment due to the reduction of carbon emissions by 95%, CO2 emissions by 25%, emissions of HC 80%, and NOx emissions by 30%.

Although the potential of natural gas owned by Indonesia is quite large but the utilization of natural gas in the country is still limited. The growth of gas consumption includes natural gas and gas products, lower than oil, which is only about 2.7%. This is due, the limited gas infrastructure (pipelines) and the limited guarantees domestic market, causing most of the production of natural gas used as an export commodity in the form of liquefied natural gas (LNG) and gas pipelines.

Export of LNG and natural gas currently associated with long-term contracts to guarantee a return on gas field development costs. Besides exporting natural gas in the form of

LNG, Indonesia also exports natural gas through pipelines to Singapore and Malaysia.

The train is a mode with efficient energy consumption per unit of which is 0,002 liters per passenger per passenger Km (Km / PNP) compared with 0.0125 bus liters per Km / PNP and private car 0.02 liters per Km / PNP and have exhaust or pollutants are low. In the future, the potential for the transport of goods by rail will be very promising, to see the industry-based natural products and manufacturing is still growing.

Currently all regular train locomotive diesel fuel is still the type of high speed diesel (HSD). Based on actual data as of early 2016, Indonesian Railways (Indonesian: PT. Kereta Api Indonesia) already has a fleet of railway ready for operation diesel oil reached 840 units in Java and Sumatra. According to the National Railways Master Plan In 2030, the projected needs of urban railway in 2030 as many as 6016 units.

The energy needs of passenger and freight trains are air base of the island in 2030 was 2.809 million liters of diesel fuel/day and electricity 37.389 million kwh/day. The MoU between Company Oil and Gas State (Indonesian: PT Company Oil and Gas State) and Indonesian Railways held in August 2015 to take advantage of LNG as an option alternative energy diesel fuel on a train middle distance and long distance, indicating that it has the support back by government to promote the use of LNG in the country.

Based on the background, and a phenomenon that has been stated above, this study deserves to be further investigated to analyze the economic, optimization, and supply chain LNG as an option alternative energy in the substitution of diesel fuel (HSD) in the railways in terms of the various factors that exist. This research is expected to be useful as an input to the government, especially Indonesian Railways, and other related parties in the decision to utilize LNG as an embodiment of the resilience and the total national energy independence.

Diversified Energy

Diversification is an attempt diversification of energy supply and utilization of energy resources in the framework of the optimization of energy supply. In the end, efficiency and diversification are key to improving energy security to reduce the risk exposure to energy (Gonzales, 2013). Diversification of energy in the transport sector to reducing greenhouse gas emissions efficiently (Daim, 2010) are included in the production process, reducing ecological impacts and resource use (Hauser, 2016).

Diversification of energy continues to be driven by the Government to reduce dependence on petroleum and improve the utilization of renewable energy. This has implications for energy cost reduction and increased national energy security. Dependence on fossil fuels a significant risk to economic development because it increases the cost is very large in the use of energy in the transport sector (Valkila and Saari 2010).

As it is known that the fuel is a fossil fuel with the highest price, while Indonesia has reserves of coal, natural gas, and new and renewable energy (EBT) are of potential use as a substitute fuel. The utilization of non-fossil fuel energy and optimum renewable energy will increase energy security and lowering energy costs nationwide. To that end, the Ministry of Energy in 2013 and 2014 have established various regulations to encourage the use of renewable energy and natural gas for transportation (Agency for the Assessment and Application of Technology, 2014).

Reduction in fuel consumption provides a reduction of subsidies and reduction of emissions. For users benefit because the price of CNG is cheaper than the price of fuel and provide business opportunities upstream and downstream gas which will increase employment (Susanti, 2011).

Liquefied Petroleum Gas (LPG)

The third resource of energy consumed over 85% of the total energy needs of the world, LPG or LNG is the cleanest gas compared with oil and coal (Khalilpour, 2012). LPG is obtained from hydrocarbons produced during the refining of crude oil and of natural gas components methane

(CH_4, 85-98% by volume), with smaller amounts of ethane (C_2H_6), propane (C_3H_8), higher hydrocarbons (C_4 +) and nitrogen as an inert component (Komar, 2013).

A mixture of several hydrocarbons including isobutene (Thompson, 2000; Won et al, 2014) can affect the efficiency of the industry of transport between 58% and 80%, and the energy efficiency of transport chains between 48% and 52% approximately one-third of the needs in the transport chain the conventional CO_2 capture and sequestration CCS (Aspelund, 2009).

As a future energy derived from natural gas that is cooled to a temperature so that the shape of dew -256ºF containing fluid (Foss, 2012), LPG can be exploited through a certain process to recover energy and to improve economic performance (Lin, 2010) and can continue to be used safe (Foss, 2003).

Company Oil and Gas State LPG introduced since 1968, dominated LNG liquid methane, a colorless, odorless, non-corrosive and non-toxic. Consists of 85-90% mol methane and ethane plus a small portion of propane, butane, and nitrogen (Sukandarrumidi, 2013). LNG taken from LNG Bontang, Tangguh, Donggi-Senoro, can also be taken from the FSRU by providing facilities 'LNG break-bulking', i.e. ship-to-ship transfer of FSRU storage tank before re-gasification.

Regasification of LNG is the process of phase change from liquid phase into the gas phase back, which at the beginning of the process of natura gas is cooled to a temperature of -1610C at 1 atm pressure into liquid form in the form of LNG (Sonmez, 2009).

The purpose of the changes in the form of a gas phase into the liquid phase of this is to facilitate the process of transportation / shipping and storage because the storage volume required for a liquid phase is 600 times smaller than in the gas phase. For the transportation process, itself uses due to the shipping process feed gas to the LNG produced at offshore (Lee, 2005).

Supply Chains

Energy supply chain is an

important asset related to the production and distribution of energy products (Urciuoli et al, 2014). The existence of barriers in the supply chain lead to negative consequences on the increased costs (Halldo'rsson and Svanberg, 2013), so it requires the selection of appropriate strategy in evaluating the costs and benefits (Colicchia et al, 2011; Deane et al, 2009; Holland and Lockett, 1997; Khan et al, 2012; Krishnan and Ulrich, 2001; Melacini et al, 2011; Tang, 2006).

LNG supply chain consists of the extraction and production of natural gas, liquefaction, sea transport, and storage of LNG, re-gasification and natural gas deliveries to consumers (Komar, 2013; Grounhaug, 2009).

Research Method

This study was designed using qualitative and quantitative approaches. A mixed methods approach is one in to base knowledge on pragmatic grounds (e.g., consequence-oriented, problem-centered, and pluralistic). It employs strategies of inquiry that involve collecting data either simultaneously or sequentially to best understand research problems.

The study begins with a broad survey to generalize results to a population and then focuses, in a second phase, on detailed qualitative, open-ended interviews to collect detailed views from participants (Creswell, 2003) A qualitative approach was used in tapping the knowledge and insight to the analysis of substitution of diesel to LNG and the railway system in Indonesia through the interview to the experts in the related fields.

Quantitative approach to analyzing the economics of LNG in the substitution of diesel fuel on the railways long-and medium in Java against the cost savings (cost saving) dual fuel and investments in LNG by comparing the investment locomotive diesel locomotives and locomotive conventional LNG. Data of the primary of the calculation include the number of locomotives, diesel fuel consumption on the island of Java, a unit of energy, the conversion of LNG demand in Java, the mileage, the investment cost of diesel locomotives and locomotive LNG, the cost of maintenance costs, and fuel costs and the economic life of diesel locomotives.

The main research subjects and engage directly with the object of this research is Indonesian Railways and PT Company Oil and Gas State. The object of this research is more focused on fuel oil is diesel train (high speed diesel), fuel gas liquefied natural gas (LNG), and the special train diesel locomotive long-and medium.

Discussion

Fuel consumption Transporter Railway Sector

Based on data from the real / actual field obtained from Indonesian Railways for HSD consumption during the period 2013 to 2015 on the locomotive, KRD, Power Train, and MPJR in Java and Sumatra, are shown in the following table.:

Table 1 Consumption of HSD in Java and Sumatra Year 2013-2015

No.	Consumption	Year (Liter)		
		2013	2014	2015
1	Locomotive	145.306.591	165.495.657	170.532.575
2	Power Train	13.169.139	17.445.248	19.019.854
3	MPJR	906.349	1.089.593	1.482.117
4	KRD	3.579.053	4.209.219	4.550.606
	Total	**162.961.132**	**188.239.717**	**195.585.152**

(Source: Indonesian Railways, 2016)

HSD needs are increasing by an average of 9.71% annually for the operational needs of the railway passenger and freight trains (Table 1). HSD consumption in Java during 2015 that used locomotives, KRD, Power Train, and other needs such as the use of diesel fuel for the generator, compressor, washing gear, and so on as follows.

Table 2 Consumption of HSD in Java 2015

No.	Consumption	Liter
1	Locomitive	105.917.312
2	Power Train	17.591.526
3	KRD	3.190.314
4	Others (Genset, kompresor, cuci gear, MPJR, dll)	1.987.716
	Total	**128.686.868**

HSD needs in the next five years based on actual data on a train HSD consumption in Java and Sumatra, with an average increase of 9.71%, the obtained HSD requirements in the table below.

Table 3 Projected Needs HSD in Java and Sumatra Year 2016-2020

No.	HSD Need	5-year projections (Liter)				
		2016	2017	2018	2019	2020
1	Java & Sumatera	214.570.802	235.399.409	258.249.869	283.318.447	310.820.458
2	Java	141.178.633	154.882.987	169.917.637	186.411.715	204.506.890

This projection produces solar requirement will increase each year to reach 310 million liters in 2020. The need for HSD 2020 is projected to reach 204 million liters, only on the island of Java. Can be shown in the graph below.

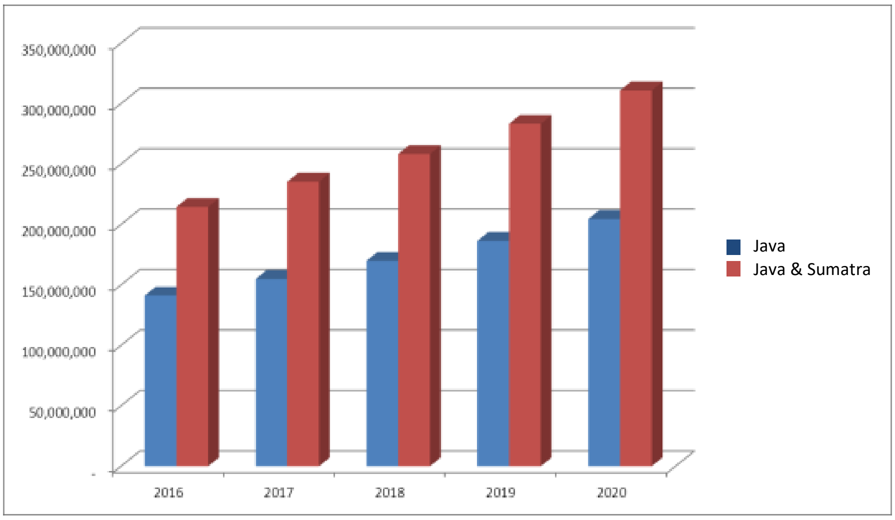

Figure 3 Projected Needs HSD

Conversion Needs LNG in locomotives in Java

The need of diesel fuel per year in liters are converted to LNG in units MMBtu, to do the conversion of the unit. In every one liter of diesel fuel energy is equal to 1.67 liter one liter LNG LNG which is equivalent to 0.023 MMBtu. While a liter of diesel is equivalent to 0.034 MMBtu. With a total diesel consumption in the transport sector based on actual train in Java in 2015 amounted to 128 686 868 liters / year of gas needs to be converted for 875 071 MMBtu/year. LNG demand after conversion to dual fuel ratio of 80:20 (Table 4).

Cost Savings (Cost Saving) Fuel with Diesel Fuel Conversion to LNG

Comparison of energy prices can be calculated conversion into an MMBtu per unit of USD as tabel 5. From these results, the cost savings by converting some diesel to LNG train in diesel engines using average prices in 2015 resulted in cost savings amounting to 432.28 billion rupiahs per year, or 36% (1 USD = IDR 13,000).

Table 4 Conversion Needs LNG in Java Year 2016-2020

Year	***Fuel Needs* per year**			***Fuel Needs* (conversion) per year**	
	Liter	**MMBtu**	**MMSCF**	**LNG 80% (MMBtu)**	**Diesel Fuel 20%**
2015	128.686.868	4.375.354	4.375	4.025.325	875.071
2016	141.178.633	4.800.074	4.800	4.416.068	960.015
2017	154.882.987	5.266.022	5.266	4.844.740	1.053.204
2018	169.917.637	5.777.200	5.777	5.315.024	1.155.440
2019	186.411.715	6.337.998	6.338	5.830.958	1.267.600
2020	204.506.890	6.953.234	6.953	6.396.976	1.390.647

Table 5 Energy Price Comparison

Fuel	**Year**			
	2014	**2015**	**2016**	**2017**
Diesel, USD/MMBtu	29.81	21.09	16.50	18.06
Natural Gas, USD/MMBtu	11.07	10.48	9.69	10.10

Table 6 Comparison of Cost Savings (Cost Saving) The use of fuel with Dual Fuel Conversion

Year	***Fuel Cost* (USD)**				***Saving Cost***	
	100% Diesel Fuel	**Conversion 80:20**				
		80% LNG	**20% Diesel Fuel**	**TC Conversion**	**USD**	**%**
2015	91,882,423	40,253,252	18,376,485	58,629,737	33,252,687	36%
2016	100,801,544	44,160,677	20,160,309	64,320,985	36,480,559	36%
2017	110,586,452	48,447,398	22,117,291	70,564,689	40,021,764	36%
2018	121,321,192	53,150,237	24,264,239	77,414,475	43,906,717	36%
2019	133,097,964	58,309,584	26,619,593	84,929,177	48,168,787	36%
2020	146,017,919	63,969,755	29,203,584	93,173,339	52,844,580	36%

From the data analysis calculation consumption needs Indonesian Railways in Java with historical data (years 2013-2015) and the projection of the next five years (2016-2020) with a growth of 9.71%, the consumption of diesel fuel in 2020 nearly 204 million liters/year from the previous 128 million liters/year by 2015, the figure needs diesel fuel will be spent only for fuel costs alone amounted to USD 91.8 million, equivalent to 1.2 trillion rupiahs in 2015. with predictions of the next five years hence will spend USD 146 million or almost as big as two trillion rupiahs.

From these results, we obtained partial results of dual fuel conversion of diesel fuel with a ratio of 80% and 20% LNG Diesel Fuel, the solar requirement in 2015 amounted to only 25.7 million liters per year. This figure saving of 103 million liters from the previous (the equivalent of 175 million liters of diesel). Although higher yet covered by the price of LNG is cheaper than diesel so that it remains far more efficient than the use of 100% diesel fuel. Diesel Fuel requirement of dual fuel conversion results obtained approximately 875 thousand MMBtu/year of LNG and 4 million MMBtu/year ~ 10 MMSCFD.

With the price of diesel and gas calculation of the current world average of $ 21/MMBtu and US $ 10 /MMBtu and the price is predicted for the next few years delivering considerable savings higher when the conversion is done. The savings obtained in 2015 amounted to USD 33.2 million or 432 billion/year, or 1.2 billion/day with an efficiency of 36%.

With a projected 2020 assuming the price is not too significant fluctuations from the current price, the savings shown by USD 52.84 million or 687 billion/year. Can be seen in Figure 2 comparison of the cost savings that can be made between the conversion of diesel LNG dual fuel usage by 36%.

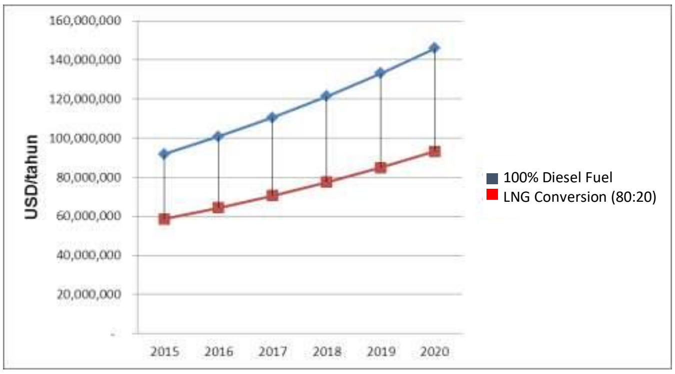

Figure 2 Cost Saving Fuel Dual Fuel Conversion

Fuel consumption on a locomotive CC Series 206 is the latest type of locomotive owned by Indonesian Railways (Table 7). So, with the Jakarta-Bandung mileage of 180 km, the average fuel usage by one trip per day will consume a liter of fuel by 442.8 ~ 450 liters for one trip only. So, with a fuel tank capacity of 3,000 liters and consumption of one trip of 450 liters, the ability of the trip can be spent on three trips back and forth. Meanwhile, Jakarta-Yogyakarta has a mileage of 512 km, with an average speed of 80 km/h it will generate travel time 6.5-7-hour trip with the addition of a tolerance range of 7-8 hours.

Table 8 General Information Line Train

Route	Jakarta-	Jakarta -Yogya	Jakarta -Surabaya
Distance (Km)	180	512	725
Locomotive	CC 206	CC 206	CC 206
Total Train	1	1	1
Total wagon	7-8	7-8	7-8
Speed average	80 Km/h	80 Km/h	80 Km/h
Time (jam)	3-3.5	7-8	9-10
Type	Argo	Argo	Argo

Jakarta-Yogyakarta is assumed to use the same locomotive series CC 206. Then the average fuel usage for one trip per day will consume a liter of fuel by 1259.5 ~ 1,260 liters. So, with a fuel tank capacity of 3,000 liters and the consumption of 1,260 liter single-trip, one can travel back and forth without the need to fill in the journey. LNG demand amounted to 14,380 MMBtu per year and diesel 3,126 MMBtu/year from the previous total of 15.631 MMBtu/year.

Train destination Jakarta - Surabaya through the north in the range 9-10-hour journey which ended in Turi Market Station (SBI). While the path taken by the long journey south 12-13 hours. With mileage Jakarta-Surabaya 725 km, the average use of fuel with one trip per day will consume a liter of fuel by 1783.5 ~ 1784 liters.

With a fuel tank capacity of 3,000 liters and 1,784 trips consumption of one liter, assuming full fill the fuel tank at the start of operation, it does not need to fill in the journey.

Efficiencies gained 36% for the conversion ratio of 80:20 LNG dual fuel and diesel with the assumption that LNG can supply the demand of fuel every day. LNG demand from the calculation of 219 806 MMBtu per year and diesel 1,099 MMBtu/year from 5,495 MMBtu/year.

Table 9 Needs Fuel

Diesel Fuel 100%	**Jkt-**	**Jkt-Yogya**	**Jkt-Surabaya**
Consumption Diesel Fuel per-trip	442.8	1259.5	1,784
Consumption Diesel Fuel per-year	162,622	459,725	650,978
Consumption Diesel Fuel	5,495	15,631	22,133
Dual Fuel LNG: Diesel Fuel (80:20)			
LNG 80% (Ltr/ year)	219,806	625,226	885,329
LNG 80% (MMBtu/year)	5,056	14,380	20,363
Diesel Fuel 20% (Ltr/ year)	32,324	91,945	130,196
Diesel Fuel 20% (MMBtu/year)	1,099	3,126	4,427
Efficiency	36%	36%	36%

Cost Saving Fuel

Based (Table 9) specification locomotive diesel and LNG same infrastructure that is considered already exist, and the supply of LNG smoothly, the cost savings (cost saving) of fuel amounted to USD 41.763 or the equivalent of 550 million rupiahs per year (1 USD = Rp. 13,000) for dual fuel ratio of 80:20. In other words, a saving of 1.5 million per day.

Cost savings (cost saving) of fuel amounted to USD 118.793 or the equivalent of 1:54 billion per year (1 USD = Rp.13.000, -) for dual fuel ratio of 80:20. For locomotive diesel and LNG specifications like existing infrastructure is considered, then the cost savings (cost saving) of fuel amounted to USD 168.213, equivalent to 2.19 billion rupiahs per year (1 USD = Rp. 13.000, -) for comparison of dual 80:20 fuel. These savings showed significant proportion of the savings on fuel costs. If in one day Argo Bromo Anggrek traveling back and forth, then savings can be made by twofold amounting 4:38 billion.

Table 10 Cost of Fuel Economy

Diesel Fuel 100%	Jkt-Bandung	Jkt-Yogya	Jkt-Surabaya
Cost of Diesel Fuel	115,398	328,244	464,798
Dual Fuel LNG: Diesel Fuel (80:20)			
LNG 80% (USD/year)	50,555	143,802	203,626
Diesel Fuel 20%	23,080	65,649	92,960
Total Cost (USD)	73,635	209,451	296,585
Saving Cost (USD)	41,763	118,793	168,213
Saving Cost (IDR)	549,920,622	1,544,307,548	2,186,763,618

Saving Fuel Consumption and Costs on Simulation Project Mileage

Calculation of fuel on the simulation project three different mileage traveled from Jakarta to Bandung, Jakarta-Yogyakarta and Jakarta-Surabaya. The need for diesel fuel for the Jakarta-Bandung 5.495 MMBtu/year. Total volume is at a cost of US $ 115.398, or 1.5 trillion. If the solar requirement may be converted to dual fuel LNG then obtained approximately 5.056 MMBtu/year and Diesel Fuel 1,099 MMBtu/year, with a total cost of US $ 73.635 conversions or 957 million rupiahs.

That savings can be made of US $ 41.763 ~ 542 million. While the number of diesel fuel needs for the Jakarta-Yogyakarta 15.631 MMBtu/year. The total volume of this will be at a cost of US $ 328.244, or 4.3 billion. If the solar requirement may be converted to dual fuel LNG then obtained approximately 14,380 MMBtu/year and Diesel Fuel 3,126 MMBtu/year, with a total cost of US $ 209.451 conversion or 2.7 billion. So, that savings can be made amounting to US $ 118.793 billion or 1:54.

Figures diesel fuel needs for the Jakarta-Surabaya 22.133 MMBtu/year. The total volume of this will be at a cost of US $ 464.798 or 6 billion. If the solar requirement may be converted to dual fuel then obtained approximately LNG 20.363 MMBtu/year and Diesel Fuel 4,427 MMBtu/year, with a total conversion cost of US $ 296.585, or 3.85 billion. So, that savings can be made amounting to US $ 168.213 billion or 2:18 (see in Figure 3). The total cost of this conversion will be necessary for the calculation of fuel costs on the investment feasibility analysis further.

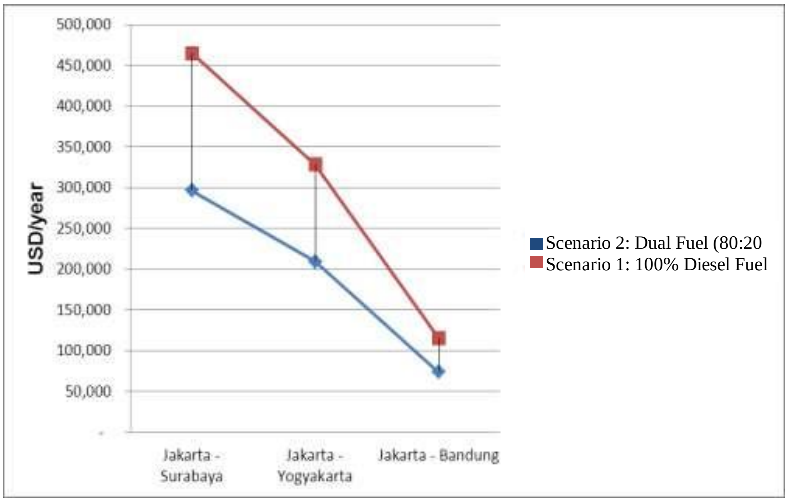

Figure 3 Cost Savings Inter Mileage

Cost Benefit Analysis and Investment

Parameters of fixed costs in this research is an investment in the purchase of railway locomotives. To calculate the investment in LNG locomotive then made comparisons between diesel locomotive diesel with the same power that is 2250 HP.

LNG locomotive can be calculated with any existing diesel locomotive plus the cost of the main components of a dual fuel system that is ISO tank, converter kit, and the tender price as ISO tank containing the LNG carrier. The components described previously in Chapter II. Estimated price comparisons second locomotive as an initial investment, can be seen in the following table.

Table 11 Comparison Locomotive Diesel Locomotive and LNG

Descriptive	Locomotive Diesel CC 206 (IDR)	Locomotive LNG (IDR)
New Locomotive	36.000.000.000	36.000.000.000
Tang of ISO/tender 20 feet		1.000.000.000
Converter Kit		4.000.000.000
Locomotive Tender		6.000.000.000
Total Cost	36.000.000.000	47.000.000.000

Diesel locomotive maintenance costs derived from the Maintenance Service Agreement between GE and Company Oil and Gas State amounting to US $ 60 million to treat 50 locomotives CC 206 for 8 years. So, from that number will be obtained by the cost of care for a locomotive for 1 year is US $ 150,000 ~ $ 2.05 billion in the year when 1 USD ~ 13 655. As for the LNG, locomotive maintenance costs obtained by the above assumption diesel maintenance costs amounted to US $ 213.841 ~ 2.9 billion. These are costs to adding the treatment to tender for transporting ISO tanks contain LNG.

The latest series locomotive maintenance costs 206 CC Indonesian Railways done with the cooperation contract with PT GE valued at USD 60 million for 50 locomotives for 8 years so that maintenance costs are approximately 2 billion for a single locomotive. From these figures, it can estimate the approximate cost of care for locomotives LNG is more expensive than diesel locomotives due to locomotive LNG need for additional maintenance costs for LNG tender locomotives.

Dual fuel conversion at the Jakarta-Yogyakarta and Jakarta-Surabaya is feasible to do because of the greater distance traveled and the use of LNG it will be more efficient against the value of the fuel is charged. However, if the use of LNG with small distances, then LNG would not be so efficient against the benefits. NPV is negative at the Jakarta-Bandung means would result in lower profitability compared to another simulated scenario. However, this value will be efficient if the use of LNG in the capacity of larger amounts for several trips.

LNG receiving terminal (LNG receiving terminal) is a terminal to receive LNG shipments from LNG tankers are located by the sea or can also waters near the mainland (Floating Receiving Terminal). The main operational LNG receiving terminal include storing and regasification of LNG, as well as send gas if necessary through the pipeline, which is connected to the pipeline transmission or distribution pipeline.

Some terminal also has

facilities highway or truck sent to the satellite LNG storage and regasification station located in marketing. The position of the receiving terminal which has a capacity of strategic storage facility will function. This terminal is not only accommodating the shipment of LNG from domestic products, but at certain times, for example at the time of the world LNG market was low demand, can also stockpiling LNG to buy from outside. LNG receiving terminal needs to be equipped with the operational capability of loading / unloading LNG vessels are large or small. Now already operated two receiving terminal and regasification of LNG for domestic use items, namely West Java FSRU with a capacity of 3 million tons per year and the ability regasification 400 MMSCFD operated by the Company Nusantara Regas owned by Company Oil and Gas State and PGN, as well as the FSRU Lampung with a capacity of 2 million tons per year and regasification capability of 250 MMSCFD owned and operated by PGN.

The second type of terminal is a floating LNG vessel which functioned as a receiving terminal and other permanent tethering. Another of the receiving terminal and regasification of LNG were immediately operated by Company Oil and Gas State is Arun terminal, the facility was built to convert the Arun LNG liquefaction plant facilities that are not operated. In the future, Indonesia needs to build a receiving terminal and regasification scattered to meet the needs for industrial gas and electricity in the area.

The following supply chain model with the construction of Mini LNG Plant in Java. Currently Mini LNG development plans in West Java, Cirebon. The mini LNG plant can accommodate about 5 MMSCFD to 10 MMSCFD. From Mini LNG receiving terminal, LNG is transported by truck/trailer to a railway locomotive station for example LNG nearest station Cirebon, Cimalaya, which can then be disseminated to users of other cities to be used in the train. Following the simulation model of distribution of LNG.

By connecting all the network infrastructure of natural gas either from the source of supply of LNG or pipeline gas, the regulation fulfillment of domestic gas supply becomes easier and more flexible. Review of the economics of the overall scope of the LNG business, including the cost of capital procurement mini LNG plants, operating costs, transportation, and distribution to the consumer is still relatively more attractive than fuel consumption.

Conclusion

Based on the analysis that has been done, as well as based on existing theory, it can be concluded:

1. Economies of LNG in the substitute fuel (HSD) in the rail transport sector in Java Indonesia indicated by the value of the savings (cost saving) of fuel consumption with dual fuel conversion of USD 33.2 million or 432 billion/year or 1.2 billion per day with an efficiency of 36%. With the value of investments in LNG locomotive of 47 billion IDR/unit with diesel locomotive investment margin amounted to 11 billion rupiahs.
2. Optimization of LNG in substituting HSD in the rail sector with a SWOT analysis shows that with the weaknesses, strengths, opportunities, and threats of the use and application of the substitution HSD to LNG in the rail sector, feasible if support for policy, regulatory, and oversight of government by accelerating the development of LNG infrastructure and testing the viability of the railway locomotive.
3. Simulation LNG supply chain to train that can be applied in Java long-distance service, which is the source of LNG coming from outside Java using existing LNG Plant and LNG sources derived from domestic / in Java with a mini LNG plant.

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