BACHELOR THESIS (ME 141502)

TECHNICAL AND ECONOMIC ANALYSIS OF USING LIQUEFIED NATURAL GAS (LNG) IN SMALL MARINE VESSEL ON MAHAKAM BLOCK TOTAL E&P INDONESIE

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DOUBLE DEGREE PROGRAM OF
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TUGAS AKHIR (ME 141502)

ANALISA TEKNIS DAN EKONOMIS PENGGUNAAN *LIQUEFIED NATURAL GAS* (LNG) UNTUK KAPAL KECIL DI BLOK MAHAKAM TOTAL E&P INDONESIE

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SURABAYA 2016

APPROVAL FORM

Technical and Economic Analysis of Using Liquefied Natural Gas (Lng) in Small Marine Vessel on Mahakam Block Total E&P

BACHELOR THESIS

Submitted to Comply One of The Requirements to Obtain a Bachelor Engineering Degree
on
Laboratory of Marine Power Plant (MPP)
Bachelor Program Department of Marine Engineering
Faculty of Marine Technology
Institut Teknologi Sepuluh Nopember

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JULY 2016

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I, who signed below hereby confirm that:

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Department : Double Degree Marine Engineering

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Dhanang Surya Prayoga

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TECHNICAL AND ECONOMIC ANALYSIS OF USING LIQUEFIED NATURAL GAS (LNG) IN SMALL MARINE VESSEL ON MAHAKAM BLOCK TOTAL E&P INDONESIE

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ABSTRACT

As well as we know that oil & gas has become the most important energy source. According to its fact, Total E&P Indonesie has reserves that approximately 6 trillion cubic feet (TCF), which is still steady for production. However, the situations of current world oil prices which decrease significantly from US$ 100/barrel to US$ 35/barrel has also affect to the operation & production. The operation & production are falling because of the drop in exploration investments. Furthermore, Total E&P Indonesie operates 200 to 300 ships to support their production and operation. However, the fuel oil usage of their vessel cost roughly for US$ 100 million per year. In order to improve the efficiency of fuel cost, its make sense that we need to drive the utilization of liquefied natural gas (LNG) as a replacement for fuel oil. The utilization of liquefied natural gas (LNG) as fuel has been applied recently. Moreover, this research aims to find out the average fuel consumption and its equivalent to liquefied natural gas need, then analyze the best consideration between the engine modification and engine replacement to occupy the natural gas usage considering the technical and economic aspect. The technical aspect consists of fuel consumption analysis using the physical conversion and actual data, then finding the adequate equipment for conversion & engine replacement by referring to its calculation, and finding the energy consumption between the modification and replacement within the same rated power based on the energy content. In addition, the economic aspect consists of Payback, Net Present Value, and Internal Rate of Return considering to CAPEX and OPEX of engine modification and engine replacement.

Keywords: Liquefied Natural Gas, Fuel Consumption, Technical Aspect, Economic Aspect.

ANALISA TEKNIS DAN EKONOMIS PENGGUNAAN *LIQUEFIED NATURAL GAS* (LNG) UNTUK KAPAL KECIL DI BLOK MAHAKAM TOTAL E&P INDONESIE

Nama	**:**	**Dhanang Surya Prayoga**
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ABSTRAK

Seperti yang kita ketahui bahwa minyak dan gas merupakan asset energy yang sangat penting. Menurut fakta, Total E&P Indonesie masih mempunyai cadangan untuk lading minyak & gas 6 sebesar *trillion cubic feet* (TCF), dimana masih sangat memungkinkan untuk produksinya. Namun, dengan melihat situasi harga minyak yang menurun drastis dari harga 100 Dollar/ barrel hingga US$ 35 Dollar/ barrel memberikan pengaruh yang besar terhadap kegiatan operasi dan produksinya. Kegiatan operasi dan produksi menjadi menurun diakibatkan karena menurunnya juga investasi untuk kegiatan eksplorasi. Selain itu, Total E&P Indonesie telah mengoperasikan kapal sekitar 200 hingga 300 kapal untuk mendukung kegiatan operasi dan produksi. Kemudian, penggunaan bahan bakar minyak untuk kapal yang dioperasikan memakan biaya sebesar 100 juta dollar per tahun. Dalam rangka memperbaiki efisiensi biaya untuk bahan bakar, maka akan sangat masuk akal bagi kita untuk melakukan perubahan dengan menggunakan *liquefied natural gas* (LNG) sebagai bahan bakar pengganti minyak. Penggunaan *liquefied natural gas* (LNG) sebagai bahan bakar sudah banyak diaplikasikan. Dengan begitu, penilitian ini mempunyai tujuan untuk mencari konsumsi rata- rata bahan bakar ekuivalen dengan kebutuhan *liquefied natural gas* (LNG), kemudian dilanjutkan dengan menganalisa pertimbangan antara konversi mesin dan penggantian mesin baru dalam rangka untuk memenuhi kebutuhan bahan bakar gas berdasarkan aspek teknis dan ekonomis. Aspek teknis untuk penelitian ini terdiri dari analisa konsumsi bahan bakar dengan menggunakan unit konversi dan data aktual, mencari peralatan untuk konversi dan penggantian mesin baru berdasarkan kalkukasi, mencari konsumsi energi antara konversi dan penggantian mesin baru dengan power dan nilai energi yang sama. Selain itu, aspek ekonomis untuk penelitian ini terdiri dari mencari nilai *Payback, Net Present Value, and Internal Rate of Return* berdasarkan nilai CAPEX dan OPEX untuk konversi mesin dan penggantian mesin baru.

Keywords: *Liquefied Natural Gas*, Konsumsi Bahan Bakar, Aspek teknis, Aspek ekonomis

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This Bachelor Thesis were submitted in order to comply with one of the requirements to obtain a Bachelor Degree in Department of Marine Engineering, Institut Teknologi Sepuluh Nopember

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CONTENTS

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LIST OF FIGURES

LIST OF TABLES

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LIST OF ABBREVIATIONS

AHTS : Anchor Handling Tug Supply Vessel

BOG : Boil-Off Gas

CAP-EX :Capital Expenditure

ECM : Engine Control Module

EGR : Exhaust Gas Recovery

GVU : Gas Valve Unit

HHV : Higher Heating Value

HSD : High-Speed Diesel

IRR : Internal Rate of Return

LHV : Lower Heating Value

LNG : Liqufied Natural Gas

MARR : Minimum Attractive Rate of Return

MMBTU : Million Metric British Thermal Units

NPV : Net Present Value

OP-EX : Operational Expenditure

PFD : Process Flow Diagram

PSC : Production-Sharing Contract

PTO : Power Take-Off

SFGC :Specific Fuel Gas Consumption

SFOC : Specific Fuel Oil Consumption

TCF : Trillion Cubic Feet

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CHAPTER I
INTRODUCTION

I.1 Background

Total E&P Indonesie is one of the contractors who contribute in Blok Mahakam operation since 1968 until contractual time of 31 December 2017. In 2018, Blok Mahakam is operated under PT. Pertamina Hulu Mahakam. As subsurface, the rest reserves that approximately 6 trillion cubic feet (TCF) is still satisfying for production. The workfield of Blok Mahakam is 2,738.51 km2 located in Delta Mahakam, is the combination of swamps, rivers, and offshore, in Kutai Kertanegara Regency, East Kalimantan. Natural gas is the dominant production that delivers to LNG (liquefied natural gas) plant in Bontang.

In order to support the production and operation, Total E&P Indonesie operates vessels between 200 to 300 ships per day in wide range of size. Type of vessel comprising is; sea truck, crew vessel, harbour tug, supply vessel, AHTS, crane barge, and swamp barge. The fuel oil usage today is high-speed diesel (HSD), which cost roughly US$ 100 million per year.

In the situation of current world oil prices are decrease dramatically since the last year from around US$ 100/barrel to US$ 35/barrel. It is very influential to oil and gas production operations, including Total E&P Indonesie. Therefore, an effort to improve efficiency in many aspects is necessity. One of the potential manners is to replace the fuel oil usage with natural gas in the vessels, which operates in Total E&P Indonesie, considering that many available gas that capable to converted to liqufied natural gas (LNG).

Utilization of liquefied natural gas (LNG) as fuel has been applied recently. It is because the manufacturers develop dual fuel engine with higher efficiency where the fuel oil combined with natural gas. It is strongly able to apply to replace fuel oil usage in vessels that operates in Blok Mahakam Total E&P Indonesie. The expectation is to provide benefits in scope of fuel cost reduction and environmental friendly concern.

I.2 Problem Formulation and Scope

The problem identification starts with historical data of the ship which operates in Total E&P Indonesie in recent five years, the average fuel oil consumption, trend of operation order, and the required forecast production based for five years period. It can be defining as the points listed below:

a. How much the average fuel consumption and its equivalent to the liquefied natural gas need?
b. Which one is technically the best consideration between diesel engine modification and engine replacement to occupy the natural gas usage?
c. Which one is the best economic feasible of applying natural gas in diesel engine modification and engine replacement?

I.3 Limitation Study

The focus of the study limited by the points listed below:

a. Assume the operation of Total E&P Indonesie based on the work plan, which has been approved by SKK Migas and estimated according to the condition of the field reservoir.
b. The ships are technical evaluated, chosen by ships that had been operated by Total E&P Indonesie.
c. Assume liquefied natural gas (LNG) plant has been available in Total E&P Indonesie.

d. Piping to utilize liquefied natural gas (LNG) comes from Total E&P Indonesie within the frameworks of the production-sharing contract (PSC).
e. Technical analysis of modification of single fuel engine to dual fuel engine refers to the method and calculation of internal combustion engine, and the products selection that are already on the market in accordance with general recognized organization.
f. The focus study of this research only limited to the gas supply fuel system, exclude to GVU system to its engine.
g. The economic parameters analyzed limited to NPV, ROR, and payback period inside the scope of cost benefit analysis.

I.4 Objective

The objectives of this study is:

a. Technical analysis modification of single fuel engine to dual fuel engine and engine replacement.
b. Technical and economic analysis to acquire the feasibility.

I.5 Benefit

The benefit of the result in this study is:

a. Recommendation to Total E&P Indonesie in scope of fuel cost reduction initiatives for the vessels that operate to fulfill the operation demand of Total E&P today, and PT. Pertamina Hulu Mahakam in 2018.
b. Information of the feasibility in fuel conversion from technical and economic side considering the emission reduction by natural gas usage.

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CHAPTER II
LITERATURE REVIEW

II.1 Theory

II.1.1 Natural Gas

Natural gases generally considered a nonrenewable fossil fuel. (There are some renewable sources of methane, the main ingredient in natural gas, also discussed in this fact sheet.) Natural gas is considered a fossil fuel because natural gas was formed from the remains of tiny sea animals and plants that died 300 to 400 million years ago. (NEED, 2015)

Gaseous hydrocarbon is composed of lighter fractions, of which the more common is methane (CH4) that refer to as natural gas. Liquid petroleum consists of the liquid hydrocarbon but also contain varying proportion of dissolved gases and bituminous materials, it is most commonly called crude oil. (Msaed, 2013)

Natural gas is sold in cubic feet. It can measure the heat contained in all these energy sources by one common unit of measure. The heat stored in a gallon of gasoline, a pound of coal, or a cubic foot of natural gas can all be measured in British thermal units or Btu. One Btu is the amount of heat needed to raise the temperature of one pound of water one degree Fahrenheit. One cubic foot of natural gas has about 1,023 Btu.(NEED, 2015)

Natural gas is usually sold to pipeline companies in standard measurements of thousands of cubic feet (Mcf). One thousand cubic feet of natural gas would fit into a box that is 10 feet deep, 10 feet long, and 10 feet wide. Most residential customers are billed by the number of therms of natural gas they use each month. A therm is a measure of the thermal energy in the gas and is equal to about 98 cubic feet. (NEED, 2015)

II.1.2 Liquefied Natural Gas (LNG)

Made mostly of methane, LNG is natural gas that's liquefied to a much smaller volume and stored and distributed in specially designed and tested containers. It can be used as a replacement for gasoline, diesel or propane. LNG not only costs much less than gasoline and diesel, but also releases fewer pollutants into the air. (Cabot Corp., 2012)

In marine field distribution or usage, the natural gas is liquefied in very low temperatures (about –162) C, or around –260 F, depending on the composition of the natural gas it condenses into a liquid.

II.1.3 Thermal Efficiency

Thermal efficiency can be defined as where the fraction of the heat input that is converted to net work output is a measure of the performance of a heat engine. The net work output (Qout) represents the magnitude of the energy wasted in order to complete the cycle. The value of net work output will never be zero because the net work output of a heat engine is always less than the amount of heat input. Then the thermal efficiency of a heat engine can be expressed as

$$\text{Thermal Efficiency} = \frac{Net\ work\ output}{Total\ heat\ input}$$

Or

$$\eta_{th} = \frac{Wnet, out}{Qin} = 1 - \frac{Qout}{Qin}$$

$$W_{net,out} = Q_{in} - Q_{out}$$

Equation 2.1. Thermal Calculation

Based on its formula, the net value of work output represents the desired output while the required input is the amount of heat supplied to the working fluid.

II.1.4 Heating Value

In order to determine the enthalpy of the reactants, we need to know the value of its heating value that can be measured directly. Heating value of fuel can be defined as the amount of heat released when a unit amount of fuel at room temperature is completely burned and the combustion products are cooled to the room temperature within 25C

Complete combustion can be happened, where all carbon is converted to CO_2, all hydrogen is converted H_2O, all hydrogen is converted to SO_2. Generally, the heating value expressed in joules per kilogram (J/kg) or joules per kilo mole of fuel (Btu/ lb.). However, the performance of combustion equipment can be characterized by combustion efficiency, which can be defined as

$$\eta_{combustion} = \frac{Q}{HV} = \frac{Amount\ of\ heat\ released\ during\ combustion}{Heating\ value\ of\ the\ fuel\ burned}$$

Equation 2.2. Combustion Efficiency Calculation

A 100 percent of combustion efficiency can be happened when the fuel is burned completely and some of gases leave the combustion chamber at room temperature, then the amount of heat released during a combustion process is equal to the heating value of the fuel.

Furthermore, the heating value can be differing as Lower Heating Value (LHV) and Higher Heating Value (HHV). The heating value of fuel can be different, which depends on whether the water in combustion products is in the liquid or vapor form. For Lower Heating Value (LHV) means that the amount of heat released when a specified amount of fuel (usually a unit of mass) at room temperature is completely burned, and the combustion products are cooled to the room temperature when the water formed during the combustion process leaves a vapor. While Higher Heating value (HHV) is the amount of heat released when a specified amount of fuel (usually a unit of mass) at room temperature is completely burned and the combustion products are cooled to the room temperature when the water formed during the combustion process is completely condensed and leaves as a liquid.

$$Heating\ Value = hc \text{ (kJ/kg fuel)}$$

$$HHV = LHV + (mh_{fg})H_2O \text{ (kJ/kg fuel)}$$

Equation 2.3 Heating Value Calculation

II.1.5 LNG Compared with Other Fuels

Liquefied natural gas has been used for many years as a road transportation fuel and more recently for ships. The problem with LNG, and to a lesser extent LNG, is its energy density. LNGs energy is around 22.2 MJ/m3. Petroleum fuels remain better at about 35 – 40 MJ/m3. This means that LNG vessels will have to have large fuel isolated tanks or short distances between refueling. (SGMF, 2014)

II.1.6 Anchor Handling Tug Supply Vessel (AHTS)

Anchor Handling Tug Supply Vessel (AHTS) are mainly use for towing and anchor handling, deep-water inspection and construction work, as well as to carry out regular supply and support duties for the offshore industry. AHTS form as the most important vessel for the offshore industry because without this vessel it would be impossible to place oil rigs in the required sea and oceanic areas. In order to support the operations for offshore industry, AHTS equipped with various functions, such as:

- Fire Fighting Equipment
- Safety/ Lifesaving Equipment
- Communication & Navigation Equipment
- Towing & Anchor Handling Equipment

II.1.7 AHTS Propulsion System

Regarding to anchor handling or towing operations, it’s necessary that AHTS required an adequate power. The power supply for normal operation of the anchor handling or towing winch is take from the same power source for propulsion, such as shaft generator, shaft power take-off (PTO).

However, an independent (redundant) power supply with sufficient capacity for the winch operation it's necessary, in order to ensure the maneuvering capability during handling or towing operations. (ABS, 2011)

Generally, AHTS are propelled by two or more large diesel engines, which are equally fitted with the same power. In the same way as energy saving and environmental friendly purpose, dual fuel diesel engine becomes one of an option.

The dual fuel diesel engine can reduce the total cost of operation and maintenance. Figure 2.1 shows the arrangement of diesel propulsion system for MAN Diesel.

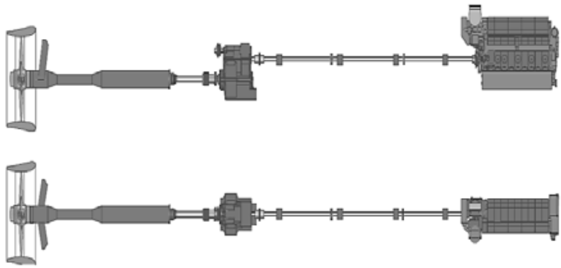


Figure 2.1. Diesel Propulsion System Arrangement (MAN Diesel, 2009)

II.1.8 ISO Tank Container

The double wall tanks consist of two layers, a steel inner tank and an outer jacket in carbon steel with an anti-corrosion coat. Inner and outer tank is separated and filled with insulating powder (perlite) in between. The maximum allowable working pressure for the inner vessels in between 18, 22, or 36 bar gauge for design temperatures range from -196°C up to 20°C. All standard tanks shall have vertical configuration, requiring little space for installation. (Linde AG, 2012)

Fuel tank technology is also available providing several options of fuel tank types. These tanks are double-wall for providing efficient insulation in different ways. LNG is stored in the tanks as a ‘boiling cryogen’ that is a very cold liquid at its boiling point. However, as efficient as the tank may be, it will not keep the LNG cold enough to remain liquid by itself (MEO Australia). As heat is transferred, the pressure in the tank rises as LNG starts evaporating. Under this condition, the gas that boils off needs to be released from the tank in order to control the pressure rates within the tank.

As LNG evaporation cannot be reduced, specialized pressurized tanks can be used to store LNG fuel in order to minimize the need for venting as they can withstand a higher internal pressure and thus increase the time between venting events. However, for the LNG fuelled vessels, where LNG is steadily being withdrawn from the tank to power the engines the pressure can be kept below the venting threshold and actually avoid the need of gases to be released (Lowell, 2013). Venting procedures will only take place if the vessel is idle for a long period.

In that respect, under the ‘auto- refrigeration’ phenomenon, the LNG can stay almost in constant temperature, as the pressure in the tank is kept constant. The boil off gases can also be re-liquefied and return to the tank or to be used for the auxiliary engines but we will have the opportunity to deepen in the boil off phenomenon, both for LNG tanks on the vessel and on shore, at a following section.

It is easy to divide the tank types in two ways. The first one is according to their shape. There are five main shapes for the LNG tanks as shown in the following table. Each tank type has its own features and the suitable type depends on a number of constraints regarding the vessel and its operation (e.g. main dimensions, fuel consumption etc.). The LNG tanks can be located either on the deck or in a tank room within the ship. The most common fuel tank is cylindrical with vacuum insulation. Today, all existing vessels use the pressurized Type C tanks (DNV-Gerd-Michael Wursig, 2013).

Furthermore, the types of gas storage tanks can be classified into two points, such as:

- Membrane Containment Tanks
- Independent Containment Tanks

II.1.8.1 Membrane Containment Tanks

The cargo containment system consists of insulated cargo tanks encased within the inner hull and situated in-line from forward to aft. The spaces between the inner hull and outer hull are used for ballast and will also protect the cargo tanks in the event of an emergency situation, such as collision or grounding. The function of the membranes is to prevent leakage, while the insulation supports and transmits the loads and, in addition, minimizes heat exchange between the cargo and the inner hull. The secondary membrane, sandwiched between the two layers of insulation, not only provides a safety barrier between the two layers of insulation, but also reduces convection currents within the insulation. In addition to the above, the insulation acts as a barrier to prevent any contact between ballast water and the primary barrier, in the event of leakage through the inner hull.

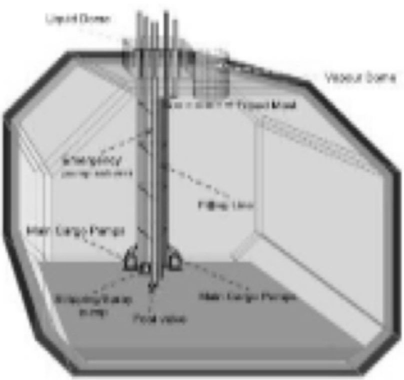


Figure 2.2. Membrane Containment Tanks

II.1.8.2 Independent Containment Tanks

Independent tanks are self-supporting; they do not form part of the ship hull and are not essential to the hull strength. In addition, there are 3 categories of independent tanks are considered:

- Independent tanks type A
  Independent tanks type A, which are designed primarily using Classification Society classical structural analysis procedures. Where such tanks are primarily constructed of plane surfaces (gravity tanks), the design vapor pressure P is to be less than 0,07 N/mm2 (0.7 bar).

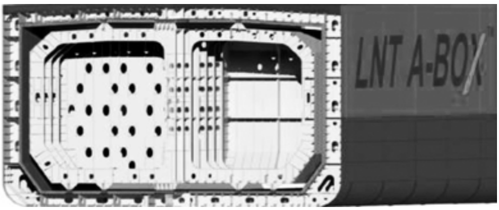


Figure 2.3. Independent tanks type A

- Independent tanks type B
  Independent tanks type B, which are designed using model tests, refined analytical tools and analysis methods to determine stress levels, fatigue life and crack propagation characteristics. Where such tanks are primarily constructed of plane surfaces (gravity tanks), the design vapor pressure P is to be less than 0,07 N/mm2 (0.7 bar).

Figure 2.4. Independent tanks type B

- Independent tanks type C

  Independent tanks type C is the most common, as mentioned earlier, because they are manufactured for low capacity. Their main characteristic is the high-pressure gas, approximately 5 bars, and a maximum allowable working pressure of 20 bars. This allows the provision of directly on machines, without having gone through pumps.

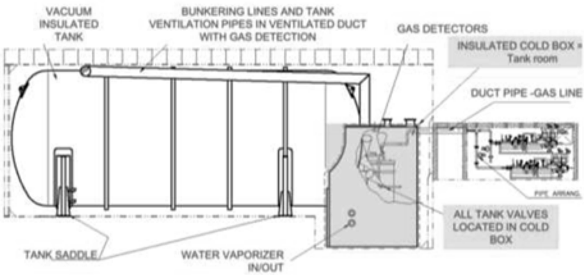


Figure 2.5. Independent tanks type C

II.1.9 Diesel Engine

Generally, diesel engine is a type of internal combustion engine that ignites the fuel by injects it into hot within high-pressure air in combustion chamber. Moreover, the diesel engine operates with different types of cycle such as two stroke or four stroke. In addition, each stroke can be attained in half revolution of the crankshaft.

II.1.9.1 Two Stroke Cycle Engine

The two stroke cycle engine performs the same cycle of events as the four cycle engine i.e. intake, compression, power, and exhaust. But a two-stroke engine requires only two strokes of the piston to complete on full cycle. Furthermore, it requires only one rotation of the crankshaft to complete a cycle. A cross-section of a two-stroke cycle engine is shown in Figure II.2.

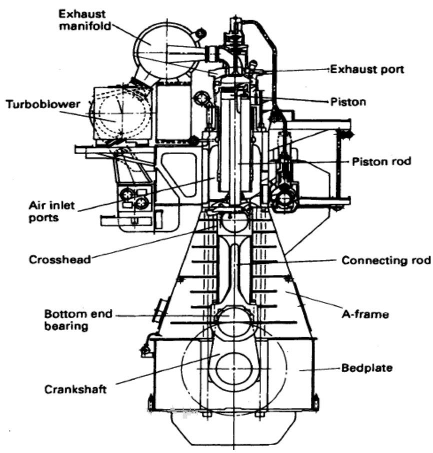


Figure 2.6. Cross-section of a two-stroke diesel engine (D. A. Taylor, 1996)

II.1.9.2 Four Stroke Cycle Engine

In four-stroke cycle engines there are four strokes completing two revolutions of the crankshaft. Respectively, the four strokes are as follows:

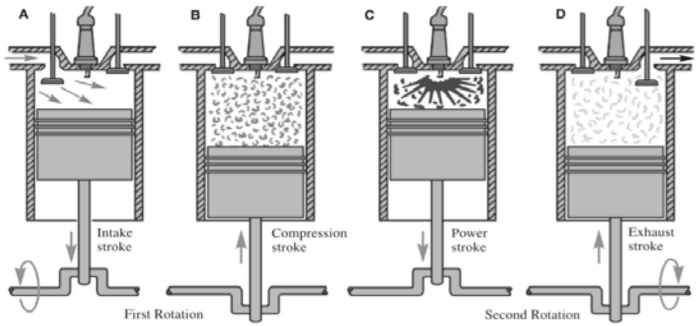


Figure 2.7. Sequence of events in a four-stroke cycle engine (The Goodheart-Willcox Co. Inc, 2009)

- Intake stroke
  According to Figure 2.7.a, it shows that the piston move to downward in the cylinder on the intake stroke. When the piston moves to downward, the volume of space above will be increased. Besides that, a partial vacuum will be created that draws the air fuel mixture through the intake valve port and into the cylinder. When the intake valve open during the intake stroke, atmospheric pressure outside the engine forces air through the carburetor. This means that a large boost will be happened to the air-fuel induction process. According to its process it means that the larger its diameter of the cylinder and the longer the stroke of the piston, the bigger volume of air that entering the cylinder on the intake stroke.

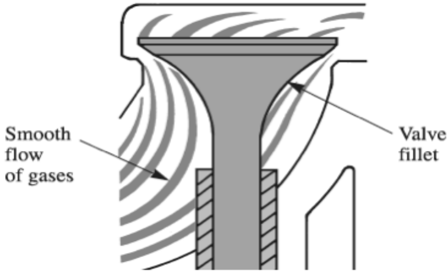


Figure 2.8. Flow of gases that enters the intake valve (The Goodheart-Willcox Co.,Inc, 2009)

According to figure above, the intake valve will perform several key functions. These key functions are as follows;

- it must open at the correct instant to permit intake of air fuel mixture
- it must close at the correct time and seal during compression; and
- the flow of gases must be shaped in streamlined that makes the flow of gases to the combustion chamber will not be obstructed. Based on its temperature, the intake valves are not subjected to as high temperatures as the exhaust valve. The incoming air fuel mixture tends to cool the intake valve during operation.

- Compression stroke

  The compression stroke is created when the piston moving upward in the cylinder. Compression is squeezing process when both valves are closed. On this stroke, the valves are tightly sealed and the piston rings prevent leakage past the piston. While the piston moves upward, the air fuel mixture is compressed into a smaller space. This process will increase the force of combustion for two reasons:

  - When atoms that make up tiny molecules of air and fuel are squeezed closer together, which makes heat created. Spontaneously, each molecule of fuel is heated very close to its flash point. Then, there will be a air-fuel mixture which practically makes a complete combustion.
  - The force of combustion is increased because most molecules are highly activated and striving to move apart. These molecules combined with expanding energy of combustion, which provides tremendous force against the piston.

- Power stroke

  According to Figure 2.7.C, it shows that both valves remain in the closed position. While the piston compresses the charge and reaches the top of the cylinder, the air-fuel mixture will be ignited that can be happened when an electrical spark jumps the gap between the electrodes of spark plug. Next, the force of explosion forces the piston into downward. In addition, the full charge does not burn at once. The flame progresses outward from the spark plug, spreading combustion and providing even pressure over the piston face throughout the power stroke.

The entire fuel charge must ignite and expand in an incredibly short period of time. Most engines have the spark timed to ignite the fuel slightly before the piston reaches top dead center (TDC) of the compression stroke. This provides a little more time for the mixture to burn and accumulate its expanding force. Basically, the amount of power produced by the power stroke depends on the volume of the air-fuel mixture in the cylinder and the compression ratio of the engine. The compression ratio is the proportionate difference in volume of cylinder and combustion chamber at bottom dead center and at top dead center. If the compression ratio is too high, the fuel may be heated to its flash point during the compression stroke and ignite too early.

- Exhaust stroke

  After the piston has completed the power stroke, the burned gases must be removed from the cylinder before introducing a fresh charge. This takes place during the exhaust stroke. According to Figure II.3D The exhaust valve opens and the rising piston pushes the exhaust gases from the cylinder. The exhaust valve has to function much like the intake valve. When closed, the valve must seal. When open, it must allow a streamlined flow of exhaust gases out through the port, which can be seen to Figure II.4. The removal of gases from the cylinder is called scavenging. The passageway that carries away exhaust gases is referred to as the exhaust manifold or exhaust port. Like the intake manifold, the exhaust manifold must be designed for smooth flow of gases.

II.1.10 Comparison of Two Stroke and Four Stroke Engine

Generally, the main difference between the two cycles is the power developed. The two-stroke cycle engine is a type of internal combustion engine that completes a power cycle with two strokes (up and down movements) of the piston during only one crankshaft revolution. This is in contrast to a "four-stroke engine", which requires four strokes of the piston to complete a power cycle. In a two-stroke engine, the end of the combustion stroke and the beginning of the compression stroke happen simultaneously, with the intake and exhaust (or scavenging) functions occurring at the same time. Two-stroke engines often have a high power-to-weight ratio, usually in a narrow range of rotational speeds called the "power band". Compared to four-stroke engines, two-stroke engines have a greatly reduced number of moving parts, and so can be more compact and significantly lighter.

II.1.11 Diesel Injection

The fuel injection system is a vital part of the diesel engine. This system pressurizes and injects the fuel. In this way the fuel is forced into air, which has been compressed to high pressure in the combustion chamber. Furthermore, the types of diesel injection classified into 2 systems such as: conventional diesel injection system & common rail diesel injection system.

II.1.11.1 Conventional Diesel Injection System

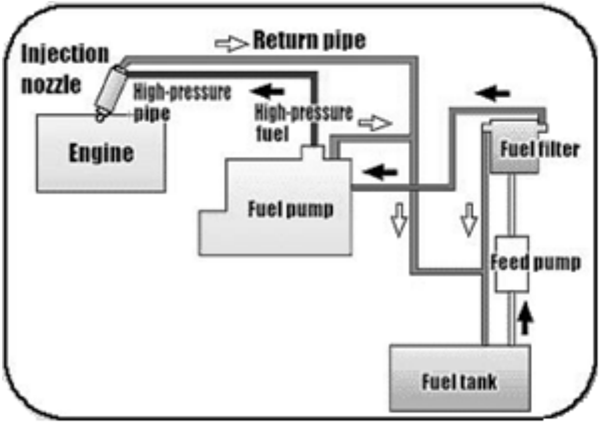


Figure 2.9. Conventional Diesel Injection System (Denso Corp, 2012)

According to Figure II.5, the conventional diesel injection system comprises into several parts such as: Fuel injection pump, injection nozzles, fuel filter, and fuel tank. Basically, the fuel is come from the fuel tanks, which is delivered by feed pump and filtered through the fuel filter. After the fuel filtered through the fuel filter, then the fuel is delivered into the injection pump. The fuel that is delivered to the injection pump is pressurized into highly compressed state, and is delivered via injection steel pipe to the injection nozzles. Then, the fuel is injected in an atomized state into the combustion chamber, where the combustion takes place.

However, an excessive fuel that is delivered to the injection nozzles may return to the fuel tank via overflow pipe. The overflow pipe provided in the fuel filter or in the injection pump itself. The overflow pipe will work automatically when the feed pressure from the feed pump exceeds a prescribed value, which makes the overflow valve opens to allow excess fuel to return to the fuel tank via the overflow pipe.

II.1.11.2 Common Rail Diesel Injection System

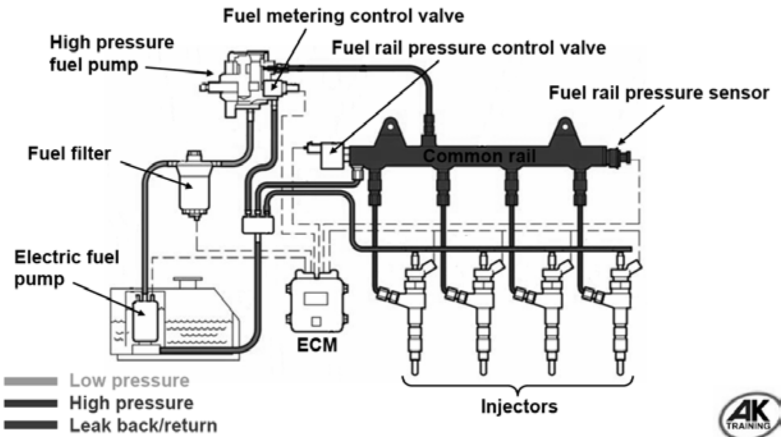


Figure 2.10. Common Rail Diesel Injection System (AK Training, 2012)

Basically, common rail diesel injection system and conventional diesel injection system have the same function to inject the fuel into the combustion chamber. However, common rail diesel engine differs from a conventional diesel engine in several important respects. A conventional diesel engine works via a mechanical injection system, which relies on the engine's diesel injection pump to deliver the required fuel pressure, at the correct time, to the diesel injector in order to allow the injector to operate.

Each individual injector on a conventional diesel engine has its own pipe or "rail" connecting the injector to the mechanical pump, allowing the delivery of fuel to the injector. Common rail diesel injection systems work on a much different principle. In this system the mechanical controls are replaced by electronic controls to allow for more precise metering and timing of the fuel delivery into the engine, and therefore the injection pump is no longer solely responsible for the operation of the injection system. Also, the individual injector rails are replaced by 1 (or 2) "common rail" which operates under a constant high pressure.

There is no injection pump associated with this system, yet a high-pressure pump is still required to deliver the high-pressure fuel to the common rail. The high-pressure pump is capable of producing (depending on the system used) approximately 29000 psi of pressure into the common rail. At the correct time the electronic injector is operated and the fuel is injected into the engine-allowing ignition to occur. The timing and fuel quantity is controlled by an advanced engine management system, which gathers data on the engine conditions via a collection of sensors. All of these sensors measure different system parameters to calculate the correct fueling for the engine at any given moment. Specifically, these are the following function of each component in common rail diesel injection system such as:

II.1.11.3 Engine Control Module (ECM)

Engine Control Module (also called the Powertrain Control Module or PCM) is the brain of the engine management system. It controls the fuel mixture, ignition timing, variable cam timing and emissions control. It constantly monitors emissions performance via its OBD (Onboard Diagnostics) programming, and it oversees the operation of the fuel pump, engine cooling fan and charging system. It also interacts with the transmission controller (if separate), ABS/traction/stability control system, body control module, climate control module and anti-theft system. In short, the engine control module performs a wide variety of functions that are necessary to operate a vehicle.

Figure 2.11. Common Rail Diesel Injection System (AK Training, 2012)

II.1.11.4 Fuel pump

Fuel pump module serves three purposes. The first is to filter the fuel in a gas tank to prevent any debris from getting into the fuel pump. The second is, obviously, to pump gasoline from the gas tank to the carburetor or fuel injection system. The third purpose is to send information to the instrument cluster for the fuel level gauge.

To achieve these three functions, a fuel pump module needs a variety of components. In order to filter the fuel, a fuel pump module needs a fuel inlet strainer. The strainer is the most important component of the module. To pump fuel from a fuel gas tank to the combustion system, the module requires an electric pump, a fuel line, and an electric system to power it. A portion of the electric system also relays information to the instrument cluster that indicates the level of fuel in the tank. This is what controls the gas gauge on the dash.

II.1.11.5 Fuel filter

Fuel filters serve a vital function in today's modern, tight-tolerance engine fuel systems. Unfiltered fuel may contain several kinds of contamination, for example paint chips and dirt that has been knocked into the tank while filling, or rust caused by moisture in a steel tank. If these substances are not removed before the fuel enters the system, they will cause rapid wear and failure of the fuel pump and injectors, due to the abrasive action of the particles on the high-precision components used in modern injection systems. Fuel filters also improve performance, as the fewer contaminants present in the fuel; the more efficiently it can be burnt.

Figure 2.12. Fuel Filter (AK Training, 2012)

II.1.11.6 High-pressure fuel pump

Figure 2.13. High-pressure fuel pump (Bosch, 2012)

The high-pressure fuel pump is the interface between the low pressure and the high-pressure side of the fuel system. Basically, the function of high-pressure fuel pump is to ensure that enough fuel is delivered at sufficient pressure across the engine's entire operating range. This includes delivery of sufficient fuel for a rapid engine start and pressure increased in the rail.

II.1.11.7 Fuel metering control valve

Fuel delivery systems on modern engines use an adjustable fuel pressure, where the pressure is adapted to accommodate the required power output of the engine. The combination of fuel pressure and injector opening time determines the amount of injected fuel in the cylinder. This kind of adaptive fuel pressure control consists of a mechanical high-pressure fuel pump with fuel metering valve. The high fuel pressures used in these systems also improve fuel atomization at the injector nozzle. Moreover, the fuel-metering valve located at back of high-pressure pump. In order to adapt the fuel pressure in the rail, the fuel-metering valve on the mechanical fuel pump controls the amount of fuel entering the pump. The plunger is held fully open by a spring to let fuel pass through. To reduce the amount of fuel, the opening of fuel inlet is reduced by moving the plunger against the spring's pressure, using a magnetic field generated by powering the solenoid. The plunger's position is controlled by the ECU, based on the required engine output and the current fuel pressure measured by the fuel pressure sensor.

Figure 2.14. Fuel metering control valve (Bosch, 2012)

II.1.11.8 Fuel rail pressure control valve

Figure 2.15. Fuel rail pressure control valve (Michel Prazisionstechnik AG, 2011)

Fuel rail pressure control valve for controlling rail pressure can be located at one rail extremity (pump-external FPCV), Figure 1, or at the pump outlet (pump-integrated FPCV), Figure II.12. The pump-external FPCV leads to lower pump manufacturing costs but the proximity of the regulator to the injectors can introduce additional disturbances in injector dynamics. In the pump-integrated PCV solution, the fuel throttled by the control valve joins the leakage flow from the pumping chambers as well as the fuel flowing in the pump's cooling and lubrication circuits. This combined flow is discharged from the pump to return to the fuel tank.

II.1.11.9 Fuel rail pressure sensor

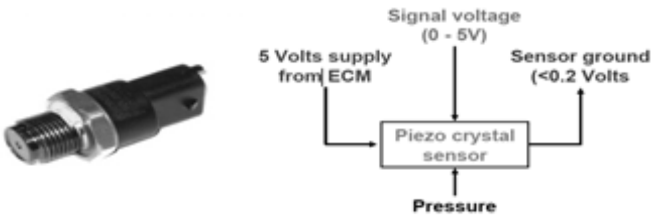


Figure 2.16. Fuel rail pressure sensor (AK Training, 2012)

According to figure, a fuel rail pressure sensor is located on the fuel rail, which is typically a piezo resistive type sensor. Basically, the fuel rail pressure sensor has a function to monitors the fuel pressure in the common rail. Then, the wiring of fuel rail pressure sensor comprises into 3 wires; 5 volt supply from engine ECM, sensor ground via engine ECM, and linear signal voltage output to ECM. The signal is used to enable the engine ECM to determine the fuel rail pressure, and used by the ECM as part of the calculation for the percentage of duty cycle applied to the rail pressure control solenoid and fuel metering solenoid. Moreover, the engine ECM applies a stabilized 5 Volts supply to the signal wire of the fuel pressure sensor. The resistive value of the sensor creates a change in the voltage on the signal wire relative to the fuel rail pressure.

II.1.11.10 Single Fuel to Dual Fuel Modification

Single fuel (diesel engine) to dual fuel diesel engine means existing diesel generation equipment is modified with dual fuel equipment. The main work is modification of the engine itself and addition of the gas fuel equipment. As a precondition of conversion, it is assumed that the generator, auxiliary equipment, etc. are mostly reused without modification.

This means that the initial investment can be reduced to approximately 1/3 of that required for new construction. Moreover, because the construction period is short, the customer can enjoy the higher profit margin resulting from conversion to fuel gas more quickly. (JFE, 2014)

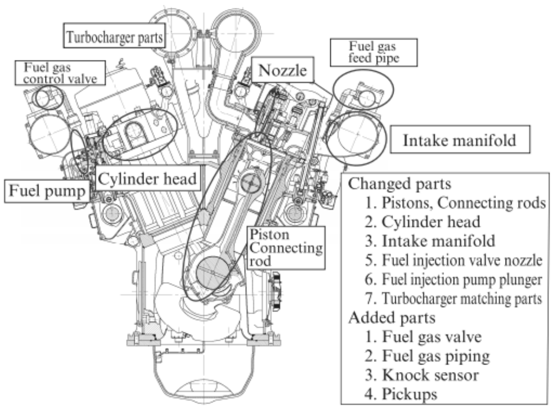


Figure 2.17. Dual Fuel Conversion (JFE, 2014)

II.1.12 Dual Fuel Engine

Nowadays, the dual fuel engines were widely employed for special stationary applications, likely for the generation of power, such as by the oil industry in the field, through cogeneration, the production of sewage gas, which was also used as a fuel for the engine. The supplies of LNG in a several countries have been increased, which also encouraged the engine maker to develop the technologies of engines whether it can operate directly on LNG or its boil off. Recently, the dual fuel system is commercially available that are offered by various manufacturers.

Although the dual fuel engine system can be work adequately, the dual fuel engine system does not necessarily have their operation sufficiently well optimized, especially for its application. For instance, the applications of dual fuel engine have been used in the stationary electric power generation and commercial vehicle sectors, which driven by the rise in the cost of fuels and reduced availability of liquid fuels.

II.1.13 The Conversion of Diesel engines to Dual Fuel Operation

Generally, the conversion of diesel engines to dual fuel operation it depends on the control system if its engine, which suitably must be matched to the operational and design characteristic of the diesel engine to be converted. Within the limitations to the application of universal engine conversion kits, it may become quite restrictive since the corresponding operation of diesel engines of recent design is the subject of demanding performance requirements, particularly in relation to emissions, fuel quality, and efficiency controls.

The implementation of dual fuel technology can improve the control of exhaust gas emissions, which can be happened through treatment of the exhaust gases, Exhaust Gas Recovery (EGR), direct high pressure during gas injection, and turbocharging, development of liquid fuel pilots, cogeneration, computer controls.

However, the conversion of diesel engines to dual fuel operation doesn’t require significant modifications to the engine, in a purpose reducing capital, operational, and maintenance cost. While the operation

II.1.14 Gas Fueled Engine Operation Modes

The premixed dual-fuel engine is basically a conventional compression ignition engine of the diesel type where the injection of some liquid fuel, often in quite small dosages, is used to provide the source for ignition. The cylinder charge is made up mainly of lean mixtures of a gaseous fuel and air such as shown in figure below.

There are a number of variations of this mode of operation, such as having the gaseous fuel injected at very high supply pressures directly into the engine cylinder so that the fuel burns into the wake of the earlier injected and already ignited liquid fuel jet. (Karim, 2015)

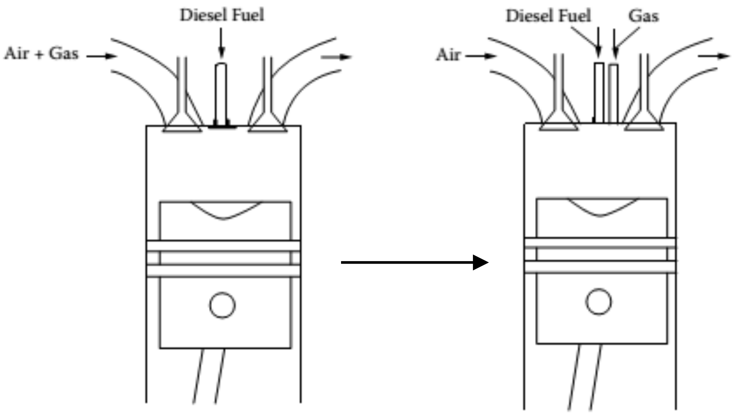


Figure 2.18. A Schematic Representation of A Premixed Dual-Fuel Engine (Karim, 2015)

II.1.15 Economic Analysis

II.1.15.1 Payback

All projects compete for funding and financial managers usually decide where the money goes and which projects get approved. Financial concern may include many different types of financial evaluations such as NPV, IRR, ROA, etc. It is correlated inside the value of payback, which can be defined as project investment per annual saving. (Woodroof, 2011)

II.1.15.2 Net Present Value

Net Present Value is an evaluation method used by financial managers to determine the overall value of a project (or a series of cash flows). NPV represents the value in today's dollars of all future cash flows. The value of money received today is worth more (assuming you can earn interest) than money received in the future. Thus, money received in the future must be "discounted" to estimate its Present Value. (Woodroof, 2011)

II.1.15.3 Internal Rate of Return

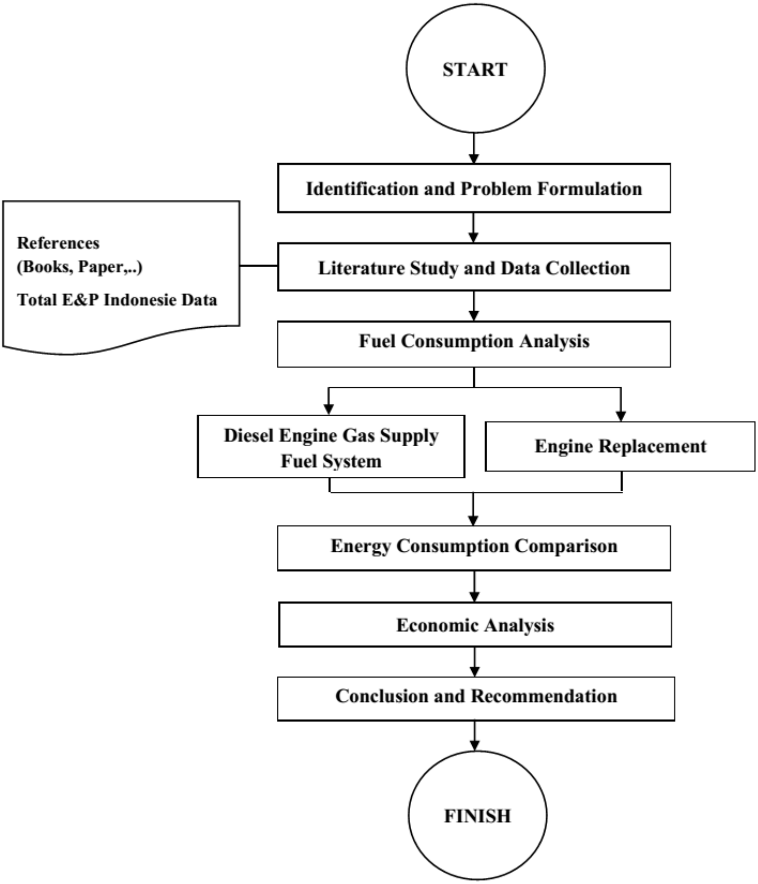
IRR is common financial evaluation metric is called the Internal Rate of Return, which can be derived using similar processes, although using a financial calculator is far quicker. It is important to note that IRR is related to a "project" or set of cash flows. In contrast, the Interest (or discount rate) applied to a project is based on company preference labeled "MARR". A company had their Minimum Attractive Rate of Return "MARR". It basically telling the "hurdle rate" to fund a project. Every company (and person) has a MARR and it basically means that more or better investment, so the project has to have a return greater than the MARR.

II.2 Previous Research

There are many previous researches about the conversion of diesel engine, which is single fuel to dual fuel diesel engine. The different between this study and those study is the scope, the technical and economic study will drive to the recommendation. The result as an information and recommendation to Blok Mahakam operation is the specific aim that creates differences.

CHAPTER III
RESEARCH METHODOLOGY

III.1 Flowchart



In this bachelor thesis, systematical methodology is necessary. In this chapter, explained the methodology that becomes the fundamental step of this study. The stages listed below:

III.2 Identification and Problem Formulation

Identification starts with the specific case that occurs in Blok Mahakam. It generated the problem formulation; the vessel clustering, the average fuel consumption and natural gas equivalent, technical analysis of diesel engine conversion, and the economic anaysis.

III.3 Literature Study and Data Collection

This stage aims to gain an understanding related to the problem. The literature study sources come from; book, journal or paper, technical review, guidance, and other similar. The data collection correlated with the problem is:

a. Historical data or report of the selected E&P Indonesie vessel represents its rated power in last five years.
a. Historical data or report of the selected E&P Indonesie vessel represents its rated power in last five years.
b. Specified diesel engine conversion equipment that available in the national or international market.
c. Specified dual fuel diesel engine for replacement purpose that available in the national or international market.
d. Specified liquefied natural gas storage tank data that available in the national or international market

III.4 Fuel Consumption Analysis

The analysis of fuel oil consumption means the clustering of the fuel oil consumption in specific sailing order. The fuel consumption information gets from the data of Total E&P Indonesie.

III.5 Diesel Engine Gas Supply Fuel System

This stage is an analysis of the equipment adequate for the single fuel engine to dual fuel engine modification. The equipment required for conversion must be available in the national or international market. The cost for that equipment noted for economic analysis purpose.

III.6 Engine Replacement

This stage is an analysis of the single fuel engine replacement. The dual fuel diesel engine aims to replace the single fuel engine.

III.7 Energy Consumption Comparison

Previous result converted to natural gas in liquefied form equivalent for comparison concern. This stage aims to get the comparison between modification engine and replaced engine consumption in the same rated power based on the energy content or heating value (or so called calorific value). The result value converted to the cost form (US$) to get the specific comparison both in technical and economic.

III.8 Economic Analysis

This stage is the input of an output of the technical analysis. The economic analysis for applied system onboard is necessary to acquire the value of investment related to the operational cost. The result is the value of recommendation considering that as the value of feasibility of this study.

III.9 Conclusion and Suggestion

The conclusion of this study based on the result of each stage above. The recommendation is necessary to give the information for further development.

CHAPTER IV
ANALYSIS AND DISCUSSION

IV.1 Vessel Overview

This research was carried out on AHTS Hailey Princess, which are mainly use for towing and anchor handling, deep-water inspection and construction work. The vessel overview is shown on this figure below

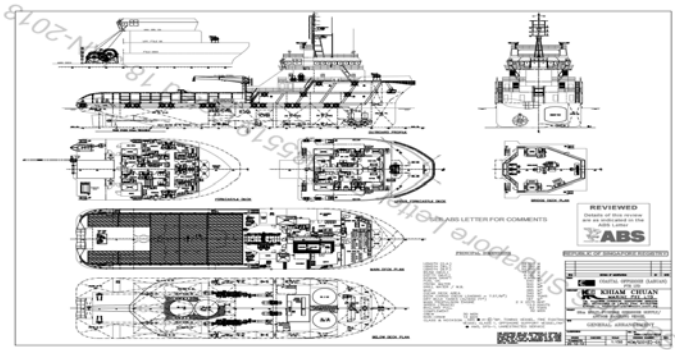


Figure 4.1. General Arrangement of AHTS Hailey Princess (Limin Marine & Offshore, 2013)

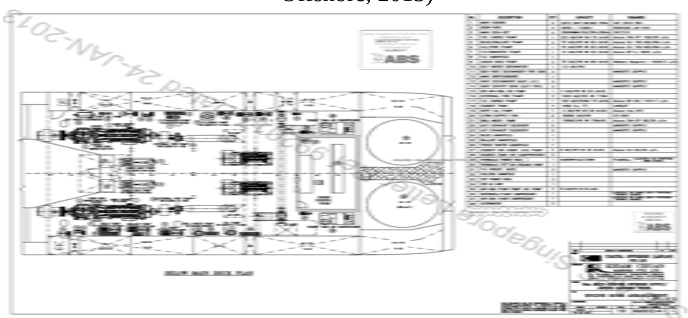


Figure 4.2. Engine Room Layout No.1 of AHTS Hailey Princess (Limin Marine & Offshore, 2013)

Generally, AHTS Hailey Princess were built by Thaumas Marine Ltd in 2013. Based on its ship dimension, this vessel was classified into a several points such as:

- **Main Characteristics**

LOA (Length Overall)	: 59.25 m
Breadth	: 14.95 m
Depth	: 6.1 m
Draft	: 4.95
GRT	: 1,678 T
DWT	: 1,300 T

- **Machinery**

Main Engine	: 2 x 2,575 HP (Caterpillar 3516C)
Reduction Gear	: 2 x *Reintjes* LAF873
Propeller	: 2 x CPP (Controllable Pitch Propeller)

Main Generator	: 2 x 350 kW (Caterpillar C18)
Shaft Generator	: 2 x 800 kW, 415V,3pH/50Hz
Emergency Diesel Gen	: 1 x 65 kW (Caterpillar C4.4)

According to its operation, the vessel mostly was operated in Delta Mahakam, which is surrounded by swamps, rivers, and offshore. However, this vessel works in different order and sailing profile.

This may be happened because the operation of its vessel were depends on the daily activities. For example, in day 1 there is anchoring activities while in day 2 the vessel works for a patrol near the working area. The different activities of its vessel will affect to the fuel consumption, whether in daily, monthly or annual.

According to its activities, the vessel was operated in a different sailing order. The sailing order were managed by contract between the client and operator before the operation. After reach the contract, there are an information for the sailing order that required for its operation, which are consists of speed and rpm.

IV.2 Fuel Consumption Analysis

Main engine is not working in constant condition. It is often for a marine vessel works in different order and sailing profile. The clustering of fuel oil consumption based on the sailing order will show the percentage of certain sailing order for certain consumption, whether it is daily, monthly, or annual average.

That is because the analysis will be based on the average fuel oil consumption per day, it is possible to construct the average of daily consumption information to monthly average and annual average. The sailing order condition, such as speed and rpm, managed by contract before operation. Several sailing order in this case is shown below:

- Full Speed (10.3 knots with 1300 rpm)
- Economical Speed (6.55 knots with 1100 rpm)
- Maneuvering (2.45 knots with 800 rpm)
- Towing (2.45 knots with 800 rpm)
- Stand by (0 knots with 650 rpm)

The contract (agreement) which define those sailing order attached in the end of this bachelor thesis. Daily report of the operation contains the duration of certain order and the total fuel oil consumption. In this case, the fuel oil consumption analysis limited for the main engine. Based on that, constructed the monthly average of fuel oil consumption.

One of the example of monthly average of January 2015 shown in the Table IV.1. Related with the monthly averages which gained, comes the graphic shown the fuel oil consumption trend start from December 2014 to February 2016.

Table 4.1 Fuel Oil Consumption Average January 2015

DATE	UTILIZATION (hours)					HSD (ltr)	LNG (m^3)
	FULL	ECO	MANEU	TOW	STAND		
1-Jan-15		8.50	7.50		7.25	7045.00	11.95
2-Jan-15			7.25		16.75	6956.00	11.80
3-Jan-15	5.08		13.66			7184.00	12.19
4-Jan-15		2.75	3.42			1679.00	2.85
5-Jan-15		2.75	11.75			3432.00	5.82
6-Jan-15	0.75	3.00	7.75			3068.00	5.21
7-Jan-15		5.75	7.50			3323.00	5.64
8-Jan-15		6.00	5.83			3213.00	5.45
9-Jan-15		5.75	2.66			2402.00	4.08
10-Jan-15		3.00	8.42			2672.00	4.53
11-Jan-15		6.08	0.66			1988.00	3.37
12-Jan-15		6.42	5.50			3240.00	5.50
13-Jan-15	6.00	4.83	2.83			5533.00	9.39
14-Jan-15			22.17			4382.00	7.44
15-Jan-15	1.66	9.66	12.50			7145.00	12.12
16-Jan-15			24.00			6680.00	11.33
17-Jan-15			24.00			6359.00	10.79
18-Jan-15	9.25	4.42	2.66			7248.00	12.30
19-Jan-15			24.00			6033.00	10.24
20-Jan-15		4.50	19.50			6243.00	10.59
21-Jan-15		4.33	7.66			3038.00	5.15
22-Jan-15		5.25	8.75			3945.00	6.69
23-Jan-15		5.75	4.42			2752.00	4.67
24-Jan-15	1.00	6.75	1.33			2900.00	4.92
25-Jan-15		5.50	4.75			2683.00	4.55
26-Jan-15		4.33	8.42			3503.00	5.94
27-Jan-15		4.25	8.66			3507.00	5.95
28-Jan-15		5.25	5.50			2884.00	4.89
29-Jan-15		4.25	10.75			3907.00	6.63
30-Jan-15		5.42	1.50		1.17	2254.00	3.82
31-Jan-15		5.33	2.83		1.33	2684.00	4.55
AVERAGE	3.96	5.19	8.97		6.63	4189.74	7.11
PRICE (US$)						6284.61	1431.46

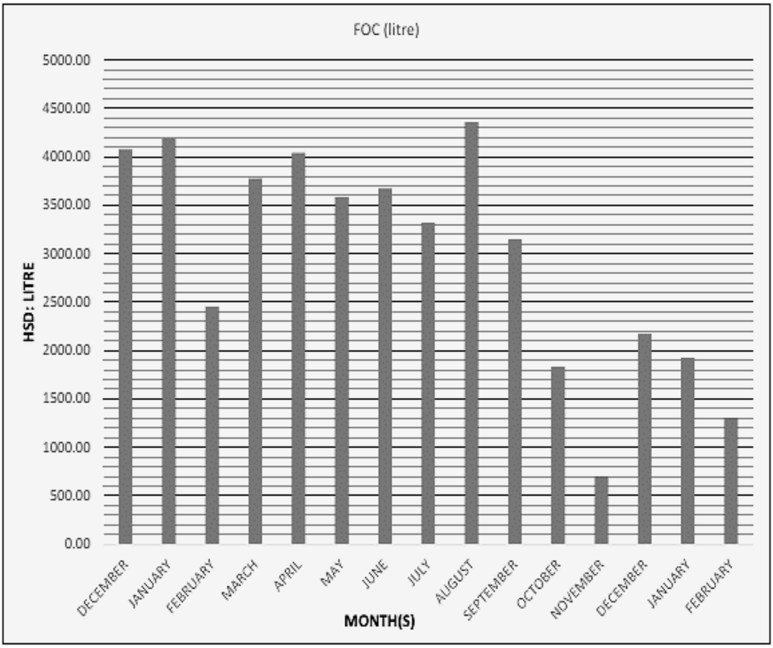


Figure 4.3. Daily Fuel Oil Consumption Average in Different Month

Table 4.3 shown the gather of daily information to monthly average. The table is applied for the other month. The monthly average later summarized in one table to makes easier for converting to its LNG equivalent, like shown in the Table IV.2. Besides, the figure above explains that the major trend of the operation which consumes more fuel is between April 2015 to August 2015. For the other monthly average detail table attached in the end of this bachelor thesis.

Table 4.2. Monthly Fuel Oil Consumption Average Summary

	MONTH	UTILIZATION (hours)					HSD (ltr)
		FULL	ECO	MANEU	TOW	STAND	
14	DECEMBER	3.40	6.67	7.43	0.00	5.90	4078.55
15	JANUARY	3.96	5.19	8.97	0.00	6.63	4189.74
15	FEBRUARY	0.75	6.61	2.21	0.00	1.70	2458.43
15	MARCH	3.44	3.70	6.09	0.00	12.82	3779.65
15	APRIL	3.37	1.03	5.17	0.00	12.15	4043.32
15	MAY	4.01	1.22	5.63	0.00	11.61	3584.19
15	JUNE	2.89	0.71	6.71	0.00	10.54	3672.68
15	JULY	3.55	0.74	5.32	0.00	10.44	3320.87
15	AUGUST	4.92	0.73	7.59	0.00	9.35	4359.68
15	SEPTEMBER	5.27	1.05	7.30	0.00	9.59	3151.90
15	OCTOBER	4.19	1.52	12.13	0.00	6.30	1836.55
15	NOVEMBER	0.25	0.00	14.49	0.00	9.32	695.57
15	DECEMBER	4.61	0.96	9.82	13.21	8.08	2179.35
16	JANUARY	5.15	1.23	16.60	11.71	3.24	1926.61
16	FEBRUARY	4.92	1.02	10.16	0.00	11.62	1298.64
	AVERAGE	3.43	1.96	7.62	1.10	9.04	2971.72
	PRICE (US$)						4457.57

The table above shown the monthly average consumption. It explains that the operation which consumes less HSD is between October 2015 to February 2016. The final average in the bottom defines the daily average of the sailing order and fuel oil consumption for the duration December 2014 to February 2016. The Price in US$ gain from the pick point US$ 1.5 per liter HSD.

The LNG equivalent to replace certain HSD comes from the conversion by lower heating value based. The equivalent value based on the calorific value (Q) in MJ of the HSD. The conversion equation shown below, comes with the value of GCV and ρ shown in the Table IV.3.

$$Q\left(\frac{MJ}{day}\right) = HSD\left(\frac{ltr}{day}\right) . LHV\left(\frac{MJ}{kg}\right) . \rho_{HSD}\left(\frac{kg}{m^3}\right) . 0.001(\frac{m^3}{ltr})$$

Equation 4.1. Calorific Value Calculation

$$LNG\ Equivalent\left(\frac{m^3}{day}\right) = \frac{Q\left(\frac{MJ}{day}\right)}{GCV_{GAS}\left(\frac{MJ}{m^3}\right) /\ \rho_{GAS}\left(\frac{kg}{m^3}\right) \cdot\ \rho_{LNG}\left(\frac{kg}{m^3}\right)}$$

Equation 4.2. LNG Equivalent Calculation

Table 4.3. LNG Equivalent Variable Value

PHYSICAL CONVERSION				
HSD	LHV	=	42.79	MJ/kg
	ρ	=	991	kg/m3
	litre	=	0.001	m3
LNG (Badak)	GCV	=	43.90	MJ/m^3
	ρ(gas)		0.801	MJ/m^3
	ρ(LNG)	=	456	MJ/m^3
PRICE				
HSD		=	1.5	$/litre
LNG		=	8.5	$/MMBTU

The table above shown the supporting variable for LNG Equivalent Calculation. The HSD comes with general properties and the LNG comes with Badak LNG properties which will conduct the LNG bunkering in this case. The price is fluctuating depend on the international oil price. The calculation of LNG Equivalent will result as shown below.

Table 4.4. LNG Equivalent Calculation Result

	MONTH	HSD (ltr/day)	Q (MJ/day)	LNG Equivalent (m^3/day)	LNG Equivalent (ton/day)
14	DECEMBER	4078.55	172954.44	6.92	3.16
15	JANUARY	4189.74	177669.70	7.11	3.24
15	FEBRUARY	2458.43	104251.83	4.17	1.90
15	MARCH	3779.65	160279.18	6.41	2.92
15	APRIL	4043.32	171460.66	6.86	3.13
15	MAY	3584.19	151990.89	6.08	2.77
15	JUNE	3672.68	155743.12	6.23	2.84
15	JULY	3320.87	140824.46	5.63	2.57
15	AUGUST	4359.68	184875.96	7.40	3.37
15	SEPTEMBER	3151.90	133659.10	5.35	2.44
15	OCTOBER	1836.55	77880.45	3.12	1.42
15	NOVEMBER	695.57	29496.12	1.18	0.54
15	DECEMBER	2179.35	92417.46	3.70	1.69
16	JANUARY	1926.61	81699.72	3.27	1.49
16	FEBRUARY	1298.64	55070.09	2.20	1.00
	AVERAGE	2971.72	126018.21	5.04	2.30

Table 4.5. Daily LNG Equivalent Calculation with Price

	MONTH	UTILIZATION (hours)					HSD (ltr)	LNG (m^3)
		FULL	ECO	MANEU	TOW	STAND		
14	DECEMBER	3.40	6.67	7.43	0.00	5.90	4078.55	6.92
15	JANUARY	3.96	5.19	8.97	0.00	6.63	4189.74	7.11
15	FEBRUARY	0.75	6.61	2.21	0.00	1.70	2458.43	4.17
15	MARCH	3.44	3.70	6.09	0.00	12.82	3779.65	6.41
15	APRIL	3.37	1.03	5.17	0.00	12.15	4043.32	6.98
15	MAY	4.01	1.22	5.63	0.00	11.61	3584.19	6.08
15	JUNE	2.89	0.71	6.71	0.00	10.54	3672.68	6.33
15	JULY	3.55	0.74	5.32	0.00	10.44	3320.87	5.63
15	AUGUST	4.92	0.73	7.59	0.00	9.35	4359.68	7.40
15	SEPTEMBER	5.27	1.05	7.30	0.00	9.59	3151.90	5.35
15	OCTOBER	4.19	1.52	12.13	0.00	6.30	1836.55	3.12
15	NOVEMBER	0.25	0.00	14.49	0.00	9.32	695.57	1.18
15	DECEMBER	4.61	0.96	9.82	13.21	8.08	2179.35	3.70
16	JANUARY	5.15	1.23	16.60	11.71	3.24	1926.61	3.27
16	FEBRUARY	4.92	1.02	10.16	0.00	11.62	1298.64	2.20
	AVERAGE	3.43	1.96	7.62	1.10	9.04	2971.72	5.06
	PRICE (US$)						4457.57	1886.75

The table above can be presented as the graphic below. It shows the cost comparison of LNG and HSD in monthly average. The price difference depends on the fluctuation of crude oil price in US$ unit.

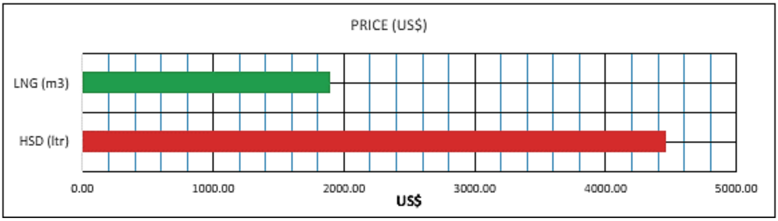


Figure 4.4. Average Cost Comparison between LNG and HSD

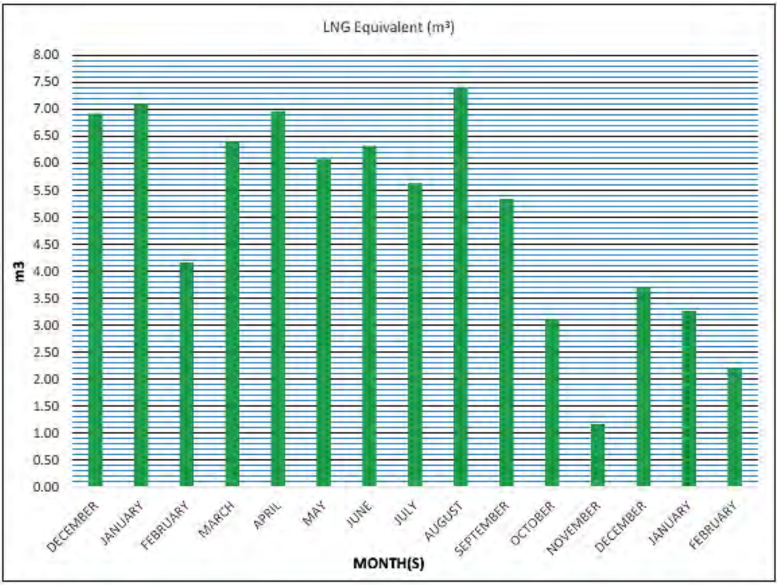


Figure 4.5. Daily LNG Consumption Average in Different Month

The figure above explains that the major trend of the operation which consumes more LNG is between April 2015 to August 2015. It is LNG Equivalent to HSD in full (100%) scenario. It is likely to create scenario or percentage of equivalence due to the operation of converted engine.

IV.3 Substitution of Bi-Fuel

On this stage, there will be a calculation for the substitution of Bi-Fuel. The calculation for the substitution of Bi-Fuel are based on the result of daily average in different month, which created several equivalence scenarios. Its presents percentage of usage of HSD and LNG. The table shown the scenarios presented below.

Table 4.6. Daily Average HSD Consumption and Its LNG Equivalent

	UTILIZATION (hours)					HSD (ltr)	LNG (m^3)
	FULL	ECO	MANEU	TOW	STAND		
AVERAGE	3.43	1.96	7.62	1.10	9.04	2971.72	5.06
PRICE (US$)						4457.57	1018.11

Table 4.7. Daily LNG Equivalent Percentage Scenarios

PERCENTAGE		DAILY CONSUMPTION		PRICE (US$)		COST (US$)
HSD	LNG	HSD (ltr)	LNG (m^3)	HSD	LNG	
30.0%	70.0%	891.51	3.54	1337.27	712.68	2049.95

From the table above, it shows that the selected percentage scenarios are 40% of HSD and 60% of LNG. The selected percentage were chosen by a consideration that most of the dual fuel engine that've been operated in industrial have a percentage of 40% of HSD and 60% of LNG. This consideration was supported by the fact of industrial brochure. After choosing the selected percentage, then it comes with the cost combination of HSD and LNG inside those scenarios.

The projection of the daily average cost information is rational to monthly and yearly preposition. It gives the trend of the cost combination created by LNG and HSD due to the combined operation, which have been selected for 40% of HSD and 60% of LNG.

Table 4.8. Cost Projection of LNG Equivalent Scenarios (selected)

	DAILY		MONTHLY		YEARLY	
	HSD	LNG	HSD	LNG	HSD	LNG
	1337.27	712.68	40118.1585	21380.3345	481418	256564

With Inflation rate 5% per year, the cost projection for the next twenty years of each scenario can be gain (from 2015 to 2035). In the actual condition, the rate will be fluctuating, in aim of analysis-it is considered to be constant. For the Cost Projection of LNG Equivalent Scenarios Graph attached in the end of this bachelor thesis.

Table 4.9. Cost Projection of LNG Equivalent Scenarios 2015 to 2035

	2015		2016		2017	
	HSD	LNG	HSD	LNG	HSD	LNG
	481418	256564	505489	269392	530763	282862
	2018		2019		2020	
	HSD	LNG	HSD	LNG	HSD	LNG
	557301	297005	585166	311855	614425	327448
	2021		2022		2023	
	HSD	LNG	HSD	LNG	HSD	LNG
	645146	343820	677403	361011	711273	379062
	2024		2025		2026	
	HSD	LNG	HSD	LNG	HSD	LNG
	746837	398015	784179	417916	823388	438812
	2027		2028		2029	
	HSD	LNG	HSD	LNG	HSD	LNG
	864557	460752	907785	483790	953175	507979
	2030		2031		2032	
	HSD	LNG	HSD	LNG	HSD	LNG
	1000833	533378	1050875	560047	1103419	588049
	2033		2034		2035	
	HSD	LNG	HSD	LNG	HSD	LNG
	1158590	617452	1216519	648324	1277345	680741

IV.4 Engine Replacement Scenarios

Based on the vessel overview, it's known that on AHTS Hailey Princess were mounted with in main engine from Caterpillar 3516C. The information of the existing engine is shown below.

- Main Engine : 2 x 2,575 HP (1920 kW), Caterpillar 3516C
- Reduction Gear : 2 x Reintjes LAF873
- RPM : 1600
- Max. Length : 3716 mm
- Max. Height : 2150 mm
- Min. Dry Weight : 79610 kg

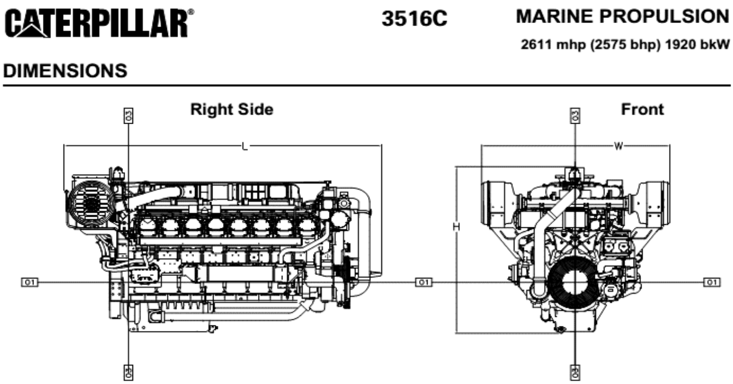
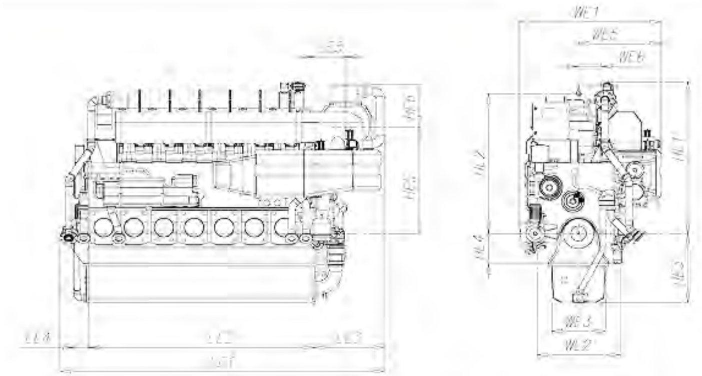


Figure 4.6. Engine Dimension of Caterpillar 3516C

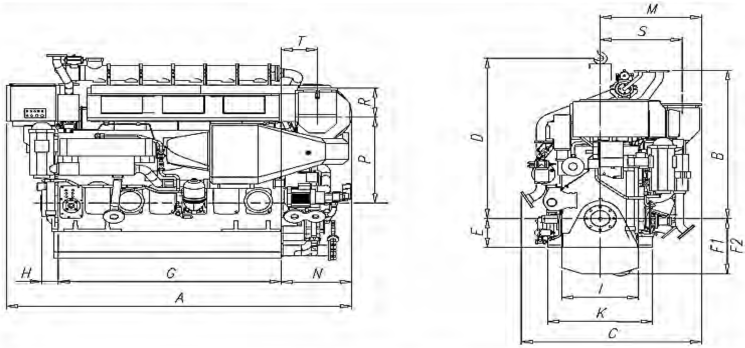
The engine replacement scenarios are depending on the information of the existing engine. For this case, the existing engine is replaced whether by dual fuel engine or gas engine. Therefore, it's possible for us to find the new engine which have a similar specification compare to the existing one by finding similar engine output and rpm.



Engine	kW/Cyl	LE1	HE1	WE1	HE2	HE4	HE3	LE2	LE4
Wärtsilä 8L34DF	500	5960	2550	2610	2345	500	1155	4230	250

Engine	kW/Cyl	WE2	WE5	LE3	HE5	HE6	WE6	LE5	WE3	Weight
Wärtsilä 8L34DF	500	1350	1650	1285	1718	607	1340	705	880	44

Figure 4.7. Engine Dimension of Wartsila 34DF (Dual Fuel)



Engine type	A	B	C	D	E	F1	F2	G	H
W 9L20DF	4076	1706	1824	1800	325	624	824	2980	155

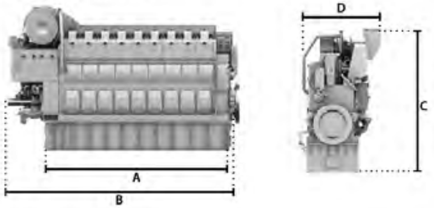
F1 for dry sump and F2 for deep wet sump

Engine type	I	K	M	N	P	R	S	T	Weight
W 9L20DF	718	980	1084	731	1000	390	863	339	11.7

Figure 4.8. Engine Dimension of Wartsila 20DF (Dual Fuel)

Propulsion engines - Gas

Bergen C26:33L



Principal dimensions

Cylinder diameter 260mm. Piston stroke 330mm.

Engine Type	A	B	C	D	Weight Dry Engine
C26:33L8PG	3930	4796	3195	1748	20700kg

Technical data

Engine Type		C26:33L8PG*
Number of cylinders		8
Engine speed	r/min	900/1000
Mean piston speed	m/s	10/11
Max. continuous rating (MCR)	kW	1940/2160
Max. continuous rating (MCR)	BHP (metric)	2675/2935
Mean effective pressure (BMEP)	bar	18.5
Specific energy consumption	kJ/kWh	7450/7500
Specific lubricating oil consumption	g/kWh	0.4
Cooling water temp. engine outlet	°C	90

* In progress • release date to be announced at a

All data subject to change without prior notice

Figure 4.9. Engine Dimension of Bergen C26:33L (Gas Engine)

The figure above shown the new engines, which have the same engine output and rpm.

After finding a similar engine output and rpm for the new engine, it's necessary that we have to look over again to the contract. The contract stated that there are several sailing order of its vessel, which are classified into full speed, economical speed, maneuvering, and stand by condition within each speed and rpm. Based on the information of its contract, it's is possible to know the new rpm of each sailing order for the new engine. This thing can be calculated by divided the rpm of each sailing order with the rpm of existing engine.

Therefore, known the percentage of its rpm over the existing engine rpm. In order to find the new rpm of each sailing order for the new engine, we have to multiply the cylinder of its engine with the percentage of its rpm. This can be seen by the table below.

Table 4.10. Sailing order with existing engine

	VS	RPM	
FULL SPEED	10.30	1300	81.25%
ECONOMICAL SP	6.55	1100	68.75%
MANEUVER	2.45	800	50.00%
STAND BY	0.00	650	40.63%
(based on Agreement Letter 16 Nov 2015)			

Table 4.11. Sailing order with new rpm

	VS	RPM	
FULL SPEED	10.30	609	81.25%
ECONOMICAL SP	6.55	516	68.75%
MANEUVER	2.45	375	50.00%
STAND BY	0.00	305	40.63%
(Wartsila 6L34DF)			

Based on the project guide of its engine, there is an information for the fuel consumption of its engine within a variation of load. By knowing the information of fuel consumption of its engine within a variation of load from the project guide, it's possible to calculate the new specific fuel oil consumption. It's shown by the table and figure below.

Table 4.12. New SFOC of HSD and LNG for Wartsila 6L34DF in Gas Mode

GAS MODE	
LNG	
Power (%)	SFOC (kJ/kWh)
100	7629
75	8010
54	8161
50	8153
32	8552
12	9348
7	9906
HSD	
Power (%)	SFOC (g/kWh)
100	2
75	2.7
54	4
50	4.5
32	6
12	9
7	10

Table 4.13. New SFOC of HSD for Wartsila 6L34DF in Diesel Mode

DIESEL MODE	
HSD	
Power (%)	SFOC (g/kWh)
100	193
75	187
54	191
50	192
32	202
12	220
7	227

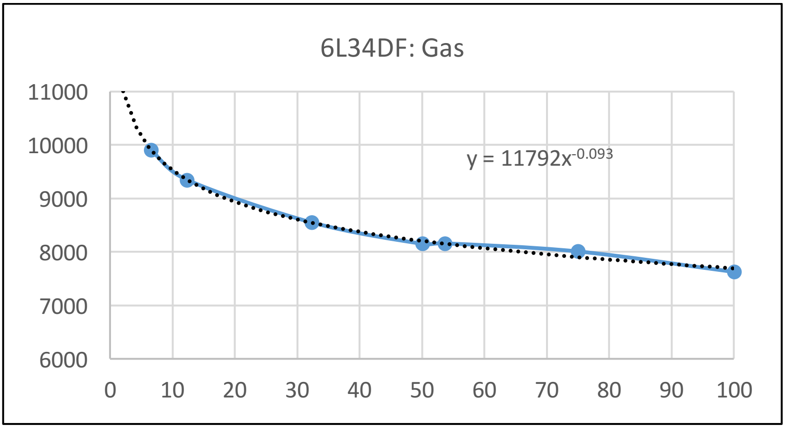


Figure 4.10. New SFOC of LNG for Wartsila 6L34DF in Gas Mode

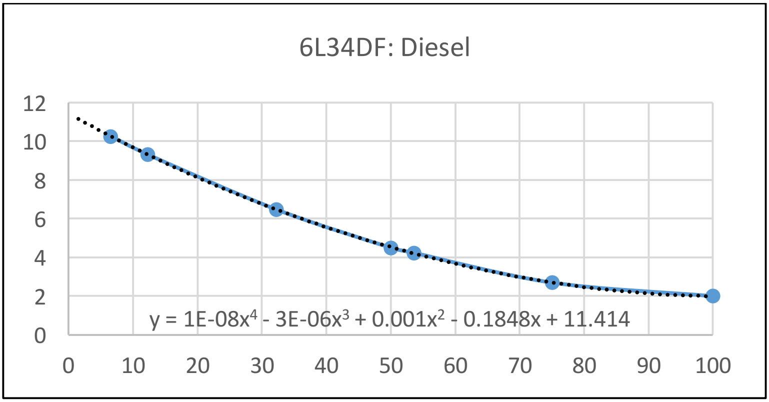


Figure 4.11. New SFOC of HSD for Wartsila 6L34DF in Gas Mode

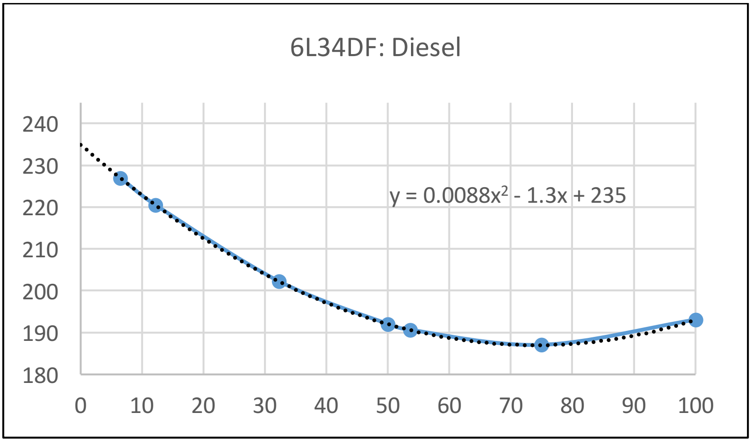


Figure 4.12. New SFOC of HSD for Wartsila 6L34DF in Diesel Mode

IV.5 Conversion

IV.5.1 Conversion Process Flow

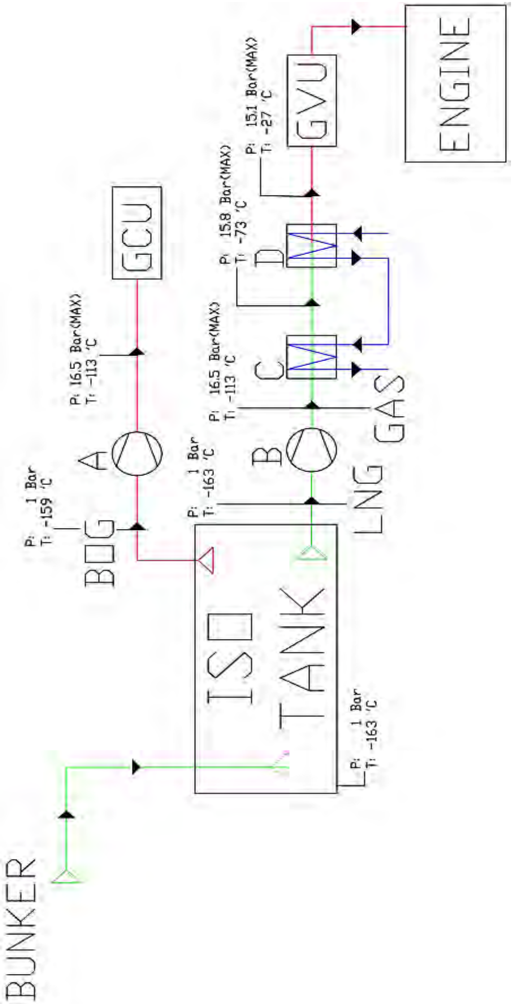


Figure 4.13. Process Flow Diagram of Gas Supply

The process flow diagram of gas supply is shown in figure above, which first comes from the bunkering of LNG. The bunkering of LNG may come from different concepts such as: Truck to ship, Port to Ship, Ship to Ship. Therefore, the LNG will be stored in ISO Tank(s) within a certain capacity and temperature (-163 C approximately). The contents of the ISO Tank(s) range from 20 feet to 40 feet. The distribution of LNG goes into two different pipes such as: BOG pipe, and LNG pipe.

IV.5.2 LNG ISO Tank(s) Scenarios

With endurance assumption 10 day(s), the duration where the LNG capable to serve before it has to bunker. It is able to consider the usage of ISO tank which adequate LNG fuel above the vessel.

Table 4.14. LNG ISO Tank Options

DANTECO Industries		
Type	Portable Tank T11	
Capacity	23750	litre (95%)
Dimension	20	feet

WESSINGTON Cryogenics		
Type	ISO VAC 40-LNG	
Capacity	41325	litre (95%)
Dimension	40	feet

CHART LNG ISO Intermodal		
Type	ICC-20-P-10	
Capacity	19352	litre (95%)
Dimension	20	feet

ARGON ISO TANK		
Type	10 FEET ISO TANK	
Capacity	7570	litre (95%)
Dimension	10	feet

Table 4.15. LNG ISO Tank Scenarios

10 DAYS (ltr)		SCENARIOS 20' + 10' (units)	SCENARIOS 40' (units)	SCENARIOS 40' (units)
HSD	LNG	2 DANTECO + 1 ARGON	1 WESSI	2 CHART
6769.57	30527.15	55070.0	41325.0	38703.0

Table IV.10 shown the possible scenarios using different size and brand of LNG ISO Tank. It is considered to use 20 feet or 40 feet LNG ISO Tank to minimize the required space onboard. It is important for minimize additional space for LNG fueled equipment to optimize the function and operation of a vessel.

IV.5.3 Boil-Off Gas Scenarios using LNG ISO Tank

According to its definition, the boil-off gas is a cryogenic fluid which is typically kept at low temperature in a ISO tank(s) or storage. However, the storage has a major challenge due to the inherent heat input which come from the environment. In addition, the effect of the heat input is warming of the cryogenic fluid within a condition: If the cryogenic fluid have a constant volume, so the pressure will get increase in the storage vessel while if the cryogenic fluid have constant pressure, so the fluid boil and boil-off vapors are released from the its venting. In accordance to this fact, it is important for us to consider the boil off gas scenarios in relation with the safety aspect.

Table 4.16. Boil-Off Gas Scenarios

	10 DAYS (ltr)	DAILY BOG RATE (ltr)
	LNG	LNG
	87.08	8.7

The table above shown the possible boil- off scenarios using CHART LNG ISO Intermodal 20 feet (the selected LNG ISO Tank) and ARGON ISO Tank 10 feet, within an estimation for 10 days and daily BOG rate. The CHART 20 feet ISO Tank have a maximum capacity of 20,370 litre. While, the ARGO ISO Tank have a 7,570 litre.

However, the usage of its ISO Tank may only come through 95% of its maximum capacity. According to its calculation, the BOG scenarios results may come from the multiplication of 95% of its maximum capacity, amount of selected ISO Tank, and assumption BOG rate within 0.15% approximately.

IV.5.4 Pipe Diameter Calculation for BOG & LNG

$$db = 0{,}0189 \text{ x } \sqrt{\frac{Qe}{Vc}}$$

Equation 4.3. Pipe Diameter Calculation

The pipe diameter can be calculated when volumetric flow rate and velocity is known. According to its equation, m = mass flowrate of fluid, ρ LNG = density of LNG, db = pipe diameter, Qe = volumetric flow rate, Vc = fluid velocity. Using these variable, its possible to calculate the pipe diameter as well as it shown on this table below.

Table 4.17. Pipe Diameter Calculation

PIPE CALCULATION				
Equation	Physical Conversion			
$db = 0{,}0189 \text{ x } \sqrt{\frac{Qe}{Vc}}$	m (BOG)	=	0.00007	kg/s
	m (LNG)	=	0.00004	kg/s
	ρ(LNG)	=	456	kg/m^3
	Vc	=	2.00000	m/s
	Results of Calculation			
BOG	Qe (BOG)	=	0.00001	m3/s
	db	=	0.00001	m
	db	=	0.0002	inch
	db	=	0.25	inch
	db	=	6.0	mm (JIS)
LNG	Qe (LNG)	=	0.00000	m3/s
	db	=	0.00000	m
	db	=	0.00017	inch
	db	=	0.25	inch
	db	=	6	mm (JIS)

IV.5.5 LT & HT Vaporizer Calculation for LNG & Coolant

$$Q = m.Cp. (T_2 - T_1)$$

Equation 4.4. Energy Transferred Calculation

The energy transferred can be calculated through these variables such as: m = mass flow rate of fluid, Cp = specific heat capacity of fluid, (T2-T1) = temperature change.

Therefore, the area & n-tube of its heat exchanger can be calculated through these 2 equations below.

$$Q = U \times A \times \Delta T_m$$

$$A = Q/ (U \times \Delta T_m)$$

$$\Delta T_m = \frac{(T_1 - t_2) - (T_2 - t_1)}{\ln \dfrac{(T_1 - t_2)}{(T_2 - t_1)}} = \ ^\circ F$$

$$A_i = n\pi D_i L$$

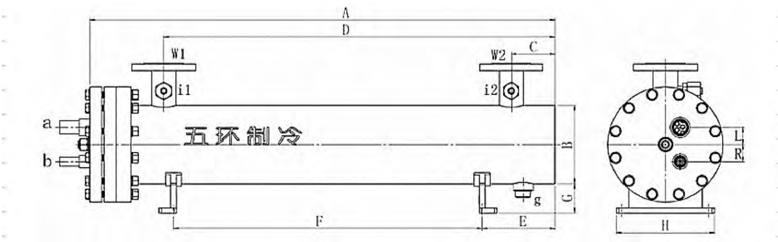
Equation 4.5. Heat Exchanger Area & n-tube calculation

In order to calculate the area of its heat exchanger, it's necessary to have these variables such a: Q = energy transferred, U = overall heat transfer coefficient, ΔTm = log mean temperature difference. While, n-tube of its heat exchanger can be calculated after we know the area of its heat exchanger, D = dinner, and L = length of HE design.

By using those equation, it's possible to calculate the area & n-tube of its heat exchanger as well as it shown on this table below

Table 4.18. Calculation of Heat Exchanger

HE Calculation					
LT Vaporizer			HT Vaporizer		
1) Q (LNG)	8.040	Joule	1) Q (LNG)	20.101	Joule
	0.008	kJ		0.020	kJ
2) Area of HE	0.0014	m2	2) Area of HE	0.0100	m2
3) Q (coolant)	8.0403	Joule	3) Q (coolant)	20.1009	Joule
	0.0080	kJ		0.0201	kJ
4) n-tube	10	pc(s)	4) n-tube	10	pc(s)
5) specification of HE			5) specification of HE		
WHB 5.0 DKG Series			*WHB 5.0 DKG Series*		
H (in design)=	200	mm	H (in design)=	200	mm
A (in design)=	660	mm	A (in design)=	660	mm
A (Shell Area)=	0.41	m2	A (Shell Area)=	0.41	m2



Shell And Stainless Steel Tube Evaporator

Model	Capacity	Water Flow	Dimension Size (mm)										Gas Out	Gas In	Water In/Out	TEMP. Sensor	Drain Port	N.W
	KW	M³/H	A	B	C	D	E	[illegible]	G	H	R	L	Øa	Øb	w1/2	i1/2	g	Kg
WHB-5.0DKG	11.6	2.0	660	170	90	500	130	400	60	200	35	35	22	19	50	1/2	25	29

Figure 4.14. Shell & Tube Heat Exchanger Specification

IV.5.6 Pump Calculation for BOG & LNG

Generally, pump may refer as a mechanical device using suction or pressure to transfer liquids, compress gases, or force air into inflatable objects such as tires through its pipeline. However, a pipeline is a circular conduit used to convey process fluid from one location in the system to another. A pipeline consists of a circular pipe full of fluid, the process fluid, and the valves and fittings used to direct the flow of fluid through the pipe in the operation. Each of these items affects the head loss in the pipeline. Most fluids used in industrial applications are Newtonian, meaning that their viscosity does not change with the rate of flow. Water, oils, solvents and petroleum products are examples of Newtonian fluids. For simplification this discussion will be limited to the flow of Newtonian fluids through circular pipelines.

When fluid flows inside a pipeline, friction occurs between the moving fluid and the stationary pipe wall. This friction converts some of the fluid’s hydraulic energy to thermal energy. This thermal energy cannot be converted back to hydraulic energy, so the fluid experiences a drop in pressure. This conversion and loss of energy is known as head loss. The head loss in a pipeline can be determined by this following equation.

$$h_{L,\,\mathrm{total}} = h_{L,\,\mathrm{major}} + h_{L,\,\mathrm{minor}}$$

$$h_{L,\,\mathrm{total}} = \left(f\frac{L}{D} + \sum K_L\right)\frac{V^2}{2g}$$

$$\mathrm{Re} = \frac{\text{Inertial forces}}{\text{Viscous forces}} = \frac{V_{\mathrm{avg}}D}{\nu} = \frac{\rho V_{\mathrm{avg}}D}{\mu}$$

Equation 4.6. Head loss calculation for pump

In order to calculate the head loss for pump, it's necessary to know the meaning of these variable such as: hL= head loss, db = pipe diameter, V = fluid velocity, ρ LNG = density of LNG, u = mean velocity, g = gravitational constant, Re = Reynolds number, f = friction factor, L = pipe length, D = inside pipe diameter. By using these variable, it's possible to calculate the total of its head loss as well as its shown below.

Table 4.19. Pump Calculation (BOG)

PUMP CALCULATION (BOG)

$$h_{L,\,\text{total}} = h_{L,\,\text{major}} + h_{L,\,\text{minor}}$$

$$h_{L,\,\text{total}} = \left(f\frac{L}{D} + \sum K_L\right)\frac{V^2}{2g}$$

$$\text{Re} = \frac{\text{Inertial forces}}{\text{Viscous forces}} = \frac{V_{\text{avg}}D}{\nu} = \frac{\rho V_{\text{avg}}D}{\mu}$$

Physical Conversion					
db	=	0.01	m		
V	=	2.00	m/s		
LNG ρ	=	456.0	kg/m3		
u	=	0.00011	kg/ms		*(Dobrota, 2013)*
g	=	9.81	m/s2		
Reynolds Number Calculation					
Re	=	8.64E+04			
ε	=	0.15			*(galvanizes steel)*
r	=	ε/db (in mm)	=	0.014	
f	=	0.0435			
Head Loss Total Calculation					
L	=	10	m (MAXIMUM)		
∑KL	=	3 x bend	=	0.9	
	=	5 x gate valve	=	1	
		tee (line flow)	=	0.2	
∑KL	=	TOTAL	=	2.1	
hL.TOTAL	=	8.94	m		
L/hL.TOTAL	=	1.12			
Pump Specification					

S/N	Model	gas deliveryNm3/h	inlet pressureMpa	outletpressureMpa	Power kw	Medium	Dimensionmm
1	ZW-0,8/10-16	450	1.0	1.6	11		1100*740*960

Table 4.20. Pump Calculation (LNG)

PUMP CALCULATION (LNG)

$$h_{L,\text{ total}} = h_{L,\text{ major}} + h_{L,\text{ minor}}$$

$$h_{L,\text{ total}} = \left(f\frac{L}{D} + \sum K_L\right)\frac{V^2}{2g}$$

$$\text{Re} = \frac{\text{Inertial forces}}{\text{Viscous forces}} = \frac{V_{\text{avg}}D}{\nu} = \frac{\rho V_{\text{avg}}D}{\mu}$$

Physical Conversion				
db	=	0.01	m	
V	=	2.00	m/s	
LNG ρ	=	456.0	kg/m3	
u	=	0.00011	kg/ms	*(Dobrota, 2013)*
g	=	9.81	m/s2	
Reynolds Number Calculation				
Re	=	0.00E+00		
ε	=	0.15		*(galvanizes steel)*
r	=	:/db (in mm	=	0.014
f	=	0.0435		
Head Loss Total Calculation				
∑KL	=	3 x bend	=	0.9
	=	8 x gate val	=	1.6
∑KL	=	TOTAL	=	2.5
hL.TOTAL	=	20.26	m	
L/hL.TOTAL	=	1.15		

Pump Specification

Mode	Type	Flow Range (L/H)	Inlet Pressure (Mpa)	Max Pressure (Mpa)
SVOC30-80/165		30-80		
SVNB50-150/165	Single	50-150		
SVNB100-450/165	Horizontal	100-450	0.02-1.6	1.65
SVMB300-600/165	Piston	300-600		
SVMA400-800/165		400-800		

IV.5.7 General Arrangement Layout

The layout plotting will stand to be different between the conversion and engine replacement. The recognized difference in the plotting of general arrangement is in the mounted conversion kit of the main engine.

The general process flowsheet shown previously. The flow comes from ISO tanks going to LNG pump. The LNG in certain pressure and temperature will through the vaporizer. It is necessary to meet the GVU required pressure which is around 5 bar in gas phase (approximately 25C).

The existing engine in conversion scenario need to be equipped with conversion kit. The mounted conversion tools consist of the monitoring of the fuel gas. The new injector and fuel module installed comes along with that equipment. That additional equipment in aims to fulfill the ability of the existing conventional diesel engine to consume fuel gas with certain ration to fuel oil.

The engine replacement scenario has slight different to the conversion. The engine itself has the ability to consume fuel gas. It means the conversion kit or additional equipment is no need to be installed. Besides, the flow process from the ISO tank through the LNG pump and the vaporizer before entering GVU stands to be the same with the conversion scenario.

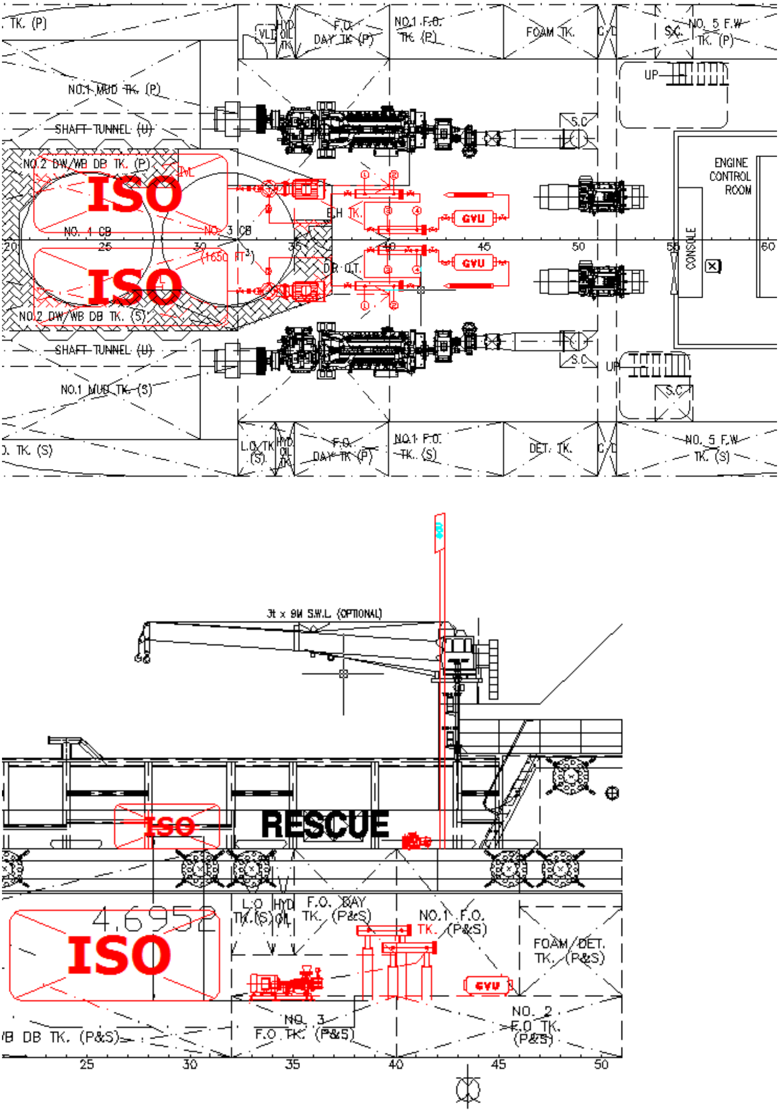


Figure 4.15. General Arrangement Layout

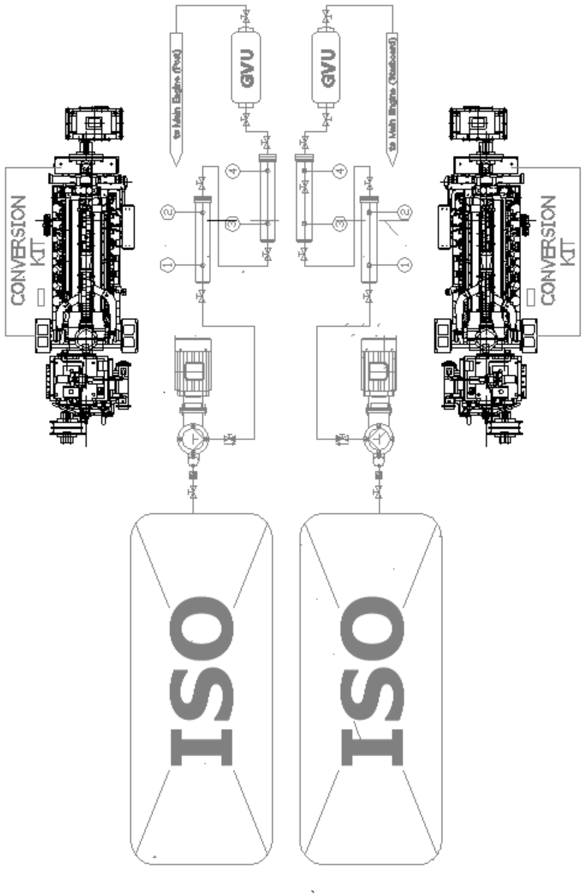


Figure 4.16. Conversion Scenario in General Arrangement Layout

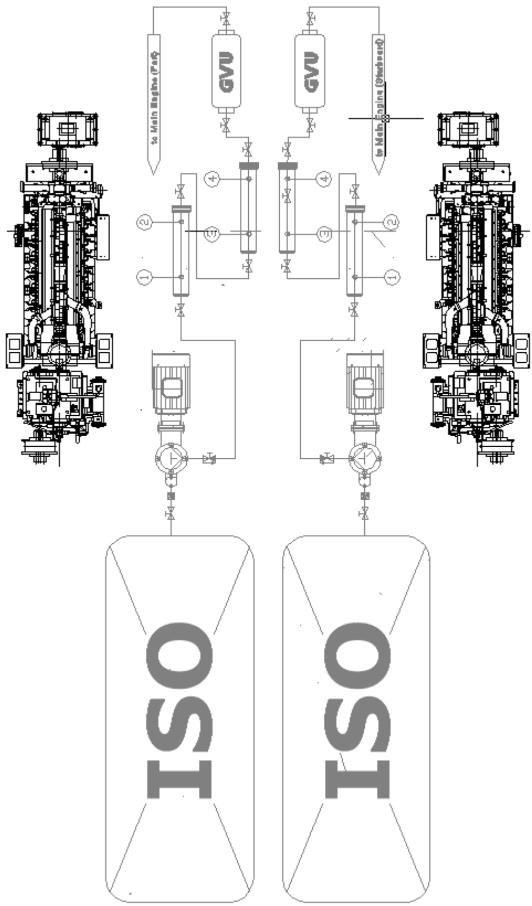


Figure 4. 17. Engine Replacement Scenario in General Arrangement Layout

IV.6 Economic Analysis

In accordance with the purpose of this research, it necessary that the comparison for engine modification and engine replacement are to be reviewed in terms of economic aspect. By considering the economic point of view, in aim to know whether the project profitable or not. Discussed in this chapter the economic analysis for engine modification and engine replacement.

IV.6.1. Capital Expenditure

An expense is considered to be a capital expenditure when the asset is a newly purchased capital asset or an investment that improves the useful life of an existing capital asset. If an expense is a capital expenditure, it needs to be capitalized. This requires the company to spread the cost of the expenditure (the fixed cost) over the useful life of the asset. However, the expense is one that maintains the asset at its current condition, the cost is deducted fully in the year of the expense. The amount of capital expenditures a company is likely to have depends on the industry it occupies. Some of the most capital intensive industries have the highest levels of capital expenditures including oil exploration and production, telecom, manufacturing and utilities. For the case of marine industry, the capital investment was in fixed assets, such as power generation, conversion cost, pump, heat exchanger, conversion kit, docking, flat bottom LNG, and Etc.

Based on this research, there are two capital expenditures (Cap-Ex) which consists of:

- **Capital expenditure for conversion (60:40)**

These are the following example of each capital expenditure as well as its shown below.

Table 4.21. Capital Expenditure for conversion

Capital Cost						Rp 4,332,750,000				
No	Items	Value	Units	Price (USD)	1 USD to IDR	Price (IDR)	Reference	Quantity	Units	Total Price
1.	Container ISO Tank 20	19352	Liter	$ 32,000	Rp 13,250	Rp 424,000,000	LNG Solution	2	Units	Rp 848,000,000
2	Argon Container ISO Tank 10	7570	Liter	$ 25,000	Rp 13,250	Rp 331,250,000	LNG Solution	1	Units	Rp 331,250,000
3	Heat Exchanger			$ 40,000	Rp 13,250	Rp 530,000,000	Alibaba	4	Units	Rp 2,120,000,000
4	Cryogenic Pump			$ 30,000	Rp 13,250	Rp 397,500,000	Alibaba	2	Units	Rp 795,000,000
5	Unit Conversion System (GCU, GVU)			$ 150,000	Rp 13,250	Rp 1,987,500,000	LNG Solution	2	Units	Rp 3,975,000,000
6	NG supply system (piping, cabling, monitoring and control system)			$ 50,000	Rp 13,250	Rp 662,500,000	LNG Solution	1	Set	Rp 662,500,000
7	Installation 5 worker/day			$ 2,000	Rp 13,250	Rp 26,500,000	ABS	30	Day	Rp 795,000,000
8	Docking			$ 250,000	Rp 13,250	Rp 3,312,500,000	PT. DKB	1		Rp 3,312,500,000
9	Flat Bottom LNG Tank			$ 6,000	Rp 13,250	Rp 79,500,000	LNG Solution	1	m3	Rp 79,500,000
Sub Total Investment										Rp 12,918,750,000
PPN 10%										Rp 1,291,875,000
Total Investment										Rp 14,210,625,000

According to the table above, it is shown that the capital expenditure of conversion are consists of:

- <u>Container ISO Tank 20</u>
  = Rp424,000,000 x 2= **Rp848,000,000**
- <u>Argon Container ISO Tank 10</u>
  = Rp331,250,000 x 1= **Rp331,250,000**
- <u>Heat Exchanger</u>
  = Rp530,000,000 x 4 = **Rp2,120,000,000**
- <u>Cryogenic Pump</u>
  = Rp397,500,000 x 2 = **Rp795,000,000**
- <u>Unit Conversion System (GCU, GVU)</u>
  = Rp1,987,500,000 x 2 = **Rp3,975,000,000**
- <u>NG supply system</u>
  = **Rp1,987,500,000 x1**
- <u>Installation 5 worker/day</u>
  = **Rp795,000,000**

- <u>Docking</u>
  = **Rp3,312,500,000**
- <u>Flat Bottom LNG Tank</u>
  = **Rp79,500,000**

- **Capital expenditure for engine replacement**

Table 4.22. Capital Expenditure for engine replacement

No	Items	Value	Units	Price (USD)	1 USD to IDR	Price (IDR)	Reference	Quantity	Units	Total Price
1	ROLLS ROYCE C2;33L Gas Engine	2935	HP	$ 2,054,500	Rp 13,250	Rp 27,222,125,000	Rolls Royce	2	Units	Rp 54,444,250,000
2	Argon Container ISO Tank 10	7570	Liter	$ 25,000	Rp 13,250	Rp 331,250,000	LNG Solution	0	Units	Rp -
2	Container ISO Tank	19352	Liter	$ 32,000	Rp 13,250	Rp 424,000,000	LNG Solution	2	Units	Rp 848,000,000
3	Heat Exchanger			$ 40,000	Rp 13,250	Rp 530,000,000	Alibaba	2	Units	Rp 1,060,000,000
4	Cryogenic Pump			$ 30,000	Rp 13,250	Rp 397,500,000	Alibaba	2	Units	Rp 795,000,000
5						Rp -				Rp -
6	Vaporizer and NG supply system (piping, cabling, monitoring and control system)			$ 50,000	Rp 13,250	Rp 662,500,000	LNG Solution	1	Set	Rp -
7	Installation 5 worker/day			$ 2,000	Rp 13,250	Rp 26,500,000	ABS	30	Day	Rp 795,000,000
8	Docking			$ 300,000	Rp 13,250	Rp 3,975,000,000	PT. DKB	1		Rp 3,975,000,000
9	Flat Bottom LNG Tank			$ 6,000	Rp 13,250	Rp 79,500,000	LNG Solution	1	m3	Rp 79,500,000
	Total Investment									Rp 61,996,750,000
	PPN 10%									Rp 6,199,675,000
	Total Investment									Rp 68,196,425,000

According to the table above, it is shown that the capital expenditure of engine replacement are consists of:

- <u>ROLLS ROYCE C2;33L Gas Engine</u>
  = Rp27,222,125,000 x 2= **Rp54,444,250,000**
- <u>Argon Container ISO Tank 10</u>
  = Rp331,250,000 x 1= **Rp331,250,000**
- <u>Container ISO Tank</u>
  = Rp424,000,000 x 2 = **Rp848,000,000**
- <u>Heat Exchanger</u>
  = Rp530,000,000 x 4 = **Rp2,120,000,000**
- <u>Cryogenic Pump</u>
  = Rp397,500,000 x 2 = **Rp795,000,000**
- <u>Installation 5 worker/day</u>
  = Rp26,500,000 x 30 days = **Rp795,000,000**
- <u>Docking</u>
  = **Rp3,975,000,000**
- <u>Flat Bottom LNG Tank</u>
  = **Rp79,500,000**

IV.6.2. Operational Expenditure

In general, operational expenditure defined as the money a company spends on an ongoing, day to day basis in order to run the business or system. For the case of marine industry, these expenses consist of inventories, costs of operational transportation, fuel oil consumption cost per annual, maintenance cost per annual. As well as we know, the different investments drive a different operational expenditure. For the case of this research, the investment consists of 2 points, whether the company need to invest the money for engine modification or engine replacement. These are the following calculation of each OPEX (operational expenditure).

IV.6.2.1. Operational Expenditure for conversion

Table 4.24. Operational Expenditure for conversion

Data Operasional		Units	Value		1 USD to IDR		Value	
Life Time		Year		20				
Investation		Rupiah	Rp	14,210,625,000	Rp	13,250	$	1,072,500
Disposal Price (20%*Investment) / Year		Rupiah	Rp	2,842,125,000	Rp	13,250	$	214,500
Annual Depreciation		Rupiah	Rp	568,425,000	Rp	13,250	$	42,900
								200

According to the table above, it is shown that the operational expenditure of conversion are consists of:

- Operational Cost

  The operational cost for conversion can be seen by this following example.

  Lifetime = **20 years**

  Investation = **Rp13,744,225,000**

  Disposal Price (20% Investment/Year) = **Rp2,748,845,000**

  Annual Depreciation = **Rp549,769,000**

- Vessel Operational Cost
  The vessel operational cost for conversion can be seen by this following example.
  Maintenance/ year = Rp549,769,000

IV.6.2.2. Operational Expenditure for engine replacement

Table 4.25. Operational Expenditure for engine replacement

Data Operasional		Units	Value		1 USD to IDR		Value	
Life Time		Year		20				
Investation		Rupiah	Rp	48,112,075,000	Rp	13,250	$	3,631,100
Disposal Price (20%*Investment) / Year		Rupiah	Rp	9,622,415,000	Rp	13,250	$	726,220
Annual Depreciation		Rupiah	Rp	1,924,483,000	Rp	13,250	$	145,244

According to the table above, it is shown that the operational expenditure of engine replacement are consists of:

- Operational Cost
  The operational cost for conversion can be seen by this following example.
  Lifetime = 20 years
  Investation = Rp68,196,425,000
  Disposal Price (20% Investment/Year) = Rp13,639,285,000
  Annual Depreciation = Rp2,727,857,000

- Vessel Operational Cost
  The vessel operational cost for conversion can be seen by this following example.
  Maintenance/ year = Rp331,250,000

IV.6.2.3. Payback Period

Payback period is the time in which the initial cash outflow of an investment is expected to be recovered from the cash inflows generated by the investment. It is one of the simplest investment appraisal techniques. The payback period is expressed in years and fractions of years.

For example, if a company invests $300,000 in a new production line, and the production line then produces cash flow of $100,000 per year, then the payback period is 3.0 years ($300,000 initial investment / $100,000 annual payback).

An investment with a shorter payback period is considered to be better, since the investor's initial outlay is at risk for a shorter period of time. The calculation used to derive the payback period is called the payback method.

The formula to calculate payback period of a project depends on whether the cash flow per period from the project is even or uneven. In case they are even, the formula to calculate payback period is:

$$Payback\ Period = \frac{Initial\ Investment}{Cash\ in\ flow\ per\ Period}$$

Equation 4.7. Payback Period Calculation

$$Payback\ Period = A + \frac{B}{C}$$

Equation 4.8. Payback Period Calculation

Variable:
A is the last period with a negative cumulative cash flow
B is the absolute value of cumulative cash flow at the end of the period A
C is the total cash flow during the period after A.
In order to calculate the payback period for the investment, it’s necessary to have these variable such as:

$$Depreciation = \frac{(Total\ Operational\ Cost - Disposal\ Price)}{Lifetime\ of\ Investment}$$

Equation 4.9. Depreciation

For example:

Total Operational Cost = 561,362 US$/ Year
Disposal Price = 112,272.36

$$Depreciation = \frac{(561{,}362 - 112{,}272.36)}{20\ years} = 22{,}454\ US\$$$

Moreover, the tax of its earning is approximately for 35% which it takes to calculate the proceeds that comes from the additional of depreciation and earnings after tax. Now, it takes to the calculation of cumulative proceeds which will be used to calculate the payback of each period.

- Revenue for conversion and engine replacement

Table 4.26. Conversion with each scenarios

CONVERSION WITH EACH SCENARIOS	REVENUE
$ 4	2,262,748,694.38
$ 5	2,116,137,964.17
$ 6	1,969,527,233.97

Table 4.26. Replacement with each scenarios

REPLACEMENT WITH EACH SCENARIOS	REVENUE
$ 4	3,771,247,823.97
$ 5	3,526,896,606.96
$ 6	3,282,545,389.95

- Conversion with each scenarios
  According to the table above, the calculation for conversion with each scenario. Example of revenue calculation for conversion with price of LNG 4 $/mmbtu

  Given data”

LNG	= 4 $/mmbtu
HSD (Liter)/year	= 534,909
HSD (kg)/year	= 534,909 x 0.85 ton/m3 (density of HSD)
	= 454,672
HSD (MJ)/year	= 454,672 x 42.791 MJ/ kg (LHV HSD)
	= 19,455,889
$ HSD (Liter/year)	= 358,389
Rp HSD (Liter/year)	= 358,389 x 0.67 x 13250
	= 4,748,652,692

  Conversion calculation (40:60)

40% HSD (MJ)/year	= 19,455,889 x 0.4
	= 7,782,356
40% HSD (kg/year)	= 7,782,356/ 42.791 MJ/ kg (LHV HSD) = 181,868.99
40% HSD (m3/year)	= 181,868.99/ (0.85 ton/m3 (density of HSD)x 1000)
	= 213.96
40% HSD (liter/year)	= 213.96 x 1000 = 213,963.51
40% HSD (Rp/year)	= 213,963.51 x 0.67 x 13250
	= 1,899,461,076.80
60% LNG (MJ)/year	= 19,455,889 x 0.6
	= 11,673,533.61
60% LNG (mmbtu/year)	= 11,673,533.61/ 1055 (MJ)
	= 11,064.96
60% LNG (Rp/year)	= 11,064.96 x 4 (price of LNG) x 13250
	= 586,442,920.82

Total dual fuel cost = 1,899,461,076.80 + 586,442,920.82
= 2,485,903,997.62

Revenue for conversion = 4,748,652,692 - 2,485,903,997.62
= 2,262,748,694.38

The revenue calculation above it also applied to the price of LNG for $5/mmbtu and $6/mmbtu within the same process of calculation

- Replacement with each scenarios
  According to the table above, the calculation for replacement with each scenario. Example of revenue calculation for replacement with price of LNG 4 $/mmbtu

Given data"
LNG = 4 $/mmbtu
HSD (Liter)/year = **534,909**
HSD (kg)/year = 534,909 x 0.85 ton/m3 (density of HSD)
= **454,672**
HSD (MJ)/year = 454,672 x 42.791 MJ/ kg (LHV HSD)
= **19,455,889**

$ HSD (Liter/year) = **358,389**
Rp HSD (Liter/year)= 358,389 x 0.67 x 13250
= **4,748,652,692**

Replacement calculation
100% LNG (MJ)/year = 19,455,889
100% LNG (mmbtu/year) = 19,455,889/ 1055 (MJ)
= 18,441.60
100% LNG (Rp/year) = 18,441.60x 4 (price of LNG) x 13250
= 977,404,868.03

Total gas fuel cost = 977,404,868.03
Revenue for conversion = 4,748,652,692 - 977,404,868.03
= 3,771,247,823.97

The revenue calculation above it also applied to the price of LNG for $5/mmbtu and $6/mmbtu within the same process of calculation

- **Payback Period for Conversion**
  According to the figure below, it is shown that the payback period for constant mode can be gained within price of LNG for 4$ in year 8, compare to the other scenarios. Moreover, we have can more saving with a value of Rp18,721,848,887.59 in year 20. Then, the payback period for variation mode can be gained within price of LNG for 4$ in year 8, which is the same with the constant mode. However, the saving for variation mode is bigger within a value of Rp48,286,819,474.72 in year 20, compare to the constant mode.

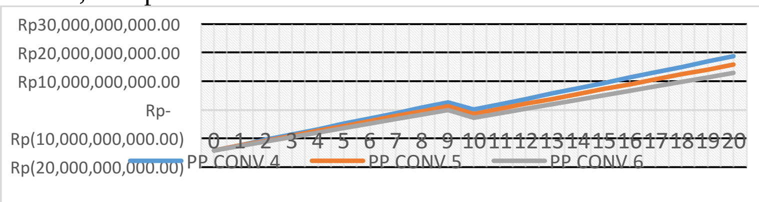


Figure 4.18. Payback Period of Conversion for each scenarios

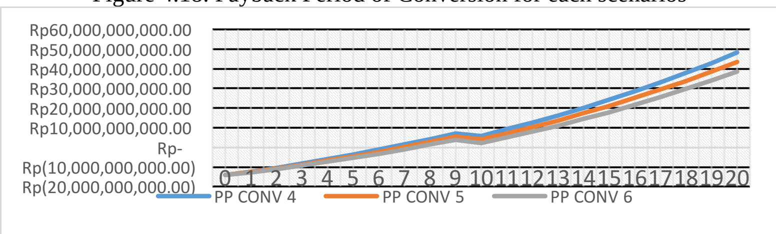


Figure 4.19. Payback Period of Conversion with Revenue Increasing

- **Payback Period for Engine Replacement**
  According to the figure below, it is shown that the payback period can be gained within price of LNG for 4$ in year 8, compare to the other scenarios. Moreover, we have can more saving with a value of Rp41,733,298,146.98 in year 20. Then, the payback period for variation mode can be gained within price of LNG for 4$ in year 6. However, the saving for variation mode is bigger within a value of Rp91,008,249,125.33 in year 20, compare to the constant mode.

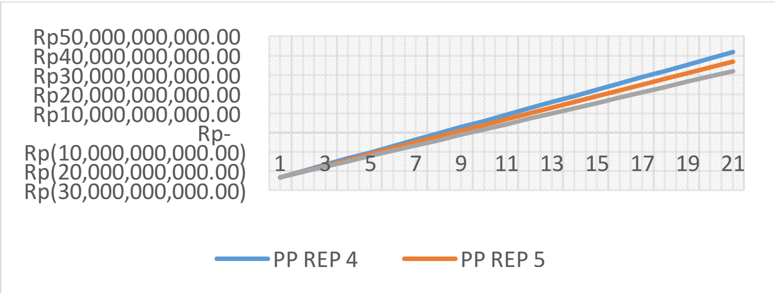


Figure 4.20. Payback Period of Replacement for each scenarios

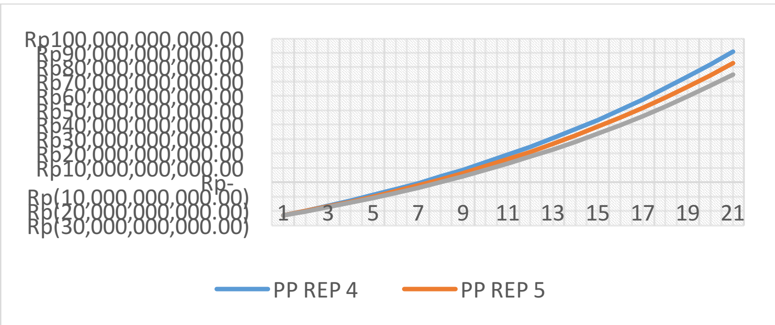


Figure 4. 21. Payback Period of Replacement with Revenue Increasing

- **Payback Period Sensitivity**
  Based on the previous result of payback period, the different scheme can be gain. The one with constant revenue, whilst the other with revenue increasing 5% annually. Below shown the sensitivity of those scheme. The red color shown the payback curve with revenue increasing and the green color shown the payback curve with constant revenue.

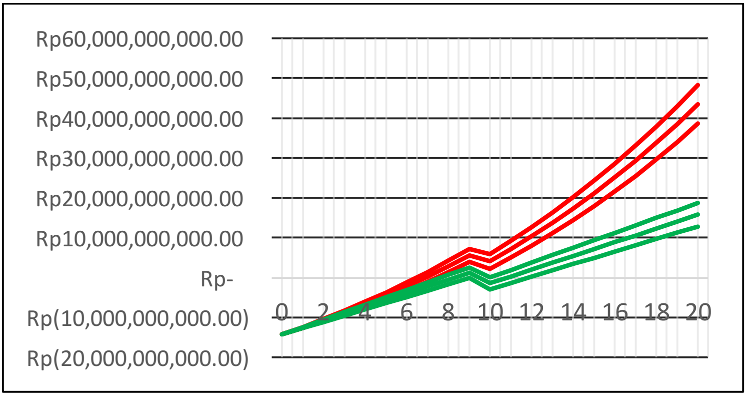


Figure 4.22. Payback Period of Conversion Sensitivity

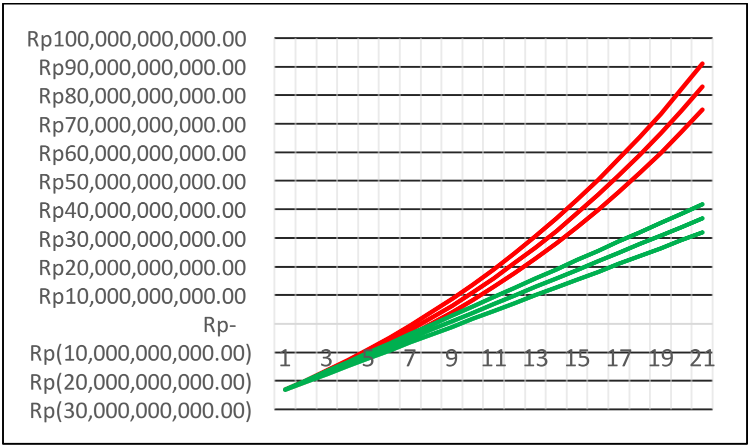


Figure 4.23. Payback Period of Replacement Sensitivity

IV.6.3. NPV and IRR

IV.6.3.1. NPV

Net Present Value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyze the profitability of a projected investment or project (Investopedia, 2016). Well, here is the following formula for calculating the NPV (Net Present Value)

$$\mathbf{NPV = -Initial\ cost + (Income\ netto / (1+r)^1) + (Income\ netto / (1+r)^2) + (Income\ netto / (1+r)^t)}$$

Equation 4.10. NPV Calculation

Where,
r = discount rate, for this research, the discount rate is in between 5% - 20%
t = lifetime of investment

These are the following results of NPV calculation for each investment such as:

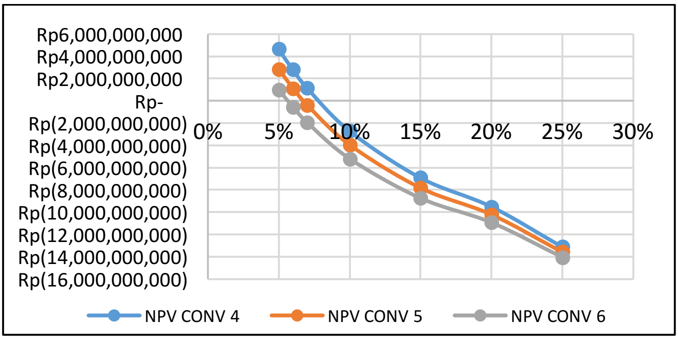


Figure 4.24. Net Present Value for Conversion (with margin 2 US$)

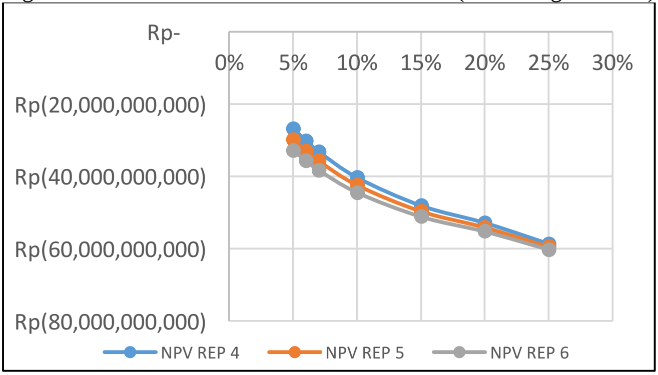


Figure 4.25. Net Present Value for Engine Replacement (with margin 2 US$)

For the complete NPV of conversion and engine replacement within a different margin can be seen in the attachment of this bachelor thesis.

IV.6.3.2. IRR

Internal rate of return (IRR) is the interest rate at which the net present value of all the cash flows (both positive and negative) from a project or investment equal zero.

Internal rate of return is used to evaluate the attractiveness of a project or investment. If the IRR of a new project exceeds a company's required rate of return, that project is desirable. If IRR falls below the required rate of return, the project should be rejected.

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CHAPTER V
CONCLUSION & SUGGESTION

V.1. Conclusion

Based on the research that've done, it's possible for us to take a conclusion such as:

1. Technical Analysis

   It is reasonable to choose the **gas engine replacement** compared to the conversion. In addition, the fuel oil consumption analysis of engine replacement is more efficient due to the ratio of fuel oil and fuel gas. The conversion is only capable to work in ratio 60:40 while the gas engine replacement works in ratio 100% gas.

2. Economic Analysis

Based on the Payback and NPV calculation, the total profit of **gas engine replacement** is higher compared to the conversion. The payback period of the conversion is in range of Year 6 to 12 while the engine replacement is in range of Year 7 to 10.

With price of LNG 4, 5, and 6 $/mmbtu for conversion with constant revenue, the payback period is in Year 8, 10, and 12. Besides, with price of LNG 4, 5, and 6 $/mmbtu for engine replacement with constant revenue, the payback period is in Year 8, 8.5, and 9. In 20 years investment, with price of LNG 4 $/mmbtu for conversion with constant revenue, Rp 18,721,848,887.59 can be gain in Year 20. In the other way, for engine replacement with constant revenue, Rp 41,733,298,146.98 can be obtain. It represents the saving with engine replacement is possible up to Rp. 23,011,449,259.39 in total investment.

V.2. Suggestion

These are the following suggestion as shown as it follows:

- It’s more possible to analyze the bunkering LNG of this vessel, in case for a further research.
- It’s more possible to calculate the stability factor of this vessel, in case for a further research.

REFERENCE

Cabot Oil and Gas Corporation, ”Liquefied Natural Gas The New Energy Revolution”, Cabot Oil and Gas Corporation, 2012

Cengel, Yunus A, Cimbala, John M. “Fluid Mechanics”, McGraw-Hill, New York, 2014.

JFE Steel Corporation, ”Dual Fuel Engine Gas Fuel Conversion Technology”, JFE Technical Report No. 19, March 2014

Karim, Ghazi A., ”Dual-Fuel Diesel Engines 1st Ed.”, CRC Press, New York, Ch. 1, 2015.

Msaed, M. Hamzah, ”Properties of Petroleum and Natural Gas”, Proc. of Chemical Engineering Dept. of University of Diyala, pp. 3-5, Diyala, November, 2013

National Energy Education Development Project (NEED), ”Natural Gas”, NEED Secondary Energy Book, 2015

Primo, Jurandir, “Shell and Tube Heat Exchangers Basic Calculations”, PDHonline: Course M371 (2 PDH), PDHcenter.com, 2010.

Shakeri, Omid; Barati, Aghil, ”Marine Transportation of Liquefied Natural Gas”, Proc. of Iranian Fuel Conversion Organization (IFCO) The 3rd Iran Gas Forum, pp. 3-6, Iran, September, 2009

Society of Gas as Marine Fuel (SGMF), ”Gas as a Marine Fuel”, SGMF Introductory Guide, September 2014

Woodroof, Eric A., ”How to Use NPV to Your Advantage”, Proc. of Profitable Green Solutions, pp. 1-3; 5, April, 2011

APPENDIX
TECHNICAL

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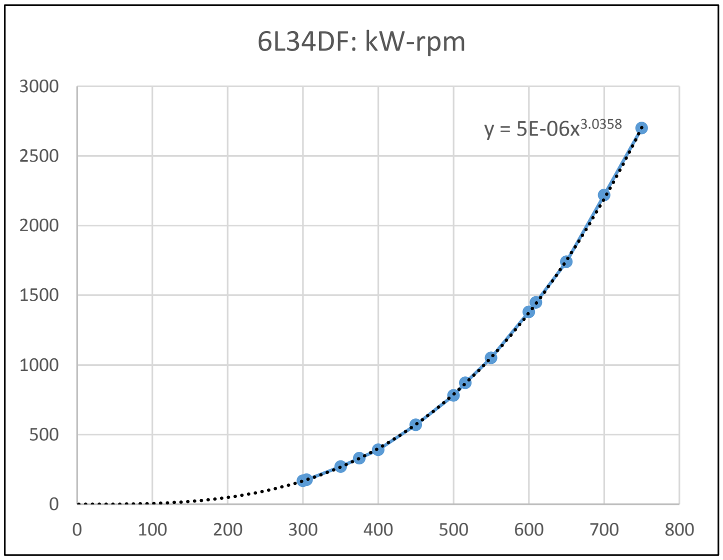
PHYSICAL CONVERSION						
HSD	LHV	=	42.79			MJ/kg
	ρ	=	850			kg/m^3
	litre	=	0.001			m^3
LNG (Badak)	GCV(Gas)	=	43.90			MJ/m^3
	ρ(Gas)	=	0.801			kg/m^3
	ρ(LNG)	=	456			kg/m^3
	LHV(LNG)	=	54.81			MJ/kg
	MMBTU	≈	1055			MJ
1 ($)		≈	13250			Rp
PRICE ($)						
HSD		=	0.67			$/litre
LNG		=	4			$/MMBTU
PRICE (Rp)						
HSD		=	8877.5			Rp
LNG		=	53000			Rp
AVERAGE OF MAIN ENGINE FUEL OIL CONSUMPTION (DAILY) AND THE LNG EQUIVALENT						
UTILIZATION (hours)					HSD (ltr)	LNG (m^3)
FULL	ECO	MANEU	TOW	STAND		
5.27	6.67	16.60	13.21	12.82	2971.72	4.34
PRICE (US$)					1991.05	0.90
LNG EQUIVALENT PERCENTAGE SCENARIOS						
	PERCENTAGE		DAILY CONSUMPTION		PRICE (US$)	
	HSD	LNG	HSD (ltr)	LNG (m^3)	HSD	LNG
SCENARIO	40.0%	60.0%	1188.7	2.6	796.4	0.5
INFLATION RATE ASSUMPTION						
INFLATION		=	5%			/year
ENDURANCE ASSUMPTION						
ENDURANCE		=	10			day(s)

LNG ISO TANK(S) SCENARIOS						
	PERCENTAGE		DAILY CONSUMPTION		MONTHLY CONSUMPTION	
	HSD	LNG	HSD (ltr)	LNG (m^3)	HSD (ltr)	LNG (ltr)
SCENARIO	40.0%	60.0%	677.0	3.1	6769.6	30527.2
ISO TANK OPTION	**DANTECO Industries**			**CHART LNG ISO Intermodal**		
	Type	Portable Tank T11		Type	ICC-20-P-10	
	Capacity	23750	litre (95%)	Capacity	19351.5	litre (95%)
	Dimension	20	feet	Dimension	20	feet
	WESSINGTON Cryogenics			**ARGON ISO TANK**		
	Type	ISO VAC 40-LNG		Type	10 FEET ISO TANK	
	Capacity	41325	litre (95%)	Capacity	7570	litre (95%)
	Dimension	40	feet	Dimension	10	feet
	MONTHLY CONSUMPTION		SCENARIOS 20' (units)		SCENARIOS 40' (units)	
	HSD (ltr)	LNG (ltr)	DANTECO	CHART	WESSI	CHART
SCENARIO	6769.6	30527.2	55070.0	0.0	41325.0	38703.0

Wartsila 6L34DF

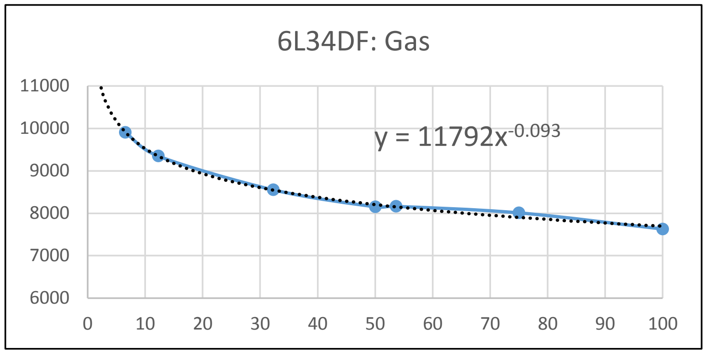
	vs	RPM	
FULL SPEED	10.30	609	81.25%
ECONOMICAL SP	6.55	516	68.75%
MANEUVER	2.45	375	50.00%
STAND BY	0.00	305	40.63%
(Wartsila 6L34DF)			

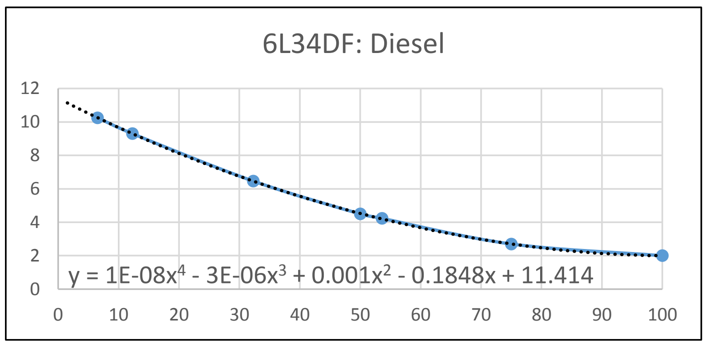
RPM	Power
750	2700
700	2220
650	1740
609	**1447**
600	1380
550	1050
516	**871**
500	780
450	570
400	390
375	**331**
350	271
305	**176**
300	168



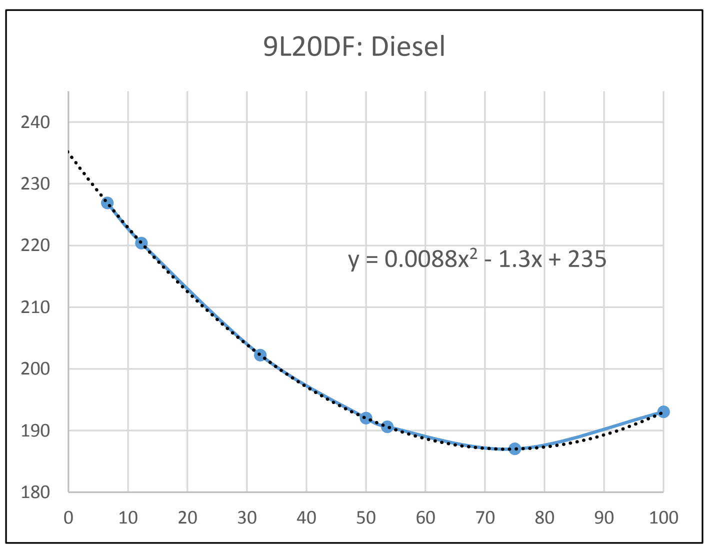
Wartsila 6L34DF

GAS MODE	
LNG	
Power (%)	**SFOC (kJ/kWh)**
100	7629
75	8010
54	**8161**
50	8153
32	**8552**
12	**9348**
7	**9906**
HSD	
Power (%)	**SFOC (g/kWh)**
100	2
75	2.7
54	**4**
50	4.5
32	**6**
12	**9**
7	**10**





DIESEL MODE	
HSD	
Power (%)	**SFOC (g/kWh)**
100	193
75	187
54	**191**
50	192
32	**202**
12	**220**
7	**227**

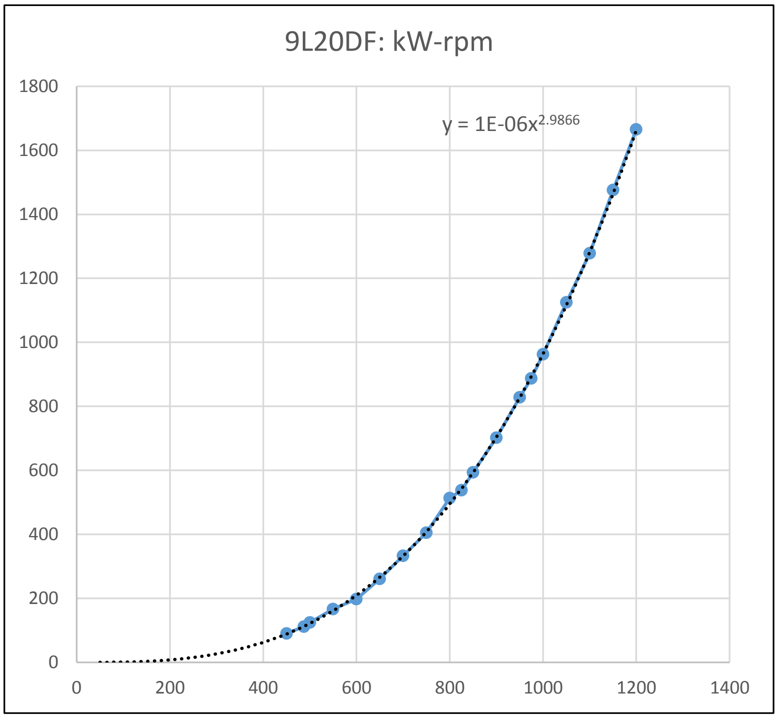


Wartsila 9L20DF

	vs	RPM	
FULL SPEED	10.30	975	81.25%
ECONOMICAL SP	6.55	825	68.75%
MANEUVER	2.45	600	50.00%
STAND BY	0.00	488	40.63%

(Wartsila 9L20DF)

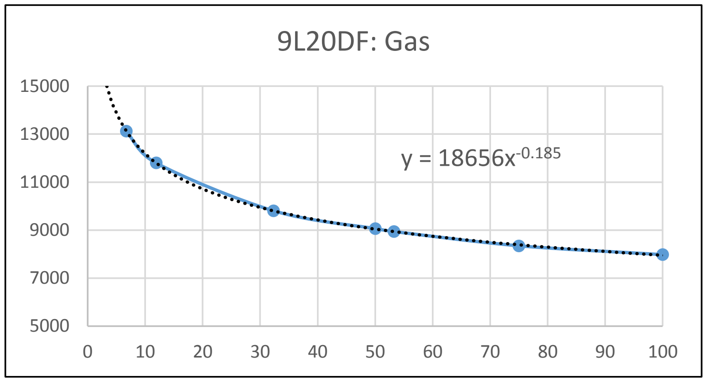
RPM	Power
1200	1665
1150	1476
1100	1278
1050	1125
1000	963
975	**887**
950	828
900	702
850	594
825	**538**
800	513
750	405
700	333
650	261
600	**198**
550	166
500	124
488	**111**
450	90

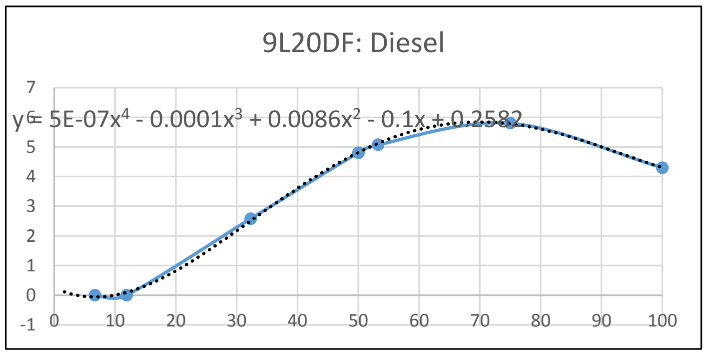


ROLLS ROYCE C26:33L

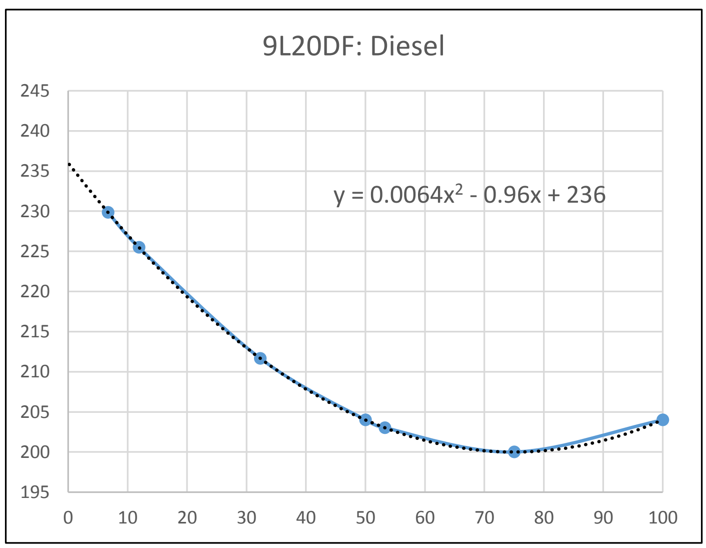
Wartsila 9L20DF

GAS MODE	
LNG	
Power (%)	SFOC (kJ/kWh)
100	7980
75	8347
53	**8940**
50	9064
32	**9807**
12	**11799**
7	**13124**
HSD	
Power (%)	SFOC (g/kWh)
100	4.3
75	5.8
53	**5**
50	4.8
32	**3**
12	**0**
7	**0**





DIESEL MODE	
HSD	
Power (%)	SFOC (g/kWh)
100	204
75	200
53	**203**
50	204
32	**212**
12	**225**
7	**230**

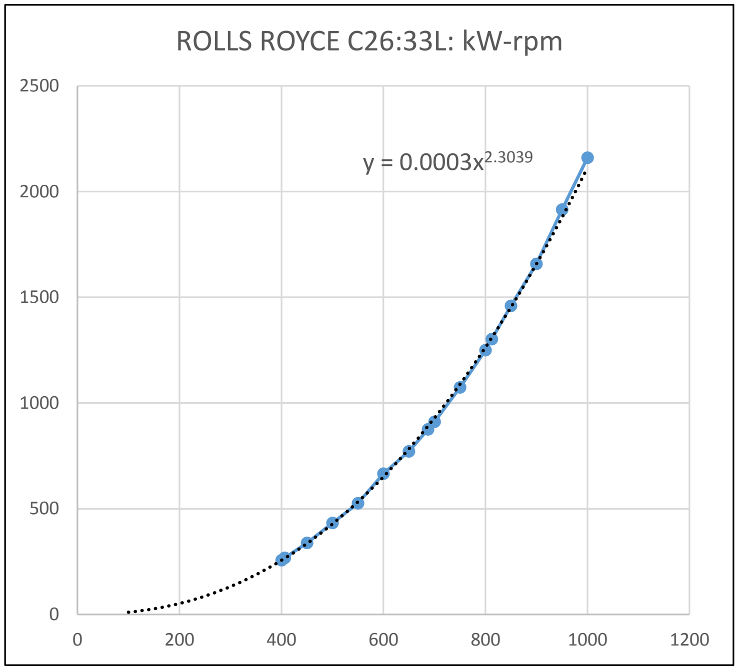


ROLLS ROYCE C26:33L

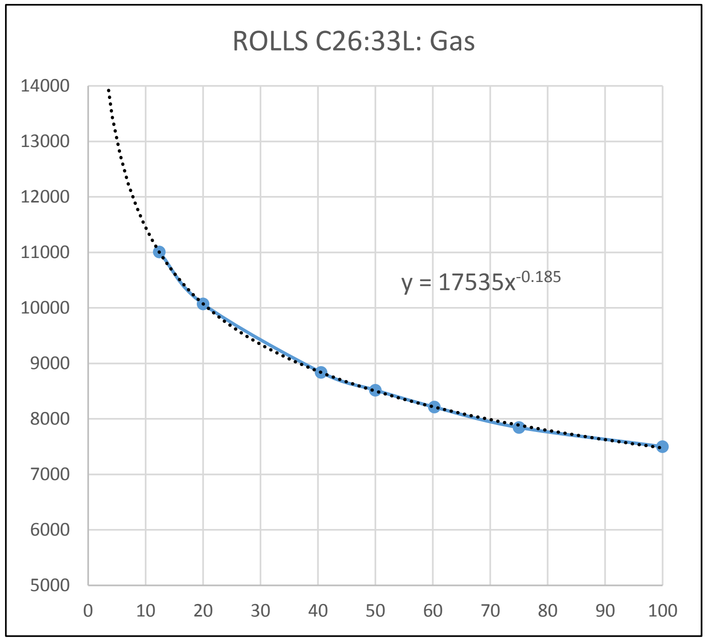
	vs	RPM	
FULL SPEED	10.30	813	81.25%
ECONOMICAL SP	6.55	688	68.75%
MANEUVER	2.45	500	50.00%
STAND BY	0.00	406	40.63%

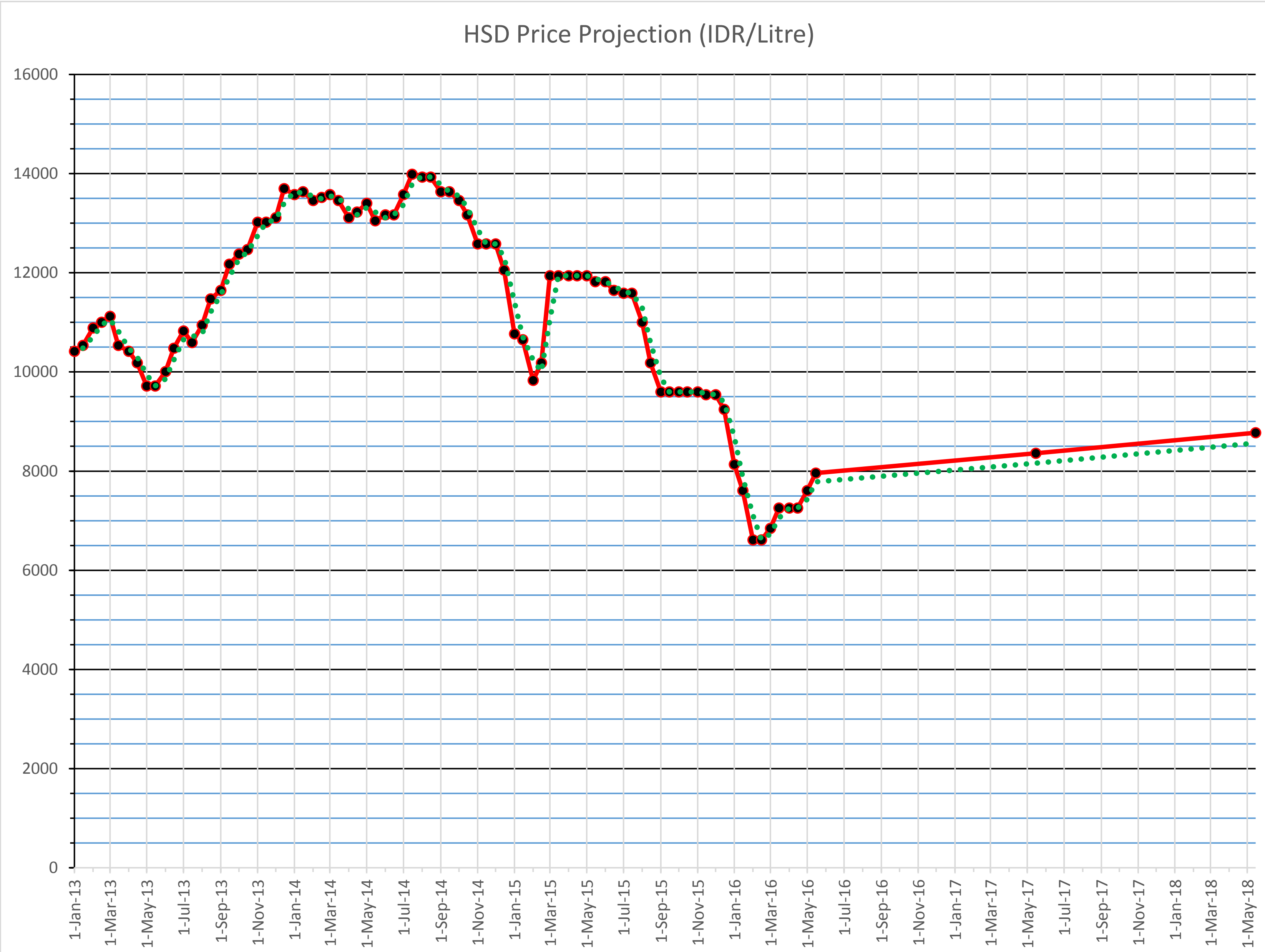
(ROLLS ROYCE C26:33L)

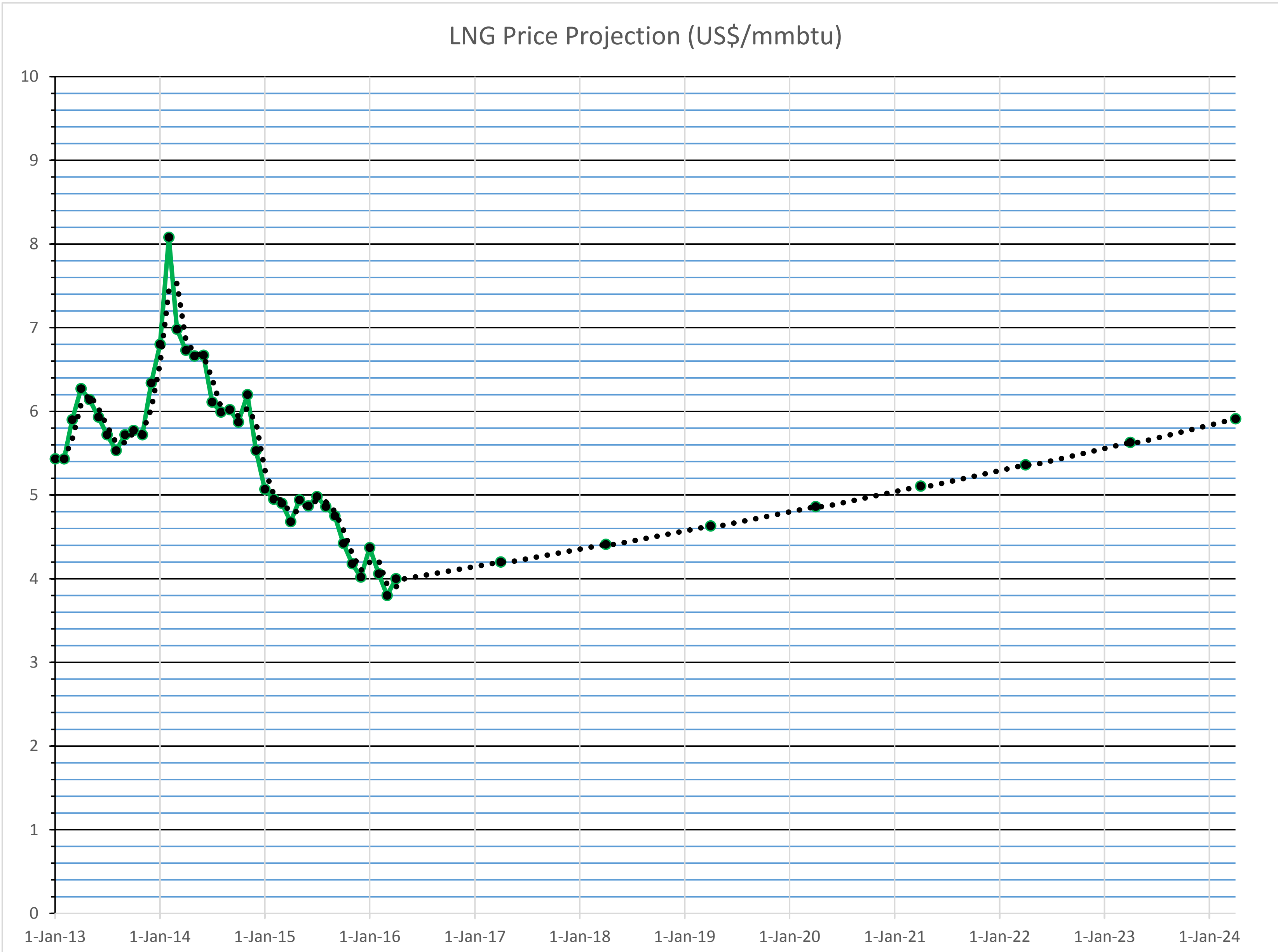
RPM	Power
1000	2160
950	1915
900	1658
850	1459
813	**1302**
800	1249
750	1074
700	911
688	**876**
650	771
600	666
550	525
500	**432**
450	339
406	**267**
400	257



GAS MODE	
LNG	
Power (%)	SFOC (kJ/kWh)
100	7500
75	7845
60	**8213**
50	8519
41	**8838**
20	**10072**
12	**11009**




HSD Price Projection (IDR/Litre)
16000
14000
12000
10000
8000
6000
4000
2000
0
1-Jan-13
1-Mar-13
1-May-13
1-Jul-13
1-Sep-13
1-Nov-13
1-Jan-14
1-Mar-14
1-May-14
1-Jul-14
1-Sep-14
1-Nov-14
1-Jan-15
1-Mar-15
1-May-15
1-Jul-15
1-Sep-15
1-Nov-15
1-Jan-16
1-Mar-16
1-May-16
1-Jul-16
1-Sep-16
1-Nov-16
1-Jan-17
1-Mar-17
1-May-17
1-Jul-17
1-Sep-17
1-Nov-17
1-Jan-18
1-Mar-18
1-May-18



LNG Price Projection (US$/mmbtu)
10
9
8
7
6
5
4
3
2
1
0
1-Jan-13
1-Jan-14
1-Jan-15
1-Jan-16
1-Jan-17
1-Jan-18
1-Jan-19
1-Jan-20
1-Jan-21
1-Jan-22
1-Jan-23
1-Jan-24

FUEL OIL CONSUMPTION DAILY AVERAGE AND LNG EQUIVALENT

	UTILIZATION (hours)					HSD (ltr)	LNG (m^3)
	FULL	ECO	MANEU	TOW	STAND		
AVERAGE	5.27	6.67	16.60	13.21	12.82	2971.72	4.34
PRICE (US$)						1991.05	0.90

DAILY LNG EQUIVALENT PERCENTAGE SCENARIOS

	PERCENTAGE		DAILY CONSUMPTION		PRICE (US$)		COST (US$)
	HSD	LNG	HSD (ltr)	LNG (m^3)	HSD	LNG	
	40.0%	60.0%	1188.69	2.60	796.42	0.54	796.96

HSD Daily Consumption (ltr/day) = HSD (ltr/day) · Percentage(%)

LNG Daily Consumption (m^3/day) = LNG (m^3/day) · Percentage(%)

LNG Price (m^3/day) = LNG Price (US$/day) · Percentage(%)

HSD Price (ltr/day) = HSD Price (US$/day) · Percentage(%)

COST PROJECTION OF LNG EQUIVALENT PERCENTAGE SCENARIO (US$)

	DAILY		MONTHLY		YEARLY	
	HSD	LNG	HSD	LNG	HSD	LNG
	796.42	0.54	23892.592	16.222471	286711	195

Monthly Price (US$) = Daily Price (US$/day) · 30

Yearly Price (US$) = Monthly Price (US$/day) · 12

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ENGINE REPLACEMENT SCENARIOS

EXISTING ENGINE (CONVENTIONAL DIESEL ENGINE)

2 x CATERPILLAR 3516C; 2575 HP
(DIRECT ARRANGEMENT)

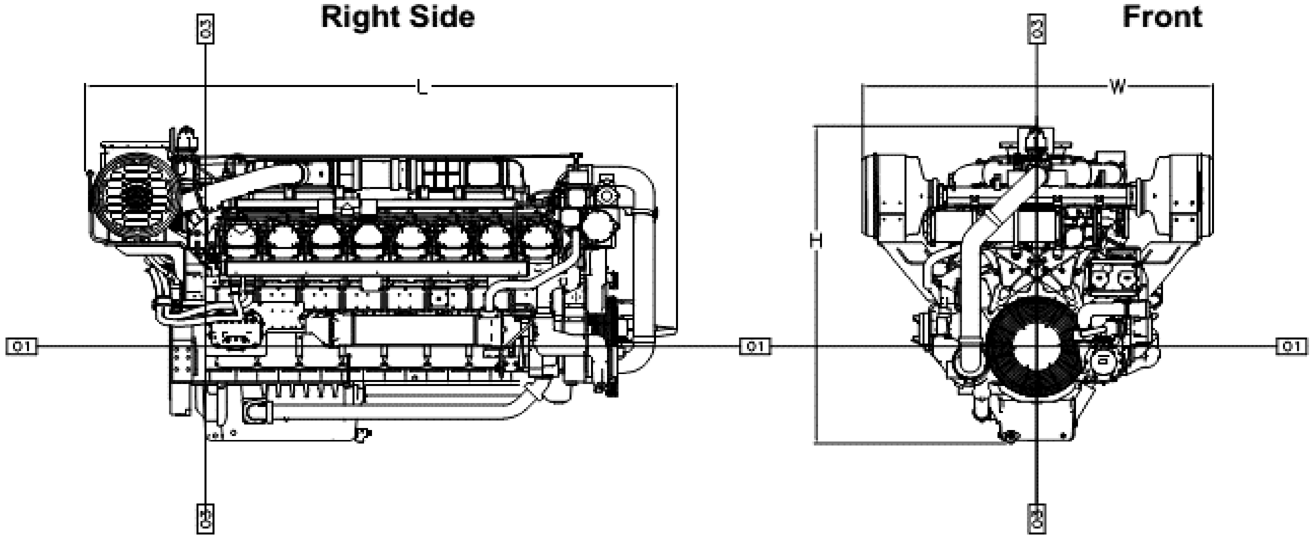
CATERPILLAR®

3516C

MARINE PROPULSION

2611 mhp (2575 bhp) 1920 bkW

DIMENSIONS

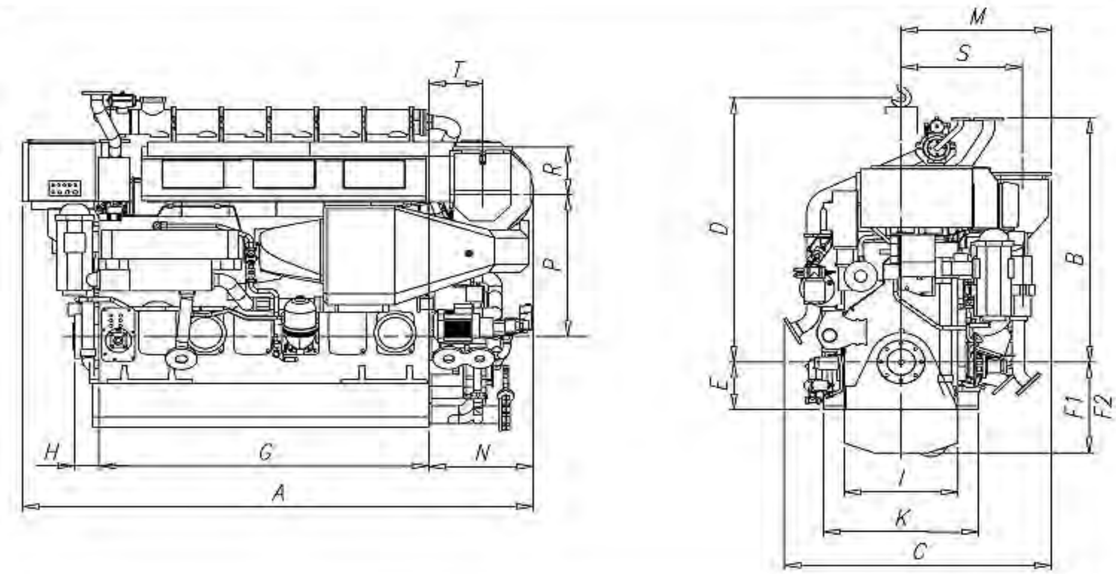


MAXIMUM LENGTH	3761	mm
MAXIMUM HEIGHT	2150	mm
MIN. DRY WEIGHT	79610	kg

with gearbox: Reintjes LAF 873, Weight 3100 kg, Ratio 7.455

#1 REPLACEMENT ENGINE (DUAL FUEL DIESEL ENGINE)

Wartsila 20DF Product Guide — 1. Main Data and Outputs



Engine type	A	B	C	D	E	F1	F2	G	H
W 9L20DF	4076	1706	1824	1800	325	624	824	2980	155

F1 for dry sump and F2 for deep wet sump

Engine type	I	K	M	N	P	R	S	T	Weight
W 9L20DF	718	980	1084	731	1000	390	863	339	11.7

** Turbocharger at flywheel end*
Dimensions in mm. Weight in tons.

2 x WARTSILA 6L34DF; 3620 HP
(DIRECT ARRANGEMENT)

MAXIMUM LENC	8700	mm
MAXIMUM HEIG	4000	mm
MIN. DRY WEIG	57000	kg
RPM	750	rpm

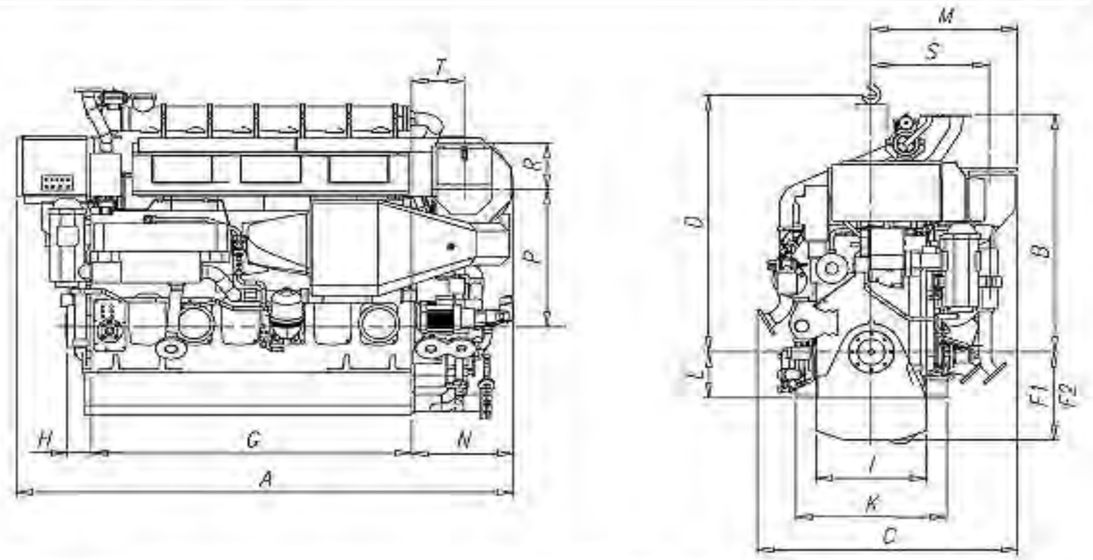
4545, Weight 8900 kg, Ratio 3.423

kW/RPM	3.6

#2 REPLACEMENT ENGINE (DUAL FUEL DIESEL ENGINE)

2 x WARTSILA 9L20DF; 2260 HP (DIRECT ARRANGEMENT)

Wärtsilä 20DF Product Guide — 1. Main Data and Outputs



Engine type	A	B	C	D	E	F1	F2	G	H
W 9L20DF	4076	1706	1824	1800	325	624	824	2980	155

F1 for dry sump and F2 for deep wet sump

Engine type	I	K	M	N	P	R	S	T	Weight
W 9L20DF	718	980	1084	731	1000	390	863	339	11.7

** Turbocharger at flywheel end*
Dimensions in mm. Weight in tons.

MAXIMUM LENC	4076	mm
MAXIMUM HEIG	1800	mm
MIN. DRY WEIG	117000	kg
RPM	1200	rpm

863, Weight 3050 kg, Ratio 5.842

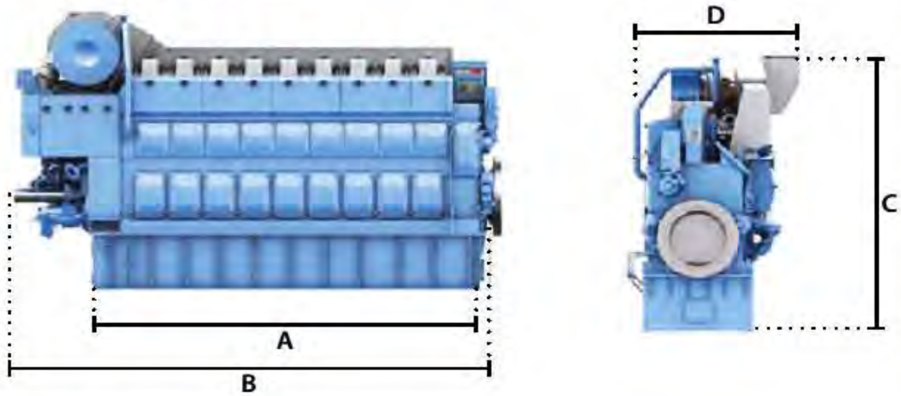
kW/RPM	1.39

#3 REPLACEMENT ENGINE (GAS ENGINE)

2 x ROLLS ROYCE C26:33L; 2935 HP (DIRECT ARRANGEMENT)

Propulsion engines - Gas

Bergen C26:33L



Principal dimensions

Cylinder diameter 260mm. Piston stroke 330mm.

Engine Type	A	B	C	D	Weight Dry Engine
C26:33L8PG	3930	4796	3195	1748	20700kg

Technical data

Engine Type		C26:33L8PG*
Number of cylinders		8
Engine speed	r/min	900/1000
Mean piston speed	m/s	10/11
Max. continuous rating (MCR)	kW	1940/2160
Max. continuous rating (MCR)	BHP (metric)	2675/2935
Mean effective pressure (BMEP)	bar	18.5
Specific energy consumption	kJ/kWh	7450/7500
Specific lubricating oil consumption	g/kWh	0.4
Cooling water temp. engine outlet	°C	90

* In progress - release date to be announced at a

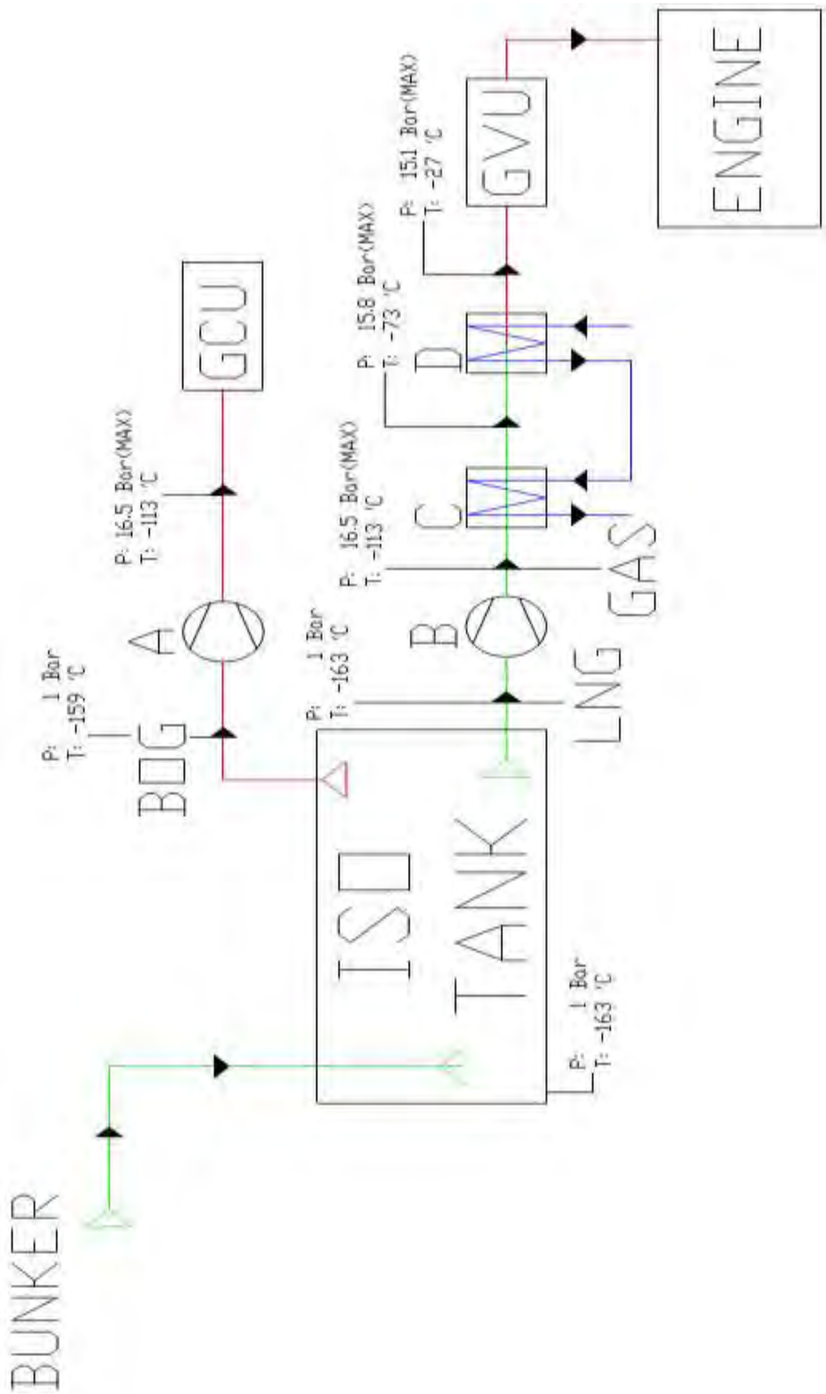
All data subject to change without prior notice

MAXIMUM LENGTH	4796	mm
MAXIMUM HEIGHT	3195	mm
MIN. DRY WEIGHT	20700	kg

RPM	1000	rpm
kW/RPM	2.22	

with gearbox: Reintjes WAF 2346, Weight 5750 kg, Ratio 4.45

CONVERSION PROCESS FLOW



PUMP (B) OUTLET PRESSURE	16.5	Bar (Maximum)
LT VAPORIZER (C) PRESSURE DROP	0.68	Bar (Maximum)
HT VAPORIZER (C) PRESSURE DROP	0.68	Bar (Maximum)
GVU INLET PRESSURE	15.14	Bar (Optimist)

*high pressure outlet is to fullfill the required pressure of GVU in not less than 5 Bar
(Karlsson, 2010)

DAILY LNG EQUIVALENT SCENARIOS

	PERCENTAGE		DAILY CONSUMPTION	
	HSD	LNG	HSD (ltr)	LNG (m^3)
	40.0%	60.0%	676.96	3.05

*with endurance **10** day(s)

LNG ISO TANK(S) SCENARIOS

DANTECO Industries		
Type	Portable Tank T11	
Capacity	23750	litre (95%)
Dimension	20	feet

CHART LNG ISO Intermodal		
Type	ICC-20-P-10	
Capacity	19352	litre (95%)
Dimension	20	feet

WESSINGTON Cryogenics		
Type	ISO VAC 40-LNG	
Capacity	41325	litre (95%)
Dimension	40	feet

ARGON ISO TANK		
Type	10 FEET ISO TANK	
Capacity	7570	litre (95%)
Dimension	10	feet

	10 DAYS (ltr)		SCENARIOS 20' + 10' (units)	SCENARIOS 40' (units)	SCENARIOS 40' (units)
	HSD	LNG	2 DANTECO + 1 ARGON	1 WESSI	2 CHART
	6769.57	30527.15	55070.0	41325.0	38703.0
			3.0	1.0	2.0

BOIL-OFF GAS SCENARIOS USING CHART 20'

	10 DAYS (ltr)	DAILY BOG RATE (ltr)
	LNG	LNG
	87.08	8.7

*with assumption BOG rate **0.15** %/day

PIPE CALCULATION (BOG)

$$db = 0{,}0189 \times \sqrt{\frac{Qe}{Ve}}$$

(Putra, 2014)

m	=	0.0001	kg/s				
LNG ρ	=	456.0	kg/m3				
Qe	=	0.00000022	m3/s				
Vc	=	2.0	m/s	*(assumed)*			
db	=	0.00001	m				
db	=	0.0003	inch				
db	=	0.25	inch	=	6	mm	(JIS)

PIPE CALCULATION (LNG)

$$db = 0{,}0189 \times \sqrt{\frac{Qe}{Ve}}$$

(Putra, 2014)

m	=	0.000035	kg/s				
LNG ρ	=	456.0	kg/m3				
Qe	=	0.00000008	m3/s				
Vc	=	2.0	m/s				
db	=	0.0000	m				
db	=	0.0002	inch				
db	=	0.25	inch	=	6	mm	(JIS)

COMPRESSOR CALCULATION (BOG)

$$h_{L,\text{ total}} = h_{L,\text{ major}} + h_{L,\text{ minor}}$$ *(Cengel, 2014)*

$$h_{L,\text{ total}} = \left(f\frac{L}{D} + \sum K_L\right)\frac{V^2}{2g}$$ *(Cengel, 2014)*

$$\text{Re} = \frac{\text{Inertial forces}}{\text{Viscous forces}} = \frac{V_{\text{avg}}D}{\nu} = \frac{\rho V_{\text{avg}}D}{\mu}$$ *(Cengel, 2014)*

db	=	0.01	m		
V	=	2.0	m/s		
LNG ρ	=	456.0	kg/m3		
u	=	0.00011	kg/ms		*(Dobrota, 2013)*
g	=	9.81	m/s2		
Re	=	8.64E+04			
ε	=	0.15			*(galvanizes steel)*
r	=	ε/db (in mm)	=	0.014	
f	=	0.0435			
L	=	10	m (MAXIMUM)		
∑KL	=	3 x bend	=	0.9	
	=	5 x gate valve	=	1	
		tee (line flow)	=	0.2	
∑KL	=	TOTAL	=	2.1	
hL.TOTAL	=	8.94	m		
L/hL.TOTAL	=	1.12			

S/N	Model	gas deliveryNm3/h	inlet pressureMpa	outletpressureMpa	Power kw	Medium	Dimensionmm
1	ZW-0,8/10-16	450	1,0	1,6	11	LPG / DME / Butadiene / Propane Isobutylene	1100*740*960
2	ZW-1.1/10-16	600	1,0	1,6	15		1100*740*960
3	ZW-1.35/10-16	750	1,0	1,6	18,5		1100*740*960
4	ZW-1.6/10-16	950	1,0	1,6	22		1400*900*1180
5	ZW-2.0/10-16	1200	1,0	1,6	30		1400*900*1180
6	ZW-2.5/10-16	1500	1,0	1,6	37		1400*900*1180

LT VAPORIZER HE CALCULATION (LNG)

$Q = m.Cp. (T_2 - T_1)$ *(Primo, 2015)*

LNG ρ	=	456	kg/m^3			
m	=	0.016	kg/s	*mass flowrate LNG consumption*		
Cp	=	10.80	J/kg.K	*(Dobrota, 2013)*		
t2	=	-163.00	C	=	110.15	K
t1	=	-182.00	C	=	91.15	K
Q1	**=**	**3.306**	**Joule**			
Q1	**=**	**0.003**	**kJ**			

$m = q / h_e$ *(Primo, 2015)*

m	=	0.016	kg/s	*mass flowrate LNG consumption*
he	=	0.129	kJ/kg	
Q2	**=**	**0.002**	**kJ**	
Q2	**=**	**2.085**	**Joule**	

$Q = m.Cp. (T_2 - T_1)$ *(Primo, 2015)*

LNG ρ	=	456	kg/m^3			
m	=	0.016	kg/s	*mass flowrate LNG consumption*		
Cp	=	10.80	J/kg.K	*(Dobrota, 2013)*		
t2	=	-41.50	C	=	231.65	K *(after LT Vap.)*
t1	=	-113.00	C	=	160.15	K *(after LNG pump)*
Q3	**=**	**12.441**	**Joule**			
Q3	**=**	**0.012**	**kJ**			

Q.total	=	17.832	Joule
Q.total	=	0.018	kJ

LT VAPORIZER HE CALCULATION (R134A)

$Q = m.Cp. (T_2 - T_1)$ *(Primo, 2015)*

m	=	1.00	m^3/jam			
RI34A ρ	=	4.25	kg/m^3			
Cp	=	880	J/kg.K	*(Talley, 2011)*		
T2	=	-41.00	C	=	232.15	K
T1	=	30.0	C	=	303.15	K
Q	**=**	**73.761**	**Joule**			
Q	**=**	**0.0178**	**kJ**			

LT VAPORIZER HE CALCULATION (AREA)

$Q = U \times A \times \Delta T_m$ *(Primo, 2015)*

$A = Q / (U \times \Delta T_m)$ *(Primo, 2015)*

$$\Delta T_m = \frac{(T_1 - t_2) - (T_2 - t_1)}{\ln \dfrac{(T_1 - t_2)}{(T_2 - t_1)}} = {}^\circ F$$ *(Primo, 2015)*

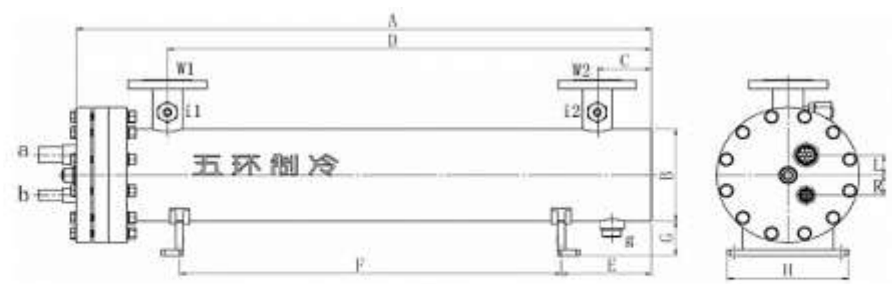
Q	**=**	**17.8322**	**Joule**
Q	**=**	**0.0178**	**kJ**
U	=	*liquid outside and gas (1 atm) inside tube*	
U	=	42.5	J/(m2.K) *(Primo, 2015)*
T1	=	303.2	K (R134A temperature)
T2	=	232.15	K
t1	=	160.15	K
t2	=	231.65	K
ΔTm	=	25.2	K
A	**=**	**0.0167**	**m2**

LT VAPORIZER HE CALCULATION (n-TUBE)

$A_i = n \pi D_i L$ *(Cengel, 2008)*

A	**=**	**0.0167**	**m2**			
WHB 5.0 DKG Series	with	H (in design)	=	200	mm	
		A (in design)	=	660	mm	
	then	A (Shell Area)	=	**0.41**	m2	

Dinner	=	0.022	m
L	=	0.66	m
n	**=**	**10**	**pc(s)**



Shell And Stainless Steel Tube Evaporator

Model	Capacity	Water Flow	Dimension Size (mm)										Gas Out	Gas In	Water In/Out	TEMP. Sensor	Drain Port	N.W
	KW	M³/H	A	B	C	D	E	F	G	H	R	L	Øa	Øb	w1/2	i1/2	g	Kg
WHB-5.0DKG	11.6	2.0	660	170	90	500	130	400	60	200	35	35	22	19	50	1/2	25	28
WHB-8.0DKG	18.6	3.2	950	170	90	790	190	600	60	200	35	35	28	19	50	1/2	25	36
WHB-10DKG	23.2	4.0	1180	170	90	1020	350	600	60	200	35	35	28	19	50	1/2	25	40
WHB-12DKG	27.0	4.8	900	200	90	740	560	600	60	200	40	40	28	19	50	1/2	25	48

HT VAPORIZER HE CALCULATION (LNG)

$Q = m.Cp.(T_2 - T_1)$ *(Primo, 2015)*

LNG ρ	=	456	kg/m^3				
m	=	0.016	kg/s	*mass flowrate LNG consumption*			
Cp	=	10.80	J/kg.K	*(Dobrota, 2013)*			
t2	=	30.00	C		=	303.15	K *(after LT Vap.)*
t1	=	-41.50	C		=	231.65	K *(after LNG pump)*
Q3	**=**	**12.441**	**Joule**				
Q3	**=**	**0.012**	**kJ**				
Q.total	=	12.441	Joule				
Q.total	=	0.012	kJ				

HT VAPORIZER HE CALCULATION (AFTERCOOLER)

$Q = m.Cp.(T_2 - T_1)$ *(Primo, 2015)*

m	=	30.0	m^3/jam	*(assumed from Wartsila 20DF)*			
Aftercooler ρ	=	1000.00	kg/m^3				
Cp	=	15	J/kg.K	*(Talley, 2011)*			
T2	=	30	C		=	303.25	K
T1	=	97.0	C		=	370.15	K
Q	**=**	**8572.213**	**Joule**				
Q	**=**	**8.5722**	**kJ**				

HT VAPORIZER HE CALCULATION (AREA)

$Q = U \times A \times \Delta T_m$ *(Primo, 2015)*

$A = Q/ (U \times \Delta T_m)$ *(Primo, 2015)*

$$\Delta T_m = \frac{(T_1 - t_2) - (T_2 - t_1)}{\ln \dfrac{(T_1 - t_2)}{(T_2 - t_1)}} = {}^\circ F$$ *(Primo, 2015)*

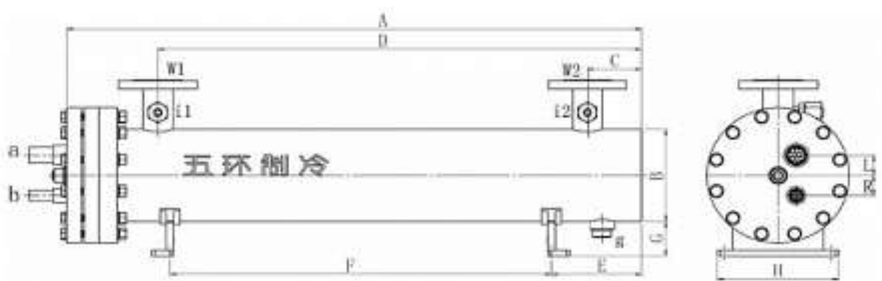
Q	=	**12.4413**	**Joule**	
Q	=	**0.0124**	**kJ**	
U	=	*liquid outside and gas (1 atm) inside tube*		
U	=	42.5	J/(m2.K)	*(Primo, 2015)*
T1	=	370.2	K (R134A temperature)	
T2	=	303.25	K	
t1	=	231.65	K	
t2	=	303.15	K	
ΔTm	=	19.1	K	
A	=	**0.0153**	**m2**	

LT VAPORIZER HE CALCULATION (n-TUBE)

$A_i = n\pi D_i L$ *(Cengel, 2008)*

A	=	**0.0153**	**m2**			
WHB 5.0 DKG Series	with	H (in design)	=	200	mm	
		A (in design)	=	660	mm	
	then	A (Shell Area)	=	**0.41**	m2	

Dinner	=	0.022	m
L	=	0.66	m
n	=	**10**	**pc(s)**



Shell And Stainless Steel Tube Evaporator

Model	Capacity	Water Flow	Dimension Size (mm)										Gas Out	Gas In	Water In/Out	TEMP. Sensor	Drain Port	N.W
	KW	M³/H	A	B	C	D	E	F	G	H	R	L	Øa	Øb	w1/2	i1/2	g	Kg
WHB-5.0DKG	11.6	2.0	660	170	90	500	130	450	60	200	35	35	22	19	50	1/2	25	29
WHB-8.0DKG	18.6	3.2	950	170	90	790	190	600	60	200	35	35	28	19	50	1/2	25	36
WHB-10DKG	23.2	4.0	1180	170	90	1020	350	600	60	200	35	35	28	19	50	1/2	25	40
WHB-12DKG	27.0	4.8	900	200	90	740	560	600	60	200	40	40	28	19	50	1/2	25	48

PUMP CALCULATION (LNG)

$$h_{L,\text{ total}} = h_{L,\text{ major}} + h_{L,\text{ minor}}$$ *(Cengel, 2014)*

$$h_{L,\text{ total}} = \left(f\frac{L}{D} + \sum K_L\right)\frac{V^2}{2g}$$ *(Cengel, 2014)*

$$\text{Re} = \frac{\text{Inertial forces}}{\text{Viscous forces}} = \frac{V_{\text{avg}}D}{\nu} = \frac{\rho V_{\text{avg}}D}{\mu}$$ *(Cengel, 2014)*

db	=	0.01	m		
V	=	2.0	m/s		
LNG ρ	=	456.0	kg/m3		
u	=	0.00011	kg/ms	*(Dobrota, 2013)*	
g	=	9.81	m/s2		
Re	=	8.64E+04			
ε	=	0.15		*(galvanizes steel)*	
r	=	ε/db (in mm)	=	0.014	
f	=	0.0435			
L	=	23.2	m (MAXIMUM)		
∑KL	=	3 x bend	=	0.9	
	=	8 x gate valve	=	1.6	
∑KL	=	TOTAL	=	2.5	
hL.TOTAL	=	20.26	m		
L/hL.TOTAL	=	1.15			

Mode	Type	Flow Range (L/H)	Inlet Pressure (Mpa)	Max Pressure (Mpa)
SVOC30-80/165		30-80		
SVNB50-150/165	Single	50-150		
SVNB100-450/165	Horizontal	100-450	0.02-1.6	1.65
SVMB300-600/165	Piston	300-600		
SVMA400-800/165		400-800		
DVNA400-1000/165	Double.	400-1000		
DVMB600-1200/165	Horizontal	600-1200	0.02-1.6	1.65
DVMA800-1600/165	Piston	800-1600		
SVNB100-200/200	Single.	100-200		
SVNB200-450/200	Horizontal	200-450	0.02-1.6	2.0
SVMB300-600/200	Piston	300-600		

*high pressure outlet is to fullfill the required pressure of GVU in not less than 5 Bar
(Karlsson, 2010)

CATERPILLAR 3516C (CONVERSION TO 60:40 - LNG:HSD)

	UTILIZATION (hours)					HSD (ltr)	LNG (m^3)
	FULL	ECO	MANEU	TOW	STAND	30%	70%
AVERAGE	5.27	6.67	16.60	13.21	12.82	**676.96**	**3.05**

	vs	RPM	
FULL SPEED	10.30	1300	**81.25%**
ECONOMICAL SP	6.55	1100	**68.75%**
MANEUVER	2.45	800	**50.00%**
STAND BY	0.00	650	**40.63%**

(based on Agreement Letter 16 Nov 2015)

Wartsila 6L34DF (DFDE)

LNG MODE	UTILIZATION (hours)					HSD (ltr)	LNG (m^3)
	FULL	ECO	MANEU	TOW	STAND		
AVERAGE	5.27	6.67	16.60	13.21	12.82	**217.43**	**4134.21**

Wartsila 9L20DF (DFDE)

LNG MODE	UTILIZATION (hours)					HSD (ltr)	LNG (m^3)
	FULL	ECO	MANEU	TOW	STAND		
AVERAGE	5.27	6.67	16.60	13.21	12.82	**38.80**	**3017.11**

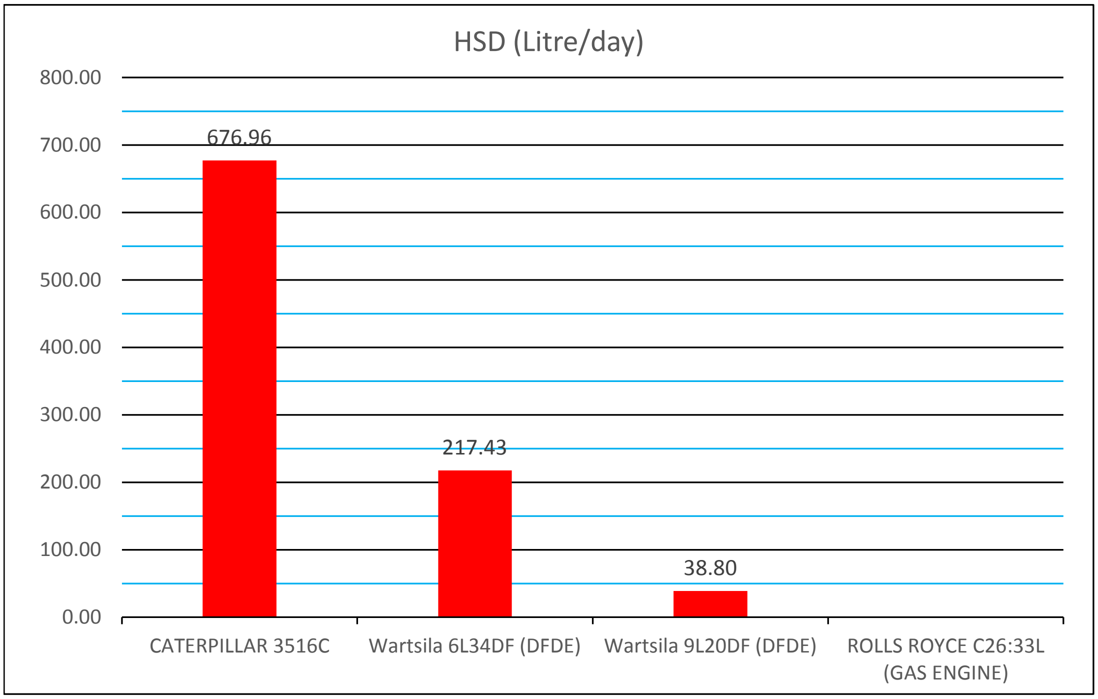
ROLLS ROYCE C26:33L (GAS ENGINE)

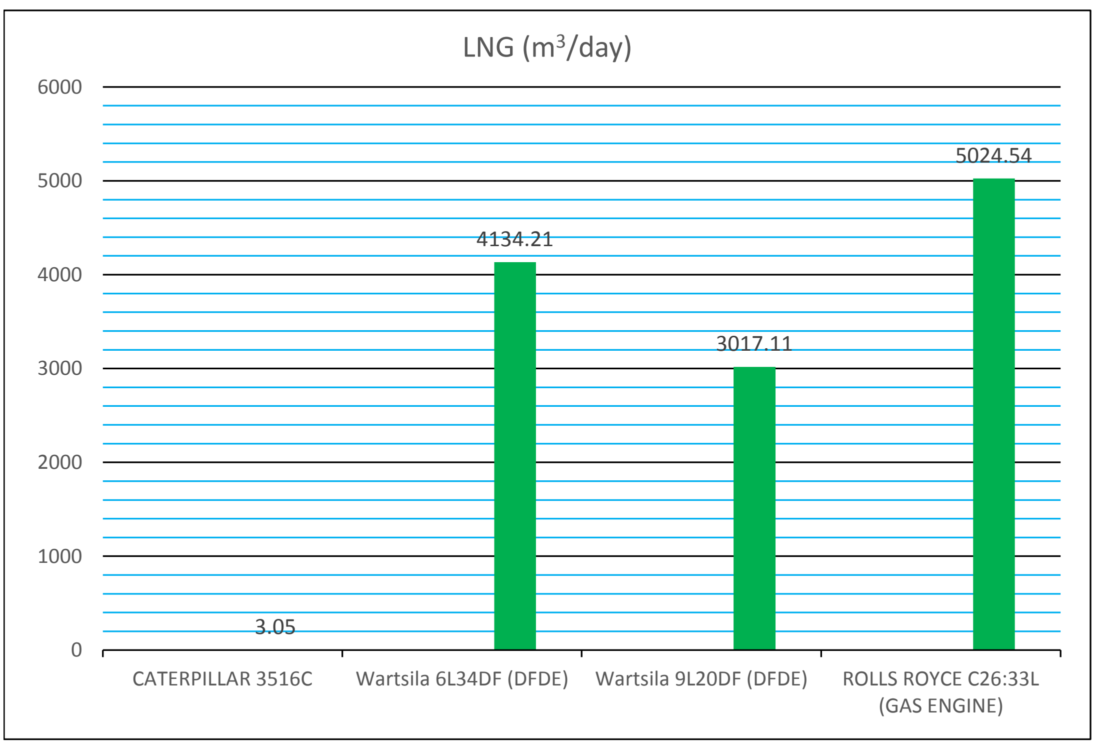
LNG MODE	UTILIZATION (hours)					HSD (ltr)	LNG (m^3)
	FULL	ECO	MANEU	TOW	STAND		
AVERAGE	5.27	6.67	16.60	13.21	12.82		**5024.54**

HSD LHV	=	42.791	**MJ/kg**
HSD ρ	=	850.000	**kg/m^3**
litre	=	0.001	**m^3**
GAS GCV	=	43.900	**MJ/m^3**
GAS ρ	=	0.801	**kg/m^3**
LNG ρ	=	456.000	**kg/m^3**
LNG LHV	=	54.810	**MJ/m^3**
MMBTU	=	1055	**MJ**

HSD	=	**0.67**	**$/litre**
LNG	=	**4**	**$/MMBTU**

MAIN ENGINE	HSD (ltr)	LNG (m^3)	LNG (MMBTU)
CATERPILLAR 3516C	676.96	3.05	0.16
Wartsila 6L34DF (DFDE)	217.43	4134.21	214.78
Wartsila 9L20DF (DFDE)	38.80	3017.11	156.75
ROLLS ROYCE C26:33L (GAS ENGINE)		5024.54	261.04





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APPENDIX
ECONOMIC

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CONVERSION (60;40)

Capital Cost

No	Items	Value	Units	Price (USD)	
1.	Container ISO Tank 20	19352	Liter	$	32,000
2	Argon Container ISO Tank 10	7570	Liter	$	25,000
3	Heat Exchanger			$	40,000
4	Cryogenic Pump			$	30,000
5	Unit Conversion System (GCU, GVU)			$	150,000
6	NG supply system (piping, cabling, monitoring and control system)			$	50,000
7	Installation 5 worker/day			$	2,000
8	Docking			$	250,000
9	Flat Bottom LNG Tank			$	6,000
					Sub Total
					PPN
					Total In

Operasional Cost

No.	Data Operasional		Units	Value	
1.	Life Time		Year		20
2.	Investation		Rupiah	Rp	14,210,625,000
3.	Disposal Price (20%*Investment) / Year		Rupiah	Rp	2,842,125,000
4.	Annual Depreciation		Rupiah	Rp	568,425,000

Vessel Operational Cost 1 USD = Rp 13,250

No.	Items of Investment	Value	Units	Price Per Item (USD)	
1	Maintenance Per Year	1	Time	$	30,000
					Total Operatio
No.	Items of Investment	Value	Units	Price Per Item (USD)	
1	Payload Loses Per Year		Units Car		
					Total Loses

*Lifetime = Period of Investation

*Investation = Capital Cost

*Disposal Price = decreasing of investment value per annual based on predicted lifetime

*Annual Depreciation = decreasing of investment value per annual

No.	Data Operasional		Units	Value	
1.	Life Time		Year		3
2.	Investation		Rupiah	Rp	34,118,750,000
3.	Disposal Price (20%*Investment) / Year		Rupiah	Rp	6,823,750,000
4.	Annual Depreciation		Rupiah	Rp	9,098,333,333
	Revenue selling of engine			Rp	25,020,416,667

	Rp	4,332,750,000				

1 USD to IDR	Price (IDR)	Reference	Quantity	Units	Total Price
Rp 13,250	Rp 424,000,000	LNG Solution	2	Units	Rp 848,000,000
Rp 13,250	Rp 331,250,000	LNG Solution	1	Units	Rp 331,250,000
Rp 13,250	Rp 530,000,000	Alibaba	4	Units	Rp 2,120,000,000
Rp 13,250	Rp 397,500,000	Alibaba	2	Units	Rp 795,000,000
Rp 13,250	Rp 1,987,500,000	LNG Solution	2	Units	Rp 3,975,000,000
Rp 13,250	Rp 662,500,000	LNG Solution	1	Set	Rp 662,500,000
Rp 13,250	Rp 26,500,000	ABS	30	Day	Rp 795,000,000
Rp 13,250	Rp 3,312,500,000	PT. DKB	1		Rp 3,312,500,000
Rp 13,250	Rp 79,500,000	LNG Solution	1	m3	Rp 79,500,000
Investment					Rp 12,918,750,000
N 10%					Rp 1,291,875,000
vestment					Rp 14,210,625,000

1 USD to IDR	Value
Rp 13,250	$ 1,072,500
Rp 13,250	$ 214,500
Rp 13,250	$ 42,900
	200

Price Per Item (IDR)	Reference	Price/Month (IDR)	Quantity	Units	Total Price/Year (IDR)
Rp 397,500,000	PT. ASDP Indonesia Ferry	Rp 397,500,000	1	Time	Rp 397,500,000
nal Cost Per Year					Rp 397,500,000
Price Per Item (IDR)	**Reference**	**Price/Month (IDR)**	**Quantity**	**Units**	**Total Price/Year (IDR)**
Rp -		Rp -	0	Month	Rp -
Cost Per Year					Rp 397,500,000

1 USD to IDR	Value
Rp 13,250	$ 2,575,000
Rp 13,250	$ 515,000
Rp 13,250	$ 686,667

REPLACEMENT

Capital Cost

No	Items	Value	Units	Price (USD)	1 USD to IDR
1	ROLLS ROYCE C2;33L Gas Engine	2935	HP	$ 1,467,500	Rp 13,250
2	Argon Container ISO Tank 10	7570	Liter	$ 25,000	Rp 13,250
2	Container ISO Tank	19352	Liter	$ 32,000	Rp 13,250
3	Heat Exchanger			$ 40,000	Rp 13,250
4	Cryogenic Pump			$ 30,000	Rp 13,250
5					
6	Vaporizer and NG supply system (piping, cabling, monitoring and control system)			$ 50,000	Rp 13,250
7	Installation 5 worker/day			$ 2,000	Rp 13,250
8	Docking			$ 300,000	Rp 13,250
9	Flat Bottom LNG Tank			$ 6,000	Rp 13,250
Total Investment					
PPN 10%					
Total Investment					

Operational Cost

No.	Data Operasional		Units	Value	1 USD to IDR
1.	Life Time		Year	20	
2.	Investation		Rupiah	Rp 48,112,075,000	Rp 13,250
3.	Disposal Price (20%*Investment) / Year		Rupiah	Rp 9,622,415,000	Rp 13,250
4.	Annual Depreciation		Rupiah	Rp 1,924,483,000	Rp 13,250

Biaya Operasional Kapal 1 USD = Rp 13,250

No.	Items of Investment	Value	Units	Price Per Item (USD)	Price Per Item (IDR)
1	Maintenance Per Year	1	Time	$ 40,000	Rp 530,000,000
				Total Operational Cost Per Year	
No.	Items of Investment	Value	Units	Price Per Item (USD)	Price Per Item (IDR)
1	Payload Loses Per Year	0	Units Car	$ -	Rp -
					Total Operational Cost Per Year

MAIN ENGINE	LOAD	BHP
CATERPILLAR 3516C	1600.00	2575.00
Wartsila 6L34DF (DFDE)	750.00	3620.00
Wartsila 9L20DF (DFDE)	1200.00	2260.00
ROLLS ROYCE C26:33L (GAS ENGINE)	1000	2935.00

*with initial cost assumption 500 US$/HP

*with initial cost assumption 500 US$/HP

Price (IDR)		Reference	Quantity	Units	Total Price	
Rp	19,444,375,000	Rolls Royce	2	Units	Rp	38,888,750,000
Rp	331,250,000	LNG Solution	0	Units	Rp	-
Rp	424,000,000	LNG Solution	0	Units	Rp	-
Rp	530,000,000	Alibaba	0	Units	Rp	-
Rp	397,500,000	Alibaba	0	Units	Rp	-
Rp	-				Rp	-
Rp	662,500,000	LNG Solution	1	Set	Rp	-
Rp	26,500,000	ABS	30	Day	Rp	795,000,000
Rp	3,975,000,000	PT. DKB	1		Rp	3,975,000,000
Rp	79,500,000	LNG Solution	1	m3	Rp	79,500,000
					Rp	43,738,250,000
					Rp	4,373,825,000
					Rp	48,112,075,000

Value	
$	3,631,100
$	726,220
$	145,244

Reference	Price/Month (IDR)		Quantity	Units	Total Price/Year (IDR)	
	Rp	530,000,000	1	Time	Rp	530,000,000
					Rp	530,000,000
Reference	Price/Month (IDR)		Quantity	Units	Total Price/Year (IDR)	
	Rp	-		Month	Rp	-
					Rp	530,000,000

kW
2160

(MAXIMUM FOR DUAL FUEL & GAS ENGINE)

TOTAL OF MAIN ENGINE FUEL OIL CONSUMPTION (MONTHLY)
AND THE LNG EQUIVALENT

	MONTH	TILIZATION (hours)			
		FULL	ECO	MANEU	TOW
14	DECEMBER	3.40	6.67	7.43	0.00
15	JANUARY	3.96	5.19	8.97	0.00
15	FEBRUARY	0.75	6.61	2.21	0.00
15	MARCH	3.44	3.70	6.09	0.00
15	APRIL	3.37	1.03	5.17	0.00
15	MAY	4.01	1.22	5.63	0.00
15	JUNE	2.89	0.71	6.71	0.00
15	JULY	3.55	0.74	5.32	0.00
15	AUGUST	4.92	0.73	7.59	0.00
15	SEPTEMBER	5.27	1.05	7.30	0.00
15	OCTOBER	4.19	1.52	12.13	0.00
15	NOVEMBER	0.25	0.00	14.49	0.00
15	DECEMBER	4.61	0.96	9.82	13.21
16	JANUARY	5.15	1.23	16.60	11.71
16	FEBRUARY	4.92	1.02	10.16	0.00
	TOTAL	54.67	32.39	125.62	24.92
	PRICE (US$)				

TOTAL OF MAIN ENGINE FUEL OIL CONSUMPTION (YEARLY) AND THE LNG EQUIVALENT

HSD LHV	=	42.791	MJ/kg
HSD ρ	=	850.000	kg/m^3
litre	=	0.001	m^3
GAS GCV	=	43.900	MJ/m^3
GAS ρ	=	0.801	kg/m^3
LNG ρ	=	456.000	kg/m^3
LNG LHV	=	54.810	MJ/m^3
MMBTU	=	1055	MJ
1 $	=	13250	Rp
HSD	=	0.67	$/litre
LNG	**=**	**4**	**$/MMBTU**
HSD	=	8877.5	Rp/litre
LNG	=	53000	Rp/MMBTU

HSD (ltr)/month	Month	HSD (ltr)/year	HSD (kg)/year	HSD (MJ)/year
44575.73	12	534909	454,672	19,455,889

REVENUE DETERMINATION FOR EACH SCENARIO

A. CONVERSION

CONV 4

Single Fuel				
HSD (Liter)/year	$ HSD (Liter/year)	Rp HSD (Liter/year)	40% HSD (MJ)/year	40% HSD (kg/year)
534,909	358,389	4,748,652,692	7,782,356	181,868.99

60% LNG (MJ)/year	60% LNG (mmbtu/year)
11,673,533.61	11,064.96

Total Dual Fuel Cost (Rp)/year	Revenue (Rp)/year
2,485,903,997.62	2,262,748,694.38

Single Fuel				
HSD (Liter)/year	$ HSD (Liter/year)	Rp HSD (Liter/year)	100% LNG (MJ)/year	100% LNG (mmbtu/year)
534,909	358,389	4,748,652,692	19,455,889	18,441.60

Total Gas Fuel Cost (Rp)/year	Revenue (Rp)/year
977,404,868.03	3,771,247,823.97

	HSD (ltr)	LNG (m^3)
STAND		
5.90	4078.55	5.94
6.63	4189.74	6.10
1.70	2458.43	3.58
12.82	3779.65	5.50
12.15	4043.32	5.98
11.61	3584.19	5.22
10.54	3672.68	5.43
10.44	3320.87	4.83
9.35	4359.68	6.34
9.59	3151.90	4.59
6.30	1836.55	2.67
9.32	695.57	1.01
8.08	2179.35	3.17
3.24	1926.61	2.80
11.62	1298.64	1.89
129.28	44575.73	65.05
	29865.74	13.52

1 Knot =	1.852	km/h		
1 km/h =	0.540	Knot	1 kg	0.054 mmbtu
1 Mile =	1.852	Km	1m3	0.041 mmbtu
ρ LNG =	0.456	ton/m^3	IGU NATURAL GAS CONVERSION BOOK pp. 22-23	
ρ HSD =	0.85	ton/m^3	IRPC Petroleum ID AL3 1202000767	
LHV HSD =	42.61	MJ/kg	Biomass Energy Data Book 2011; Low Sulphur Diesel	
LHV LNG =	54.81	MJ/kg	IGU NATURAL GAS CONVERSION BOOK pp. 22-23	
LNG Price =	9.24	$/mmbtu	Badak LNG Price (Local)	
HSD Price =	Rp 9,643	Rp/L	Harga Non Subsidi Wilayah 2 Kalimantan	
1 mmBtu =	18.69	kg	IGU NATURAL GAS CONVERSION BOOK pp. 22-23	
1 $ =	13,220	Rupiah		
LNG Storage =	105	m3		

Dual Fuel (40:60)			
40% HSD (m3/year)	40% HSD (liter/year)	40% HSD (Rp/year)	
213.96	213,963.51	1,899,461,076.80	

Dual Fuel (40:60)			
60% LNG (Rp/year)			
586,442,920.82			

Replacement Gas Engine (100% Gas)			
100% LNG (Rp/year)			
977,404,868.03			

ENGINE CONVERSION

CONV 4

Tahun	Nilai Investasi	Revenue	Operasional Cost	Payload Loses/Year	Depresiasi
0	Rp 14,210,625,000				
1		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
2		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
3		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
4		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
5		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
6		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
7		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
8		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
9		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
10	Rp 4,372,500,000	2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
11		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
12		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
13		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
14		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
15		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
16		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
17		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
18		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
19		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
20		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
					11,368,500,000

ASSUMED CONSTANT REVENUE

PV

Cash Flow		Proceeds		Cumulative Cash Flow		Discount Factor	Cash Flow Discounted (Present Value)	
						5%		
Rp	-14,210,625,000	Rp	(14,210,625,000)	Rp	(14,210,625,000.00)	1.00	-	14,210,625,000
Rp	1,296,823,694	Rp	1,865,248,694	Rp	(12,345,376,305.62)	0.95	Rp	1,776,427,327.98
Rp	1,296,823,694	Rp	1,865,248,694	Rp	(10,480,127,611.24)	0.91	Rp	1,691,835,550.46
Rp	1,296,823,694	Rp	1,865,248,694	Rp	(8,614,878,916.86)	0.86	Rp	1,611,271,952.82
Rp	1,296,823,694	Rp	1,865,248,694	Rp	(6,749,630,222.48)	0.82	Rp	1,534,544,716.97
Rp	1,296,823,694	Rp	1,865,248,694	Rp	(4,884,381,528.10)	0.78	Rp	1,461,471,159.02
Rp	1,296,823,694	Rp	1,865,248,694	Rp	(3,019,132,833.72)	0.75	Rp	1,391,877,294.30
Rp	1,296,823,694	Rp	1,865,248,694	Rp	(1,153,884,139.34)	0.71	Rp	1,325,597,423.15
Rp	1,296,823,694	Rp	1,865,248,694	Rp	711,364,555.04	0.68	Rp	1,262,473,736.33
Rp	1,296,823,694	Rp	1,865,248,694	Rp	2,576,613,249.41	0.64	Rp	1,202,355,939.36
Rp	1,296,823,694	Rp	1,865,248,694	Rp	69,361,943.79	0.61	Rp	1,145,100,894.63
Rp	1,296,823,694	Rp	1,865,248,694	Rp	1,934,610,638.17	0.58	Rp	1,090,572,280.60
Rp	1,296,823,694	Rp	1,865,248,694	Rp	3,799,859,332.55	0.56	Rp	1,038,640,267.24
Rp	1,296,823,694	Rp	1,865,248,694	Rp	5,665,108,026.93	0.53	Rp	989,181,206.89
Rp	1,296,823,694	Rp	1,865,248,694	Rp	7,530,356,721.31	0.51	Rp	942,077,339.90
Rp	1,296,823,694	Rp	1,865,248,694	Rp	9,395,605,415.69	0.48	Rp	897,216,514.19
Rp	1,296,823,694	Rp	1,865,248,694	Rp	11,260,854,110.07	0.46	Rp	854,491,918.27
Rp	1,296,823,694	Rp	1,865,248,694	Rp	13,126,102,804.45	0.44	Rp	813,801,826.93
Rp	1,296,823,694	Rp	1,865,248,694	Rp	14,991,351,498.83	0.42	Rp	775,049,358.98
Rp	1,296,823,694	Rp	1,865,248,694	Rp	16,856,600,193.21	0.40	Rp	738,142,246.65
Rp	1,296,823,694	Rp	1,865,248,694	Rp	18,721,848,887.59	0.38	Rp	702,992,615.85
								9,034,496,571

ENGINE CONVERSION

CONV 5

Tahun	Nilai Investasi	Revenue	Operasional Cost	Payload Loses/Year	Depresiasi
0	Rp 14,210,625,000				
1		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
2		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
3		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
4		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
5		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
6		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
7		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
8		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
9		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
10	Rp 4,372,500,000	Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
11		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
12		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
13		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
14		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
15		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
16		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
17		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
18		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
19		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
20		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
					11,368,500,000

ASSUMED CONSTANT REVENUE

PV

Cash Flow	Proceeds	Cumulative Cash Flow	Discount Factor	Cash Flow Discounted (Present Value)
			5%	
Rp -14,210,625,000	Rp (14,210,625,000)	Rp (14,210,625,000.00)	1.00	Rp (14,210,625,000.00)
Rp 1,150,212,964	Rp 1,718,637,964	Rp (12,491,987,035.83)	0.95	Rp 1,636,798,061.12
Rp 1,150,212,964	Rp 1,718,637,964	Rp (10,773,349,071.65)	0.91	Rp 1,558,855,296.30
Rp 1,150,212,964	Rp 1,718,637,964	Rp (9,054,711,107.48)	0.86	Rp 1,484,624,091.72
Rp 1,150,212,964	Rp 1,718,637,964	Rp (7,336,073,143.30)	0.82	Rp 1,413,927,706.40
Rp 1,150,212,964	Rp 1,718,637,964	Rp (5,617,435,179.13)	0.78	Rp 1,346,597,815.62
Rp 1,150,212,964	Rp 1,718,637,964	Rp (3,898,797,214.95)	0.75	Rp 1,282,474,110.11
Rp 1,150,212,964	Rp 1,718,637,964	Rp (2,180,159,250.78)	0.71	Rp 1,221,403,914.39
Rp 1,150,212,964	Rp 1,718,637,964	Rp (461,521,286.60)	0.68	Rp 1,163,241,823.23
Rp 1,150,212,964	Rp 1,718,637,964	Rp 1,257,116,677.57	0.64	Rp 1,107,849,355.46
Rp 1,150,212,964	Rp 1,718,637,964	Rp (1,396,745,358.25)	0.61	Rp 1,055,094,624.25
Rp 1,150,212,964	Rp 1,718,637,964	Rp 321,892,605.92	0.58	Rp 1,004,852,023.09
Rp 1,150,212,964	Rp 1,718,637,964	Rp 2,040,530,570.10	0.56	Rp 957,001,926.75
Rp 1,150,212,964	Rp 1,718,637,964	Rp 3,759,168,534.27	0.53	Rp 911,430,406.43
Rp 1,150,212,964	Rp 1,718,637,964	Rp 5,477,806,498.45	0.51	Rp 868,028,958.51
Rp 1,150,212,964	Rp 1,718,637,964	Rp 7,196,444,462.62	0.48	Rp 826,694,246.20
Rp 1,150,212,964	Rp 1,718,637,964	Rp 8,915,082,426.80	0.46	Rp 787,327,853.52
Rp 1,150,212,964	Rp 1,718,637,964	Rp 10,633,720,390.97	0.44	Rp 749,836,050.97
Rp 1,150,212,964	Rp 1,718,637,964	Rp 12,352,358,355.15	0.42	Rp 714,129,572.35
Rp 1,150,212,964	Rp 1,718,637,964	Rp 14,070,996,319.32	0.40	Rp 680,123,402.24
Rp 1,150,212,964	Rp 1,718,637,964	Rp 15,789,634,283.50	0.38	Rp 647,736,573.56
				7,207,402,812

ENGINE CONVERSION

CONV 6

Tahun	Nilai Investasi	Revenue	Operasional Cost	Payload Loses/Year	Depresiasi
0	Rp 14,210,625,000				
1		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
2		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
3		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
4		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
5		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
6		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
7		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
8		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
9		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
10	Rp 4,372,500,000	Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
11		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
12		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
13		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
14		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
15		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
16		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
17		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
18		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
19		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
20		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
					11,368,500,000

ASSUMED CONSTANT REVENUE

PV

Cash Flow		Proceeds		Cumulative Cash Flow		Discount Factor 5%	Cash Flow Discounted (Present Value)	
Rp	-14,210,625,000	Rp	(14,210,625,000)	Rp	(14,210,625,000.00)	1.00	Rp	(14,210,625,000.00)
Rp	1,003,602,234	Rp	1,572,027,234	Rp	(12,638,597,766.03)	0.95	Rp	1,497,168,794.26
Rp	1,003,602,234	Rp	1,572,027,234	Rp	(11,066,570,532.06)	0.91	Rp	1,425,875,042.15
Rp	1,003,602,234	Rp	1,572,027,234	Rp	(9,494,543,298.09)	0.86	Rp	1,357,976,230.62
Rp	1,003,602,234	Rp	1,572,027,234	Rp	(7,922,516,064.12)	0.82	Rp	1,293,310,695.83
Rp	1,003,602,234	Rp	1,572,027,234	Rp	(6,350,488,830.15)	0.78	Rp	1,231,724,472.22
Rp	1,003,602,234	Rp	1,572,027,234	Rp	(4,778,461,596.18)	0.75	Rp	1,173,070,925.92
Rp	1,003,602,234	Rp	1,572,027,234	Rp	(3,206,434,362.21)	0.71	Rp	1,117,210,405.64
Rp	1,003,602,234	Rp	1,572,027,234	Rp	(1,634,407,128.24)	0.68	Rp	1,064,009,910.13
Rp	1,003,602,234	Rp	1,572,027,234	Rp	(62,379,894.27)	0.64	Rp	1,013,342,771.55
Rp	1,003,602,234	Rp	1,572,027,234	Rp	(2,862,852,660.29)	0.61	Rp	965,088,353.86
Rp	1,003,602,234	Rp	1,572,027,234	Rp	(1,290,825,426.32)	0.58	Rp	919,131,765.58
Rp	1,003,602,234	Rp	1,572,027,234	Rp	281,201,807.65	0.56	Rp	875,363,586.27
Rp	1,003,602,234	Rp	1,572,027,234	Rp	1,853,229,041.62	0.53	Rp	833,679,605.97
Rp	1,003,602,234	Rp	1,572,027,234	Rp	3,425,256,275.59	0.51	Rp	793,980,577.11
Rp	1,003,602,234	Rp	1,572,027,234	Rp	4,997,283,509.56	0.48	Rp	756,171,978.20
Rp	1,003,602,234	Rp	1,572,027,234	Rp	6,569,310,743.53	0.46	Rp	720,163,788.77
Rp	1,003,602,234	Rp	1,572,027,234	Rp	8,141,337,977.50	0.44	Rp	685,870,275.02
Rp	1,003,602,234	Rp	1,572,027,234	Rp	9,713,365,211.47	0.42	Rp	653,209,785.73
Rp	1,003,602,234	Rp	1,572,027,234	Rp	11,285,392,445.44	0.40	Rp	622,104,557.84
Rp	1,003,602,234	Rp	1,572,027,234	Rp	12,857,419,679.41	0.38	Rp	592,480,531.27
								5,380,309,054

ENGINE REPLACEMENT

REP 4

Tahun	Nilai Investasi	Revenue	Operasional Cost	Payload Loses/Year	Depresiasi
0	Rp 48,112,075,000	Rp 25,020,416,667	Rp -	Rp (1)	Rp -
1		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
2		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
3		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
4		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
5		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
6		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
7		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
8		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
9		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
10		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
11		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
12		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
13		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
14		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
15		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
16		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
17		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
18		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
19		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
20		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
					38,489,660,000

ASSUMED CONSTANT REVENUE

PV

Cash Flow		Proceeds		Cumulative Cash Flow		Discount Factor	Cash Flow Discounted (Present Value)	
						5%		
Rp	25,020,416,668	Rp	25,020,416,668	Rp	(23,091,658,332.33)	1.00	Rp	25,020,416,667.67
Rp	1,316,764,824	Rp	3,241,247,824	Rp	(19,850,410,508.37)	0.95	Rp	3,086,902,689.49
Rp	1,316,764,824	Rp	3,241,247,824	Rp	(16,609,162,684.40)	0.91	Rp	2,939,907,323.32
Rp	1,316,764,824	Rp	3,241,247,824	Rp	(13,367,914,860.44)	0.86	Rp	2,799,911,736.50
Rp	1,316,764,824	Rp	3,241,247,824	Rp	(10,126,667,036.47)	0.82	Rp	2,666,582,606.19
Rp	1,316,764,824	Rp	3,241,247,824	Rp	(6,885,419,212.50)	0.78	Rp	2,539,602,482.09
Rp	1,316,764,824	Rp	3,241,247,824	Rp	(3,644,171,388.54)	0.75	Rp	2,418,669,030.56
Rp	1,316,764,824	Rp	3,241,247,824	Rp	(402,923,564.57)	0.71	Rp	2,303,494,314.82
Rp	1,316,764,824	Rp	3,241,247,824	Rp	2,838,324,259.39	0.68	Rp	2,193,804,109.35
Rp	1,316,764,824	Rp	3,241,247,824	Rp	6,079,572,083.36	0.64	Rp	2,089,337,247.00
Rp	1,316,764,824	Rp	3,241,247,824	Rp	9,320,819,907.32	0.61	Rp	1,989,844,997.14
Rp	1,316,764,824	Rp	3,241,247,824	Rp	12,562,067,731.29	0.58	Rp	1,895,090,473.47
Rp	1,316,764,824	Rp	3,241,247,824	Rp	15,803,315,555.25	0.56	Rp	1,804,848,069.97
Rp	1,316,764,824	Rp	3,241,247,824	Rp	19,044,563,379.22	0.53	Rp	1,718,902,923.78
Rp	1,316,764,824	Rp	3,241,247,824	Rp	22,285,811,203.19	0.51	Rp	1,637,050,403.60
Rp	1,316,764,824	Rp	3,241,247,824	Rp	25,527,059,027.15	0.48	Rp	1,559,095,622.48
Rp	1,316,764,824	Rp	3,241,247,824	Rp	28,768,306,851.12	0.46	Rp	1,484,852,973.79
Rp	1,316,764,824	Rp	3,241,247,824	Rp	32,009,554,675.08	0.44	Rp	1,414,145,689.32
Rp	1,316,764,824	Rp	3,241,247,824	Rp	35,250,802,499.05	0.42	Rp	1,346,805,418.40
Rp	1,316,764,824	Rp	3,241,247,824	Rp	38,492,050,323.01	0.40	Rp	1,282,671,827.05
Rp	1,316,764,824	Rp	3,241,247,824	Rp	41,733,298,146.98	0.38	Rp	1,221,592,216.24
								65,413,528,822

ENGINE REPLACEMENT

REP 5

Tahun	Nilai Investasi	Revenue	Operasional Cost	Payload Loses/Year	Depresiasi
0	Rp 48,112,075,000	Rp 25,020,416,667	Rp -	Rp (1)	Rp -
1		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
2		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
3		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
4		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
5		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
6		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
7		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
8		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
9		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
10		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
11		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
12		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
13		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
14		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
15		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
16		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
17		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
18		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
19		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
20		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
					38,489,660,000

ASSUMED CONSTANT REVENUE

PV

Cash Flow	Proceeds	Cumulative Cash Flow	Discount Factor 5%	Cash Flow Discounted (Present Value)
Rp 25,020,416,668	Rp 25,020,416,668	Rp (23,091,658,332.33)	1.00	Rp 25,020,416,667.67
Rp 1,072,413,607	Rp 2,996,896,607	Rp (20,094,761,725.38)	0.95	Rp 2,854,187,244.72
Rp 1,072,413,607	Rp 2,996,896,607	Rp (17,097,865,118.42)	0.91	Rp 2,718,273,566.40
Rp 1,072,413,607	Rp 2,996,896,607	Rp (14,100,968,511.46)	0.86	Rp 2,588,831,968.00
Rp 1,072,413,607	Rp 2,996,896,607	Rp (11,104,071,904.50)	0.82	Rp 2,465,554,255.24
Rp 1,072,413,607	Rp 2,996,896,607	Rp (8,107,175,297.54)	0.78	Rp 2,348,146,909.75
Rp 1,072,413,607	Rp 2,996,896,607	Rp (5,110,278,690.58)	0.75	Rp 2,236,330,390.24
Rp 1,072,413,607	Rp 2,996,896,607	Rp (2,113,382,083.63)	0.71	Rp 2,129,838,466.90
Rp 1,072,413,607	Rp 2,996,896,607	Rp 883,514,523.33	0.68	Rp 2,028,417,587.52
Rp 1,072,413,607	Rp 2,996,896,607	Rp 3,880,411,130.29	0.64	Rp 1,931,826,273.83
Rp 1,072,413,607	Rp 2,996,896,607	Rp 6,877,307,737.25	0.61	Rp 1,839,834,546.50
Rp 1,072,413,607	Rp 2,996,896,607	Rp 9,874,204,344.21	0.58	Rp 1,752,223,377.62
Rp 1,072,413,607	Rp 2,996,896,607	Rp 12,871,100,951.17	0.56	Rp 1,668,784,169.16
Rp 1,072,413,607	Rp 2,996,896,607	Rp 15,867,997,558.12	0.53	Rp 1,589,318,256.35
Rp 1,072,413,607	Rp 2,996,896,607	Rp 18,864,894,165.08	0.51	Rp 1,513,636,434.62
Rp 1,072,413,607	Rp 2,996,896,607	Rp 21,861,790,772.04	0.48	Rp 1,441,558,509.16
Rp 1,072,413,607	Rp 2,996,896,607	Rp 24,858,687,379.00	0.46	Rp 1,372,912,865.86
Rp 1,072,413,607	Rp 2,996,896,607	Rp 27,855,583,985.96	0.44	Rp 1,307,536,062.73
Rp 1,072,413,607	Rp 2,996,896,607	Rp 30,852,480,592.92	0.42	Rp 1,245,272,440.69
Rp 1,072,413,607	Rp 2,996,896,607	Rp 33,849,377,199.87	0.40	Rp 1,185,973,753.04
Rp 1,072,413,607	Rp 2,996,896,607	Rp 36,846,273,806.83	0.38	Rp 1,129,498,812.42
				62,368,372,558

ENGINE REPLACEMENT

REP 6

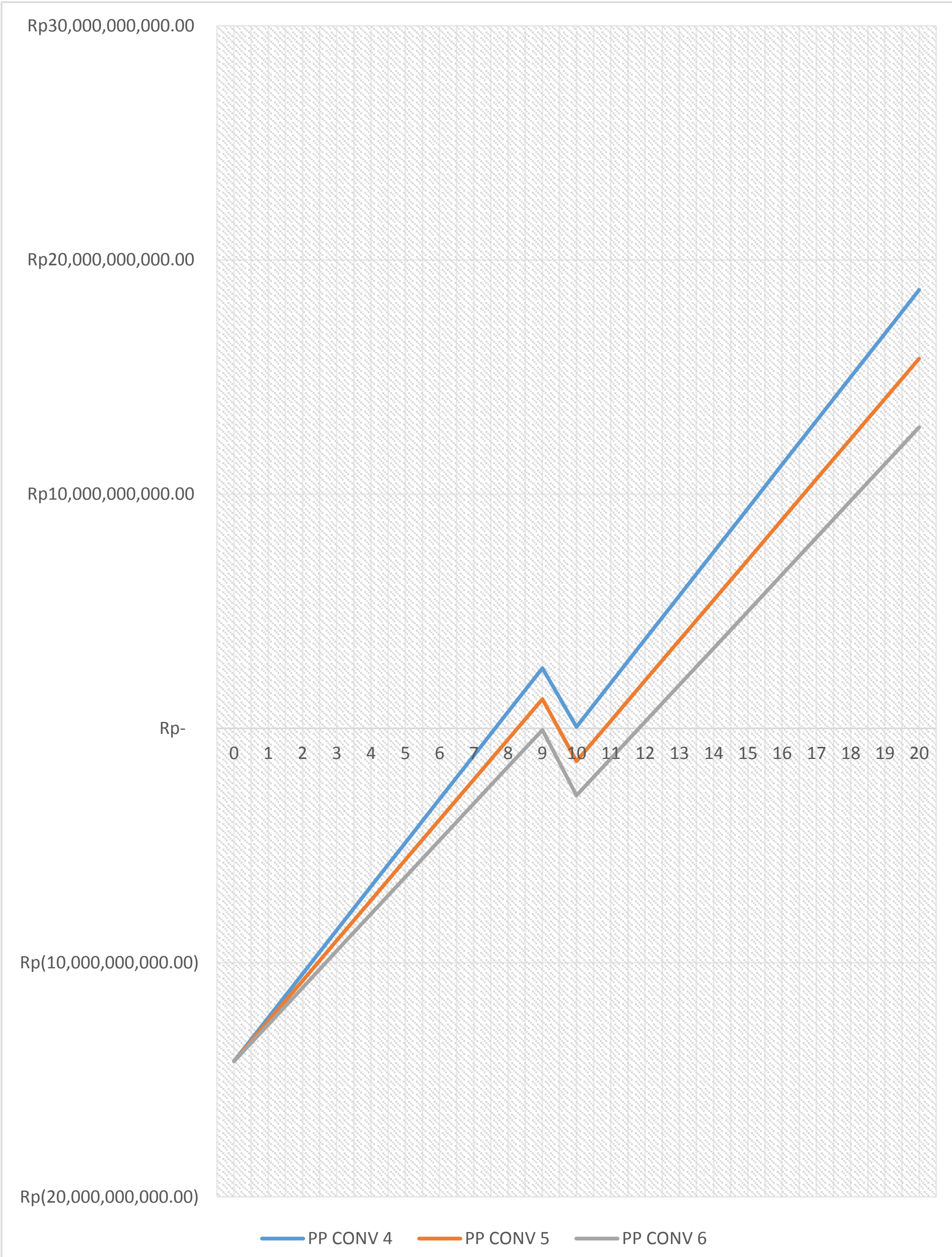
Tahun	Nilai Investasi	Revenue	Operasional Cost	Payload Loses/Year	Depresiasi
0	Rp 48,112,075,000	Rp 25,020,416,667	Rp -	Rp (1)	Rp -
1		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
2		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
3		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
4		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
5		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
6		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
7		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
8		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
9		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
10		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
11		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
12		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
13		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
14		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
15		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
16		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
17		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
18		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
19		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
20		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
					38,489,660,000

ASSUMED CONSTANT REVENUE

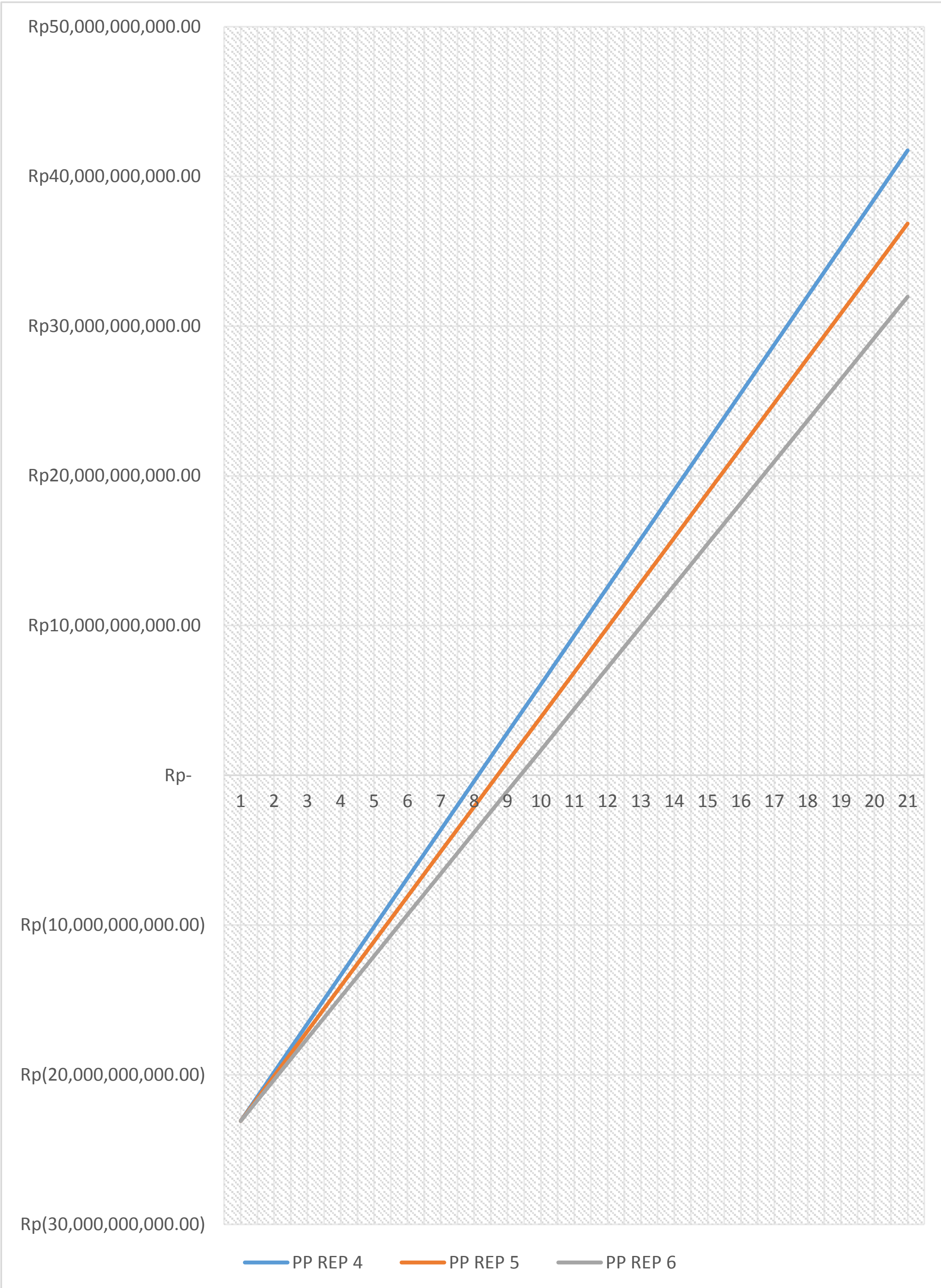
PV

Cash Flow		Proceeds		Cumulative Cash Flow		Discount Factor 5%	Cash Flow Discounted (Present Value)	
Rp	25,020,416,668	Rp	25,020,416,668	Rp	(23,091,658,332.33)	1.00	Rp	25,020,416,667.67
Rp	828,062,390	Rp	2,752,545,390	Rp	(20,339,112,942.38)	0.95	Rp	2,621,471,799.95
Rp	828,062,390	Rp	2,752,545,390	Rp	(17,586,567,552.43)	0.91	Rp	2,496,639,809.48
Rp	828,062,390	Rp	2,752,545,390	Rp	(14,834,022,162.48)	0.86	Rp	2,377,752,199.50
Rp	828,062,390	Rp	2,752,545,390	Rp	(12,081,476,772.53)	0.82	Rp	2,264,525,904.29
Rp	828,062,390	Rp	2,752,545,390	Rp	(9,328,931,382.58)	0.78	Rp	2,156,691,337.42
Rp	828,062,390	Rp	2,752,545,390	Rp	(6,576,385,992.63)	0.75	Rp	2,053,991,749.92
Rp	828,062,390	Rp	2,752,545,390	Rp	(3,823,840,602.68)	0.71	Rp	1,956,182,618.97
Rp	828,062,390	Rp	2,752,545,390	Rp	(1,071,295,212.73)	0.68	Rp	1,863,031,065.69
Rp	828,062,390	Rp	2,752,545,390	Rp	1,681,250,177.22	0.64	Rp	1,774,315,300.66
Rp	828,062,390	Rp	2,752,545,390	Rp	4,433,795,567.18	0.61	Rp	1,689,824,095.86
Rp	828,062,390	Rp	2,752,545,390	Rp	7,186,340,957.13	0.58	Rp	1,609,356,281.77
Rp	828,062,390	Rp	2,752,545,390	Rp	9,938,886,347.08	0.56	Rp	1,532,720,268.36
Rp	828,062,390	Rp	2,752,545,390	Rp	12,691,431,737.03	0.53	Rp	1,459,733,588.91
Rp	828,062,390	Rp	2,752,545,390	Rp	15,443,977,126.98	0.51	Rp	1,390,222,465.63
Rp	828,062,390	Rp	2,752,545,390	Rp	18,196,522,516.93	0.48	Rp	1,324,021,395.84
Rp	828,062,390	Rp	2,752,545,390	Rp	20,949,067,906.88	0.46	Rp	1,260,972,757.94
Rp	828,062,390	Rp	2,752,545,390	Rp	23,701,613,296.83	0.44	Rp	1,200,926,436.13
Rp	828,062,390	Rp	2,752,545,390	Rp	26,454,158,686.78	0.42	Rp	1,143,739,462.98
Rp	828,062,390	Rp	2,752,545,390	Rp	29,206,704,076.73	0.40	Rp	1,089,275,679.03
Rp	828,062,390	Rp	2,752,545,390	Rp	31,959,249,466.68	0.38	Rp	1,037,405,408.60
								59,323,216,295

ENGINE CONVERSION



ENGINE REPLACEMENT



ENGINE CONVERSION

CONV 4

Tahun	Nilai Investasi	Revenue	Operasional Cost	Payload Loses/Year	Depresiasi
0	Rp 14,210,625,000				
1		2,262,748,694	Rp 397,500,000	Rp -	Rp 568,425,000
2		2,375,886,129	Rp 397,500,000	Rp -	Rp 568,425,000
3		2,494,680,436	Rp 397,500,000	Rp -	Rp 568,425,000
4		2,619,414,457	Rp 397,500,000	Rp -	Rp 568,425,000
5		2,750,385,180	Rp 397,500,000	Rp -	Rp 568,425,000
6		2,887,904,439	Rp 397,500,000	Rp -	Rp 568,425,000
7		3,032,299,661	Rp 397,500,000	Rp -	Rp 568,425,000
8		3,183,914,644	Rp 397,500,000	Rp -	Rp 568,425,000
9		3,343,110,376	Rp 397,500,000	Rp -	Rp 568,425,000
10	Rp 4,372,500,000	3,510,265,895	Rp 397,500,000	Rp -	Rp 568,425,000
11		3,685,779,190	Rp 397,500,000	Rp -	Rp 568,425,000
12		3,870,068,150	Rp 397,500,000	Rp -	Rp 568,425,000
13		4,063,571,557	Rp 397,500,000	Rp -	Rp 568,425,000
14		4,266,750,135	Rp 397,500,000	Rp -	Rp 568,425,000
15		4,480,087,642	Rp 397,500,000	Rp -	Rp 568,425,000
16		4,704,092,024	Rp 397,500,000	Rp -	Rp 568,425,000
17		4,939,296,625	Rp 397,500,000	Rp -	Rp 568,425,000
18		5,186,261,456	Rp 397,500,000	Rp -	Rp 568,425,000
19		5,445,574,529	Rp 397,500,000	Rp -	Rp 568,425,000
20		5,717,853,255	Rp 397,500,000	Rp -	Rp 568,425,000
					11,368,500,000

ASSUMED INFLATION WILL INCREASE SERVICE COST **5%** **per year**

PV

Cash Flow		Proceeds		Cumulative Cash Flow		Discount Factor	Cash Flow Discounted (Present Value)	
						5%		
Rp	-14,210,625,000	Rp	(14,210,625,000)	Rp	(14,210,625,000.00)	1.00	-	14,210,625,000
Rp	1,296,823,694	Rp	1,865,248,694	Rp	(12,345,376,305.62)	0.95	Rp	1,776,427,327.98
Rp	1,409,961,129	Rp	1,978,386,129	Rp	(10,366,990,176.52)	0.91	Rp	1,794,454,538.86
Rp	1,528,755,436	Rp	2,097,180,436	Rp	(8,269,809,740.97)	0.86	Rp	1,811,623,311.14
Rp	1,653,489,457	Rp	2,221,914,457	Rp	(6,047,895,283.64)	0.82	Rp	1,827,974,522.82
Rp	1,784,460,180	Rp	2,352,885,180	Rp	(3,695,010,103.44)	0.78	Rp	1,843,547,105.38
Rp	1,921,979,439	Rp	2,490,404,439	Rp	(1,204,605,664.23)	0.75	Rp	1,858,378,136.39
Rp	2,066,374,661	Rp	2,634,799,661	Rp	1,430,193,996.93	0.71	Rp	1,872,502,927.83
Rp	2,217,989,644	Rp	2,786,414,644	Rp	4,216,608,641.16	0.68	Rp	1,885,955,110.15
Rp	2,377,185,376	Rp	2,945,610,376	Rp	7,162,219,017.60	0.64	Rp	1,898,766,712.36
Rp	2,544,340,895	Rp	3,112,765,895	Rp	5,902,484,912.86	0.61	Rp	1,910,968,238.27
Rp	2,719,854,190	Rp	3,288,279,190	Rp	9,190,764,102.88	0.58	Rp	1,922,588,739.14
Rp	2,904,143,150	Rp	3,472,568,150	Rp	12,663,332,252.40	0.56	Rp	1,933,655,882.83
Rp	3,097,646,557	Rp	3,666,071,557	Rp	16,329,403,809.40	0.53	Rp	1,944,196,019.67
Rp	3,300,825,135	Rp	3,869,250,135	Rp	20,198,653,944.25	0.51	Rp	1,954,234,245.24
Rp	3,514,162,642	Rp	4,082,587,642	Rp	24,281,241,585.84	0.48	Rp	1,963,794,460.06
Rp	3,738,167,024	Rp	4,306,592,024	Rp	28,587,833,609.52	0.46	Rp	1,972,899,426.56
Rp	3,973,371,625	Rp	4,541,796,625	Rp	33,129,630,234.37	0.44	Rp	1,981,570,823.23
Rp	4,220,336,456	Rp	4,788,761,456	Rp	37,918,391,690.47	0.42	Rp	1,989,829,296.24
Rp	4,479,649,529	Rp	5,048,074,529	Rp	42,966,466,219.37	0.40	Rp	1,997,694,508.64
Rp	4,751,928,255	Rp	5,320,353,255	Rp	48,286,819,474.72	0.38	Rp	2,005,185,187.11
								23,935,621,520

ENGINE CONVERSION

CONV 5

Tahun	Nilai Investasi	Revenue	Operasional Cost	Payload Loses/Year	Depresiasi
0	Rp 14,210,625,000				
1		Rp 2,116,137,964	Rp 397,500,000	Rp -	Rp 568,425,000
2		2,221,944,862	Rp 397,500,000	Rp -	Rp 568,425,000
3		2,333,042,106	Rp 397,500,000	Rp -	Rp 568,425,000
4		2,449,694,211	Rp 397,500,000	Rp -	Rp 568,425,000
5		2,572,178,921	Rp 397,500,000	Rp -	Rp 568,425,000
6		2,700,787,867	Rp 397,500,000	Rp -	Rp 568,425,000
7		2,835,827,261	Rp 397,500,000	Rp -	Rp 568,425,000
8		2,977,618,624	Rp 397,500,000	Rp -	Rp 568,425,000
9		3,126,499,555	Rp 397,500,000	Rp -	Rp 568,425,000
10	Rp 4,372,500,000	3,282,824,533	Rp 397,500,000	Rp -	Rp 568,425,000
11		3,446,965,759	Rp 397,500,000	Rp -	Rp 568,425,000
12		3,619,314,047	Rp 397,500,000	Rp -	Rp 568,425,000
13		3,800,279,750	Rp 397,500,000	Rp -	Rp 568,425,000
14		3,990,293,737	Rp 397,500,000	Rp -	Rp 568,425,000
15		4,189,808,424	Rp 397,500,000	Rp -	Rp 568,425,000
16		4,399,298,845	Rp 397,500,000	Rp -	Rp 568,425,000
17		4,619,263,788	Rp 397,500,000	Rp -	Rp 568,425,000
18		4,850,226,977	Rp 397,500,000	Rp -	Rp 568,425,000
19		5,092,738,326	Rp 397,500,000	Rp -	Rp 568,425,000
20		5,347,375,242	Rp 397,500,000	Rp -	Rp 568,425,000
					11,368,500,000

ASSUMED INFLATION WILL INCREASE SERVICE COST 5% per year

PV

Cash Flow		Proceeds		Cumulative Cash Flow		Discount Factor 5%	Cash Flow Discounted (Present Value)	
Rp	-14,210,625,000	Rp	(14,210,625,000)	Rp	(14,210,625,000.00)	1.00	Rp	(14,210,625,000.00)
Rp	1,150,212,964	Rp	1,718,637,964	Rp	(12,491,987,035.83)	0.95	Rp	1,636,798,061.12
Rp	1,256,019,862	Rp	1,824,444,862	Rp	(10,667,542,173.44)	0.91	Rp	1,654,825,272.00
Rp	1,367,117,106	Rp	1,935,542,106	Rp	(8,732,000,067.94)	0.86	Rp	1,671,994,044.27
Rp	1,483,769,211	Rp	2,052,194,211	Rp	(6,679,805,857.16)	0.82	Rp	1,688,345,255.96
Rp	1,606,253,921	Rp	2,174,678,921	Rp	(4,505,126,935.84)	0.78	Rp	1,703,917,838.52
Rp	1,734,862,867	Rp	2,303,287,867	Rp	(2,201,839,068.46)	0.75	Rp	1,718,748,869.53
Rp	1,869,902,261	Rp	2,438,327,261	Rp	236,488,192.29	0.71	Rp	1,732,873,660.96
Rp	2,011,693,624	Rp	2,580,118,624	Rp	2,816,606,816.08	0.68	Rp	1,746,325,843.28
Rp	2,160,574,555	Rp	2,728,999,555	Rp	5,545,606,371.06	0.64	Rp	1,759,137,445.49
Rp	2,316,899,533	Rp	2,885,324,533	Rp	4,058,430,903.79	0.61	Rp	1,771,338,971.41
Rp	2,481,040,759	Rp	3,049,465,759	Rp	7,107,896,663.15	0.58	Rp	1,782,959,472.28
Rp	2,653,389,047	Rp	3,221,814,047	Rp	10,329,710,710.48	0.56	Rp	1,794,026,615.96
Rp	2,834,354,750	Rp	3,402,779,750	Rp	13,732,490,460.18	0.53	Rp	1,804,566,752.81
Rp	3,024,368,737	Rp	3,592,793,737	Rp	17,325,284,197.37	0.51	Rp	1,814,604,978.37
Rp	3,223,883,424	Rp	3,792,308,424	Rp	21,117,592,621.41	0.48	Rp	1,824,165,193.20
Rp	3,433,373,845	Rp	4,001,798,845	Rp	25,119,391,466.66	0.46	Rp	1,833,270,159.70
Rp	3,653,338,788	Rp	4,221,763,788	Rp	29,341,155,254.16	0.44	Rp	1,841,941,556.37
Rp	3,884,301,977	Rp	4,452,726,977	Rp	33,793,882,231.05	0.42	Rp	1,850,200,029.38
Rp	4,126,813,326	Rp	4,695,238,326	Rp	38,489,120,556.78	0.40	Rp	1,858,065,241.78
Rp	4,381,450,242	Rp	4,949,875,242	Rp	43,438,995,798.79	0.38	Rp	1,865,555,920.25
								21,143,036,183

ENGINE CONVERSION

CONV 6

Tahun	Nilai Investasi	Revenue	Operasional Cost	Payload Loses/Year	Depresiasi
0	Rp 14,210,625,000				
1		Rp 1,969,527,234	Rp 397,500,000	Rp -	Rp 568,425,000
2		2,068,003,596	Rp 397,500,000	Rp -	Rp 568,425,000
3		2,171,403,775	Rp 397,500,000	Rp -	Rp 568,425,000
4		2,279,973,964	Rp 397,500,000	Rp -	Rp 568,425,000
5		2,393,972,662	Rp 397,500,000	Rp -	Rp 568,425,000
6		2,513,671,296	Rp 397,500,000	Rp -	Rp 568,425,000
7		2,639,354,860	Rp 397,500,000	Rp -	Rp 568,425,000
8		2,771,322,603	Rp 397,500,000	Rp -	Rp 568,425,000
9		2,909,888,734	Rp 397,500,000	Rp -	Rp 568,425,000
10	Rp 4,372,500,000	3,055,383,170	Rp 397,500,000	Rp -	Rp 568,425,000
11		3,208,152,329	Rp 397,500,000	Rp -	Rp 568,425,000
12		3,368,559,945	Rp 397,500,000	Rp -	Rp 568,425,000
13		3,536,987,942	Rp 397,500,000	Rp -	Rp 568,425,000
14		3,713,837,340	Rp 397,500,000	Rp -	Rp 568,425,000
15		3,899,529,206	Rp 397,500,000	Rp -	Rp 568,425,000
16		4,094,505,667	Rp 397,500,000	Rp -	Rp 568,425,000
17		4,299,230,950	Rp 397,500,000	Rp -	Rp 568,425,000
18		4,514,192,498	Rp 397,500,000	Rp -	Rp 568,425,000
19		4,739,902,123	Rp 397,500,000	Rp -	Rp 568,425,000
20		4,976,897,229	Rp 397,500,000	Rp -	Rp 568,425,000
					11,368,500,000

ASSUMED INFLATION WILL INCREASE SERVICE COST **5%** **per year**

PV

Cash Flow		Proceeds		Cumulative Cash Flow		Discount Factor 5%	Cash Flow Discounted (Present Value)	
Rp	-14,210,625,000	Rp	(14,210,625,000)	Rp	(14,210,625,000.00)	1.00	Rp	(14,210,625,000.00)
Rp	1,003,602,234	Rp	1,572,027,234	Rp	(12,638,597,766.03)	0.95	Rp	1,497,168,794.26
Rp	1,102,078,596	Rp	1,670,503,596	Rp	(10,968,094,170.36)	0.91	Rp	1,515,196,005.14
Rp	1,205,478,775	Rp	1,773,903,775	Rp	(9,194,190,394.91)	0.86	Rp	1,532,364,777.41
Rp	1,314,048,964	Rp	1,882,473,964	Rp	(7,311,716,430.68)	0.82	Rp	1,548,715,989.10
Rp	1,428,047,662	Rp	1,996,472,662	Rp	(5,315,243,768.25)	0.78	Rp	1,564,288,571.66
Rp	1,547,746,296	Rp	2,116,171,296	Rp	(3,199,072,472.69)	0.75	Rp	1,579,119,602.67
Rp	1,673,429,860	Rp	2,241,854,860	Rp	(957,217,612.35)	0.71	Rp	1,593,244,394.10
Rp	1,805,397,603	Rp	2,373,822,603	Rp	1,416,604,991.00	0.68	Rp	1,606,696,576.42
Rp	1,943,963,734	Rp	2,512,388,734	Rp	3,928,993,724.52	0.64	Rp	1,619,508,178.63
Rp	2,089,458,170	Rp	2,657,883,170	Rp	2,214,376,894.72	0.61	Rp	1,631,709,704.55
Rp	2,242,227,329	Rp	2,810,652,329	Rp	5,025,029,223.42	0.58	Rp	1,643,330,205.42
Rp	2,402,634,945	Rp	2,971,059,945	Rp	7,996,089,168.57	0.56	Rp	1,654,397,349.10
Rp	2,571,062,942	Rp	3,139,487,942	Rp	11,135,577,110.96	0.53	Rp	1,664,937,485.95
Rp	2,747,912,340	Rp	3,316,337,340	Rp	14,451,914,450.48	0.51	Rp	1,674,975,711.51
Rp	2,933,604,206	Rp	3,502,029,206	Rp	17,953,943,656.98	0.48	Rp	1,684,535,926.34
Rp	3,128,580,667	Rp	3,697,005,667	Rp	21,650,949,323.80	0.46	Rp	1,693,640,892.84
Rp	3,333,305,950	Rp	3,901,730,950	Rp	25,552,680,273.96	0.44	Rp	1,702,312,289.50
Rp	3,548,267,498	Rp	4,116,692,498	Rp	29,669,372,771.63	0.42	Rp	1,710,570,762.52
Rp	3,773,977,123	Rp	4,342,402,123	Rp	34,011,774,894.18	0.40	Rp	1,718,435,974.91
Rp	4,010,972,229	Rp	4,579,397,229	Rp	38,591,172,122.86	0.38	Rp	1,725,926,653.39
								18,350,450,845

ENGINE REPLACEMENT

REP 4

Tahun	Nilai Investasi	Revenue	Operasional Cost	Payload Loses/Year	Depresiasi
0	Rp 48,112,075,000	Rp 25,020,416,667	Rp -	Rp (1)	Rp -
1		Rp 3,771,247,824	Rp 530,000,000	Rp -	Rp 1,924,483,000
2		Rp 3,959,810,215	Rp 530,000,000	Rp -	Rp 1,924,483,000
3		Rp 4,157,800,726	Rp 530,000,000	Rp -	Rp 1,924,483,000
4		Rp 4,365,690,762	Rp 530,000,000	Rp -	Rp 1,924,483,000
5		Rp 4,583,975,300	Rp 530,000,000	Rp -	Rp 1,924,483,000
6		Rp 4,813,174,065	Rp 530,000,000	Rp -	Rp 1,924,483,000
7		Rp 5,053,832,769	Rp 530,000,000	Rp -	Rp 1,924,483,000
8		Rp 5,306,524,407	Rp 530,000,000	Rp -	Rp 1,924,483,000
9		Rp 5,571,850,627	Rp 530,000,000	Rp -	Rp 1,924,483,000
10		Rp 5,850,443,159	Rp 530,000,000	Rp -	Rp 1,924,483,000
11		Rp 6,142,965,317	Rp 530,000,000	Rp -	Rp 1,924,483,000
12		Rp 6,450,113,583	Rp 530,000,000	Rp -	Rp 1,924,483,000
13		Rp 6,772,619,262	Rp 530,000,000	Rp -	Rp 1,924,483,000
14		Rp 7,111,250,225	Rp 530,000,000	Rp -	Rp 1,924,483,000
15		Rp 7,466,812,736	Rp 530,000,000	Rp -	Rp 1,924,483,000
16		Rp 7,840,153,373	Rp 530,000,000	Rp -	Rp 1,924,483,000
17		Rp 8,232,161,041	Rp 530,000,000	Rp -	Rp 1,924,483,000
18		Rp 8,643,769,093	Rp 530,000,000	Rp -	Rp 1,924,483,000
19		Rp 9,075,957,548	Rp 530,000,000	Rp -	Rp 1,924,483,000
20		Rp 9,529,755,426	Rp 530,000,000	Rp -	Rp 1,924,483,000
					38,489,660,000

ASSUMED INFLATION WILL INCREASE SERVICE COST 5% per year

PV

Cash Flow		Proceeds		Cumulative Cash Flow		Discount Factor 5%	Cash Flow Discounted (Present Value)	
Rp	25,020,416,668	Rp	25,020,416,668	Rp	(23,091,658,332.33)	1.00	Rp	25,020,416,667.67
Rp	1,316,764,824	Rp	3,241,247,824	Rp	(19,850,410,508.37)	0.95	Rp	3,086,902,689.49
Rp	1,505,327,215	Rp	3,429,810,215	Rp	(16,420,600,293.20)	0.91	Rp	3,110,938,970.67
Rp	1,703,317,726	Rp	3,627,800,726	Rp	(12,792,799,567.28)	0.86	Rp	3,133,830,667.03
Rp	1,911,207,762	Rp	3,835,690,762	Rp	(8,957,108,805.06)	0.82	Rp	3,155,632,282.61
Rp	2,129,492,300	Rp	4,053,975,300	Rp	(4,903,133,504.73)	0.78	Rp	3,176,395,726.02
Rp	2,358,691,065	Rp	4,283,174,065	Rp	(619,959,439.39)	0.75	Rp	3,196,170,434.04
Rp	2,599,349,769	Rp	4,523,832,769	Rp	3,903,873,329.22	0.71	Rp	3,215,003,489.28
Rp	2,852,041,407	Rp	4,776,524,407	Rp	8,680,397,736.27	0.68	Rp	3,232,939,732.38
Rp	3,117,367,627	Rp	5,041,850,627	Rp	13,722,248,363.66	0.64	Rp	3,250,021,868.66
Rp	3,395,960,159	Rp	5,320,443,159	Rp	19,042,691,522.43	0.61	Rp	3,266,290,569.88
Rp	3,688,482,317	Rp	5,612,965,317	Rp	24,655,656,839.13	0.58	Rp	3,281,784,571.04
Rp	3,995,630,583	Rp	5,920,113,583	Rp	30,575,770,421.67	0.56	Rp	3,296,540,762.62
Rp	4,318,136,262	Rp	6,242,619,262	Rp	36,818,389,683.34	0.53	Rp	3,310,594,278.41
Rp	4,656,767,225	Rp	6,581,250,225	Rp	43,399,639,908.09	0.51	Rp	3,323,978,579.17
Rp	5,012,329,736	Rp	6,936,812,736	Rp	50,336,452,644.07	0.48	Rp	3,336,725,532.26
Rp	5,385,670,373	Rp	7,310,153,373	Rp	57,646,606,016.86	0.46	Rp	3,348,865,487.60
Rp	5,777,678,041	Rp	7,702,161,041	Rp	65,348,767,058.29	0.44	Rp	3,360,427,349.82
Rp	6,189,286,093	Rp	8,113,769,093	Rp	73,462,536,151.78	0.42	Rp	3,371,438,647.17
Rp	6,621,474,548	Rp	8,545,957,548	Rp	82,008,493,699.95	0.40	Rp	3,381,925,597.03
Rp	7,075,272,426	Rp	8,999,755,426	Rp	91,008,249,125.53	0.38	Rp	3,391,913,168.33
								90,248,737,071

ENGINE REPLACEMENT

REP 5

Tahun	Nilai Investasi	Revenue	Operasional Cost	Payload Loses/Year	Depresiasi
0	Rp 48,112,075,000	Rp 25,020,416,667	Rp -	Rp (1)	Rp -
1		Rp 3,526,896,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
2		Rp 3,703,241,437	Rp 530,000,000	Rp -	Rp 1,924,483,000
3		Rp 3,888,403,509	Rp 530,000,000	Rp -	Rp 1,924,483,000
4		Rp 4,082,823,685	Rp 530,000,000	Rp -	Rp 1,924,483,000
5		Rp 4,286,964,869	Rp 530,000,000	Rp -	Rp 1,924,483,000
6		Rp 4,501,313,112	Rp 530,000,000	Rp -	Rp 1,924,483,000
7		Rp 4,726,378,768	Rp 530,000,000	Rp -	Rp 1,924,483,000
8		Rp 4,962,697,706	Rp 530,000,000	Rp -	Rp 1,924,483,000
9		Rp 5,210,832,592	Rp 530,000,000	Rp -	Rp 1,924,483,000
10		Rp 5,471,374,221	Rp 530,000,000	Rp -	Rp 1,924,483,000
11		Rp 5,744,942,932	Rp 530,000,000	Rp -	Rp 1,924,483,000
12		Rp 6,032,190,079	Rp 530,000,000	Rp -	Rp 1,924,483,000
13		Rp 6,333,799,583	Rp 530,000,000	Rp -	Rp 1,924,483,000
14		Rp 6,650,489,562	Rp 530,000,000	Rp -	Rp 1,924,483,000
15		Rp 6,983,014,040	Rp 530,000,000	Rp -	Rp 1,924,483,000
16		Rp 7,332,164,742	Rp 530,000,000	Rp -	Rp 1,924,483,000
17		Rp 7,698,772,979	Rp 530,000,000	Rp -	Rp 1,924,483,000
18		Rp 8,083,711,628	Rp 530,000,000	Rp -	Rp 1,924,483,000
19		Rp 8,487,897,210	Rp 530,000,000	Rp -	Rp 1,924,483,000
20		Rp 8,912,292,070	Rp 530,000,000	Rp -	Rp 1,924,483,000
					38,489,660,000

ASSUMED INFLATION WILL INCREASE SERVICE COST **5%** **per year**

PV

Cash Flow		Proceeds		Cumulative Cash Flow		Discount Factor 5%	Cash Flow Discounted (Present Value)	
Rp	25,020,416,668	Rp	25,020,416,668	Rp	(23,091,658,332.33)	1.00	Rp	25,020,416,667.67
Rp	1,072,413,607	Rp	2,996,896,607	Rp	(20,094,761,725.38)	0.95	Rp	2,854,187,244.72
Rp	1,248,758,437	Rp	3,173,241,437	Rp	(16,921,520,288.07)	0.91	Rp	2,878,223,525.90
Rp	1,433,920,509	Rp	3,358,403,509	Rp	(13,563,116,778.90)	0.86	Rp	2,901,115,222.26
Rp	1,628,340,685	Rp	3,552,823,685	Rp	(10,010,293,094.27)	0.82	Rp	2,922,916,837.84
Rp	1,832,481,869	Rp	3,756,964,869	Rp	(6,253,328,225.41)	0.78	Rp	2,943,680,281.26
Rp	2,046,830,112	Rp	3,971,313,112	Rp	(2,282,015,113.10)	0.75	Rp	2,963,454,989.27
Rp	2,271,895,768	Rp	4,196,378,768	Rp	1,914,363,654.82	0.71	Rp	2,982,288,044.52
Rp	2,508,214,706	Rp	4,432,697,706	Rp	6,347,061,361.13	0.68	Rp	3,000,224,287.61
Rp	2,756,349,592	Rp	4,680,832,592	Rp	11,027,893,952.77	0.64	Rp	3,017,306,423.89
Rp	3,016,891,221	Rp	4,941,374,221	Rp	15,969,268,173.98	0.61	Rp	3,033,575,125.11
Rp	3,290,459,932	Rp	5,214,942,932	Rp	21,184,211,106.25	0.58	Rp	3,049,069,126.27
Rp	3,577,707,079	Rp	5,502,190,079	Rp	26,686,401,185.14	0.56	Rp	3,063,825,317.85
Rp	3,879,316,583	Rp	5,803,799,583	Rp	32,490,200,767.97	0.53	Rp	3,077,878,833.64
Rp	4,196,006,562	Rp	6,120,489,562	Rp	38,610,690,329.95	0.51	Rp	3,091,263,134.40
Rp	4,528,531,040	Rp	6,453,014,040	Rp	45,063,704,370.02	0.48	Rp	3,104,010,087.50
Rp	4,877,681,742	Rp	6,802,164,742	Rp	51,865,869,112.09	0.46	Rp	3,116,150,042.83
Rp	5,244,289,979	Rp	7,168,772,979	Rp	59,034,642,091.27	0.44	Rp	3,127,711,905.05
Rp	5,629,228,628	Rp	7,553,711,628	Rp	66,588,353,719.41	0.42	Rp	3,138,723,202.40
Rp	6,033,414,210	Rp	7,957,897,210	Rp	74,546,250,928.96	0.40	Rp	3,149,210,152.27
Rp	6,457,809,070	Rp	8,382,292,070	Rp	82,928,542,998.98	0.38	Rp	3,159,197,723.56
								85,594,428,176

ENGINE REPLACEMENT

REP 6

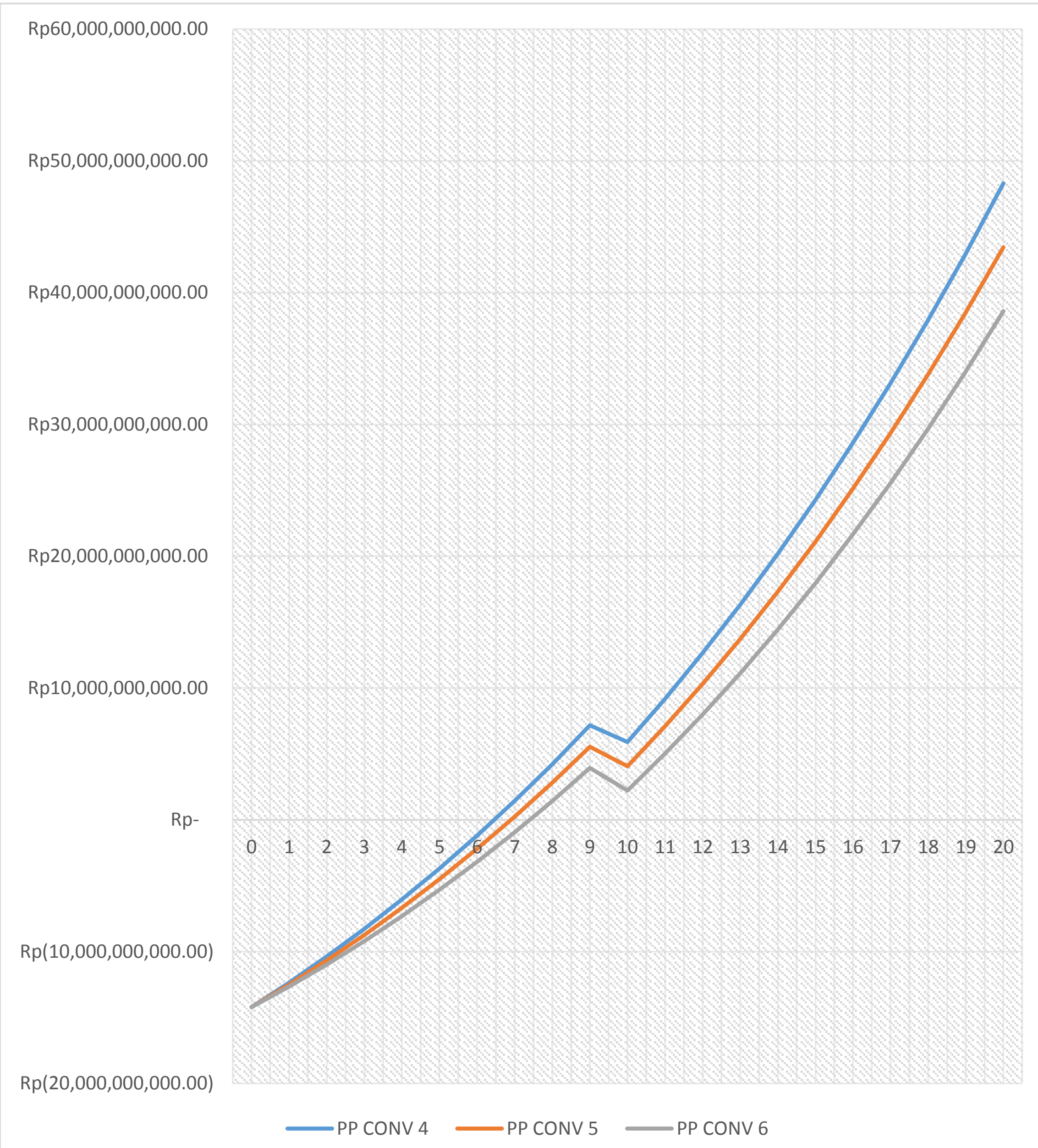
Tahun	Nilai Investasi	Revenue	Operasional Cost	Payload Loses/Year	Depresiasi
0	Rp 48,112,075,000	Rp 25,020,416,667	Rp -	Rp (1)	Rp -
1		Rp 3,282,545,390	Rp 530,000,000	Rp -	Rp 1,924,483,000
2		Rp 3,446,672,659	Rp 530,000,000	Rp -	Rp 1,924,483,000
3		Rp 3,619,006,292	Rp 530,000,000	Rp -	Rp 1,924,483,000
4		Rp 3,799,956,607	Rp 530,000,000	Rp -	Rp 1,924,483,000
5		Rp 3,989,954,437	Rp 530,000,000	Rp -	Rp 1,924,483,000
6		Rp 4,189,452,159	Rp 530,000,000	Rp -	Rp 1,924,483,000
7		Rp 4,398,924,767	Rp 530,000,000	Rp -	Rp 1,924,483,000
8		Rp 4,618,871,006	Rp 530,000,000	Rp -	Rp 1,924,483,000
9		Rp 4,849,814,556	Rp 530,000,000	Rp -	Rp 1,924,483,000
10		Rp 5,092,305,284	Rp 530,000,000	Rp -	Rp 1,924,483,000
11		Rp 5,346,920,548	Rp 530,000,000	Rp -	Rp 1,924,483,000
12		Rp 5,614,266,575	Rp 530,000,000	Rp -	Rp 1,924,483,000
13		Rp 5,894,979,904	Rp 530,000,000	Rp -	Rp 1,924,483,000
14		Rp 6,189,728,899	Rp 530,000,000	Rp -	Rp 1,924,483,000
15		Rp 6,499,215,344	Rp 530,000,000	Rp -	Rp 1,924,483,000
16		Rp 6,824,176,111	Rp 530,000,000	Rp -	Rp 1,924,483,000
17		Rp 7,165,384,917	Rp 530,000,000	Rp -	Rp 1,924,483,000
18		Rp 7,523,654,163	Rp 530,000,000	Rp -	Rp 1,924,483,000
19		Rp 7,899,836,871	Rp 530,000,000	Rp -	Rp 1,924,483,000
20		Rp 8,294,828,714	Rp 530,000,000	Rp -	Rp 1,924,483,000
					38,489,660,000

ASSUMED INFLATION WILL INCREASE SERVICE COST **5%** **per year**

PV

Cash Flow		Proceeds		Cumulative Cash Flow		Discount Factor 5%	Cash Flow Discounted (Present Value)	
Rp	25,020,416,668	Rp	25,020,416,668	Rp	(23,091,658,332.33)	1.00	Rp	25,020,416,667.67
Rp	828,062,390	Rp	2,752,545,390	Rp	(20,339,112,942.38)	0.95	Rp	2,621,471,799.95
Rp	992,189,659	Rp	2,916,672,659	Rp	(17,422,440,282.93)	0.91	Rp	2,645,508,081.13
Rp	1,164,523,292	Rp	3,089,006,292	Rp	(14,333,433,990.51)	0.86	Rp	2,668,399,777.49
Rp	1,345,473,607	Rp	3,269,956,607	Rp	(11,063,477,383.47)	0.82	Rp	2,690,201,393.08
Rp	1,535,471,437	Rp	3,459,954,437	Rp	(7,603,522,946.08)	0.78	Rp	2,710,964,836.49
Rp	1,734,969,159	Rp	3,659,452,159	Rp	(3,944,070,786.81)	0.75	Rp	2,730,739,544.50
Rp	1,944,441,767	Rp	3,868,924,767	Rp	(75,146,019.59)	0.71	Rp	2,749,572,599.75
Rp	2,164,388,006	Rp	4,088,871,006	Rp	4,013,724,986.00	0.68	Rp	2,767,508,842.84
Rp	2,395,331,556	Rp	4,319,814,556	Rp	8,333,539,541.87	0.64	Rp	2,784,590,979.12
Rp	2,637,822,284	Rp	4,562,305,284	Rp	12,895,844,825.53	0.61	Rp	2,800,859,680.34
Rp	2,892,437,548	Rp	4,816,920,548	Rp	17,712,765,373.37	0.58	Rp	2,816,353,681.50
Rp	3,159,783,575	Rp	5,084,266,575	Rp	22,797,031,948.61	0.56	Rp	2,831,109,873.08
Rp	3,440,496,904	Rp	5,364,979,904	Rp	28,162,011,852.61	0.53	Rp	2,845,163,388.87
Rp	3,735,245,899	Rp	5,659,728,899	Rp	33,821,740,751.81	0.51	Rp	2,858,547,689.63
Rp	4,044,732,344	Rp	5,969,215,344	Rp	39,790,956,095.96	0.48	Rp	2,871,294,642.73
Rp	4,369,693,111	Rp	6,294,176,111	Rp	46,085,132,207.33	0.46	Rp	2,883,434,598.06
Rp	4,710,901,917	Rp	6,635,384,917	Rp	52,720,517,124.26	0.44	Rp	2,894,996,460.28
Rp	5,069,171,163	Rp	6,993,654,163	Rp	59,714,171,287.04	0.42	Rp	2,906,007,757.64
Rp	5,445,353,871	Rp	7,369,836,871	Rp	67,084,008,157.96	0.40	Rp	2,916,494,707.50
Rp	5,840,345,714	Rp	7,764,828,714	Rp	74,848,836,872.43	0.38	Rp	2,926,482,278.79
								80,940,119,280

ENGINE CONVERSION



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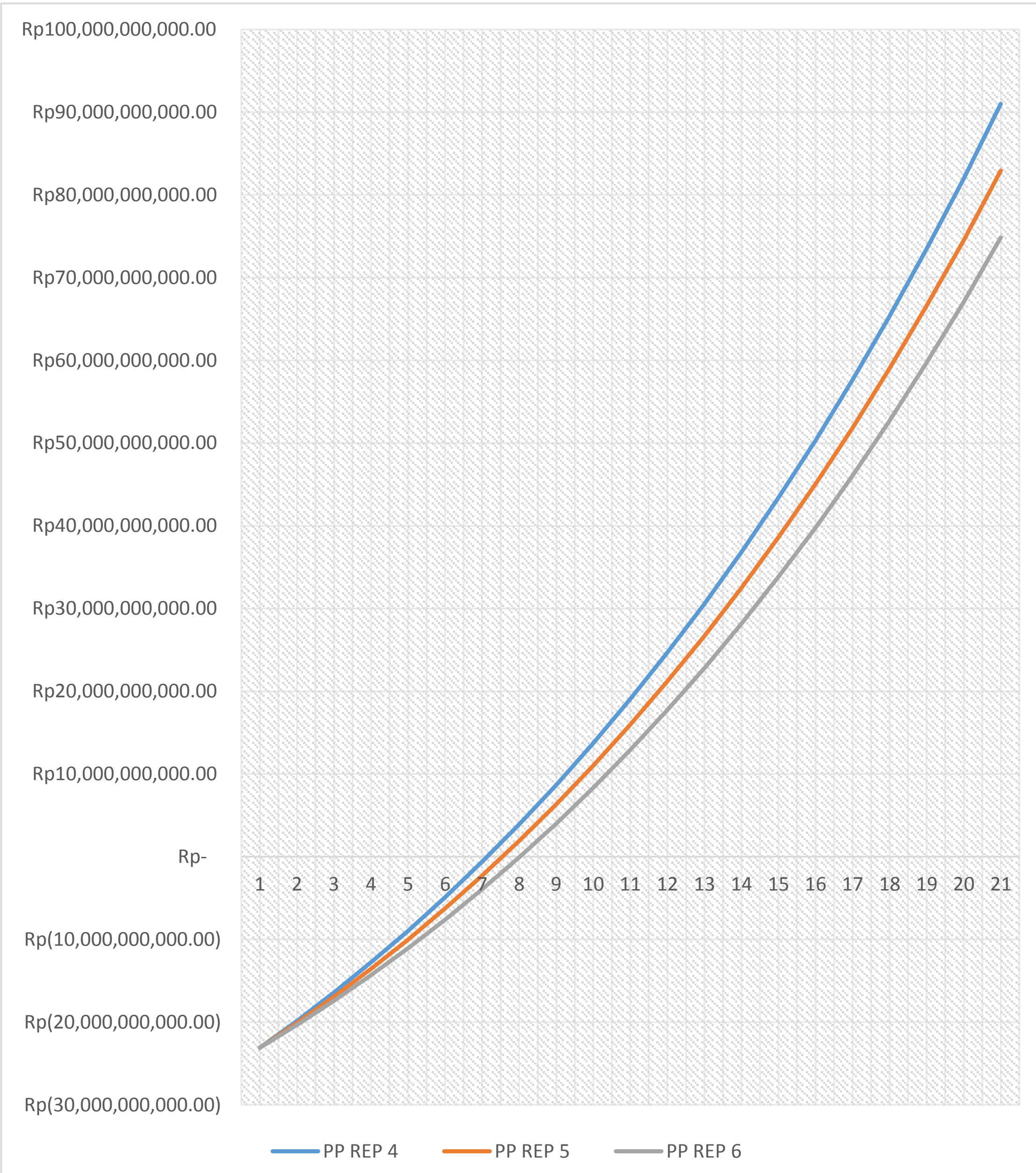

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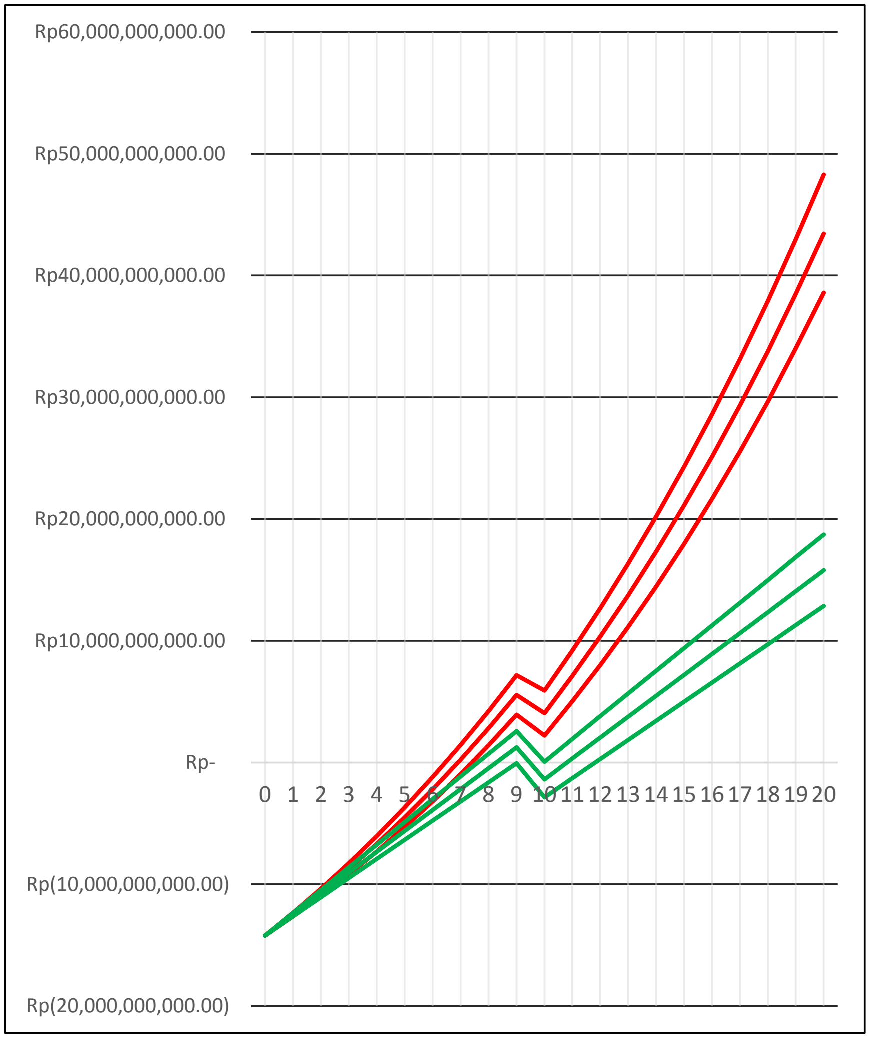

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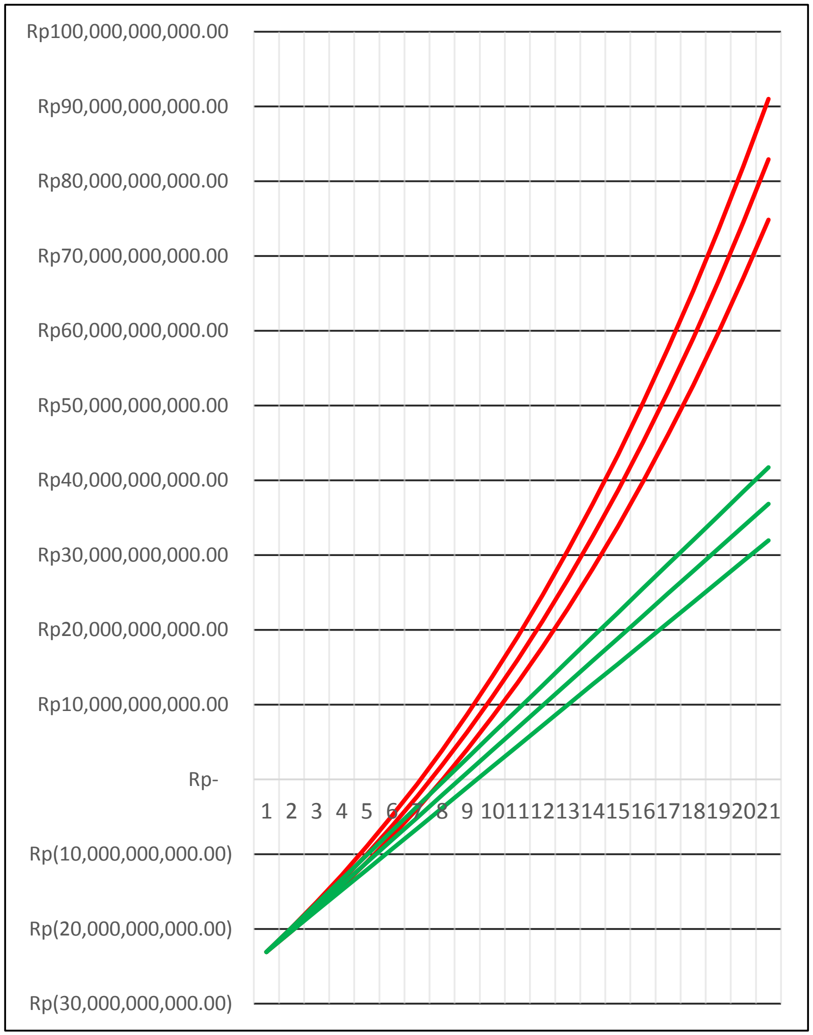
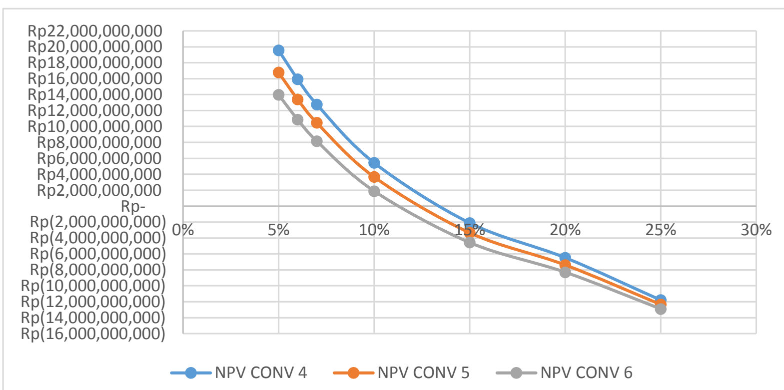


NET PRESENT VALUE ANALYSIS CONV 4

Tahun	Nilai Investasi	Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value
			5%		*6%*		*7%*	
0	Rp 14,210,625,000	Rp (14,210,625,000)	1.00	Rp (14,210,625,000)		Rp (14,210,625,000)		Rp (14,210,625,000)
1		Rp 1,865,248,694	0.95	Rp 1,776,427,328	0.9434	Rp 1,759,668,580	0.9346	Rp 1,743,223,079
2		Rp 1,978,386,129	0.91	Rp 1,794,454,539	0.8900	Rp 1,760,756,612	0.8734	Rp 1,727,999,065
3		Rp 2,097,180,436	0.86	Rp 1,811,623,311	0.8396	Rp 1,760,833,134	0.8163	Rp 1,711,923,937
4		Rp 2,221,914,457	0.82	Rp 1,827,974,523	0.7921	Rp 1,759,964,362	0.7629	Rp 1,695,087,901
5		Rp 2,352,885,180	0.78	Rp 1,843,547,105	0.7473	Rp 1,758,212,681	0.7130	Rp 1,677,574,615
6		Rp 2,490,404,439	0.75	Rp 1,858,378,136	0.7050	Rp 1,755,636,859	0.6663	Rp 1,659,461,632
7		Rp 2,634,799,661	0.71	Rp 1,872,502,928	0.6651	Rp 1,752,292,258	0.6227	Rp 1,640,820,809
8		Rp 2,786,414,644	0.68	Rp 1,885,955,110	0.6274	Rp 1,748,231,019	0.5820	Rp 1,621,718,692
9		Rp 2,945,610,376	0.64	Rp 1,898,766,712	0.5919	Rp 1,743,502,256	0.5439	Rp 1,602,216,876
10	Rp 4,372,500,000	Rp 3,112,765,895	0.61	Rp (2,461,531,762)	0.5584	Rp (2,634,347,782)	0.5083	Rp (2,790,127,661)
11		Rp 3,288,279,190	0.58	Rp 1,922,588,739	0.5268	Rp 1,732,224,457	0.4751	Rp 1,562,237,756
12		Rp 3,472,568,150	0.56	Rp 1,933,655,883	0.4970	Rp 1,725,759,983	0.4440	Rp 1,541,861,788
13		Rp 3,666,071,557	0.53	Rp 1,944,196,020	0.4688	Rp 1,718,797,404	0.4150	Rp 1,521,289,360
14		Rp 3,869,250,135	0.51	Rp 1,954,234,245	0.4423	Rp 1,711,373,066	0.3878	Rp 1,500,561,912
15		Rp 4,082,587,642	0.48	Rp 1,963,794,460	0.4173	Rp 1,703,521,180	0.3624	Rp 1,479,717,641
16		Rp 4,306,592,024	0.46	Rp 1,972,899,427	0.3936	Rp 1,695,273,946	0.3387	Rp 1,458,791,717
17		Rp 4,541,796,625	0.44	Rp 1,981,570,823	0.3714	Rp 1,686,661,663	0.3166	Rp 1,437,816,498
18		Rp 4,788,761,456	0.42	Rp 1,989,829,296	0.3503	Rp 1,677,712,843	0.2959	Rp 1,416,821,719
19		Rp 5,048,074,529	0.40	Rp 1,997,694,509	0.3305	Rp 1,668,454,310	0.2765	Rp 1,395,834,673
20		Rp 5,320,353,255	0.38	Rp 2,005,185,187	0.3118	Rp 1,658,911,294	0.2584	Rp 1,374,880,383
			NPV 5%	Rp 19,563,121,520	NPV 6%	Rp 15,932,815,124	NPV 7%	Rp 12,769,087,391

Interest Rate	5%	6%	7%	10%	15%	20%	25%
NPV	Rp 19,563,121,520	Rp 15,932,815,124	Rp 12,769,087,391	Rp 5,439,335,809	Rp (2,112,027,820)	Rp (6,477,805,172)	Rp (11,798,478,218)
IRR	12.23%						

Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value
10%		***15%***		***20%***		***25%***	
	Rp (14,210,625,000)		Rp (14,210,625,000)		Rp (14,210,625,000)		Rp (14,210,625,000)
0.9091	Rp 1,695,680,631	0.8696	Rp 1,621,955,386	0.8333	Rp 1,554,373,912	0.8000	Rp 1,421,141,862
0.8264	Rp 1,635,029,859	0.7561	Rp 1,495,944,143	0.6944	Rp 1,373,879,256	0.6400	Rp 1,148,450,905
0.7513	Rp 1,575,642,701	0.6575	Rp 1,378,930,179	0.5787	Rp 1,213,646,085	0.5120	Rp 927,551,135
0.6830	Rp 1,517,597,471	0.5718	Rp 1,270,386,802	0.4823	Rp 1,071,525,105	0.4096	Rp 748,738,365
0.6209	Rp 1,460,956,579	0.4972	Rp 1,169,799,772	0.4019	Rp 945,571,783	0.3277	Rp 604,093,515
0.5645	Rp 1,405,768,381	0.4323	Rp 1,076,670,564	0.3349	Rp 834,031,408	0.2621	Rp 487,162,678
0.5132	Rp 1,352,068,836	0.3759	Rp 990,518,785	0.2791	Rp 735,324,230	0.2097	Rp 392,692,326
0.4665	Rp 1,299,882,996	0.3269	Rp 910,883,890	0.2326	Rp 648,030,991	0.1678	Rp 316,410,762
0.4241	Rp 1,249,226,345	0.2843	Rp 837,326,311	0.1938	Rp 570,879,025	0.1342	Rp 254,848,154
0.3855	Rp (3,172,393,998)	0.2472	Rp (3,603,071,877)	0.1615	Rp (3,869,770,930)	0.1074	Rp (4,636,804,960)
0.3505	Rp 1,152,521,796	0.2149	Rp 706,793,326	0.1346	Rp 442,562,873	0.0859	Rp 165,149,115
0.3186	Rp 1,106,467,229	0.1869	Rp 649,047,817	0.1122	Rp 389,471,627	0.0687	Rp 132,879,820
0.2897	Rp 1,061,930,344	0.1625	Rp 595,839,119	0.0935	Rp 342,645,268	0.0550	Rp 106,883,307
0.2633	Rp 1,018,894,491	0.1413	Rp 546,835,929	0.0779	Rp 301,362,605	0.0440	Rp 85,948,131
0.2394	Rp 977,339,022	0.1229	Rp 501,727,507	0.0649	Rp 264,982,276	0.0352	Rp 69,094,875
0.2176	Rp 937,239,900	0.1069	Rp 460,222,965	0.0541	Rp 232,934,488	0.0281	Rp 55,532,182
0.1978	Rp 898,570,249	0.0929	Rp 422,050,479	0.0451	Rp 204,713,508	0.0225	Rp 44,621,008
0.1799	Rp 861,300,841	0.0808	Rp 386,956,439	0.0376	Rp 179,870,845	0.0180	Rp 35,845,578
0.1635	Rp 825,400,524	0.0703	Rp 354,704,576	0.0313	Rp 158,009,094	0.0144	Rp 28,789,812
0.1486	Rp 790,836,610	0.0611	Rp 325,075,068	0.0261	Rp 138,776,378	0.0115	Rp 23,118,211
NPV 10%	Rp 5,439,335,809	NPV 15%	Rp (2,112,027,820)	NPV 20%	Rp (6,477,805,172)	NPV 25%	Rp (11,798,478,218)



NET PRESENT VALUE ANALYSIS CONV 5

Tahun	Nilai Investasi	Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value
			5%		*6%*		*7%*	
0	Rp 14,210,625,000	Rp (14,210,625,000)	1.00	Rp (14,210,625,000)		Rp (14,210,625,000)		Rp (14,210,625,000)
1		Rp 1,718,637,964	0.95	Rp 1,636,798,061	0.9434	Rp 1,621,356,570	0.9346	Rp 1,606,203,705
2		Rp 1,824,444,862	0.91	Rp 1,654,825,272	0.8900	Rp 1,623,749,433	0.8734	Rp 1,593,540,800
3		Rp 1,935,542,106	0.86	Rp 1,671,994,044	0.8396	Rp 1,625,118,475	0.8163	Rp 1,579,978,911
4		Rp 2,052,194,211	0.82	Rp 1,688,345,256	0.7921	Rp 1,625,530,030	0.7629	Rp 1,565,609,138
5		Rp 2,174,678,921	0.78	Rp 1,703,917,839	0.7473	Rp 1,625,046,597	0.7130	Rp 1,550,516,016
6		Rp 2,303,287,867	0.75	Rp 1,718,748,870	0.7050	Rp 1,623,727,060	0.6663	Rp 1,534,777,960
7		Rp 2,438,327,261	0.71	Rp 1,732,873,661	0.6651	Rp 1,621,626,890	0.6227	Rp 1,518,467,672
8		Rp 2,580,118,624	0.68	Rp 1,746,325,843	0.6274	Rp 1,618,798,344	0.5820	Rp 1,501,652,530
9		Rp 2,728,999,555	0.64	Rp 1,759,137,445	0.5919	Rp 1,615,290,644	0.5439	Rp 1,484,394,941
10	Rp 4,372,500,000	Rp 2,885,324,533	0.61	Rp (2,601,161,029)	0.5584	Rp (2,761,349,851)	0.5083	Rp (2,905,747,316)
11		Rp 3,049,465,759	0.58	Rp 1,782,959,472	0.5268	Rp 1,606,420,521	0.4751	Rp 1,448,779,215
12		Rp 3,221,814,047	0.56	Rp 1,794,026,616	0.4970	Rp 1,601,142,877	0.4440	Rp 1,430,523,967
13		Rp 3,402,779,750	0.53	Rp 1,804,566,753	0.4688	Rp 1,595,355,931	0.4150	Rp 1,412,032,620
14		Rp 3,592,793,737	0.51	Rp 1,814,604,978	0.4423	Rp 1,589,096,135	0.3878	Rp 1,393,347,355
15		Rp 3,792,308,424	0.48	Rp 1,824,165,193	0.4173	Rp 1,582,397,805	0.3624	Rp 1,374,507,094
16		Rp 4,001,798,845	0.46	Rp 1,833,270,160	0.3936	Rp 1,575,293,244	0.3387	Rp 1,355,547,722
17		Rp 4,221,763,788	0.44	Rp 1,841,941,556	0.3714	Rp 1,567,812,854	0.3166	Rp 1,336,502,298
18		Rp 4,452,726,977	0.42	Rp 1,850,200,029	0.3503	Rp 1,559,985,250	0.2959	Rp 1,317,401,242
19		Rp 4,695,238,326	0.40	Rp 1,858,065,242	0.3305	Rp 1,551,837,354	0.2765	Rp 1,298,272,523
20		Rp 4,949,875,242	0.38	Rp 1,865,555,920	0.3118	Rp 1,543,394,498	0.2584	Rp 1,279,141,824
			NPV 5%	Rp 16,770,536,183	NPV 6%	Rp 13,401,005,659	NPV 7%	Rp 10,464,825,216

Interest Rate	5%	6%	7%	10%	15%	20%	25%
NPV	Rp 16,770,536,183	Rp 13,401,005,659	Rp 10,464,825,216	Rp 3,663,574,321	Rp (3,340,453,867)	Rp (7,387,565,062)	Rp (12,350,556,022)
IRR	11.62%						

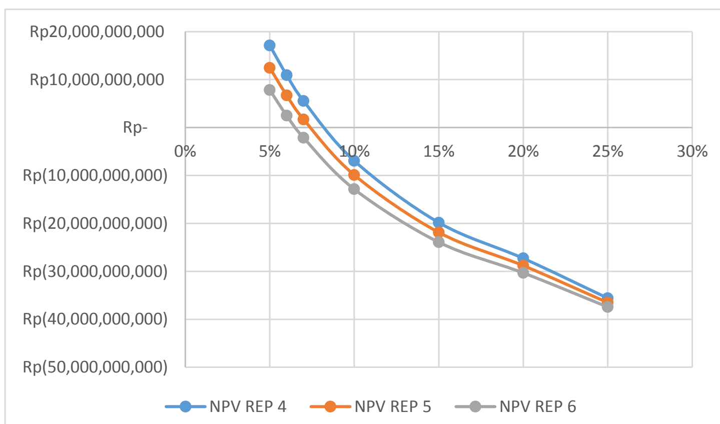
Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value
10%		*15%*		*20%*		*25%*	
	Rp (14,210,625,000)		Rp (14,210,625,000)		Rp (14,210,625,000)		Rp (14,210,625,000)
0.9091	Rp 1,562,398,149	0.8696	Rp 1,494,467,795	0.8333	Rp 1,432,198,303	0.8000	Rp 1,309,438,449
0.8264	Rp 1,507,805,671	0.7561	Rp 1,379,542,429	0.6944	Rp 1,266,975,599	0.6400	Rp 1,059,088,174
0.7513	Rp 1,454,201,432	0.6575	Rp 1,272,650,353	0.5787	Rp 1,120,105,385	0.5120	Rp 856,060,951
0.6830	Rp 1,401,676,259	0.5718	Rp 1,173,348,701	0.4823	Rp 989,676,992	0.4096	Rp 691,546,217
0.6209	Rp 1,350,304,513	0.4972	Rp 1,081,199,766	0.4019	Rp 873,954,685	0.3277	Rp 558,339,797
0.5645	Rp 1,300,145,955	0.4323	Rp 995,774,906	0.3349	Rp 771,366,446	0.2621	Rp 450,559,704
0.5132	Rp 1,251,247,429	0.3759	Rp 916,657,533	0.2791	Rp 680,492,388	0.2097	Rp 363,409,946
0.4665	Rp 1,203,644,380	0.3269	Rp 843,445,355	0.2326	Rp 600,053,130	0.1678	Rp 292,984,859
0.4241	Rp 1,157,362,212	0.2843	Rp 775,751,996	0.1938	Rp 528,898,397	0.1342	Rp 236,107,431
0.3855	Rp (3,260,082,489)	0.2472	Rp (3,659,291,903)	0.1615	Rp (3,906,503,980)	0.1074	Rp (4,651,797,539)
0.3505	Rp 1,068,819,145	0.2149	Rp 655,461,998	0.1346	Rp 410,421,454	0.0859	Rp 153,155,052
0.3186	Rp 1,026,569,244	0.1869	Rp 602,180,082	0.1122	Rp 361,347,886	0.0687	Rp 123,284,570
0.2897	Rp 985,664,086	0.1625	Rp 553,046,840	0.0935	Rp 318,036,995	0.0550	Rp 99,207,106
0.2633	Rp 946,094,881	0.1413	Rp 507,764,717	0.0779	Rp 279,830,366	0.0440	Rp 79,807,171
0.2394	Rp 907,848,485	0.1229	Rp 466,053,792	0.0649	Rp 246,141,566	0.0352	Rp 64,182,107
0.2176	Rp 870,908,024	0.1069	Rp 427,651,312	0.0541	Rp 216,448,867	0.0281	Rp 51,601,968
0.1978	Rp 835,253,459	0.0929	Rp 392,311,144	0.0451	Rp 190,288,590	0.0225	Rp 41,476,837
0.1799	Rp 800,862,086	0.0808	Rp 359,803,133	0.0376	Rp 167,249,042	0.0180	Rp 33,330,241
0.1635	Rp 767,708,985	0.0703	Rp 329,912,427	0.0313	Rp 146,965,016	0.0144	Rp 26,777,542
0.1486	Rp 735,767,414	0.0611	Rp 302,438,758	0.0261	Rp 129,112,810	0.0115	Rp 21,508,395
NPV 10%	Rp 3,663,574,321	NPV 15%	Rp (3,340,453,867)	NPV 20%	Rp (7,387,565,062)	NPV 25%	Rp (12,350,556,022)

NET PRESENT VALUE ANALYSIS CONV 6

Tahun	Nilai Investasi	Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value
			5%		*6%*		*7%*	
0	Rp 14,210,625,000	Rp (14,210,625,000)	1.00	Rp (14,210,625,000)		Rp (14,210,625,000)		Rp (14,210,625,000)
1		Rp 1,572,027,234	0.95	Rp 1,497,168,794	0.9434	Rp 1,483,044,560	0.9346	Rp 1,469,184,331
2		Rp 1,670,503,596	0.91	Rp 1,515,196,005	0.8900	Rp 1,486,742,253	0.8734	Rp 1,459,082,536
3		Rp 1,773,903,775	0.86	Rp 1,532,364,777	0.8396	Rp 1,489,403,816	0.8163	Rp 1,448,033,886
4		Rp 1,882,473,964	0.82	Rp 1,548,715,989	0.7921	Rp 1,491,095,698	0.7629	Rp 1,436,130,374
5		Rp 1,996,472,662	0.78	Rp 1,564,288,572	0.7473	Rp 1,491,880,514	0.7130	Rp 1,423,457,416
6		Rp 2,116,171,296	0.75	Rp 1,579,119,603	0.7050	Rp 1,491,817,260	0.6663	Rp 1,410,094,287
7		Rp 2,241,854,860	0.71	Rp 1,593,244,394	0.6651	Rp 1,490,961,523	0.6227	Rp 1,396,114,536
8		Rp 2,373,822,603	0.68	Rp 1,606,696,576	0.6274	Rp 1,489,365,669	0.5820	Rp 1,381,586,368
9		Rp 2,512,388,734	0.64	Rp 1,619,508,179	0.5919	Rp 1,487,079,031	0.5439	Rp 1,366,573,007
10	Rp 4,372,500,000	Rp 2,657,883,170	0.61	Rp (2,740,790,295)	0.5584	Rp (2,888,351,920)	0.5083	Rp (3,021,366,972)
11		Rp 2,810,652,329	0.58	Rp 1,643,330,205	0.5268	Rp 1,480,616,585	0.4751	Rp 1,335,320,675
12		Rp 2,971,059,945	0.56	Rp 1,654,397,349	0.4970	Rp 1,476,525,770	0.4440	Rp 1,319,186,147
13		Rp 3,139,487,942	0.53	Rp 1,664,937,486	0.4688	Rp 1,471,914,457	0.4150	Rp 1,302,775,881
14		Rp 3,316,337,340	0.51	Rp 1,674,975,712	0.4423	Rp 1,466,819,203	0.3878	Rp 1,286,132,797
15		Rp 3,502,029,206	0.48	Rp 1,684,535,926	0.4173	Rp 1,461,274,430	0.3624	Rp 1,269,296,547
16		Rp 3,697,005,667	0.46	Rp 1,693,640,893	0.3936	Rp 1,455,312,542	0.3387	Rp 1,252,303,728
17		Rp 3,901,730,950	0.44	Rp 1,702,312,290	0.3714	Rp 1,448,964,046	0.3166	Rp 1,235,188,097
18		Rp 4,116,692,498	0.42	Rp 1,710,570,763	0.3503	Rp 1,442,257,657	0.2959	Rp 1,217,980,765
19		Rp 4,342,402,123	0.40	Rp 1,718,435,975	0.3305	Rp 1,435,220,398	0.2765	Rp 1,200,710,372
20		Rp 4,579,397,229	0.38	Rp 1,725,926,653	0.3118	Rp 1,427,877,702	0.2584	Rp 1,183,403,265
			NPV 5%	Rp 13,977,950,845	NPV 6%	Rp 10,869,196,194	NPV 7%	Rp 8,160,563,041

Interest Rate	5%	6%	7%	10%	15%	20%	25%
NPV	Rp 13,977,950,845	Rp 10,869,196,194	Rp 8,160,563,041	Rp 1,887,812,833	Rp (4,568,879,915)	Rp (8,297,324,952)	Rp (12,902,633,826)
IRR	9.50%						

Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value
10%		*15%*		*20%*		*25%*	
	Rp (14,210,625,000)		Rp (14,210,625,000)		Rp (14,210,625,000)		Rp (14,210,625,000)
0.9091	Rp 1,429,115,667	0.8696	Rp 1,366,980,203	0.8333	Rp 1,310,022,695	0.8000	Rp 1,197,735,035
0.8264	Rp 1,380,581,484	0.7561	Rp 1,263,140,715	0.6944	Rp 1,160,071,941	0.6400	Rp 969,725,443
0.7513	Rp 1,332,760,162	0.6575	Rp 1,166,370,527	0.5787	Rp 1,026,564,685	0.5120	Rp 784,570,766
0.6830	Rp 1,285,755,047	0.5718	Rp 1,076,310,599	0.4823	Rp 907,828,879	0.4096	Rp 634,354,069
0.6209	Rp 1,239,652,447	0.4972	Rp 992,599,760	0.4019	Rp 802,337,586	0.3277	Rp 512,586,079
0.5645	Rp 1,194,523,528	0.4323	Rp 914,879,249	0.3349	Rp 708,701,485	0.2621	Rp 413,956,729
0.5132	Rp 1,150,426,021	0.3759	Rp 842,796,280	0.2791	Rp 625,660,547	0.2097	Rp 334,127,567
0.4665	Rp 1,107,405,764	0.3269	Rp 776,006,820	0.2326	Rp 552,075,269	0.1678	Rp 269,558,955
0.4241	Rp 1,065,498,078	0.2843	Rp 714,177,681	0.1938	Rp 486,917,768	0.1342	Rp 217,366,708
0.3855	Rp (3,347,770,980)	0.2472	Rp (3,715,511,930)	0.1615	Rp (3,943,237,029)	0.1074	Rp (4,666,790,117)
0.3505	Rp 985,116,495	0.2149	Rp 604,130,669	0.1346	Rp 378,280,036	0.0859	Rp 141,160,990
0.3186	Rp 946,671,260	0.1869	Rp 555,312,347	0.1122	Rp 333,224,145	0.0687	Rp 113,689,320
0.2897	Rp 909,397,828	0.1625	Rp 510,254,560	0.0935	Rp 293,428,721	0.0550	Rp 91,530,906
0.2633	Rp 873,295,271	0.1413	Rp 468,693,506	0.0779	Rp 258,298,126	0.0440	Rp 73,666,211
0.2394	Rp 838,357,949	0.1229	Rp 430,380,077	0.0649	Rp 227,300,857	0.0352	Rp 59,269,339
0.2176	Rp 804,576,148	0.1069	Rp 395,079,659	0.0541	Rp 199,963,247	0.0281	Rp 47,671,753
0.1978	Rp 771,936,668	0.0929	Rp 362,571,808	0.0451	Rp 175,863,672	0.0225	Rp 38,332,665
0.1799	Rp 740,423,331	0.0808	Rp 332,649,827	0.0376	Rp 154,627,238	0.0180	Rp 30,814,903
0.1635	Rp 710,017,446	0.0703	Rp 305,120,278	0.0313	Rp 135,920,938	0.0144	Rp 24,765,272
0.1486	Rp 680,698,218	0.0611	Rp 279,802,448	0.0261	Rp 119,449,241	0.0115	Rp 19,898,580
NPV 10%	Rp 1,887,812,833	NPV 15%	Rp (4,568,879,915)	NPV 20%	Rp (8,297,324,952)	NPV 25%	Rp (12,902,633,826)



NET PRESENT VALUE ANALYSIS REP 4

Tahun	Nilai Investasi	Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value
			5%		*6%*		*7%*	
0	Rp 48,112,075,000	Rp (48,112,075,000)	1.00	Rp (48,112,075,000)		Rp (48,112,075,000)		Rp (48,112,075,000)
1		Rp 3,241,247,824	0.95	Rp 3,086,902,689	0.9434	Rp 3,057,780,966	0.9346	Rp 3,029,203,574
2		Rp 3,429,810,215	0.91	Rp 3,110,938,971	0.8900	Rp 3,052,518,881	0.8734	Rp 2,995,729,073
3		Rp 3,627,800,726	0.86	Rp 3,133,830,667	0.8396	Rp 3,045,971,444	0.8163	Rp 2,961,366,030
4		Rp 3,835,690,762	0.82	Rp 3,155,632,283	0.7921	Rp 3,038,226,347	0.7629	Rp 2,926,230,117
5		Rp 4,053,975,300	0.78	Rp 3,176,395,726	0.7473	Rp 3,029,366,176	0.7130	Rp 2,890,428,361
6		Rp 4,283,174,065	0.75	Rp 3,196,170,434	0.7050	Rp 3,019,468,704	0.6663	Rp 2,854,059,732
7		Rp 4,523,832,769	0.71	Rp 3,215,003,489	0.6651	Rp 3,008,607,164	0.6227	Rp 2,817,215,689
8		Rp 4,776,524,407	0.68	Rp 3,232,939,732	0.6274	Rp 2,996,850,505	0.5820	Rp 2,779,980,693
9		Rp 5,041,850,627	0.64	Rp 3,250,021,869	0.5919	Rp 2,984,263,640	0.5439	Rp 2,742,432,681
10	Rp -	Rp 5,320,443,159	0.61	Rp 3,266,290,570	0.5584	Rp 2,970,907,671	0.5083	Rp 2,704,643,514
11		Rp 5,612,965,317	0.58	Rp 3,281,784,571	0.5268	Rp 2,956,840,109	0.4751	Rp 2,666,679,388
12		Rp 5,920,113,583	0.56	Rp 3,296,540,763	0.4970	Rp 2,942,115,079	0.4440	Rp 2,628,601,231
13		Rp 6,242,619,262	0.53	Rp 3,310,594,278	0.4688	Rp 2,926,783,511	0.4150	Rp 2,590,465,055
14		Rp 6,581,250,225	0.51	Rp 3,323,978,579	0.4423	Rp 2,910,893,321	0.3878	Rp 2,552,322,305
15		Rp 6,936,812,736	0.48	Rp 3,336,725,532	0.4173	Rp 2,894,489,588	0.3624	Rp 2,514,220,165
16		Rp 7,310,153,373	0.46	Rp 3,348,865,488	0.3936	Rp 2,877,614,709	0.3387	Rp 2,476,201,863
17		Rp 7,702,161,041	0.44	Rp 3,360,427,350	0.3714	Rp 2,860,308,557	0.3166	Rp 2,438,306,937
18		Rp 8,113,769,093	0.42	Rp 3,371,438,647	0.3503	Rp 2,842,608,625	0.2959	Rp 2,400,571,500
19		Rp 8,545,957,548	0.40	Rp 3,381,925,597	0.3305	Rp 2,824,550,157	0.2765	Rp 2,363,028,476
20		Rp 8,999,755,426	0.38	Rp 3,391,913,168	0.3118	Rp 2,806,166,283	0.2584	Rp 2,325,707,823
			NPV 5%	Rp 17,116,245,404	NPV 6%	Rp 10,934,256,435	NPV 7%	Rp 5,545,319,206

Interest Rate	5%	6%	7%	10%	15%	20%	25%
NPV	Rp 17,116,245,404	Rp 10,934,256,435	Rp 5,545,319,206	Rp (6,946,593,126)	Rp (19,830,884,946)	Rp (27,291,322,638)	Rp (35,599,683,390)
IRR	0.00%						

Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value
10%		*15%*		*20%*		*25%*	
	Rp (48,112,075,000)		Rp (48,112,075,000)		Rp (48,112,075,000)		Rp (48,112,075,000)
0.9091	Rp 2,946,588,931	0.8696	Rp 2,818,476,369	0.8333	Rp 2,701,039,853	0.8000	Rp 2,469,522,152
0.8264	Rp 2,834,553,897	0.7561	Rp 2,593,429,274	0.6944	Rp 2,381,812,649	0.6400	Rp 1,991,000,941
0.7513	Rp 2,725,620,380	0.6575	Rp 2,385,337,865	0.5787	Rp 2,099,421,716	0.5120	Rp 1,604,521,302
0.6830	Rp 2,619,828,401	0.5718	Rp 2,193,068,642	0.4823	Rp 1,849,773,709	0.4096	Rp 1,292,546,983
0.6209	Rp 2,517,199,707	0.4972	Rp 2,015,542,205	0.4019	Rp 1,629,201,751	0.3277	Rp 1,040,841,352
0.5645	Rp 2,417,740,098	0.4323	Rp 1,851,734,347	0.3349	Rp 1,434,426,328	0.2621	Rp 837,856,902
0.5132	Rp 2,321,441,511	0.3759	Rp 1,700,676,300	0.2791	Rp 1,262,518,701	0.2097	Rp 674,235,100
0.4665	Rp 2,228,283,888	0.3269	Rp 1,561,454,301	0.2326	Rp 1,110,866,916	0.1678	Rp 542,397,282
0.4241	Rp 2,138,236,843	0.2843	Rp 1,433,208,620	0.1938	Rp 977,144,429	0.1342	Rp 436,210,551
0.3855	Rp 2,051,261,157	0.2472	Rp 1,315,132,179	0.1615	Rp 859,281,274	0.1074	Rp 350,715,279
0.3505	Rp 1,967,310,102	0.2149	Rp 1,206,468,854	0.1346	Rp 755,437,696	0.0859	Rp 281,903,148
0.3186	Rp 1,886,330,632	0.1869	Rp 1,106,511,558	0.1122	Rp 663,980,135	0.0687	Rp 226,536,556
0.2897	Rp 1,808,264,436	0.1625	Rp 1,014,600,153	0.0935	Rp 583,459,411	0.0550	Rp 182,001,845
0.2633	Rp 1,733,048,877	0.1413	Rp 930,119,262	0.0779	Rp 512,590,979	0.0440	Rp 146,190,124
0.2394	Rp 1,660,617,817	0.1229	Rp 852,496,030	0.0649	Rp 450,237,101	0.0352	Rp 117,400,593
0.2176	Rp 1,590,902,361	0.1069	Rp 781,197,857	0.0541	Rp 395,390,793	0.0281	Rp 94,262,184
0.1978	Rp 1,523,831,501	0.0929	Rp 715,730,145	0.0451	Rp 347,161,385	0.0225	Rp 75,670,097
0.1799	Rp 1,459,332,691	0.0808	Rp 655,634,076	0.0376	Rp 304,761,579	0.0180	Rp 60,734,439
0.1635	Rp 1,397,332,348	0.0703	Rp 600,484,449	0.0313	Rp 267,495,855	0.0144	Rp 48,738,684
0.1486	Rp 1,337,756,298	0.0611	Rp 549,887,567	0.0261	Rp 234,750,100	0.0115	Rp 39,106,096
NPV 10%	Rp (6,946,593,126)	NPV 15%	Rp (19,830,884,946)	NPV 20%	Rp (27,291,322,638)	NPV 25%	Rp (35,599,683,390)

NET PRESENT VALUE ANALYSIS REP 5

Tahun	Nilai Investasi	Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value
			5%		*6%*		*7%*	
0	Rp 48,112,075,000	Rp (48,112,075,000)	1.00	Rp (48,112,075,000)		Rp (48,112,075,000)		Rp (48,112,075,000)
1		Rp 2,996,896,607	0.95	Rp 2,854,187,245	0.9434	Rp 2,827,260,950	0.9346	Rp 2,800,837,950
2		Rp 3,173,241,437	0.91	Rp 2,878,223,526	0.8900	Rp 2,824,173,583	0.8734	Rp 2,771,631,966
3		Rp 3,358,403,509	0.86	Rp 2,901,115,222	0.8396	Rp 2,819,780,347	0.8163	Rp 2,741,457,654
4		Rp 3,552,823,685	0.82	Rp 2,922,916,838	0.7921	Rp 2,814,169,127	0.7629	Rp 2,710,432,178
5		Rp 3,756,964,869	0.78	Rp 2,943,680,281	0.7473	Rp 2,807,422,703	0.7130	Rp 2,678,664,028
6		Rp 3,971,313,112	0.75	Rp 2,963,454,989	0.7050	Rp 2,799,619,038	0.6663	Rp 2,646,253,611
7		Rp 4,196,378,768	0.71	Rp 2,982,288,045	0.6651	Rp 2,790,831,551	0.6227	Rp 2,613,293,795
8		Rp 4,432,697,706	0.68	Rp 3,000,224,288	0.6274	Rp 2,781,129,379	0.5820	Rp 2,579,870,423
9		Rp 4,680,832,592	0.64	Rp 3,017,306,424	0.5919	Rp 2,770,577,619	0.5439	Rp 2,546,062,790
10	Rp -	Rp 4,941,374,221	0.61	Rp 3,033,575,125	0.5584	Rp 2,759,237,556	0.5083	Rp 2,511,944,088
11		Rp 5,214,942,932	0.58	Rp 3,049,069,126	0.5268	Rp 2,747,166,882	0.4751	Rp 2,477,581,821
12		Rp 5,502,190,079	0.56	Rp 3,063,825,318	0.4970	Rp 2,734,419,902	0.4440	Rp 2,443,038,197
13		Rp 5,803,799,583	0.53	Rp 3,077,878,834	0.4688	Rp 2,721,047,722	0.4150	Rp 2,408,370,490
14		Rp 6,120,489,562	0.51	Rp 3,091,263,134	0.4423	Rp 2,707,098,436	0.3878	Rp 2,373,631,376
15		Rp 6,453,014,040	0.48	Rp 3,104,010,087	0.4173	Rp 2,692,617,295	0.3624	Rp 2,338,869,254
16		Rp 6,802,164,742	0.46	Rp 3,116,150,043	0.3936	Rp 2,677,646,872	0.3387	Rp 2,304,128,538
17		Rp 7,168,772,979	0.44	Rp 3,127,711,905	0.3714	Rp 2,662,227,209	0.3166	Rp 2,269,449,936
18		Rp 7,553,711,628	0.42	Rp 3,138,723,202	0.3503	Rp 2,646,395,969	0.2959	Rp 2,234,870,705
19		Rp 7,957,897,210	0.40	Rp 3,149,210,152	0.3305	Rp 2,630,188,564	0.2765	Rp 2,200,424,892
20		Rp 8,382,292,070	0.38	Rp 3,159,197,724	0.3118	Rp 2,613,638,290	0.2584	Rp 2,166,143,558
			NPV 5%	Rp 12,461,936,508	NPV 6%	Rp 6,714,573,994	NPV 7%	Rp 1,704,882,248

Interest Rate	5%	6%	7%	10%	15%	20%	25%
NPV	Rp 12,461,936,508	Rp 6,714,573,994	Rp 1,704,882,248	Rp (9,906,195,606)	Rp (21,878,261,692)	Rp (28,807,589,122)	Rp (36,519,813,063)
IRR	0.00%						

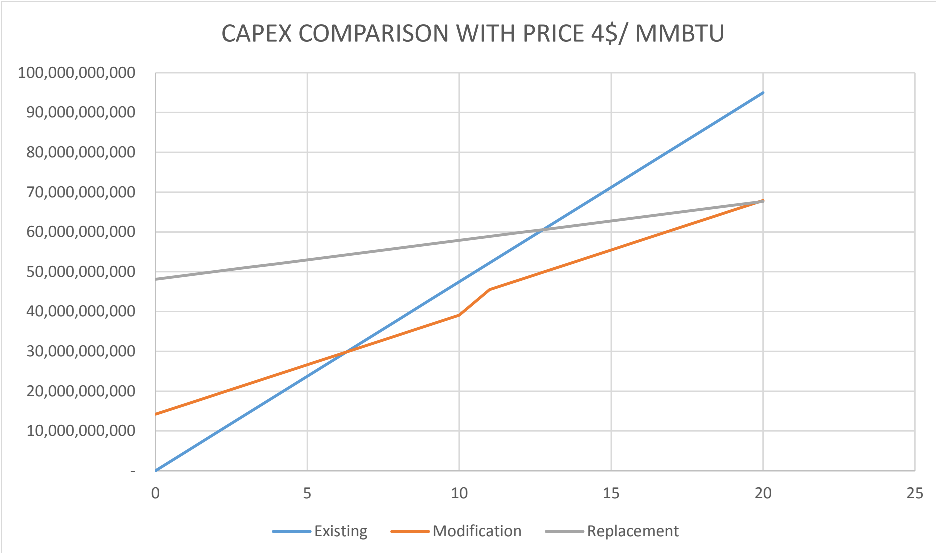
Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value
10%		*15%*		*20%*		*25%*	
	Rp (48,112,075,000)		Rp (48,112,075,000)		Rp (48,112,075,000)		Rp (48,112,075,000)
0.9091	Rp 2,724,451,461	0.8696	Rp 2,605,997,050	0.8333	Rp 2,497,413,839	0.8000	Rp 2,283,349,796
0.8264	Rp 2,622,513,585	0.7561	Rp 2,399,426,418	0.6944	Rp 2,203,639,887	0.6400	Rp 1,842,063,057
0.7513	Rp 2,523,218,264	0.6575	Rp 2,208,204,822	0.5787	Rp 1,943,520,549	0.5120	Rp 1,485,370,994
0.6830	Rp 2,426,626,381	0.5718	Rp 2,031,338,473	0.4823	Rp 1,713,360,187	0.4096	Rp 1,197,226,737
0.6209	Rp 2,332,779,597	0.4972	Rp 1,867,875,528	0.4019	Rp 1,509,839,920	0.3277	Rp 964,585,155
0.5645	Rp 2,241,702,720	0.4323	Rp 1,716,908,250	0.3349	Rp 1,329,984,726	0.2621	Rp 776,851,945
0.5132	Rp 2,153,405,832	0.3759	Rp 1,577,574,212	0.2791	Rp 1,171,132,299	0.2097	Rp 625,431,134
0.4665	Rp 2,067,886,194	0.3269	Rp 1,449,056,743	0.2326	Rp 1,030,903,815	0.1678	Rp 503,354,109
0.4241	Rp 1,985,129,954	0.2843	Rp 1,330,584,763	0.1938	Rp 907,176,715	0.1342	Rp 404,976,013
0.3855	Rp 1,905,113,672	0.2472	Rp 1,221,432,135	0.1615	Rp 798,059,524	0.1074	Rp 325,727,649
0.3505	Rp 1,827,805,684	0.2149	Rp 1,120,916,640	0.1346	Rp 701,868,665	0.0859	Rp 261,913,044
0.3186	Rp 1,753,167,324	0.1869	Rp 1,028,398,667	0.1122	Rp 617,107,233	0.0687	Rp 210,544,473
0.2897	Rp 1,681,154,006	0.1625	Rp 943,279,687	0.0935	Rp 542,445,622	0.0550	Rp 169,208,178
0.2633	Rp 1,611,716,193	0.1413	Rp 865,000,576	0.0779	Rp 476,703,913	0.0440	Rp 135,955,190
0.2394	Rp 1,544,800,256	0.1229	Rp 793,039,838	0.0649	Rp 418,835,919	0.0352	Rp 109,212,646
0.2176	Rp 1,480,349,234	0.1069	Rp 726,911,769	0.0541	Rp 367,914,758	0.0281	Rp 87,711,826
0.1978	Rp 1,418,303,516	0.0929	Rp 666,164,586	0.0451	Rp 323,119,854	0.0225	Rp 70,429,811
0.1799	Rp 1,358,601,433	0.0808	Rp 610,378,566	0.0376	Rp 283,725,240	0.0180	Rp 56,542,211
0.1635	Rp 1,301,179,784	0.0703	Rp 559,164,200	0.0313	Rp 249,089,058	0.0144	Rp 45,384,901
0.1486	Rp 1,245,974,304	0.0611	Rp 512,160,384	0.0261	Rp 218,644,153	0.0115	Rp 36,423,070
NPV 10%	Rp (9,906,195,606)	NPV 15%	Rp (21,878,261,692)	NPV 20%	Rp (28,807,589,122)	NPV 25%	Rp (36,519,813,063)

NET PRESENT VALUE ANALYSIS REP 6

Tahun	Nilai Investasi	Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value
			5%		*6%*		*7%*	
0	Rp 48,112,075,000	Rp (48,112,075,000)	1.00	Rp (48,112,075,000)		Rp (48,112,075,000)		Rp (48,112,075,000)
1		Rp 2,752,545,390	0.95	Rp 2,621,471,800	0.9434	Rp 2,596,740,934	0.9346	Rp 2,572,472,327
2		Rp 2,916,672,659	0.91	Rp 2,645,508,081	0.8900	Rp 2,595,828,284	0.8734	Rp 2,547,534,858
3		Rp 3,089,006,292	0.86	Rp 2,668,399,777	0.8396	Rp 2,593,589,249	0.8163	Rp 2,521,549,278
4		Rp 3,269,956,607	0.82	Rp 2,690,201,393	0.7921	Rp 2,590,111,908	0.7629	Rp 2,494,634,239
5		Rp 3,459,954,437	0.78	Rp 2,710,964,836	0.7473	Rp 2,585,479,231	0.7130	Rp 2,466,899,696
6		Rp 3,659,452,159	0.75	Rp 2,730,739,544	0.7050	Rp 2,579,769,372	0.6663	Rp 2,438,447,490
7		Rp 3,868,924,767	0.71	Rp 2,749,572,600	0.6651	Rp 2,573,055,939	0.6227	Rp 2,409,371,900
8		Rp 4,088,871,006	0.68	Rp 2,767,508,843	0.6274	Rp 2,565,408,254	0.5820	Rp 2,379,760,153
9		Rp 4,319,814,556	0.64	Rp 2,784,590,979	0.5919	Rp 2,556,891,598	0.5439	Rp 2,349,692,899
10	Rp -	Rp 4,562,305,284	0.61	Rp 2,800,859,680	0.5584	Rp 2,547,567,441	0.5083	Rp 2,319,244,661
11		Rp 4,816,920,548	0.58	Rp 2,816,353,681	0.5268	Rp 2,537,493,655	0.4751	Rp 2,288,484,253
12		Rp 5,084,266,575	0.56	Rp 2,831,109,873	0.4970	Rp 2,526,724,724	0.4440	Rp 2,257,475,163
13		Rp 5,364,979,904	0.53	Rp 2,845,163,389	0.4688	Rp 2,515,311,933	0.4150	Rp 2,226,275,924
14		Rp 5,659,728,899	0.51	Rp 2,858,547,690	0.4423	Rp 2,503,303,550	0.3878	Rp 2,194,940,447
15		Rp 5,969,215,344	0.48	Rp 2,871,294,643	0.4173	Rp 2,490,745,003	0.3624	Rp 2,163,518,342
16		Rp 6,294,176,111	0.46	Rp 2,883,434,598	0.3936	Rp 2,477,679,035	0.3387	Rp 2,132,055,214
17		Rp 6,635,384,917	0.44	Rp 2,894,996,460	0.3714	Rp 2,464,145,862	0.3166	Rp 2,100,592,936
18		Rp 6,993,654,163	0.42	Rp 2,906,007,758	0.3503	Rp 2,450,183,313	0.2959	Rp 2,069,169,910
19		Rp 7,369,836,871	0.40	Rp 2,916,494,707	0.3305	Rp 2,435,826,971	0.2765	Rp 2,037,821,308
20		Rp 7,764,828,714	0.38	Rp 2,926,482,279	0.3118	Rp 2,421,110,297	0.2584	Rp 2,006,579,293
			NPV 5%	Rp 7,807,627,613	NPV 6%	Rp 2,494,891,552	NPV 7%	Rp (2,135,554,710)

Interest Rate	5%	6%	7%	10%	15%	20%	25%
NPV	Rp 7,807,627,613	Rp 2,494,891,552	Rp (2,135,554,710)	Rp (12,865,798,086)	Rp (23,925,638,438)	Rp (30,323,855,606)	Rp (37,439,942,737)
IRR	0.00%						

Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value	Discount Rate	Net Present Value
10%		***15%***		***20%***		***25%***	
	Rp (48,112,075,000)		Rp (48,112,075,000)		Rp (48,112,075,000)		Rp (48,112,075,000)
0.9091	Rp 2,502,313,991	0.8696	Rp 2,393,517,730	0.8333	Rp 2,293,787,825	0.8000	Rp 2,097,177,440
0.8264	Rp 2,410,473,272	0.7561	Rp 2,205,423,561	0.6944	Rp 2,025,467,125	0.6400	Rp 1,693,125,172
0.7513	Rp 2,320,816,148	0.6575	Rp 2,031,071,779	0.5787	Rp 1,787,619,382	0.5120	Rp 1,366,220,686
0.6830	Rp 2,233,424,361	0.5718	Rp 1,869,608,303	0.4823	Rp 1,576,946,666	0.4096	Rp 1,101,906,491
0.6209	Rp 2,148,359,487	0.4972	Rp 1,720,208,851	0.4019	Rp 1,390,478,089	0.3277	Rp 888,328,958
0.5645	Rp 2,065,665,342	0.4323	Rp 1,582,082,154	0.3349	Rp 1,225,543,124	0.2621	Rp 715,846,987
0.5132	Rp 1,985,370,153	0.3759	Rp 1,454,472,125	0.2791	Rp 1,079,745,897	0.2097	Rp 576,627,168
0.4665	Rp 1,907,488,501	0.3269	Rp 1,336,659,185	0.2326	Rp 950,940,713	0.1678	Rp 464,310,936
0.4241	Rp 1,832,023,065	0.2843	Rp 1,227,960,905	0.1938	Rp 837,209,001	0.1342	Rp 373,741,475
0.3855	Rp 1,758,966,186	0.2472	Rp 1,127,732,091	0.1615	Rp 736,837,774	0.1074	Rp 300,740,018
0.3505	Rp 1,688,301,266	0.2149	Rp 1,035,364,426	0.1346	Rp 648,299,634	0.0859	Rp 241,922,939
0.3186	Rp 1,620,004,016	0.1869	Rp 950,285,776	0.1122	Rp 570,234,331	0.0687	Rp 194,552,389
0.2897	Rp 1,554,043,576	0.1625	Rp 871,959,221	0.0935	Rp 501,431,833	0.0550	Rp 156,414,511
0.2633	Rp 1,490,383,510	0.1413	Rp 799,881,890	0.0779	Rp 440,816,847	0.0440	Rp 125,720,257
0.2394	Rp 1,428,982,694	0.1229	Rp 733,583,647	0.0649	Rp 387,434,737	0.0352	Rp 101,024,699
0.2176	Rp 1,369,796,108	0.1069	Rp 672,625,681	0.0541	Rp 340,438,724	0.0281	Rp 81,161,469
0.1978	Rp 1,312,775,532	0.0929	Rp 616,599,027	0.0451	Rp 299,078,324	0.0225	Rp 65,189,525
0.1799	Rp 1,257,870,175	0.0808	Rp 565,123,056	0.0376	Rp 262,688,901	0.0180	Rp 52,349,982
0.1635	Rp 1,205,027,219	0.0703	Rp 517,843,952	0.0313	Rp 230,682,261	0.0144	Rp 42,031,118
0.1486	Rp 1,154,192,311	0.0611	Rp 474,433,200	0.0261	Rp 202,538,206	0.0115	Rp 33,740,044
NPV 10%	Rp (12,865,798,086)	NPV 15%	Rp (23,925,638,438)	NPV 20%	Rp (30,323,855,606)	NPV 25%	Rp (37,439,942,737)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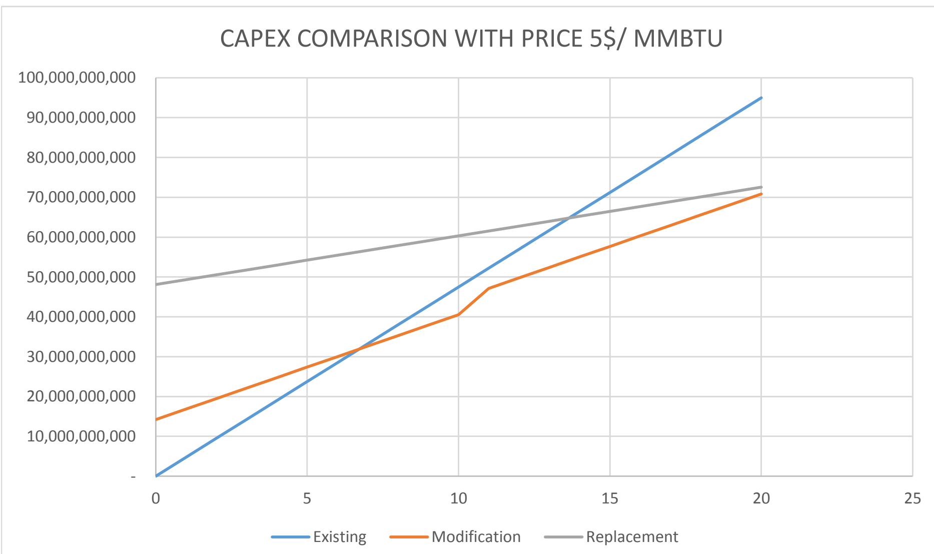
Replacement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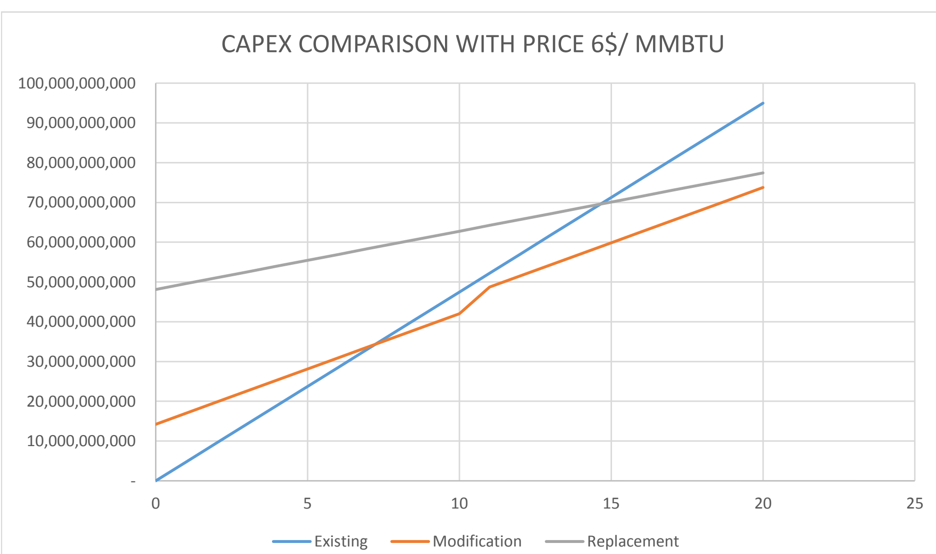
CAPEX COMPARISON WITH PRICE 6$/ MMBTU
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Existing
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Replacement

CHAPTER V
CONCLUSION & SUGGESTION

V.1. Conclusion

Based on the research that've done, it's possible for us to take a conclusion such as:

1. Technical Analysis

   It is reasonable to choose the **gas engine replacement** compared to the conversion. In addition, the fuel oil consumption analysis of engine replacement is more efficient due to the ratio of fuel oil and fuel gas. The conversion is only capable to work in ratio 60:40 while the gas engine replacement works in ratio 100% gas.

2. Economic Analysis

Based on the Payback and NPV calculation, the total profit of **gas engine replacement** is higher compared to the conversion. The payback period of the conversion is in range of Year 6 to 12 while the engine replacement is in range of Year 7 to 10.

With price of LNG 4, 5, and 6 $/mmbtu for conversion with constant revenue, the payback period is in Year 8, 10, and 12. Besides, with price of LNG 4, 5, and 6 $/mmbtu for engine replacement with constant revenue, the payback period is in Year 8, 8.5, and 9. In 20 years investment, with price of LNG 4 $/mmbtu for conversion with constant revenue, Rp 18,721,848,887.59 can be gain in Year 20. In the other way, for engine replacement with constant revenue, Rp 41,733,298,146.98 can be obtain. It represents the saving with engine replacement is possible up to Rp. 23,011,449,259.39 in total investment.

V.2. Suggestion

These are the following suggestion as shown as it follows:

- It’s more possible to analyze the bunkering LNG of this vessel, in case for a further research.
- It’s more possible to calculate the stability factor of this vessel, in case for a further research.

REFERENCE

Cabot Oil and Gas Corporation, ”Liquefied Natural Gas The New Energy Revolution”, Cabot Oil and Gas Corporation, 2012

Cengel, Yunus A, Cimbala, John M. “Fluid Mechanics”, McGraw-Hill, New York, 2014.

JFE Steel Corporation, ”Dual Fuel Engine Gas Fuel Conversion Technology”, JFE Technical Report No. 19, March 2014

Karim, Ghazi A., ”Dual-Fuel Diesel Engines 1st Ed.”, CRC Press, New York, Ch. 1, 2015.

Msaed, M. Hamzah, ”Properties of Petroleum and Natural Gas”, Proc. of Chemical Engineering Dept. of University of Diyala, pp. 3-5, Diyala, November, 2013

National Energy Education Development Project (NEED), ”Natural Gas”, NEED Secondary Energy Book, 2015

Primo, Jurandir, “Shell and Tube Heat Exchangers Basic Calculations”, PDHonline: Course M371 (2 PDH), PDHcenter.com, 2010.

Shakeri, Omid; Barati, Aghil, ”Marine Transportation of Liquefied Natural Gas”, Proc. of Iranian Fuel Conversion Organization (IFCO) The 3rd Iran Gas Forum, pp. 3-6, Iran, September, 2009

Society of Gas as Marine Fuel (SGMF), ”Gas as a Marine Fuel”, SGMF Introductory Guide, September 2014

Woodroof, Eric A., ”How to Use NPV to Your Advantage”, Proc. of Profitable Green Solutions, pp. 1-3; 5, April, 2011

BIOGRAPHY

Dhanang Surya Prayoga was born in Jakarta, 13 December 1994. The author is the first born of two children. The author accomplished his formal education in SD Mutiara 17 Agustus (Primary School), SMP Victory Plus (Middle School), SMA Victory Plus (High School). The author continues his study in Double Degree Marine Engineering Department, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember (ITS) Surabaya with Hochschule Wismar Germany. The author has fulfilled two On The Job Training in PT. Yasa Wahana Tirta Samudera, Semarang and Eni Indonesia, Jakarta. The author did his final project in Marine Power Plant Laboratory (MPP).