BACHELOR THESIS - ME184834

Economic Analysis of LNG Distribution for Power Plant and City Gas in Bali

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INSTITUT TEKNOLOGI SEPULUH NOPEMBER
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APPROVAL SHEET

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Submitted to Fulfil One of the Requirements to Obtain an Engineering Degree
On
Reliability Availability Management and Safety Field of Study (RAMS)
Bachelor Program Department of Marine Engineering
Faculty of Marine Technology
Sepuluh Nopember Institute of Technology

By:
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PREFACE

First of all, all thanks to God, for His blessing, under the grace of His love author may finish this bachelor thesis well and finish the thesis under the title;

"ECONOMIC ANALYSIS OF LNG DISTRIBUTION FOR POWER PLANT AND CITY GAS IN BALI"

Submitted as one of the requirements for completing the study of engineering programs in the Department of Marine Engineering, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember Surabaya. On this occasion, the author would like to thank all those who have role in the process of making this bachelor thesis for assistance and support so that this thesis can be resolved properly. In particular the author would like to thank to:

1. Both of my parents Budi Legawa and Teriyati who always provide motivation, prayer, financial and moral support to the author to finish this bachelor thesis. Also for my brother and sister, Yoseph Tommy Ariesta Legawa and Angelina Kharisma Dewi Legawa who are always support in their care, prayer and support to overcome the problem author faced.
2. Prof. Dr. Ketut Buda Artana, ST., M.Sc. as the first supervisor who is willing to take the time to share knowledge and be available to guide the writer until this thesis is completed. Thank you also for the motivation that is always given to the writer all this time.
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6. The entire RAMS laboratory extended family, lecturers, staff, and students who always take the time to help the writer in completing this thesis.
7. All lecturers of Marine Engineering Department ITS who have provided knowledge to the author for four years of education in college.
8. All parties who have helped either directly or indirectly that the author cannot mention one by one.

The author is fully aware that the research undertaken is still far from perfect so it needs to get criticism, suggestions and corrections from readers. Finally, I hope this research can be useful for writers and readers for the advancement of Science.

Surabaya, June 2020

Author

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ECONOMIC ANALYSIS OF LNG DISTRIBUTION FOR POWER PLANT AND CITY GAS IN BALI

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ABSTRACT

Indonesia is a country that contains great potential for economic development and it is also impact on increased electricity demand in Indonesia. Ministry of Energy and Mineral Resources stated that increasing demand for electricity in Indonesia have reached 6,9% annually. PT. PLN as the electrical company in Indonesia has designed long term strategic development of power plant to anticipate increasing demand for electricity in Indonesia as documented at “Rencana Usaha Penyediaan Tenaga Listrik” (RUPTL) PT. PLN on 2018-2027. The government has plan to change the energy that will be used on power plants into the utilization of natural gas in Indonesia. PT. PLN is prioritizing the power plant that will operate by using Liquefied Natural Gas (LNG) as the main energy. PT.PLN also want to build the new Power Plant (PLTGU) in Celukan Bawang, Bali. The power plant will have 350 MWx2 as the additional power supply to reduce deficit of electrical power in Bali. Analyzing economic indicators is an important point to determined requirement Infrastructure and distribution Natural Gas at every district in Bali. In this study MCDM (Multiple Criteria Decision Making) is applied to model and solve multiple criteria optimization problems in economic process. The AHP method is presented to compare the best alternatives route of distribution LNG, the requirement to construct mini Natural Gas filling station, economical value of the distribution, and supply-demand at every district in Bali. Payback period (PP) and Return of Investment (ROI) calculation must be considered to develop economic value and fulfil the needs at every district by establishing a new mini LNG filling station in certain locations. The result of this research is expected to provide recommendation on best LNG distribution, which will assume lowest gas price at the end user. Accordingly, this will support the program of Bali clean and green.

Keywords: Natural Gas, LNG, Distribution LNG, Power Plant, Economic Analysis

ECONOMIC ANALYSIS OF LNG DISTRIBUTION FOR POWER PLANT AND CITY GAS IN BALI

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ABSTRAK

Indonesia adalah negara yang memiliki potensi besar untuk pembangunan ekonomi dan juga berdampak pada peningkatan permintaan listrik di Indonesia. Kementerian Energi dan Sumber Daya Mineral menyatakan bahwa peningkatan permintaan listrik di Indonesia meningkat 6,9% setiap tahun. PT. PLN sebagai perusahaan listrik di Indonesia telah merancang pengembangan strategis jangka panjang pembangkit listrik untuk mengantisipasi meningkatnya permintaan listrik di Indonesia sebagaimana tertulis pada “Rencana Usaha Penyediaan Tenaga Listrik” (RUPTL) PT. PLN pada 2018-2027. Pemerintah memiliki rencana untuk mengubah energi yang akan digunakan pada pembangkit listrik menjadi pemanfaatan gas alam di Indonesia. PT. PLN memprioritaskan pembangkit listrik yang akan beroperasi dengan menggunakan Liquefied Natural Gas (LNG) sebagai energi utama. PT.PLN juga ingin membangun Pembangkit Listrik (PLTGU) baru di Celukan Bawang, Bali. Pembangkit listrik akan memiliki 350 MWx2 sebagai salah satu daya tambahan untuk mengurangi defisit daya listrik di Bali. Menganalisa indikator ekonomi merupakan poin penting untuk menentukan kebutuhan Infrastruktur dan distribusi Gas Bumi di setiap kabupaten di Bali. Dalam penelitian ini MCDM (Multiple Criteria Decision Making) diterapkan untuk memodelkan dan menyelesaikan berbagai masalah optimisasi kriteria dalam proses ekonomi. Metode AHP disajikan untuk membandingkan rute alternatif terbaik distribusi LNG, persyaratan untuk membangun SPBU mini, nilai ekonomis distribusi, dan permintaan-penawaran di setiap kabupaten di Bali. Perhitungan Payback Period (PP) dan Return of Investment (ROI) harus dipertimbangkan untuk mengembangkan nilai ekonomi dan memenuhi kebutuhan di setiap kabupaten dengan membangun stasiun pengisian mini LNG baru di lokasi tertentu. Hasil penelitian ini diharapkan dapat memberikan rekomendasi distribusi LNG terbaik, yang akan mengasumsikan harga gas terendah pada pengguna akhir. Dengan demikian, ini akan mendukung program Bali bersih dan hijau.

Kata Kunci: Natural Gas, LNG, Distribution LNG, Power Plant, Economic Analysis

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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CHAPTER 1.
INTRODUCTION

1.1. Background

Tourism is one of important aspect in Bali Island. The growth expected on January 2018 until December 2019 is 7.100.000, but, the realization on January 2018 – December 2019 is 6.291.141. annually, the percentage of increasing tourism in Bali on January 2018-December 2019 is 3,64%. In this situation Bali population in 2018 is 4.292.200, and it grows along every year with an increase the number of tourist each year. This is will affecting the economic value on demand of infrastructure development of industries and hospitality. Increased infrastructure development of industries and hospitality also affecting the increasing demand of electricity in Bali. Bali is one province in Indonesia which has high demand in the electrical power. The increasing demand of electricity in Indonesia also have reached 6,9% each annually (Ministry of Energy and Mineral Resources, 2018). It is because electrical energy is used for any activity there such as industrial, urban, residential, and tourism, which is resulting on huge demand of electrical power. These electrical power need to be produced by power plants. In the moment, 340 MW electrical power which is used in Bali is still supplied from Java. This electrical power that supplied from power plant in Java is being transferred using subsea cables which is put underwater across the strait between Java and Bali

Cadangan	Sudah Berproduksi		Belum Berproduksi		Jumlah
	Terbukti	Potensial	Terbukti	Potensial	
Minyak (MMSTB)	2,763.46	3,806.29	407.42	557.73	7,534.91
Gas (TSCF)	31.74	16.62	68.62	25.74	142.72
a Associated	3.42	2.67	0.68	0.40	7.17
b Non Associated	28.32	13.95	67.94	25.34	135.55

49 tahun

production to reserve ratio

- Asumsi rata-rata produksi 2.9 TSCF/tahun
- Cadangan gas terbesar saat ini *(Remaining Reserved)* terdapat di wilayah East Natuna sebesar 46 TSCF; Papua - Maluku - Sulawesi sebesar 40.61 TSCF; dan Kalimantan sebesar 15.35 TSCF.

Figure 1.1. Natural Gas Reserve in Indonesia
(source: Neraca Gas Indonesia, ESDM Minister)

Nowdays, Bali is only able to supply the electricity into all island with 1300 MW which the power is supplied by four power plant in bali, these power plants are Pesanggaran power plant, Pemaron power plant, Gilimanuk power plant, and Celukan Bawang power plant. Pesanggaran power plant is able to provide 380 MW totally that is 180 MW by PLTG Pesanggaran and 200 MW by PLTDG Pesanggaran. PLTDGU in Celukan Bawang also can provide 350x2MW. Pemaron and Gilimanuk power plant role are 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 Power plant 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. The gas that will be transferred into Pesanggaran Powerplant will be sent by pipeline 8 kilo meters long from LNG terminal in Benoa. LNG converted first into gas through the FRU (Floating Regasification Unit) before it sent to Pesanggaran Power Plant.

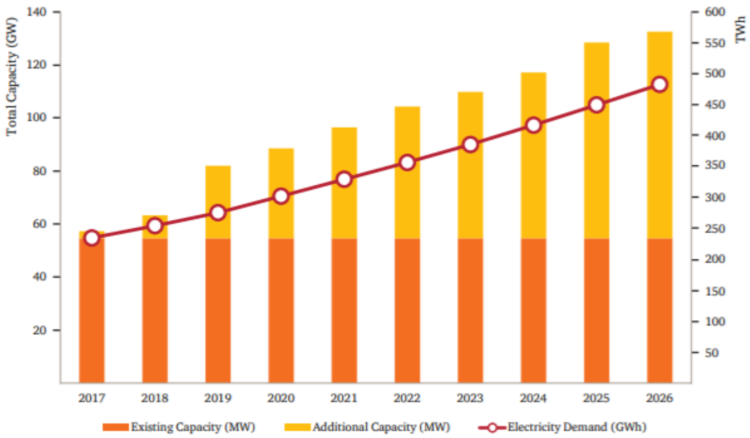

Figure 1.2. Increasing Demand of Electricity
(source: RUPTL 2017)

PT. PLN Planning some development of power plant in Indonesia for anticipating the increasing demand of electricity in all sector of Indonesia with “Rencana Usaha Penyediaan Tenaga Listrik” (RUPTL) PT. PLN on 2018-2027. The electrical power that will be produced by PLTGU (Gas and Steam (Thermal) Power plant) is getting bigger which resulting on bigger power production needed to increase efficiency electrical usage and distribution. The biggest consumer is from of industrial purpose followed by public powering, tourism and last is housing needs. This is the one that will be affecting the electrical demand in Bali. As the time pass by, the demand from each end user is increasing and result on the bigger need and more effective source of power (LNG) distribution.

In this research, the issue that is being raised is about the inefficiency of natural gas distribution in Bali. In order to maximize the usage of natural gas, efficient distribution scenario and design distribution in Bali need to be improved along with the maximize the economical aspect to calculating best design for increase the capability of power plant, the most efficient scenario to distribute Natural Gas into end user at lowest price which will benefit all the users, and this thing\can actualize Bali as the Clean and Green Island.

1.2. Problem Statement

Formula of the problem that will be discus on this Paper is:

1. What is the best scenario to distribute the natural gas for end user (Power plant, Industries & Hospitality, housing, and transportation) in Bali?
2. What is the requirement infrastructure to develop distribution of natural gas in Bali?
3. How to analyze the economic distribution of natural gas in Bali?

1.3. Research Objectives

Based on problems mentioned above, the goals of this research are:

1. Choosing the best scenario to distribute natural gas for end user in Bali.
2. Determine the requirement of infrastructure distribution in Bali.
3. Determine the economic and efficient scenario distribution of natural gas for end user in Bali.

1.4. Research Limitation

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

1. Data supply of electricity in Bali is referring to all four power plants in Bali (Pesanggaran power plant, Gilimanuk power plant, Celukan Bawang power plant).
2. Data demand of natural gas for tourism, transportation, and housing is referring to Badan Pusat Statistik (BPS) Bali.
3. The data processing is using excel for the calculation, AHP method for the selection or optimization.
4. Determine the most efficient scenario using economical aspect (Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP), Return of Investment (ROI) method).
5. This Research focus on develop distribution of natural gas for power plant, hotel & industry, housing and transportation in Bali.

1.5. Research Benefit

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

1. Provide information on demand of electricity in Bali.
2. Provide analysis on demand distribution of natural gas for end user in Bali.
3. Present a recommendation for location of infrastructure distribution natural gas in Bali.
4. Provide capacity and utilities of infrastructure for distribution natural gas in Bali.
5. Provide the design scenario of distribution natural gas in Bali.
6. Present the recommendation type of distribution that can increase effectivity and efficiency of Natural Gas distribution in Bali.

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CHAPTER 2.
LITERATURE STUDY

2.1. Natural Gas Reserve in Indonesia

Natural gas is the alternative energy that most used domestically after petroleum and coal. For this reason, natural gas plays an important role in the energy mix policy (*kebijakan bauran energi*) in Indonesia (ESDM Minister, 2018). Natural gas reserves are determined as an estimate of the volume of natural gas in the reservoir that can be ordered in accordance with the country's economic requirements and Government regulations at that time. Indonesia has natural gas reserves of 72 TSCF (as of January 2017) by proving proven reserves of 100.36 TSCF and potential reserves of 42.36 TSCF. The distribution of Indonesia's gas reserves is divided into 6 regions, Region I includes Aceh and North Sumatra, Region II includes Central Sumatra, Southern Sumatra, Riau Islands, Natuna and West Java, Region III include Central Java area, Region IV is Eastern Java area, and Region V includes Kalimantan and Bali Region and Region VI Cover Sulawesi, Nusa Tenggara, Maluku and Papua. The largest gas reserves in Indonesia currently are in Region II of 74.83 TSFC which includes the East Natuna area of 46 TSCF, then Region VI of 40.61 TSCF and Region V of 15.35 TSCF. According to the Indonesian Gas Balance in 2018-2027, until 2024 domestic gas needs can still be met.

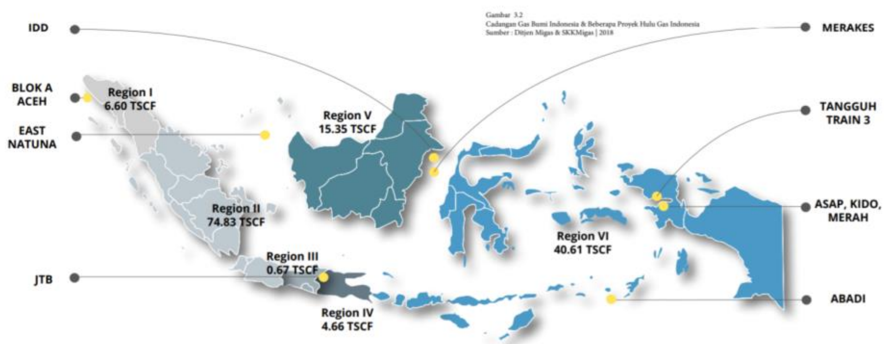

Figure 2.1. Gas Reserve in Indonesia
(Source: Ditjen Migas & SKK Migas, 2018)

2.2. Liquefied Natural Gas (LNG)

Liquefied Natural Gas (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. 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. LNG is cleaned from other component such as CO2, SOx, 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 -161°C at 1 bar pressure condition (normal pressure condition). By cooling natural gas to -161°C, the density is greater and so the pressure.

Component	Typical Analysis (mol %)	Range (mol%)
Methane	94,9	87,0-96,0
Ethane	2,5	1,8-5,1
Propane	0,2	0,1-1,5
Iso-Butane	0,03	0,01-0,3
Normal-Butane	0,03	0,01-0,4
Iso-Pentane	0,01	trace-0,14
Normal-Pentane	0,01	trace-0,04
Hexanes Plus	0,01	trace-0,06
Nitrogen	1,6	1,3-5,6
Carbon Dioxide	0,7	0,1-1,0
Oxygen	0,02	0,01-0,1
Hydrogen	trace	trace-0,02
Specify Gravity	0,585	0,57-0,62
Gross Heating Value	37,8	36,0-40,2

Table 2.1. Natural Gas Component
(Source: kompasiana.com)

The other side, volume needed to contain the LNG is far decreasing. The comparison between gas form natural gas and LNG is 1:600. 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 comes 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 capability 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 cannot easily detect by smell or sight. And when natural gas 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.

2.3. Vertical Gas Liquid (VGL)

The growth of tourism is affected on increasing hospitality and industries in Bali annually. Based on BPS data, the addition growth of Bali hospitality industries is 12% increasing every year. The hospitality business is competed to offer the best facilities to their guest. Natural gas as clean energy utilization is one of reliable aspects and could be used continuously for hotel operational because it is not produce a lot of emission and it is also may not disturb customer comfort. Recently, 140 MMBTU per month is supplied by PTGN (PT. Pertagas Niaga) for The Patra Bali Resort and Villas in Bali (PT. Patra Jasa, 2018). The distribution is using the VGL (Vertical Gas Liquid) that the LNG is supplied from terminal filling station PT. Badak NGL in Bontang, East Kalimantan.

Figure 2.2. VGL Cylinder
(Source: nissonindonesia.com)

2.4. Isotank

Figure 2.3. Isotank Pertamina
(Source pertagasniaga.pertamina.com/lng)

Iso Tank is container in the form of a tank that has a certain standard size and is used to load the very low temperature liquid and gas cargo. Iso tank is a stainless steel container that surround by an insulation and protective layer of usual polyurethane and aluminum. This tank is built to transport hazardous and non-hazardous cargo.

2.5. Database Bali

2.5.1. Power Plant

There are four power plants in Bali that distribute the Electricity, 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 Celukan Bawang power plant in Buleleng region. The last power plant is Gilimanuk power plant which is located in Jembrana, Bali. the Pesanggaran Powerplant provide capacity around 380 MW electrical power for Bali. Pesanggaran power plant provide constant power which Bali island need all time. Celukan Bawang Power Plant has capacity about 350 MWx2 which enable bigger electrical production in Bali. Different with those power plant, Pemaron Power Plant and Gilimanuk power plant is the alternative support of Pesanggaran Power Plant whenever the required load from local demand is rising. Pemaron Power Plant provide capacity around 80 MW electrical power for Bali and Gilimanuk Power Plant provide around 130MW electrical power. Totally, over four powerplant in Bali, over 1300 MW electrical power can be generated. Pesanggaran, Pemaron, and Gilimanuk owned by PT Indonesia Power.

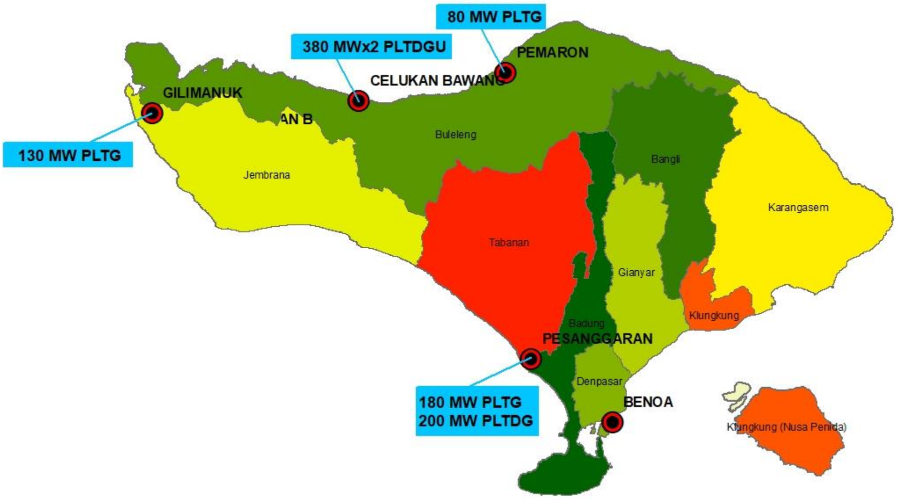

Figure 2.4. Power Plant in Bali & Benoa LNG Terminal
(Source: Personal Archive)

The location of every power plant in Bali and the distance between them is being one of the consideration and affecting the calculation of the economical approach. Distance between Pesanggaran and Pemaron power plant itself is 163 km. The distance from Benoa to Pesanggaran is just about 4 km. Then the distance between Pemaron power plant to Celukan Bawang power plant are 28 km. The distance between Pesanggaran and Gilimanuk powerplant is 134 km. The distance between Pesanggaran power plant and Celukan Bawang power plant is 104 km. the distance between Gilimanuk power plant and Celukan Bawang power plant is 55 km. The last is distance between Pemaron power plant and Gilimanuk power plant is 82 km.

2.5.2. Hospitality

Figure 2.5. Hotel in Bali are already using LNG
(Source: Personal patra-jasa.com)

Hospitality industry is the industry that responsible for providing place to stay overnight, food and also facilities that will make the costumer satisfied. Bali is one of developing places for the hotel industry, as the one of favorite tourism place in Indonesia and increasing demand tourism in Bali every year, the supply for infrastructure need to be developed. LNG is can be use as the alternative energy for kitchen purpose and also can be to support the developing of infrastructure and facility of hospitality in Bali. Recently, The Patra Bali Resort and Villas in Bali is supplied 140 MMBTU per month by PTGN (PT. Pertagas Niaga), (PT. Patra Jasa, 2018). The LNG use also can support the clean energy utilization in Bali and can support the Bali island as the Clean and Green City.

2.5.3. Housing

Figure 2.6. Housing Pipeline Natural Gas
(Source: migas.esdm.go.id)

One strategic step to replace usage of petroleum fuel is increasing utilization of the natural gas for household or small scale customer. City Gas Distribution System. It is for distributing the natural gas energy into the household or small scale customer by using pipeline lane. Bali can optimizing the use of natural gas by designing the efficient distribution design of the natural gas distribution. It is also can reduce the use of petroleum as the housing purpose because of the emission and natural gas is the energy that clean, safety and cheaper than petroleum.

2.5.4. Transportation

Data Kendaraan Tahun 2018							
No	Kabupaten/Kota	Mobil Penumpang	Bus	Truk	Sepeda Motor	Lainnya	Jumlah
1	Jembrana	10436	345	7805	182346	-	200932
2	Tabanan	32025	770	18371	353638	-	404804
3	Badung	101844	2041	24488	716307	-	844680
4	Gianyar	40131	581	13251	378049	-	432012
5	Klungkung	9506	146	5814	113213	1	128680
6	Bangli	7178	106	8600	98529	-	114413
7	Karangasem	12050	218	9186	168654	-	190108
8	Buleleng	24318	662	14824	387154	-	426958
9	Denpasar	185350	3774	45899	1118525	29	1353577
	Bali	**422838**	**8643**	**148238**	**3516415**	**30**	**4117949***

Table 2.2. Data of Vehicle in Bali 2018
Source (BPS-Bali, 2018)

Bali with 4.117.949 vehicles that using the petroleum fuel will cause a lot of emission, the usage of the petroleum fuel must be replace with the clean energy. Natural gas energy is one of the alternative fuel that can replace the use of petroleum. Natural gas has little emissions and the price is cheaper than petroleum fuel. Designing mini filling station of natural gas can make the distribution of the natural gas is effective and also it can make Bali have a little emission to be a clean city. The use of transportation in Bali also can be used to distribute the natural gas energy by using Truck that carrying VGL cylinder for optimizing the distribution of natural gas in Bali to the end user.

2.6. LNG Filling Station

2.6.1. Major LNG Filling Station

Figure 2.7. Benoa Receiving Terminal LNG in Bali
(Source: Jurnalmaritim.com)

The LNG receiving terminal in Bali is located in Benoa. Benoa LNG receiving terminal in Bali has role as the Major LNG Filling Station that distribute the natural gas into end user in Bali. Before distribute the natural gas into end user such as the Pesanggaran Power Plant, LNG liquid is regasified first at FRU (Floating Regasification Unit) in Benoa terminal. After the LNG is turned into natural gas form then it will be distributed by the pipeline that 8 kilo meters long directly into Pesanggaran Power Plant.

2.6.2. Mini LNG Filling Station (Satellite)

Figure 2.8. Mini LNG Filling Station
(Source: https://gplconsulting.wordpress.com)

SPBG (Stasiun Pengisian Bahan bakar Gas) or mini filling station of LNG, is consist of mini regasification system (compressor, vaporizer, BOG compressor, storage tank, pipeline, pump, etc). The process of distribution is combining the delivery to power plant and to mini filling station in every district on Bali. After the distribution from the LNG terminal in Benoa, the distribution for power plant (ex: Pesanggaran Power Plant) is using pipeline and the distribution to mini filling station is by truck that carry LNG on liquid form or carrying the LNG with Vertical Gas Liquefied (VGL cylinder) or using isotank. Then after the Natural Gas has arrive on mini filling terminal station the LNG is processed in the regasification system and change it into gas form for the fuel of the LGV (Liquefied Gas Vehicle) transportation and then the VGL cylinder that carried by truck also will be distributed to the housing, Hospitality, and any industries in need.

2.7. Economic Variables

Economic Variables 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. Economic Variables 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:

2.7.1. 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 timeline project. If the money earned from the revenue is passing the capital expenditure, the project starting to produce net profit. The capital expenditure of this bachelor thesis such as:

- Storage Tanks
- Pumps
- Compressors
- Vaporizers
- Transportations (Trucks and Tanks)
- Filling Stations

2.7.2. 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:

- LNG Purchase Cost
- Transportation Cost
- Port Cost
- Salary, accommodation of crew, and insurance

2.7.3. 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.

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.

2.7.4. Tax

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

2.7.5. 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$).

2.7.6. Cash Flow

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. Cash flow value is value which is from the project. In this project, cash flow value is based represent the on yearly range with a decade total estimation.

2.7.7. 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 Net Present Value, Internal Rate of Return, Payback Period, and Return of Investment.

2.8. Analytical Hierarchy Process (AHP)

AHP is a method to help set priorities from various choices by using several criteria (multi criteria). Because of its multi-criteria nature, AHP is widely used in priority setting. The problem hierarchy is structured to help the decision making process that takes into account all the decision elements involved in the system. Most problems become difficult to solve because the process of solving them is done without seeing the problem as a system with a particular structure. A hierarchy in AHP is a collection of elements arranged in several levels, where each level includes several homogeneous elements. An element becomes the criteria and benchmarks for the formation of the elements below show a decision hierarchy.

AHP also has properties that are based on a structural and logical process, there are 3 stages of AHP in compiling a priority:

1. Problem decomposition
2. Assessment to compare elements of decomposition
3. Synthesis of priority

a. Decomposition

After defining the problem / problem, it is necessary to do a decomposition, namely: breaking the whole problem into its elements, down to the smallest details, so that the level of the problem is obtained. Therefore, this analysis process is called hierarchy. There are two types of hierarchy, namely complete hierarchy and incomplete hierarchy. In a complete hierarchy all elements at one level have all the elements at the next level, if not, they are called incomplete hierarchies.

b. Comparative Judgment

This principle means making judgments about the relative importance of two elements at a certain level in relation to the level above it. This assessment is the core of AHP, because it will affect the priority of elements. The results of this assessment are more easily presented in the form of a pairwise comparison matrix. In order to obtain a useful scale, the party providing the answers needs to have a comprehensive understanding of the elements compared and their relevance to the criteria studied.

c. Synthesis of Priority,

From each pairwise comparison matrix then the given vectors are searched to get local priority, because pairwise comparison matrices exist at each level, then, to do global must be synthesized among Local priorities. The procedure for performing different syntheses according to the form of a hierarchy.

d. Logical Consistency

Consistency of respondents' answers in determining priority elements is a basic principle that will determine the validity of data and the results of decision making. In general, respondents must have consistency in making comparisons of elements. If A> B and B> C then the respondent logically must state that A> C, based on the numerical value provided.

2.8.1.Hierarchy Structure

The problem hierarchy is structured to help the decision making process that takes into account all the decision elements involved in the system. Most problems become difficult to solve because the process of solving them is done without seeing the problem as a system with a particular structure. A hierarchy in AHP is a collection of elements arranged in several levels, where each level describe the elements or alternative decisions identified. Abstraction of hierarchy arrangement consist of the focus, factors, sub factors, objective, and alternative. Each level and hierarchy of decisions affect the top factors or main focus with different intensities. Through of the mathematical theory to hierarchy, a method that evaluate the impact of decision level closest to it can be optimized, based on the composition of the relative priority and each element at the decision level to each element and the closest decision level to selecting.

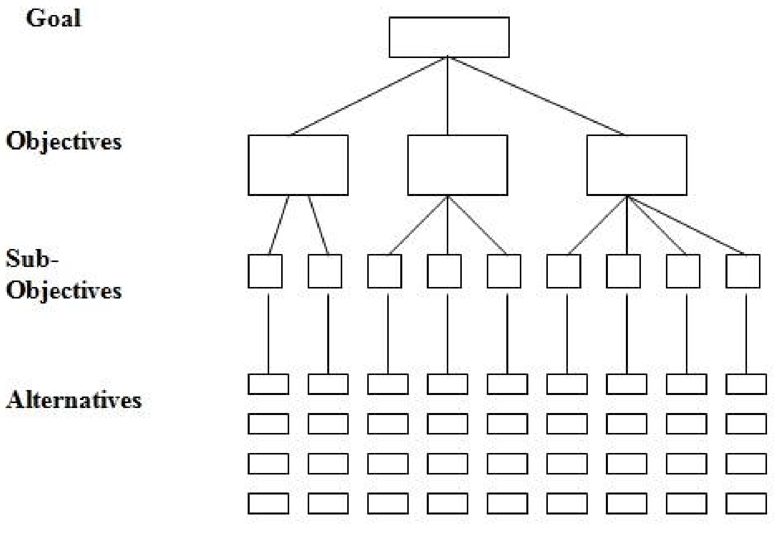

Figure 2.9. Decision Hierarchy
Source: Saaty (1993)

In decision making, the thing that needs to be considered is when data collection, where this data is expected to be close to its true value, for example, the cost of infrastructure that can be done with a pairwise comparison approach. Pairwise comparisons are often used to determine the relative importance of the elements and criteria. The pairwise comparisons are repeated for all elements in each level. The element with the highest weight is a choice of decisions that are worth considering.

Compared to

Asset		Asset A	Asset B	Asset C	Asset D	Total
	Asset A		3	2	3	8
	Asset B	1		3	2	6
	Asset C	2	1		1	4
	Asset D	1	2	3		6

Figure 2.10. Pairwise Comparison
Source: testmyprep.com

2.9. Selection Method

The selection method has the purpose to know which solution that is giving the most optimal result between the possible solution. The method is Net Present Value (NPV), Internal Rate Return (IRR), Payback Period (PP) and the last one is Return of Investment (ROI). The economic data is required to start this process which is going to be the last result of this project. (Ben-Horin 2016).

2.9.1. Net Present Value (NPV)

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

$$NPV = \frac{R_t}{(1+i)^t}$$

Where:
NPV = The present value of the overall cash flow at the interest rate i%
Rt = Net Cash flow
i = Discount Rate
t = Project Period (year)

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 purpose. The purpose 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 cash flow 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 income flow 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 investment 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.

2.9.2. Internal Rate 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 investment that will consistently giving profits. IRR can be calculated by formula:

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

Where:
i1 = Discount rate which give positive NPV (%)
i2 = Discount rate which give negative NPV (%)
NPV1 = NPV that has positive value (US$)
NPV2 = NPV that has negative value (US$)
i = Discount rate value of Investment (%)
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.

2.9.3.Payback Period

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

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

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

Where:
a = Initial Expenditure (US$)
b = Total cash flow cumulative at (n) year (US$)
c = Total cash flow cumulative at (n+1) year (US$)

At = Cash flow at period of (t) (US$)
N' = Payback period that will be calculated (year)

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

2.9.4.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 on net income divided by original cost of the investment.

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

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

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

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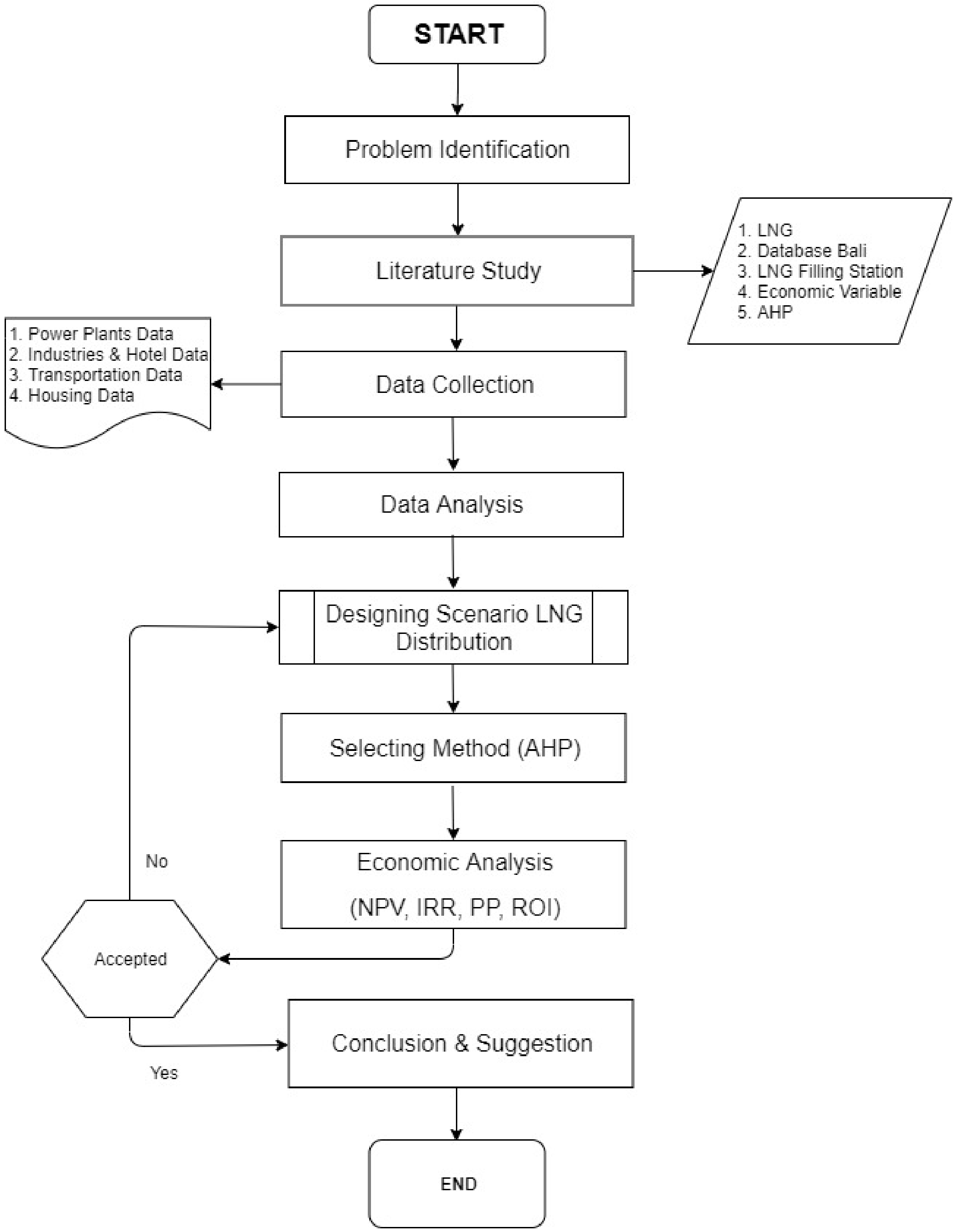
CHAPTER 3.
METHODOLOGY



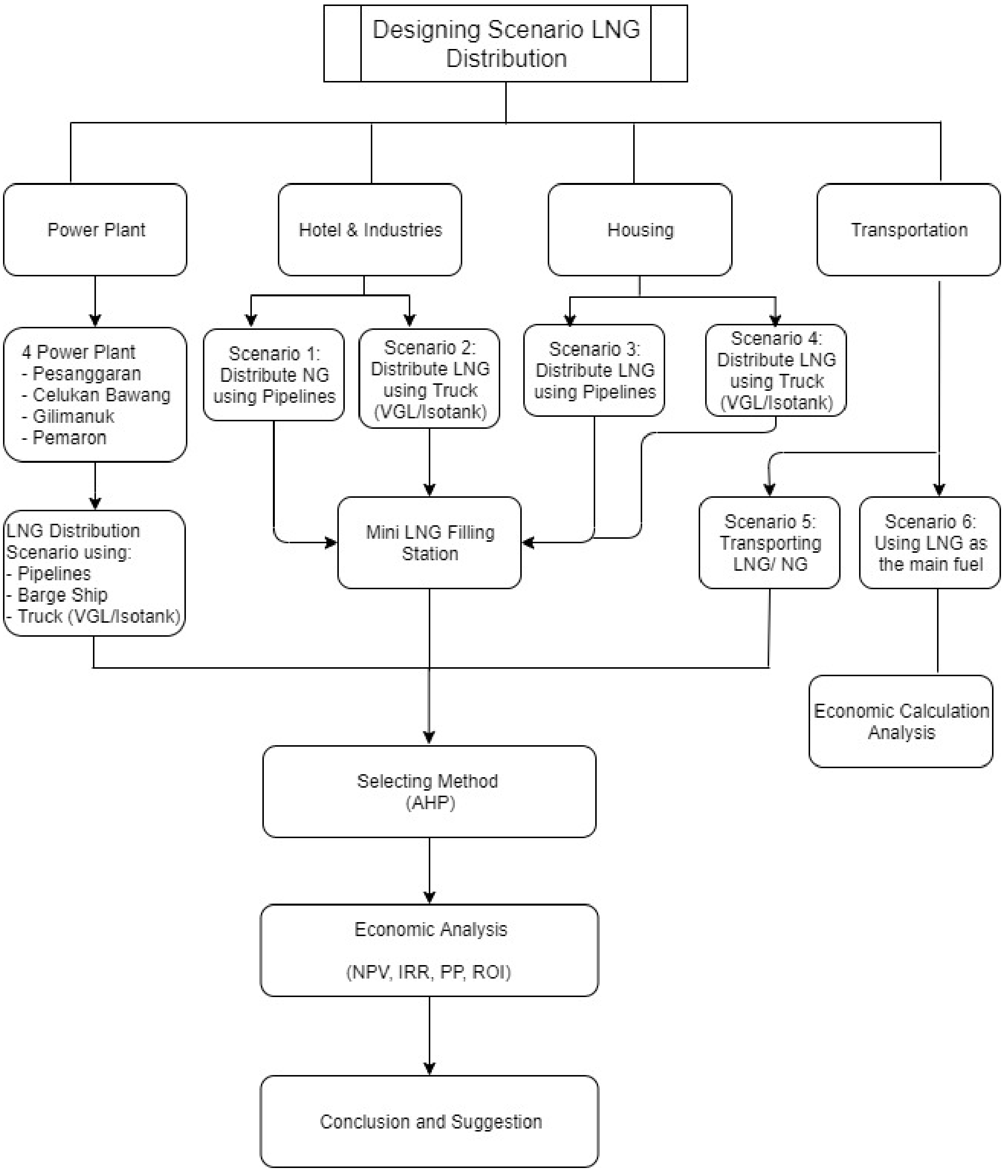


Figure 3.1. Methodology Chart

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 distribution system of natural gas in Bali is still valid or need to be improved from the previous state. There is some inefficiency in the current condition which are exist in the electrical energy distribution in Bali. The unit that will be identified is power plant, hotel and industries, housing, and transportation. Knowing the condition of the electrical supply in Bali, the condition of power plant, the demand of tourism in Bali, the demand of electricity in every district and the distribution for power plants, hotel, industries, housing and transportation. In this research, the solution will be solved using AHP method and Excel to calculating the data and selection or optimization to complete this project.

3.2. Literature Study

The next step 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 until its completion. The literature study of this final project is about the learning about the natural gas supply chain, the power plants in Bali, the economical variable, and the other.

3.3. Data Collection

Data that is needed to be gathered in the project can be collected from the power plants, hotel & industries, housing and transportation. Data that needed is about the overall demand of electricity for end user. This data used for analysis including: General information about the electrical power demanded from each end user. Data is required to modelling the electrical demand into the graphs that will visualize the characteristic of electrical demand in Bali based on place. 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 economic data about the fund used between power plants, differs caused by different electrical demand and energy sources. Data of vehicle can be used in the distribution of natural gas between power plants in Bali and to comparing the efficiency use of natural gas as fuel, and also data demand of industries and hospitality in Bali. The data is hopefully can interpret the needs of distribution type in Bali.

3.4. Data Analysis

Inputting data into the Excel is one process to make the requirement 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 requirement that support the distribution using pipeline and truck that carrying VGL based on area in Bali. The economic data that needed to be acquired is the data of every parts, operating and maintaining requirement, and the other utilities. 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 the requirements thing, capital cost, and operational cost.

3.5. Designing Scenario LNG Distribution

By the result of determining calculation and modelling before, factors that affecting the requirement of distribution for natural gas in Bali. Besides the information of modelling that already achieved from previous step, factors such transport time, natural gas distribution state whether using pipelines or transportation like truck 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 and will be checked until the final economical calculation. From the result between three scenarios, the result which has best of payback period or the most effective will be chosen for the best solution compared the other choices. The steps that can be applied are:

1. Input analysis data for designing scenario of LNG distribution plan.

   Input economic data such as the initial data requirement for completing the natural gas requirement, power plants capacity, or the demand of each area in Bali,
2. Processing economic data for the base calculation of LNG distribution plan.

   From the economic data, we can design the management of LNG distribution that may generate the better effectivity. By considering several aspects such as capital expenditure which area need the developing of infrastructure such as mini LNG filling station capital cost and etc.
3. Getting the result of Long list and Short list design.

   Result of the data value is represented by final Long list of many scenario. After Designing the scenarios of the distribution, five best option base on some economic variables such as capital cost, operational cost, tax, cash flow and so on is choose, then its data become short list design of the scenario LNG Distribution in Bali.

3.6. Selecting Method

From the result of the existing scenario, we achieve five short list that is the most effective project cost that will be compared one another. In this section, there will be selection or optimization from the short list of LNG Distribution scenario and between these five alternative scenario, AHP method approach is the best method to know the most effective scenario. At this point AHP Method is going to selecting one of the best scenario comparing the other to be calculating on the economy analysis. Or the AHP Method is going to optimizing the five short list scenario and then choosing one of the most effective to be calculate with economic analysis.

3.7. Economic Analysis

The result of selecting method is one scenario that is the most effective comparing to other scenario, then the result of scenario is calculated on economical aspect using 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 business 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 and 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 until 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 research and provide solution to similar problem with different location in Bali.

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CHAPTER 4.
ANALYSIS

4.1. Data Analysis

Bali Regency Data

Bali Island data used in this thesis is based on data collected from BPS Bali (Badan Pusat Statistik). The collected data is about gas needs from households and hotels in every district in Bali. The data collected is used to provide a recommendation plan for satellite placement and gas distribution in each regencies.

1. Denpasar Regency

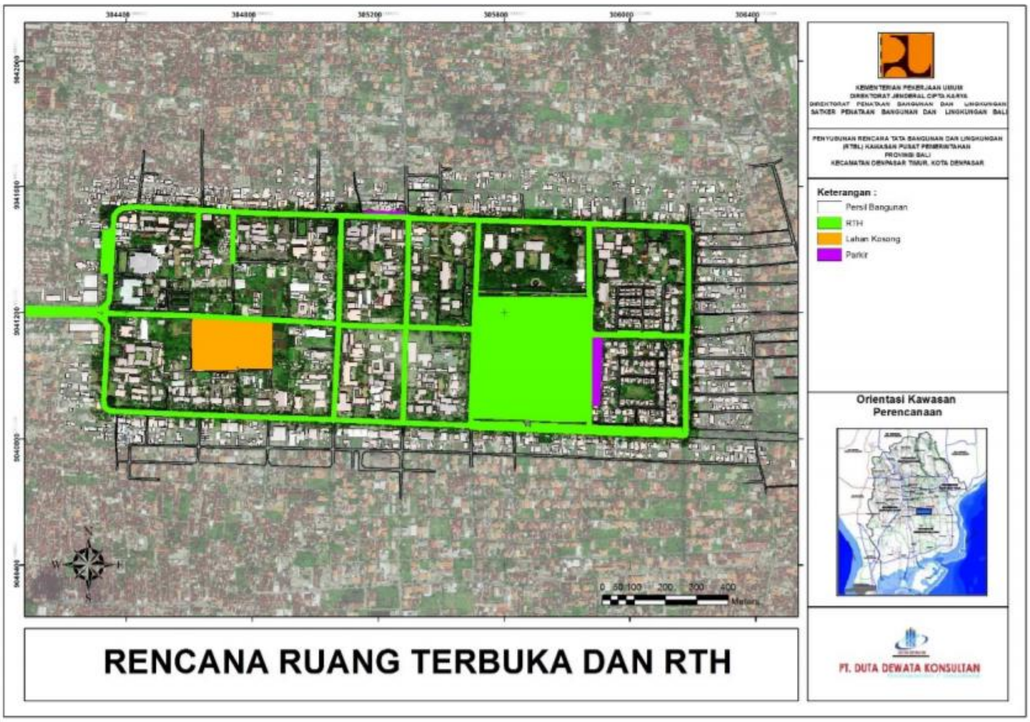

Figure 4.1. Recommendation Location satellite in Denpasar City

From figure above, satellite location recommendation in Denpasar is located on Renon area, which is the orange area on the picture. That is empty area contained in Denpasar City. The green area is protected area, we can't build anything such as office building, commercial area, or industrial purpose because the government saving the green area for green open space.

Demand of Denpasar City

*Household Gas Demand (Thousand)

Table 4.1. Denpasar household gas demand

2014		2015		2016	
Total (Household)	MMSCFD	Total (Household)	MMSCFD	Total (Household)	MMSCFD
220150	11,653	220150	11,653	224325	11,874

2017		2018	
Total (Household)	MMSCFD	Total (Household)	MMSCFD
228575	12,099	232650	12,3146

Total Gas Needs in 5 Year: 59,594 MMSCFD
Average Gas Needs Monthly: 0,994 MMSCFD

* Hotel Gas Demand

Table 4.2. Denpasar hotel gas demand

2013		2014		2015	
Total (Room)	MMSCFD	Total (Room)	MMSCFD	Total (Room)	MMSCFD
3913	0,105	3480	0,093	3781	0,101

2017		2018	
Total (Room)	MMSCFD	Total (Room)	MMSCFD
4835	0,130	5437	0,146

Average Gas Needs for Hotels Monthly: 0,0096 MMSCFD

From the data, Denpasar regency needs gas for household as much as 0,994 MMSCFD/per month, and for hotel purpose as much as 0,0096 MMSCFD/ per month. The data is obtained from the average of gas demand of households and hotels for 5 years.

2. Badung Regency

Figure 4.2. Recommendation Location satellite 1 in Badung Regency (Jimbaran)

From the figure, the recommendation of location satellite 1 in Badung regency is near the Pertamina gas station 54.803.10. because it can facilitate access to vehicle that want to refuel and also in this area there is empty space nearby the Pertamina gas station.

Figure 4.3. Recommendation Location satellite 2 In Badung Regency (Airport)

From the figure, the recommendation of location satellite 2 in Badung regency is near the Airport because it can facilitate access to vehicle that want to refuel near the airport, and beside the gas station there is some empty space that may use for the satellite.

*Household Gas Demand (Thousand)

Table 4.3. Badung household gas demand

2014		2015		2016	
Total (Household)	MMSCFD	Total (Household)	MMSCFD	Total (Household)	MMSCFD
154100	8,157	154100	8,157	157500	8,337

2017		2018	
Total (Household)	MMSCFD	Total (Household)	MMSCFD
160875	8,515	164225	8,693

Total Gas Needs in 5 Year: 41,858MMSCFD
Average Gas Needs Monthly: 0,698 MMSCFD

* Hotel Gas Demand

Table 4.4. Badung hotel gas demand

2013		2014		2015	
Total (Room)	MMSCFD	Total (Room)	MMSCFD	Total (Room)	MMSCFD
18895	0,507	23172	0,623	25154	0,676

2017		2018	
Total (Room)	MMSCFD	Total (Room)	MMSCFD
58694	1,577	44571	1,197

Average Gas Needs for Hotels Monthly: 0,0763 MMSCFD

From the data, Badung regency needs gas for household as much as 0,689 MMSCFD/per month, and for hotel purpose as much as 0,0763 MMSCFD/ per month. The data is obtained from the average of gas demand of households and hotels for 5 years.

3. Tabanan Regency

Figure 4.4. Recommendation Location satellite in Tabanan Regency

From the figure, the recommendation of location satellite in Tabanan regency is near the primary road access so it can facilitate access to vehicle that want to refuel, and beside the gas station there is some empty space that may use for the satellite.

* Household Gas Demand (Thousand)

Table 4.5. Tabanan household gas demand

2014		2015		2016	
Total (Household)	MMSCFD	Total (Household)	MMSCFD	Total (Household)	MMSCFD
108975	5,768	108975	5,768	109625	5,803

2017		2018	
Total (Household)	MMSCFD	Total (Household)	MMSCFD
110250	5,836	110875	5,869

Total Gas Needs in 5 Year: 29,043 MMSCFD
Average Gas Needs Monthly: 0,484 MMSCFD

* Hotel Gas Demand

Table 4.6. Tabanan hotel gas demand

2013		2014		2015	
Total (Room)	MMSCFD	Total (Room)	MMSCFD	Total (Room)	MMSCFD
326	0,0087	326	0,0087	338	0,0090

2017		2018	
Total (Room)	MMSCFD	Total (Room)	MMSCFD
193	0,0051	191	0,0051

Average Gas Needs for Hotels Monthly: 0,00061 MMSCFD

From the data, Tabanan regency needs gas for household as much as 0,484 MMSCFD/per month, and for hotel purpose as much as 0,00061 MMSCFD/ per month. The data is obtained from the average of gas demand of households and hotels for 5 years.

4. Bangli Regency

Figure 4.5. Recommendation Location satellite in Bangli Regency

From the figure, the recommendation of location satellite in Bangli regency is near Pertamina Gas Station 54.806.07 because it can facilitate access to vehicle that want to refuel near the gas station, and beside the gas station there is lots of empty space in this area that may use for the satellite facility.

* Household Gas Demand (Thousand)

Table 4.7. Bangli household gas demand

2014		2015		2016	
Total (Household)	MMSCFD	Total (Household)	MMSCFD	Total (Household)	MMSCFD
55650	2,946	55650	2,946	55950	2,961

2017		2018	
Total (Household)	MMSCFD	Total (Household)	MMSCFD
56275	2,979	56550	2,993

Total Gas Needs in 5 Year: 14,823 MMSCFD
Average Gas Needs Monthly: 0,247 MMSCFD

*Hotel Demand

Table 4.8. Bangli hotel gas demand

2013		2014		2015	
Total (Room)	MMSCFD	Total (Room)	MMSCFD	Total (Room)	MMSCFD
0	0	0	0	0	0

2017		2018	
Total (Room)	MMSCFD	Total (Room)	MMSCFD
0	0	0	0

Average Gas Needs for Hotels Monthly: 0 MMSCFD

From the data, Bangli regency needs gas for household as much as 0,247 MMSCFD/per month, and for hotel purpose as much as 0 MMSCFD/ per month, it is because based on BPS Bali Province there is no starred hotel (hotel 1 star until 5 star) in Bangli. The data is obtained from the average of gas demand of households and hotels for 5 years.

5. **Buleleng Regency**

Figure 4.6. Recommendation Location satellite 1 in Buleleng Regency(Seririt)

From the figure, the recommendation of location satellite in Buleleng regency is near Pertamina Gas Station 54.811.05 because it can facilitate access to vehicle that want to refuel near the primary road, and beside the gas station there is empty space beside the gas station that may use for the satellite facility.

Figure 4.7. Recommendation Location satellite 2 in Buleleng Regency (Singaraja)

From the figure, the recommendation of location satellite in Buleleng regency is near Pertamina Gas Station 54.811.02 because it can easily facilitate to access for vehicle that want to refuel near the household area, beside that there is a near empty space in this area that may use for the satellite.

* Household Gas Demand (Thousand)

Table 4.9. Buleleng household gas demand

2014		2015		2016	
Total (Household)	MMSCFD	Total (Household)	MMSCFD	Total (Household)	MMSCFD
161550	8,551	161550	8,551	162525	8,602

2017		2018	
Total (Household)	MMSCFD	Total (Household)	MMSCFD
163400	8,649	164300	8,696

Total Gas Needs in 5 Year: 43,051 MMSCFD
Average Gas Needs Monthly: 0,717 MMSCFD

* Hotel Gas Demand

Table 4.10. Buleleng hotel gas demand

2013		2014		2015	
Total (Room)	MMSCFD	Total (Room)	MMSCFD	Total (Room)	MMSCFD
561	0,015	541	0,014	781	0,021

2017		2018	
Total (Room)	MMSCFD	Total (Room)	MMSCFD
709	0,019	807	0,022

Average Gas Needs for Hotels Monthly: 0,0015 MMSCFD

From the data, Buleleng regency needs gas for household as much as 0,717 MMSCFD/per month, and for hotel purpose as much as 0,0015 MMSCFD/ per month. The data is obtained from the average of gas demand of households and hotels for 5 years.

6. Gianyar Regency

Figure 4.8. Recommendation Location satellite in Gianyar Regency

From the figure, the recommendation of location satellite in Gianyar regency is near Pertamina Gas Station 54.805.19 because it can easily facilitate to access for vehicle that want to refuel near the household area, and beside the gas station there is a near empty space that may use for the satellite facility.

*Household Gas Demand (Thousand)

Table 4.11. Gianyar household gas demand

2014		2015		2016	
Total (Household)	MMSCFD	Total (Household)	MMSCFD	Total (Household)	MMSCFD
123775	6,552	123775	6,552	124900	6,611

2017		2018	
Total (Household)	MMSCFD	Total (Household)	MMSCFD
125975	6,668	127025	6,724

Total Gas Needs in 5 Year: 33,106 MMSCFD
Average Gas Needs Monthly: 0,552 MMSCFD

* Hotel Gas Demand

Table 4.12. Gianyar hotel gas demand

2013		2014		2015	
Total (Room)	MMSCFD	Total (Room)	MMSCFD	Total (Room)	MMSCFD
679	0,018	845	0,023	1001	0,027

2017		2018	
Total (Room)	MMSCFD	Total (Room)	MMSCFD
1135	0,030	1221	0,032

Average Gas Needs for Hotels Monthly: 0,0021 MMSCFD

From the data, Gianyar regency needs gas for household as much as 0,552 MMSCFD/per month, and for hotel purpose as much as 0,0021 MMSCFD/ per month. The data is obtained from the average of gas demand of households and hotels for 5 years.

7. Jembrana Regency

Figure 4.9. Recommendation Location satellite in Jembrana Regency (Batuagung)

From the figure, the recommendation of location satellite in Buleleng regency is near Pertamina Gas Station 54.822.13 because it can easily facilitate to access for vehicle that want to refuel near the household area, beside that there is a lots of empty space in this area that may use for the satellite facility.

* Household Gas Demand (Thousand)

Table 4.13. Jembrana household gas demand

2014		2015		2016	
Total (Household)	MMSCFD	Total (Household)	MMSCFD	Total (Household)	MMSCFD
67900	3,594	67900	3,594	68325	3,616

2017		2018	
Total (Household)	MMSCFD	Total (Household)	MMSCFD
68725	3,638	69150	3,660

Total Gas Needs in 5 Year: 18,103 MMSCFD
Average Gas Needs Monthly: 0,302 MMSCFD

* Hotel Gas Demand

Table 4.14. Jembrana hotel gas demand

2013		2014		2015	
Total (Room)	MMSCFD	Total (Room)	MMSCFD	Total (Room)	MMSCFD
77	0,002	65	0,0017	87	0,0023

2017		2018	
Total (Room)	MMSCFD	Total (Room)	MMSCFD
119	0,0031	119	0,0032

Average Gas Needs for Hotels Monthly: 0,00021 MMSCFD

From the data, Jembrana regency needs gas for household as much as 0,302 MMSCFD/per month, and for hotel purpose as much as 0,00021 MMSCFD/ per month. The data is obtained from the average of gas demand of households and hotels for 5 years.

8. Karangasem Regency

Figure 4.10. Recommendation Location satellite in Karangasem

From the figure, the recommendation of location satellite in Karangasem regency is near Pertamina TBBM Manggis Bali because it can easily facilitate to access for vehicle that want to refuel near the primary road and there is Pertamina gas station too near the Pertamina TBBM Manggis Bali, beside that there is a near empty space in this area that may use for the satellite facility.

* Household Gas Demand (Thousand)

Table 4.15. Karangasem household gas demand

2014		2015		2016	
Total (Household)	MMSCFD	Total (Household)	MMSCFD	Total (Household)	MMSCFD
102175	5,408	102175	5,408	102700	5,436

2017		2018	
Total (Household)	MMSCFD	Total (Household)	MMSCFD
103200	5,463	103700	5,489

Total Gas Needs in 5 Year: 27,204 MMSCFD
Average Gas Needs Monthly: 0,453 MMSCFD

* Hotel Gas Demand

Table 4.16. Karangasem hotel gas demand

2013		2014		2015	
Total (Room)	MMSCFD	Total (Room)	MMSCFD	Total (Room)	MMSCFD
287	0,0077	290	0,0077	350	0,0094

2017		2018	
Total (Room)	MMSCFD	Total (Room)	MMSCFD
329	0,0088	321	0,0086

Average Gas Needs for Hotels Monthly: 0,00070 MMSCFD

From the data, Karangasem regency needs gas for household as much as 0,453 MMSCFD/per month, and for hotel purpose as much as 0,00070 MMSCFD/ per month. The data is obtained from the average of gas demand of households and hotels for 5 years.

9. Klungkung Regency

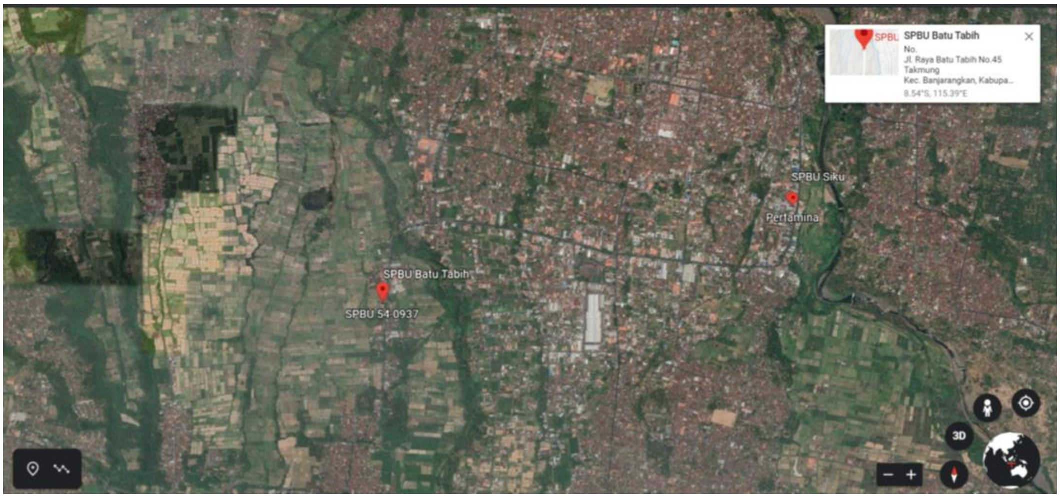

Figure 4.11. Recommendation Location satellite in Klungkung Regency

From the figure, the recommendation of location satellite in Klungkung regency is near Pertamina Gas Station Batu Tabih because it can easily facilitate to access for vehicle that want to refuel near the primary road from Klungkung to Denpasar and Gianyar, and that there is a near empty space in this area that may use for the satellite.

*Household Gas Demand (Thousand)

Table 4.17. Klungkung household gas demand

2014		2015		2016	
Total (Household)	MMSCFD	Total (Household)	MMSCFD	Total (Household)	MMSCFD
43925	2,325	43925	2,325	44175	2,338

2017		2018	
Total (Household)	MMSCFD	Total (Household)	MMSCFD
44350	2,347	44575	2,359

Total Gas Needs in 5 years: 11,695 MMSCFD
Average Gas Needs Monthly: 0,195 MMSCFD

* Hotel Demand

Table 4.18. Klungkung hotel gas demand

2013		2014		2015	
Total (Room)	MMSCFD	Total (Room)	MMSCFD	Total (Room)	MMSCFD
122	0,0032	92	0,0024	104	0,0027

2017		2018	
Total (Room)	MMSCFD	Total (Room)	MMSCFD
263	0,0070	260	0,0069

Average Gas Needs for Hotels Monthly: 0,00037MMSCFD

From the data, Klungkung regency needs gas for household as much as 0,195 MMSCFD/per month, and for hotel purpose as much as 0,00037 MMSCFD/ per month. The data is obtained from the average of gas demand of households and hotels for 5 years.

4.2. Long List and Short List

Long list is the list of distribution scenario of developing infrastructure of LNG to distribute Natural Gas in Bali especially into household, transportation, hotel of all regency in Bali. Some scenario of the long list will be choose to be some scenario short list and from the short list will be choose the best one scenario using the AHP method and colleting answer from questionnaire.

***Long List Scenario**
1. Truck to all power plants & satellite
2. Barge to all power plants & truck to all satellite
3. Pipeline to all power plants & truck to all satellite

Celukan Bawang Power Plant as Major Terminal
4. Pipeline to Gilimanuk PP & Pemaron PP + Barge to Benoa + truck to all satellite
5. Pipeline to Gilimanuk PP + Barge to Benoa + Truck to Pemaron PP and to all satellite
6. Truck to Gilimanuk PP & Pemaron PP + Barge to Benoa + truck to all satellite

Gilimanuk Power Plant as Major Terminal
7. Pipeline to Celukan Bawang PP & Pemaron PP + Barge to Benoa + truck to all satellite
8. Pipeline to Celukan Bawang PP + Barge to Pemaron PP & Benoa + truck to all satellite
9. Pipeline to Celukan Bawang PP + Barge to Benoa + Truck to Pemaron PP and to all satellite
10. Truck to Celukan Bawang PP & Pemaron PP + Barge to Benoa + truck to all satellite

Benoa (Pesanggaran Powerplant) as Major Terminal
11. Barge to Gilimanuk PP & Celukan Bawang PP & Pemaron PP + truck to all satellite
12. Pipeline to Gilimanuk PP + Barge to Celukan Bawang PP & Pemaron PP + truck to all satellite
13. Truck to Gilimanuk PP + Barge to Celukan Bawang PP & Pemaron PP + truck to all satellite

***Short List Scenario**
1. Pipeline to all power plants & truck to all satellite
2. Barge to all power plants & truck to all satellite
5. Pipeline to Gilimanuk PP + Barge to Benoa + Truck to Pemaron PP and to all satellite (CB)
9. Pipeline to Celukan Bawang PP + Barge to Benoa + Truck to Pemaron PP and to all satellite (G)
11. Barge to Gilimanuk PP & Celukan Bawang PP & Pemaron PP + truck to all satellite
12. Pipeline to Gilimanuk PP + Barge to Celukan Bawang PP & Pemaron PP + truck to all satellite

1. Pipeline to all power plants & trucks to all satellites

* The reason for using the gas pipeline to all power plants is because it takes into account long-term investment where using the pipeline will facilitate the distribution of gas because there is little risk arising and there is no dense path in the distribution process. However, there is a drawback that the construction of a long and expensive pipeline infrastructure is another consideration. Meanwhile, if

using trucks to satellites in the districts is more effective because not all districts need gas on a large scale and if using trucks can facilitate the achievement of gas delivery to remote areas that cannot be reached by pipelines, but there is a big risk because to certain regions there are differences in topography and slope of the land so that it can generate new risks.

2. Barge to all power plants & trucks to all satellites

* (Example: Gilimanuk as a major powerplant) The reason for using a barge is to reduce the risk of gas distribution and can minimize costs when compared to building pipeline infrastructure, but the drawbacks if the powerplant distance is close enough to be quite large and there are several powerplants that are does not have adequate infrastructure to receive gas distribution from ship transportation because it does not have a receiving port or sea water depth that is not up to ship standards. For distribution to satellites in districts using trucks is more effective because the needs of each district are different and if using trucks can facilitate the achievement of gas delivery to remote areas that cannot be reached by pipelines, but there is a big risk because if you go to certain areas there are topographical differences and land slope so that it can generate new risks.

5. Pipeline to Gilimanuk PP + Barge to Benoa + Truck to Pemaron PP and to all satellite (CB)

* (Celukan Bawang as a major power plant) reasons for using the gas pipeline from Celukan Bawang Power Plant to Gilimanuk Power Plant because the distance is close enough and the demand is also large enough so that if infrastructure investment in the form of a gas pipeline will be profitable because of its appropriate needs and minimize risk in the distribution process, while using a barge from Celukan Bawang Power Plant to Benoa due to its long distance so that it will be detrimental when using a gas pipeline that can actually be replaced by the barge due to its lower costs and with the same risk its small Then consider using a truck as a means of transportation for gas distribution because the demand from Pemaron is a small power plant and the distance is close to the Celukan Bawang power plant, in addition to that the price incurred is relatively small. While distribution to satellite uses trucks to facilitate the achievement of gas delivery to remote areas that cannot be reached by pipelines, but there is a big risk because if you go to certain areas there are differences in topography and slope of the land so that it can generate new risks.

9. Pipeline to Celukan Bawang PP + Barge to Benoa + Truck to PP Pemaron and to all satellite (G)

* (Gilimanuk as a major powerplant) the reason for using the gas pipeline from the Gilimanuk Power Plant to Celukan Bawang Power Plant because the distance is close enough and the demand is also large enough so that if infrastructure investment in the form of a gas pipeline will be profitable because of its appropriate needs and minimize risks in distribution process, while using a barge from Gilimanuk Power Plant to Benoa because of its long distance so it will be detrimental to use a gas pipeline that can actually be replaced by a barge due to its lower costs and with the same small risk. Then consider using trucks as a means

of transportation for gas distribution because the demand from Pemaron power plant is small and the distance is quite close to the Gilimanuk power plant, besides the price incurred is relatively small but there is a considerable risk because in the distribution process using a truck will pass the traffic flow which is quite dense. While distribution to satellite uses trucks to facilitate the achievement of gas delivery to remote areas that cannot be reached by pipelines, but there is a big risk because if you go to certain areas there are differences in topography and slope of the land so that it can generate new risks.

11. Barge to Gilimanuk PP & Celukan Bawang PP & Pemaron PP + truck to all satellite

* (Benoa as a major Terminal) the reason for using a barge from Benoa Terminal to Gilimanuk Power Plant, Celukan Bawang Power Plant, Pemaron Power Plant because of its distance and demand is also quite large so that if using a barge can save operational costs and can minimize risk because traffic at sea is not as dense as on land and there is adequate infrastructure in Gilimanuk and Celukan Bawang, but not in pemaron. While distribution to satellite in each district using trucks will facilitate the achievement of gas delivery to remote areas that cannot be reached by pipelines, but there is a big risk because if you go to certain areas there are differences in topography and slope of the land so that it can generate new risks.

12. Pipeline to Gilimanuk PP + Barge to Celukan Bawang PP & Pemaron PP + truck to all satellite

* (Benoa as Major Terminal) the reason for using the gas pipeline from Benoa Terminal to the Gilimanuk Power Plant is because it takes into account long-term investment in which the pipeline is also passed by districts with large gas demand (Badung, Denpasar, Tabanan, Jembrana), factors others also pose a small risk and easy distribution process. While still using the barges to Celukan Bawang power plant and Pemaron power plant because of the distance and can save costs compared to using pipelines and using trucks that have a greater risk. While distribution to satellite in each district using trucks will facilitate the achievement of gas delivery to remote areas that cannot be reached by pipelines.

The 3 chosen scenario using AHP method is:

5. Pipeline to Gilimanuk PP + Barge to Benoa + Truck to Pemaron PP and to all satellite (CB)
9. Pipeline to Celukan Bawang PP + Barge to Benoa + Truck to PP Pemaron and to all satellite (G)
11. Barge to Gilimanuk PP & Celukan Bawang PP & Pemaron PP + truck to all satellite

4.3. Analytical Hierarchy Process Analysis

The first step is carried out in an AHP analysis, namely by making a questionnaire comparing the criteria to obtain data that will be inputted into the software expert's choice. The questionnaire was shared to the respondent to get weight and comparison scores. The criteria are taken from the social and economic aspect that may influence the design of the LNG terminal and some consideration for the surrounding environment. Based on the types of criteria for the impact of terminal, the terminal criteria can be divided into three types, that is criteria that affect these conditions and demand, criteria that affect the terminal conditions and surrounding environtment and the last is criteria that affect the economic value for investing and operating the distribution scenario, several sub-criteria that affect the location of the LNG terminal is: The gas demand in every area in Bali, safety reason and purpose for each facility, the distance between the terminal-mini filling station and the terminal-terminal, the possible disaster because of the topology and natural disaster. While several sub-criteria that have an effect on economic value is the calculation about investment and operation, and the time for building or investing new infrastructure facility. The following is a hierarchy of criteria that occurs in the selection of the best distribution scenario. Hierarchy creation is used to break down the problem into smaller parts. The hierarchy consists of several levels, where the top level is the main objective, the second level is the criteria and the last level is the sub-criteria to be scored.

Type of criteria:

a. Social criteria (Influence terminal and environment)
   - Demand
   - Safety

b. Environmental criteria (Influence environment)
   - Distance
   - Topological Effect
   - Potential of Disaster

c. Economic criteria (Influence terminal)
   - Investment
   - Time
   - Operational

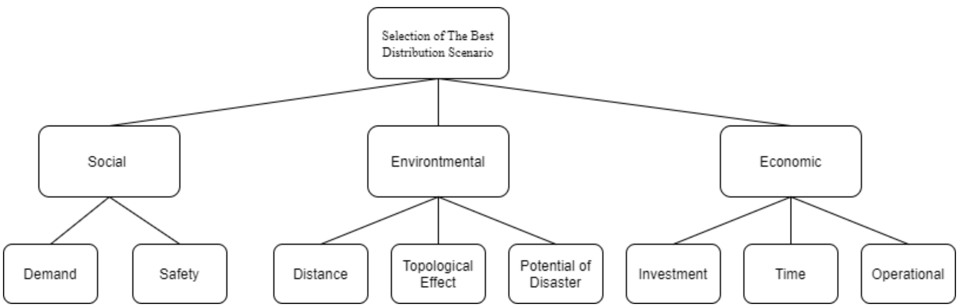

Figure. 4.12. Hierarchy Criteria Aspect

4.4. Economic Calculation Analysis

In this section the economic calculation will be the main focus of the research. As known in this bachelor thesis, this section woll be dicided into 3 sub chapter which is represented by each scenario. Every scenario is represented below. For economic calculation, 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 BPS (Badan Pusat Statistik) Bali and from mean price of item that being used in Alibaba and Amazon online store.

4.4.1.Scenario 1 – Celukan Bawang as Major Power Plant

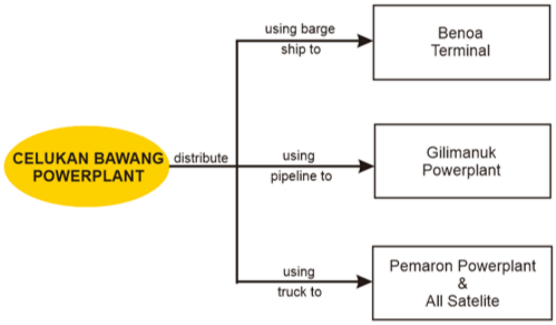

Figure 4.12. Scenario 1 (Celukan Bawang as Major Power Plant)

In this scenario, LNG is used to be an energy source of the power plant soon. It is known that the maximum power output of the Celukan Bawang PLTU is 380 MW(now) using coal as energy source. But, soon will be build Celukan Bawang PLTDGU power plant that have power 380x2 MW using LNG as main energy source. From this power plant, the need for natural gas can be known to calculate the demand for natural gas. The table below shows the need for liquefied natural gas to supply Celukan Bawang power plants for one day.

Table 4.19. Celukan Bawang Data Table – Scenario 1
*Assumption (Will be built soon)

Power Plant	**Celukan Bawang**	
Power Plant Type	Base Load*	
Engine Type	Typical Steam Cycle	
Power	380x2	MW
Gas Requirement	152	MMscfd
Daily Consumption	152000	Mmbtu
	5320	m^3/day

CAPEX (Capital Expenditure)

To ensure the quantity is in safe keep, LNG storage tank is needed. This tank is calculated from the volume of the liquefied natural gas required. The selection of LNG Storage tank is represented in table below. Table below is table that represent the general information of Celukan Bawang Power plant. In the table, known that the type of power plant is Base Load Power Plant*. With typical steam cycle engine. From the capacity of 380x2MW, the gas needed for powering the power plant is (760x2) divided by 5 becoming 152 MMscfd. Then the result before times by 35 to know the amount of dialy needed gas, that is 5320 m³/day. 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 Celukan Bawang 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 5500 m³. 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 4.20. LNG Storage Tank Selection – Scenario 1

LNG STORAGE TANK		
Model	**ZCF-250**	
Storage tank requirement	5320	m³
Each tank capacity	5000	m³
Design Pressure	0,35	Bar
Design BOG Rate	0,11	%
Height	22,43	M
Diameter	22,3	M
Number of tanks	1	Unit
Total capacity	5000	m³
Price	2000	US$/m³
Price (each)	5.000.000	US$
Price Total	5.000.000	US$
Model	**ZCF-250**	
Storage tank requirement	320	m³
Each tank capacity	400	m³
Design Pressure	0,35	Bar
Design BOG Rate	0,28	%
Height	13,6	M

Diameter	9,8	M
Number of tanks	1	Unit
Total capacity	400	m³
Price	2000	US$/m³
Price (each)	400.000	US$
Price Total	400.000	US$
All Price Total	5.400.000	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°C. LNG boiled off into normal natural 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 storage 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
= 0,11% X 5000 m^3
= 3300 m^3/day (LNG)
= 137,50 Nm^3/hour (nominal 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. 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 4.21. LNG Compressor Selection – Scenario 1

LNG BOG Compressor		
Brand	NTTC	
Type	Reciprocating	
Capacity	2.083,33	Nm³/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. 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 Nm³/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 4.22. Vaporizer Selection – Scenario 1

Vaporizer		
Model	CYYV1	
Type	Ambient Air	
Nominal Capacity	50	Nm³/hour
Max Pressure	15	bar
Power	0,1	kW
Area	0,5355	m^2
Weight	130	kg
Length	85	mm
Width	63	mm
Height	247	mm
Voltage	220/380	volt
Number of Vaporizer	3	unit
Price	2000	US$/m³
Price (each)	100.000	US$
Price Total	300.000	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 power plants 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/hour, the pump value is priced US$ 100. If the pump capacity is 50 Nm/hour the price of the pump is US$ 5.000.

Table 4.23. LNG Pump Selection – Scenario 1

LNG PUMP		
Required Capacity	16,49	m^3/hour
Pressure into Vaporizer	15	bar
LP Pump Model	CYY 15-200	
Type	Centrifugal	
Head	10-1000	m^3/hour
LP Pump Capacity	83-3,320	liter/min
	5-200	m^3/hour
Chosen Pump Capacity	50	m^3/hour
Pressure LP Pump	20	bar
Speed	960-5000	
Number of Pump	2	
Price	100	US$(/$m^3$/h)
Price (each)	5.000	US$
Price Total	10.000	US$
HP Pump Model	CYY 15-200	
Type	Centrifugal	
Head	10-1000	m^3/hour
HP Pump Capacity	83-3,320	liter/min
	5-200	m^3/hour
Chosen Pump Capacity	50	m^3/hour
Pressure HP Pump	20	bar
Speed	960-5000	
Number of Pump	2	

Price	100	US$(/m³/h)
Price (each)	5.000	US$
Price Total	10.000	US$
Total Pump Price Overall	20.000	US$

For transferring the LNG from the Celukan Bawang to Pemaron Power plant and all Satellite, 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 Celukan Bawang 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 have fuel consumption of 0,4 1/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 m3. The price that is mentioned in the table is the price which will affect the total of canital 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 i5 containing the value of truck itself the fanks nd the trailer. Combined and the price of total trucks set is estimated around US$ 200.000. This explanation is for the table below.

Table 4.24. Truck and Tank selection – Scenario 1

Truck and Tank		
Brand	Sino Truck	
Model	Sino Truck	
Power	251-350	HP
Engine capacity	9,726	Liter
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	liter/km

Tank Volume	50	m³
Number of Truck	19	unit
Price	200.000	US$
Total	2.800.000	US$

After LNG is arrived to Celukan Bawang Power plant, LNG inside LNG tank should be transferred out into LNG storage tank in Celukan Bawang. Discharge pump is available at the installation of every trucks. LNG filling station is needed in Celukan Bawang to transfer the LNG from whether LNG tank in Celukan Bawang or directly from the ship and also needed transfer into all distric in Bali. 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 Celukan Bawang 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 4.25. LNG Filling Station Selection – Scenario 1

LNG Filling Station / Satellite		
Brand	BTV standard	
Model	CGQ/LNG-30/60	
Capacity	60	m³
Filling Capacity	340	Liter/min
	20,4	m³/hour
Equipment Power	17	kW
Pressure	2,5	Mpa
Price	150.000	US$

In this scenario, LNG is used to be an energy source of the power plant will be sent too into Gilimanuk, Pemaron, and Pesanggaran Power Plant. It is known that the maximum power output of the Gilimanuk Power Plant is 180 MW , Pemaron Power Plant is 80 MW and Pesanggaran Power Plant is 380MW and all is using gas as energy source. From this power plant, the need for natural gas can be known to calculate the demand for natural gas. The table below shows the need for liquefied natural gas to supply power plants for one day.

Table 4.26. Gilimanuk Data Table – Scenario 1
*Assumption

Power Plant	**Gilimanuk**	
Power Plant Type	Base Load*	
Engine Type	Typical Steam Cycle	
Power	180	MW
Gas Requirement	26	MMscfd
Daily Consumption	26000	Mmbtu
	910	m³/day

The selection of LNG Storage tank is represented in table below. Table below is table that represent the general information of Gilimanuk Power plant. The gas needed for powering the power plant is (180x2) divided by 5 becoming 26 MMscfd. Then the result before times by 3 to know the amount of daily needed gas, that is 910 m³/day. After calculating the liquefied natural gas requirement, the quantity of the daily demand is known. From the table below there are specification of storage tank that is selected to be the tank in Gilimanuk 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 500 m³ x 2. 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

Table 4.27. LNG Storage Tank Selection – Scenario 1

LNG STORAGE TANK		
Model	ZCF-250	
Storage tank requirement	910	m³
Each tank capacity	500	m³
Design Pressure	0,35	Bar
Design BOG Rate	0,27	%
Height	12,65	M
Diameter	11,2	M
Number of tanks	2	Unit
Total capacity	1000	m³
Price	2000	US$/m³
Price (each)	500.000	US$
Price Total	1.000.000	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°C. LNG boiled off into normal natural 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 storage 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
= 0,27% X 500 m^3
= 810 m^3/day (LNG)
= 33,75 Nm^3/hour (nominal cubic/hour).

Table 4.28. Pemaron Data Table – Scenario 1
*Assumption

Power Plant	**Pemaron**	
Power Plant Type	Base Load*	
Engine Type	Typical Steam Cycle	
Power	80	MW
Gas Requirement	16	MMscfd
Daily Consumption	16000	Mmbtu
	560	m^3/day

The selection of LNG Storage tank is represented in table below. Table below is table that represent the general information of Pemaron Power plant. The gas needed for powering the power plant is (80x2) divided by 5 becoming 16 MMscfd. Then the result before times by 3 to know the amount of dialy needed gas, that is 560 m^3/day. After calculating the liquefied natural gas requirement, the quantity of the daily demand is known. 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 250 m^3 x 2. The design BOG rate is to calculate the BOG normal rate to select compressor.

Table 4.29. LNG Storage Tank Selection – Scenario 1

LNG STORAGE TANK		
Model	ZCF-250	
Storage tank requirement	560	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	2000	US$/$m^3$
Price (each)	250.000	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°C. LNG boiled off into normal natural 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 storage 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
= 690 m^3/day (LNG)
= 28,75 Nm^3/hour (nominal cubic/hour)

Table 4.30. Pesanggaran Data Table – Scenario 1
*Assumption

Power Plant	**Pesanggaran (Benoa)**	
Power Plant Type	Base Load*	
Engine Type	Typical Steam Cycle	
Power	380	MW
Gas Requirement	76	MMscfd
Daily Consumption	76000	Mmbtu
	2660	m^3/day

The selection of LNG Storage tank is represented in table below. Table below is table that represent the general information of Pesanggaran Power plant. The gas needed for powering the power plant is (380x2) divided by 5 becoming 76 MMscfd. Then the result before times by 3 to know the amount of daily needed gas, that is 2660 m^3/day. After calculating the liquefied natural gas requirement, the quantity of the daily demand is known. From the table below there are specification of storage tank that is selected to be the tank in Pesanggaran 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 500 m^3 x 6. 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 4.31. LNG Storage Tank Selection – Scenario 1

LNG STORAGE TANK		
Model	ZCF-250	
Storage tank requirement	2660	m^3
Each tank capacity	500	m^3
Design Pressure	0,35	Bar
Design BOG Rate	0,27	%
Height	12,65	M
Diameter	11,2	M
Number of tanks	6	Unit
Total capacity	3000	m^3
Price	2000	US$/$m^3$
Price (each)	500.000	US$
Price Total	3.000.000	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°C. LNG boiled off into normal natural 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 storage 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
= 0,27% X 500 m^3
= 810 m^3/day (LNG)
= 33,75 Nm^3/hour (nominal cubic/hour)

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. 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, and some item at Gilimanuk, Pemaron and Pesanggaran Power Plant is same like, the vaporizer, pump and etc. But the number of some item is different in every power plants. 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$ 36.225.000

Table 4.32. Capital Cost – Scenario 1

Capital Cost			
ITEM	PRICE ($)	Number of Items	Cost ($)
LNG Storage Tank	9.900.000*	12*	9.900.000
BOG Handling	80.000	11	880.000
Vaporizer	100.000	11	1.100.000
Pump	5.000	40	200.000
Truck and Storage tank	200.000	22	4.400.000
Mini Filling Station	250.000	10	2.500.000
Pipe from Gilimanuk to CB	10.000.000		10.000.000
Total 1			28.980.000
Tax 25% and etc.			7.245.000
Total Fix Cost			36.225.000

OPEX (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 50 m2. The average speed that is being considered here is about 45 km/h. the fuel consumption that is listed below is important in tem of fuel purchasing for the trucks. And for the pricing value is important for completing the economic data requirement.

Table 4.33. Truck and Tank Selection Scenario 1

Vessel Spesification		
Spesification	Value	Unit
Vessel	Trucks	
Brand	Sino Trucks	
LNG Volume	30	m³
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 on the data listed below.

Table 4.34. Time Allocation – Scenario 1

Time Allocation	Value	Time
Loading time	0,625	day
Unloading time	0,625	day
Total time	1,25	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 caleulating 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.

Table 4.35. Fuel Cost– Scenario 1

Fuel Cost	7900	IDR/Liter
Diesel Fuel	0,5642857	US$/Liter
Diesel Fuel	0,832	kg/Liter
Density Diesel Fuel	0,678228	US$/kg
Diesel Fuel Ship Cost	700	US$/ton

Fuel cost per round trip is obtained by calculating fuel consumption, 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 Alibaba online store and some information on Internet. As for the obtained data from Alibaba online store and some information on internet is the charter cost and the port cost with the assumption. As for charter cost it is counted for everyday and will be calculated in term of every year. Then the port cost, which the only different is the duration that is needed when the ship is in port.

The Operational Expenditure that may be got from the cumulative cost consist of fuel cost, crew cost, LNG purchase and LNG transport cost are named total operation expenditure which is US$ 14.972.000. For each cost is already listed in the table below. For fuel cost of LNG distribution that is sent by trucks from Celukan Bawang is listed below and has the value of US$ 10.000.000 including the barge fuel cost. The crew cost itself can be seen from the table below and valued USS 2.000.000. The LNG cost that is being purchased from Bontang also mentioned below. By the current condition, the price of LNG is US$ 3 for each MMbtu. For the Pemaron power plant, as this power plant require 16000 MMbtu/day, the daily price of purchased natural gas is US$ 48.000. For the Gilimanuk power plant, as it need daily energy of 26000 MMbtu/day, the price of daily need of natural gas is US$ 78.000. For the Pesanggaran power plant, as it need daily energy of 76000 MMbtu/day, the price of daily need of natural gas is US$ 228.000 And for the Celukan Bawang power plant itself, as it need daily energy of 152000 MMbtu/day, the price of daily need of natural gas is US$ 456.000. For the transport cost of LNG through the sea, this value is obtained by summing the fuel cost of carrier, charter cost, and port cost.

Table 4.36. Operational Cost –Scenario 1

Operational Cost			
ITEM	PRICE ($)	Number of Items	Cost ($)
Barge charter cost (year)	500.000	2	1.000.000
Barge and Trucks Fuel cost (year)	10.000.000		10.000.000
Port Cost	400.000		400.000
Management Cost	900.000		900.000
LNG cost (3PP)	810.000		810.000
Maintenance Cost	90.000		90.000
Crew Cost	2.000.000		2.000.000
Total Variable Cost			15.200.000

After obtaining the value of capital expenditure and operational expenditure, the calculation of economic result can be done. It can be seen the summary of Cost of capital expenditure and operational expenditure. The capital expenditure that is calculated before is US$ 36.225.000. And for the operational expenditure of this scenario is valued US$ 15.200.000.

Table 4.37. Economic Analysis Scenario 1

Investment	Price (US$)
Capex	36.225.000
Opex	15.200.000

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$ 27.168.750. Total depreciation is the cumulative of all yearly depreciation in the duration of time. The value of yearly depreciation is US$ 905.625, while the contract duration is 10 years, resulting on the total depreciation is US$ 9.056.250. The disposal price that is mentioned in the table is salvage value reduced value of multiplication yearly depreciation and contract duration. In this scenario, the value of disposal price is US$ 18.112.500.

Table 4.38. Economic Input Data Scenario 1

Item	Value
Contract Duration (Year)	10
Total Investment (US$)	36.225.000
Salvage Value (US$)	27.168.750
Disposal Value (US$)	18.112.500
Yearly Depreciation (US$)	905.625
Depreciation Value	9.056.250

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$ 3, yearly income of the selling is USS 12.338.793. For the margin US$ 3.5, the yearly revenue is higher than the margin US$ 3, the value is US$ 12.935.381. And for the margin US$ 4, the yearly revenue is US$ 13.930.895.

Table 4.39. Revenue Scenario 1

Selling Price		
ITEM	**UNITS**	**PRICE**
LNG Cost / day	MMbtu	14.000,00
LNG Cost / Year	MMbtu	5.110.000
	MARGIN ($)	
Profit from LNG Selling	3	15.330.000
	3,5	17.885.000
	4	20.440.000

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 4.40. Economical Calculation Margin 3US$ - Scenario 1

Year	CAPEX	Revenue	OPEX	Depreciation	Earning Before Tax (EBT)	Tax(25%)	Earning After Tax	Proceeds (Cashflow)	Commulative Proceeds	PP Margin 3$
0	36.225.000									-36.225.000
1		15.330.000	15.200.000	905.625	-775.625	-193.906	-581.719	323.906	323.906	-35.901.094
2		15.330.000	15.652.813	905.625	-1.228.438	-307.109	-921.328	-15.703	308.203	-35.592.891
3		15.330.000	16.105.625	905.625	-1.681.250	-420.313	-1.260.938	-355.313	-47.109	-35.640.000
4		15.330.000	16.558.438	905.625	-2.134.063	-533.516	-1.600.547	-694.922	-742.031	-36.382.031
5		15.330.000	17.011.250	905.625	-2.586.875	-646.719	-1.940.156	-1.034.531	-1.776.563	-38.158.594
6		15.330.000	17.464.063	905.625	-3.039.688	-759.922	-2.279.766	-1.374.141	-3.150.703	-41.309.297
7		15.330.000	17.916.875	905.625	-3.492.500	-873.125	-2.619.375	-1.713.750	-4.864.453	-46.173.750
8		15.330.000	18.369.688	905.625	-3.945.313	-986.328	-2.958.984	-2.053.359	-6.917.813	-53.091.563
9		15.330.000	18.822.500	905.625	-4.398.125	-1.099.531	-3.298.594	-2.392.969	-9.310.781	-62.402.344
10		15.330.000	19.275.313	905.625	-4.850.938	-1.212.734	-3.638.203	-2.732.578	-12.043.359	-74.445.703

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 and lower, it means the project with the current margin is not profitable and it will not paid back. From this graph, it can be seen that first scenario with margin US$ 3 is negative, in other word, this option is very unprofitable.

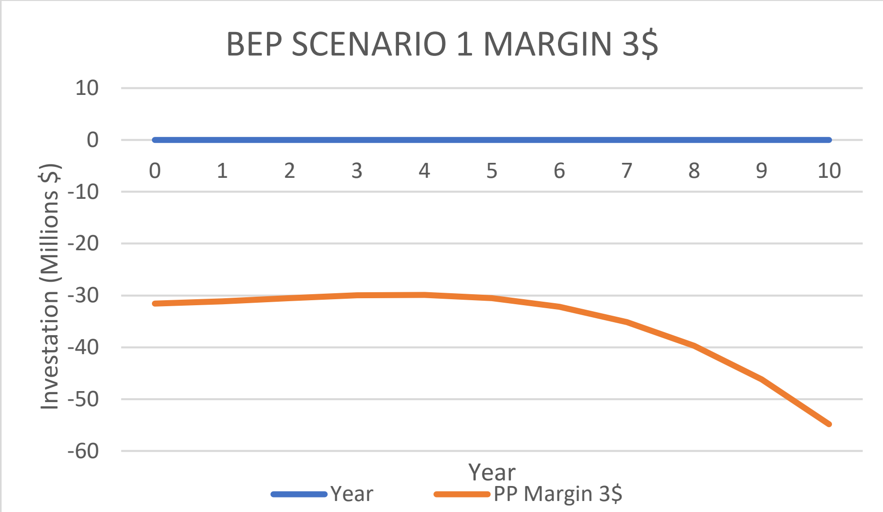

Figure 4.13. Payback Period Scenario 1 Margin 3$

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 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$ -36.225.000. The value of NPV is negative, in the actual meaning, this option is unprofitable.

Table 4.41. Discount Rate Cashflow, NPV – Scenario 1 Margin 3US$

Year	Cash Flow	i	NPV Margin 3$
0	-36.225.000		-36.225.000
1	323.906		294.460
2	-15.703		-12.978
3	-355.313		-266.952
4	-694.922		-474.641
5	-1.034.531	10%	-642.363
6	-1.374.141		-775.667
7	-1.713.750		-879.425
8	-2.053.359		-957.907
9	-2.392.969		-1.014.852
10	-2.732.578		-1.053.527
Total	-12.043.359		-42.008.851

From the result that obtained and listed, it can be seen the value of NPV is US$ -36.225.000, the value of IRR cannot be calculated, from this option, it can be seen it is not too good for making profit.

Similar with the previous calculation, scenario 1 margin US$3, the difference only at the margin. This time, margin used is US$ 3.5. 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 4.42. Economical Calculation Margin 3.5US$ - Scenario 1

Year	CAPEX	Revenue	OPEX	Depreciation	Earning Before Tax (EBT)	Tax(25%)	Earning After Tax	Proceeds (Cashflow)	Commulative Proceeds	PP Margin 3.5$
0	36.225.000									-36.225.000
1		17.885.000	15.200.000	905.625	1.779.375	444.844	1.334.531	2.240.156	2.240.156	-33.984.844
2		17.885.000	15.652.813	905.625	1.326.563	331.641	994.922	1.900.547	4.140.703	-29.844.141
3		17.885.000	16.105.625	905.625	873.750	218.438	655.313	1.560.938	5.701.641	-24.142.500
4		17.885.000	16.558.438	905.625	420.938	105.234	315.703	1.221.328	6.922.969	-17.219.531
5		17.885.000	17.011.250	905.625	-31.875	-7.969	-23.906	881.719	7.804.688	-9.414.844
6		17.885.000	17.464.063	905.625	-484.688	-121.172	-363.516	542.109	8.346.797	-1.068.047
7		17.885.000	17.916.875	905.625	-937.500	-234.375	-703.125	202.500	8.549.297	7.481.250
8		17.885.000	18.369.688	905.625	-1.390.313	-347.578	-1.042.734	-137.109	8.412.188	15.893.438
9		17.885.000	18.822.500	905.625	-1.843.125	-460.781	-1.382.344	-476.719	7.935.469	23.828.906
10		17.885.000	19.275.313	905.625	-2.295.938	-573.984	-1.721.953	-816.328	7.119.141	30.948.047

After 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. Is shows that the graph has good prospect that shown the project will paid back the capital expenditure starting around 5 year.

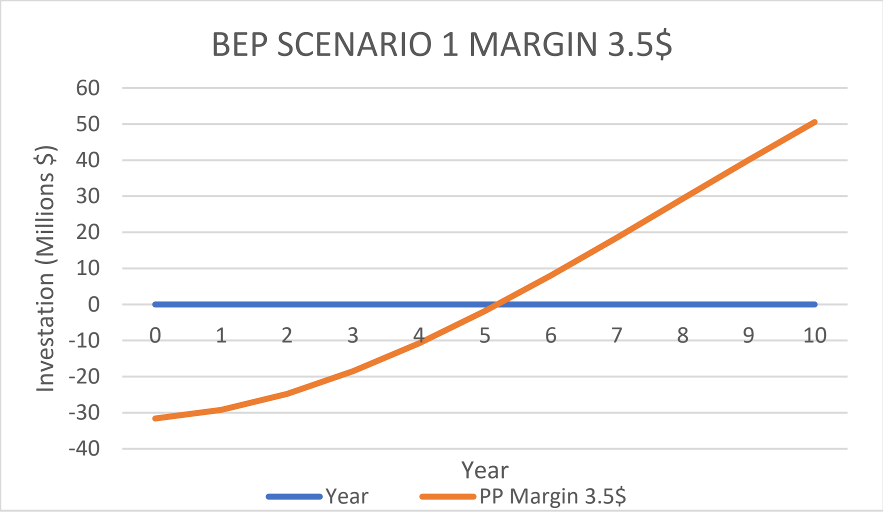

Figure 4.14. Payback Period Scenario 1 Margin 3.5$

Below are the table that showing the discount rate, cash flow, and NPV value of the scenario 1 with margin US$3.5. From the table below it can be seen thevalue or yearly NPV the scenario 1 with margin US$ 3.5 is various. The total NPV of this option is US$ -30.234.324by the end of 10 years pure revenue is US$ 7.119.141.

The economic approach, only differs of the margin with the previous calculation. This time, the margin using value of US$ 4. From the table below, the calculation of the economic approach of scenario 1 with margin US$ 4 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.

Table 4.43. Discount Rate Cashflow, NPV – Scenario 1 Margin 3.5US$

Year	Cash Flow	i	NPV Margin 3.5$
0	-36.225.000	10%	-36.225.000
1	2.240.156		2.036.506
2	1.900.547		1.570.700
3	1.560.938		1.172.755
4	1.221.328		834.184
5	881.719		547.478
6	542.109		306.007
7	202.500		103.915
8	-137.109		-63.963
9	-476.719		-202.175
10	-816.328		-314.730
Total	7.119.141		-30.234.324

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 theproceed which is already cumulated from the previous year of the project investment state is the condition which current debt or the current Profit.

Table 4.44. Economical Calculation Margin 4US$ - Scenario 1

Year	CAPEX	Revenue	OPEX	Depreciation	Earning Before Tax (EBT)	Tax(25%)	Earning After Tax	Proceeds (Cashflow)	Commulative Proceeds	PP Margin 4$
0	36.225.000									-36.225.000
1		20.440.000	15.200.000	905.625	4.334.375	1.083.594	3.250.781	4.156.406	4.156.406	-32.068.594
2		20.440.000	15.652.813	905.625	3.881.563	970.391	2.911.172	3.816.797	7.973.203	-24.095.391
3		20.440.000	16.105.625	905.625	3.428.750	857.188	2.571.563	3.477.188	11.450.391	-12.645.000
4		20.440.000	16.558.438	905.625	2.975.938	743.984	2.231.953	3.137.578	14.587.969	1.942.969
5		20.440.000	17.011.250	905.625	2.523.125	630.781	1.892.344	2.797.969	17.385.938	19.328.906
6		20.440.000	17.464.063	905.625	2.070.313	517.578	1.552.734	2.458.359	19.844.297	39.173.203
7		20.440.000	17.916.875	905.625	1.617.500	404.375	1.213.125	2.118.750	21.963.047	61.136.250
8		20.440.000	18.369.688	905.625	1.164.688	291.172	873.516	1.779.141	23.742.188	84.878.438
9		20.440.000	18.822.500	905.625	711.875	177.969	533.906	1.439.531	25.181.719	110.060.156
10		20.440.000	19.275.313	905.625	259.063	64.766	194.297	1.099.922	26.281.641	136.341.797

After 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. Is shows that the graph has good prospect that shown the project will paid back the capital expenditure starting around 3.5 year.

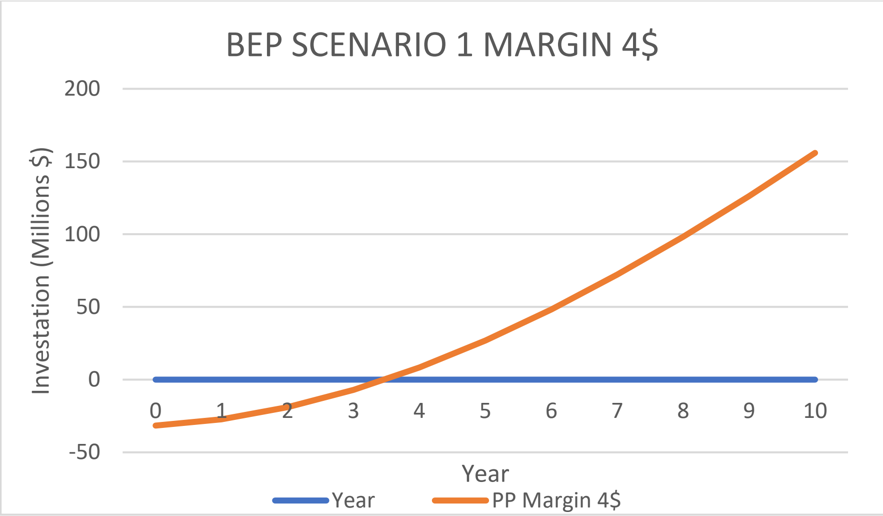

Figure 4. 15. Payback Period Scenario 1 Margin 4$

Below are the table that showing the discount rate, cash flow, and NPV value of the scenario 1 with margin US$4. From the table below it can be seen the value or yearly NPV the scenario 1 with margin US$ 4 is various. The total NPV of this option is US$ -18.459.797 by the end of 10 years pure revenue is US$ 26.281.641.

Table 4.45. Discount Rate Cashflow, NPV – Scenario 1 Margin 4US$

Year	Cash Flow	i	NPV Margin 4$
0	-36.225.000	10%	-36.225.000
1	4.156.406		3.778.551
2	3.816.797		3.154.378
3	3.477.188		2.612.462
4	3.137.578		2.143.008
5	2.797.969		1.737.318
6	2.458.359		1.387.680
7	2.118.750		1.087.254
8	1.779.141		829.982
9	1.439.531		610.502
10	1.099.922		424.067
Total	26.281.641		-18.459.797

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$ 3, margin US$ 3.5 and margin US$ 4. Shown in the graphs, the option which has positive result of the economical approach is option with margin US$ 3.5 and margin US$ 4. The option of margin US$ 3 is not giving any profit from the beginning whether the future. It can be seen that option is not feasible.

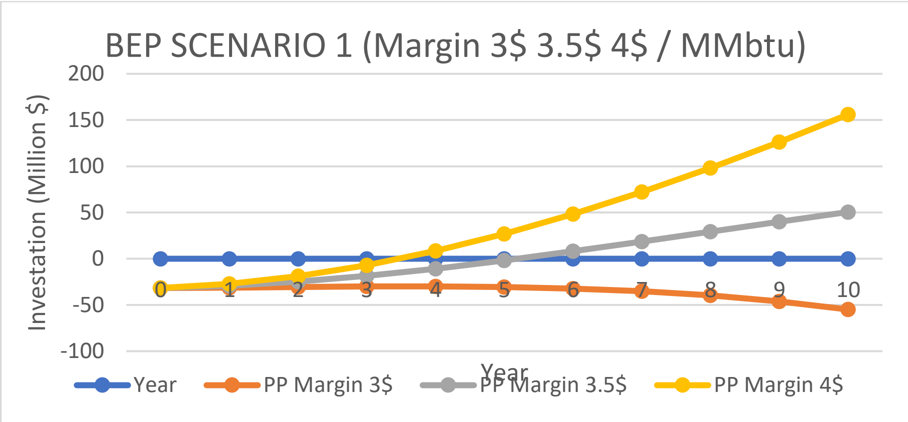

Figure 4.16. Payback Period Scenario 1

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$ 4. The second high is margin US$ 3.5 and the last is margin US$ 3. This graph can be constructed like this

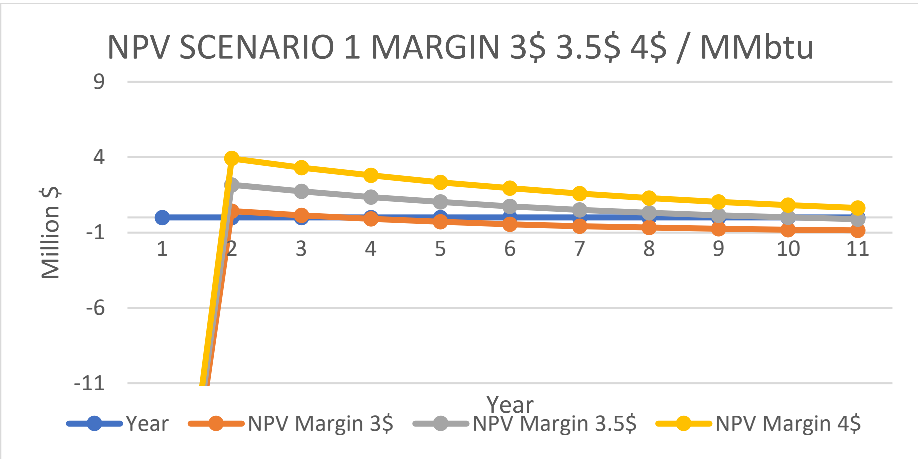

Figure 4. 17. NPV Graph Scenario 1

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.

4.4.2.Scenario 2 – Gilimanuk as Major Power Plant

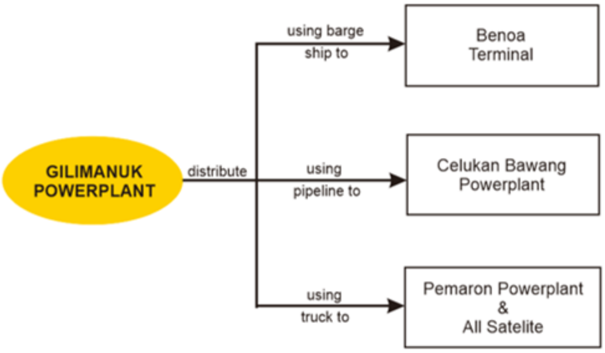

Figure 4.18. Scenario 2 (Gilimanuk as Major Power Plant)

In this scenario, LNG is used to be an energy source of the power plant soon. It is known that the maximum power output of the Gilimanuk Power Plant is 180 MW using gas as energy source. From this power plant, the need for natural gas can be known to calculate the demand for natural gas. The table below shows the need for liquefied natural gas to supply Gilimanuk power plants for one day.

Table 4.46. Gilimanuk Data Table – Scenario 2
*Assumption

Power Plant	Gilimanuk	
Power Plant Type	Base Load*	
Engine Type	Typical Steam Cycle	
Power	180	MW
Gas Requirement	26	MMscfd
Daily Consumption	26000	Mmbtu
	910	m^3/day

To ensure the quantity is in safe keep, LNG storage tank is needed. This tank is calculated from the volume of the liquefied natural gas required. The selection of LNG Storage tank is represented in table below. Table below is table that represent the general information of Gilimanuk Power plant. In the table, known that the type of power plant is Base Load Power Plant*. With typical steam cycle engine. From the capacity of 180MW, the gas needed for powering the power plant is (180x2) divided by 5 becoming 26 MMscfd. Then the result before times by 3 to know the amount of daily needed gas, that is 910 m^3/day. 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 Gilimanuk 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 500 m³ x 2. 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 4.47. LNG Storage Tank Selection – Scenario 2

LNG STORAGE TANK		
Model	ZCF-250	
Storage tank requirement	910	m³
Each tank capacity	500	m³
Design Pressure	0,35	Bar
Design BOG Rate	0,27	%
Height	12,65	M
Diameter	11,2	M
Number of tanks	2	Unit
Total capacity	1000	m³
Price	2000	US$/m³
Price (each)	500.000	US$
Price Total	1.000.000	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°C. LNG boiled off into normal natural 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 storage 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
= 0,27% X 500 m³
= 810 m³/day (LNG)
= 33,75 Nm³/hour (nominal 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. 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 4.48. LNG Compressor Selection – Scenario 2

LNG BOG Compressor		
Brand	NTTC	
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. 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 4.49. Vaporizer Selection – Scenario 2

Vaporizer		
Model	CYYV1	
Type	Ambient Air	
Nominal Capacity	50	Nm³/hour
Max Pressure	15	bar
Power	0,1	kW
Area	0,5355	m^2
Weight	130	kg
Length	85	mm
Width	63	mm
Height	247	mm
Voltage	220/380	volt
Number of Vaporizer	2	unit
Price	2000	US$/m³
Price (each)	100.000	US$
Price Total	300.000	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 are for both of high-pressure pump and low-pressure pump. Head of chosen pumps is 10-1.000 m. The capacity of these power plants is same, which is around 5-200 m³/hour. But the chosen capacity of the pump is 50 m³/hour. The outlet pressure of these pumps is 20 bar. As for the pump, the initial price of pump is based on the capacity of pump which can be obtained. As for each m/hour, the pump value is priced US$ 100. If the pump capacity is 50 Nm/hour the price of the pump is US$ 5.000.

Table 4.50. LNG Pump Selection – Scenario 2

LNG PUMP		
Required Capacity	16,49	m³/hour
Pressure into Vaporizer	15	bar
LP Pump Model	CYY 15-200	
Type	Centrifugal	
Head	10-1000	m³/hour
LP Pump Capacity	83-3,320	liter/min

	5-200	m³/hour
Chosen Pump Capacity	50	m³/hour
Pressure LP Pump	20	bar
Speed	960-5000	
Number of Pump	2	
Price	100	US$(/m³/h)
Price (each)	5.000	US$
Price Total	10.000	US$
HP Pump Model	CYY 15-200	
Type	Centrifugal	
Head	10-1000	m³/hour
HP Pump Capacity	83-3,320	liter/min
	5-200	m³/hour
Chosen Pump Capacity	50	m³/hour
Pressure HP Pump	20	bar
Speed	960-5000	
Number of Pump	2	
Price	100	US$(/m³/h)
Price (each)	5.000	US$
Price Total	10.000	US$
Total Pump Price Overall	20.000	US$

For transferring the LNG from the Gilimanuk to Pemaron Power plant and all satellite, 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 Gilimanuk through the filling station that is designed in this scenario as well. The Gilimanuk 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 have fuel consumption of 0,4 1/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 m3. The price that is mentioned in the table is the price which will affect the total of capital expenditure. This pricing 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 i5 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 4.51. Truck and Tank selection – Scenario 2

Truck and Tank		
Brand	Sino Truck	
Model	Sino Truck	
Power	251-350	HP
Engine capacity	9,726	Liter
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	liter/km
Tank Volume	30	m^3
Number of Truck	14	unit
Price	200.000	US$
Total	2.800.000	US$

After LNG is arrived to Gilimanuk Power plant, LNG inside LNG tank should be transferred out into LNG storage tank in Gilimanuk Power Plant. Discharge pump is available at the installation of every trucks. LNG filling station is needed in Gilimanuk to transfer the LNG from whether LNG tank in Gilimanik or directly from the ship and also into all district in Bali. 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. 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 4.52. LNG Filling Station Selection – Scenario 2

LNG Filling Station / Satellite		
Brand	BTV standard	
Model	CGQ/LNG-30/60	
Capacity	60	m^3
Filling Capacity	340	Liter/min
	20,4	m^3/hour
Equipment Power	17	kW
Pressure	2,5	Mpa
Price	150.000	US$

In this scenario, LNG is used to be an energy source of the power plant will be sent too into Celukan Bawang, Pemaron, and Pesanggaran Power Plant. It is known that the maximum power output of the Celukan Bawang Power Plant is 380x2 MW that will be built soon, Pemaron Power Plant is 80 MW and Pesanggaran Power Plant is 380MW and all is using gas as energy source. From this power plant, the need for natural gas can be known to calculate the demand for natural gas. The table below shows the need for liquefied natural gas to supply power plants for one day.

Table 4.53. Gilimanuk Data Table – Scenario 2
*Assumption (will be built soon)

Power Plant	**Celukan Bawang**	
Power Plant Type	Base Load*	
Engine Type	Typical Steam Cycle	
Power	760	MW
Gas Requirement	152	MMscfd
Daily Consumption	152000	Mmbtu
	5320	m^3/day

The selection of LNG Storage tank is represented in table below. Table below is table that represent the general information of Celukan Bawang Power plant. The gas needed for powering the power plant is (180x2) divided by 5 becoming 26 MMscfd. Then the result before times by 3 to know the amount of daily needed gas, that is 910 m^3/day. After calculating the liquefied natural gas requirement, the quantity of the daily demand is known. From the table below there are specification of storage tank that is selected to be the tank in Celukan Bawang 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 500 m^3 x 2. 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.

Table 4.54. LNG Storage Tank Selection – Scenario 2

LNG STORAGE TANK		
Model	**ZCF-250**	
Storage tank requirement	5320	m³
Each tank capacity	5000	m³
Design Pressure	0,35	Bar
Design BOG Rate	0,11	%
Height	22,43	M
Diameter	22,3	M
Number of tanks	1	Unit
Total capacity	5000	m³
Price	2000	US$/m³
Price (each)	5.000.000	US$
Price Total	5.000.000	US$
Model	**ZCF-250**	
Storage tank requirement	320	m³
Each tank capacity	400	m³
Design Pressure	0,35	Bar
Design BOG Rate	0,28	%
Height	13,6	M
Diameter	9,8	M
Number of tanks	1	Unit
Total capacity	400	m³
Price	2000	US$/m³
Price (each)	400.000	US$
Price Total	400.000	US$
All Price Total	5.400.000	US$

LNG characteristic has trait to boiled off when the temperature is getting hotter than normal LNG temperature, which is around 160°C. LNG boiled off into normal natural 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 storage tank. Using the boiled off gas rate of the selected tank, normal rate of boiled off gas can be calculated. 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

= 0,11% X 5000 m^3

= 3300 m^3/day (LNG)

= 137,50 Nm^3/hour (nominal cubic/hour).

Table 4.55. Pemaron Data Table – Scenario 2 (*assumption)

Power Plant	**Pemaron**	
Power Plant Type	Base Load*	
Engine Type	Typical Steam Cycle	
Power	80	MW
Gas Requirement	16	MMscfd
Daily Consumption	16000	Mmbtu
	560	m^3/day

The selection of LNG Storage tank is represented in table below. Table below is table that represent the general information of Pemaron Power plant. The gas needed for powering the power plant is (80x2) divided by 5 becoming 16 MMscfd. Then the result before times by 3 to know the amount of dialy needed gas, that is 560 m^3/day. After calculating the liquefied natural gas requirement, the quantity of the daily demand is known. 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 250 m^3 x 2. The design BOG rate is to calculate the BOG normal rate to select compressor.

Table 4.56. LNG Storage Tank Selection – Scenario 2

LNG STORAGE TANK		
Model	ZCF-250	
Storage tank requirement	560	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	2000	US$/$m^3$
Price (each)	250.000	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°C. LNG boiled off into normal natural 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 storage 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
= 690 m^3/day (LNG)
= 28,75 Nm^3/hour (nominal cubic/hour)

Table 4.57. Pesanggaran Data Table – Scenario 2(*assumption)

Power Plant	**Pesanggaran (Benoa)**	
Power Plant Type	Base Load*	
Engine Type	Typical Steam Cycle	
Power	380	MW
Gas Requirement	76	MMscfd
Daily Consumption	76000	Mmbtu
	2660	m^3/day

Table below is table that represent the LNG cargo tank general information of Pesanggaran Power plant. The gas needed for powering the power plant is (380x2) divided by 5 becoming 76 MMscfd. Then the result before times by 3 to know the amount of daily needed gas, that is 2660 m^3/day. After calculating the liquefied natural gas requirement, the quantity of the daily demand is known. From the table below there are specification of storage tank that is selected to be the tank in Pesanggaran 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 500 m^3 x 6. 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 4.58. LNG Storage Tank Selection – Scenario 2

LNG STORAGE TANK		
Model	ZCF-250	
Storage tank requirement	2660	m³
Each tank capacity	500	m³
Design Pressure	0,35	Bar
Design BOG Rate	0,27	%
Height	12,65	M
Diameter	11,2	M
Number of tanks	6	Unit
Total capacity	3000	m³
Price	2000	US$/m³
Price (each)	500.000	US$
Price Total	3.000.000	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°C. LNG boiled off into normal natural 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 storage 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
= 0,27% X 500 m^3
= 810 m^3/day (LNG)
= 33,75 Nm^3/hour (nominal cubic/hour)

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. 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, and some item at Gilimanuk, Pemaron and Pesanggaran Power Plant is same like, the vaporizer, pump and etc. But the number of some item is different in every power plants. 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 2 is US$ 31.600.000

Table 4.59. Capital Cost – Scenario 2

Capital Cost			
ITEM	PRICE ($)	Number of Items	Cost ($)
LNG Storage Tank	9.900.000*	5*	9.900.000
BOG Handling	80.000	11	880.000
Vaporizer	100.000	11	1.100.000
Pump	5.000	40	200.000
Truck and Storage tank	200.000	22	4.400.000
Mini Filling Station	250.000	10	2.500.000
Pipe from Gilimanuk to CB	10.000.000		10.000.000
Total 1			28.980.000
Tax 25% and etc.			7.245.000
Total Fix Cost			36.225.000

OPEX (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 50 m2. The average speed that is being considered here is about 45 km/h. the fuel consumption that is listed below is important in tem of fuel purchasing for the trucks. And for the pricing value is important for completing the economic data requirement.

Table 4.60. Truck and Tank Selection Scenario 2

Vessel Spesification		
Spesification	Value	Unit
Vessel	Trucks	
Brand	Sino Trucks	
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 on the data listed below.

Table 4.61. Time Allocation – Scenario 2

Time Allocation	Value	Time
Loading time	0,625	day
Unloading time	0,625	day
Total time	1,25	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.

Table 4.62. Fuel Cost– Scenario 2

Fuel Cost	7900	IDR/Liter
Diesel Fuel	0,5642857	US$/Liter
Diesel Fuel	0,832	kg/Liter
Density Diesel Fuel	0,678228	US$/kg
Diesel Fuel Ship Cost	700	US$/ton

Fuel cost per round trip is obtained by calculating fuel consumption, 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 the obtained data from Alibaba online store and some information on internet is the charter cost and the port cost with the assumption. As for charter cost it is counted for everyday and will be calculated in term of every year. Then the port cost, which the only different is the duration that is needed when the ship is in port.

The Operational Expenditure that may be got from the cumulative cost consist of fuel cost, crew cost, LNG purchase and LNG transport cost are named total operation expenditure which is US$ 14.972.000. For each cost is already listed in the table below. For fuel cost of LNG distribution that is sent by trucks from Gilimanuk is listed below and has the value of US$ 10.000.000 including the barge fuel cost. The crew cost itself can be seen from the table below and valued USS 2.000.000. The LNG cost that is being purchased from Bontang also mentioned below. By the current condition, the price of LNG is US$ 3 for each MMbtu. For the Pemaron powerplant, as this powerplant require 16000 MMbtu/day, the daily price of purchased natural gas is US$ 48.000. For the Pesanggaran power plant, as it need daily energy of 76000 MMbtu/day, the price of daily need of natural gas is US$ 228.000 And for the Celukan Bawang power plant itself, as it need daily energy of 152000 MMbtu/day, the price of daily need of natural gas is US$ 456.000. For the transport cost of LNG through the sea, this value is obtained by summing the fuel cost of carrier, charter cost, and port cost.

Table 4.63. Operational Cost –Scenario 2

Operational Cost			
ITEM	PRICE ($)	Number of Items	Cost ($)
Barge charter cost (year)	500.000	2	1.000.000
Barge and Trucks Fuel cost (year)	10.000.000		10.000.000
Port Cost	400.000		400.000
Management Cost	900.000		900.000
LNG cost (3PP)	810.000		810.000
Maintenance Cost	90.000		90.000
Crew Cost	2.000.000		2.000.000
Total Variable Cost			15.200.000

After obtaining the value of capital expenditure and operational expenditure, the calculation of economic result can be done. Below 15 mentioned the pricing of capital expen d 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$ 36.225.000. And for the operational expenditure of this scenario is valued US$ 15.200.000.

Investment	Price (US$)
Capex	36.225.000
Opex	15.200.000

Table 4.64. Economic Analysis Scenario 2

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$ 27.168.750. Total depreciation is the cumulative of all yearly depreciation in the duration of time. The value of yearly depreciation is US$ 905.625, while the contract duration is 10 year, resulting on the total depreciation is US$ 9.056.250. The disposal price that is mentioned in the table is salvage value reduced value of multiplication yearly depreciation and contract duration. In this scenario, the value of disposal price is US$ 18.112.500.

Table 4.65. Economic Input Data Scenario 2

Item	Value
Contract Duration (Year)	10
Total Investment (US$)	36.225.000
Salvage Value (US$)	27.168.750
Disposal Value (US$)	18.112.500
Yearly Depreciation (US$)	905.625
Depreciation Value	9.056.250

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. 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$ 3, yearly income of the selling is USS 15.330.000. For the margin US$ 3.5, the yearly revenue is higher than the margin US$ 3, the value is US$ 17.885.000. And for the margin US$ 4, the yearly revenue is US$ 20.440.000.

Table 4.66. Revenue Scenario 2

Selling Price		
ITEM	**UNITS**	**PRICE**
LNG Cost / day	MMbtu	14.000,00
LNG Cost / Year	MMbtu	5.110.000
	MARGIN ($)	
Profit from LNG Selling	3	15.330.000
	3,5	17.885.000
	4	20.440.000

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 4.67. Economical Calculation Margin 3US$ - Scenario 2

Year	CAPEX	Revenue	OPEX	Depreciation	Earning Before Tax (EBT)	Tax(25%)	Earning After Tax	Proceeds (Cashflow)	Commulative Proceeds	PP Margin 3$
0	36.225.000									-36.225.000
1		15.330.000	15.200.000	905.625	-775.625	-193.906	-581.719	323.906	323.906	-35.901.094
2		15.330.000	15.652.813	905.625	-1.228.438	-307.109	-921.328	-15.703	308.203	-35.592.891
3		15.330.000	16.105.625	905.625	-1.681.250	-420.313	-1.260.938	-355.313	-47.109	-35.640.000
4		15.330.000	16.558.438	905.625	-2.134.063	-533.516	-1.600.547	-694.922	-742.031	-36.382.031
5		15.330.000	17.011.250	905.625	-2.586.875	-646.719	-1.940.156	-1.034.531	-1.776.563	-38.158.594
6		15.330.000	17.464.063	905.625	-3.039.688	-759.922	-2.279.766	-1.374.141	-3.150.703	-41.309.297
7		15.330.000	17.916.875	905.625	-3.492.500	-873.125	-2.619.375	-1.713.750	-4.864.453	-46.173.750
8		15.330.000	18.369.688	905.625	-3.945.313	-986.328	-2.958.984	-2.053.359	-6.917.813	-53.091.563
9		15.330.000	18.822.500	905.625	-4.398.125	-1.099.531	-3.298.594	-2.392.969	-9.310.781	-62.402.344
10		15.330.000	19.275.313	905.625	-4.850.938	-1.212.734	-3.638.203	-2.732.578	-12.043.359	-74.445.703

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 and lower, it means the project with the current margin is not profitable and it will not paid back. From this graph, it can be seen that first scenario with margin US$ 3 is negative, in other word, this option is very unprofitable.

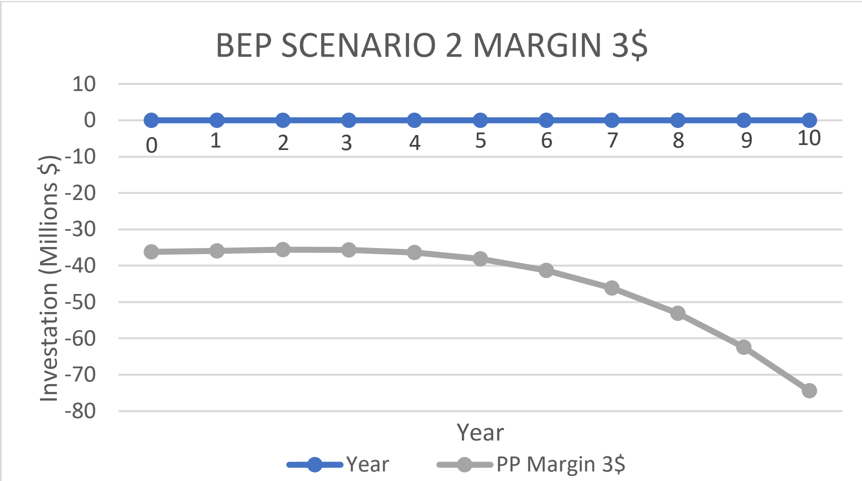

Figure 4.19. Payback Period Scenario 2 Margin 3$

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 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$ -42.008.851. The value of NPV is negative, in the actual meaning, this option is unprofitable.

Table 4.68. Discount Rate Cashflow, NPV – Scenario 2 Margin 3US$

Year	Cash Flow	i	NPV Margin 3$
0	-36.225.000	10%	-36.225.000
1	323.906		294.460
2	-15.703		-12.978
3	-355.313		-266.952
4	-694.922		-474.641
5	-1.034.531		-642.363
6	-1.374.141		-775.667
7	-1.713.750		-879.425
8	-2.053.359		-957.907
9	-2.392.969		-1.014.852
10	-2.732.578		-1.053.527
Total	-12.043.359		-42.008.851

From the result that obtained and listed, it can be seen the value of NPV is US$ -42.008.851the value of IRR cannot be calculated, from this option, it can be seen it is not too good for making profit.

Similar with the previous calculation, scenario 2 margin US$3, the difference only at the margin. This time, margin used is US$ 3.5. Below the table that contain the calculation of the scenario 2 margin US$3.5. In the table of economic below, it can be seen the calculation of the economical approach of the first scenario with margin US$ 3.5 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 4.69. Economical Calculation Margin 3.5US$ - Scenario 2

Year	CAPEX	Revenue	OPEX	Depreciation	Earning Before Tax (EBT)	Tax(25%)	Earning After Tax	Proceeds (Cashflow)	Commulative Proceeds	PP Margin 3.5$
0	36.225.000									-36.225.000
1		17.885.000	15.200.000	905.625	1.779.375	444.844	1.334.531	2.240.156	2.240.156	-33.984.844
2		17.885.000	15.652.813	905.625	1.326.563	331.641	994.922	1.900.547	4.140.703	-29.844.141
3		17.885.000	16.105.625	905.625	873.750	218.438	655.313	1.560.938	5.701.641	-24.142.500
4		17.885.000	16.558.438	905.625	420.938	105.234	315.703	1.221.328	6.922.969	-17.219.531
5		17.885.000	17.011.250	905.625	-31.875	-7.969	-23.906	881.719	7.804.688	-9.414.844
6		17.885.000	17.464.063	905.625	-484.688	-121.172	-363.516	542.109	8.346.797	-1.068.047
7		17.885.000	17.916.875	905.625	-937.500	-234.375	-703.125	202.500	8.549.297	7.481.250
8		17.885.000	18.369.688	905.625	-1.390.313	-347.578	-1.042.734	-137.109	8.412.188	15.893.438
9		17.885.000	18.822.500	905.625	-1.843.125	-460.781	-1.382.344	-476.719	7.935.469	23.828.906
10		17.885.000	19.275.313	905.625	-2.295.938	-573.984	-1.721.953	-816.328	7.119.141	30.948.047

After 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. Is shows that the graph has good prospect that shown the project will paid back the capital expenditure starting around 5 year.

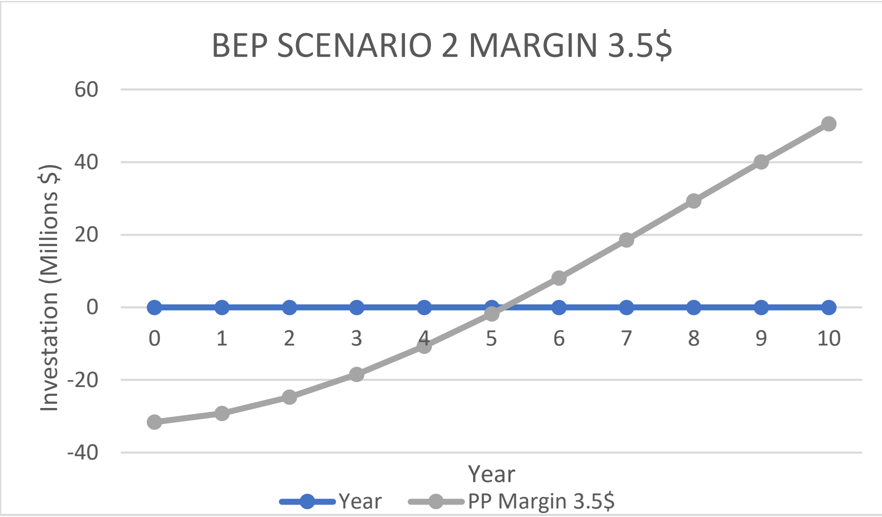

Figure 4.20. Payback Period Scenario 2 Margin 3.5$

Below are the table that showing the discount rate, cash flow, and NPV value of the scenario 1 with margin US$3.5. From the table below it can be seen the value or yearly NPV the scenario 1 with margin US$ 3.5 is various. The total NPV of this option is US$ -30.234.324 by the end of 10 year pure revenue is US$ 7.119.141

Table 4.70. Discount Rate Cashflow, NPV – Scenario 2 Margin 3.5US$

Year	Cash Flow	i	NPV Margin 3.5$
0	-36.225.000	10%	-36.225.000
1	2.240.156		2.036.506
2	1.900.547		1.570.700
3	1.560.938		1.172.755
4	1.221.328		834.184
5	881.719		547.478
6	542.109		306.007
7	202.500		103.915
8	-137.109		-63.963
9	-476.719		-202.175
10	-816.328		-314.730
Total	7.119.141		-30.234.324

Below is the economic approach, only differs of the margin with the previous calculation. This time, the margin using value of US$ 4. From the table below, the calculation of the economic approach of scenario 2 with margin US$ 4 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 current debt or the current Profit.

Year	CAPEX	Revenue	OPEX	Depreciation	Earning Before Tax (EBT)	Tax(25%)	Earning After Tax	Proceeds (Cashflow)	Commulative Proceeds	PP Margin 4$
0	36.225.000									-36.225.000
1		20.440.000	15.200.000	905.625	4.334.375	1.083.594	3.250.781	4.156.406	4.156.406	-32.068.594
2		20.440.000	15.652.813	905.625	3.881.563	970.391	2.911.172	3.816.797	7.973.203	-24.095.391
3		20.440.000	16.105.625	905.625	3.428.750	857.188	2.571.563	3.477.188	11.450.391	-12.645.000
4		20.440.000	16.558.438	905.625	2.975.938	743.984	2.231.953	3.137.578	14.587.969	1.942.969
5		20.440.000	17.011.250	905.625	2.523.125	630.781	1.892.344	2.797.969	17.385.938	19.328.906
6		20.440.000	17.464.063	905.625	2.070.313	517.578	1.552.734	2.458.359	19.844.297	39.173.203
7		20.440.000	17.916.875	905.625	1.617.500	404.375	1.213.125	2.118.750	21.963.047	61.136.250
8		20.440.000	18.369.688	905.625	1.164.688	291.172	873.516	1.779.141	23.742.188	84.878.438
9		20.440.000	18.822.500	905.625	711.875	177.969	533.906	1.439.531	25.181.719	110.060.156
10		20.440.000	19.275.313	905.625	259.063	64.766	194.297	1.099.922	26.281.641	136.341.797

Table 4.71. Economical Calculation Margin 4US$ - Scenario 2

After 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. Is shows that the graph has good prospect that shown the project will paid back the capital expenditure starting around 3.5 year.

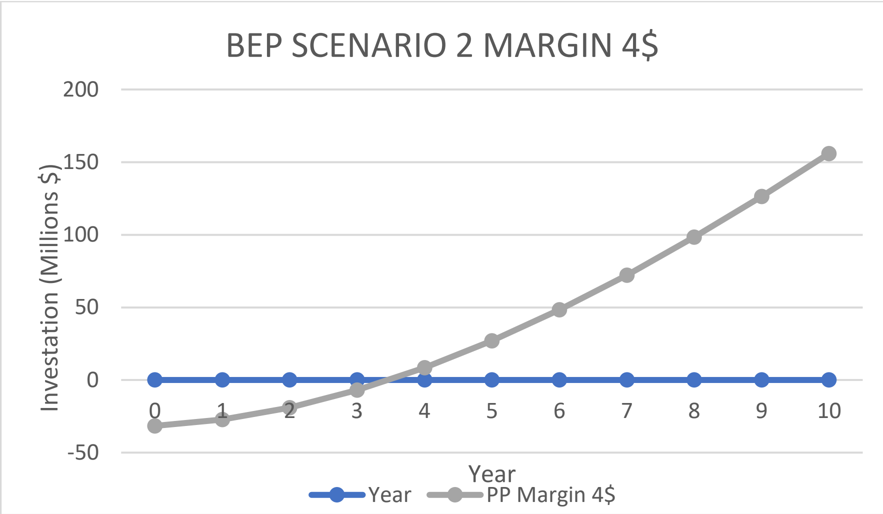

Figure 4.21. Payback Period Scenario 2 Margin 4$

Below are the table that showing the discount rate, cash flow, and NPV value of the scenario 1 with margin US$4. From the table below it can be seen thevalue or yearly NPV the scenario 1 with margin US$ 4 is various. The total NPV of this option is US$ -18.459.797 by the end of 10 year pure revenue is US$ 26.281.641.

Table 4.72. Discount Rate Cashflow, NPV – Scenario 2 Margin 4US$

Year	Cash Flow	i	NPV Margin 4$
0	-36.225.000	10%	-36.225.000
1	4.156.406		3.778.551
2	3.816.797		3.154.378
3	3.477.188		2.612.462
4	3.137.578		2.143.008
5	2.797.969		1.737.318
6	2.458.359		1.387.680
7	2.118.750		1.087.254
8	1.779.141		829.982
9	1.439.531		610.502
10	1.099.922		424.067
Total	26.281.641		-18.459.797

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$ 3, margin US$ 3.5 and margin US$ 4. Shown in the graphs, the option which has positive result of the economical approach is option with margin US$ 4. The option of margin US$ 3 and margin US$ 3.5 is not giving any profit from the beginning whether the future. It can be seen that this option is not feasible.

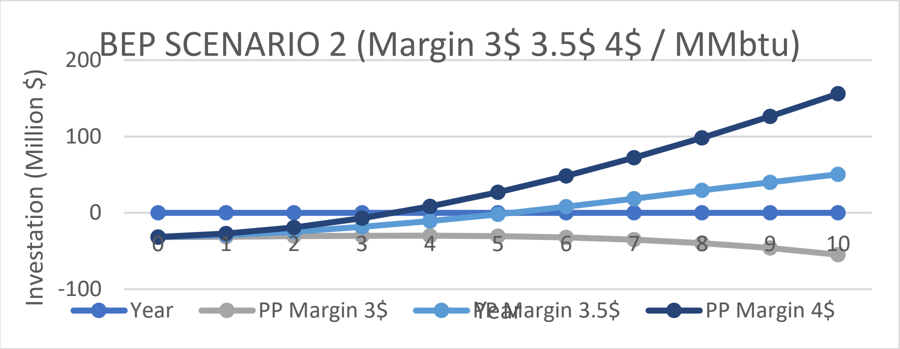

Figure 4.22. Payback Period Scenario 2

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$ 4. The second high is margin US$ 3.5 and the last is margin US$ 3. This graph can be constructed like this

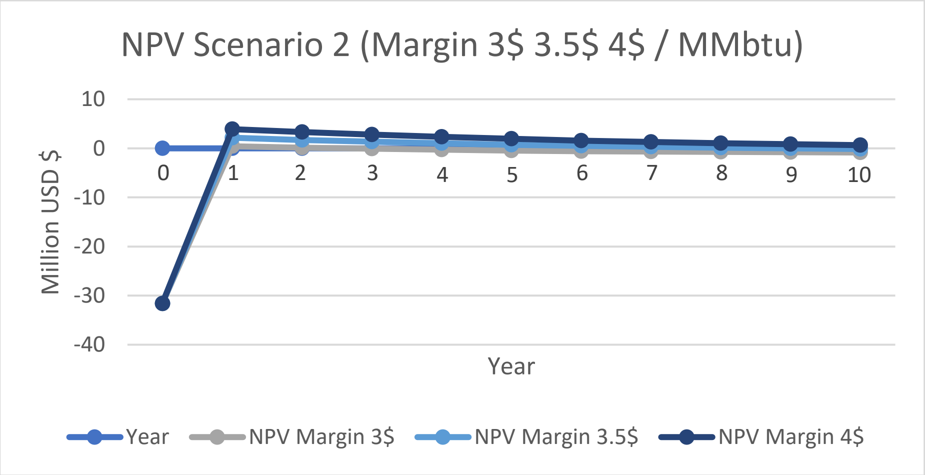

Figure 4.23. NPV Graph Scenario 2

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

4.4.3.Scenario 3 – Benoa as Major Terminal

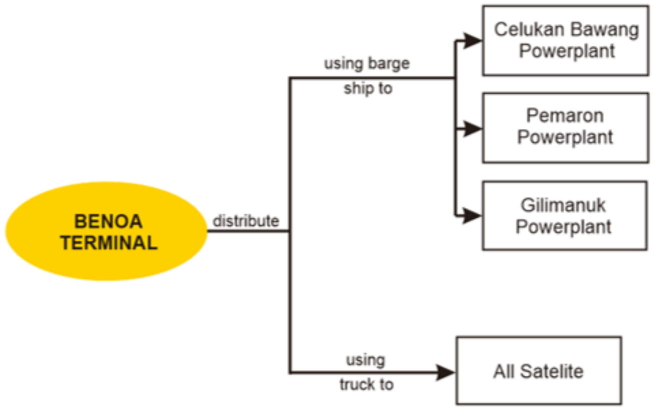

Figure 4.24. Scenario 3 (Benoa as Major Terminal)

In this scenario, LNG is used to be an energy source of the power plant soon. It is known that the maximum power output of the Pesanggaran Power Plant is 380 MW using gas as energy source. From this power plant, the need for natural gas can be known to calculate the demand for natural gas. The table below shows the need for liquefied natural gas to supply Pesanggaran power plants for one day.

Table 4. 73. Pesanggaran Data Table – Scenario 3
*Assumption

Power Plant	Pesanggaran	
Power Plant Type	Base Load*	
Engine Type	Typical Steam Cycle	
Power	380	MW
Gas Requirement	76	MMscfd
Daily Consumption	76000	Mmbtu
	2660	m^3/day

To ensure the quantity is in safe keep, LNG storage tank is needed. This tank is calculated from the volume of the liquefied natural gas required. The selection of LNG Storage tank is represented in table below. Table below is table that represent the general information of Pesanggaran Power plant. In the table, known that the type of power plant is Base Load Power Plant*. With typical steam cycle engine. From the capacity of 380MW, the gas needed for powering the power plant is (380x2) divided by 5 becoming 76 MMscfd. Then the result before times by 35 to know the amount of dialy needed gas, that is 2660 m^3/day. 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 Pesanggaran 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 500 m³ x 6. 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 4.74. LNG Storage Tank Selection – Scenario 3

LNG STORAGE TANK		
Model	ZCF-250	
Storage tank requirement	2660	m³
Each tank capacity	500	m³
Design Pressure	0,35	Bar
Design BOG Rate	0,27	%
Height	12,65	M
Diameter	11,2	M
Number of tanks	6	Unit
Total capacity	3000	m³
Price	2000	US$/m³
Price (each)	500.000	US$
Price Total	3.000.000	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°C. LNG boiled off into normal natural 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 storage 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
= 0,27% X 500 m³
= 810 m³/day (LNG)
= 33,75 Nm³/hour (nominal 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. 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 4.75. LNG Compressor Selection – Scenario 3

LNG BOG Compressor		
Brand	NTTC	
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. 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 4.76. Vaporizer Selection – Scenario 3

Vaporizer		
Model	CYYV1	
Type	Ambient Air	
Nominal Capacity	50	Nm³/hour
Max Pressure	15	bar
Power	0,1	kW
Area	0,5355	m^2
Weight	130	kg
Length	85	mm
Width	63	mm
Height	247	mm
Voltage	220/380	volt
Number of Vaporizer	3	unit
Price	2000	US$/m³
Price (each)	100.000	US$
Price Total	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 are for both of high-pressure pump and low-pressure pump. Head of chosen pumps is 10-1.000 m. The capacity of these power plants is same, which is around 5-200 m³/hour. But the chosen capacity of the pump is 50 m³/hour. The outlet pressure of these pumps is 20 bar. As for the pump, the initial price of pump is based on the capacity of pump which can be obtained. As for each m/hour, the pump value is priced US$ 100. If the pump capacity is 50 Nm/hour the price of the pump is US$ 5.000.

Table 4.77. LNG Pump Selection – Scenario 3

LNG PUMP		
Required Capacity	16,49	m³/hour
Pressure into Vaporizer	15	ba
LP Pump Model	CYY 15-200	
Type	Centrifugal	
Head	10-1000	m³/hour
LP Pump Capacity	83-3,320	liter/min

	5-200	m³/hour
Chosen Pump Capacity	50	m³/hour
Pressure LP Pump	20	bar
Speed	960-5000	
Number of Pump	8	
Price	100	US$(/m³/h)
Price (each)	5.000	US$
Price Total	10.000	US$
HP Pump Model	CYY 15-200	
Type	Centrifugal	
Head	10-1000	m³/hour
HP Pump Capacity	83-3,320	liter/min
	5-200	m³/hour
Chosen Pump Capacity	50	m³/hour
Pressure HP Pump	20	bar
Speed	960-5000	
Number of Pump	8	
Price	100	US$(/m³/h)
Price (each)	5.000	US$
Price Total	10.000	US$
Total Pump Price Overall	20.000	US$

For transferring the LNG from the Gilimanuk 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 have fuel consumption of 0,4 1/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 m3. The price that is mentioned in the table is the price which will affect the total of capital expenditure. This pricing 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 i5 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 4.78. Truck and Tank selection – Scenario 3

Truck and Tank		
Brand	Sino Truck	
Model	Sino Truck	
Power	251-350	HP
Engine capacity	9,726	Liter
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	liter/km
Tank Volume	30	m^3
Number of Truck	14	unit
Price	200.000	US$
Total	2.800.000	US$

After LNG is arrived to Benoa Terminal, LNG inside LNG tank should be transferred out into LNG storage tank in Benoa Terminal. 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 and also into all district in Bali. 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. 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 4.79. LNG Filling Station Selection – Scenario 3

LNG Filling Station / Satellite		
Brand	BTV standard	
Model	CGQ/LNG-30/60	
Capacity	60	m³
Filling Capacity	340	Liter/min
	20,4	m³/hour
Equipment Power	17	kW
Pressure	2,5	Mpa
Price	150.000	US$

In this scenario, LNG is used to be an energy source of the power plant will be sent too into Celukan Bawang, Pemaron, and Gilimanuk Power Plant. It is known that the maximum power output of the Celukan Bawang Power Plant is 380x2 MW that will be built soon, Pemaron Power Plant is 80 MW and Gilimanuk Power Plant is 180MW and all is using gas as energy source. From this power plant, the need for natural gas can be known to calculate the demand for natural gas. The table below shows the need for liquefied natural gas to supply power plants for one day.

Table 4.80. Gilimanuk Data Table – Scenario 3
*Assumption (will be buildt soon)

Power Plant	**Celukan Bawang**	
Power Plant Type	Base Load*	
Engine Type	Typical Steam Cycle	
Power	760	MW
Gas Requirement	152	MMscfd
Daily Consumption	152000	Mmbtu
	5320	m³/day

The selection of LNG Storage tank is represented in table below. Table below is table that represent the general information of Celukan Bawang Power plant. The gas needed for powering the power plant is (180x2) divided by 5 becoming 26 MMscfd. Then the result before times by 3 to know the amount of daily needed gas, that is 910 m³/day. After calculating the liquefied natural gas requirement, the quantity of the daily demand is known. From the table below there are specification of storage tank that is selected to be the tank in Celukan Bawang 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 500 m³ x 2. The design BOG rate is to calculate the BOG normal rate to select compressor. 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.

Table 4.81. LNG Storage Tank Selection – Scenario 3

LNG STORAGE TANK		
Model	**ZCF-250**	
Storage tank requirement	5320	m³
Each tank capacity	5000	m³
Design Pressure	0,35	Bar
Design BOG Rate	0,11	%
Height	22,43	M
Diameter	22,3	M
Number of tanks	1	Unit
Total capacity	5000	m³
Price	2000	US$/m³
Price (each)	5.000.000	US$
Price Total	5.000.000	US$
Model	**ZCF-250**	
Storage tank requirement	320	m³
Each tank capacity	400	m³
Design Pressure	0,35	Bar
Design BOG Rate	0,28	%
Height	13,6	M
Diameter	9,8	M
Number of tanks	1	Unit
Total capacity	400	m³
Price	2000	US$/m³
Price (each)	400.000	US$
Price Total	400.000	US$
All Price Total	5.400.000	US$

LNG characteristic has trait to boiled off when the temperature is getting hotter than normal LNG temperature, which is around 160°C. LNG boiled off into normal natural 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 storage tank. Using the boiled off gas rate of the selected tank, normal rate of boiled off gas can be calculated. 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
= 0,11% X 5000 m³
= 3300 m³/day (LNG)
= 137,50 Nm³/hour (nominal cubic/hour).

Table 4.82. Pemaron Data Table – Scenario 3
*Assumption

Power Plant	**Pemaron**	
Power Plant Type	Base Load*	
Engine Type	Typical Steam Cycle	
Power	80	MW
Gas Requirement	16	MMscfd
Daily Consumption	16000	Mmbtu
	560	m³/day

The selection of LNG Storage tank is represented in table below. Table below is table that represent the general information of Pemaron Power plant. The gas needed for powering the power plant is (80x2) divided by 5 becoming 16 MMscfd. Then the result before times by 3 to know the amount of daily needed gas, that is 560 m³/day. After calculating the liquefied natural gas requirement, the quantity of the daily demand is known. 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 250 m³ x 2. The design BOG rate is to calculate the BOG normal rate to select compressor.

Table 4.83. LNG Storage Tank Selection – Scenario 3

LNG STORAGE TANK		
Model	ZCF-250	
Storage tank requirement	560	m³
Each tank capacity	250	m³
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	m³
Price	2000	US$/m³
Price (each)	250.000	US$
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°C. LNG boiled off into normal natural 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 storage 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
= 690 m^3/day (LNG)
= 28,75 Nm^3/hour (nominal cubic/hour)

Table 4.84. Gilimanuk Data Table – Scenario 3
*Assumption

Power Plant	**Gilimanuk**	
Power Plant Type	Base Load*	
Engine Type	Typical Steam Cycle	
Power	180	MW
Gas Requirement	26	MMscfd
Daily Consumption	26000	Mmbtu
	910	m^3/day

The selection of LNG Storage tank is represented in table below. Table below is table that represent the general information of Gilimanuk Power plant. The gas needed for powering the power plant is (180x2) divided by 5 becoming 26 MMscfd. Then the result before times by 3 to know the amount of dialy needed gas, that is 910 m^3/day. After calculating the liquefied natural gas requirement, the quantity of the daily demand is known. From the table below there are specification of storage tank that is selected to be the tank in Gilimanuk 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 500 m^3 x 2. 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 4.85. LNG Storage Tank Selection – Scenario 1

LNG STORAGE TANK		
Model	ZCF-250	
Storage tank requirement	910	m^3
Each tank capacity	500	m^3
Design Pressure	0,35	Bar
Design BOG Rate	0,27	%
Height	12,65	M
Diameter	11,2	M
Number of tanks	2	Unit
Total capacity	1000	m^3
Price	2000	US$/$m^3$
Price (each)	500.000	US$
Price Total	1.000.000	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°C. LNG boiled off into normal natural 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 storage 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
= 0,27% X 500 m^3
= 810 m^3/day (LNG)
= 33,75 Nm^3/hour (nominal cubic/hour).

The capital expenditure summary can be seen in table below. 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, and some item at Celukan Bawang, Pemaron and Gilimanuk Power Plant is same like, the vaporizer, pump and etc. 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 3 is US$ 20.725.000

Table 4.86. Capital Cost – Scenario 3

Capital Cost			
ITEM	PRICE ($)	Number of Items	Cost ($)
LNG Storage Tank	9.900.000*	12*	9.900.000
BOG Handling	80.000	11	880.000
Vaporizer	100.000	11	1.100.000
Pump	5.000	40	200.000
Truck and Storage tank	200.000	10	2.000.000
Mini Filling Station	250.000	10	2.500.000
Total 1			16.580.000
Tax 25% and etc.			4.145.000
Total Fix Cost			20.725.000

OPEX (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 50 m2. The average speed that is being considered here is about 45 km/h. the fuel consumption that is listed below is important in tem of fuel purchasing for the trucks. And for the pricing value is important for completing the economic data requirement.

Table 4.87. Truck and Tank Selection Scenario 3

Vessel Specification		
Specification	Value	Unit
Vessel	Trucks	
Brand	Sino Trucks	
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 on the data listed below.

Table 4.88. Time Allocation – Scenario 2

Time Allocation	Value	Time
Loading time	0,625	day
Unloading time	0,625	day
Total time	1,25	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 caleulating 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.

Table 4.89. Fuel Cost– Scenario 2

Fuel Cost	7900	IDR/Liter
Diesel Fuel	0,5642857	US$/Liter
Diesel Fuel	0,832	kg/Liter
Density Diesel Fuel	0,678228	US$/kg
Diesel Fuel Ship Cost	700	US$/ton

Fuel cost per round trip is obtained by calculating fuel consumption, 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 the obtained data from Alibaba online store and some information on internet is the charter cost and the port cost with the assumption. As for charter cost it is counted for everyday and will be calculated in term of every year. Then the port cost, which the only different is the duration that is needed when the ship is in port.

Table 4.90. Barge Spesification – Scenario 3

Vessel Spesification		
Spesification	Value	Unit
Vessel	Barge	
Company	Zhengzhou Focus Machinery	
Rpm	1100	
Weight	35	Ton
Speed	5	km/h
Length	20	m
Width	4,2	m
Depth	2,6	m
Max. Capacity	30	ton
Capacity	30.000	m^3
Price	500.000	US$

The Operational Expenditure that may be got from the cumulative cost consist of fuel cost, crew cost, LNG purchase and LNG transport cost are named total operation expenditure which is US$ 14.972.000. 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$ 10.000.000 including the barge fuel cost. The crew cost itself can be seen from the table below and valued USS 2.000.000. The LNG cost that is being purchased from Bontang also mentioned below. By the current condition, the price of LNG is US$ 3 for each MMbtu. For the Pemaron power plant, as this power plant require 16000 MMbtu/day, the daily price of purchased natural gas is US$ 48.000. For the Gilimanuk power plant, as it need daily energy of 26000 MMbtu/day, the price of daily need of natural gas is US$ 78.000. For the Pesanggaran power plant, as it need daily energy of 76000 MMbtu/day, the price of daily need of natural gas is US$ 228.000 And for the Celukan Bawang power plant itself, as it need daily energy of 152000 MMbtu/day, the price of daily need of natural gas is US$ 456.000. For the transport cost of LNG through the sea, this value is obtained by summing the fuel cost of carrier, charter cost, and port cost.

Table 4.91. Operational Cost –Scenario 3

Operational Cost			
ITEM	PRICE ($)	Number of Items	Cost ($)
Barge charter cost (year)	500.000	4	2.000.000
Barge and Trucks Fuel cost (year)	10.000.000		10.000.000
Port Cost	400.000		400.000
Management Cost	900.000		900.000
LNG cost (3PP)	582.000		582.000
Maintenance Cost	90.000		90.000
Crew Cost	2.000.000		2.000.000
Total Variable Cost			15.972.000

After obtaining the value of capital expenditure and operational expenditure, the calculation of economic result can be done. Below 15 mentioned the pricing of capital expen d 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$ 20.725.000. And for the operational expenditure of this scenario is valued US$ 15.972.000.

Table 4.92. Economic Analysis Scenario 3

Investment	Price (US$)
Capex	20.725.000
Opex	15.972.000

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$ 15.543.750. Total depreciation is the cumulative of all yearly depreciation in the duration of time. The value of yearly depreciation is US$ 518.125, while the contract duration is 10 year, resulting on the total depreciation is US$ 5.181.250. The disposal price that is mentioned in the table is salvage value reduced value of multiplication yearly depreciation and contract duration. In this scenario, the value of disposal price is US$ 10.362.500.

Table 4.93. Economic Input Data Scenario 3

Item	Value
Contract Duration (Year)	10
Total Investment (US$)	20.725.000
Salvage Value (US$)	15.543.750
Disposal Value (US$)	10.362.500
Yearly Depreciation (US$)	518.125
Depreciation Value	5.181.250

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. 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$ 3, yearly income of the selling is USS 15.330.000. For the margin US$ 3.5, the yearly revenue is higher than the margin US$ 3, the value is US$ 17.885.000. And for the margin US$ 4, the yearly revenue is US$ 20.440.000

Selling Price		
ITEM	**UNITS**	**PRICE**
LNG Cost / day	MMbtu	14.000,00
LNG Cost / Year	MMbtu	5.110.000
	MARGIN ($)	
Profit from LNG Selling	3	15.330.000
	3,5	17.885.000
	4	20.440.000

Table 4.94. Revenue Scenario 3

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 4.95. Economical Calculation Margin 3US$ - Scenario 3

Year	CAPEX	Revenue	OPEX	Depreciation	Earning Before Tax (EBT)	Tax(25%)	Earning After Tax	Proceeds (Cashflow)	Commulative Proceeds	PP Margin 3$
0	20.725.000									-20.725.000
1		15.330.000	15.972.000	518.125	-1.160.125	-290.031	-870.094	-351.969	-351.969	-21.076.969
2		15.330.000	16.231.063	518.125	-1.419.188	-354.797	-1.064.391	-546.266	-898.234	-21.975.203
3		15.330.000	16.490.125	518.125	-1.678.250	-419.563	-1.258.688	-740.563	-1.638.797	-23.614.000
4		15.330.000	16.749.188	518.125	-1.937.313	-484.328	-1.452.984	-934.859	-2.573.656	-26.187.656
5		15.330.000	17.008.250	518.125	-2.196.375	-549.094	-1.647.281	-1.129.156	-3.702.813	-29.890.469
6		15.330.000	17.267.313	518.125	-2.455.438	-613.859	-1.841.578	-1.323.453	-5.026.266	-34.916.734
7		15.330.000	17.526.375	518.125	-2.714.500	-678.625	-2.035.875	-1.517.750	-6.544.016	-41.460.750
8		15.330.000	17.785.438	518.125	-2.973.563	-743.391	-2.230.172	-1.712.047	-8.256.063	-49.716.813
9		15.330.000	18.044.500	518.125	-3.232.625	-808.156	-2.424.469	-1.906.344	-10.162.406	-59.879.219
10		15.330.000	18.303.563	518.125	-3.491.688	-872.922	-2.618.766	-2.100.641	-12.263.047	-72.142.266

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 and lower, it means the project with the current margin is not profitable and it will not paid back. From this graph, it can be seen that first scenario with margin US$ 3 is negative, in other word, this option is very unprofitable.

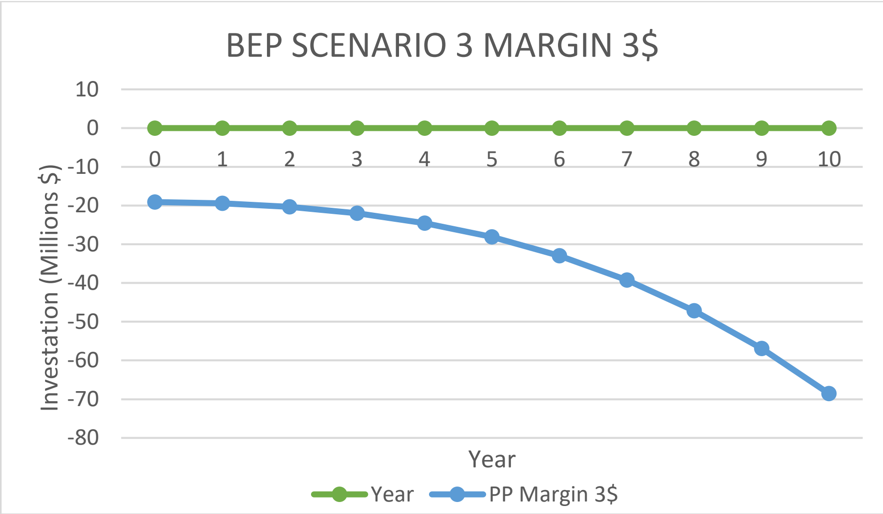

Figure 4.25. Payback Period Scenario 3 Margin 3$

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 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$ -27.335.412. The value of NPV is negative, in the actual meaning, this option is unprofitable.

Table 4.96. Discount Rate Cashflow, NPV – Scenario 3 Margin 3US$

Year	Cash Flow	i	NPV Margin 3$
0	-20.725.000	10%	-20.725.000
1	-351.969		-319.972
2	-546.266		-451.459
3	-740.563		-556.396
4	-934.859		-638.522
5	-1.129.156		-701.117
6	-1.323.453		-747.055
7	-1.517.750		-778.846
8	-1.712.047		-798.683
9	-1.906.344		-808.476
10	-2.100.641		-809.888
Total	-12.263.047		-27.335.412

From the result that obtained and listed, it can be seen the value of NPV is US$ -27.335.412, the value of IRR cannot be calculated, from this option, it can be seen it is not too good for making profit.

Similar with the previous calculation, scenario 1 margin US$3, the difference only at the margin. This time, margin used is US$ 3.5. Below the table that contain the calculation of the scenario 1 margin US$3.5. 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 4.97. Economical Calculation Margin 3.5US$ - Scenario 3

Year	CAPEX	Revenue	OPEX	Depreciation	Earning Before Tax (EBT)	Tax(25%)	Earning After Tax	Proceeds (Cashflow)	Commulative Proceeds	PP Margin 3.5$
0	20.725.000									-20.725.000
1		17.885.000	15.972.000	518.125	2.431.125	607.781	1.823.344	1.305.219	1.305.219	-19.419.781
2		17.885.000	16.231.063	250.000	1.903.938	475.984	1.427.953	1.177.953	2.483.172	-16.936.609
3		17.885.000	16.356.063	250.000	1.778.938	444.734	1.334.203	1.084.203	3.567.375	-13.369.234
4		17.885.000	16.481.063	250.000	1.653.938	413.484	1.240.453	990.453	4.557.828	-8.811.406
5		17.885.000	16.606.063	250.000	1.528.938	382.234	1.146.703	896.703	5.454.531	-3.356.875
6		17.885.000	16.731.063	250.000	1.403.938	350.984	1.052.953	802.953	6.257.484	2.900.609
7		17.885.000	16.856.063	250.000	1.278.938	319.734	959.203	709.203	6.966.688	9.867.297
8		17.885.000	16.981.063	250.000	1.153.938	288.484	865.453	615.453	7.582.141	17.449.438
9		17.885.000	17.106.063	250.000	1.028.938	257.234	771.703	521.703	8.103.844	25.553.281
10		17.885.000	17.231.063	250.000	903.938	225.984	677.953	427.953	8.531.797	34.085.078

After 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. Is shows that the graph has good prospect that shown the project will paid back the capital expenditure starting around 5 year.

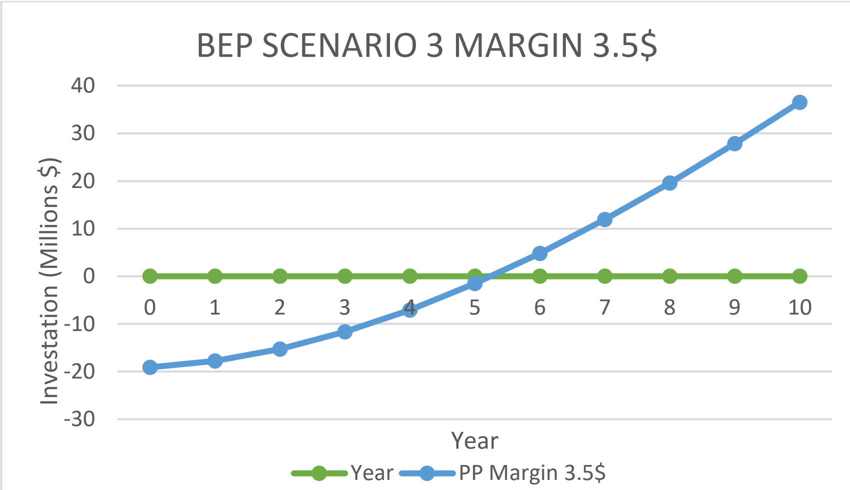

Figure 4.26. Payback Period Scenario 3 Margin 3.5$

Below are the table that showing the discount rate, cash flow, and NPV value of the scenario 1 with margin US$3.5. From the table below it can be seen thevalue or yearly NPV the scenario 1 with margin US$ 3.5 is various. The total NPV of this option is US$ -15.026.529by the end of 10 year pure revenue is US$ 8.531.797

Table 4.98. Discount Rate Cashflow, NPV – Scenario 3 Margin 3.5US$

Year	Cash Flow	i	NPV Margin 3.5$
0	-20.725.000	10%	-20.725.000
1	1.305.219		1.186.563
2	1.177.953		973.515
3	1.084.203		814.578
4	990.453		676.493
5	896.703		556.782
6	802.953		453.246
7	709.203		363.933
8	615.453		287.113
9	521.703		221.253
10	427.953		164.994
Total	8.531.797		-15.026.529

Below is the economic approach, only differs of the margin with the previous calculation. This time, the margin using value of US$ 4. From the table below, the calculation of the economic approach of scenario 1 with margin US$ 4 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 theproceed which is already cumulated from the previous year of the project investment state is the condition which current debt or the current Profit.

Table 4.99. Economical Calculation Margin 4US$ - Scenario 3

Year	CAPEX	Revenue	OPEX	Depreciation	Earning Before Tax (EBT)	Tax(25%)	Earning After Tax	Proceeds (Cashflow)	Commulative Proceeds	PP Margin 4$
0	20.725.000									-20.725.000
1		20.440.000	15.972.000	518.125	4.986.125	1.246.531	3.739.594	3.221.469	3.221.469	-17.503.531
2		20.440.000	16.231.063	250.000	4.458.938	1.114.734	3.344.203	3.094.203	6.315.672	-11.187.859
3		20.440.000	16.356.063	250.000	4.333.938	1.083.484	3.250.453	3.000.453	9.316.125	-1.871.734
4		20.440.000	16.481.063	250.000	4.208.938	1.052.234	3.156.703	2.906.703	12.222.828	10.351.094
5		20.440.000	16.606.063	250.000	4.083.938	1.020.984	3.062.953	2.812.953	15.035.781	25.386.875
6		20.440.000	16.731.063	250.000	3.958.938	989.734	2.969.203	2.719.203	17.754.984	43.141.859
7		20.440.000	16.856.063	250.000	3.833.938	958.484	2.875.453	2.625.453	20.380.438	63.522.297
8		20.440.000	16.981.063	250.000	3.708.938	927.234	2.781.703	2.531.703	22.912.141	86.434.438
9		20.440.000	17.106.063	250.000	3.583.938	895.984	2.687.953	2.437.953	25.350.094	111.784.531
10		20.440.000	17.231.063	250.000	3.458.938	864.734	2.594.203	2.344.203	27.694.297	139.478.828

After 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. Is shows that the graph has good prospect that shown the project will paid back the capital expenditure starting around 3 year.

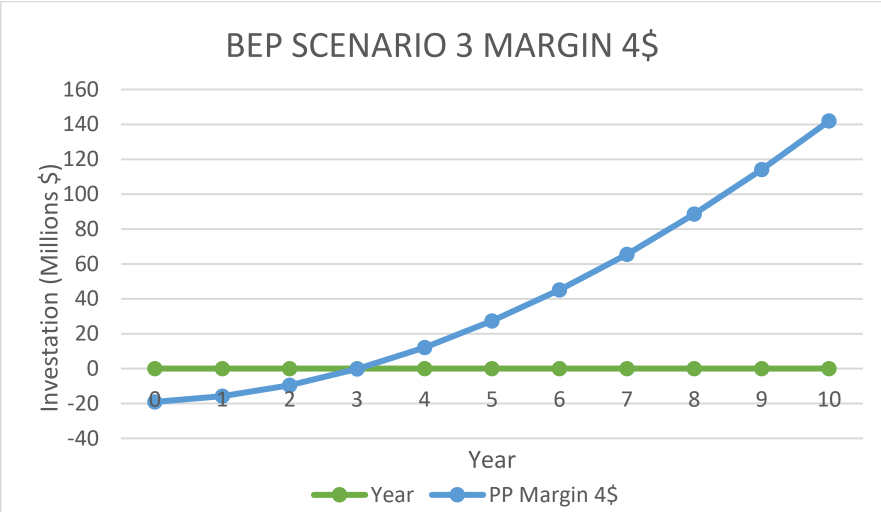

Figure 4.27. Payback Period Scenario 3 Margin 4$

Below are the table that showing the discount rate, cash flow, and NPV value of the scenario 1 with margin US$4. From the table below it can be seen thevalue or yearly NPV the scenario 1 with margin US$ 4 is various. The total NPV of this option is US$ -3.252.003by the end of 10 years pure revenue is US$ 27.694.297

Table 4.100. Discount Rate Cashflow, NPV – Scenario 3 Margin 4US$

Year	Cash Flow	i	NPV Margin 4$
0	-20.725.000	10%	-20.725.000
1	3.221.469		2.928.608
2	3.094.203		2.557.193
3	3.000.453		2.254.285
4	2.906.703		1.985.317
5	2.812.953		1.746.623
6	2.719.203		1.534.919
7	2.625.453		1.347.273
8	2.531.703		1.181.058
9	2.437.953		1.033.930
10	2.344.203		903.792
Total	27.694.297		-3.252.003

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 3. Payback period graph of margin US$ 3, margin US$ 3.5 and margin US$ 4. Shown in the graphs, the option which has positive result of the economical approach is option with margin US$ 3.5 and margin US$ 4. The option of margin US$ 3 is not giving any profit from the beginning whether the future. It can be seen that this option is not feasible.

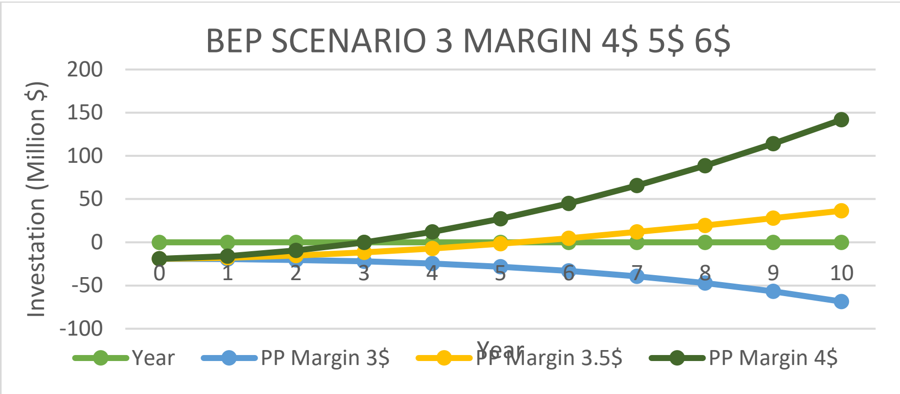

Figure 4.28. Payback Period Scenario 3

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$ 4. The second high is margin US$ 3.5 and the last is margin US$ 3. This graph can be constructed like this

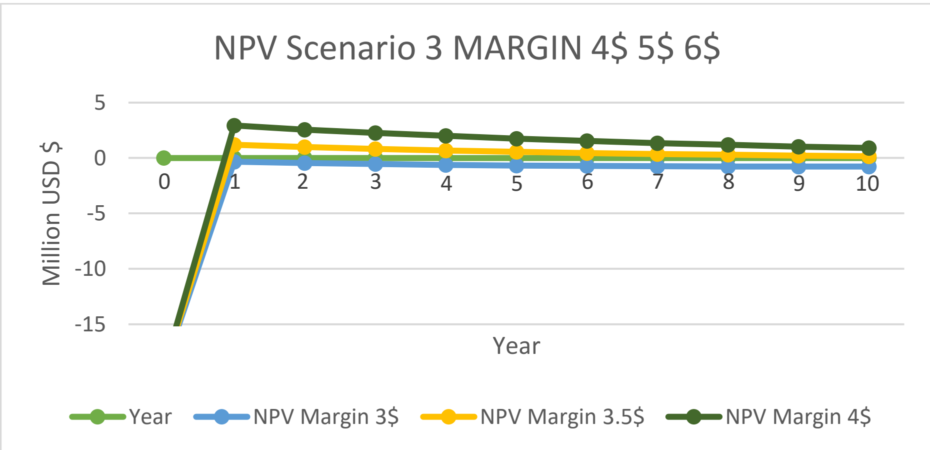

Figure 4.29. NPV Graph Scenario 3

By the representive of the graph of scenario 3, the calculation of three scenarios 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$ 3.5 and margin US$ 4, scenario 2 with margin US$ 3.5 and margin US$ 4, and the scenario 3 with margin US$ 3.5 and margin US$ 4. Among these option there are option that is not feasible caused by the very low value of NPV which is eliminating the option of scenario 1 margin US$ 3.5 and scenario 2 with margin US$ 3.5. 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$ 4 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$ 4 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 scenario 3 with margin US$3.5.

CHAPTER 5.
CONCLUSION

From this chapter, there will be conclusion and suggestion that will be the answer of the research problem and the achievement for the research objectives. Conclusion will be as the answer of the research problem and research objective. And the suggestion will be the part for improve future research or another study that may be have same topic with this research.

5.1. Conclusion

In this bachelor thesis, it can be concluded that:

1. Three chosen scenario for the economic analysis process is:
   a. Scenario 1 (Celukan Bawang as Major Power Plant): Distributing LNG to Gilimanuk power plant, then using barge ship to Benoa Terminal, and using truck to Pemaron power plant and to all satellite.
   b. Scenario 2 (Gilimanuk as Major Power Plant): Distributing LNG to Celukan Bawang power plant, then using barge ship to Benoa Terminal, and using truck to Pemaron power plant and to all satellite.
   c. Scenario 3 (Benoa as Major Terminal): Distributing LNG to Gilimanuk power plant, Celukan Bawang , and Pemaron power plant using barge ship and last is using truck to all satellite.

2. From the calculation of economical approach, it can be seen that the only option that is getting good profit are:
   - Scenario 1 using Margin US$ 4
   - Scenario 2 using Margin US$ 3.5
   - Scenario 2 using Margin US$ 4
   - Scenario 3 using Margin US$ 3.5
   - Scenario 3 using Margin US$ 4

3. From this five scenario, chosen that is scenario 3 with margin US$ 3.5 is the best option among all the profitable result with payback period around 5 year. This scenario using LNG as main source energy and distributed by barge ship to all power plants in Bali. Even though the other scenario has much shorter payback period time, Scenario 3 with margin US$ 3.5 is the most realistic and profitable option, because compared to other option scenario, the others will need high ratio of natural gas price and high investment in built of piping distribution infrastructure between power plant, which it can result on the expensive price of natural gas and for capital expenditure investment.

5.2. Suggestion

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

1. Other research that will be conducted with similar objectives in other locations can increase the use of natural gas to reduce pollution to the environment.
2. The calculation can be improved by using solver as application to calculate the economic analysis of distribution scenario, also using more detail realistic value and more realistic scheme that fit the actual condition in the future.

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APPENDIX

- Crew Cost Calculation

Crew Expenditure Salary					
No	Posistion	Crew	Salary ($)	Total($)	Per Year ($)
1	Head of Operation	1	1400	1400	16800
2	Storage Master	3	1000	3000	36000
3	Storage Personel	6	650	3900	46800
4	Loading Master	3	1000	3000	36000
5	Loading Personel	6	650	3900	46800
6	Discharge Master	3	1000	3000	36000
7	Discharge Personnel	6	650	3900	46800
8	Compressor Master	3	1000	3000	36000
9	Compressor Personner	6	650	3900	46800
10	Vaporizer Master	3	1000	3000	36000
11	Vaporizer Personel	6	650	3900	46800
12	Pump Master	3	1000	3000	36000
13	Pump Personel	6	650	3900	46800
14	MT. Master	3	1000	3000	36000
15	Mt. Personnel	6	650	3900	46800
16	Driver	144	600	86400	1036800
	Total	208			1633200

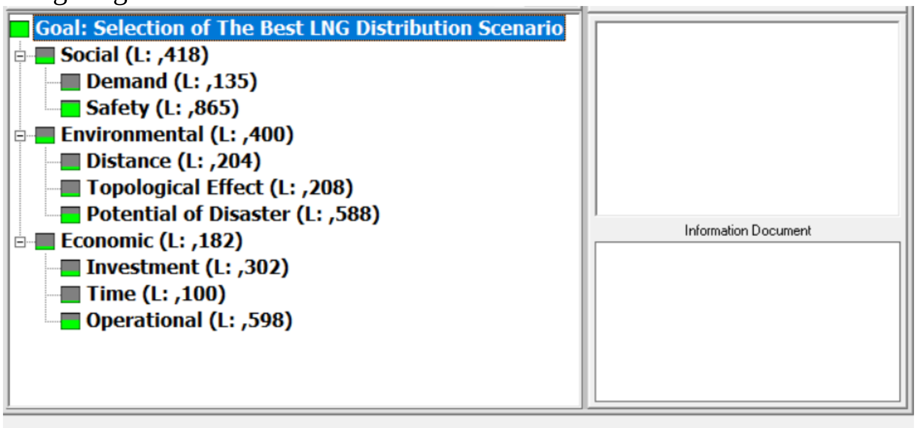
Crew Insurance				
No	Posistion	Crew	Insurance / Year ($)	Total
1	Head of Operation	1	2000	2000
2	Storage Master	3	1400	4200
3	Storage Personel	6	950	5700
4	Loading Master	3	1400	4200
5	Loading Personel	6	950	5700
6	Discharge Master	3	1400	4200
7	Discharge Personnel	6	950	5700
8	Compressor Master	3	1400	4200
9	Compressor Personner	6	950	5700
10	Vaporizer Master	3	1400	4200
11	Vaporizer Personel	6	950	5700
12	Pump Master	3	1400	4200
13	Pump Personel	6	950	5700
14	MT. Master	3	1400	4200
15	Mt. Personnel	6	950	5700
16	Driver	144	1000	144000
	Total	208		215300

Crew Accomodation				
No	Posistion	Crew	Accomodation / Year ($)	Total
1	Head of Operation	1	1600	1600
2	Storage Master	3	1100	3300
3	Storage Personel	6	700	4200
4	Loading Master	3	1100	3300
5	Loading Personel	6	700	4200
6	Discharge Master	3	1100	3300
7	Discharge Personnel	6	700	4200
8	Compressor Master	3	1100	3300
9	Compressor Personner	6	700	4200
10	Vaporizer Master	3	1100	3300
11	Vaporizer Personel	6	700	4200
12	Pump Master	3	1100	3300
13	Pump Personel	6	700	4200
14	MT. Master	3	1100	3300
15	Mt. Personnel	6	700	4200
16	Driver	144	700	100800
	Total	208		154900

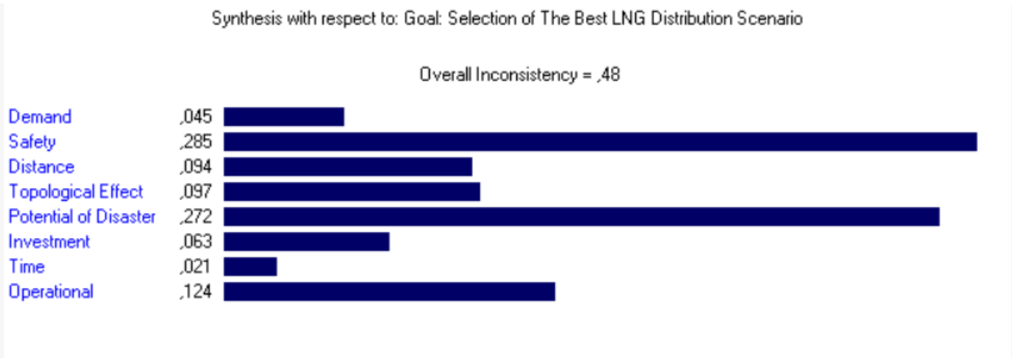
Total Crew Cost Overall		
No	Crew Cost (US$)	Total
1	Salary	1633200
2	Insurance	215300
3	Accomodation	154900
	Total	2003400

- AHP (Analytical Hierarchy Process) Questionnaire result

Weighting Criteria and Sub Criteria of Selected Distribution Scenarios



Scenario Criteria Scoring



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BIOGRAPHY

Until now, author has been study in Santo Yoseph Elementary School Bali, Santo Yoseph Junior High School Bali, SMAN 4 Senior High School Denpasar Bali. In 2016, Author accepted in Institut Teknologi Sepuluh Nopember as college student in Marine Engineering Department, Faculty of Marine Technology with NRP 04211641000020 through invitation batch. In Marine Engineering Department, author active in the various organization and committee activites, such as being Staff of the Department of External Affairs in the ITS HIMASISKAL 2017/2018, Staff of Talkshow ITS Expo 2017, Vice President of FlagFootball ITS 2017/2018, Staff Inspiring Career Talk of Petrolida 2017, and KMK ITS. The Job on training experience that has been taken by the author at Samudera Shipyard Semarang and PT. Nusantara Regas Jakarta. In the fourth year of college, the author took the concentration of Final Projects in the field of Reliability Availibility Management and Safety (RAMS).

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