BACHELOR THESIS - (ME 141501)

DESIGN OF NATURAL GAS DISTRIBUTION PLAN IN BALI ISLAND BASED ON ECONOMICAL ASPECT

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BACHELOR THESIS & COLLOQUIUM – ME 141502

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APPROVAL FORM

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BACHELOR THESIS

Is being proposed to fulfill one of the requirement to achieve the title of
Bachelor of Engineering
at
In field of *Reliability, Availability, Management and Safety* (RAMS)
Study Program Bachelor Degree Department of Marine Engineering
Faculty of Marine Technology
Institut Teknologi Sepuluh Nopember

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DESAIN RANCANG DISTRIBUSI GAS ALAM DI PULAU BALI BERDASARKAN ASPEK EKONOMI

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ABSTRAK

Bali adalah pulau dengan kebutuhan tenaga listrik yang besar dikarenakan adanya banyak aktivitas yang berhubungan dengan industri dan pariwisata. Tenaga listrik dihasilkan oleh empat pembangkit yang ada di Bali. Pembangkit ini adalah Unit Pembangkit Pesanggaran, Unit Pembangkit Pemaron, Unit Pembangkit Gilimanuk dan Unit Pembangkit Celukan Bawang. Pembangkit ini menggunakan mesin yang dikopel dengan generator untuk menghasilkan energi listrik. Di Bali terdapat fluktuasi permintaan energi listrik yang terbagi berdasarkan waktu dan musim, seperti siang dan malam, hari kerja atau hari minggu. Gas alam adalah salah satu energi terbaik Indonesia pada masa kini. Fluktuasi permintaan energi listrik menyebabkan distribusi gas alam yang tidak efisien dan menyebakan kerugian ekonomi. Tugas akhir ini memiliki tujuan untuk menemukan opsi yang terbaik sebagai rekomendasi untuk mengatur dan memilih distribusi antara menggunakan gas alam cair atau gas alam cair, antara pembangkit *peaker* atau pembangkit *base load*. Pembangkit yang diperhitungkan disini adalah Pembangkit Pemaron dan Gilimanuk. Dengan pertimbangan faktor seperti efisiensi antara gas alam terkompresi dengan gas alam cair perhitungan ekonomi harus dihitung. Dalam penulisantugas akhir, metode yang digunakan dalam memilih adalah *Net Present Value* (NPV), *Internal Rate of Return* (IRR), *Payback Period* (PBP), and *Return of Investment* (ROI) untuk menentukan hasil terbaik. Setelah mendapatkan informasi permintaan energi listrik, kapasitas pembangkit, data ekonomi yang diperlukan dan data lainnya, perhitungan bisa dilakukan. Hasil yang diperkirakan dari tugas akhir ini adalah memastikan apakah pembangkit peaker atau pembangkit base load, menggunakan gas alam terkompresi atau gas alam cair dan mendapatkan skenario yang akan memaksimalkan distribusi gas alam di Bali. Hasil yang didapat dari penelitian dan perhitungan memastikan diketahuinya permasalahan dan tujuan. Dari penelitian dan survey yang dilakukan, diketahui bahwa model terbaik untuk kedua pembangkit adalah pembangkit *peaker*. Untuk bentuk gas alam yang didistribusikan adalah bentuk gas alam cair. Untuk distribusi gas alam, sudah didapatkan hasil dan dipilih untuk skenario 1 dan *margin* 5 US$. Dengan pertimbangan tipe gas alam terbaik, distrbusi dan *margin* yang paling memungkinkan skenario ini dipilih.

Kata Kunci: *Liquified Natural Gas*, Distribusi, *Compressed Natural Gas*, *Net Present Value*, *Interest rate of Return*, *Payback Period*, *Return of Investment*.

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DESIGN OF NATURAL GAS DISTRIBUTION PLAN IN BALI ISLAND BASED ON ECONOMICAL ASPECT

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ABSTRACT

Bali is an island which is require lot of electrical power caused by a lot of activity including industrial and tourism. Electrical power is generated by four powerplant that is existed in Bali. These powerplant are Pesanggaran Powerplant, Pemaron Powerplant, Gilimanuk Powerplant, and Celukan Bawang Powerplant. These powerplants using engine and coupled with generator to produce electrical energy. In Bali there are fluctuation about the electrical demand which is distributed according to time and season, such as day or night, weekend or weekdays, workdays or holidays. Natural gas is one of the best energy sources in Indonesia nowadays. Fluctuation of electrical demand causing inefficiency of natural gas distribution. This inefficiency result on economical loss. This final project has purpose to find the best option as recommendation about managing and choosing distribution between using LNG or CNG to the peaker or base load powerplant. Powerplants that going to be considered here is Pemaron and Gilimanuk Power plant. By considering factors such efficiency between LNG and CNG and investment needed to be prepared. This project will use four method Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PBP), and Return of Investment (ROI) to find the best choice. After acquiring electrical demand information, powerplants capacity, economical data of the required calculation and other data required to support the processing. Expected output from this project is to ensure the choice whether the peaker load powerplant becoming LNG or CNG user powerplant and make scenario plan that will maximize the natural gas distribution in Bali. The result from the research and the calculation make sure the knowing of research problem and objectives. From research and survey, it is known that the best type of load powerplant for Pemaron and Gilimanuk Powerplant is peaker type. For the type of natural gas will be distributed to the powerplant, it is calculated and resulted on liquified natural gas (LNG) is the best option. For the distribution and handling, it is calculated and selected using scenario 1 margin 5 US$. Under the consideration of best natural gas type, distribution and most possible margin, this scenario is chosen.

Keywords: Liquified Natural Gas, Distribution, Compressed Natural Gas, Net Present Value, Interest rate of Return, Payback Period, Return of Investment.

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PREFACE

Thanks to God, in His blessing, under the grace of His love author could finally finish this bachelor thesis well and finish the last project titled "Design of Natural Gas Distribution Plan in Bali Island Based in Economical Aspect". This bachelor thesis is proposed as one of the graduation necessity from Department of Marine Engineering, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember.

In this occasion, author want to say thank you to people who has role in the process of making this bachelor thesis or along the author study period:

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13. For all parties who are author cannot list precisely, author say thanks for the support which already been given to the author.

In the making of this bachelor thesis, author know that this bachelor thesis is still not perfect and has a lot to be improved, because of that, constructing criticism and suggestion from all party is hoped in order to keep improving this bachelor thesis.

Lastly, author hope that this bachelor thesis able to be useful and empower every person who read and study this bachelor thesis.

Surabaya, July 2018

Author

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CHAPTER I INTRODUCTION

1.1. Background

Bali is one area in Indonesia which has high demand in the electrical power. It is because electrical energy is vital to any activity there such as industrial, urban, residential, and tourism, which is resulting on huge demand of electrical power in Bali. These electrical power need to be produced by powerplants. In the moment, 340 MW electrical power which is used in Bali is still supplied from Jawa. This electrical power is supplied from powerplant in Jawa and being transferred using subsea cables which is put underwater across the strait between Jawa and Bali.

There are four powerplants which existed Bali. These powerplants are Pesanggaran Powerplant, Pemaron Powerplant, Gilimanuk Powerplant, and Celukan Bawang Powerplant. These four powerplants has their own role in order to fulfill the requirement of electrical power in Bali. First, Pesanggaran powerplant is the one powerplant that has role as base load powerplant. Base load powerplant is powerplant which has to provide the minimum electrical power to the required location. Pesanggaran Powerplant counted to able to provide 362 MW totally. Pemaron and Gilimanuk powerplant are the peaker load powerplant. Their role is to ensure the power provided is enough to cover all the additional electrical demand in Bali, such as at the night time. Pemaron and Gilimanuk Powerplant counted to be able to provide 80 MW and 130 MW. LNG that is distributed in Bali is provided from Bontang. LNG transferred to Benoa FSRU terminal using LNG vessel. Gas that going to be used in Pesanggaran Powerplant will be sent from Benoa to Pesanggaran by using pipeline. In Pesanggaran, LNG converted first into gas through the FRU (Floating Regasification Unit). Nowadays, powerplant in Bali which already using gas as its main energy sources is only Pesanggaran. The other powerplant such Gilimanuk and Pemaron Powerplant is still using gas-diesel engine and diesel fuel to produce electrical power. The last one, Celukan Bawang Powerplant is powerplants that has big capacity compared to the other, which is 380 MW. The difference between this powerplant and the other is this powerplant using coal as its main fuel instead of diesel fuel or gas fuel.

The electrical distribution in Bali is divided between these powerplants in order to maximize help the electrification stability of all location in Bali. Along with the diversity of electrical demand within areas in Bali, which has various characteristic such at the industrial which is high in the day but lower in the night and on the contrary at residential which is low in the day but higher at the night. And also at the recreation place or tourism at the weekend and the residential at weekend each area has their own fluctuation. This unknown pattern of electrical demand will result on the ineffectiveness of by the increasing of unused capacity that exist whether in Gilimanuk or Pemaron Powerplant. By the occurence of ineffectiveness, the distribution of energy sources especially natural gas will be hampered and resulting on the wasted energy that will affecting the economical profits.

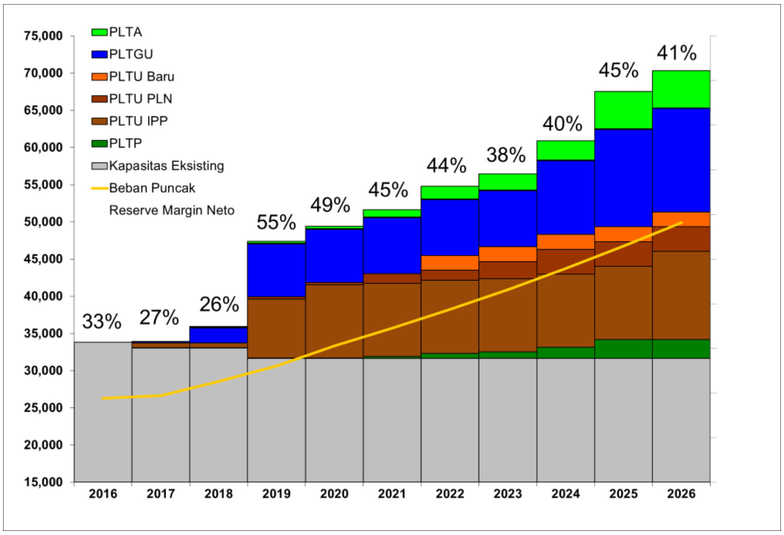

Figure 1.1 Power Distribution Based Powerplant in Jawa - Bali

Taken from PT. PLN Planning of the future development, this is the result of the Keputusan Menteri ESDM No. 1415 K/20/MEM/2017 at date 29 March 2017, that resulting on bigger need of electrical need all over Indonesia, especially here in Jawa-Bali. From the figure above, the electrical power that will be produced by PLTGU (Gas and Steam (Thermal) Powerplant) is getting bigger which resulting on bigger power production needed to increase efficiency electrical usage and distribution. But the other hand, industrial area such powerplants is one factors that is affecting the condition of environment caused by its contamination. Powerplant is one big asset and common to have another drawback. There are some aspect that are influenced by the existence of thermal powerplant. Such aspects are; water aspect, land aspect, air aspect, socio-economic aspect, and biological aspect.

First, water aspect that is decreasing caused by thermal powerplant has two contamination. Those are contamination caused by heated water to environment and harmful component in liquid form that may disturb the water condition in its vicinity. Second, the land aspect, which is presented the condition of land in area of powerplant. The existence of powerplant has effect to area where it is being installed. Powerplant has its area requirement in order to maximize its usage. The other hand by the installment of powerplant, it will affect the soil which powerplant being installed and the surrounding area. The soil characteristic may change caused by the powerplant or the usage of coal as its fuel if it is in area of thermal powerplant. Third, air aspect will be highly contaminated by the exhaust of powerplant. SO_X, NO_X, and suspended particle matter (SPM) or respirable suspended particle matter (RSPM) produced by the electrical power generation can affect air condition that resulting on bad influence to health of living being. Thermal powerplant also produce mercury and fly ashes that affects the environment. Fourth, socio-economic aspect can be affected too caused by thermal powerplant. Resettlement and rehabilitation, local civic amenities, and work related hazard for the employees of powerlant which is related to socio aspect having connection to economic state of the company. In such facility for socio aspect, a lot of investment is needed. Fifth, the biological aspect of area where powerplant is installed will be affected too. Produced fly ashes can hamper the photosynthesis process. The other affect is the probability of acid rain that can make vegetation suffer and gets into bad condition.

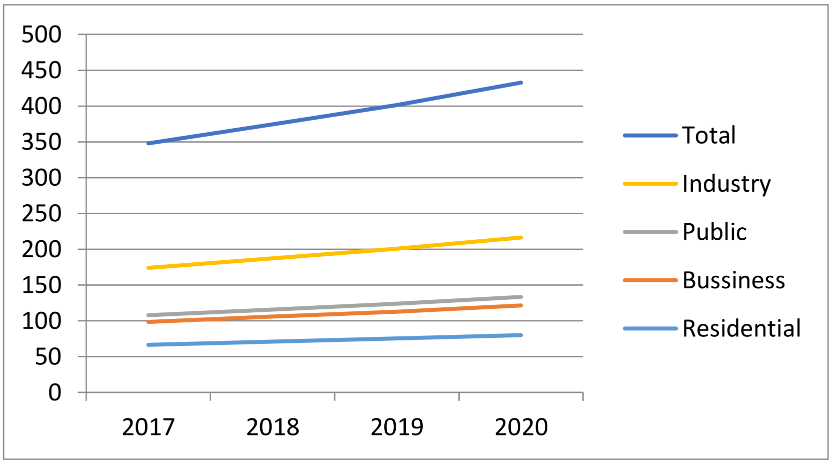

Figure 1.2 Power Distribution Based on Consumer in Jawa Bali

The figure above is one representative of the characteristic of the electrical demand in scope of Jawa-Bali. The biggest consumer is from group of industrial purpose followed by public powering, bussiness group and last residential needs. This characteristics is the one will be affecting the electrical demand from the corresponding area. As the time pass by, the demand from each group is increasing and result on the bigger need and more effective source of power (LNG) distribution.

In this research, background problem that is being raised is about the unusable powerplant and the inefficiency of natural gas distribution in Bali. In order to maximize the usage of natural gas, efficient distribution line need to be enhanced. Along with the maximize the distribution, there are other aspect such as contamination to environment that will affecting the climate of powerplant area or even the earth.

1.2. Research Problems

Based on background mentioned above, it can be concluded some problems of this final project are:

a. What are the best type of load powerplant for Pemaron and Gilimanuk Powerplant to support the electrical need in Bali?
b. What type of natural gas used that fit based on the condition in Bali?
c. What is the best natural gas management in term of handling and scheduling in order to maximize the natural gas distribution between Pemaron and Gilimanuk power plant in Bali?

1.3. Research Limitations

This final project can be focused and organized, with limitations on problem which are:

a. Location that will be used to be the research location and taking data is Pesanggaran Powerplant, Pemaron Powerplant, and Gilimanuk Powerplant at Bali.
b. The data processing from two power plant is solved using Excel for mathematical calculation.
c. The method that will be used to determine the choice are *Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period (PBP)*.
d. This research will be focused on the distribution of natural gas in Bali.

1.4. Research Objectives

Based on problems mention above, the objectives of this final project are:

a. To know the factors that affecting the fluctuation in the need of electrical energy and and the effects of the factors to the powerplant type.
b. To identify the most effective ways to distribute natural gas whether in compressed gas state or liquified natural gas state.
c. To know the economical state of project between powerplants in Bali Island in term of natural gas distribution.

1.5. Research Benefits

This final project is expected to give benefits for the various kind of parties. The benefits that can be obtained are:

a. Provides option plan about the distribution of energy (natural gas) which can increase effectivity and efficieny in natural gas distribution.
b. Provides recommendation about the type of distribution that resulting on the best energy effectivity.
c. Provides information about the economical approach plan about natural gas distribution in Bali.

CHAPTER II LITERATURE STUDY

2.1. Liquefied Natural Gas

Liquefied Natural Gas or so be called LNG is one form state that is based on the natural gas. The energy that is produced from natural gas is high and eclipsed crude oil and other oil resource in term of efficiency and wastes that is produced during the process. Crude oil and other oil is producing mass waste that can polluting the environment and the other hand, natural gas is not producing any waste that affecting the environment. Liquefied natural gas is one of the best energy resource nowadays in Indonesia because of the great energy in terms of the efficiency and more eco-friendly compared to another energy resources. Compared with diesel fuel oil such as heavy fuel oil (HFO), high speed diesel oil (HSD) or other fuel, natural gas is far more eco-friendly in term of the combustion emission such CO_2 nd SO_2. Basically combustion of natural gas do not produces CO_2, NO_X, and SO_X. Which is make the process of natural gas combustion is very clean compared another fuel.

Natural Gas has been developed and used in the recent years. Natural gas has characteristic which is very unique. Natural gas itself, colorless and odorless substances, non-toxic to environment. Natural gas is one gas energy form which is containing mostly methane and other percentage of other CH-bonds. LNG is cleaned from other component such as CO_2, SO_X, heavy CH-chain, mercury content, and other aromatics. LNG containing more than 90% of methane, which is lightest component of hydrocarbon chain. LNG treated and cooled till -162^{o}C at 1 bar pressure condition (normal pressure condition). By cooling natural gas to -162^{o}C, the density is greater and so the pressure. The other side, volume needed to contain the LNG is far decreasing. The comparison between gas form natural gas and LNG is 1:600. As for 1m^3 liquified natural gas, the volume is same compared with 600m^3 natural gas and compared to water, the weights of LNG is lighter by half. By cooling natural gas and changing it into its liquid form, we can transfer bigger volume of natural gas in the most efficient way.

Compared to another fuel or hydrocarbon substances, LNG is a lot safer. When LNG is leaking from its tank, LNG will be easily detected because of the visible moisture cloud as result of LNG vaporizing. Then the LNG leak that causing LNG pool is safe enough because of its non-explosive nature and the slow-speed fire travel within the LNG. But the other side of LNG, there is other aspect that need to be noticed. Because of the very low temperature, it may cause frostbite if LNG is come to touching human skin. If LNG leaking and come contact to component such as steel or ship hull it can make them brittle and resulting on fracture. LNG keeping is using cryogenic tank which has capablity to contain the LNG which is cryogenic liquid. Cryogenic liquid is one classification of liquid which is classed based on its extreme low temperature. The other side of natural gas is that it is has unique characteristic compared to other substances. Pure natural gas is odorless and colorless. Which means natural gas can not easiliy detected by smell or sight. And when natural gas is extracted from earth, natural gas usually is mixed with another component such as water or carbon dioxide which is being a residue part of natural gas. So in order to converting the natural gas into liquefied natural gas, there are some process need to be done such as cleaning the natural gas and depleting the water and CO_2 content from gas obtained from under the earth layer.

Normally, natural gas is extracted from earth layer and sucted out and processed to be liquefied natural gas and will be transported to the consumers. From the natural gas resource spot that is discovered through exploration, production site is being made in order to utilize the energy. Energy that acquired here need to be planned how much will be used to empower the local user or will be transported to another location. For some terminal or production site, natural gas can be used to empower the local user to increase sustainability of power. Gas engine or dual fuel engine in power plant is used to convert natural gas to electrical energy in cycle of the power plant system. If the natural gas planned to transported to another location that requires more resource far from local range, liquefaction unit for liquefying natural gas is essential. Whether the transport way is through land or water, liquefaction is one process is vital to transporting natural gas. Through land, LNG transporting usually using trucks or pipeline, and for the water transportation, of course ship, LNG tanker or even barge and LCT is used. Transporting LNG end in a station which has regasification unit. Regasification unit is a unit that can convert liquefied natural gas back into natural gas by heating it. After natural gas is obtained again, natural gas is will be distributed to the costumers or to another power plant.

LNG receiving terminal essentially has regasification unit which is very important in the process of LNG conversion and transporting. Its role is to manage the transported LNG and the natural gas transportation further from receiving terminal. Residential and industrial costumers will receive the actual state of natural gas, which is gas, not the liquid state of natural gas. After LNG arrive at the receiving terminal, it will start to be vaporized by regasification unit through regasification process. In order to make the best possible plan, some things need to be calculated. For the usage of power industry, there are conversion between natural gas and liquefied natural gas. Below is the conversion between natural gas, liquefied natural gas and its value of energy in the industry of energy.

1 MTPY LNG = 140 MMSCFD

1 Meter Cubic LNG = 600 Meter Cubic Gas

1 Million Meter Cubic LNG = 460.000 tonnes LNG = 21.200 Cubic Feet Gas

1 Meter Cubic LNG = 21,2 MMBTU

Specific Gravity LNG = 0,46

Calorific value = 1000 BTU/Standart Cubic Feet

Gas to Energy Conversion

100 MMSCFD = 700 MW (typical combined cycle)

100 MMSCFD = 500 MW (typical steam cycle)

Gas to Liquid Products Conversion

100 MMSCFD = 730.000 TPY LNG

100 MMSCFD = 2.100 TPD LNG

(Artana, 2006)

By using the listed conversion equation, the calculation of needed natural gas can be done. These equation will be needed to be the standart of the calculation that leads to the calculation of item that will be needed in the corresponding industry.

2.2. Base Load and Peak Load

Load is one terms interpret as electrical energy (current) which is being drawn by all electrical component in one area. By having more electrical component in an area, the load needed to empower all of the component is getting higher. Load is classified into two type; Base Load and Peak Load. Base load is type of powerplant which load is needed to be available all time, in another words, 24 hours a day. This load has to be stable in all condition to support the base electrical need which is needed to running at all times. This load also referred as continuous load. The other one is peak load. This load is considered as the fluctuative load compared with base load. Peak load represent the need of electrical power when the high demand occured. Usually this load is frequent (not constant requirement) and occured for short period of time. This may interpretted as the difference of base demand and highest demand. This type of powerplant is counted to be having 1/3 of the total power noted. Usually this load is very high, but sometimes can be very low. There are lot of factors that affecting this type load. The most common factors is the daily demand of electrical power which differs from the operation time scale, whether it is at the morning, noon, or evening.

This classification is also used in the classification of the power plant. Base load power plant and peak load power plant. Base load power plant is power plant which constantly provide electrical energy. And peak load power plant is power plant which provides the electrical energy when the electrical demand is rising. Based on these characteristic, there are some classification of powerplant type also. For base load powerplant, usually the power generation of powerplant is using coal energy generation, steam or thermal energy generation, biogas and biomass energy generation, nucelar type energy generation, current or geothermal energy generation. Differs with the base load type, peak load powerplant usually has characteristic of fast start-up which are gas energy generation, wind turbines and diesel energy generation.

Data that is required in order to make the calculation based on the base load and peak load. For example data that wil be used to calculate and know the characteristic, below mentioned data from previous research that has similar topic with this project. Data mentioned here is data about daily load of Bali in period of 24 hours at 9th June 2011, its forecast load and MAPE value. From the table below we know that is forecast is similar with the actual load because forecast need to be close with the actual load in order to maximize the efficiency of distribution of energy. MAPE, that stand for Mean Absolute Percentage Error, is one value that is used in the field of electricity that represent accuracy of electricity consumption forecast planning.

Table 2.1 Table of Load, Forecast and MAPE

Time	Actual Load	Forecasting Load (MW)	MAPE Value (%)
1:00	344,4	333,79	3,08
2:00	329,8	328,43	0,41
3:00	318,2	305,22	4,08
4:00	309,6	298,77	3,5
5:00	316,7	307,94	2,77
6:00	341,9	324,38	5,12
7:00	337,0	333,91	0,92
8:00	358,0	359,27	-0,36
9:00	400,6	399,61	0,25
10:00	432,6	423,35	2,14
11:00	443,5	439,02	1,01
12:00	441,1	454,31	-2,99
13:00	439,7	445,06	-1,22
14:00	449,3	438,52	2,4
15:00	444,1	424,12	4,5
16:00	436,6	423,81	2,93
17:00	425,6	418,8	1,6
18:00	450,3	445,1	1,15
19:00	530,0	531,48	-0,28
20:00	522,5	513,59	1,65
21:00	504,1	492,65	2,27
22:00	453,1	445,36	1,71
23:00	408,9	415,79	-1,68
24:00	369,7	360,63	2,45
MAPE Average			1,56

From the table above, it can be seen that electrical demand is increasing when night is coming. Electrical demand is rising and peaking at 20.00 with 522,5 MW. It can be seen that the value of actual load is going along with the time of day. The other side, it can be seen in the table that at 04.00, the load that emerge is around 309,6 MW.

2.3. Boiled-Off Gas

Boiled-off gas is one occurence that is happening on liquefied natural gas. LNG is boiled off from its liquid state into gas state caused by heat that going into the system which contains LNG. Heat will turn LNG into natural gas because the characteristic of natural gas. This occurence happens because of the characteristic of LNG which is converting into gas in temperature higher than -160^{o}C under normal pressure. Other factors that can cause BOG is the mechanical energy input that also give heat between the moving part or moving substances. Actually by using cryogenic tank and cryogenic pipe, boiled-off gas occurence is decreasing a lot. And the limit now of boiled-off gas generation is about 0,15% per day. For small volume LNG distribution cases, this occurence is not really affecting the profit of the company. But for the huge scale of LNG distribution, this percentage really affect the profit. Occurence of delayed trip of LNG carrier can result on the big loss for the company. Other disadvantages of boiled off gas generation is the safety issue. And by the increasing of boiled off gas in the system or tanks, pressure that is increasing and may cause problems. The other side, in order to managing the boil-off gas, overtreatment results on wasted excess energy. Between them, an exact handling of boil-off gas is required for optimal system in LNG receiving terminal. Nowadays, the request of electrical power keep increasing and the efficiency of energy supply should be increased too. Boiled-off gas recently already been used to empowering the units around the regasification unit. Regasification unit utilizing the waste boiled off gas to be of use again and maximize the usage of the wasted energy.

There are two method in common practice that is used to handle BOG. The first is recondensation and the second is direct compression. Recondensation method of BOG is by compressing the BOG first to 10 bar inside the BOG compressor, mixed to the LNG, then pumped together to obtain the same pressure LNG. After that, the mixed subtances will be compressed using high pressure pump and later will be vaporized using seawater. The second method is by compressing the BOG through 2 phase compression in the pipeline. This method has higher operating expenditure to be operated caused by the big energy requirement. As the process of BOG occurence happen from LNG tank, BOG is compressed in BOG compressor then sent to recondenser to be mixed with LNG. While sending BOG to the recondenser, the flow rate of LNG should be sufficient in order fully condense the BOG that going inside the condenser. But if there are BOG remaining in the recondenser, it will absorbed and compressed again through high pressure compressor and will be mixed in the natural gas. This process relatively cost a lot because the needs of abundant energy to operate the system. Mixed LNG and BOG that has been compressed by high pressure pump has high cryogenic characteristic. This energy can be used to improve the process of BOG handling. The method used to use this energy is by heating the high pressured LNG which is at -120 ^{o}C to 0 ^{o}C using seawater vaporizer.

2.4. Compressed Natural Gas

Compressed natural gas is one of natural gas state where natural gas is compressed until the pressure of 200 - 250 bar (20-25 MPa). The compressed gas of natural gas volume comparison with natural gas is 1:200. It means in the 1m^3 volume, 200 bar pressured natural gas, it contain the same energy as 200 m^3 natural gas. Handling of compressed gas is more simple and cost less than LNG because of the different requirement of handling item and tank between CNG and LNG. Because of this CNG is high-pressurized substances, the tank need to withstand the condition of high pressure inside the tank. The are two type of compressed natural gas tank which is recognized which are tank type 1 and that is effective for the easier handling.

(World Heritage Encyclopedia)

Compared to LNG, CNG has cheaper production and storage. Because the production only need compressor as main component. Then the handling and storing of CNG is not as expensive as LNG. The minimum requirement of LNG handling is cryogenic tanks, which is designed with single purpose to contain LNG. Cryogenic tanks known as very expensive tanks compared with others type of tanks.

2.5. Powerplant in Bali

In this project, there are four power plants that is needed to be take into account. First one is Power Plant in Pesanggaran which is in the nearest location to Benoa LNG terminal. The second one is Pemaron Power Plant, located in Buleleng, Bali. Then the next power plant is Gilimanuk Power Plant, which is located in Jembrana, Bali. The last powerplant is Celukan Bawang Powerplant in Buleleng region. Every powerplant has their own role in order to satisfy the electrical need in Bali. Where the Pesanggaran Powerplant act as base load power plant, Pesanggaran provide capacity around 362 MW electrical power for Bali. Pesanggaran powerplant provide constant power which this island need all time. Celukan Bawang similar with Pesanggaran Powerplant which act as base load powerplant. This powerplant has capacity about 380 MW which enable bigger electrical production in Bali. Differs with those powerplant, Pemaron Power Plant and Gilimanuk Power Plant act as peak load power plant which is support Pesanggaran Power Plant whenever the required load from local demand rising. Pemaron Powerplant provide capacity around 80 MW electrical power for Bali at the peak load happening. And the other one, Gilimanuk provide around 130MW electrical power. Totally, over four powerplant in Bali, over 1200 MW electrical power can be generated. Pesanggaran, Pemaron, and Gilimanuk owned by PT Indonesia Power. These powerplants energy source are different, there are three energy source that is used in these powerplant at the moment. Natural gas in Pesanggaran Powerplant, this natural gas is supplied from Bontang. Differ with Pesanggaran Powerplant, Gilimanuk and Pemaron energy sources now is still using diesel fuel because there is yet natural gas supply coming to these powerplant. The other one, Celukan Bawang Powerplant using coal as its main fuel coupled with turbine to powering generator to generate electrical power.

Based on the data from BPS, energy requirement keep increasing and really hard to rely on diesel engine power only. Data from BPS that used in this project is electrical energy that is set, generated and distributed energy in Bali. Data that I acquire is from 2014 which is 441,89 MW set, 2.374,48 GWh generated 4.335,03 MW distributed in Bali. And the last update which is in 2015 energy set is 1.017,19 MW, 1.919,80 GWh energy generated and 4.594,18 MW energy distributed in overall Bali. This data show the energy requirement is increasing but the generating is stagnant. So the necessity of electrical energy is very high.

Figure 2.1 Power Plants in Bali Island

From the figure above, it can be seen the location of every powerplant in Bali and the distance between them. There are distance between them that is being one of the consideration and affecting the calculation of the economical approach. Distance between Pesanggaran and Pemaron powerplant itself is 163 km. Distance between Pesanggaran and Gilimanuk Powerplant is 134 km. the distance from Benoa to Pesanggaran is just about 4 km. Then the distance between Pemaron and Gilimanuk Powerplant to Celukan Bawang Powerplant are 28 and 56 km.

2.6. Economical Approach

Economical Approach is one big of the main aspect of a project vision and mission. To make profit from an idea which is set by many forms of development. Economical approach is approach of project from the aspect of investment and income from which project it is being calculated. Based on these calculation, the assessment of Net Present Value, Internal Rate of Return, Payback Period, and Return of Investment is being calculated. The aspect which is contained in the calculation are:

2.6.1. Capital Expenditure

Capital Expenditure is aspect of economical calculation that is in form of allocated money for the project that spent on the item that has future value. This means capital expenditure for every project is spent at the beginning of the project. The capital expenditure of this bachelor thesis such as:

- Storage Tanks
- Vaporizers
- Compressors

- Pumps
- Trucks and its tank
- Filling Station

A project usually only has one capital expenditure at the beginning of timeline. If the money earned from the revenue is passing the capital expenditure, the project starting to produce net profit.

2.6.2. Operational Expenditure

Operational Expenditure is money allocation for the operational expenses during the time of a project. These expenses interpret as the yearly expenses. The expenses increasing every year. And operational expenditure usually has its ratio to increase, 0.5% ratio of operational expenditure raising is used. The operational expenditure of this bachelor thesis such as:

- Salary, insurance, accommodation of crew
- Fuel cost of LCT and trucks
- LCT Charter and port cost
- LNG purchase cost

2.6.3. Revenue

Revenue is income value of the project. Revenue is a gross income, which mean Revenue need to be reduced by the operational expenditure, tax, depreciation. In this bachelor thesis, this value is obtained from the multiplication of yearly gas sale (MMbtu) with the margin of gas sale (US$).

2.6.4. Depreciation Value

Depreciation value is a decreasing value of one property or an asset caused by the time and usage. Not all of the property can be known the value of depreciation. The characteristic of item that has depreciation value are:

- Must be used for the project production and making profit.
- Has economic age that can be known.
- Economic age must have to be more than 1 year
- Property is an equipment whose value can decrease over time

(Pujawan, 2012)

Depreciation in the calculation interpret as value of percentage. Percentage of the total asset value of the project. In this bachelor thesis, value of yearly depreciation is around 2 - 2,5% of total capital expenditure.

2.6.5. Earning Before Tax (EBT) Value

Earning before tax is a value of the earning (revenue) that already reduced by operational expenditure and the depreciation. This value is going to be reduced by the tax in the next process.

2.6.6. Tax

Tax value in Indonesia is based from PP no. 43 year 2013, that applied from 1 July of 2013. This PP is ruling about tax of earning over earning from company with special distribution. The tax percentage from this PP is 25% of the earning before tax.

2.6.7. Earning After Tax (EAT) Value

Earning after tax is value of earning after reduced by the value of tax. This value is going to be used for obtaining the value of cashflow value/ proceed.

2.6.8. Cash flow Value/ Proceed

Cash flow can be happening if there is an exchange of money or some sort (form) from one subject to another subject. If one subject accept money or check there will be cash flow in and if one send / spent money or check, there will be cash flow out. (Pujawan, 2012). Cash flow value is value which is represent the earning from the project. In this project, cash flow value is based on yearly range with a decade total estimation.

2.6.9. Cumulative Cash flow Value/ Proceed

The value of cumulative cash flow is a cumulative value of the cash flow of the current year, added by the previous year (if yearly) cumulative cash flow. The value of cumulative cash flow is the cumulative of pure earning of the project. The value of cumulative cash flow will be next needed to calculating

2.6.10. Discount Rate

Discount rate (i) is a value that used in the process of economical process in the role of ensure the must be lower than 1 which is used to multiplying a value of something in the future to be the present value. Discount rate will be multiplied to cash flow to obtain the value of Net Present Value.

2.6.11. Investment State Value

Investment state value is value of the current condition of economical of the project. Investment state value is obtained from adding the value of capital expenditure (negative condition) by the value of cash flow for the first year. The next year, it will be calculated by the value of previous year investment state value added by its year cash flow.

After calculating these value of economical approach, the assessment of whether the project is profitable or not is being calculated. By using Net Present Value, Internal

Rate of Return, Payback Period and the return of investment the economical profitable calculation is being processed.

2.7. Selection Method

Method selection has the purpose to know which solution that is giving the most optimal result between the possible solution that is stated in the previous subchapter. In this project, methods that are planned to be used are three method. The methods are Net Present Value (NPV), Internal Rate Return (IRR), Payback Period (PBP) and the last one is Return of Investment (ROI). The economical data is required to start this process which is going to be the last result of this project. (Ben-Horin, 2016).

2.7.1. Net Present Value (NPV)

Net present value is one method to measure the investation that is empashized on the comparison of the expenses present value to the revenue present value. This NPV shows the net benefits which is acquired from bussiness for some period under some of value of discount rate. This discount rate is also common to be called Minimum Atractive Rate of Return (MARR). Below is the formula of net present value that is used in the calculation:

$$\textbf{NPV = Cashflow x Discount factor}$$

$$\textbf{Discount factor} = \frac{\mathbf{1}}{(\mathbf{1+i})^{\mathbf{n}}}$$

Where:

NPV(i)	= The present value of the overall cash flow at the interest rate i% (US$)
CFi	= Cashflow for (i) year (US$)
I_0	= Initial Investation (US$)
n	= Project period (year)
i	= Discount rate (%)

The value of NPV is more than 0, it means the project is making profit. If the value of NPV is 0, then the investment value and the expenses is same, not making any profit nor loss. But of the NPV value is less than 0, the project is not making profit which is not possible. Based on its capability, NPV has several usage. The usages of NPV are to support the selection process then continued by evaluation of choices/action that is being set and enhances the best possible decision based on financial aspect as well as choosing the most profitable option for long-term project. Actually, decision making in NPV concept is based on some factors. Factors that affecting the decision making are: time value of money, perception of risk, forecast of inflation, condition for cost capital, opportunities for alternative investment.

The other side, there are some aspect that are affecting the value of NPV as well, such as; estimated sell price, cost of capital, life of the project, initial cost, operating cost, sales volume and estimated risk level.

There is a necessity to calibrate the cashflow from the different years into the present value in current condition in order to know the upcoming/future cash flow. The value of NPV is stated as the sum of future cash in flows of discounted projects by interest rate and deducted by the initial cash outflow. Interest rate is one value form of subjective evaluation to know the risk of the project, forecast of inflation and capital cost. Need to be remembered that NPV is determined by minimally expected yield. And in one method, NPV show the accumulation wealth growth of investation during the time of the project. Also NPV show the uprising value/ amount of assets that was accumulated during the project time. But in the other hand, NPV do not shows the capital investment profitability clearly.

2.7.2. Internal Rate of Return (IRR)

Internal rate of return is one method that is used to calculate the value of internal rate that belongs to NPV should be 0. This formula is used to calculate the internal rate on investation that will consistently giving profits. IRR can be calculated by formula:

$$\mathbf{IRR} = \mathbf{i_I} + \frac{(NPV_1)}{NPV_1 - NPV_2}(\mathbf{i_2} - \mathbf{i_1}) = 0$$

Where:

I1	= Discount rate which give positive NPV (%)
I2	= Discount rate which give negative NPV (%)
NPV1	= NPV has positive value(US$)
NPV2	= NPV has negative value (US$)
I	= Value of ROR investation (%)
N	= Project period (year)

Internal rate of return shows the information about the real yield of interest rate of investment and income at regular periods. But the other side of internal rate of return is the requirement of reliable information which is impossible to get caused by model condition from adaptation of internal rate of return. In this bachelor thesis, calculation of IRR is using feature IRR calculation that exist in Excel.

2.7.3. Payback Period (PP)

Payback period is one range of time period that respresent the time of the project will overcome all the expended fund. The range time of period time can be calculated by the formula below.

$$\mathbf{0 = -P + \sum_{t=1}^{N'} At\ x\ \left(\frac{P}{F}, i\%, t\right)}$$

Payback Period = n + (a-b) / (c-b) x 1 year

Where:

a = Inital Expenditure (US$)

b = Total Cashflow Cumulative at n Year (US$)

c = Total Cashflow Cumulative at n+1 Year(US$)

Where:

At = Cashflow at period of t (US$)

N’ = Payback period that will be calculated (year)

After every scenario calculated, every choices wil be compared one another and the best one will be chosen as the solution of the problem about energy natural gas distribution in Bali.

2.7.4. Return of Investment (ROI)

Return of Investment is a measuring value that is used to evaluate the investment efficiency or can be called as the benefit for the investor that can be used to receive relation of the investment cost. The formula is based of net income divided by original cost of the investment.

$$\mathbf{ROI} = \frac{\textit{Net Income}}{\textit{Cost of Investment}}$$

or

$$\mathbf{ROI} = \frac{\textit{Investment Gain}}{\textit{Investment Base}}$$

This aspect can be interpret as the more positive the value of ROI, the more profitable the project is.

CHAPTER III METHODOLOGY

Methodology is a represents of basic framework stages from the beginning to the final segment of the project. The methodology that is mentioned in this chapter has function to support this project to accomplish the final purpose. Stages of the methodology is represented by using scheme in Figure 3.1 and Figure 3.2.

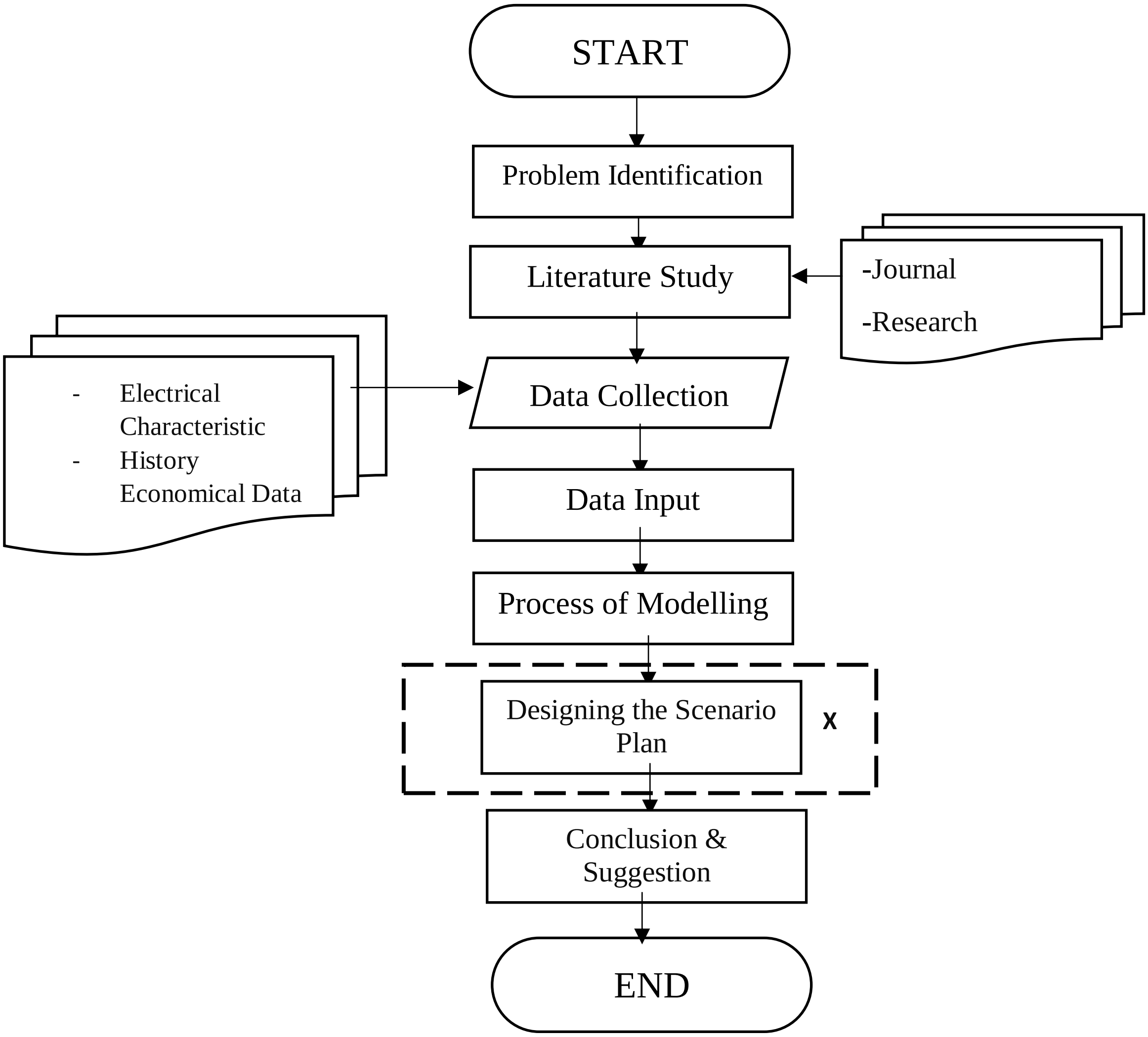

Figure 3.1 Metholodogy Flowchart (A)

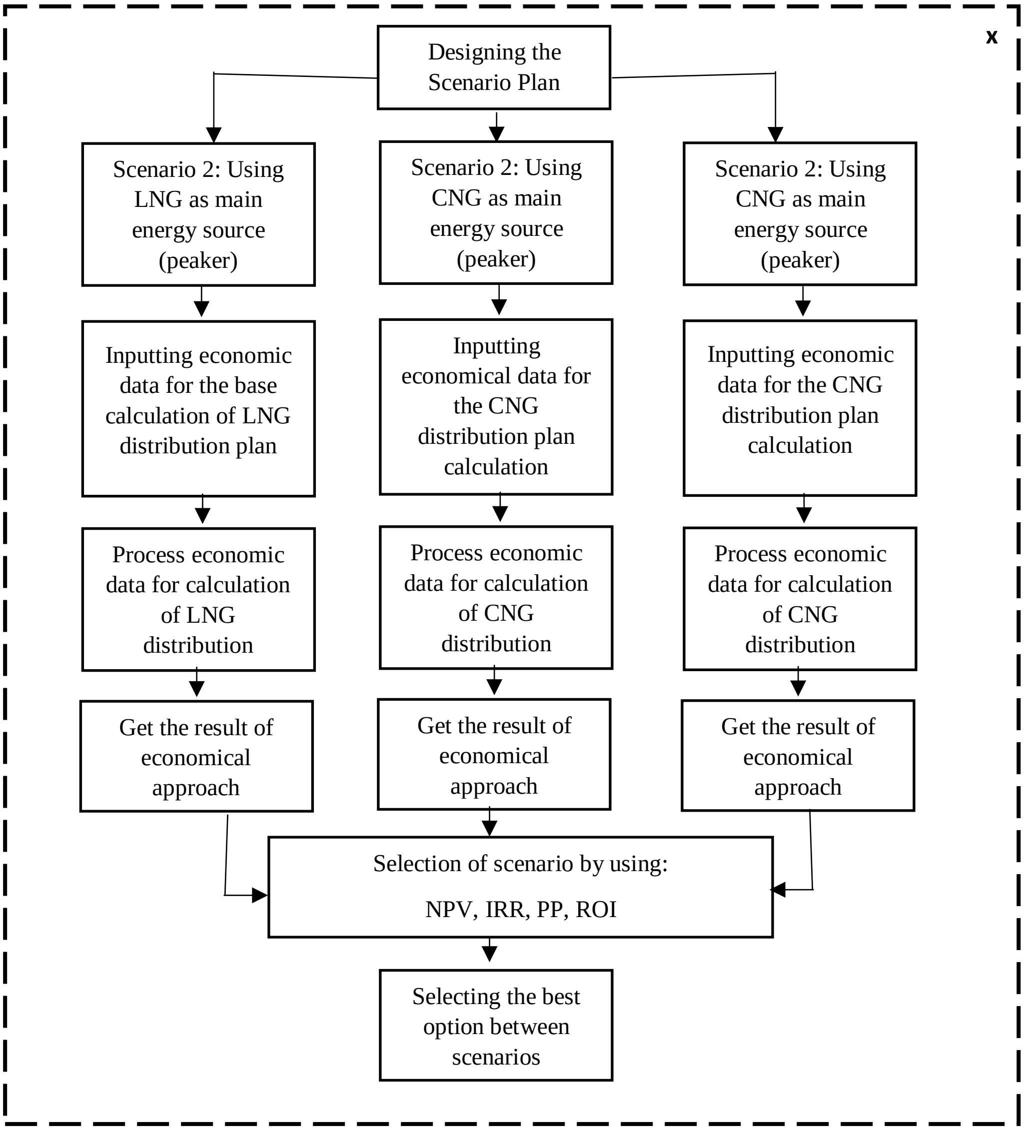

Figure 3.2 Methodology Chart (B)

Explanation of the stages of this methodology is as follows:

3.1. Problem Identification

This first stage identifies the problems that will be the background of this project. This step is the base of this project. By doing this process, it will be determined whether the problem is viable and need to be improved from the previous state. There are some inefficiency in the current condition which are exist in the electrical energy distribution in Bali. The unit that will be identified is electrical demand in the four power plant in Bali which is Pesanggaran Powerplant, Pemaron Powerplant, Gilimanuk Powerplant and Celukan Bawang Powerplant. Knowing the condition of the electrical supply in Bali, the condition of powerplant and the distribution of natural gas between powerplants and between powerplant to consumers.

In this final project, the solution will be solved using Excel as the data managing software. And using some calculation method to complete the final project.

3.2. Literature Study

The next stage is to conduct a literature study in order to getting the knowledge about the necessary knowledge and theory of related matter. Literature study is studying knowledge that is acquired from paper, journal, learning module, and research that will support the processing of this project. By doing literature study we will find the right method between the choice that will be happen in the process of research and support the operation untill its completion. The literature study of this final project is about the learning about the condition of Bali electrical need characteristic, learning about the systematical of natural gas supply chain, and the other.

3.3. Data Collection

Data that is needed to be gathered in the project can be collected from the powerplants and refer to the requirement to make the base status of the scenario. The data needed is prefered quantitative data about the overall electrical capacity from the powerplant. From its beginning of process untill the operation is finished. The data is hopefully can interpret the characteristic of Bali. The data used for analysis including:

- General information about the electrical power demanded from each powerplant based on time classified for duration a day, a week, a month and a year. This data is required to modelling the electrical demand into the graphs that will visualize the characteristic of electrical demand in Bali based on times.
- General information about the electrical power demanded from area which is divided into some region in Bali that can be interpret as the distribution of electrical need.
- The history economical data about the fund used between powerplants, differs caused by different electrical demand and energy sources.
- Data of vehicle can be used in the distribution of natural gas between powerplant in Bali.

3.4. Data Input

Inputting data into the software is one process to make the calculation of the system. The data inputted is in table, graphs or other scientific data type in order to maximize the accuracy of the modelling of characteristic. The data that will be inputted to the calculation are electrical demand that based on area in Bali, the economical data about the process between using LNG and CNG. The economical data that needed to be acquired is the data of capital expenditure, operating expenditure, and the economical record result of the project. Based on the quantitative data, it can be represented into table containing data and records. And those data will be processed into calculation that resulting on the economical condition of project.

3.5. Process of Modelling

Processing the listed data into the modelling such as graphs or maps which can represent the character of electrical need in Bali regional in a specific time. This process of modelling mainly will use software Excel to make the modelling such as graphs. This modelling will be assessed in some different aspect. For example, modelling of Bali distribution will be in maps, because the modelling will give the best visualization in all region of Bali. It will give the visualization of the distribution of electrical demand in a region during one period of time, the period of time can be set in the various period of time, such as morning, noon, evening and will be done monthly. Or on the bigger scale a semester which can tells the characteristic of electrical energy fluctuation.

3.6. Designing the Scenario Plan

By the result of determining calculation and modelling before, factors that affecting the shortage is known and the location where the shortage also known. Besides the information of modelling that already achieved from previous step, factors such transport time, natural gas state whether using LNG or CNG and its transport style can be determined in this step so, it will result on the better distribution mechanism which is fit best to the condition of Bali. The final solution will be chosen from the set of distribution scenario mentioned in chapter II.

The distribution scenario from chapter II will be checked untill the final economical calculation. From the result between three scenario, the result which has best of payback period or the most effective will be chosen for the best solution compared the other choices. The result will be one of the listed scenario. The scenario that can be applied are:

3.6.1. Using LNG as main energy source for peaker powerplants (Scenario 1)

This choice is one plan selection to give overview if natural gas distribution is purely using liquified natural gas as its main form. The economical approach for this choice is based on the most effective and better to the current condition of Bali Island. This scenario based on the condition of LNG transfer from Benoa LNG Terminal. This choice is considered because the current facility that already exist in Benoa LNG Terminal. The sequences of this scenario are:

a. Inputting economic data for the calculation of LNG distribution plan.
   Inputting economical data such as for the initial data requirement for completing the natural gas requirement or powerplants capacity.

b. Process economic data for the base calculation of LNG distribution plan.
   Based on the economical data, we design one of the possible management of LNG distribution that may resulting on the better

effectivity. Considering the aspect of capital expenditure which LNG require as the main storage and the BOG risk that may cause bigger loss.

c. Get the result of economic approach.

Result of the economical approach is represented by final value of capital and operational expenditure.

The data required in order to perform this scenario is the one that represent the capacity for each powerplant, the current item that already installed there and item which is required to complete the supply chain. In this scenario, there will be a route that will be set before too, in order to make the clear scenario. Normally there are two option that may be used in this scenario. There is the LNG transfer using LNG tanker to transfer from Benoa to Celukan Bawang then transported using trucks. The other one is LNG sent directly from Benoa to Pemaron and Gilimanuk by using trucks. But in this matter, used option is by the one which using trucks. To Represent the scenario mapping, there is figure that can be used to modelling the route of this scenario. The mapping contain the land route from Benoa to Pemaron and Gilimanuk.

Figure 3.3 Distribution Mapping Scenario 1

3.6.2. Using CNG as main energy source for the peaker powerplants (Scenario 2)

This choice is one plan selection to give overview if natural gas distribution is purely transporting CNG. The economical approach for this choice is based on the comparison between the current condition and the changing. In this scenario, CNG that is being distributed to Pemaron and Gilimanuk Powerplant is also come from Benoa LNG Terminal. The consideration in this choices are:

a. Inputting economic data for the CNG distribution calculation plan.

Inputting economical data such as for the initial data requirement for completing the natural gas requirement or powerplants capacity.

b. Process economic data for the CNG distribution calculation plan.

Inputting economical data such as for the initial data requirement for completing the natural gas requirement or powerplants capacity.

c. Get the result of economic approach

Based on the economical data, we design one of the possible management of CNG distribution and resulting on the better effectivity. Considering the aspect of volume of CNG which is bigger than LNG, and the capital expenditure which may cost less compared to LNG.

The result have to refer the valid data of cost of operation. The result here will be represented by capital expenditure and operational expenditure.

The data required for this scenario is the one that represent the capacity of powerplant and its item that already installed there. This scenario will be represented also by route that already been set before. This is being attempted to know the difference between using LNG and CNG. In this scenario there are two approach of route that may be applied of this situation. The first is CNG transport by using CNG vessel by water. The second is by using CNG trucks. In this scenario, route that is chosen is the one which using the trucks.

After the known data is processed, we can make the LNG distribution plan and efficiency analysis from available data. This process is same for every options in the project. And so after getting the best possible valid result from each condition (base load, LNG distribution and CNG distribution) we can compare one to another which one is give the best profit to the project. Below is the figure that represent the distribution of CNG distribution in Bali. The figure show the distribution of CNG distribution using trucks in Bali Island.

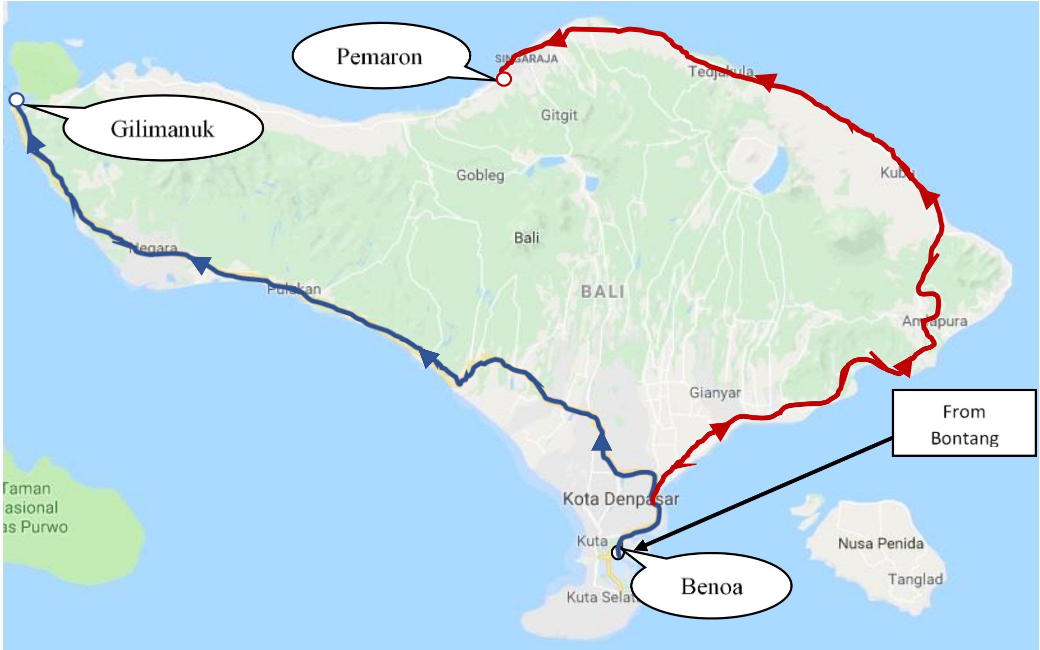

Figure 3.4 Distribution Mapping Scenario 2

3.6.3. Using CNG as main energy source supplied from Celukan Bawang to other powerplants (Scenario 3)

This choice is one plan selection to give overview if natural gas distribution is using CNG. This choice is made from the current condition which is the occurrence of natural gas flaring in the Celukan Bawang Powerplant. Natural gas which is exist in this powerplant is flared. If the natural gas is flared, it would be better if the natural gas is being transported into the other peaker powerplant such as Pemaron and Gilimanuk Powerplants. The economical approach for this choice is based on the comparison between the current condition and the changing. The consideration in this choices are:

a. Inputting economic data for the CNG distribution calculation plan.

Inputting economical data such as for the initial data requirement for completing the natural gas requirement or powerplants capacity.

b. Process economic data for the LNG distribution calculation plan.

Based on the economical data, we design how CNG transferred from Celukan Bawang to Pemaron and Gilimanuk.

c. Get the result of economic approach.

The result must refer to valid data of cost of operation. The result here will be represented by capital expenditure and operational expenditure.

The data required for this scenario is the one that represent the capacity of powerplant and its item that already installed there. This scenario will be represented also by route that already been set before. This is being attempted to know the difference between transporting natural gas from Benoa or Celukan Bawang. In this scenario there are scenario which using trucks or pipeline from celukan bawang to Pemaron and Gilimanuk Powerplant. The second is by using CNG trucks. In this scenario, route that is just straight from Celukan Bawang to Gilimanuk and Pemaron Powerplant.

After the known data is processed, we can know the effectivity of this scenario. And so after getting the best possible valid result from each condition, we can compare one to another which one is give the best profit to the project. Below is the figure that represent the distribution of CNG from Celukan Bawang to Pemaron and Gilimanuk in Bali.

Figure 3.5 Distribution Mapping Scenario 3

3.7. Selection Method

From the result of the existing scenario, we achieve the most effective project cost that will be compared one another. In this section, there will be three alternative that possible to be utilized. And between these three alternative/choices, economical approach to know the best method is used. The methods that will be used are by calcualting Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP) and Return of Investment (ROI). NPV is used to know the net benefits which is acquired from bussiness for some period under some of value of discount rate. IRR is used to know calculate the internal rate on investation that will consistently giving profits. Then PP is used to calculate how long the time, project will take to start producing net profit. Last, ROI is used to calculate how much the return rate that received from the project.

3.8. Conclusion & Suggestion

At the end of this project, conclusion will be taken from all the process of this project. Conclusion will answer the the problem that is appointed in this project. Conclusion is taken from the result of the progress that has been made from the beginning untill the end of the project. In the end of this project, suggestion will be given to complete the project. Suggestion expected to improve the future further research and provide solution to similar problem in different location.

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CHAPTER IV ANALYSIS

4.1. Overview of Research Problem

Based on vision of this final project mentioned in chapter I, it can be concluded some problems of this final project are:

a. What are the best type of load powerplant for Pemaron and Gilimanuk Powerplant to support the electrical need in Bali?

   This research problem interpret as the selection of the best type of powerplant in Bali. There are two type of powerplant. Whether Pemaron or Gilimanuk chosen to be changed from peaker to base load or being maintained as peaker just like the current condition. This problems can be solved by surveying to the actual powerplant in Bali.

b. What type of natural gas used that fit based on the condition in Bali?

   This research problem interpret as the selection form that will be used to transport natural gas. Whether its in form of liquid in this term is liquified natural gas and in form of gas, which is presented as compressed natural gas in order to maximize the volume efficiency. This problem can be solved by caluclating the economical approach for each scenario that is already been set. Especially by comparing the result from scenario 1 and 2.

c. What is the best natural gas management in term of handling and scheduling in order to maximize the natural gas distribution between three power plant in Bali?

   This research problem interpret as the determination of natural gas management, whether in the term of distribution transportation, distribution handling and volume of natural gas distributed every trip based on the economical approach for each option. This can be concluded by comparing all of the scenario which is intrepet the variety of the natural gas distribution.

Those are the reasearch problem and reasearch objective that is being the main focus of this final project. To complete the core of this final project, these research problem have to be solved and the research objective have to be achieved. These research problem and research objective will be solved in this chapter in the next subchapter starting subchapter of 4.1.1.

4.2. Best Type of Powerplant Load

In this section there are choice that will be determined in order to maximize the profit or the best efficiency between two option. There are two type of powerplant which exist:

a. Base Load

This type of powerplant has characteristic of having constant electrical production. Usually this type of powerplant has cheaper fuel price. This aspect is very important in the term of long electrical production run because fuel price is proved one of the most affecting aspect in the electrical production. The longer runtime of powerplant or engine, more difference will be resulted based on the fuel usage. This type of powerplant usually has long start-up system because the engine used in these type of powerplant has longer start-up and longer synchronization time than the peaker load type. Currently the powerplant which supplying the base load electrical power in Bali are Pesanggaran Powerplant and Celukan Bawang Poweplant which using diesel fuel, gas, and coal as its fuel.

b. Peaker Load

This type of powerplant has characteristic of back up powerplant. Which is backing up the base load powerplant when the current base load powerplant can not provide enough power to supply the electrical demand. Commonly, peaker load type powerplant will be used in time started at the evening untill morning. Usually this type of powerplant is using engine which can be started-up and ready immediately, in order to fulfill its role. But the drawback, the fuel price mosly has higher price compared to the base load type engine. However, the role of this powerplant is really supporting the disadvantages of the base load type powerplant. The example of this load type powerplant in Bali is Pemaron Powerplant and Gilimanuk Powerplant. Both of them using diesel engine and diesel fuel to operate.

In this section these two base option that will be the final result of powerplant type for Gilimanuk Powerplant and Pemaron Powerplant.

Between these two type of powerplant, there are factors that affects the result of powerplant type selection considering the current condition in Bali. Those factors really affecting the fluctuation in the need of electrical energy and and the effects of the factors to the electrical demand.

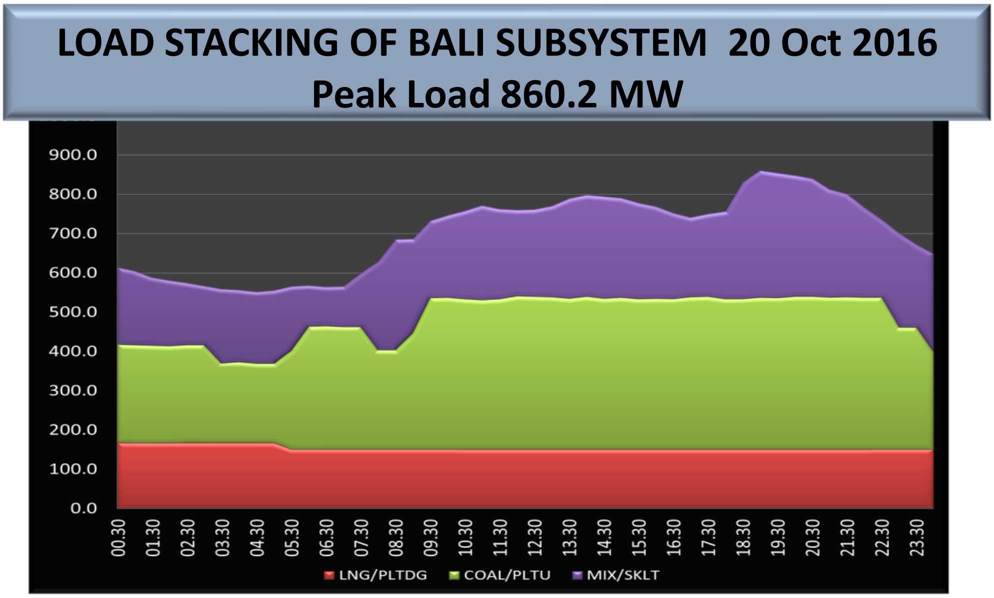

Figure 4.1 Load Stacking of Bali Subsystem

In the figure of load stacking of Bali subsystem above, there are graphs that measure the amount of load that has been increasing and decreasing. This graps, figuring the condition in Bali subsystem at 20 October 2016. Where the red one is power that produced by using LNG as the main fuel or it is produced by diesel ad gas powerplant. The red graph is figured as stagnant from the beginning untill the end. This can be interpret as base load powerplant characteristic. The green graph represent the power that produced by coal powered powerplant. This graph represent the characteristic of coal based powerplant, that is considered base load powerplant too. Eventhough the rate of power produced not as stable as the LNG powerplant. This powerplant is supplying the major needed power in Bali. The purple graph represent the power produced from mixed powerplants, or can be said the peaker type powerplant. It can be see that the production is very fluctuative compared to te base load type powerplant.

The current condition of Bali electrical system is being integrated with the distribution of East Java, Madura and Bali. By using this regional grid of electrical system, Bali Island already has enough electrical supply to cover the electrical demand all over Bali areas. The electrical demand and the electrical supply can be seen in figure below.

From table below, it can be seen that the supply capacity that supporting Bali is abundant. From the table retreived from March 2018, we can see that only from Pesanggaran Powerplant, 362 MW can be produced. Electrical supply from Java by subsea cable which is measured can supply up to 340 MW to Bali Island. The powerplant which has highest production at the moment, Celukan Bawang Steam Powerplant can produce 380 MW. The other side, Gilimanuk Powerplant and Pemaron Powerplant can produce 130 MW and 80 MW. Totally supply capacity that Bali can produce is up to 1292 MW. On the other hand, the highest recorded electrical demand value in Bali is only 851 MW. In order to match the supply with the electrical demand, some powerplant status changed. From the previous status peaker into stand-by. This set of condition is the only choice that can be used. Minimize the electrical power production, but still can be relied when emergency condition is occured. By doing this, the electrical production decreased and more fitted to the electrical demand. Around 30% of total supply capacity, 393 MW power that can be produced is being energy reserve because of the fitting between demand and the supply.

Table 4.1 Updated Condition of Bali Electrical Power Grid

POWERPLANT	
PLTD/DG/G Pesanggaran	362 MW
PLTG Gilimanuk	130 MW
PLTG Pemaron	80 MW
Subsea Cable	340 MW
PLTU Celukan Bawang	380 MW
Total Supply Capacity	1292 MW
Est. Peak Load 2017 (ROT)	899 MW
Real Peak Load 2017	851 MW
Reserve	393 MW
	30 %

The capacity of electrical power that can be supplied from the powerplant which are currently being used is higher compared to the demand itself. In order to match the production of powerplant and the demand, the engine usage is controlled. Not all of the engine in the powerplant is used in order to fitting the power produced and the demand.

4.3. Type of Natural Gas

In this section, we will determining which one of natural gas type that fit best to the condition of natural gas distribution in Bali. There are two type of natural gas which will be determined to become the most efficient option to distribute natural gas in Bali. The type which will be used whether is it in liquefied form or compressed gas form. This two type selection will result on the difference of the handling natural gas. The difference of natural gas type will affect the investment that will be spent on the needed requirement. There are some aspect that resulting on the difference of capital expenditure, such as:

- Tank used to contain the natural gas,
- Types of item that will be used in the powerplant,
- The area which will be needed to store the natural gas,
- The type of transportation that will be used to transport the natural gas,

- Many other aspect

In this final project, type of natural gas will be determined based on economical aspect which represent the quantitative result in the comparison between liquefied natural gas and compressed natural gas. The selection is performed based on data acquired from the statistic report, historical data of economical expenses, and data which is acquired from powerplant itself. The data which is acquired from statistic report is given in this chapter. From the statistic report there are a lot of data can be taken in all sort of data presentation. But in this final project, there are only several type of data which is considered as the base data comparison between the report and the actual condition in the powerplant.

The first one is the installed capacity existed in every powerplant in Bali. From the table below, data of installed capacity is acquired. It shown in the table below that in 2016 Pesanggaran has power of 199,66 MW, 97,6 MW in Pemaron Power plant and 133,8 MW in Gilimanuk Power plant. For Pesanggaran Powerplant, there are some decreasing of capacity in 2013 and 2014 to 75,82 MW and 41,46 MW. But in the 2015 forward, the power capacity of Pesanggaran is becoming very big with 199,66 MW. For Pemaron Powerplant, there are some increasing and decreasing as well. In 2012, the capacity is increasing from 45 MW to 125 MW, but after a year, the capacity is decreasing again to total capacity of 97,6 MW max power. For Gilimanuk Powerplant, capacity of powerplant is stable from the beginning until last year with the value of 133,8 MW.

Table 4.2 Table of Installed Capacity Bali Powerplant (MW)

Power plant	**Year**					
	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Pesanggaran	80	80	75,82	41,46	199,66	199,66
Pemaron	45	125	97,6	97,6	97,6	97,6
Gilimanuk			133,8	133,8	133,8	133,8

Modelling process in order to know the fluctuation of installed capacity is presented below.

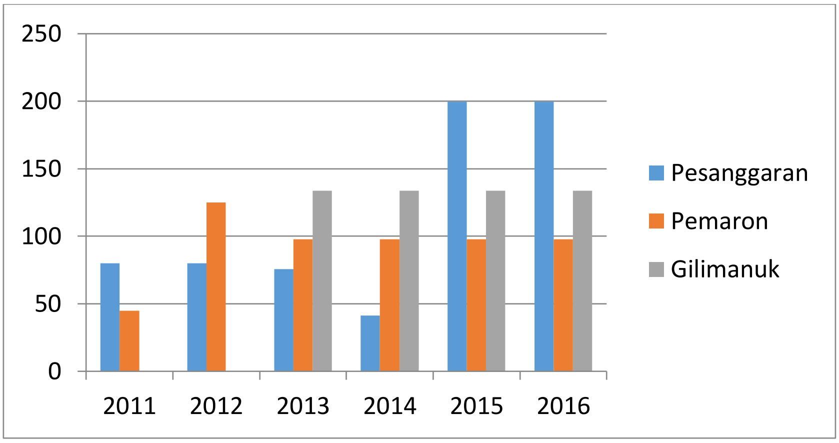

Figure 4.2 Bar Chart of Installed Capacity in Bali (MW)

In this data, the capacity of Gilimanuk and Pemaron Powerplant is known 133,8 and 97,6. This power is presented from the capacity of the new engine. As time going on, it may has decreasing the maximal power. The other hand, it is now in stand-by state. For the further process, power that is used in calculation is stated as 80MW for Pemaron Powerplant and 130 MW for Gilimanuk Powerplant. In the current condition, Pesanggaran Powerplant is still the highest powerplant compared to the other two powerplants.

The second one which is important and required for this final project is the production realization. This aspect will be divided according the powerplant which is producing the electrical power.

The first powerplant is Pesanggaran Powerplant. From the table below which is acquired from the statistic report, modelling into bar chart becoming possible. From the table below, the planning of energy production, in the latest years becoming lower. At year 2016, 424,45 GWh is planned to be produced. But the actual condition is different with the planning, the realization is only 18,57 GWh.

Table 4.3 Table of Production Realization Pesanggaran Power Plant (GWh)

Term	2013	2014	2015	2016
Planning	350,04	1.324,67	429,24	424,45
Realization	739,87	1.549,38	580,46	18,57

From the data above, the result of the bar chart is represented below.

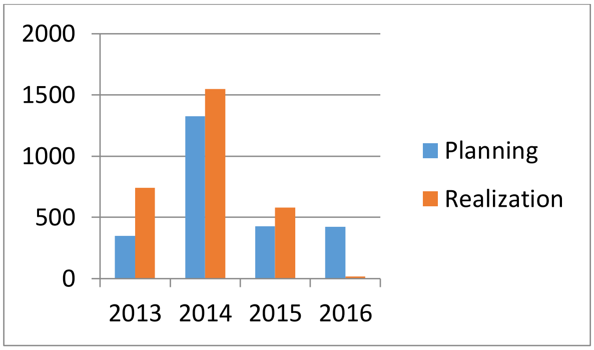

Figure 4.3 Production Realization of Pesanggaran Powerplant (GWh)

Above are the graph of production realization of Pesanggaran Powerplant. In this graph it can be seen that the production is peaked at year 2014 and decreasing again in the 2015 and 2016. The realization is increasing and decereasing according to the planning. But have bigger production than the plan, except of 2016. In year 2016, the electrical demand is decreasing in the Pesanggaran, caused by there are more powerplant exist in Bali.

The second one is Pemaron Powerplant. From the table below which is acquired from the yearly statistic report, modelling into bar chart can be made. Table below represent the production realization in Pemaron Powerplant. In the table it is mentioned in the planning of production that the production will be around 667,92 GWh. But it can be seen that the data of power production of 2014 is 363,15 GWh. The realization is far below the actual planning.

Table 4.4 Table of Production Realization in Pemaron Powerplant (GWh)

Term	**2013**	**2014**
Planning	200,04	667,92
Realization	757,06	363,15

From the data above, the result of the bar chart is represented below.

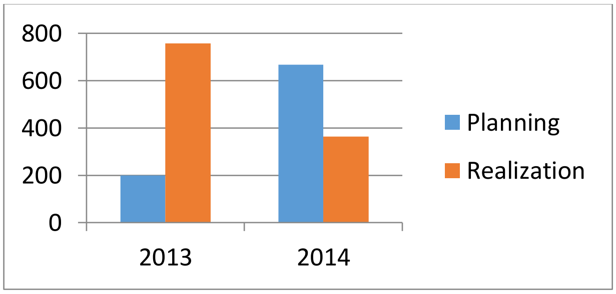

Figure 4.4 Production Realization of Pemaron Powerplant (GWh)

In graph above, it can be seen that the active year only until 2014, for 2015 and 2016, it is not producing power. It is caused by the existing of new powerplant which is has lesser operational expenditure compared to Pemaron in Bali. In 2013, the realization is much higher than the planning. But in 2014, the realization become the lower value than the planning. From this table, it also can be interpret the difference between the planning and realization of Pemaron Powerplant. There are differences between the planning and the realization that resulted from the current condition of the electrical demand in Bali.

4.4. Natural Gas Management

In this section, how is the managing of natural gas distribution will be selected and determined. There are some option that maybe really effective and fit as it implemented in the current condition of Bali. The distribution itself is made in order to maximize the efficiency of natural gas distribution from Benoa. As we know, the natural gas is supplied from Bontang, Kalimantan. The distribution of this natural gas from Bontang is using ship across the sea. There are data that acquired from Pesanggaran Powerplant about the current condition of electrical power distribution in Bali. This information is in a form of electrical power substation mapping of Bali.

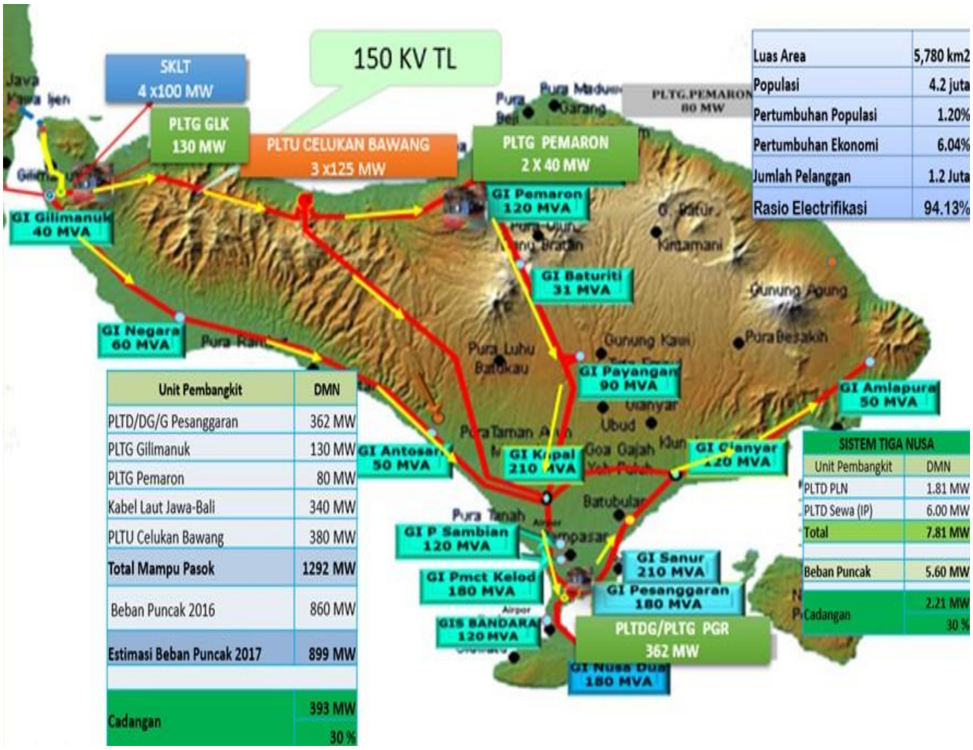

Figure 4.5 Power Demand Distribution between Area in Bali

From the figure above, there informations about the electrical demand distribution between areas in Bali. From the map above there are substation which present electrical power:

- Substation Gilimanuk = 40MVA
- Substation Negara = 60MVA
- Substation Antosari = 50 MVA
- Substation P Sambian = 120 MVA

- Substation Pmct Kelod = 180 MVA
- Substation Bandara = 120 MVA
- Substation Nusa Dua = 180 MVA
- Substation Pesanggaran = 180 MVA
- Substation Sanur = 210 MVA
- Substation Gianyar = 120 MVA
- Substation Amlapura = 50 MVA
- Substation Payangan = 90 MVA
- Substation Kapal = 210 MVA
- Substation Baturiti = 90 MVA
- Substation Pemaron = 210 MVA

From the figure above, it can be seen that are some area in Bali has bigger electrical demand compared to another area. For example, the area of Sanur, Pemaron and Kapal have biggest electrical substation production with 210 MVA. Naturally those area which have bigger electrical electrical supply than the other, they also have bigger electrical demand.

Besides the current condition of the capacity of each substation, there are additional information about the primary condition of Bali. Bali has area about 5780 km^2 and about 4,2 million people live there. The population growth rate of Bali around 1,2% last year. On the other hand, Bali has economical growth around 6,04% last year. In electrical term, Bali has around 1,2 million consumers. In the term of area electrification, Bali has high electrification percentage eventhough not reaching 100% electrification. The electrification of Bali is at percentage of 94,13%. This percentage is shown in the figure below. Figure below present the electrification ratio/ percentage in all over the Bali region/ district.

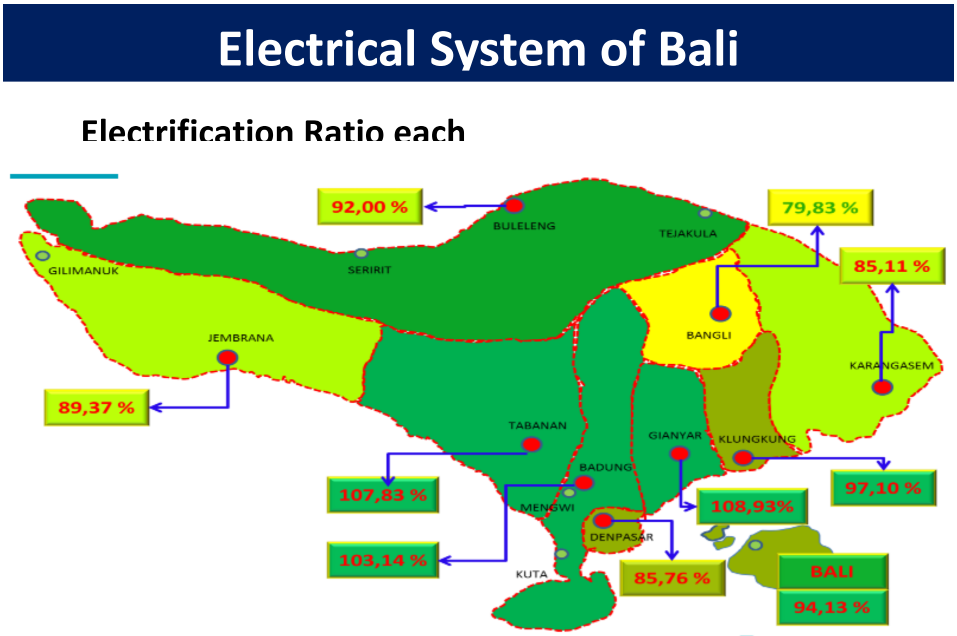

Figure 4.6 Electrification System of Bali

From the figure above, it can be seen that all Bali area has high electrification ratio. In the term of total electrification ratio, Bali has some region that is not reach out to 100%, for example, Karangasem with 85,11% electrification ratio, Jembrana with 89,37% electrification ratio or Bangli with only 79,83% electrification ratio. The odd things here is the electrification ratio of Denpasar. Because it is very unreasonable how can Denpasar which is the capital of the province, only has 85,76% electrification ratio. Known as all over Denpasar is supplied with electrical power all times, it is impossible if Denpasar only has around 85% eletrification ratio. The most probable reason is the concept of electrification ratio is based on the number of heads of households. there have to be a miss when calculating the electrification ratio in Denpasar. The other side, the electrification ratio of Gianyar, Tabanan and Badung is over than 100%, they are reaching value of 108,93% at Gianyar District. This maybe there are another miss in the concept of electrification ratio in Bali.

Below is data acquired from Pesanggaran powerplant about Electricity production in Bali in 2017.

Table 4.5 Table of Power Production Realization in GWh 2017

Month	PLTDG 1	PLTDG 2	PLTDG 3	PLTDG 4	PLTG PGR	PLTG GLK	PLTG PMR
Jan	10,87	9,82	25,87	17,83	0	0	0
Feb	19,07	23,4	19,72	21,48	0	0	0
March	22,76	31,01	29,44	29,1	1,91	0	0
Apr	27,9	24,52	17,28	26,98	0,18	1,12	0,01
May	4,23	1,78	10,7	13,07	0	0	0
June	23,89	12,69	13,77	11,34	0,04	0	0
July	21,89	28,44	23,3	17,94	0	0	0
Aug	13,69	19,38	25,7	20,98	0	0	0
Sept	18,16	18,6	19,54	25,26	0,33	0	0
Oct	26,91	21,71	4,46	22,05	0,53	0	0
Nov	29,54	29,48	9,57	5,66	0	0	0,07
Dec	9,67	19,77	25,28	21,21	0,15	0	0
Total	228,58	240,6	224,63	232,9	3,14	1,12	0,08

From table above we can see the current condition, we can see how low the production in Pesanggaran Powerplant which using gas engine, in Pemaron Powerplant, and in Gilimanuk Powerplant. It can be seen that the production of electrical power in Pemaron and Gilimanuk Powerplant is really low even not producing electrical power.

4.5. Calculation of Economical Approach

In this section the calculation is will be the main focus. As known in this bachelor thesis, economical approach is the main essence in this bachelor thesis. This section will be divided into 3 sub chapter which is represented by each scenario. Every scenario is represented below. For this economic approach, there is assumption used to complete this calculation. Caused by the lack of definite information of pricing from actual company that currently in the industry, assumption is used in order to complete the calculation. Data used in this calculation is taken from the economical estimation status of PT PLN in Batam and from mean price of item that is being used in Alibaba Online Store.

4.5.1. Scenario 1 – Using LNG as main energy source

In this scenario, LNG is used to be the energy source of the power plant. From the information acquired from Pesanggaran Power plant, known that Pemaron Power plant max power output is 80 MW. From this power plant power, the requirement of natural gas can be known in order to calculate the demand of natural gas. Table below show the requirement of liquefied natural gas to supply Pemaron Power plant for a day.

Table 4.6 Pemaron Power Plant Data Table – SC 1

Power plant	**Pemaron**	
Power plant Type	Peaker	
Engine Type	Typical Steam Cycle	
Power	80	MW
Gas Requirement	5,33	MMscfd
	1.946,67	MMscfy
LNG Conversion	38.933,33	TPY
	112	TPD
Yearly Consumption	84.637,68	m^3py
	1.946.666,67	MMbtuy
Daily Consumption	243,48	m^3pd
	5.333,33	MMbtud
Hourly Consumption	10,14	m^3ph
Total Tank Capacity	243,48	m^3

CAPITAL EXPENDITURE

To ensure the quantity is in safe keep, cryogenic LNG ISO tank is needed. This tank is calculated from the volume of the liquefied natural gas required. The selection of LNG ISO tank is represented in table below. Table below is table that represent the general information of Pemaron Power plant. In the table, known that the type of power plant is peaker. With typical steam cycle engine. From the capacity of 80 MW, the gas needed for powering the power plant is 80 divided by 5 and divided by 3 becoming 5,33 MMscf consumption per day. 5,33 multiplied by 365 becoming 1.946,67 MMscf consumption per year. To obtain the LNG conversion from the consumption per day, the gas requirement need to be multiplied by 7.300 to become ton unit. For year range, it become 38.933,33 TPY and 112 TPD a day. LNG is delivered in liquefied form, so the vital aspect is volume to deliver it. To convert ton to cubic meter, the value need to be divided by 460.000 and multiplied by 1.000.000 as well for convert from the million from MMbtu to normal meter cubic. For the gas requirement, to obtain the consumption in MMbtu, it will need to be multiplied by 1.000. From the table, known for the tank capacity needed is 243,48 m^3 to ensure daily consumption in the power plant. After calculating the liquefied natural gas requirement, the quantity of the daily demand is known. Item that is required to make sure the project is going on is need to be exist in the location. This is called capital expenditure.

From the table below there are specification of storage tank that is selected to be the tank in Pemaron Power plant. The important in this specification is the volume capacity, BOG rate, dimension and its price. The volume should be sufficient to contain daily consumption of LNG which is 243,48 m^3. The design BOG rate is to calculate the BOG normal rate to select compressor. The price is to complete the economical approach calculation. In this selection, there is assumption used to stating the item price. From Alibaba Online Store, there are some sale which mention storage tank with similar price. From the stated price in Alibaba, the range of price is around US$ 1.500 to US$ 3.000 per cubic meter. So the taken value for this scenario is US$ 2.000.

Table 4.7 LNG Storage Tank Selection Table – SC 1

Item	Value	Unit
Model	ZCF-250	
Storage Tank Requirement	243,48	m^3
Each Tank Capacity	250	m^3
Design Pressure	9,2	Bar
Design BOG rate	0,46	%
Height	5,8	M
Diameter	2,4	M
Number of tanks	1	Unit
Total Capacity	500	m^3
Price	2.000	US$ / m^3
Price (each)	500.000	US$
Price Total	500.000	US$

As known of LNG characteristic which has trait to boiled off when the temperature is getting hotter than normal LNG temperature, which is around -160^oC. LNG boiled off into normal natural gas which can be dispersed slowly during containment duration. In order to avoid this occurrence, tank is used to contain LNG and reduce the rate of boiled gas as much as possible. But boiled off gas cannot be avoided completely so there is BOG rate in every cryogenic tank. Using the boiled off gas rate of the selected tank, normal rate of boiled off gas can be calculated.

Below is the calculation to obtain the normal rate of boiled off gas. In the calculation below, based on the BOG rate which tank provides, Boiled-off gas always happening in LNG containment, so naturally it will affect the economical aspect of a project. In order to ensure the LNG is 100% used in this project, compressor is used to regulate the pressure of boiled off gas which is produced during the containment or transferring process of LNG. Later, the boiled off gas which is already controlled by compressor will go straight to engine.

BOG Rate = BOG rate x total of LNG

= 0,46% x 250 m^3

= 1,15 m^3 (LNG)

= 690 m^3/day (gas)

Normal rate = 28,75 Nm^3/hour (nominal hour cubic/hour)

Table below present the BOG handling compressor selection based on the normal flowrate (capacity) and the output pressure. Based on the table of selection below, the specification of compressor that will be used in power plant is known. The vital specification of compressor is the flow capacity and pressure. The chosen compressor in this scenario has specification 2.083,33 Nm3/hour. This compressor has specification pressure 1 bar inlet pressure and 10 bar outlet pressure. The pricing of compressor is taken from Alibaba and changed by using assumption, then the pricing is stated as US$ 80.000.

Table 4.8 LNG BOG Compressor Selection Table - SC1

Item	Value	Unit
Brand	NTTC	
Model	V, M, D type	
Type	Reciprocating	
Capacity	2.083,33	Nm^3/hour
Voltage	380	Volt
Inlet Pressure	1	Bar
Outlet Pressure	10	Bar
Weight	4	Ton
Installed Power	45	kW
Price	80.000	US$

Liquefied natural gas need to be in the natural gas form in order to be used as the energy source for the engine. In order to change liquefied natural gas into natural gas form, vaporizer is needed. To know the specification needed for vaporizer, nominal capacity for the vaporizer should be known first by setting the de rating time of engine. Below is the nominal capacity calculation of vaporizer.

Total De-rating time = 8 hours

De-rating time / unit = 4 hours

De-rating Factor = 1

Nominal Capacity = LNG flowrate/de-rating factors

= 10,14 / 1

= 10,14 Nominal m^3/hour

After the requirement of vaporizer calculated, the specification needed for vaporizer listed below. With the known information of nominal capacity which is shown in the table below, vaporizer can be selected. Below is the information of selected vaporizer. In the selection of vaporizer, the vital specification aspect is nominal capacity, pressure and its price. Nominal capacity for the flow of the natural gas, pressure to maintain the inlet pressure to engine and its price to calculate the economical aspect.

Table 4.9 Vaporizer Calculation Table - SC1

Item	Value	Unit
Supply Gas Requirement	10,14	m^3/hour
Operation time	24	hour /day
Nominal Capacity	10,14	Nominal m^3/hour
Pressure Requirement	15	Bar

Vaporizer needed to vapor the LNG which is in the liquefied form. By this vaporizer, LNG can be converted from liquefied state into gas state which engine able to process. The selected vaporizer below inform that the capacity of vaporizer is 50 Nm^3/hour. The pressure of vaporizer is 15 bar. And the price of this vaporizer is considered US$ 100.000. This price is obtained by taking the means of product that being sold in Alibaba and increasing the value caused by the price of the distribution and additional price, the stated price is US$ 100.000 each.

Table 4.10 Vaporizer Selection Table - SC 1

Item	Value	Unit
Model	CYYV1	
Type	Ambient Air	
Nominal Capacity	50	Nm^3/hour
Max Pressure	15	Bar
Power	0,1	kW
Area	0,5355	m^2
Weight	130	Kg
Voltage	220/380	Volt
Length	85	Mm
Width	63	Mm
Height	247	Mm

Table Extension from table 4.10

Item	Value	Unit
Number of Vaporizer	2	Unit
Price	2.000	US$ (/Nm^3/h)
Price (each)	100.000	US$
Total Price	200.000	US$

LNG also need to be pumped into the engine. The specification of LNG pump which vital are the capacity and the pressure capacity. But pump will need to transport LNG from the tank to engine through the equipment. The capacity is the aspect which determine the speed of transfer of LNG from tank to the engine. Below is the LNG pump selection to this scenario. It can be seen that the chosen pump need to fulfil the requirement which is pressure, head, and capacity. The chosen pumps here is for both of high-pressure pump and low-pressure pump. Head of chosen pumps is 10-1.000 m. The capacity of these powerplants is same, which is around 5-200 m^3/hour. But the chosen capacity of the pump is 50 m^3/hour. The outlet pressure of these pumps is 20 bar. As for the pump, the initial price of pump is based n the capacity of pump which can be obtained. As for each m^3/hour, the pump value is priced US$ 100. If the pump capacity is 50 Nm^3/hour the price of the pump is US$ 5.000.

Table 4.11 LNG Pump Selection Table – SC 1

Item	Value	Unit
Required Capacity	10,14	m^3/ hour
Pressure into Vaporizer	15	Bar
LP Pump Model	CYY15-200	
Type	Centrifugal	
Head	10 - 1.000	M
LP pump Capacity	83 - 3.320	l/min
	5 - 200	m^3/hour
Chosen Pump Capacity	50	m^3/hour
Pressure LP Pump	20	Bar
Speed	960 - 5.000	
Number of Pump	2	
Price	100	US$ (/m^3/hour)
Price (each)	5000	US$
Total Price	10.000	US$
HP Pump Model	CYY15-200	
Type	Centrifugal	
Head	10 - 1.000	M
HP pump Capacity	83-3.320	l/min
	5-200	m^3/hour
Chosen Pump Capacity	50	m^3/hour

Table extension from table 4.11

Pressure HP Pump	20	Bar
Speed	960-5.000	
Number of Pump	2	
Price	100	US$ (/m^3/hour)
Price (each)	5.000	US$
Total Price	10.000	US$
Total Pump Price Overall	20.000	US$

For transferring the LNG from the Benoa to Pemaron Power plant, transportation is needed. In this scenario, land transportation is used. Land transportation in this project is using trucks with portable tank. Portable tank in this project is filled in Benoa through the filling station that is designed in this scenario as well. The number of tanks are divided to the possible capacity of the tank during a day consumption. The number of trucks also similar with the tank number because of the LNG transporting is taking long time, single truck cannot do two deliveries in a day. Table below is the trucks and tanks selection in accordance of the requirement. In the selection of trucks and tanks there are some aspect which is important and vital. The important aspect in this distribution of the trucks and tanks are the speed, fuel consumption, tank volume and the price. Speed that is considered in the calculation is the average speed of trucks. This chosen is selected because the trucks will not operate in full speed at all time. The chosen speed of the trucks is 40 km/h. fuel consumption is needed to be known in order to estimate the expenses in the fuel cost that is vital to the matter of the distribution using trucks. The selected trucks has fuel consumption of 0,4 l/km. tank volume is the base reasoning to select the trucks and tanks, by this capacity, the number of trucks and tanks will be calculated. The selected truck has capacity of 30 m^3. The price that is mentioned in the table is the price which will affect the total of capital expenditure. This pricing of of trucks is taken from the mean value that is obtained from several specification of LNG trucks from Alibaba. And for the pricing of 1 set of trucks is containing the value of truck itself, the tanks and the trailer. Combined and the price of total trucks set is estimated around US$ 200.000. This explanation is for the table below.

Table 4.12 Trucks and Tanks Selection Table – SC 1

Item	Value	Unit
Brand	Sinotruck Howo	
Model	Sinotruck Howo	
Power	251-350	HP
Engine Capacity	9,726	L
Overall Dimension	11.860x2.490x3.550	mm
Gross Vehicle Weight	31.000	Kg
Tanker Dimension	9.100x2.460x1.650	mm

Table extension from table 4.12

Item	Value	Unit
Max Speed	80	km/h
Avg. Speed	40	km/h
Fuel Consumption	0,4	l/km
Tank Volume	30	m^3
Number of trucks	9	unit
Price (each)	200.000	US$
Total Price	1.800.000	US$

After LNG is arrived to Pemaron Power plant, LNG in LNG tank should be transferred out into LNG storage tank in Pemaron. Discharge pump is available at the installation of every trucks.

LNG filling station is needed in Benoa to transfer the LNG from whether LNG tank in Benoa or directly from the ship. The important factor of LNG filling station is the capacity especially the filling capacity. To increase the efficiency of transfer, higher filling capacity is better. Below is the LNG filling station which is selected to complete the component of the LNG transfer from Benoa to Pemaron. The specification of selected filling station in this scenario is shown in the table below. Reasoning why this filling station is chosen is the filling station capacity which affect the time of LNG filling. And the other vital is price value. By knowing the price of filling station, the completion of capital expenditure can be achieved. For this item pricing, the information is taken from the mean pricing of filling station in Alibaba. The stated price for fuel is US$ 150.000.

Table 4.13 LNG Filling Station Selection Table – SC 1

Item	Value	Unit
Brand	BTV Standart	
Model	CGQ/LNG-30/60	
Capacity	60	m^3
Filling Capacity	340	l/min
	20,4	m^3/hour
Equipment Power	17	Kw
Pressure	2,5	MPa
Price	150.000	US$

In this scenario, LNG which is used to be the energy source of the power plant will be sent not only to Pemaron but to Gilimanuk Power plant also. But different with Pemaron Power plant, Gilimanuk Power plant has bigger max power output which is around 130 MW. This information can be used to calculate the natural gas demand for this power plant. Table below show the requirement of liquefied natural gas to supply Gilimanuk Power plant for a day.

Table 4.14 Liquefied Natural Gas Calculation Gilimanuk Power Plant – SC 1

Power plant	**Gilimanuk**	
Power plant Type	Peaker	
Engine Type	Typical Steam Cycle	
Power	130	MW
Gas Requirement	8,67	MMscfd
	3.163,33	MMscfy
LNG Conversion	63.266,67	TPY
	182	TPD
Yearly Consumption	137.536	m^3py
	3.163.333,3	MMbtuy
Daily Consumption	396	m^3pd
	8.666,67	MMbtud
Hourly Consumption	16,49	m^3ph
Total Tank Capacity	396	m^3

The general information of powerplant capacity is listed on the table above. From the table, known that the type of powerplant is peaker type with typical steam cycle engine. The capacity of this powerplant is 130 MW and this capacity can be calculated and converted using energy conversion to know how much the natural gas needed to fulfil the requirement. The capacity of 130 MW need to be converted into the gas consumption by dividing the capacity by 5 for the gas needed and divided again by 3 caused by the characteristic of peaker type. Then the gas needed for the powerplant is 8,67 MMscf a day and 3.163,33 MMscf per year. As for these gas requirement, the conversion of gas to mass is becoming 63.266,67 ton per year and 182 ton per day. This conversion is by multiplying the gas requirement with value of 7.300. The consumption volume of natural gas in a year is 137.536 cubic meter. The calculation of MMbtu is just by multiplying MMscf with 1.000. The hourly consumption of the powerplant here is 16,49 cubic meter. In order to get the safe condition of stock in powerplant, tank is needed to contain the natural gas. The capacity of tank need to fulfil a day worth of energy, then minimal storage tank volume is 396 cubic meter. In order to convert ton to cubic meter, the value need to be divided by 460.000 and multiplied by 1.000.000 as well for convert from the million from MMbtu to normal meter cubic. For the gas requirement, to obtain the consumption in MMbtu, it will need to be multiplied by 1.000. From the table, known for the tank capacity needed is 243,48 m^3 to ensure daily consumption in the power plant.

After calculating the requirement of liquefied natural gas metioned above, the quantity of the daily demand is known. Item that is required to make sure the project is going on is need to be exist in the location. This is called capital expenditure. Natural gas requirement as the main information needed to know the quantity of LNG is known, especially the daily need of LNG. The LNG will be stored in Gilimanuk Power plant using cryogenic tank. The calculation of tank should result on the capacity of tank which can contain the daily demand of the powerplant. The LNG tank selection is represented in table below. Listed in the table below, there are the selected LNG storage tank for Gilimanuk. Specification of storage tank has several aspects that is vital to the selection. These aspects are the capacity, BOG rate pressure and the price. Capacity that is very vital to the selection of tank because the choosing will be made in how many this storage tank can be LNG stored up. Pressure that is taken here need to be comply to the requirement of the medium which is being stored up. The design BOG rate is vital enough to be considered. Because this specification will result on the value of the boiled-off gas in the tank. This will result on the selection of the compressor which will be calculated next. The price of the storage also important in order to complete the requirement of economic data for the economical approach. Similar with the tank that is being used in Pemaron Powerplant. The pricing of this tank is using the value of US$ 2.000 per m^3. Then the tank cost is US$ 500.000 for each tank that can contain 250 m^3.

Table 4.15 LNG Storage Tank Selection Table - SC 1

Item	Value	Unit
Model	ZCF-250	
Storage Tank Requirement	395,65	m^3
Each Tank Capacity	250	m^3
Design Pressure	9,2	Bar
Design BOG Rate	0,46	%
Height	5,8	M
Diameter	2,4	M
Number of Tanks	2	Unit
Total Capacity	500	m^3
Price	2.000	US$ (/m^3)
Price (each)	500.000	US$
Total Price	1.000.000	US$

As the characteristic of LNG which is boiling off during the process of containment and transfer or other process which can result on the rising temperature of the cryogenic even the LNG itself. LNG dispersion can result on the economic loss, because the bought-up LNG will be gone if the duration gets longer to be contained. LNG boiled off into natural gas which can be dispersed slowly during containment duration. In order to avoid that, tank is used to contain LNG and reduce the rate of boiled gas as much as possible. But boiled off gas cannot be avoided completely so there is BOG rate in every cryogenic tank. Using the boiled off gas rate of the selected tank, normal rate of boiled off gas can be calculated. Below is the calculation to obtain the normal rate of boiled off gas.

BOG Rate = BOG rate x total of LNG

= 0,46% x 500 m^3

= 2,3 m^3 (LNG)

= 1.380 m^3/day (gas)

Normal rate = 57,5 Nm^3/hour (nominal cubic meter/hour)

Boiled-off gas normal rate which obtained from calculation will be used to calculate the BOG handling compressor specification. This handling compressor is vital. In a process of BOG handling, especially when the effectivity is the main concern of a project. By using this, the bought LNG will be maximized to be used to empower the power plant. The selection of BOG handling compressor is based on the requirement of capacity and pressure. The BOG normal rate which already been obtained in the calculation will be used to make the base of compressor selection. And the selected compressor has specification of capacity which is 2.083,33 Nm^3/hour. The outlet pressure of this compressor is around 10 bar. The selected compressor has value that is taken from mean price of compressor with same capacity in Alibaba. The price of each compressor is US$ 80.000.

Table 4.16 LNG BOG Compressor Selection Table – SC 1

Item	Value	Unit
Brand	NTTC	
Model	V, M, D Type	
Type	Reciprocating	
Capacity	2.083,33	Nm^3/hour
Voltage	380	volt
Inlet Pressure	1	bar
Outlet Pressure	10	bar
Weight	4	ton
Installed Power	45	kW
Price	80.000	US$

Liquefied natural gas need to be its gas form when it will be used. In order to convert it to the gas state, vaporizer is needed. Choosing vaporizer that will fit to the requirement need the data of nominal capacity of the vaporizer. Nominal capacity is obtained by calculating based on the de-rating time of engine. Below is the nominal capacity calculation of vaporizer.

Total De-rating time = 8 hours

De-rating time / unit = 4 hours

De-rating Factor = 1

Nominal Capacity = LNG flowrate/de-rating factors

= 16,49 / 1

= 16,49 Nominal m^3/hour

After the nominal capacity is calculated, vaporizer can be selected using some additional basic information such as operation time and pressure requirement.

Table 4.17 Vaporizer Calculation Table – SC 1

Item	Value	Unit
Supply Gas Requirement	16,49	m^3/hour
Operation time	24	Hour /day
Nominal Capacity	16,49	Nominal m^3/hour
Pressure Requirement	15	bar

Based on the nominal capacity of the compressor, the selection of vaporizer can be done. In the calculation above, the capacity of supply gas is 16,49 m^3/hour with pressure of 15 bar. With the known information of nominal capacity, vaporizer can be selected. Below is the information of selected vaporizer. Table below represent the selection of vaporizer for this scenario. It can be seen that in the selected vaporizer has capacity of 50 Nm^3/hour. The other vital aspect is pressure and the price. The selected vaporizer pressure specification is 15 bar which is already comply with the requirement. The price that mentioned below is the value that is will be affecting the value of capital expenditure and lead to the economical approach. Known that the pricing of vaporizer is based on the capacity. For each Nm^3/hour it is priced US$ 2.000. then the price of each vaporizer is US$ 100.000 for the capacity of 50 Nm^3/hour

Table 4.18 Vaporizer Selection Table – SC 1

Item	Value	Unit
Model	CYYV1	
Type	Ambient Air	
Nominal Capacity	50	Nm^3/hour
Max Pressure	15	bar
Power	0,1	kW
Area	0,5355	m^2
Weight	130	kg
Voltage	220/380	volt
Length	85	mm
Width	63	mm
Height	247	mm

Table extension from table 4.18

Number of Vaporizer	2	unit
Price	2.000	US$ (/Nm^3/h)
Price (each)	100.000	US$
Total Price	200.000	US$

LNG which is stored in the LNG tank, need to be pumped so LNG can go into the engine. The selection of pump need to be based on the specification of capacity needed into the engine. Capacity is the aspect which determine the speed of transfer of LNG from tank to the engine. Below is the LNG pump selection to this scenario. The specification vital of pump is the capacity, head, and the price. As for the completion of the required another specification and pricing value. From the table below, it can be seen that all the pumps specification fit to the requirement. Both of the selected pump has same specification. For both pumps, has head of 10-1.000 m. the capacity of these pumps need to be take into consideration as well. The capacity of pump which will affect the process of the filling. The chosen pumps have capacity of 50 Nm^3/hour. The outlet capacity of these pumps can be up to 20 bar. This price can be considered to be the component of economical calculation. The pricing value of pump that is selected from the mean value is US$ 100 for every m^3/hour of pump capacity. This statement is used based on the pricing value that is taken from Alibaba.

Table 4.19 LNG Pump Selection Table – SC 1

Item	Value	Unit
Required Capacity	16,49	m^3/ hour
Pressure into Vaporizer	15	bar
LP pump model	CYY15-200	
Type	Centrifugal	
Head	10 - 1.000	m
LP pump Capacity	83 - 3.320	l/min
	5 – 200	m^3/hour
Chosen Pump Capacity	50	m^3/hour
Pressure LP pump	20	Bar
Speed	960 - 5.000	
Number of Pump	2	
Price	100	US$ (/m^3/hour)
Price (each)	5.000	US$
Total Price	10.000	US$
HP pump model	CYY15 – 200	
Type	Centrifugal	
Head	10 - 1.000	m
HP pump Capacity	83 - 3.320	l/min

Table extension from table 4.19

Item	Value	Unit
	5 – 200	m^3/hour
Chosen Pump Capacity	50	m^3/hour
Pressure HP pump	20	
Speed	960 - 5.000	
Number of Pump	2	unit
Price	100	US$ (/m^3/hour)
Price (each)	5.000	US$
Total Price	10.000	US$
Total Pump Price Overall	20.000	US$

For transferring the LNG from the Benoa to Gilimanuk Power plant, which has distance around 136 km by land, land transportation is needed. Land transportation used in this project is trucks with portable tank. Technically, portable tank used in this project will be filled at the filling station in Benoa. The amount of trucks and tanks which will be used is based on the capacity of the transporting of the LNG and the daily need of the power plant. The daily need of LNG supply in Gilimanuk Power plant is 396 m3 per day, as 16,41 m^3 per hour.

Based on the capacity of the tanks and trucks, such as speed and the tank capacity, the amount of the tanks can be calculated. As for this project trucks cannot do two times delivery to Gilimanuk Power plant. Then the amount of tanks will be the same as the initial requirement for the LNG supply. Table below is the trucks and tanks selection in accordance of the requirement. LNG which is contained in LNG tank on trucks is transferred as fast as possible with safe care. When the truck is arrived to Gilimanuk Power plant, LNG should be pumped out from the tank. Then LNG will be stored to LNG storage tank in Gilimanuk Power plant. Usually, trucks have its own pump to transfer LNG out from the tank itself. The important part of this selection is the capacity of tank, speed and the price. The capacity here selected has maximal capacity of 30 m^3. The specification of speed is best to be considered the average speed which can ensure the trip will be on time. The price is mentioned in the table below, and it will affect the result of the economical approach. Similar with the previous pricing in Pemaron Power plant, the value of each trucks set is stated US$ 200.000 that will contain the trailer, tanks and the trucks itself. This pricing is taken from several product in Alibaba.

Table 4.20 Trucks and Tanks Selection Table- SC 1

Item	Value	Unit
Brand	Sinotruck Howo	
Model	Sinotruck Howo	
Power	251-350	HP
Engine Capacity	9,726	l
Overall Dimension	11.860x2.490x3.550	mm
Gross Vehicle Weight	31.000	kg
Tanker Dimension	9.100x2.460x1.650	mm
Max Speed	80	km/h
Avg. Speed	40	km/h
Fuel Consumption	0,4	l/km
Tank Volume	30	m^3
Number of Truck	14	Unit
Price	200.000	US$
Total Price	2.800.000	US$

In this project LNG filling station is needed in Benoa in order to transfer LNG. Whether the transferred LNG tank is from LNG tank in Benoa or directly from the ship. The base selection of filling station is the capacity especially the speed of filling capacity. The higher capacity the filling station has, the better and faster of the filling station be. But usually it is followed by bigger power capacity and of course the operation cost. Below is the LNG filling station which is selected to complete the component of the LNG transfer from Benoa to Gilimanuk. The filling station is component that has job to pumping LNG into tanks. The vital specification needed are capacity, filling capacity, pressure and prices. In these specification, mentioned that filling capacity of this filling station is 340 l/min, which is around, 20,4 m^3/hour. This filling capacity is the one which will affect the speed of LNG loading to trucks. Similar with the filling station that is being set in Pemaron Powerplant. The pricing of filling station is stated on US$ 150.000. This pricing is stated based on assumption of mean price that filling station which is being sell in Alibaba.

Table 4.21 LNG Filling Station Selection Table - SC 1

Item	Value	Unit
Brand	BTV Standard	
Model	CGQ/LNG-30/60	
Capacity	60	m^3
Filling Capacity	340	l/min
	20,4	m^3/hour
Equipment Power	17	kW
Pressure	2,5	MPa
Price	150.000	US$

All of these items that has been chosen, it will be made to be a base of capital expenditure calculation. The capital expenditure summary can be seen in table below. Table below represent the capital expenditure of this first scenario. This capital expenditure means the list of prices of the corresponding item which required for this scenario, followed by the prices and total of capital expenditure. This table also listed the number of items and the price of each corresponding items. In this table also mention about the percentage of tax, de-commissioning and another miscellaneous aspect that will result on the bigger value of capital expenditure. From this table it is known that the total capital expenditure of scenario 1 is US$ 10.234.000.

Table 4.22 Capital Expenditure Scenario 1

Item	Price (US$)	Number of Item	Expenditure (US$)
LNG Storage Tank	500.000	3	1.500.000
BOG Handling	80.000	4	320.000
Vaporizer	100.000	4	400.000
Pump	5.000	8	40.000
Trucks and Portable Tanks	200.000	23	4.600.000
Filling Station	150.000	3	450.000
Total Capital Expenditure			7.310.000
Tax, Permit, etc.	25%		1.827.500
Miscellaneous	5%		365.500
De-commissioning	10%		731.000
Total Capital			10.234.000

OPERATIONAL EXPENDITURE

Operational Expenditure is one aspect in economical approach that count about the operational financial condition. This operational expenditure listing all the operational expenses during the period time of the project which is not included in the capital expenditure. From the table below it can be seen that the trucks selected is based on the requirement for another component of this project. From trucks, the important factors are the volume capacity, price, average speed, and fuel consumption. The volume capacity of trucks chosen is 30 m^3. The average speed that is being considered here is about 45 km/h. the fuel consumption that is listed below is important in term of fuel purchasing for the trucks. And for the pricing value is important for completing the economic data requirement.

Table 4.23 Vessel Specification Table – SC 1

Specification	Value	Unit
Vessel	Trucks	
Brand	Sinotrucks	
LNG Volume	30	m^3
Weight	31	Ton
Price	200.000	US$
Max Speed	80	km/h
Avg. Speed	45	km/h
Length	11.860	Mm
Breadth	2.460	mm
Fuel Consumption	0,4	l/km
	0,3328	kg/m

After calculating and choosing the specification of trucks, time allocation for the loading, unloading and slack time is stated. These data is listed below.

Table 4.24 Time Allocation Table – SC 1

Time Allocation	Value	Time
Loading/Unloading time	0,0625	day
	0,625	day
Total time	0,125	day
Slack time	0,063	day
Period	10	year

Time allocation is needed to count the time that linked with the period of process. Such as loading and unloading time, slack time and project period. Below is listed information that is known and set as condition for calculating the operational expenditure. Fuel ship which is mentioned below is condition that has been set based on an assumption that taking consideration of current price of fuel in Indonesia. In the end, the price of fuel stated to be 700US$/ton. And for the price of trucks diesel fuel is US$ 0,564/liter. In this bachelor thesis, this fuel price will be processed in the calculation with the distance of transporting and transport time.

Fuel Cost

Diesel Fuel = 7.900 IDR/l

Diesel Fuel = 0,5642857 US$/l

Density Diesel Fuel = 0,832 kg/l

Diesel Cost = 0,678228US$/kg

Diesel Fuel Ship Cost = 700 US$/ton

Below are the distance that is will be used to calculate the fuel cost in aspect of distance between the natural gas source and the destination. This data is taken from googlemaps.com.

Land Transport

Benoa – Pemaron = 167 km

Trip Duration = 0,15463 day

Fuel Consumption = 66,8 l/trip

Benoa – Gilimanuk = 137 km

Trip Duration = 0,12777 day

Fuel Consumption = 55,2 l/trip

Fuel consumption that is being mentioned above, is being obtained by multiplying fuel consumption (l/km) to the distance.

Below table that represent the vessel specification that will be used to transport LNG from Bontang to Benoa. The important aspect of choosing LNG vessel are the speed, capacity, fuel consumption and the charter price. Speed is used to calculate the trip duration in which LCT going through. Price is important to be the information of economical approach. Information then obtained from PT PLN Batam, the usage of LCT is available and the pricing value is US 2.250 for a day charter.

Table 4.25 Vessel Specification Table – SC 1

Vessel	LCT 300ft	LCT 200ft	Unit
Loa	97,83	61,6	m
Breadth	19,8	12,29	m
Draft	5,75	3,2	m
Vs	8	8	knot
FO consumption	5,2	4	ton/day
	6.250	4.807,69	l/day
Load Capacity	60	36	m^3
Number of LCT	9	1	unit
Charter Price	2.250	1.982	US$/day

Below is the information that is already been taken from seadistance.org. In the calculation below, it can be seen that is everything is in contact one another. Fuel cost per round trip is obtained by calculating fuel consumption, number of LCT, trip duration, fuel price and multiplied by 2. As for the fuel cost per year, the calculation is 365 divided by 2 that multiplied by the trip duration, and last multiplied with fuel cost. This information is obtained from the economical estimation calculation from PT PLN Batam. As for the obtained data from PT PLN Batam is the charter cost and the port cost with the assumption. As for charter cost it is counted for every day and will be calculated in term of every year. Then do the port cost, which the only different is the duration that is needed when the ship is in port.

Distance Bontang – Benoa	= 576 NM
Trip Duration	= 3 day
Fuel Cost (US/RT)	= 213.360
Fuel Cost (US/year)	= 12.979.400
Charter Cost (US$/day)	= 22.232
Charter Cost (US$/year)	= 8.114.680
Port Cost (US$/RT)	= 6.300
Port Cost (US$/year)	= 383.250

Below listed the Operational Expenditure that may be got from doing the project. From the table below, it can be seen the cumulative cost consist of fuel cost, crew cost, LNG purchase and LNG transport cost are named total operation expenditure which is US$ 22.533.783,8. For each cost is already listed in the table below. For fuel cost of LNG distribution that is sent by trucks from Benoa is listed below and has the value of US$ 45.253,8. The crew cost itself can be seen from the table below and valued US$ 899.200. The detail of crew cost is being shown in attachment. The LNG cost that is being purchased from Bontang also mentioned below. By the current condition, the price of LNG is US$ 8 for each MMbtu. For the Pemaron powerplant, as this powerplant require 5.333,33 MMbtud, The daily price of purchased natural gas is US$ 42.666.67. For the Gilimanuk powerplant, as it need daily energy of 8.666.67 MMbtu, the price of daily need of natural gas is US$ 69.333,33. And for the transport cost of LNG through the sea, it need the cost of US$ 21.477.330. This value is obtained by summing the fuel cost of carrier, charter cost, and port cost.

Table 4.26 Total Operational Expenditure Table – SC 1

Power plant Name	LNG Consumption (m^3)	Number of LNG Trucks	Transport Time (day)	Fuel Consumption (trip)	Round Trip (day)
Pemaron	243,48	9	0,15463	66,8	1,5
Gilimanuk	395,65	14	0,127778	55,2	2,07

Fuel Cost (/RT) (US$)	Fuel Cost (/year) (US$)	Crew Cost (US$) (/year)	LNG Cost (US$)	LNG Transport Cost (US$) (/year)	Total Operation Expenditure (US$)
104,9	25.584,8	899.200,0	42.666,67	21.477.330	22.533.783,8
111,4	19.669		69.333,33		

After obtaining the value of capital expenditure and operational expenditure, the calculation of economical result can be done. Below is mentioned the pricing of capital expenditure and operational expenditure of scenario 1 in a table. In the table below, it can be seen the summary of cost of capital expenditure and operational expenditure. The capital expenditure that is calculated before is US$ 10.234.000. And for the operational expenditure of this scenario is valued US$ 22.533.783,77.

Table 4.27 Economic Analysis Table - SC 1

Investment	Unit	Price (US$)
Capex	Set	10.234.000
Total		10.234.000
Opex	Set	22.533.783,77
Total		22.533.783,77

Input data in the below is the information that will be get into the calculation. Tabls below is listing the input data that is used to complete economic approach. The total investment that is mentioned below is the capital expenditure. The salvage value of the table means the value of the capital expenditure reduced by total depreciation. In the current scenario, the value is US$ 7.675.500. Total depreciation is the cumulative of all yearly depreciation in the duration of time. The value of yearly depreciation is US$ 255.850, while the contract duration is 10 year, resulting on the total depreciation is US$ 2.558.500. The disposal price that is mentioned in the table is salvage value reduced by the value of multiplication of yearly depreciation and contract duration. In this scenario, the value of disposal price is US$ 5.117.000.

Table 4.28 Input Data Table – SC 1

Item	Value
Contract Duration (Year)	10
Total Investment (US$)	10.234.000
Salvage value (US$)	7.675.500
Disposal Price (US$)	5.117.000
Yearly Depreciation (US$)	255.850

After all of the input data is known and calculated, the next value that is needed to be calculated is the revenue value of this project. Table below shows the revenue of the project. Revenue is obtained by multiplying gas sent and processed in the power plants with the margin. Margin is one form of revenue aspect which really affect the future of the project. The bigger of margin, it will make faster payback period but it may not be feasible to have high margin which can affect the value of purchase. At the table below, it is listed the revenue of first scenario. With margin US$ 4, yearly income of the selling is US$ 20.440.000. For the margin US$ 5, the yearly revenue is higher than the margin US$ 4, the value is US$ 25.550.000. And for the margin US$ 6, the yearly revenue is US$ 30.660.000.

Table 4.29 Revenue Table – SC 1

Item	Unit	Value
Daily Gas Processed	MMbtu	14.000,00
Yearly Gas Processed	MMbtu	5.110.000,00
Income from LNG selling	**Margin**	**Total**
	4	20.440.000
	5	25.550.000
	6	30.660.000

Below are table of depreciation of first scenario. Depreciation is value of the decreasing value of capital expenditure. Depreciation percentage in this bachelor thesis, value of 2,5% is used. In table below, the value of depreciation is being represented and salvage value is obtained. The value of yearly depreciation is same. The value of total depreciation is the cumulative of all depreciation during the duration of the project. In the table below, it can be known that the value of total depreciation is US$ 2.558.500, and the salvage value is US$ 7.675.500.

Table 4.30 Depreciation Table – SC 1

Year	Capex (US$)	Percentage (2,5%)	Depreciation (US$)
0	10.234.000	2,50%	
1		2,50%	255.850
2		2,50%	255.850
3		2,50%	255.850
4		2,50%	255.850
5		2,50%	255.850
6		2,50%	255.850
7		2,50%	255.850
8		2,50%	255.850
9		2,50%	255.850
10		2,50%	255.850
Total Depreciation			2.558.500
Salvage Value			7.675.500

Table below listing the calculation of economic approach. Based in the value of capital expenditure. Followed by value of revenue and operational expenditure. Depreciation is also needed to mentioned here to ease the calculation of economic approach. Then, the value of earning is already achieved. This value is achieved by reducing the value of revenue by operational and depreciation. This earning need to be reduced by the tax which is has value of percentage 25%. This tax is achieved from the multiplication of the earning before tax with the tax. Then, it will result to earnings after tax. Cash flow or can be called proceed can be achieved by adding the value of depreciation with the value of earning after tax. The cumulative proceed is the value which is accumulated from the proceed of current ear and the previous year. Investment state is the value of the project at the current ear where it is calculated. This value is obtained by reducing the value capital expenditure with value of proceed.

Table 4.31 Economical Calculation - SC 1 Margin US$ 4 (US$)

Year	**CAPEX**	**Revenue**	**OPEX**	**Depreciation**	**EBT**	**Tax 25%**	**EAT**	**Proceeds**	**Cum Proceed**	**Investment State**
0	**10.234.000**				-	-	-	-	-	-10.234.000
1		20.440.000	22.533.784	255.850	-2.349.634	-587.408	-1.762.225	-1.506.375	-1.506.375	-11.740.375
2		20.440.000	22.646.453	255.850	-2.462.303	-615.576	-1.846.727	-1.590.877	-3.097.252	-13.331.252
3		20.440.000	22.759.685	255.850	-2.575.535	-643.884	-1.931.651	-1.675.801	-4.773.054	-15.007.054
4		20.440.000	22.873.483	255.850	-2.689.333	-672.333	-2.017.000	-1.761.150	-6.534.204	-16.768.204
5		20.440.000	22.987.851	255.850	-2.803.701	-700.925	-2.102.776	-1.846.926	-8.381.129	-18.615.129
6		20.440.000	23.102.790	255.850	-2.918.640	-729.660	-2.188.980	-1.933.130	-10.314.259	-20.548.259
7		20.440.000	23.218.304	255.850	-3.034.154	-758.539	-2.275.616	-2.019.766	-12.334.025	-22.568.025
8		20.440.000	23.334.396	255.850	-3.150.246	-787.561	-2.362.684	-2.106.834	-14.440.859	-24.674.859
9		20.440.000	23.451.067	255.850	-3.266.917	-816.729	-2.450.188	-2.194.338	-16.635.197	-26.869.197
10		20.440.000	23.568.323	255.850	-3.384.173	-846.043	-2.538.130	-2.282.280	-18.917.477	-29.151.477

After the calculation is done, payback period can be represented by graph below. From the graph below, it can be seen that the graph is becoming lower and lower, it means the project with the current margin is not profitable. From the first year, the economic condition is in negative state. During the project time, the deficit is become bigger and bigger. From this graph, it can be seen that first scenario with margin US$ 4 is not profitable.

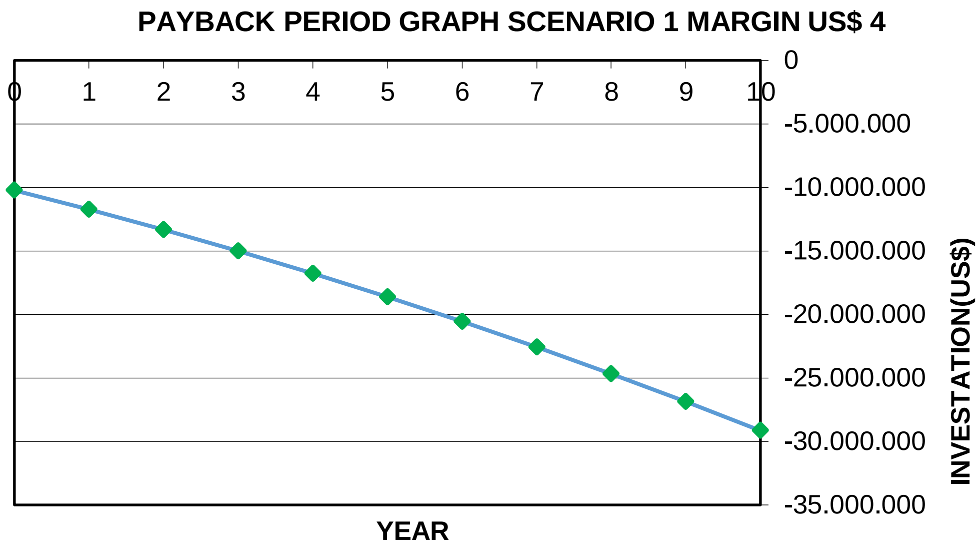

Figure 4.7 Payback Period Graphs Scenario 1 Margin US$ 4

Below is given the table of discount rate, cash flow, and the value of net present value. From the table below, it can be seen that the cash flow discount and the value of NPV. From the data, it is all in negative result, it will affect the final result of NPV, IRR, PP and ROI. From the table below can be seen that the value of total NPV value is US$ -21.447.990,84. The value of NPV is negative, in the actual meaning, this option is very unprofitable.

Table 4.32 Discount Rate Cash Flow, NPV – SC 1 Margin US$4 (US$)

Year	**I**	**Cashflow Disc.**	**NPV**
	10,00%		
0	1	-10.234.000	$ -10.234.000,00
1	0,909090909	- 1.506.375	- 1.369.432
2	0,826446281	- 1.590.877	- 1.314.774
3	0,751314801	- 1.675.801	- 1.259.054
4	0,683013455	- 1.761.150	- 1.202.889
5	0,620921323	- 1.846.926	- 1.146.795
6	0,56447393	- 1.933.130	- 1.091.202
7	0,513158118	- 2.019.766	- 1.036.459
8	0,46650738	- 2.106.834	- 982.854
9	0,424097618	- 2.194.338	- 930.614
10	0,385543289	- 2.282.280	- 879.918
Total		- 18.917.477	$ -21.447.990,84

From the result that is obtained and listed in table below, it can be seen the value of NPV is US$ - 21.447.991, the value of the IRR cannot be calculated, this option is not making profit. It can be seen from the negative result of the payback period. The return of investment is -18% which is not profitable at all to apply this option.

Table 4.33 Result Scenario 1 Margin US$ 4

i	NPV	IRR	PP	ROI
10,00%	$(21.447.991)	-	-5,0	-18%

Similar with the previous calculation, scenario 1 margin US$4, the difference only at the margin. This time, margin used is US$ 5. Below the table that contain the calculation of the scenario 1 margin US$5. In the table of economic below, it can be seen the calculation of the economical approach of the first scenario with margin US$ 5 is presented. This calculation is mostly affected by the value of capital expenditure, revenue, operational expenditure, depreciation percentage and tax. The value of capital expenditure, revenue, operational expenditure, depreciation is obtained from previous calculation. The value of earning before tax (EAT) is obtained by reducing revenue by operational expenditure and depreciation. In this calculation, tax is very important part to be considered to have the complete calculation of the economic approach. Tax is used to reduce the earning in order to calculate the real value of earning. Tax used to reduce the value of earning before tax to obtain the value of earning after tax. Then the next calculation is to know value of proceed. Proceed is obtained by reducing the earning after tax with the depreciation. Cumulative proceed is the value of the cumulative proceed from the current year and the previous year. Investment state show the condition of project, whether it still in progress to reaching payback or the value after the payback.

Table 4.34 Economical Calculation Scenario1 Margin US$ 5 (US$)

Year	CAPEX	Revenue	OPEX	Depreciation	EBT	Tax 25%	EAT	Proceeds	Cum Proceed	Investment State
0	**10.234.000**				-	-	-	-	-	-10.234.000
1		25.550.000	22.533.784	255.850	2.760.366	690.092	2.070.275	2.326.125	2.326.125	-7.907.875
2		25.550.000	22.646.453	255.850	2.647.697	661.924	1.985.773	2.241.623	4.567.748	-5.666.252
3		25.550.000	22.759.685	255.850	2.534.465	633.616	1.900.849	2.156.699	6.724.446	-3.509.554
4		25.550.000	22.873.483	255.850	2.420.667	605.167	1.815.500	2.071.350	8.795.796	-1.438.204
5		25.550.000	22.987.851	255.850	2.306.299	576.575	1.729.724	1.985.574	10.781.371	547.371

Table Extension from table 4.34

Year	CAPEX	Revenue	OPEX	Depreciation	EBT	Tax	EAT	Proceeds	Cum Proceed	Investment State
6		25.550.000	23.102.790	255.850	2.191.360	547.840	1.643.520	1.899.370	12.680.741	2.446.741
7		25.550.000	23.218.304	255.850	2.075.846	518.961	1.556.884	1.812.734	14.493.475	4.259.475
8		25.550.000	23.334.396	255.850	1.959.754	489.939	1.469.816	1.725.666	16.219.141	5.985.141
9		25.550.000	23.451.067	255.850	1.843.083	460.771	1.382.312	1.638.162	17.857.303	7.623.303
10		25.550.000	23.568.323	255.850	1.725.827	431.457	1.294.370	1.550.220	19.407.523	9.173.523

After the calculation is done, payback period can be represented by graph below. From the figure graph below, it can be seen that the payback period graph is increasing. It shows that the graph has good prospect that shown the project will pay back the capital expenditure starting around 4,9 years.

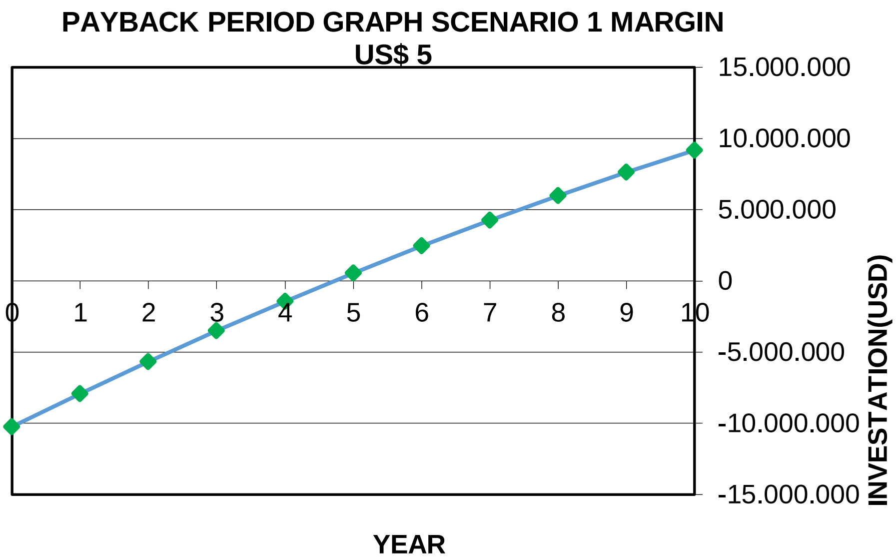

Figure 4.8 Payback Period Graph Scenario 1 Margin US$ 5

Below are the table that showing the discount rate, cash flow and NPV value of the scenario 1 with margin US$ 5. From the table below, it can be seen the value of yearly NPV of the scenario 1 with margin US$ 5 is various.

The total NPV of this option is US$ 2.101.062,59. By the end of 10 years, pure revenue is US$ 19.407.523.

Table 4.35 Discount Rate, Cash Flow and NPV – SC 1

Year	i	Cash flow Disc.	NPV
	10,00%		
0	1	-10.234.000	$ -10.234.000,00
1	0,909090909	2.326.125	2.114.659
2	0,826446281	2.241.623	1.852.581
3	0,751314801	2.156.699	1.620.360
4	0,683013455	2.071.350	1.414.760
5	0,620921323	1.985.574	1.232.885
6	0,56447393	1.899.370	1.072.145
7	0,513158118	1.812.734	930.219
8	0,46650738	1.725.666	805.036
9	0,424097618	1.638.162	694.741
10	0,385543289	1.550.220	597.677
Total		19.407.523	$ 2.101.062,59

Below are the table of result of this scenario with this margin US$ 5. Table below show the value of NPV, IRR, Payback Period and value of ROI. From the table of result below, it can be seen the NPV of the project scenario 1 using margin US$ 5 is US$ 2.101.063. From the point of interest rate of return is 15%. Based on the calculation, after 4,9 years, it already been giving profit., the value of ROI is 19%. It has bigger value from the IRR and it means the option is good to be implemented.

Table 4.36 Result Table Scenario 1 Margin US$ 5

i	**NPV**	**IRR**	**PP**	**ROI**
10,00%	$ 2.101.063	15%	4,9	19%

Below is the economic approach, only differs of the margin with the previous calculation. This time, the margin using value of US$ 6. From the table below, the calculation of the economic approach of scenario 1 with margin US$ 6 can be known. In table below, value of all aspect, which are earning before tax, tax, earning after tax, proceed, cumulative proceed and investment state. Capital expenditure, revenue, operational expenditure, depreciation is obtained from previous calculation. Earning before tax (EAT) is obtained by reducing revenue by operational expenditure and depreciation. Tax is one factor that is considered for calculating the real value of cash flow. Earning after tax is earning that is calculated by reducing EBT with tax. Then, by adding depreciation to the value of the EAT proceed can be obtained. Cumulative proceed is just simply summing all of the proceed which is already cumulated from the previous year of the project. Investment state is the condition which the current debt or the current profit.

Table 4.37 Economical Calculation Scenario 1 Margin US$ 6

Year	CAPEX	Revenue	OPEX	Depreciation	EBT	Tax 25%	EAT	Proceeds	Cum Proceed	Investment State
0	**11,284,000**				-	-	-	-	-	-11,284,000
1		26,611,991	23,465,480	282,100	2,864,411	716,103	2,148,308	2,430,408	2,430,408	-8,853,592
2		26,611,991	23,582,808	282,100	2,747,084	686,771	2,060,313	2,342,413	4,772,821	-6,511,179
3		26,611,991	23,700,722	282,100	2,629,170	657,292	1,971,877	2,253,977	7,026,798	-4,257,202
4		26,611,991	23,819,225	282,100	2,510,666	627,666	1,882,999	2,165,099	9,191,898	-2,092,102
5		26,611,991	23,938,321	282,100	2,391,570	597,892	1,793,677	2,075,777	11,267,675	-16,325
6		26,611,991	24,058,013	282,100	2,271,878	567,970	1,703,909	1,986,009	13,253,684	1,969,684
7		26,611,991	24,178,303	282,100	2,151,588	537,897	1,613,691	1,895,791	15,149,475	3,865,475
8		26,611,991	24,299,195	282,100	2,030,697	507,674	1,523,022	1,805,122	16,954,597	5,670,597
9		26,611,991	24,420,691	282,100	1,909,201	477,300	1,431,901	1,714,001	18,668,598	7,384,598
10		26,611,991	24,542,794	282,100	1,787,097	446,774	1,340,323	1,622,423	20,291,021	9,007,021

After the calculation is done, payback period can be represented by graph below. From the graph below, it can be seen that the payback period is very fast. Just by 1,7 years, this project is already making profit. By the approach of economic side, the scenario is very profitable, on the basis of US$ 6 margin.

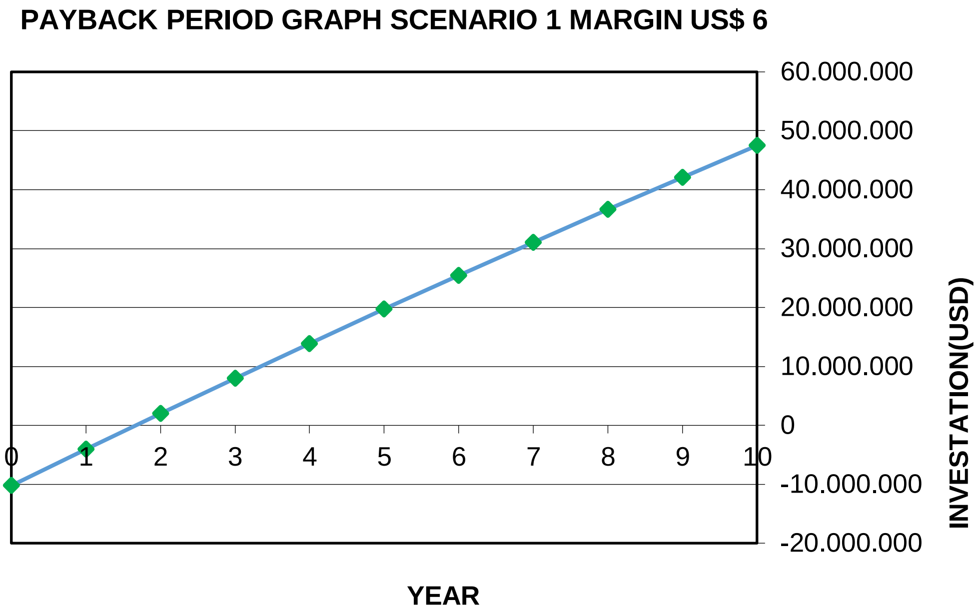

Figure 4.9 Payback Period Graph Scenario 1 Margin US$ 6

After the payback period graph is obtained, the value of NPV and cash flow is the next to be calculated in order to get the final result of the current scenario with this margin. From the table below, it can be seen the value of yearly NPV of the scenario 1 with margin US$ 6 is various. The total NPV of this option is US$ 25.650.116,02. By the end of 10 years, pure revenue is US$ 57.732.523. This value is very big compared with another option of margin in the same scenario.

Table 4.38 Discount Rate, Cash Flow and NPV – SC 1

Year	i 10.00%	Cash flow Disc.	NPV
0	1	-10.234.000	$-10.234.000,00
1	0,909090909	6.158.625	5.598.750
2	0,826446281	6.074.123	5.019.936
3	0,751314801	5.989.199	4.499.774
4	0,683013455	5.903.850	4.032.409
5	0,620921323	5.818.074	3.612.566
6	0,56447393	5.731.870	3.235.491
7	0,513158118	5.645.234	2.896.898
8	0,46650738	5.558.166	2.592.925
9	0,424097618	5.470.662	2.320.095
10	0,385543289	5.382.720	2.075.272
Total		57.732.523	$ 25.650.116,02

After the value of cash flow and NPV is known the final result is knowing the value of interest rate of return, payback period and return of investment. From the table of result below, it can be seen the NPV of the project scenario 1 using margin US$ 6 is US$ 25.650.116. From the point of interest rate of return is 58%. Based on the calculation, after 1,7 years, it already been giving profit, the value of ROI is 56%. It has lower value from the IRR and it means the option is not good to be implemented. In the fact of normal economic condition, valur of IRR which is 58% and ROI of 56% is very big.

Table 4.39 Result Table Scenario 1 Margin US$ 6

i	NPV	IRR	PP	ROI
8,00%	$ 25.650.116	58%	1,7	56%

Below shown graph of payback period of overall first scenario. There are three graphs from previous each graph. Graphs below is the combined graphs of payback period in scenario 1. Payback period graph of margin US$ 4, margin US$ 5 and margin US$ 6. Shown in the graphs, the option which has positive result of the economical approach is option with margin US$ 5 and margin US$ 6. The option of margin US$ 4 is not giving any profit from the beginning whether the future. It can be seen that this option is not feasible.

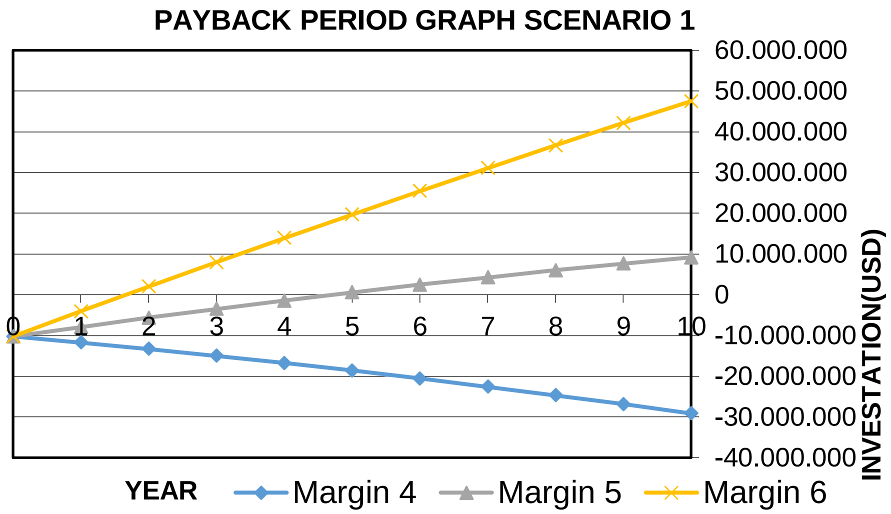

Figure 4.10 Payback Period Graph Scenario 1

After making the graph of payback period, there are graph of net present value. This graph shows the level of item value of the project. From the graph below, it shown that the graphs are increasing at the beginning of duration of project but decreasing eventually year by year. The highest NPV among them is the one with margin US$ 6. The second high is margin US$ 5 and the last is margin US$ 4. This graph can be constructed like this because of the characteristic of NPV which is always decreasing by the year. It is caused by there are depreciation and the increasing of operational expenditure.

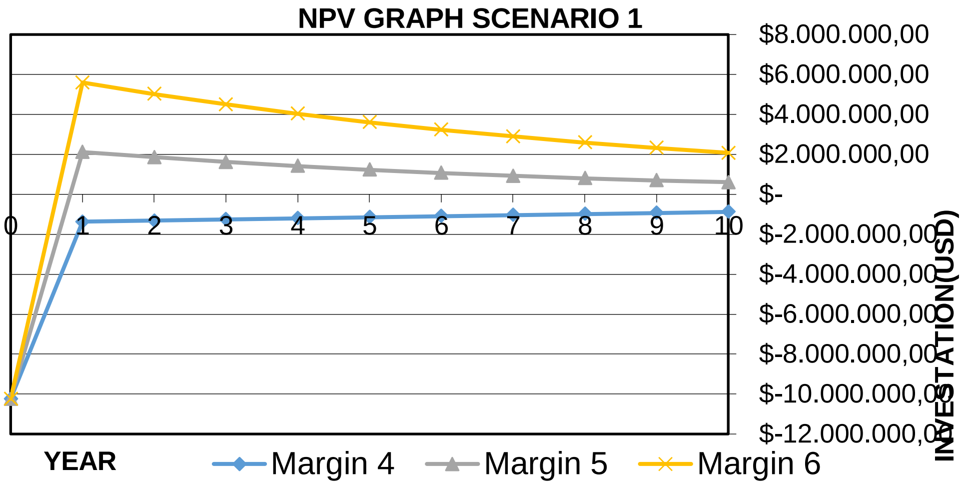

Figure 4.11 NPV Graph Scenario 1

And that define the result of the scenario which is one from three scenarios that stated. Then, the next scenario, which is second scenario will be explained.

4.5.2. Scenario 2 – CNG as main energy source

In this scenario, CNG is the energy source that will be used to powering the power plant. CNG that will be used in this scenario is CNG that will be produced in Benoa. Natural gas which is transferred to Benoa is in liquefied form. In Benoa, LNG will be evaporated and compressed until reaching 200-250 bar and become compressed natural gas. From the information obtained from Pesanggaran Power plant, power that can be produced in Pemaron and Gilimanuk Power plant is 80 MW and 130 MW. Based on the power known in these power plant supply of CNG can be calculated. Table below show the requirement of liquefied natural gas to supply Pemaron Power plant for a day. Based on the power plant specification below, CNG storage tank can be selected and it will be placed in Pemaron Power plant can be selected. As for the Pemaron Powerplant, has gas requirement of 5,33 MMscfd which is 1946,67 MMscfy. And the calculation of consumption.

Table 4.40 Pemaron Power Plant Specification Table

Power plant		**Pemaron**	
Power plant Type		Peaker	
Engine Type		Typical Steam Cycle	
Power		80	MW
Gas Requirement		5,33	MMscfd
		1946,67	MMscfy
CNG	Natural Gas Consumption	144000	m^3
	Yearly Consumption	210240	m^3py
	Daily Consumption	576,00	m^3pd
	Hourly Consumption	24,00	m^3ph
	Total Tank Capacity	576,00	m^3

After the requirement of the natural gas in scenario 2 is known, then, capital expenditure is needed to be calculated in order to calculate the overall expenses of the scenario. In this calculation there are some items that is been calculated in order to complete the supply chain and natural gas processing.

CAPITAL EXPENDITURE

In the capital expenditure, some items that need to be completed are selected and shown in the table below. The items are tanks, pressure reducer, compressor and trucks.

The first item that need to be calculated is CNG storage tank which can affect the selection of all other items. The important aspect of CNG tank are capacity, pressure capacity, and the temperature. Table below present the selected CNG storage tank specification for this scenario. From the table below, it can be seen that the selected storage tank has the capacity of 19.89 m3. This should have capacity of pressure 200-250 bar in order to contain the CNG. The pricing of this tank is relatively low because the capacity itself is very slight volume. The pricing value of this tank is low with price US$ 50.000 for each tank with capacity of 19,89 m3. Then the total price for storage tank is US$ 1.450.000. This data is obtained by taking conclusion from several CNG tank in Alibaba which has same capacity.

Table 4.41 CNG Storage Tank Selection Table

Item	**Value**	**Unit**
Model	LRC series	
Brand	Luoyang Runcheng	
Material	Steel	
Storage Tank Requirement	576	m^3
Each Tank Capacity	19,89	m^3
Design Pressure	200-250	bar

Table extension from table 4.41

Item	Value	Unit
Working Temperature	(-40) - 60	ºC
Number of Tank	29	unit
Total Capacity Req	576	m^3
Price	50.000	US$
Total Price	1.450.000	US$

In the process of CNG usage, there are a limitation of natural gas that can be processed in the engine. The natural gas needed to be in a compatible pressure in order to be operable into the engine. The suitable pressure that is being flowed into engine should be around 6-10 bar. In order to change the pressure of compressed natural gas which is 200-250 bar, pressure reducer is needed to change this. Below is the specification of first pressure reducer selected which can reduce the pressure from around 206 bar to 34 bar.

Table 4.42 CNG Pressure Reducer 1 Selection Table

Item	Value	Unit
Brand	ZMU-LOK	
Model Number	7882,78	
Parent Hole	A	
Inlet Pressure	3.000	psi
	206,8	bar
Outlet Pressure	500	psi
	34,5	bar
Intake Form	00:1/4" NPT (F)	
Out of Gas Form	00:1/4" NPT (F)	
Price	8.000	US$

. After CNG going through the process of first pressure reducer, CNG will go through the second pressure reducer to reducing the pressure again. This time, the pressure is dropping from 34 bar to 17 bar. Below is the table which contain the selected pressure reducer specification.

Table 4.43 CNG Pressure Reducer 2 Selection Table

Item	Value	Unit
Brand	ZMU-LOK	
Model Number	7882,78	
Parent Hole	B	
Inlet Pressure	500	psi
	34,5	bar
Outlet Pressure	250	psi
	17,2	bar

Table extension from table 4.43

Item	Value	Unit
Intake Form	01:1/4" NPT (M)	
Out of Gas Form	10:1/8" Card connector	
Price	8.000	US$

The second pressure reducer is needed to reduce the pressure of compressed natural gas from the pressure of around 34,5 bar to 17,2 bar. The last pressure reducer able to reduce the pressure from 17 bar into around 6,8 bar. The pricing of this pressure reducer is same with the first pressure reducer which has price of US$ 8.000. This value is taken from several pricing of pressure reducer in Alibaba.

Below is the table which present the specification of third pressure reducer. From the table below, it can be known that the specification of third pressure reducer. This pressure reducer can reduce the pressure from 17 Br to 6 bar. Similar with the previous pressure reducer, the pricing of this pressure reducer is US$ 8.000.

Table 4.44 CNG Pressure Reducer 3 Selection Table

Item	Value	Unit
Brand	ZMU-LOK	
Model Number	7882,78	
Parent Hole	C	
Inlet Pressure	-	psi
	-	bar
Outlet Pressure	100	psi
	6,89	bar
Intake Form	C330:CGA330	
Out of Gas Form	11:1/4" Card connector	
Price	8.000	US$

In the process of CNG usage, compressor is needed when LNG is arrived from Bontang. LNG will be converted into its gas state again, then compressed into the state of CNG. Below is the specification of selected compressor natural gas. In the table below, it can be seen that the compressor has capacity of 360 nominal hour per hour. The outlet pressure can be set into the required pressure. Compressor that is chosen in this scenario is similar with the previous scenario 1. This compressor has similar capacity and the pricing of this compressor is same which is priced US$ 100.000. This specification is taken from several data from Alibaba.

Table 4.45 Compressor Natural Gas Selection Table (Benoa)

Item	Value	Unit
Model	ZW-3/2-250	
Capacity	360	Nm^3/hour
Dimension	3.150 x 1.350 x 2.350	mm
Inlet Pressure	2	bar
Outlet Pressure	250	bar
Speed	585	RPM
Installed Power	90	kW
Price	100.000	US$

In the transferring the CNG from Benoa to Pemaron and Gilimanuk, CNG trucks is used. CNG trucks and tanks is different compared to LNG trucks and tanks. It is basically different because of the handling of LNG and CNG. For the CNG transporting can use CNG tank which can contain high-pressured substance. Usually these tanks characteristic has thick layer to contain high-pressure substance.

Table 4.46 Trucks Selection Table

Item	Value	Unit
Brand	CIMC	
Model	GSJ9-2210-CNG-25	
Gas Cylinder Number	9	
Overall Dimension	12192x2438x1890	mm
Cabinet Weight	28721	kg
Loading Weight	4511	kg
Tank Volume (Payload)	19,89	m^3
Number of Trucks	29	unit
Price (each)	125.000	US$
Price Total	3.625.000	US$

Trucks which is selected in this scenario is based on the requirement and the capacity of powerplant. the selected trucks can contain about 19,89 m^3 CNG. This truck can contain around 9 tank cylinders. In this scenario, 29 trucks is needed to be fulfilled in order to achieve the requirement of calculating the scenario of CNG usage in Pemaron. The price of the CNG trucks set that is obtained from several data from Alibaba is in range of US$ 120.000 up to US$ 150.000. The price that taken into calculation is US$ 125.000.

Then the next step is to calculate the scenario at Gilimanuk. Information presented by table below is the specification of Gilimanuk Power plant. Based on the power plant specification below, CNG storage tank that will be placed in Gilimanuk Power plant selected. From the capacity of powerplant, the gas requirement can be calculated. By dividing the power capacity with 5 and multiplied by 100, gas requirement can be obtained, followed by divided by 3 as this is peaker power plant. Value of 8,67 MMscfd is obtained which can be used to calculate natural gas consumption. Then by multiplying the value of natural gas consumption by 0,3 which already powered up by 3 and multiplied by 1 million. In order to obtain the value if daily consumption, the value of natural gas consumption need to be divided by 250. Then, the capacity of tank is required to fulfil the daily volume of gas.

Table 4.47 Gilimanuk Power Plant Specification Table

Powerplant		**Gilimanuk**	
Type		Typical Steam Cycle	
Power		130	MW
Gas Requirement		8,67	MMscfd
		3163,33	MMscfy
CNG	Natural Gas Consumption	234.000	m^3
	Yearly Consumption	341.640	m^3py
	Daily Consumption	936,00	m^3pd
	Hourly Consumption	39,00	m^3ph
	Total Tank Capacity	936,00	m^3

The vital specification of CNG tank are the capacity, pressure capacity, and the temperature. Table below present the selected CNG storage tank specification for this scenario.

Table 4.48 CNG Tank Selection Specification Table

Item	**Value**	**Unit**
Model	LRC series	
Brand	Luoyang Runcheng	
Material	Steel	
Storage Tank Requirement	936	m^3
Each Tank Capacity	19,89	m^3
Design Pressure	200-250	bar
Working Temperature	(-40) - 60	^oC
Number of Tank	48	unit
Total Capacity	954,72	m^3
Price (each)	50.000	US$
Price	2.400.000	US$

Compressed natural gas is gas with characteristic of high-pressure which contained in pressure of 200-250 bar. Natural gas which can be used in power generation is about 6-10 bar. In this scenario three pressure reducer with different specification is used to change the high-pressured natural gas into normal state of natural gas. Table below represent the specification of first pressure reducer which can change the pressure from around 206 bar to around 34 bar. Then the pricing of this CNG tank is US$ 50.000 for the capacity of 19,89 m^3. This data is taken from Alibaba using the mean of price which has similar specification one another.

Listed in the table below, that the specification of pressure reducer is completing the requirement of the natural gas handling. The pressure will be reduced from around 200 bar into around 35 bar. The pressure reducer of this scenario is same with the previous scenario. Then the pricing value of these pressure reducers are also same which is US$ 8.000.

Table 4.49 CNG Pressure Reducer 1 Selection Table

Item	Value	Unit
Brand	ZMU-LOK	
Model Number	7882,78	
Parent Hole	A	
Inlet Pressure	3.000	psi
	206,8	bar
Outlet Pressure	500	psi
	34,5	bar
Intake Form	00:1/4" NPT (F)	
Out of Gas Form	00:1/4" NPT (F)	
Price	8.000	US$

After going through the first pressure reducer, natural gas is going through the second pressure reducer to reduce the pressure again to fulfil the pressure requirement. In the table below, it can be seen that the specification of second pressure reducer allow the pressure reduction from around 35 bar to 17 bar. From the table is also known that the price of the second pressure reducer is same with the previous pressure reducer, which has value of US$ 8.000.

Table 4.50 CNG Pressure Reducer 2 Selection Table

Item	Value	Unit
Brand	ZMU-LOK	
Model Number	7882,78	
Parent Hole	B	
Inlet Pressure	500	psi
	34,5	bar
Outlet Pressure	250	psi
	17,2	bar
Intake Form	01:1/4" NPT (M)	
Out of Gas Form	10:1/8" Card connector	
Price	8.000	US$

CNG that already passed through second pressure reducer going into third pressure reducer which can resulting CNG has the required pressure into the engine. Below is the table which present the third pressure reducer specification. Table below inform the specification of the third pressure reducer. From the specification, this pressure reducer can reduce the pressure of natural gas from around 17 bar into natural gas with pressure of 6 bar which is compatible to the engine inlet. Same with previous pressure reducer obtained from Alibaba with price of US$ 8.000.

Table 4.51 CNG Pressure Reducer 3 Selection Table

Item	Value	Unit
Brand	ZMU-LOK	
Model Number	7882,78	
Parent Hole	C	
Inlet Pressure	-	psi
	-	bar
Outlet Pressure	100	psi
	6,89	bar
Intake Form	C330:CGA330	
Out of Gas Form	11:1/4" Card connector	
Price	8.000	US$

In the process of CNG usage, compressor needed when LNG is arrived from Bontang. It is needed to have compressor in order to convert LNG to natural gas into CNG. Below is the specification of selected compressor natural gas. The selected compressor is selected in the table below. In the table, it can be seen the selected compressor specification. This compressor has capacity of 360 Nm3/hour. The engine speed of this compressor is 585 RPM. This compressor already suitable to the requirement of this scenario. The price of compressor selected is same as the previous scenario which is has value of US$ 100.000. This pricing taken from the Alibaba with several similar specification and price value.

Table 4.52 Compressor Natural Gas Selection Table (Benoa)

Item	Value	Unit
Model	ZW-3/2-250	
Capacity	360	Nm^3/hour
Dimension	3.150 x 1.350 x 2.350	mm
Inlet Pressure	2	bar
Outlet Pressure	250	bar
Number of Compressor	2	
Speed	585	RPM
Installed Power	90	kW
Price (each)	100.000	US$
Price Total	200.000	US$

Trucks and tanks of CNG handling differs with the LNG usage. For LNG, they need cryogenic tank and truck which is fit with the capacity of very low temperature. The other hand, CNG trucks and tanks need more of high-pressure characteristics in their items. Obviously for the CNG tanks, it will be layered with thicker metal that can endure high-pressured substance. For this distribution, there is selected trucks that suitable for it. The specification of selected trucks is listed in table below. Table below inform the specification of selected trucks of this scenario. In this table it can be known that the capacity of selected trucks is 19,89 m3. In this scenario, the required number of trucks are 48 unit to ensure the daily supply of electric power. The selected set of trucks and tank has price about US$ 125.000. This value is taken from Alibaba and using assumption to make it more realistic for the tax and sending of the item. And the result of this calculation for trucks and tanks is US$ 6.000.000.

Table 4.53 Trucks Selection Table

Item	Value	Unit
Brand	CIMC	
Model	GSJ9-2210-CNG-25	
Gas Cylinder Number	9	
Overall Dimension	12.192 x 2.438 x 1.890	mm
Cabinet Weight	28.721	kg
Loading Weight	4.511	kg
Tank Volume (Payload)	19,89	m^3
Number truck	48	unit
Price (each)	125.000	US$
Price Total	6.000.000	US$

All of the required item to ensure the supply chain and energy generation is completed. In this occasion, the summary of the economic calculation is need to be presented. Below is the economical calculation of capital expenditure processed. Mentioned in table below, there are pricing of CNG storage tank, pressure reducer, compressor and trucks. Multiplied by the number of the items, it will be totaled up and the value of capital expenditure can be obtained. This value then will be added by the value of tax, miscellaneous and price of de-commissioning. The actual capital expenditure cost is US$ 13.771.000. Added by the value of tax, miscellaneous and de-commissioning which is each has percentage about 25%, 5% and 10%, the value of total capital expenditure can be obtained. From the calculation, the total capital expenditure is calculated and has value of US$ 19.279.400.

Table 4.54 Capital Expenditure Scenario 2

Item	Unit	Price (US$)	Total Price (US$)
CNG Storage Tank	77	50.000	3.850.000
Pressure Reducer	12	8.000	96.000
Natural Gas Compressor	2	100.000	200.000
Trucks	77	125.000	9.625.000
Total Capital Expenditure			13.771.000
Tax, Permit, etc.		25% Capex	3.442.750
Miscellaneous		5% Capex	688.550
De-commissioning		10% Capex	1.377100
Total Capital Expenditure			19.279.400

After the total of capital expenditure is calculated, the next step is to calculate the value of operational expenditure. Below is the operational expenditure of the scenario 2.

OPERATIONAL EXPENDITURE

Operational Expenditure is one aspect in economical approach that count about the operational financial condition. This operational expenditure listing all the operational expenses during the period time of the project which is not included in the capital expenditure. Operational expenditure of second scenario has some vital aspect that is take into account. These vital aspects are vessel to distribute the natural gas from Bontang and its fuel price, the fuel price of land transportation, crew cost, charter cost and LNG cost itself. This first to be calculated and selected is the fuel consumption that leads to the fuel cost of trucks. Below are the table of vessel specification of scenario 2. In this table, vessel used to transport CNG are trucks which has capacity 24,5 m3.the price of this selected trucks is US$ 200.000. it means the total set of trucks, trailer and its tanks is has value of US$ 200.000. In this specification the other important aspect is the fuel consumption. This value is affecting the result of the yearly operational expenditure. This value is obtained from the economical estimation of PT PLN Batam.

Table 4.55 Vessel Specification – SC 2

Vessel	Trucks	
Brand	Sinotrucks	
CNG Volume	24,5	m^3
Weight	50	ton
Price	200.000	US$
Avg. Speed	50	km/h
Fuel Consumption	0,3	L/KM
	0,2496	kg/m

Other aspect that affecting the fuel cost is the time of transport, load time, and slack time. These factors is listed in table below.

Table 4.56 Time Allocation – SC 2

Time Allocation	Value	Time
Loading/Unloading time	0,0625	day
	0,0625	day
Total time	0,125	day
Slack time	0,063	day
Period	10	year

Time allocation is needed to count the time that corresponding to the period of process. Time delay for example loading and unloading time, slack time and project period. For loading and unloading time, this value is calculated from the capacity of pump that used in the filling station. Below is listed information that is known and set as condition for calculating the operational expenditure. Fuel ship cost which already calculated below is achieved under the assumption from current fuel cost in Indonesia. The price of fuel used here is based on the updated price of fuel in the nation. Below is the distance that will be used to calculate the fuel cost in aspect of distance between the natural gas source and the destination. This data is taken from googlemaps.com. Fuel consumption that is being mentioned below, is being obtained by multiplying fuel consumption (l/km) to the distance between the origin place to the destination. The value of fuel consumption is obtained from the specification. These values is used to calculate the requirement of fuel cost in the land transportation.

Fuel Cost

Diesel Fuel = 7.900 IDR/L

Diesel Fuel = 0,5642857 US$/L

Diesel Fuel Ship = 700 US$/ton

Density Diesel Fuel = 0,832 kg/L

Land Transport

Benoa – Pemaron = 167 km

Trip Duration = 0,139167 day

Fuel Consumption = 50,1 l/trip

Benoa – Gilimanuk = 138 km

Trip Duration = 0,115 day

Fuel Consumption = 41,4 l/trip

After calculating the distance and fuel consumption, the following calculation is to know the value of LNG transport cost from Bontang to

Benoa. Below are table that represent the vessel specification that will be used to transport LNG from Bontang to Benoa.

Table 4.57 Vessel Specification – SC 2

Vessel	LCT 300ft	LCT 200ft	Unit
Loa	97,83	61,6	m
Breadth	19,8	12,29	m
Draft	5,75	3,2	m
Vs	8	8	knot
FO consumption	5,2	4	ton/day
	6.250	4.807,69	l/day
Load Cap	60	36	m^3
Number of LCT	9	1	
Charter Price	2.250	1.982	US$/day

The vital aspect of choosing LNG vessel are the speed, capacity, fuel consumption and the charter price. Speed is used to calculate the trip duration in which LCT going through. Price is important to be the information of economical approach. Below is the information that is already been taken from seadistance.org. In the calculation below, it can be seen that is everything is in contact one another. Fuel cost per round trip is obtained by calculating fuel consumption, number of LCT, trip duration, fuel price and multiplied by 2. As for the fuel cost per year, the calculation is 365 divided by 2 that multiplied by the trip duration, and last multiplied with fuel cost. As for charter cost it is counted for every day and will be calculated in term of every year. Then do the port cost, which the only different is the duration that is needed when the ship is in port.

Distance Bontang – Benoa = 576 nm

Trip Duration = 3 day

Fuel Cost (US/RT) = 213.360

Fuel Cost (US/year) = 12.979.400

Charter Cost (US$/day) = 22.232

Charter Cost (US$/year) = 8.114.680

Port Cost (US$/RT) = 6.300

Port Cost (US$/year) = 383.250

Below listed the Operational Expenditure that may be got from doing the project. In table below, overall operational expenditure is calculated. This scenario using CNG as main energy that being sent from Benoa. Fuel cost is obtained from multiplying fuel consumption, transport time, number of CNG trucks, and the fuel price. From the table below, it is concluded that the crew cost is US$ 1.726.400, LNG cost is US$ 112.000, LNG transport cost has value of US$ 21.477.330. That is concluded the total operation expenditure is US$ 23.351.692,1.

Table 4.58 Operational Expenditure Total Scenario 2

Powerplant Name	LNG Consumption (m^3)	LNG Trucks Amount	Transport Time (day)	Fuel Consumption (trip)	Round Trip (day)
Pemaron	576	29	0,139167	50,1	3,97
Gilimanuk	936	48	0,115	41,4	6,29

Fuel Cost (/RT) (US$)	Fuel Cost (/Year) (US$)	Crew Cost (US$) (/Year)	LNG Cost (US$)	LNG Transport Cost (US$) (/year)	Total Operation Expenditure
228,2	21.001,9	1.726.400	42.666,67	21.477.330,00	23.351.692,1
257,9	14.960,2		69.333,33		

After obtaining the value of capital expenditure and operational expenditure, the calculation of economical result can be done. Below economic analysis is represented by calculating the NPV, IRR, PP and ROI. In the table below, it can be seen the summary of cost of capital expenditure and operational expenditure.

Table 4.59 Investment Scenario 2

Investment	Unit	Price (US$)
Capex	set	19.279.400
Total		19.279.400
Opex	set	23.351.692,12
Total		23.351.692,12

Input data in the below is the information that will be get into the calculation. These input data is needed to complete the economical approach calculation requirement. Below are the input data which affecting the economic approach. From the table below, listed the value of investment, salvage value and disposal value that is achieved also from yearly depreciation. In this scenario which has 10 years contract duration, the value of investment is US$ 19.279.400. The salvage value of this project is US$ 14.459.550. This salvage value is obtained from reducing the value of capital expenditure with the value of total depreciation of these 10 years. The disposal value of this project is US$ 9.639.700. This disposal value is obtained from the calculation of salvage value reduced by the value of total depreciation with 10 years period. Below are the input data and the that will be used to complete the calculation.

Table 4.60 Input Data Scenario 2

Item	Value
Contract Duration (year)	10
Total Investment (US$)	19.279.400
Salvage value (US$)	14.459.550
Disposal Price (US$)	9.639.700
Yearly Depreciation (US$)	481.985

Table below shows the revenue of the project. Revenue is obtained by multiplying gas sent and processed in the power plants with the margin. Margin is one form of revenue aspect which really affect the future of the project. The bigger of margin, it will make faster payback period but it may not be feasible to have high margin which can affect the value of purchase.

Table 4.61 Revenue Table Scenario 2

Item	Unit	Value
Daily Gas Processed	MMbtu	14.000
Yearly Gas Processed	MMbtu	5.110.000
Income from LNG selling	**Margin**	**Total**
	4	20.440.000
	5	25.550.000
	6	30.660.000

In table below, the value of depreciation is being represented and salvage value is obtained. As mentioned before, salvage value is the value that is the vital value of item in the project. The value of yearly depreciation is same. The value of total depreciation is the cumulative of all depreciation during the duration of the project.

Table 4.62 Depreciation Scenario 2

Year	Capex	Percentage (2,5%)	Depreciation
0	19.279.400	2,50%	
1		2,50%	481.985
2		2,50%	481.985
3		2,50%	481.985
4		2,50%	481.985
5		2,50%	481.985
6		2,50%	481.985
7		2,50%	481.985
8		2,50%	481.985
9		2,50%	481.985

Table extension from table 4.62

Year	Capex	Percentage (2,5%)	Depreciation
10		2,50%	481.985
Total Depreciation			4.819.850
Salvage Value			14.459.550

After this information already calculated, the next step is to calculate the economical approach. In the table of economical approach below, it can be seen that calculation of the economical approach of the second scenario. All of the aspects are capital expenditure, revenue, operational expenditure, depreciation, earning before tax, tax, earning after tax, proceed (cash flow), cumulative proceed, and investment state. Four of them, capital expenditure, revenue, operational expenditure, depreciation is already obtained from previous calculation. The value of earning before tax is obtained by reducing revenue by operational expenditure and depreciation. Tax is one factor that is considered for calculating the real value of cash flow. This tax using the statement of government rules which has value of 25% of earning. And the result of reducing the value of earning by the tax, the value of earning after tax is obtained. Then, proceed can be obtained by adding depreciation to the value of the EAT. Cumulative proceed is the proceed which is already cumulated from the previous year of the project. Investment state is the condition which the current debt or the current profit.

Table 4.63 Economical Calculation Scenario 2 Margin US$ 4 (US$)

Year	CAPEX	Revenue	OPEX	Depreciation	EBT	Tax 25%	EAT	Proceeds	Cum Proceeds	Investment State
0	**19.279.400**				-	-	-	-	-	-19.279.400
1		20.440.000	23.351.692	481.985	-3.393.677	-848.419	-2.545.258	-2.063.273	-2.063.273	-21.342.673
2		20.440.000	23.468.451	481.985	-3.510.436	-877.609	-2.632.827	-2.150.842	-4.214.115	-23.493.515
3		20.440.000	23.585.793	481.985	-3.627.778	-906.944	-2.720.833	-2.238.848	-6.452.963	-25.732.363
4		20.440.000	23.703.722	481.985	-3.745.707	-936.427	-2.809.280	-2.327.295	-8.780.258	-28.059.658
5		20.440.000	23.822.240	481.985	-3.864.225	-966.056	-2.898.169	-2.416.184	-11.196.442	-30.475.842
6		20.440.000	23.941.352	481.985	-3.983.337	-995.834	-2.987.502	-2.505.517	-13.701.959	-32.981.359

Table Extension from table 4/63

Year	CAPEX	Revenue	OPEX	Depreciation	EBT	Tax	EAT	Proceeds	Cum Proceeds	Investment State
7		20.440.000	24.061.058	481.985	-4.103.043	-1.025.761	-3.077.283	-2.595.298	-16.297.257	-35.576.657
8		20.440.000	24.181.364	481.985	-4.223.349	-1.055.837	-3.167.511	-2.685.526	-18.982.784	-38.262.184
9		20.440.000	24.302.270	481.985	-4.344.255	-1.086.064	-3.258.192	-2.776.207	-21.758.990	-41.038.390
10		20.440.000	24.423.782	481.985	-4.465.767	-1.116.442	-3.349.325	-2.867.340	-24.626.330	-43.905.730

After the calculation is done, payback period can be represented by graph below. The characteristic of payback can be known by analyzing the graph. From the graph below, it can be seen that the payback period is decreasing and not going up at all. By the time going, the value is keep decreasing. This scenario with combination of margin US$ 4. In the graph of payback, this mean that the project will not having any profit.

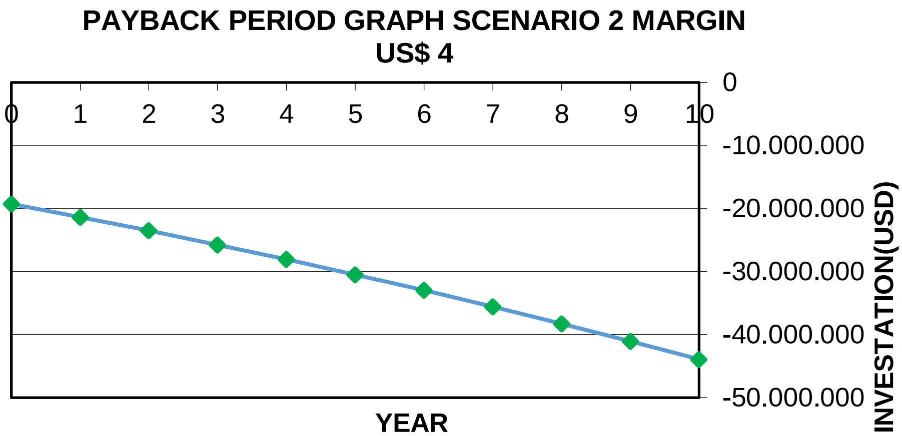

Figure 4.12 Payback Period Graph Scenario 2 Margin US$ 4

After the payback period of this scenario with margin US$ 4, the cash flow and NPV is obtained by calculating it. The calculation is being presented in table below. From the table below, it can be seen the value of yearly NPV of the scenario 2 with margin US$ 4 is various. The total NPV of this option is US$ - 33.986.353,22. By the end of 10 years, this project will result on deficit of US$ - 24.626.330. This show that the project is not profitable at all.

Table 4.64 Discount Rate, Cash flow and NPV Scenario 2 Margin US$ 4

Year	i 10.00%	Cashflow Disc.	NPV
0	1	-19.279.400	$ -19.279.400,00
1	0,909090909	- 2.063.273	- 1.875.703
2	0,826446281	- 2.150.842	- 1.777.555
3	0,751314801	- 2.238.848	- 1.682.080
4	0,683013455	- 2.327.295	- 1.589.574
5	0,620921323	- 2.416.184	- 1.500.260
6	0,56447393	- 2.505.517	- 1.414.299
7	0,513158118	- 2.595.298	- 1.331.798
8	0,46650738	- 2.685.526	- 1.252.818
9	0,424097618	- 2.776.207	- 1.177.383
10	0,385543289	- 2.867.340	- 1.105.484
Total		- 24.626.330	$ -33.986.353,22

In table below, it shows the result of the economical approach in the current scenario with margin US$ 4. From the table of result below, it can be seen the NPV of the project scenario 1 using margin US$ 4 is US$ - 33.986.353. From the point of interest rate of return it cannot be interpreted because too small. Based on the calculation, this project with this margin is deficit. This option has ROI value of -13%. This option has value of negative which is not feasible to be implemented.

Table 4.65 Result Table Scenario 2 Margin US$ 4

i	NPV	IRR	PP	ROI
10.00%	$(33.986.353)	-	-7,5	-13%

In the table below, it can be seen the economical approach which contain calculation second scenario with margin US$ 5. The aspect which is mentioned below are capital expenditure, revenue, operational expenditure, depreciation, earning before tax, tax, earning after tax, proceed (cash flow), cumulative proceed, and investment state. Among all of them, capital expenditure, revenue, operational expenditure, depreciation is already obtained. The aspect of earning before tax is obtained by reducing revenue by operational expenditure and depreciation. Tax is one factor that is considered for calculating the real value of cash flow. Tax has value of 25% of the earning. Earning after tax is earning that is calculated by reducing EBT with tax. Then, proceed can be obtained by adding depreciation to the value of the EAT. Cumulative proceed is the proceed which is already cumulated from the previous year of the project. Investment state is the condition which the current debt or the current profit.

Table 4.66 Economical Calculation Scenario 2 Margin US$ 5 (US$)

Year	CAPEX	Revenue	OPEX	Depreciation	EBT	Tax 25%	EAT	Proceeds	Cum Proceed	Investment State
0	**19.279.400**				-	-	-	-	-	-19.279.400
1		25.550.000	23.351.692	481.985	1.716.323	429.081	1.287.242	1.769.227	1.769.227	-17.510.173
2		25.550.000	23.468.451	481.985	1.599.564	399.891	1.199.673	1.681.658	3.450.885	-15.828.515
3		25.550.000	23.585.793	481.985	1.482.222	370.556	1.111.667	1.593.652	5.044.537	-14.234.863
4		25.550.000	23.703.722	481.985	1.364.293	341.073	1.023.220	1.505.205	6.549.742	-12.729.658
5		25.550.000	23.822.240	481.985	1.245.775	311.444	934.331	1.416.316	7.966.058	-11.313.342
6		25.550.000	23.941.352	481.985	1.126.663	281.666	844.998	1.326.983	9.293.041	-9.986.359
7		25.550.000	24.061.058	481.985	1.006.957	251.739	755.217	1.237.202	10.530.243	-8.749.157
8		25.550.000	24.181.364	481.985	886.651	221.663	664.989	1.146.974	11.677.216	-7.602.184
9		25.550.000	24.302.270	481.985	765.745	191.436	574.308	1.056.293	12.733.510	-6.545.890
10		25.550.000	24.423.782	481.985	644.233	161.058	483.175	965.160	13.698.670	-5.580.730

After the calculation is done, payback period can be represented by graph below. The characteristic of this option can be known by analyzing and taking conclusion of this graph. From the graph below, information that can be obtained that the payback period is increasing which is good for the project. But for this option, margin US 5 take long time for getting payback. From the calculation the payback need time more time than the contract duration of this project. This may be affected by the value of operational expenditure which is keep increasing annually.

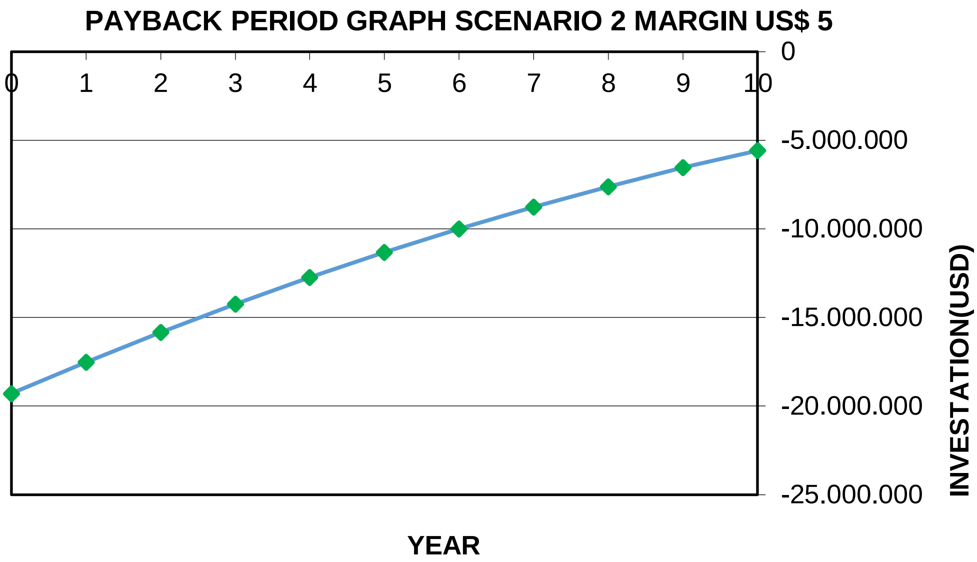

Figure 4.13 Payback Period Graph Scenario Margin US$ 5

From the table below, it can be seen the value of yearly NPV of the scenario 2 with margin US$ 5 is positive and various. The total NPV of this option is US$ -10.437.299,79. By the end of 10 years, this project will result on deficit of US$ 13.698.670.

Table 4.67 Discount Rate, Cash Flow, NPV Scenario 2 Margin US$ 5

Year	i	Cash flow Disc.	NPV
	10.00%		
0	1	-19.279.400	$ -19.279.400,00
1	0,909090909	1.769.227	1.608.388
2	0,826446281	1.681.658	1.389.800
3	0,751314801	1.593.652	1.197.334
4	0,683013455	1.505.205	1.028.075
5	0,620921323	1.416.316	879.421
6	0,56447393	1.326.983	749.047
7	0,513158118	1.237.202	634.880
8	0,46650738	1.146.974	535.072
9	0,424097618	1.056.293	447.972
10	0,385543289	965.160	372.111
Total		13.698.670	$ -10.437.299,79

After calculating the cash flow and NPV, the result can be obtained. The result is in result of NPV, IRR, payback period and return of investment. From the table of result below, it can be seen the NPV of the project scenario 2 using margin US$ 5 is US$ - 10.437.300. From the point of interest rate of return it has very small and it really not feasible. Based on the calculation, this project has payback after 13,5 years. This option has ROI value of 7%.

Table 4.68 Result Table Scenario 2 Margin 5

i	NPV	IRR	PP	ROI
10.00%	$ (10.437.300)	-6%	13,5	7%

The result of scenario 2 with margin US$ 5 is obtained, and the next is obtaining the result is second scenario but with margin US$ 6. Below is the economical approach of second scenario with margin of US$ 6. In the table below, it can be seen the economical approach which contain calculation second scenario with margin US$ 6. The elements that is involve in this calculation are capital expenditure, revenue, operational expenditure, depreciation, earning before tax, tax, earning after tax, proceed (cash flow), cumulative proceed, and investment state. Some of them, capital expenditure, revenue, operational expenditure, depreciation is already obtained. The aspect of earning before tax is obtained by reducing revenue by operational expenditure and depreciation. Tax is one factor that is considered for calculating the real value of cash flow. Earning after tax is earning that is calculated by reducing Earning Before Tax with tax. Then, proceed can be obtained by adding depreciation to the value of the EAT. Cumulative proceed is the collective proceed which is accumulated from the previous year of the project. Investment state is the condition which the current debt or the current profit.

Table 4.69 Economical Calculation Scenario 2 Margin US$ 6 (US$)

Year	CAPEX	Revenue	OPEX	Depreciation	EBT	Tax 25%	EAT	Proceeds	Cum Proceed	Investment State
0	**19.279.400**				-	-	-	-	-	-19.279.400
1		30.660.000	23.351.692	481.985	6.826.323	1.706.581	5.119.742	5.601.727	5.601.727	-13.677.673
2		30.660.000	23.468.451	481.985	6.709.564	1.677.391	5.032.173	5.514.158	11.115.885	-8.163.515
3		30.660.000	23.585.793	481.985	6.592.222	1.648.056	4.944.167	5.426.152	16.542.037	-2.737.363
4		30.660.000	23.703.722	481.985	6.474.293	1.618.573	4.855.720	5.337.705	21.879.742	2.600.342

Table extension from table 4.69

Year	CAPEX	Revenue	OPEX	Depreciation	EBT	Tax	EAT	Proceeds	Cum Proceed	Investment State
5		30.660.000	23.822.240	481.985	6.355.775	1.588.944	4.766.831	5.248.816	27.128.558	7.849.158
6		30.660.000	23.941.352	481.985	6.236.663	1.559.166	4.677.498	5.159.483	32.288.041	13.008.641
7		30.660.000	24.061.058	481.985	6.116.957	1.529.239	4.587.717	5.069.702	37.357.743	18.078.343
8		30.660.000	24.181.364	481.985	5.996.651	1.499.163	4.497.489	4.979.474	42.337.216	23.057.816
9		30.660.000	24.302.270	481.985	5.875.745	1.468.936	4.406.808	4.888.793	47.226.010	27.946.610
10		30.660.000	24.423.782	481.985	5.754.233	1.438.558	4.315.675	4.797.660	52.023.670	32.744.270

After the calculation is done, payback period can be represented by graph below. This graph will represent the characteristic of this option. From the graph below, information that can be learn that the payback period in this option is increasing which is great for the project. But for this option, margin US$ 6 is too high to be implemented in Indonesia, which can result on the unsold natural gas because too expensive. In the condition of revenue this option is really good but this pricing of natural gas is not feasible.

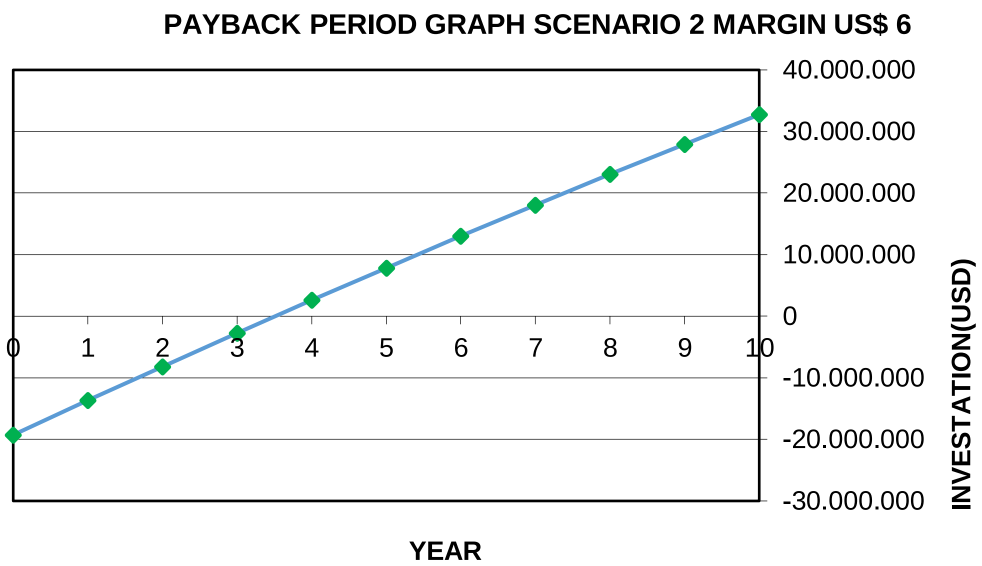

Figure 4.14 Payback Period Graph Scenario 2 Margin US$ 6

From the table below, it can be seen the value of yearly NPV of the scenario 2 with margin US$ 5 is positive and various. The total NPV of this option is US$ -10.437.299,79. By the end of 10 years, this project will result on deficit of US$ 13.698.670.

Table 4.70 Discount Rate, Cash Flow and NPV Scenario 2 Margin US$ 6

Year	**i**	**Cash flow Disc.**	**NPV**
	10.00%		
0	1	-19.279.400	$-19.279.400,00
1	0,909090909	5.601.727	5.092.479
2	0,826446281	5.514.158	4.557.156
3	0,751314801	5.426.152	4.076.748
4	0,683013455	5.337.705	3.645.724
5	0,620921323	5.248.816	3.259.102
6	0,56447393	5.159.483	2.912.393
7	0,513158118	5.069.702	2.601.559
8	0,46650738	4.979.474	2.322.961
9	0,424097618	4.888.793	2.073.326
10	0,385543289	4.797.660	1.849.706
Total		52.023.670	$ 13.111.753,64

From the result table of scenario 2 margin US$ 6 below, it can be seen the NPV of the project scenario 2 using margin US$ 6 is US$ -13.111.754. From the point of interest rate of return it has very high value which is 25%. Based on the calculation, this project has payback after 3,6 years. This option has ROI value of 27%. This option considered very good but there is aspect that difficult to be implemented which is the margin is too high. The high margin will result on expensive natural gas purchase that may end in the unsold quantity of natural gas.

Table 4.71 result Table Scenario 2 Margin US$ 6

i	**NPV**	**IRR**	**PP**	**ROI**
10.00%	$ 13.111.754	25%	3,6	27%

Below represented the payback period graph of second scenario with all margin. This graph can represent the characteristic of second scenario. Graphs below is the combined graphs of payback period in scenario 2. This graph interpreted the payback period graph scenario 2 of margin US$ 4, margin US$ 5 and margin US$ 6. Shown in the graphs, the option which has positive result of the economical approach is option with margin US$ 5 and margin US$ 6. But the margin of US$ 5 is still so low to be implemented it takes so much time to get the return of the payback.

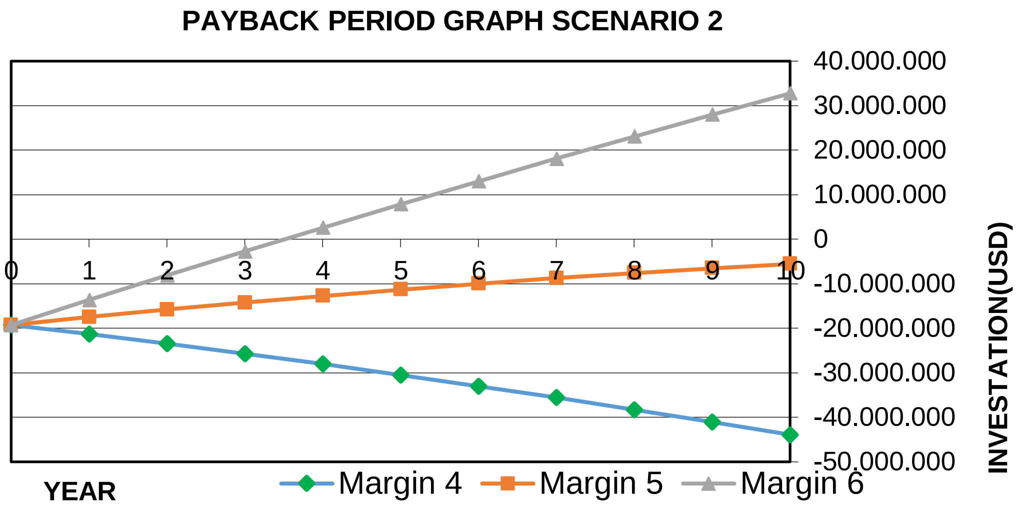

Figure 4.15 Payback Period Graph Scenario 2

From the graph below, it shown that the graphs are also increasing at the beginning of duration of project caused by the capital expenditure but decreasing eventually year by year. The highest NPV among them is the one with margin US$ 6. Followed by margin of US$ 5 and the last is margin US$ 4. This graph characteristic is like this because of the characteristic of NPV value that keeps on decreasing by the year. It is caused by there are depreciation and the increasing of operational expenditure.

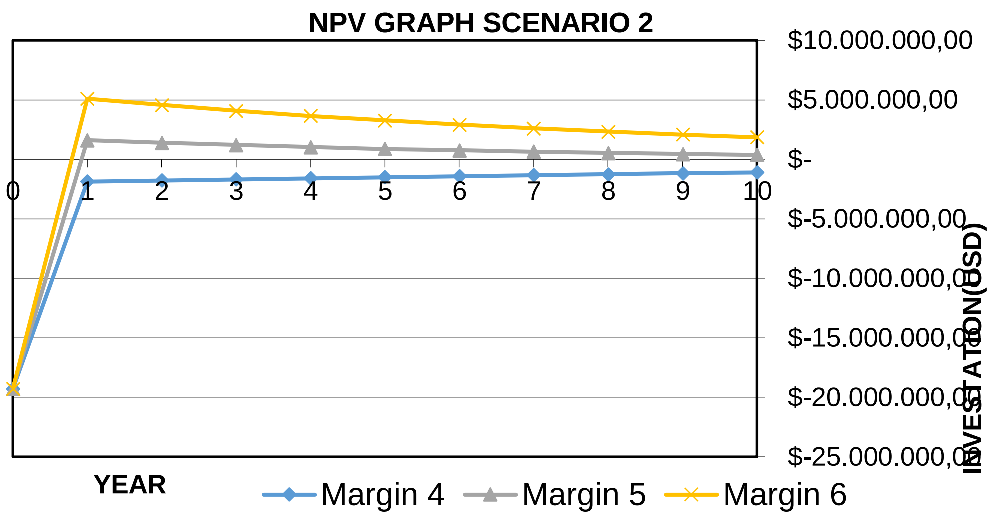

Figure 4.16 NPV Graph Scenario 2

That is finishing the calculation of economical approach of second scenario. This scenario is considered the one option that may be applied in the real life. But this scenario also compared with the first scenario and later with third scenario. The calculation of third scenario will be presented in the following subchapter.

4.5.3. Scenario 3 – CNG as main energy source, different route than scenario 1 and scenario 2

In this scenario, CNG is used to be the energy source of the power plant. Similar with the second scenario which is using CNG as its main energy power. But different in the supply chain from the origin of natural gas. Known in second scenario, LNG is supplied from Bontang to Benoa. Then by using trucks, CNG is sent to Pemaron and Gilimanuk by land. Differs from second scenario, LNG which is sent from Bontang go directly to Celukan Bawang Port which is located in North side of Bali Island. After LNG arrived, natural gas whether it is boiled-off or still in LNG form, will be converted into CNG. These CNG will be contained into CNG trucks and will be sent to Pemaron and Gilimanuk. The power used here is same with the previous scenario, Pemaron Power plant has 80 MW power and Gilimanuk Power plant has 130 MW power. Table below show the requirement of liquefied natural gas to supply Pemaron Power plant in form of volume. Based on the power plant specification mentioned below, CNG storage tank that will be placed in Pemaron Power plant can be selected. From the table it can be known that the need of natural gas requirement to fulfil the requirement is 5,33 MMscf per day. From this value, the value of natural gas consumption can be calculated. In this scenario which is operating using CNG, volume of gas consumption is 144.000 m3 needed every day. Converted into daily consumption, it need 567 cubic meters per day. In order to be operated well, there are some items that needed to in the powerplant.

Table 4.72 Pemaron Power Plant Data Table

Power plant		**Pemaron**	
Power plant Type		Peaker	
Engine Type		Typical Steam Cycle	
Power		80	MW
Gas Requirement		5,33	MMscfd
		1946,67	MMscfy
CNG	Natural Gas Consumption	144.000	m^3
	Yearly Consumption	210.240	m^3py
	Daily Consumption	576,00	m^3pd
	Hourly Consumption	24,00	m^3ph
	Total Tank Capacity	576,00	m^3

The first items that need to be considered is CNG storage tank. The important aspect CNG tank are capacity, pressure capacity, and the temperature. Table below present the selected CNG storage tank specification for this scenario. For the handling of CNG, high-pressured tank are needed to contain CNG. These tanks should have capacity to contain 200-250 bar pressure natural gas. But when natural gas entering engine, the normal pressure intake of engine is only about 6-10. In this compressed natural gas need to be de-pressurized.

Table 4.73 CNG Storage Tank Selection Table

Item	Value	Unit
Model	LRC series	
Brand	Luoyang Runcheng	
Material	Steel	
Storage Tank Requirement	576	m^3
Each Tank Capacity	19,89	m^3
Design Pressure	200-250	bar
Working Temperature	(-40) - 60	ºC
Number of Tank	29	unit
Total Capacity	576	m^3
Price	50.000	US$
Total Price	1.450.000	US$

The selected pressure reducer information is given in table below. The specification is vital at aspect of inlet and outlet pressure. From the table known that the inlet pressure is around 200 bar and the outlet pressure is 34 bar. From the table below, it can be seen the price of the first pressure reducer. Below is the specification of first pressure reducer selected which can reduce the pressure from around 206 bar to 34 bar. From the table below it can be seen that the pricing of CNG storage tank is listed below. From the pricing that is obtained from Alibaba, the selected price of storage tank is US$ 50.000.

Table 4.74 Pressure Reducer 1 Selection Table

Item	Value	Unit
Brand	ZMU-LOK	
Model Number	7882,78	
Parent Hole	A	
Inlet Pressure	3.000	psi
	206,8	bar
Outlet Pressure	500	psi
	34,5	bar
Intake Form	00:1/4" NPT (F)	
Out of Gas Form	00:1/4" NPT (F)	
Price	8.000	US$

After the going on process through the first pressure reducer, reduced pressure CNG will go through the second pressure reducer to reducing the pressure again. The pressure will drop from 34 bar to 17 bar. Below is the table which contain the selected pressure reducer specification. At the table below, it can be seen that the pressure reducer can reduced the pressure from around 34 bar into 17 bar. From the current table, it can be seen the price of the pressure reducer. In this scenario, the pressure reducer price is same, with value of US$ 8.000. the price is same with the previous pressure reducer which is selected in previous scenario.

Table 4.75 CNG Pressure Reducer 2 Selection Table

Item	Value	Unit
Brand	ZMU-LOK	
Model Number	7882,78	
Parent Hole	B	
Inlet Pressure	500	psi
	34,5	bar
Outlet Pressure	250	psi
	17,2	bar
Intake Form	01:1/4" NPT (M)	
Out of Gas Form	10:1/8" Card connector	
Price	8.000	US$

The last pressure reducer able to reduce the pressure from 17 bar into around 6,8 bar. Below is the table which present the specification of pressure reducer. In table below, information of the pressure reducer can be seen. In the table, specification of pressure reducer can reduce the pressure to around 6,8 bar. This selected pressure reducer also has the same price with the previous pressure reducer which is US$ 8.000.

Table 4.76 CNG Pressure Reducer 3 Selection Table

Item	Value	Unit
Brand	ZMU-LOK	
Model Number	7882,78	
Parent Hole	C	
Inlet Pressure	-	psi
	-	bar
Outlet Pressure	100	psi
	6,89	bar
Intake Form	C330:CGA330	
Out of Gas Form	11:1/4" Card connector	
Price	8.000	US$

In the process of CNG handling, a compressor is needed for converting it back to gas state again, then compressed into the state of CNG. Below is the specification of selected compressor natural gas.

From table below, it can be seen that the chosen compressor is fulfilling the requirement of supply chain. Minimal inlet pressure is 2 bar. The capacity of compressor is 360 Nm3/hour. For this items price, the used price is taken from Alibaba. And the price that used in calculation is US$ 100.000.

Table 4.77 Compressor Natural Gas Selection Table

Item	Value	Unit
Model	ZW-3/2-250	
Capacity	360	Nm^3/hour
Dimension	3.150 x 1.350 x 2.350	mm
Inlet Pressure	2	bar
Outlet Pressure	250	bar
Speed	585	RPM
Installed Power	90	kW
Price	100.000	US$

The next concern in the calculation is to calculate the requirement of trucks. In this scenario, trucks have characteristic coupled with tanks. These CNG trucks is different compared to LNG trucks and its tanks. It is basically different because of the handling of LNG and CNG. For the CNG transporting can use CNG tank which is required to contain high-pressured substance, whether gas or liquid. These tanks should have characteristic of thick layer to contain high-pressure substance. From the table below, it can be seen about the selection of trucks which is going to be used for this scenario. The important aspect in this selection is the capacity of tanks, price, and the number of trucks. The selected specification of tank volume is 19,89 m3. The selected trucks specification of gas cylinder is 9 cylinders. The number of trucks that is being calculated is 29 unit. Below are the table which contain the data of power plant at Gilimanuk and the natural gas requirement. For these trucks and tanks, there are several prices that is in Alibaba. These pricing based on the similar specification and the similar price. Then the price of US$ 150.000 is taken to complete the data requirement.

Table 4.78 Trucks and Tanks Selection Table

Item	Value	Unit
Brand	CIMC	
Model	GSJ9-2210-CNG-25	
Gas Cylinder Number	9	
Overall Dimension	12.192 x 2.438 x 1.890	mm
Loading Weight	28.721	kg
Cabinet Weight	4.511	kg
Tank Volume (Payload)	19,89	m^3
Number of Trucks	29	unit
Price (each)	150.000	US$
Price Total	4.350.000	US$

In table below, it can be seen that the power of Gilimanuk powerplant is mentioned. Based from the specification gas requirement of this powerplant is 8,67 MMscfd. This value then is calculated and achieved the value of 234.000 m^3. In this powerplant, the needed gas is 936.000 cubic meters in daily consumption. Then the need of storage tank is also following the value of daily gas requirement.

Table 4.79 Gilimanuk Power Plant Data Table

Power plant		Gilimanuk	
Power plant Type		Peaker	
Type		Typical Steam Cycle	
Power		130	MW
Gas Requirement		8,67	MMscfd
		3.163,33	MMscfy
CNG	Natural Gas Consumption	234.000	M^3
	Yearly Consumption	341.640	m^3py
	Daily Consumption	936,00	m^3pd
	Hourly Consumption	39,00	m^3ph
	Total Tank Capacity	936,00	m^3

Based on the power plant specification above, CNG storage tank that will be placed in Gilimanuk Power plant can be selected. The vital specification of CNG tank are the capacity, pressure capacity, and the temperature. Table below present the selected CNG storage tank specification for this scenario. Based on the table below, it can be known the specification of storage tank. The selected storage tank has capacity of 19,89 m3. The design pressure of the tank need to comply the standard of compressed natural gas. This powerplant need 48 unit of storage tank in order to operating well. Compressed natural gas is energy source with characteristic of high-pressure which contained in pressure of 200-250 bar. In this selection, the pricing of storage tank is taken from several data that is been exist in Alibaba. By using the data of several similar data with similar price and based on assumption of the uprising price, the price of storage tank is US$ 50.000.

Table 4.80 CNG Storage Tank Selection Specification Table

Item	Value	Unit
Model	LRC series	
Brand	Luoyang Runcheng	
Material	Steel	
Storage Tank Requirement	936	m^3
Each Tank Capacity	19,89	m^3
Design Pressure	200-250	bar
Working Temperature	(-40) - 60	^oC
Number of Tank	48	unit
Total Capacity	954,72	m^3
Price (each)	50.000	US$
Price Total	2.400.000	US$

Normal working pressure of natural gas in power generation is about 6-10 bar. In this scenario, sufficient pressure reducer is needed to convert this high-pressured is three units. Table below represent the specification of first pressure reducer which can change the pressure from around 206 bar to around 34 bar. Based on the requirement of engine, pressure of compressed gas need to be reduced. From the actual pressure of CNG which is around 200 bars, the pressure need to be reduced until 6-10 bar. In order to achieve this, pressure reducer is needed. This pressure reducer being set here is also same with the previous scenario which set price US$ 8.000.

Table 4.81 CNG Pressure Reducer 1 Selection Table

Item	Value	Unit
Brand	ZMU-LOK	
Model Number	7882,78	
Parent Hole	A	
Inlet Pressure	3.000	psi
	206,8	bar
Outlet Pressure	500	psi
	34,5	bar
Intake Form	00:1/4" NPT (F)	
Out of Gas Form	00:1/4" NPT (F)	
Price	8.000	US$

After passing through the first pressure reducer, compressed natural gas is going through the second pressure reducer to reduce the pressure again to fulfil the pressure requirement. And the pressure reducer mentioned below has to reduce the pressure of natural gas from

34 bar into 17 bar. This pressure reducer is same as the previous pressure reducer which has value of price US 8.000.

Table 4.82 CNG Pressure Reducer 2 Selection Table

Item	Value	Unit
Brand	ZMU-LOK	
Model Number	7882,78	
Parent Hole	B	
Inlet Pressure	500	psi
	34,5	bar
Outlet Pressure	250	psi
	17,2	bar
Intake Form	01:1/4" NPT (M)	
Out of Gas Form	10:1/8" Card connector	
Price	8.000	US$

CNG that already passed through second pressure reducer going into third pressure reducer which can resulting CNG has the required pressure into the engine. Below is the table which present the third pressure reducer specification. In order to achieve the required pressure last pressure reducer is installed to reduce the pressure until pressure of 6 bar. The pricing of this pressure reducer is also same like the previous pressure reducer, which is US$ 8.000. this value is taken from Alibaba with some consideration of similar capacity and price with another specification and set based on assumption that result on pricing value of US$ 8.000.

Table 4.83 CNG Pressure Reducer 3 Selection Table

Item	Value	Unit
Brand	ZMU-LOK	
Model Number	7.882,78	
Parent Hole	C	
Inlet Pressure	-	psi
	-	bar
Outlet Pressure	100	psi
	6,89	bar
Intake Form	C330:CGA330	
Out of Gas Form	11:1/4" Card connector	
Price	8.000	US$

In the process of CNG handling inside the power plant, compressor needed when LNG is arrived from Bontang. It is essential to have compressor in order to convert LNG to natural gas into CNG. Below is the specification of selected compressor natural gas. The compressor chosen in order complete the requirement of scenario is selected. The vital specification of the compressor is the capacity, which already chosen around 360 Nm3/hour. Trucks of CNG handling differs with the LNG usage. For LNG, they need cryogenic tank and truck which is fit with the capacity of very low temperature. The other hand, CNG trucks and tanks need more of high-pressure characteristics in their items. Obviously for the CNG tanks, it will be layered with thicker metal that can endure high-pressured substance. In this specification selection the capacity of compressor selected is 360 Nm3/hour. And the price of this compressor is taken also from Alibaba. It is already be set based on the pricing of similar specification and similar price, the price of US$ 100.000 is chosen.

Table 4.84 Compressor Natural Gas Selection Table

Item	Value	Unit
Model	ZW-3/2-250	
Capacity	360	Nm^3/hour
Dimension	3.150 x 1.350 x 2.350	mm
Inlet Pressure	2	bar
Outlet Pressure	250	bar
Number of Compressor	2	
Speed	585	RPM
Installed Power	90	kW
Price	100.000	US$

The selected trucks for this option is mentioned in table below. From this table it is known that the volume capacity which is vital to the distribution can contain up to 19,89 m^3. The number of trucks needed in this option is 48 unit. The pricing mentioned are needed to be calculated in the economical approach. Each of the trucks price is US$ 125.000. This data taken from the mean price of the trucks in Alibaba. Based on the several similar data of specification and price, this value is chosen.

Table 4.85 Trucks and Tanks Selection Table

Item	Value	Unit
Brand	CIMC	
Model	GSJ9-2210-CNG-25	
Gas Cylinder Number	9	
Overall Dimension	12192x2438x1890	mm
Cabinet Weight	28721	kg
Loading Weight	4511	kg
Tank Volume (Payload)	19.89	m^3
Number of Truck	48	unit
Price (each)	125.000	US$
Price Total	6.000.000	US$

Below is the calculation of the economical started by capital expenditure and operational expenditure.

After the specification of items needed is complete, calculation of economical approach can be done. Below presented the summary of the capital expenditure of the items that is already chosen before. From the table below, it can be known that the initial capital expenditure is US$ 15.696.000. after obtaining this value, the total capital expenditure is needed to be calculated. The other addition of the capital expenditure is calculated to know it. The rate of tax is 25% of capital expenditure, the value of miscellaneous is about 5% of total capital expenditure and the last is the value of de-commissioning is about 10% of the capital expenditure.

Table 4.86 Capital Expenditure Table Scenario 3

Item	Unit	Price (US$)	Total Price (US$)
CNG Storage Tank	77	50.000	3.850.000
Pressure Reducer	12	8.000	96.000
Natural Gas Compressor	2	100.000	200.000
Trucks	77	150.000	1.1550.000
Total Capital Expenditure			15.696.000
Tax, Permit, etc.		25% Capex	3.924.000
Miscellaneous		5% Capex	784.800
De-commissioning		10% Capex	1.569.600
Total Capital Expenditure			21.974.400

After calculating the capital expenditure, operational expenditure based on the scenario can be calculated.in this calculation, operational expenditure which mentioned here are expenditure about vessel, fuel cost, the natural gas purchase and transport cost.

OPERATIONAL EXPENDITURE

Operational expenditure consists of the related matter to the scenario. In this scenario the operational expenditure both of sea and land fuel, LCT charter, crew cost and LNG cost. Started with the vessel calculation, the specification and calculation is presented below. The table below inform the specification of selected trucks that will transporting compressed natural gas to the powerplant. the selected trucks volume is 24,5 m3. After the specification of trucks is acquired, allocation time of transport can be calculated and the operational cost can be estimated.

Table 4.87 Vessel Specification Table Scenario 3

Vessel	Trucks	
Brand	Sinotrucks	
LNG Volume	24,5	m^3
Weight	50	ton
Price	200.000	US$
Avg. Speed	50	km/h
Fuel Consumption	0,3	l/km
	0,2496	kg/m

Below are table of allocation time during the operational time. Time allocation is needed to calculate the time related to the period of process. Necessary time delay for example loading and unloading time, slack time used to sharpen the calculation of the economical matter. The other thing, project period is considered the range time to the project to have big chance to make big income.

Table 4.88 Allocation Time Table Scenario 3

Allocation Time	Value	Time
Loading/Unloading time	0,0625	day
	0,0625	day
Total time	0,125	day
Slack time	0,063	day
Period	10	year

Below is listed information that is known and set as condition for calculating the operational expenditure. The price of fuel ship which mentioned and calculated below is one condition that is stated to be an assumption based on the current price of fuel in Indonesia. The used price of fuel is based on the updated price of fuel in the nation. The density of fuel is also needed to be calculated as it is important to know the volume needed.

Fuel Cost

Diesel Fuel = 7.900 IDR/l

Diesel Fuel = 0,5642857 US$/l

Diesel Fuel Ship = 700 US$/ton

Density Diesel Fuel = 0,832 kg/l

Below is the distance that will be used to calculate the fuel cost in aspect of distance between the natural gas source and the destination. This data is taken from googlemaps.com. Fuel consumption that is being mentioned below, is being obtained by multiplying fuel consumption (l/km) to the distance. From the calculation below, it can be seen that the trip duration value is obtained from dividing the value of 28 km by average speed and 24, for daily period. And for the fuel consumption, the result can be obtained by multiplying the value of distance and the value of fuel consumption per kilometer.

Land Transport

Celukan Bawang – Pemaron	= 28 km
Trip Duration	= 0,0233 day
Fuel Consumption	= 8,4 l/trip
Celukan Bawang – Gilimanuk	= 56 km
Trip Duration	= 0,0466 day
Fuel Consumption	= 16,8 l/trip

Below are table that represent the vessel specification that will be used to transport LNG from Bontang to Benoa. In table below, there are selected vessel that will be used in the scenario. The most vital aspect of LNG vessel selection in this bachelor thesis are the speed, capacity, fuel consumption and the charter price. Speed is used to calculate the trip duration in which LCT going through. Price is vital to be the base information of economical approach.

Table 4.89 Vessel Specification Table Scenario 3

Vessel	LCT 300ft	LCT 200ft	Unit
Loa	97,83	61,6	m
Breadth	19,8	12,29	m
Draft	5,75	3,2	m
Vs	8	8	knot
FO consumption	5,2	4	ton/day
	6.250	4.807,69	l/day
Load Cap	60	36	m^3
Number of LCT	9	1	
Charter Price	2.250	1.982	US$/day

The next important aspect is the distance, trip duration Below is the information that is already been taken from seadistance.org. In the listed calculation below, it can be seen that every factors here is related one another. The cost of fuel calculated by the fuel consumption multiplied by number of vessel, trip duration, fuel price and the value of 2 for the round trip. The annual fuel cost is calculated by 365 divided by 2 that already multiplied by trip duration, then multiplied with fuel cost. And as for charter cost it is counted for every day and will be calculated in annual period. As well the port cost, which the only different is the duration that is needed when the ship is in port.

Distance Bontang – Celukan Bawang = 543 nm

Trip Duration = 2,83 day

Fuel Cost (US/RT) = 216.666

Fuel Cost (US/year) = 13.972.277,39

Charter Cost (US$/day) = 22.232

Charter Cost (US$/year) =8.114.680

Port Cost (US$/RT) = 6.300

Port Cost (US$/year) = 383.250

Below listed the Operational Expenditure that may be got from doing the project. In the table below, there are aspect that is mentioned that will complete the requirement of the economic calculation later. In the table below, there are the listed operational expenditures in this scenario. This calculation is based on the condition of LNG which is transported from Bontang to Benoa. The listed expenditure is fuel cost of trucks that used to transport natural gas in Bali, crew cost of the distribution in Bali, LNG purchasing from Bontang, LNG transport cost by the sea. The scenario operational expenditure is calculated and obtaining the value of total operational expenditure which has value of US$ 24.530.666,4.

Table 4.90 Operational Expenditure Total Scenario 3

Powerplant Name	LNG Consumption (m^3)	LNG Trucks Amount	Transport Time (day)	Fuel Consumption (trip)	Round Trip (day)
Pemaron	576	29	0,023333	8,4	0,047
Gilimanuk	936	48	0,04667	16,8	0,093

Fuel Cost (/RT) (US$)	Fuel Cost (/Year) (US$)	Crew Cost (US$) (/year)	LNG Cost (US$)	LNG Transport Cost (US$) (/year)	Total Operation Expenditure (US$)
6,4	50.172,9	1.735.800	41.293,91	22.470.207,39	24.530.666,4
42,5	166.089,6		67.102,61		

After obtaining the value of capital expenditure and operational expenditure, the calculation of economical result can be done. Below economic analysis is represented by calculating the NPV, IRR, PP and ROI. From table below, it can be known that the capital expenditure of scenario 3 is US$ 19.279.400. Bigger than the value of capital expenditure, operational expenditure has cost about US$ 23.593.384. In the future the value of operational expenditure can be increased caused by the value of inflation.

Table 4.91 Economic Analysis Table Scenario 3

Investment	Unit	Price (US$)
Capex	set	19.279.400
Total		19,279,400
Opex	set	23.593.384
Total		23.593.384

Below is already presented input data table for scenario 3 which is has function to gives required information that is will be used as the material for calculating the economical approach. Table below consist the input data that will be used later in this bachelor thesis. The duration of this project is set to be 10 years. Salvage value and disposal value is one aspect that is considered in the calculation of economic. In this scenario the value of salvage is calculated US$ 16.480.800. this salvage value is obtained by reducing the value of capital expenditure by the value of total depreciation. Yearly depreciation is obtained by multiplying the depreciation percentage with the capital expenditure. Then, the disposal value of the scenario is obtained by reducing the value of salvage value by the value of total depreciation

Table 4.92 Input Data Table Scenario 3

Item	Value
Contract Duration (year)	10
Total Investment (US$)	21.974.400
Salvage value (US$)	16.480.800
Disposal Price (US$)	10.987.200
Yearly Depreciation (US$)	549.360

After that, the value of revenue is being calculated in order to know the income to get the profit. From the table below, table of revenue of scenario 3, it can be known that the gas that will be processed yearly is 5.110.000 MMbtu. Multiplied by margin US$ 4, US$ 5, and US$ 6, it can be calculated the revenue of table is each of them US$ 20.440.000, US$ 25.550.000, US$ 30.660.000.

Table 4.93 Revenue Table Scenario 3

Item	Unit	Value
Daily Gas Processed	MMbtu	14.000
Yearly Gas Processed	MMbtu	5.110.000
Income from LNG selling	**Margin**	**Total**
	4	20.440.000
	5	25.550.000
	6	30.660.000

The value of depreciation is mentioned below. This value is vital to complete the calculation of economic approach. From table below information that can be retrieved are the percentage and depreciation value. The percentage that is used here is 2,5%. This value is stated under the consideration that is being stated which depreciation value is around 2-2,5% of total capital expenditure.

Table 4.94 Depreciation Table Scenario 3

Year	Capex	Percentage	Depreciation
0	19.279.400	2,50%	
1		2,50%	481.985
2		2,50%	481.985
3		2,50%	481.985
4		2,50%	481.985
5		2,50%	481.985
6		2,50%	481.985
7		2,50%	481.985
8		2,50%	481.985
9		2,50%	481.985
10		2,50%	481.985
Total			4.819.850
Asset Value			14.459.550

The next step is to calculated the economical approach. In this occasion the calculated value is earning before tax, tax, earning after tax, proceed, cumulative proceed and investment state. The previous value are capital expenditure, revenue, operational expenditure and depreciation which are already calculated from the previous table. Based on the table below, it can be seen that the calculation of economical approach has a lot of factors. The table below consist of some aspect that is already obtained from previous calculation or table. The known aspect is the capital expenditure, operational expenditure, depreciation, and revenue of the project. Other than them, there are the calculated aspect in the economic approach. These are earning before tax, tax, earning after tax, proceed (cash flow), cumulative proceed, and investment state is being calculated here. The aspect of earning before tax is obtained by reducing revenue by operational expenditure and depreciation. Tax is one factors that affects the result of the economic state. Earning that will be calculated to be cash flow need to be reduced first by tax. After that, the next step is to calculate the value of proceed. Proceed value can be obtained by adding the value of depreciation and the value of earning after tax. The cumulative proceed is the value of the total of proceed from previous year added with the proceed value of current year. Investment state inform the value of the current year. It means the positive or negative status. Investment state is the condition which the current debt or the current profit.

Table 4.95 Economical Calculation Scenario 3 Margin US$ 4 (US$)

Year	CAPEX	Revenue	OPEX	Depreciation	EBT	Tax 25%	EAT	Proceeds	Cum Proceed	Investment State
0	**19.279.400**				-	-	-	-	-	-19.279.400
1		20.440.000	23.593.385	481.985	-3.635.370	-908.842	-2.726.527	-2.244.542	-2.244.542	-21.523.942
2		20.440.000	23.711.352	481.985	-3.753.337	-938.334	-2.815.002	-2.333.017	-4.577.560	-23.856.960
3		20.440.000	23.829.908	481.985	-3.871.893	-967.973	-2.903.920	-2.421.935	-6.999.495	-26.278.895
4		20.440.000	23.949.058	481.985	-3.991.043	-997.761	-2.993.282	-2.511.297	-9.510.792	-28.790.192
5		20.440.000	24.068.803	481.985	-4.110.788	-1.027.697	-3.083.091	-2.601.106	-12.111.898	-31.391.298
6		20.440.000	24.189.147	481.985	-4.231.132	-1.057.783	-3.173.349	-2.691.364	-14.803.262	-34.082.662
7		20.440.000	24.310.093	481.985	-4.352.078	-1.088.019	-3.264.058	-2.782.073	-17.585.336	-36.864.736
8		20.440.000	24.431.643	481.985	-4.473.628	-1.118.407	-3.355.221	-2.873.236	-20.458.572	-39.737.972
9		20.440.000	24.553.802	481.985	-4.595.787	-1.148.947	-3.446.840	-2.964.855	-23.423.427	-42.702.827
10		20.440.000	24.676.571	481.985	-4.718.556	-1.179.639	-3.538.917	-3.056.932	-26.480.359	-45.759.759

After the calculation is done, payback period can be represented by graph below. Graph of payback can represent the characteristic of the payback period of third scenario. The graph is given below. From the graph below, information that can be learn that the payback period is impossible to achieve. The graph is decreasing and not giving any sign of going up. This means the scenario with margin US$ 4 is not feasible to be implemented.

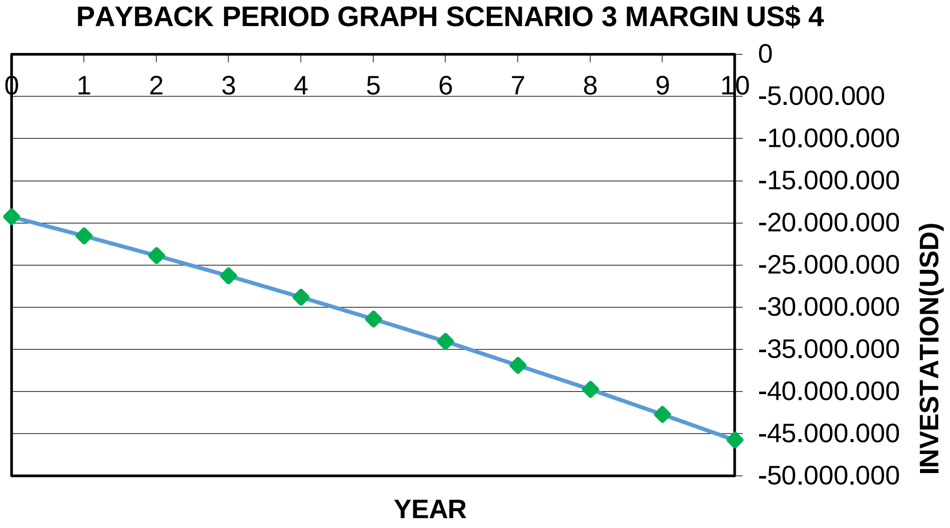

Figure 4.17 Payback Period Graph Scenario 3 Margin US$ 4

After that, discount rate, cash flow and NPV is calculated. The value of cash flow and NPV is calculated based on the value of the discount rate. The discount rate here using the value of 10%. This means the discount rate of the scenario is 10%. Discount rate will be multiplied by the year period in order to achieve the value of net present value. From the table below, it can be known that cash flow of the scenario with margin US$ 4 is US$ -26.480.359. Total NPV of the scenario with this margin is US$ -35.121.176,31.

Table 4.96 Discount Rate, Cash Flow and NPV Scenario 3 Margin US$ 4

Year	**i**	**Cash flow Disc.**	**NPV**
	10.00%		
0	1	-19.279.400	$ -19.279.400,00
1	0,909090909	- 2.244.542	- 2.040.493
2	0,826446281	- 2.333.017	- 1.928.114
3	0,751314801	- 2.421.935	- 1.819.636
4	0,683013455	- 2.511.297	- 1.715.250
5	0,620921323	- 2.601.106	- 1.615.082
6	0,56447393	- 2.691.364	- 1.519.205
7	0,513158118	- 2.782.073	- 1.427.644
8	0,46650738	- 2.873.236	- 1.340.386
9	0,424097618	- 2.964.855	- 1.257.388
10	0,385543289	- 3.056.932	- 1.178.580
Total		- 26.480.359	$ -35.121.176,31

The next step is to calculate the value of the interest rate of return, payback period and the value return of interest. From the result table of scenario 3 margin US$ 4 below, it can be seen the NPV of scenario 3 using margin US$ 4 is US$ - 35.121.176. From the point of interest rate of return it has very low IRR until it is negated. Based on the calculation, this project cannot make payback because the project is in deficit state. This option has ROI value of -14%.

Table 4.97 Result Table Scenario 3 Margin US$ 4

i	NPV	IRR	PP	ROI
10.00%	$(35.121.176)	-	-7,0	-14%

After calculating the result of the scenario with margin US$ 4, the next calculation is to calculate the economic approach. This economic approach is calculating the value earning before tax, tax, earning after tax, proceed, cumulative proceed and investment state. This calculation is being presented by table below. In the table of economical approach below, it can be seen that calculation of the economical approach of the third scenario is already done. There are aspects that is already been obtained before. These aspects are the capital expenditure, operational expenditure, depreciation and the revenue value. Others than that, value of earning before tax, tax, earning after tax, proceed, cumulative proceed and the investment state will be calculated. The aspect of earning before tax can be obtained by reducing the value of revenue by operational expenditure and depreciation. Tax is one factor that is considered for calculating the real value of cash flow. Earning after tax is earning that is calculated by reducing EBT with tax. Then, proceed can be obtained by adding depreciation to the value of the EAT. Cumulative proceed is the value of proceed which is already cumulated from the previous year of the project. Investment state is the condition which the current debt or the current profit.

Table 4.98 Economical Calculation Scenario 3 Margin US$ 5 (US$)

Year	CAPEX	Revenue	OPEX	Depreciation	EBT	Tax 25 %	EAT	Proceeds	Cum Proceed	Investment State
0	**19.279.400**				-	-	-	-	-	-19.279.400
1		25.550.000	23.593.385	481.985	1.474.630	368.658	1.105.973	1.587.958	1.587.958	-17.691.442
2		25.550.000	23.711.352	481.985	1.356.663	339.166	1.017.498	1.499.483	3.087.440	-16.191.960
3		25.550.000	23.829.908	481.985	1.238.107	309.527	928.580	1.410.565	4.498.005	-14.781.395
4		25.550.000	23.949.058	481.985	1.118.957	279.739	839.218	1.321.203	5.819.208	-13.460.192

Table extension from table 4.98

Year	CAPEX	Revenue	OPEX	Depreciation	EBT	Tax	EAT	Proceeds	Cum Proceed	Investment State
5		25.550.000	24.068.803	481.985	999.212	249.803	749.409	1.231.394	7.050.602	-12.228.798
6		25.550.000	24.189.147	481.985	878.868	219.717	659.151	1.141.136	8.191.738	-11.087.662
7		25.550.000	24.310.093	481.985	757.922	189.481	568.442	1.050.427	9.242.164	-10.037.236
8		25.550.000	24.431.643	481.985	636.372	159.093	477.279	959.264	10.201.428	-9.077.972
9		25.550.000	24.553.802	481.985	514.213	128.553	385.660	867.645	11.069.073	-8.210.327
10		25.550.000	24.676.571	481.985	391.444	97.861	293.583	775.568	11.844.641	-7.434.759

After the calculation is done, payback period can be represented by graph below. The value of payback already been calculated before and will be represented in the graph below. From the graph below, information that can be obtained that the payback period in this option is increasing which is good for the project. But the time to overcome the investment in the beginning, around 15,6 years needed to be overcome the expenditure. In this option, this is may be not the best option exist there. Because the period of payback is over the contract duration of the projec

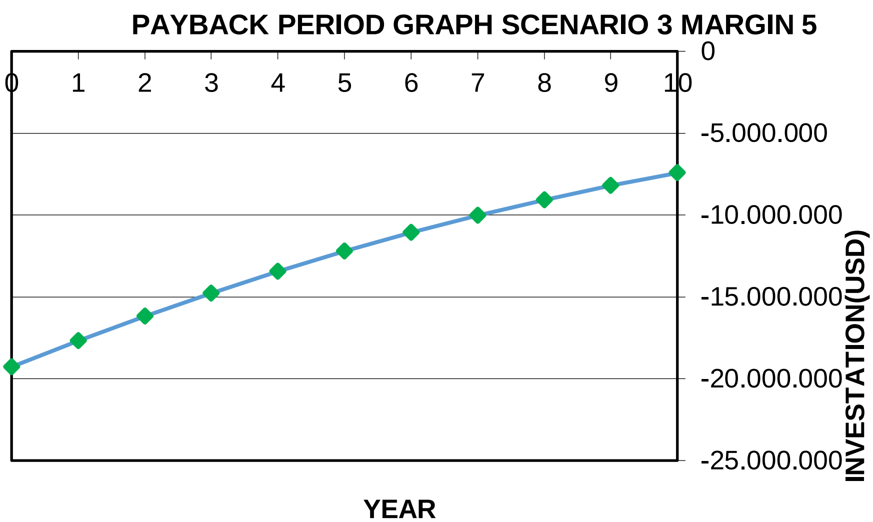

Figure 4.18 Payback Period Graph Scenario 3 Margin US$ 5

After discussing about the payback period graph above, the next step is to calculate the value of cash flow and net present value of the current option. By using the discount rate of 10%, the calculation has been made up. From the table below, it can be interpreted that total cash flow is positive with value of US$ 11.844.641. And the NPV of this scenario with margin US$ is US$ -11.572.122. The result which is informing the net present value has negative value, this means the project is not profitable.

Table 4.99 Discount Rate, Cash Flow and Table Scenario 3 Margin US$ 5

Year	**i**	**Cashflow Disc.**	**NPV**
	10.00%		
0	1	-19.279.400	$ -19.279.400,00
1	0,909090909	1.587.958	1.443.598
2	0,826446281	1.499.483	1.239.242
3	0,751314801	1.410.565	1.059.778
4	0,683013455	1.321.203	902.399
5	0,620921323	1.231.394	764.599
6	0,56447393	1.141.136	644.141
7	0,513158118	1.050.427	539.035
8	0,46650738	959.264	447.504
9	0,424097618	867.645	367.966
10	0,385543289	775.568	299.015
Total		11.844.641	$ -11.572.122,87

Then, the result which is being calculated is been completed in the table below. Table below represent the value of interest rate of return, payback period and return of investment. From the result table of scenario 3 margin US$ 5 below, it can be seen the NPV of scenario 3 using margin US$ 5 is US$ - 11.572.123. From the point of interest rate of return it has very low IRR until it is negated, with the value of -9%. Based on the calculation, this project can make the payback in 15,6 years. This option has ROI value of 6%. These value show that the profitability of these scenario with margin of US$ 5 is low. It can be known from the negative result of interest rate of return and net present value. The payback period is taking so much time its over than the contract duration. The last, the rate of return of investment is low by the value of 6% only.

Table 4.100 Result Table Scenario 3 Margin US$ 5

i	**NPV**	**IRR**	**PP**	**ROI**
10.00%	$(11.572.123)	-9%	15,6	6%

After the calculation of scenario 3 with margin US$ 5, the next step is to know the economical approach on scenario 3 with margin US$ 6. The economical calculation is being presented by table below. From the table of economical approach below, it can be seen that calculation of the economical approach of the third scenario is already done. Calculation started from the capital expenditure, revenue, operational expenditure, depreciation, earning before tax, tax, earning after tax, proceed (cash flow), cumulative proceed, and investment state. Capital expenditure, revenue, operational expenditure, depreciation is obtained from previous calculation. The aspect of earning before tax is obtained by reducing revenue by operational expenditure and depreciation. The value of tax is one factor that is considered for calculating the real value of cash flow. Even though the value is minor, but this is required for getting the real result of the economical approach. Earning after tax is earning / income that is obtained by reducing EBT with tax. Then, proceed can be obtained by adding depreciation to the value of the EAT. Cumulative proceed is the proceed which is already cumulated from the previous year of the project. Investment state is the condition which the current debt or the current profit. All of the elements will have different value one another.

Table 4.101 Economical Calculation Scenario 3 Margin US$ 6 (US$)

Year	CAPEX	Revenue	OPEX	Depreciation	EBT	Tax 25%	EAT	Proceeds	Cum Proceed	Investment State
0	**19.279.400**				-	-	-	-	-	-19.279.400
1		30.660.000	23.593.385	481.985	6.584.630	1.646.158	4.938.473	5.420.458	5.420.458	-13.858.942
2		30.660.000	23.711.352	481.985	6.466.663	1.616.666	4.849.998	5.331.983	10.752.440	-8.526.960
3		30.660.000	23.829.908	481.985	6.348.107	1.587.027	4.761.080	5.243.065	15.995.505	-3.283.895
4		30.660.000	23.949.058	481.985	6.228.957	1.557.239	4.671.718	5.153.703	21.149.208	1.869.808
5		30.660.000	24.068.803	481.985	6.109.212	1.527.303	4.581.909	5.063.894	26.213.102	6.933.702
6		30.660.000	24.189.147	481.985	5.988.868	1.497.217	4.491.651	4.973.636	31.186.738	11.907.338
7		30.660.000	24.310.093	481.985	5.867.922	1.466.981	4.400.942	4.882.927	36.069.664	16.790.264
8		30.660.000	24.431.643	481.985	5.746.372	1.436.593	4.309.779	4.791.764	40.861.428	21.582.028
9		30.660.000	24.553.802	481.985	5.624.213	1.406.053	4.218.160	4.700.145	45.561.573	26.282.173
10		30.660.000	24.676.571	481.985	5.501.444	1.375.361	4.126.083	4.608.068	50.169.641	30.890.241

After the calculation is done, payback period can be represented by graph below. The characteristic of the payback period can be known by analyzing the graph below. From the figure of payback period graph below, it can be seen the graph is increasing from the first year. And this graph is already positive across

3,7 years. It only need 3,7 years for the project to have pure income. This period considered very fast in term of the similar project. This is caused by the high value of margin.

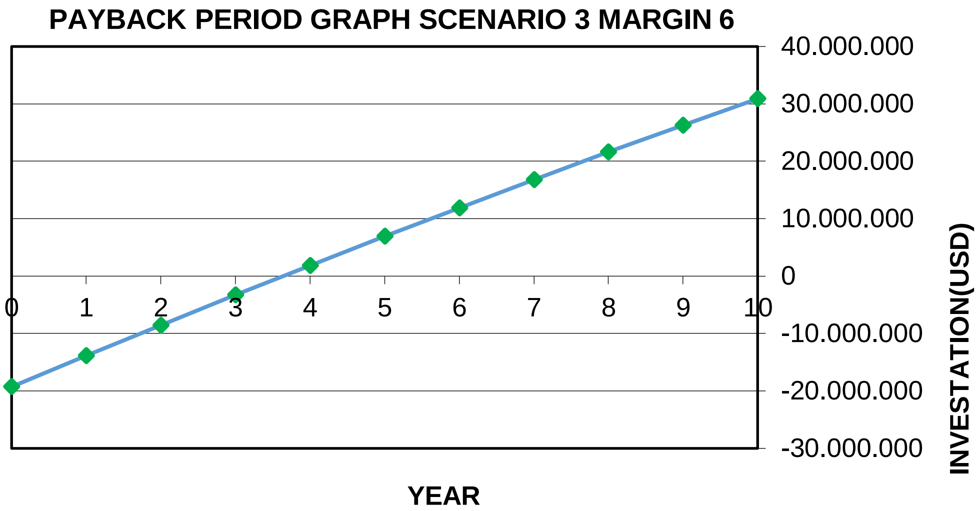

Figure 4.19 Payback Period Graph Scenario 3 Margin US$ 6

After analyzing the graph of payback period, there is next step which calculating the cash flow and value of net present value. The discount rate which is used to calculate the cash flow and net present value is as big as 10%. Shown in the table below, by using I with value 10%, cash flow that is acquired by the end of the 10 year is US$ 50.169.641. Then, the value of NPV of this scenario using margin US$ 6 is US$ 11.976.930,56. This value is great considering the value of total cash flow and the net present value.

Table 4.102 Discount Rate, Cash Flow and Scenario 3 Margin US$ 6

Year	i	Cash flow Disc.	NPV
	10.00%		
0	1	-19.279.400	$-19.279.400,00
1	0,909090909	5.420.458	4.927.689
2	0,826446281	5.331.983	4.406.597
3	0,751314801	5.243.065	3.939.192
4	0,683013455	5.153.703	3.520.048
5	0,620921323	5.063.894	3.144.280
6	0,56447393	4.973.636	2.807.488
7	0,513158118	4.882.927	2.505.713
8	0,46650738	4.791.764	2.235.393
9	0,424097618	4.700.145	1.993.320
10	0,385543289	4.608.068	1.776.610
Total		50.169.641	$ 11.976.930,56

After calculating the cash flow and net present value, the next step to be calculated is the result of the scenario. The result table which presenting the result of last scenario with margin US$ 6 is below. From the information in result table of scenario 3 margin US$ 6 below, it can be seen the NPV of scenario 3 using margin US$ 6 is US$ 11.976.931. And from the point of interest rate of return it has value of 24%. Also based on the result of calculation, this project can make the payback in only 3,7 years. And the ROI of this option has value of 26%. These values are high and this is very good for the project income. But the condition if margin is very high. This may affecting on the low purchasing of the gas. This option is not feasible for the natural gas sale in the market.

Table 4.103 Result Table Scenario 3 Margin US$ 6

i	NPV	IRR	PP	ROI
10.00%	$ 11.976.931	24%	3,7	26%

After analyzing the table of result, the next is to analyzing the graph of payback period in scenario 3. From the previous explanation, it can be seen that with the bigger margin, the payback become faster to have the profit. But it may be not feasible in other aspect. From the figure below, which contain 3 graph of payback period among the scenario 3, it can be seen the characteristic of the condition of this scenario. By using margin US$ 4, the project will not giving any profit to the practicee. By using margin US$ 5, the graph is better, but it will need very long time of start of making net profit. The most profitable option is by using margin of US$ 6. By around 3,7 year, this project already making net profit.

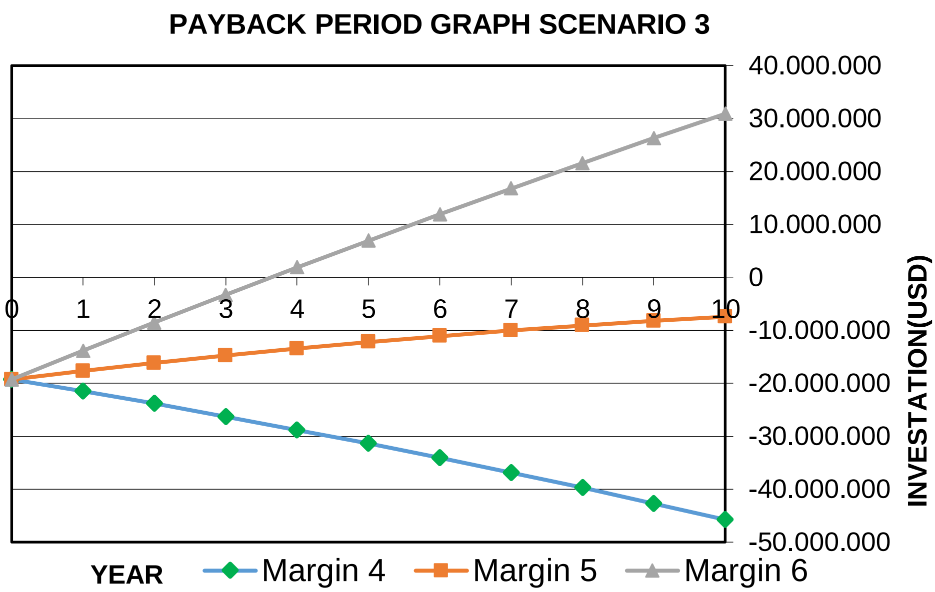

Figure 4.20 Payback Period Graph Scenario 3

After analyzing the payback period graph the next step is to analyze the net present value graph. The graphs is presented below. Also from the figure below, it can be seen the graph of net present value of the project that is compared between margin US$ 4, margin US$ 5 and margin US$ 6. Shown in this graph that during the tenth year of operation, the option that is still in positive result is the one with margin US$ 6. For the margin US$ 5 is almost zero in the tenth year duration. And the last is the margin of US$ 4. This margin is not feasible at all caused by the profitability of the scenario is already negative from the beginning.

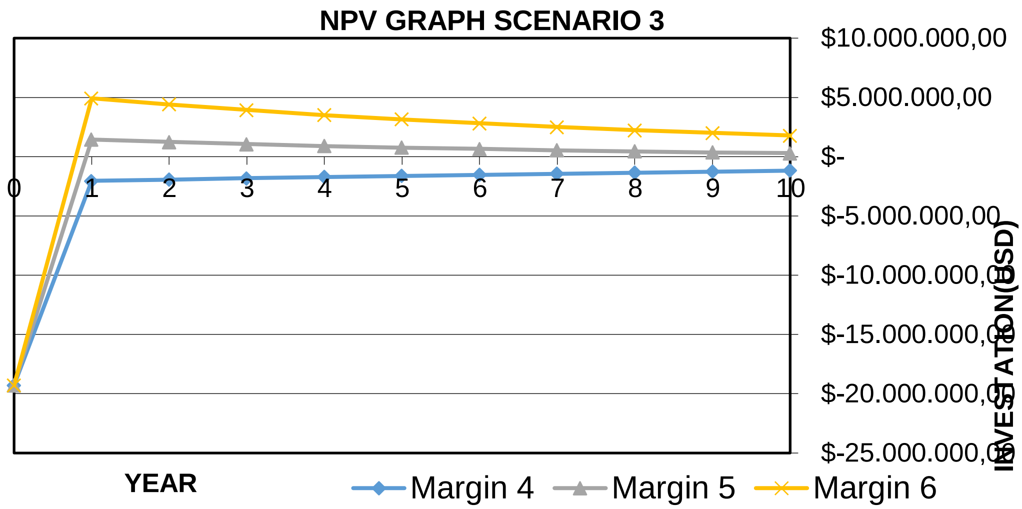

Figure 4.21 NPV Graph Scenario 3

By the representive of the graph of scenario 3, the calculation of three scenario is done. From the calculation, it will be presented in form of table. Table below represent the final result of this final project. From this table also can be concluded which is the best option between the existing scenario and income margin. It is known from the tables that there are several option that is has good result represented by the positive value of the payback period. From these statement, the possible result to be the best are the scenario 1 with margin US$ 5 and 6, scenario 2 with margin US$ 5 and 6, and the scenario 3 with margin US$ 5 and 6. Among these option there are option that is not feasible caused by the very low value of IRR which is eliminating the option of scenario 2 with margin US$ 5 and scenario 3 with margin US$ 6. Then, to choose the best option between the profitable option, the most feasible option must be chosen. In this state, the usage of margin US$ 6 is too high in the term of natural gas industry. By the status of high margin will result on the the unsellable natural gas in the industry. The option which using margin US$ 6 is good in term of payback period if the natural gas is able to be sold, but in the actual condition it may not be easy to sell the high-priced natural gas. Then the last option that is feasible to be the best choice in this project is using scenario1 with margin US$ 5.

Table 4.104 Summary of All Scenario Calculation

Scenario	Margin (US$)	NPV (US$)	IRR (%)	PBP (year)	ROI (%)
1	4	-21447990,84	-	-5	-18
	5	2101062,59	15	4,9	19
	6	25650116,02	58	1,7	56
2	4	-33986353,22	-	-7,5	-13
	5	-10437299,79	-6	13,5	7
	6	13111753,64	25	3,6	27
3	4	-35121176,30	-	-7	-14
	5	-11572122,87	-9	15,6	6
	6	11976930,55	24	3,7	26

And the final result of this bachelor thesis is obtained. The best option from existing scenario and stated margin, is the option of scenario 1 with margin of US$ 5. In this option, the payback period is positive and has the best interest rate of return and return of investment condition. The other side, this is also has the most feasible result compared with the other profiting option. The options with margin of US$ 6 is not feasible caused by the high price of the natural gas.

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CHAPTER V CONCLUSION

In this chapter, there will be conclusion and suggestion that will be act as the answer of the research problem and the achievement for the research objective. Conclusion will act as the answer of the research problem and research objectives. And the suggestion is one part that can be media to improve the future research or another study.

5.1. Conclusion

From this this bachelor thesis, it can be concluded that:

1. The best type of load power plant for Pemaron and Gilimanuk Power plant is Peaker type of power plants. Because the current condition, Pemaron and Gilimanuk Power plants still being an unproductive power plant, caused by cheaper and simpler other power plants which has bigger profit at operational process. Peaker act as back up when electrical demand is higher caused by higher load, for example the night time.
2. From the calculation of economical approach, it can be seen that the only option that is getting positive result (positive net present value and interest rate of return) are:
    a. Scenario 1 margin US$ 5
    b. Scenario 1 margin US$ 6
    c. Scenario 2 margin US$ 6
    d. Scenario 3 margin US$ 6

    Between these results, it can be seen the most positive result is in scenario 1 which is using liquefied natural gas. Liquefied natural gas is better than compressed natural gas.
3. From the calculation of economical approach also, the best option of scenario can be decided. From the scenarios that giving profit are:
    a. Scenario 1, using LCT to transport LNG from Bontang to Benoa, using trucks from Benoa to Gilimanuk and Pemaron with margin 5 US$

    b. Scenario 1, using LCT to transport LNG from Bontang to Benoa, using trucks to transport LNG from Benoa to Gilimanuk and Pemaron with margin 6 US$

    c. Scenario 2, using LCT to transport LNG from Bontang to Benoa, using trucks to transport CNG from Benoa to Gilimanuk and Pemaron with margin 6 US$

    d. Scenario 3, using LCT to transport LNG from Bontang to Celukan Bawang, using trucks to transport CNG from Celukan Bawang to Gilimanuk and Pemaron with margin 6 US$

From these four scenario, chosen that is Scenario 1 with Margin US$ 5 is the best option among the profitable result. This scenario using LNG as main source energy and distributed by LCT and trucks. Even though, the other scenario can give much shorter payback period time, scenario 1 margin US$ 5 is the most realistic option. Compared to other option, the other option will need high ratio of natural gas price, which can result on the expensive price of natural gas.

5.2. Suggestion

This bachelor thesis may be finished here. But the future development need to be continuously updated and upgraded. Suggestion that can be a help are:

1. Other research being done in similar approach in other location to improve the usage of natural gas and decrease the pollution to environment.
2. The calculation can be improved by using more realistic value and more realistic scheme that fit the actual condition.

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ATTACHMENTS

Attachment 1

CREW COST EXPENDITURES

Scenario 1

Crew Expenditure (Salary)

Crew Expenditure (Salary)					
Scenario 1					
No	Position	Crew	Salary	Per Month	Per Year
1	Head of Operation	1	1400	1400	16800
2	Storage Master	2	1000	2000	24000
3	Storage Personnel	4	650	2600	31200
4	Loading Master	2	1000	2000	24000
5	Loading Personnel	6	650	3900	46800
6	Discharge Master	2	1000	2000	24000
7	Discharge Personnel	4	650	2600	31200
8	Driver	46	600	27600	331200
9	MT. Master	2	1000	2000	24000
10	MT. Personnel	4	650	2600	31200
11	Compressor Master	2	1000	2000	24000
12	Compressor Personnel	4	650	2600	31200
13	Vaporizer Master	2	1000	2000	24000
14	Vaporizer Personnel	4	650	2600	31200
15	Pump Master	2	1000	2000	24000
16	Pump Personnel	4	650	2600	31200
Total		91		62500	750000

Crew Expenditure (Assurance)

Crew Expenditure (Assurance)			
Scenario 1			
No	Position	Crew	Asurance /year (US$)
1	Head of Operation	1	2000
2	Storage Master	2	2800
3	Storage Personnel	4	3800
4	Loading Master	2	2800
5	Loading Personnel	4	3800
6	Discharge Master	2	2800
7	Discharge Personnel	4	3800
8	Driver	46	39100
9	MT. Master	2	2800
10	MT. Personnel	4	3800
11	Compressor Master	2	2800
12	Compressor Personnel	4	3800
13	Vaporizer Master	2	2800
14	Vaporizer Personnel	4	3800
15	Pump Master	2	2800
16	Pump Personnel	4	3800
Total		89	87300

Crew Expenditure (Accomodation)

Crew Expenditure (Accomodation)			
Scenario 1			
No	Position	Crew	Accomodation /year (US$)
1	Head of Operation	1	1600
2	Storage Master	2	2200
3	Storage Personnel	4	2800
4	Loading Master	2	2200
5	Loading Personnel	4	2800
6	Discharge Master	2	2200
7	Discharge Personnel	4	2800
8	Driver	46	25300
9	MT. Master	2	2200
10	MT. Personnel	4	2800
11	Compressor Master	2	2200
12	Compressor Personnel	4	2800
13	Vaporizer Master	2	2200
14	Vaporizer Personnel	4	2800
15	Pump Master	2	2200
16	Pump Personnel	4	2800
Total		89	61900

Summary of crew cost

Total Crew Cost (/Year)			
1	Salary (US$)	750000	
2	Assurance (US$)	87300	
3	Accomodation (US)	61900	
Total		899200	

Scenario 2

Crew Expenditure (Salary)

	Crew Expenditure (Salary)				
	Scenario 2				
No	Position	Crew	Salary	Per	Per Year
1	Head of Operation	1	1400	1400	16800
2	Storage Master	2	1000	2000	24000
3	Storage Personnel	4	650	2600	31200
4	Loading Master	2	1000	2000	24000
5	Loading Personnel	4	650	2600	31200
6	Discharge Master	2	1000	2000	24000
7	Discharge Personnel	4	650	2600	31200
8	Driver	144	600	86400	1036800
9	MT. Master	2	1000	2000	24000
10	MT. Personnel	4	650	2600	31200
11	Compressor Master	2	1000	2000	24000
12	Compressor Personnel	4	650	2600	31200
13	Vaporizer Master	2	1000	2000	24000
14	Vaporizer Personnel	4	650	2600	31200
15	Pump Master	2	1000	2000	24000
16	Pump Personnel	4	650	2600	31200
	Total	187		120000	1440000

Crew Expenditure (Assurance)

Crew Expenditure (Assurance)			
Scenario 2			
No	Position	Crew	Asurance /year (US$)
1	Head of Operation	1	2000
2	Storage Master	2	2800
3	Storage Personnel	4	3800
4	Loading Master	2	2800
5	Loading Personnel	4	3800
6	Discharge Master	2	2800
7	Discharge Personnel	4	3800
8	Driver	144	122400
9	MT. Master	2	2800
10	MT. Personnel	4	3800
11	Compressor Master	2	2800
12	Compressor Personnel	4	3800
13	Vaporizer Master	2	2800
14	Vaporizer Personnel	4	3800
15	Pump Master	2	2800
16	Pump Personnel	4	3800
Total		187	170600

Crew Expenditure (Accomodation)

Crew Expenditure (Accomodation)			
Scenario 2			
No	Position	Crew	Accomodation /year (US$)
1	Head of Operation	1	1600
2	Storage Master	2	2200
3	Storage Personnel	4	2800
4	Loading Master	2	2200
5	Loading Personnel	4	2800
6	Discharge Master	2	2200
7	Discharge Personnel	4	2800
8	Driver	144	79200
9	MT. Master	2	2200
10	MT. Personnel	4	2800
11	Compressor Master	2	2200
12	Compressor Personnel	4	2800
13	Vaporizer Master	2	2200
14	Vaporizer Personnel	4	2800
15	Pump Master	2	2200
16	Pump Personnel	4	2800
Total		187	115800

Summary of crew cost

Total Crew Cost (/Year)			
1	Salary (US$)	1440000	
2	Assurance (US$)	170600	
3	Accomodation (US)	115800	
Total		1726400	

Scenario 3

Crew Expenditure (Salary)

	Crew Expenditure (Salary)				
	Scenario 3				
No	Position	Crew	Salary	Per	Per Year
1	Head of Operation	1	1400	1400	16800
2	Storage Master	2	1000	2000	24000
3	Storage Personnel	4	650	2600	31200
4	Loading Master	2	1000	2000	24000
5	Loading Personnel	4	650	2600	31200
6	Discharge Master	2	1000	2000	24000
7	Discharge Personne	4	650	2600	31200
8	Driver	144	600	86400	1036800
9	MT. Master	2	1000	2000	24000
10	MT. Personnel	4	650	2600	31200
11	Compressor Master	2	1000	2000	24000
12	Compressor Person	4	650	2600	31200
13	Vaporizer Master	2	1000	2000	24000
14	Vaporizer Personne	4	650	2600	31200
15	Pump Master	2	1000	2000	24000
16	Pump Personnel	4	650	2600	31200
Total		187		120000	1440000

Crew Expenditure (Assurance)

	Crew Expenditure (Assurance)		
	Scenario 3		
No	Position	Crew	Asurance /year (US$)
1	Head of Operation	1	2000
2	Storage Master	2	2800
3	Storage Personnel	4	3800
4	Loading Master	2	2800
5	Loading Personnel	4	3800
6	Discharge Master	2	2800
7	Discharge Personne	4	3800
8	Driver	144	122400
9	MT. Master	2	2800
10	MT. Personnel	4	3800
11	Compressor Master	2	2800
12	Compressor Personn	4	3800
13	Vaporizer Master	2	2800
14	Vaporizer Personnel	4	3800
15	Pump Master	2	2800
16	Pump Personnel	4	3800
Total		187	170600

Crew Expenditure (Accomodation)

Crew Expenditure (Accomodation)			
Scenario 3			
No	Position	Crew	Accomodation /year (US$)
1	Head of Operation	1	1600
2	Storage Master	2	2200
3	Storage Personnel	4	2800
4	Loading Master	2	2200
5	Loading Personnel	4	2800
6	Discharge Master	2	2200
7	Discharge Personne	4	2800
8	Driver	144	79200
9	MT. Master	2	2200
10	MT. Personnel	4	2800
11	Compressor Master	2	2200
12	Compressor Personn	4	2800
13	Vaporizer Master	2	2200
14	Vaporizer Personne	4	2800
15	Pump Master	2	2200
16	Pump Personnel	4	2800
Total		187	115800

Summary of crew cost

Total Crew Cost (/Year)			
1	Salary (US$)	1440000	
2	Assurance (US$)	170600	
3	Accomodation (US)	115800	
Total		1726400	

BIOGRAPHY

Author born in Purworejo at 4 June 1996, is son from Yohanes Fung Tjoen Fong and Ratnaningrum Tjokrosudigdho. Until now, author had been in study in Tri Tunggal Elementary School Semarang, Tri Tunggal Junior High School Semarang, Tri Tunggal Senior High School Semarang. In 2014, Author is accepted in Institut Teknologi Sepuluh Nopember as college student in Marine Engineering Department, Faculty of Marine Technology with NRP 4214101003 through invitation batch. In Marine Engineering Department, author join Reliability, Availability, Maintainability, and Safety (RAMS) Laboratory in the term of taking final project. As long author been a student college in ITS, author active in the organization of BEM FTK ITS, PMK ITS, and being a member of RAMS Laboratory. Author will finish the bachelor degree study in eight semester. For author, being in Marine Engineering Department and RAMS Laboratory is very precious moment where author can study and learn a lot of knowledge as well the value of life.

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