Koleksi digital milik UPT Perpustakaan ITB untuk keperluan pendidikan dan penelitian

ECONOMIC ANALYSIS OF FLARE GAS UTILIZATION FOR ELECTRIC POWER GENERATION IN PT. CPI

FINAL PROJECT

by

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29118284

Master of Business Administration Program

School of Business and Management

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ABSTRACT

For generating electric power, PT CPI purchases gas from the third party for fuel in large portion beside utilize own gas from several gas production facilities. There is opportunity to reduce operating expenditure for that gas purchasing by utilization of Alfa & Beta flare gas. For the years, associated gas production in Alfa and Beta stations were flared and have not been utilized for any economic purpose. Total cost to produce electric power by executing new proposal will be compared with existing condition.

This research used a quantitative approach with data sources include associated gas production forecasts from the subsurface team, gas composition analysis from lab team, cost estimation by using the unit price of the current contract, and lessons learned from previous similar projects.

Alfa and Beta Flare Gas Recovery facilities will be built to process and deliver flare gas from these 2 stations to Pager Gas Plant (GP). In Pager GP, existing gas compressor delivers gas to Duri Power Plant, to be used further as fuel of power generation. On the other hand, capital investment and additional operational costs are needed for routine operation & maintenance activities, compressor overhaul, electric power, pipeline maintenance, chemical injection, and others. In terms of project feasibility analysis, cost-saving PV is $916,386, with IRR = 23%, and the payback period of investment is 1,8 years.

By conducting sensitivity analysis, it's concluded that the parameter that has the most impact on the variance of project economic result is gas production forecast (% decline rate), continued by gas price forecast ($/MMBTU), and continued by capital expenditure ($).

By considering the analysis above, it's concluded that Alfa and Beta Flare Gas Utilization is economically feasible and it's recommended to execute soon when the Riau block is already handed over from PT CPI to PT PTM in 2021.

Keywords :

Flare Gas, Power Generator Fuel, Project Feasibility, Cost Saving

ANALISIS EKONOMI ATAS PEMANFAATAN FLARE GAS UNTUK PEMBANGKITAN LISTRIK DI PT. CPI

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ABSTRAK

Untuk membangkitkan listrik, PT CPI membeli gas dari pihak ketiga untuk bahas bakar gas di samping juga menggunakan gas produksi sendiri dari fasilitas produksi yang sudah ada. Terdapat peluang untuk mengurangi biaya operasi untuk pembelian fuel gas dari pihak ketiga dengan memanfaatkan flare gas dari stasiun Alfa dan Beta. Selama bertahun-tahun beroperasi, *associated gas* di stasiun Alfa and Beta hanya dibakar di flare stack dan tidak dimanfaatkan untuk tujuan yang bernilai ekonomis. Biaya total untuk memproduksi listrik dengan mengeksekusi proposal di atas akan dibandingkan dengan skenario saat ini.

Riset ini menggunakan pendekatan kuantitatif dengan sumber data meliputi proyeksi produksi *associated gas* dari team subsurface, analysis komposisi gas dari team lab, estimasi biaya dengan menggunakan harga satuan dari kontrak yang sedang berjalan, serta pelajaran dari proyek sejenis sebelumnya.

Fasilitas *Alfa and Beta Flare Gas Recovery* akan dibangun untuk memproses dan mengirimkan *flare gas* dari 2 stasiun ini ke Pager Gas Plant (GP). Gas compressor di Pager GP mengirimkan gas sampai ke Duri Power Plant, untuk digunakan lebih lanjut sebagai bahan bakar pada generator pembangkit listrik. Di sisi lain, biaya investasi dan tambahan biaya operasional diperlukan untuk fasilitas baru *Alfa and Beta Flare Gas Recovery* ini, misalnya biaya rutin aktivitas *operation & maintenance*, *compressor overhaul*, *electric power*, *pipeline maintenance*, *chemical injection* dan lain-lain. Dari analysis kelayakan proyek, untuk alternative 1, PV penghematan biaya sebesar $916,386, dengan IRR = 23%, dan periode pengembalian investasi selama 1,8 tahun.

Dari *sensitivity analysis* yang dilakukan, dapat disimpulkan bahwa parameter yang paling berpengaruh terhadap perubahan nilai ekonomis dari proyek adalah proyeksi produksi gas atau nilai proyeksi persentase penurunan tingkat produksi, yang kemudian diikuti oleh proyeksi harga gas ($/MMBTU), dan kemudian diikuti oleh biaya capital ($).

Dengan menimbang analisis di atas, dapat disimpukan bahwa proyek *Alfa and Beta Flare Gas Utilization* layak secara ekonomis dan direkomendasikan untuk mengeksekusi segera setelah serah terima blok Riau dari PT CPI ke PT PTM di tahun 2021.

Kata Kunci :

Flare Gas, Bahan Bakar Generator, Studi Kelayakan Proyek, Penghematan Biaya

VALIDATION PAGE

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FOREWORD

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Koleksi digital milik UPT Perpustakaan ITB untuk keperluan pendidikan dan penelitian

CHAPTER 1. INTRODUCTION

1.1. Background

Riau block is one of the oil and gas working areas in Indonesia currently operated by PT CPI. PT CPI is an oil and gas company with a production sharing contract (PSC) with the Government of Indonesia (GOI) to conduct oil and gas exploration and exploitation in Indonesia. GOI has *Satuan Kerja Khusus Pelaksana Usaha Hulu Minyak dan Gas Bumi (SKK Migas)* as a bridge for business relations with oil and gas contractors. Riau block is one of Indonesia's biggest blocks based on its contribution to national oil production.

The main products from the Riau block is crude oil. Alfa and Beta are major Gathering Stations in PT CPI that have high crude oil production. These two stations also produce associated gas which has not been utilized to deliver any economic benefit. But the gas is only burned at the flare stack.

The figure below shows the location of the Alfa and Beta field. The location is 180 km from Pekanbaru, capital of Riau province.

Figure 1.1. Location of Alfa and Beta field

There are two major options for reduction of associated gas flaring: the first is reinjection of gas into the ground for future reuse, while a second option is gas utilisation for domestic and commercial purposes, which could involve acquiring equipment for liquidification and transportation (Odumugbo, 2010).

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There are some generated alternative solutions of flare gas utilization from Alfa and Beta stations. They are (1) Directly transfer gas to a reservoir or activate the Gas Lift System, (2) Utilize gas for Heater Treater, (3) Convert gas into Liquefied Hydrocarbon/LNG, (4) Utilize gas to generate electricity with localized Power Generation at the site, and (5) Transfer gas to the nearest other gas facility with the final destination is the existing Gas Power Plant/Generator. By considering some selection criterias include schedule, constructability, operability, and maintainability, the selected alternative for Alfa and Beta flare gas is option 5 (Transfer gas to the nearest another gas facility with the final destination is the existing Power Plant/Generator).

Fuel gas requirement for power plants in PT CPI is fulfilled by purchasing from third parties in large portion and utilizing gas production from PT CPI in small portion. By utilizing Alfa & Beta flare gas, the volume of gas purchases from third-party will reduce, thereby reducing the company's Operating Expenditure (OPEX) cost.

This final project studies economic analysis of Alfa and Beta flare gas utilization as fuel gas of power plant, to assess whether it can be financially feasible or profitable.

1.2. Company Profile

CVX is a leading integrated energy company in the world, based in the United States. The company's vision is being the global energy company most admired for its people, partnership, and performance. Refer to corporate website (Chevron Corporation, 2020), the company's values are :

- High performance,
- Diversity and inclusion
- Integrity and trust
- Protect people and the environment, and
- Partnership

The company has three primary business strategies. Those are upstream exploration & production, downstream & chemical, and midstream. It also has enterprise strategies, include :

- Growth: Grow profits and returns by using our competitive advantages.
- Execution: Deliver results through disciplined operational excellence, capital stewardship, and cost-efficiency.
- People: Invest in people to develop and empower a highly-competent workforce that delivers results in the right way.

- Technology and functional excellence: Differentiate performance through technology and functional expertise.

The company has business activities worldwide, including Indonesia, which works in the upstream exploration and production sectors. PT CPI has been a leading producer of energy in Indonesia for more than 90 years. PT CPI holds a 100%-owned and operated interest in the Riau block Production Sharing Contract (PSC), which will expire in 2021.

Power Generation and Transmission (PG&T) operation team is one of the divisions in PT CPI, which operates facilities that produce, transmit, and distribute electricity to all locations within all company's operation areas. Plant Operation team is one of the divisions in PT CPI that processes production fluid from well and produces the final product (crude oil and gas). Facility Engineering (FE) Projects team is one of the divisions in PT CPI that responsible for the development and execution of projects in all Sumatra Operations. This team manages resources associated with all phases of project activities and ensures the organizational capability to manage, execute, and deliver the business plan safely on budget, schedule, and quality.

The figure below shows PG&T Operation, Plant Operation, and FE Projects in the company's organization chart of Sumatra Operations.

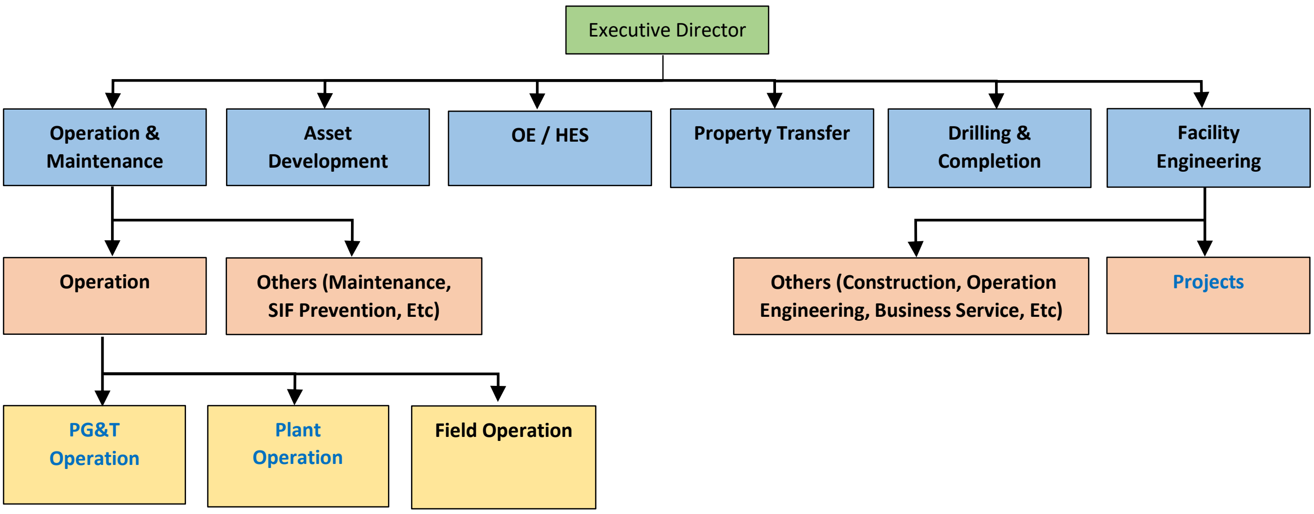

Figure 1.2. Company's Organization Chart

1.3. Business Issue

Alfa and Beta stations produce crude oil as the main product and deliver it to the market through the Dumai terminal. They also produce associated gas in a reasonably large amount (total ~ 3.5 MMSCFD) and burn it at the flare stack continuously.

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Figures 1.3 and 1.4 below show gas flaring in Alfa and Beta stations.

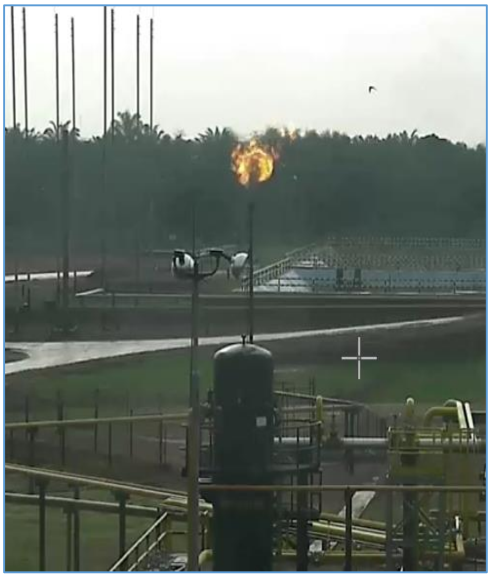

Figure 1.3. Flare Stack in Alfa Station

Figure 1.4. Flare Stack in Beta Station

Currently, Alfa and Beta stations do not have facilities to recover flare gas further. Even though, these flare gas have high hydrocarbon content based on laboratory test. These flare gas has lower quality (lower BTU number) than purchased gas from third party. However, flare gas utilization will still have benefit as cost-saving for gas purchasing. This cost-saving contributes to reduce overall PT CPI's operating cost.

On the other hand, there are some regulation from the Government of Indonesia that related to flare gas utilization include :

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- The ESDM Minister Decree No. 32 of 2017, which states that Production Sharing Contract (PSC) contractors must propose a plan to optimize the use of flare gas to SKK Migas. Contractors can do utilization gas flaring with a mechanism: addition of upstream gas facilities; or utilized by Business Entity that holds Commercial Business Permits. The government encourages PSC contractors to optimize the utilization of flare gas for generator fuel or other purposes.
- The Environment Minister Decree No.129 of 2003, which regulates the quality standard of business emission in oil and gas activities. This focuses on monitoring gas emissions and prohibits burning of gas waste openly.
- The Government Regulation No.34 of 2005 which regulates the activities of upstream oil and gas business. The Government Regulation contains the obligations of the upstream oil and gas business entities to manage the environment including the management of flare gas.

Flare gas utilization from Alfa and Beta stations instead of continuous flaring will align with those government regulations.

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1.4. Research Question

- Is it feasible economically to utilize flare gas from Alfa and Beta field for power generation in PT. CPI ?

  Currently, PT CPI generate electric power by purchasing fuel gas from third party. To reduce operating expenditure for gas purchasing, there is opportunity to utilize flare gas from Alfa and Beta field. To evaluate this opportunity, the economic feasibility analysis will be conducted.

1.5. Research Objective

This final project has an objective to provide inputs from financial terms for decision-makers whether Alfa and Beta flare gas utilization is justified to be executed as an investment project. All required CAPEX and OPEX cost for Alfa and Beta flare gas utilization will be calculated and compared with current cost for gas purchasing from the third party.

Cost saving from between current condition and new proposal will become the company’s operation expenditure saving. Sensitivity analysis is also conducted to provide quantitative information to decision-makers on the impact of variations on financial effects.

1.6. Scope and Limitation

This study is limited to several conditions, such as:

- Gas source is Alfa and Beta flare gas
- Power generation type is gas generator
- The study scope is 10 years frame under several financial assumptions.
- Sensitivity analysis is limited to 3 parameters which is considered as the most impactful to project economic. They are Decline Rate of Gas Production, Gas Price, and Capital Expenditure.

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CHAPTER 2. BUSINESS ISSUE EXPLORATION

2.1. Research Methodology

Research Methodology is science of studying how research is done scientifically. A way to systematically solve the research problem by logically adopting various steps. Methodology helps to understand not only the products of scientific inquiry but the process itself. Research Methodology aims to describe and analyze methods, throw light on their limitations and resources, clarify their limitations and resources, clarify their presuppositions and consequences, relating their potentialities to the twilight zone at the frontiers of knowledge (Patel *et.al*, 2019).

The final investment decision is based on the results of the economic analysis. This final project conducts an economic analysis of Alfa & Beta flare gas utilization project as a business opportunity to reduce company operating expenditure in producing electric power. This opportunity will be compared with the existing practice (Purchase gas from the third party to produce electric power). Discounted Cash Flow (DCF) method and sensitivity analysis are used to evaluate the economic investment of this project. The flow chart of the investment analysis is shown in the figure below.

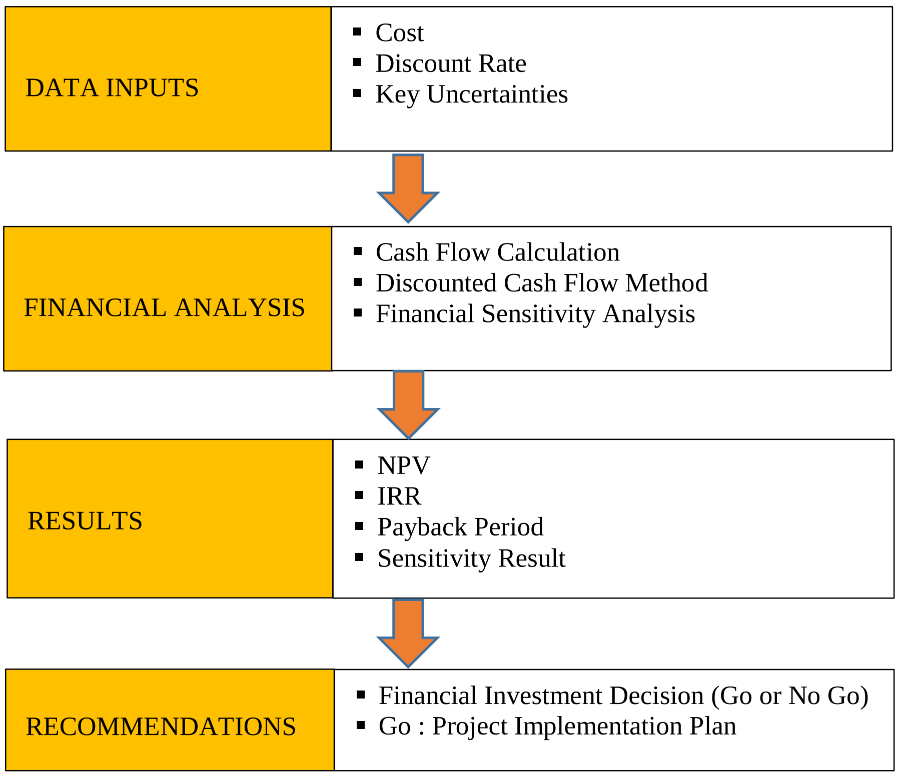

Figure 2.1. Flow Chart of Investment Analysis

This final project uses a quantitative research method. Quantitative research is used to quantify the problems in making numerical data or data that can be transformed into statistics. Quantitative research uses measurable data to formulate facts and uncover patterns in research. The quantitative data will be obtained from existing data from the company. After calculating all technical and financial parameters, projected cost saving will then be estimated.

This research will be further analyzed using capital budgeting methods such as Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period. Sensitivity analysis will be performed to provide inputs which parameter is significantly affect the financial feasibility.

2.2. Conceptual Framework

The conceptual framework in the below figure shows the conceptual framework to solve the business issue.

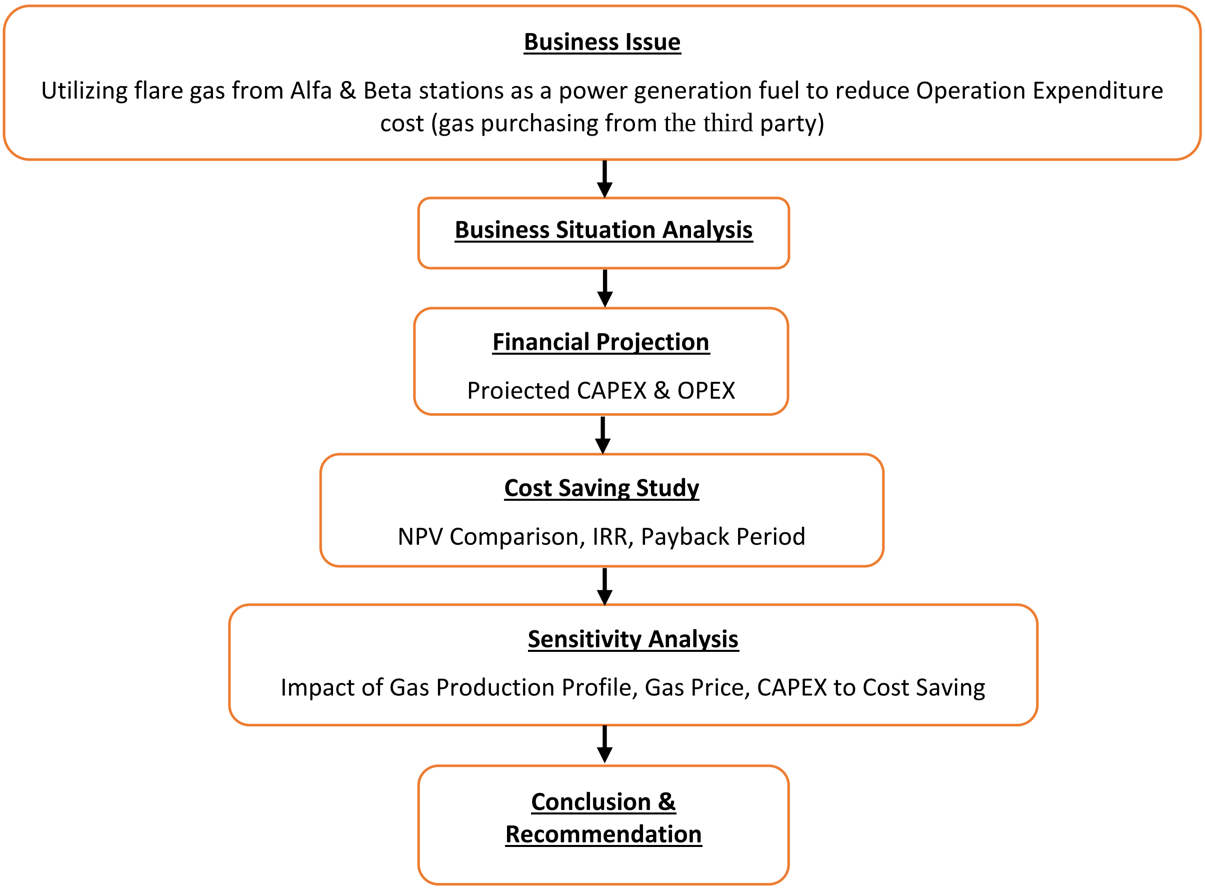

Figure 2.2 Conceptual Framework

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2.3. Technical Analysis

2.3.1. Natural Gas

Natural gas consists largely of methane (CH_4) and ethane (C_2H_6), with also propane (C_3H_8) and butane (C_4H_{10}), some higher alkanes (C_5H_{12} and above) (used for gasoline), nitrogen (N_2), oxygen (O_2), carbon dioxide (CO_2), hydrogen sulfide (H_2S), and sometimes valuable helium (He). It is used as an industrial and domestic fuel, and also to make carbon-black and chemical synthesis. Natural gas is transported by large pipelines or (as a liquid) in refrigerated tankers. Natural gas is combustible mixture of hydrocarbon gases, and when burned it gives off a great deal of energy (Ali, 2010).

2.3.1.1. Natural Gas Composition

Methane is the main element of hydrocarbon. Gas with more than 95% methane portion, it is sometimes termed dry or lean gas while gas with less than 95% methane portion and more than 5% of heavier hydrocarbon (ethane, propane, butane) is sometimes termed rich gas or wet gas. This type of gas usually produces HC liquids during process treatment.

Commonly, methane is the most common component transported by pipelines and converted to liquefied natural gas (LNG) if the end-user is far from the gas producer. LNG is the liquid product produced by cooling methane. Methane may also be converted to liquid fuels through gas-to-liquids (GTL) processes. Methane is commonly used in power generators, industrial and residential users.

Natural gas liquids (NGLs) include components that remain gaseous at reservoir conditions but can be processed to produce liquid at surface conditions. These include ethane, propane, condensates, and natural gasoline. Condensates are low-density liquid mixtures of pentanes and other heavier hydrocarbons. Liquefied petroleum gas (LPG) refers specifically to propane and butane when they are stored, transported, and marketed in pressurized containers. Natural gas can also contain non -hydrocarbon components such as carbon dioxide (CO_2), hydrogen sulfide (H_2S), hydrogen, nitrogen, helium, and argon. Gases with high levels of H_2S are also called sour gas, referring to the sour smell of sulfur. Conversely, gases with low levels of sulfur are called sweet gases. All of these impurities, especially CO_2 and H_2S, must be removed from the natural gas stream before the sale (Natgas.info, 2020).

2.3.1.2. Natural Gas Measurement

The amounts of gas accumulated in a reservoir, as well as produced from wells and transported through pipelines, are measured by volume, calculated in either cubic meters or

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cubic feet. The calculations are made regarding the volume occupied by the gas at standard atmospheric pressure (i.e., 760 mm of mercury, or 14.7 pounds per square inch) and a temperature of 15 °C (60 °F). Due to gas in the reservoir is compressed by the high pressures exerted underground, it expands upon reaching the surface and thus occupies more space. However, due to volume calculation refer to standard conditions of temperature and pressure, this expansion does not constitute an increase in the amount of gas produced. Natural gas reserves are usually measured in billions and trillions of cubic meters or billions and trillions of cubic feet. Daily volumes produced at wells are frequently measured in thousands and millions of cubic meters or thousands and millions of cubic feet.

On the market, the transaction of natural gas is usually by calorific value, noted above as approximately 38 MJ per cubic metre or about 1,050 BTUs per cubic foot. These units are frequently abbreviated as MJ/m3 and BTU/ft3. In the British system, 1 MMBTU is conveniently equivalent to roughly 1,000 cubic feet of natural gas. Natural gas price is frequently cited per therm, per MMBTU, or GJ (Britannica, 2020).

2.3.1.3. Gas Flaring

Flare gas is hydrocarbon gas produced by exploration and production or processing of oil or natural gas which is burned because it cannot be handled by the available production or processing facilities so that it has not been utilized. The combusted gas can come from various sources, namely excess gas from producers that cannot be supplied to consumers, unburned gas at process facilities, interference from process systems, equipment replacement or maintenance and shutdown processes that require temporary combustion （Rochmi *et.al*., 2019）.

Flare gas is gas produced by oil and gas exploration and production or processing activities, which is burned because it cannot be handled by available production or processing facilities so that it has not been utilized. Gas flaring is a form of waste of natural resource and carries along huge economic impacts. It reduces the revenue generation. (Ojiiagwo *et.al*, 2016) In Indonesia, The Ministry of Energy and Mineral Resources seeks to increase the use of flaring gas in all business entities for power plants, industrial or household fuels, processed into Compressed Natural Gas, Liquefied Petroleum Gas (LPG), Dimethyl Ether, and other needs. For this concern, the government issue ESDM Minister Regulation Number 32, the Year 2017. Government targets to utilize gas flares optimally in Indonesia before 2030. To pursue this target, the government cooperates with the World Gas Flaring Reduction (GGFR), the World Bank.

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Flare gas contributes to climate change and the environment through CO_2 emissions, black carbon, and other pollutants. Flaring gas also wastes valuable energy that can be used to promote sustainable development for producing countries. The government of Indonesia committed to contributing to Reducing Green House Gas (GHG) Emissions as mandated by the Paris Agreement in the Conference of the Parties (COP) 21. Based on satellite data launched by GGFR World Bank, Indonesia ranks 15th in gas flares from exploration and production activities. In 2017, Indonesian gas from exploration and production activities contributed to Routine Flaring on average by 179 MMSCFD. Due to the volume of flare gas is small, there is a challenge both in terms of engineering and financial. The price of flare gas is relatively lower than the gas produced in the field. However, flare gas volumes are small, unstable, and generally have high CO_2 and H_2S contents that need more treatment and cost.

About 5% of global supply of gas is wasted due to flaring and or venting as a result of lack of processing facilities, thereby causing the release of about 300 million tons of CO_2 per year into the environment (Fielden, 2015). Flaring and venting of associated gas contributes significantly to greenhouse gas (GHG) emissions and has negative impacts on the environment. The flare gas is substantially dominated by methane and carbon dioxide. The combustion process of these gases is a major contributor to the supply of greenhouse gases in the atmosphere and adds to the chaos of climate change (Dada, 2015). In addition to the impacts on the environmental, burning of residual gas may pose a health risk. Flare gas contains toxins that pollute the air (Saheed, 2012).

2.3.2. Gas Power Generator

In GE Power website, a gas turbine is defined as a combustion engine that can convert energy from natural gas fuel into mechanical energy. Then, this energy drives a generator that produces electrical energy. Following is the gas generator work process in producing electric power. To generate electric power, the gas turbine heats a mixture of fuel and air at very high temperatures. This heating will cause the turbine blades to rotate. The rotating turbine drives a generator that converts mechanical energy into electric power. The gas turbine can be combined with a steam turbine—in a combined-cycle power plant to create power extremely efficiently. Below is the detail work process.

a. Air-fuel mixture ignites.
b. Hot gas rotates turbine blades.
c. Rotating blades turn the drive shaft.
d. Turbine rotation powers the generator.

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e. Generator magnet makes electrons to move and creates electric power (GE Power, 2020).

Generally, gas turbine has combustion capacity with fuel gas specification as shown in table 2.1 below (GE Power System, 2002).

Table 2.1. Natural Gas Characteristic Specification as Fuel of Gas Turbine Generator

No	Fuel Gas Characteristic	Maximum Limit	Minimum Limit
1	Pressure	Depend on unit & combustor type	Depend on unit & combustor type
2	Temperature	-	Depend on gas pressure
3	LHV (Low Heating Value), Btu/Scf	-	100-300
4	MWI (Modified Wobbe Index)		
	• Absolute Limits	54	40
	• Limit Range Value	5%	-5%
5	Flammability Ratio		2.2 : 1
6	Gas Component Limit		
	• Methane	100	85
	• Ethane	15	0
	• Propane	15	0
	• Buthane and C4+	5	0
	• Hydrogen	Trace	0
	• CO	Trace	0
	• O2	Trace	0
	• Total Inert Gas	15	0

2.3.3. Alfa and Beta Flare Gas Recovery Facilities

The brief scope of works for the project is described below:

1. On Plot Alfa GS

a. Gas Compressor

- Relocation from old location (Sebanga) to new location (Alfa GS)
- Gas engine and control system modification to improve air emission compliance

b. Gas Processing Equipment

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- Relocation of several equipments (Inlet Cooler, Inter stage Cooler, LTS (Low Temp Separator) Bottle, Blowcase Bottle, Inlet Separator Bottle, 3 Phase Separator Bottle, Accumulator Bottle, Inlet Scrubber, Inter stage Scrubber, Discharge Scrubber, Condensate Pump, and Transfer Pump) from several locations to new location (Alfa GS)

c. Utilities Equipment
   - Relocation of several equipments (PLC, Air Compressor, Switch rack and MCC 480V) from several locations to new location (Alfa GS)
   - New installation of several equipments (Transformer and Jib Crane) at Alfa GS

d. Piping installation
e. Cable installation
f. Instrument devices installation
g. Civil foundation

2. On Plot Beta GS

a. Gas Compressor
   - Relocation from old locations (Libo and Pinang) to new location (Beta GS)

b. Gas Processing Equipment
   - Relocation of several equipments (Inlet Separator, Inlet Cooler, Inter stage Cooler, Gas Scrubber, Liquid (3 Phase) Scrubber, Condensate Pump, Water Pump, and Pig Launcher) from several locations to new location (Beta GS)

c. Utilities Equipment at Beta GS
   - Relocation of several equipments (Transformer, PLC, MCC 4160V, and Switch rack & MCC 480V) from old location (Pinang) to new location (Beta GS)
   - New installation of Air Compressor at Beta GS

d. Piping installation
e. Cable installation
f. Instrument devices installation
g. Civil foundation

3. Off Plot Alfa

a. New 4” piping installation from Alfa GS to tie-in point of existing gas shipping line

   Below is process flow diagram of Flare Gas Recovery in Alfa GS :

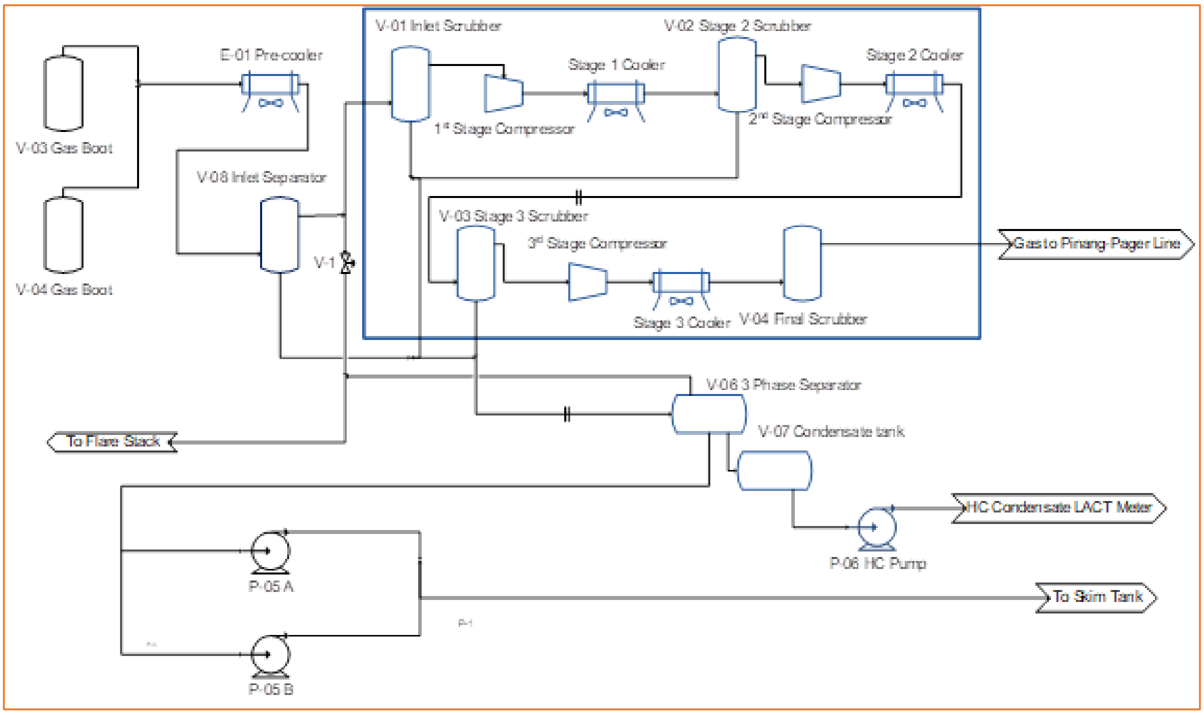

Figure 2.3. Process Flow Diagram – Alfa Flare Gas Recovery

Below is process flow diagram of Flare Gas Recovery in Beta GS :

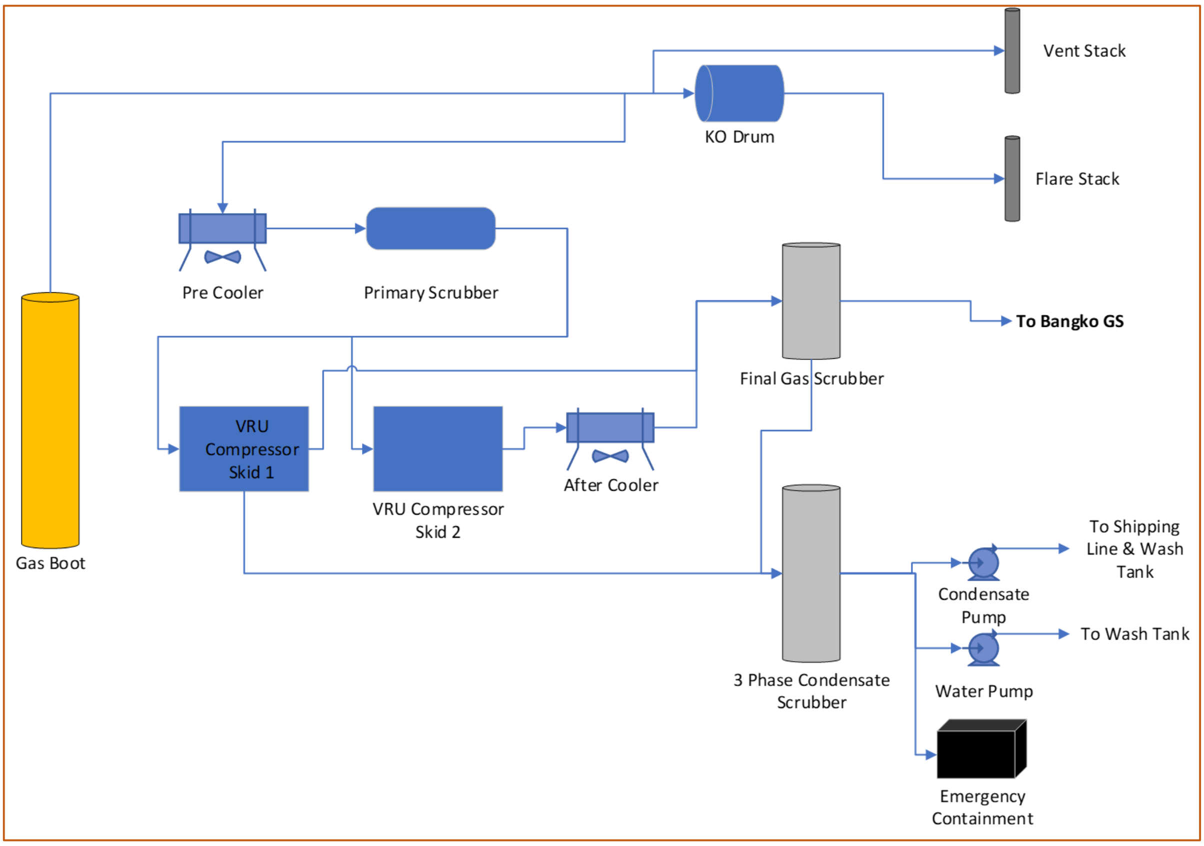

Figure 2.4. Process Flow Diagram – Beta Flare Gas Recovery

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2.4. Theoretical Foundation

2.4.1. Financial Analysis

Financial analysis is the process and results of carrying out corporate financial activities that are based on the research and evaluation of the company's financial statements and other information, which can reveal the advantages and disadvantages of the business enterprises in the past, analyze financial condition and predict future trends, so that it can be better to help companies plan for the future, optimize investment decisions. Financial analysis can help business enterprises to understand the past, evaluate the present situation of enterprises, forecast the future, and provide accurate information for company to make the right decisions and financial basis is an important tool for enterprises to carry out the daily management. The accuracy of financial analysis in business decision-making and the establishment of a scientific financial system promote the standardization of financial management, improve business efficiency and the quality of financial personnel (Wang *et.al*, 2016).

2.4.2. Project Finance

Project finance is the process of financing a specific economic unit that the sponsors create, in which creditors share much of the venture's business risk and funding is obtained strictly for the project itself. Project finance creates value by reducing the costs of funding, maintaining the sponsors financial flexibility, increasing the leverage ratios, avoiding contamination risk, reducing corporate taxes, improving risk management, and reducing the costs associated with market imperfections (Pinto, 2017).

2.4.3. Capital Expenditure (CAPEX)

A capital expenditure (CAPEX) budget is a formal plan that states the amounts and timing of fixed asset purchases by an organization. This budget is part of the annual budget used by a firm, which is intended to organize activities for the upcoming year. Capital expenditures can involve a wide array of expenditures, including upgrades to existing assets, the construction of new facilities, and equipment required for new hires (Accounting Tools, 2020).

The capital expenditure decision has its effects over a long time span and inevitably affects the company's future cost structure. Capital expenditure management includes addition, disposition, modification and replacement of fixed assets. A systematic blending of current and fixed assets into a profitable combination is challenging task for the financial management (Selam *et.al*, 2012).

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2.4.4. Operational Expenditure (OPEX)

Operating Expenditure (OPEX) is the cost that firm / plant pay to operate the plant or business to produce product or service. The firm meets the operating expenditure daily and continuously. Operating expenditure are written off against profit for the period. They include salaries, wages and facilities or other operating expenses, such as rent, electricity, etc (Appuhami, 2008).

2.4.5. Capital Budgeting

Refer to Principles of Managerial Finance book, Chapter 10, Capital Budgeting is the process of evaluating and selecting long-term investments that are consistent with the firm's goal of maximizing owners' wealth. The process of capital budgeting as five distinct but interrelated steps : Proposal generation, Review and analysis, Decision making, Implementation and Follow-up (Gitman *et.al*, 2015, p.442).

2.4.5.1. Return on Investment (ROI) :

ROI (Return On Investment) is an indicator that shows to which extent a specific business produce gain from the use of capital. ROI is calculated as the ratio between operating profit obtained after the action of investment and the total amount invested (or the total investment costs) (Zamfir *et.al*, 2016). ROI can be calculated using the method below :

$$ROI = \frac{Profit\ After\ Investment}{Invested\ Capital} * 100\% \qquad (1)$$

Where :

Profit After Investment = Revenues After Investment – Invested Capital

2.4.5.2. Net Present Value (NPV) :

NPV is a sophisticated capital budgeting technique; found by subtracting a project's initial investment from the present value of its cash inflows discounted at a rate equal to the firm's cost of capital (Gitman *et.al*, 2015, p.449).

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} - CF_0 \qquad (2)$$

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Where :

CF_0 = Project's Initial Investment

CF_t = Present Value of its Cash Inflows

r = Firm's cost of capital

Decision Criteria :

NPV > \$0 → accept the project

NPV < \$0 → reject the project

2.4.5.3. Profitability Index (PI)

Profitability Index (PI) is the ratio of the present value of cash inflows, at the required rate of return, to the initial cash outflow of the investment proposal. This approach measures the present value of returns per rupee invested. There are some advantages of PI : It considers all cash flows, It helps to rank projects, It gives due consideration to time value of money, It is consistent with the objective of maximization of shareholders wealth (Selam *et.al*, 2012).

$$PI = \frac{Present\ Value\ of\ Cash\ Inflows}{Present\ Value\ of\ Cash\ Outflows} \quad (3)$$

$$PI = \frac{\sum_{t=1}^{n} \frac{CF_t}{(1+IRR)^t}}{CF_0}$$

2.4.5.4. IRR

IRR is the discount rate that equates the NPV of an investment opportunity with \$0 (because the present value of cash inflows equals the initial investment). It is the rate of return that the firm will earn if it invests in the project and receives the given cash inflows (Gitman *et.al*, 2015, p.453).

$$\$0 = \sum_{t=1}^{n} \frac{CF_t}{(1+IRR)^t} - CF_0 \quad (4)$$

$$\sum_{t=1}^{n} \frac{CF_t}{(1+IRR)^t} = CF_0$$

Decision Criteria :

IRR > the cost of capital → accept the project

IRR < the cost of capital → reject the project

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Refer to Interdisciplinary Journal of Contemporary Research in Business, NPV and IRR are the capital budgeting techniques mostly used to evaluate the projects or investments. NPV is preferable because it is to calculate and reinvest the cash flows at the cost of capital. NPV is preferable when the projects are mutually exclusive. IRR is preferable because it gives answer in percentage and it is to understand (Arshad, 2012).

2.4.5.5. Payback Period

The payback period is the amount of time required for the firm to recover its initial investment, as calculated from cash inflows. When the payback period is used to make accept-reject decisions, a project is accepted if it is less than the maximum acceptable payback period (Gitman *et.al*, 2015, p.445).

Payback Period method has some advantages : It is very simple and easy to understand, The cost involvement in calculating PBP is much less compare to modern methods, and It helps to take investment decision (Selam *et.al*, 2012).

2.4.6. Sensitivity Analysis

Sensitivity analysis is an approach that uses several possible alternative scenarios to obtain a sense of the variability of outcomes, in this case, measured by NPV. This technique is useful in getting a feel for the variability of return in response to changes in a critical outcome. In capital budgeting, one of the most common scenario approaches is to estimate the NPVs associated with pessimistic (worst), most likely (expected), and optimistic (best) estimates of cash inflow. The range can be determined as the difference between pessimistic-outcome NPV and the optimistic-outcome NPV.

A tornado diagram can be used for displaying the sensitivity of probabilities and values in decision trees, and of weights and weighted values in multi-criteria models. The difference compared to traditional tornado diagrams is that interval ranges have already been specified by the decision-maker and taken account of in the resulting expected value interval (Idefeldt et.al, 2007).

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2.5. Analysis of Business Situation

2.5.1. Global Business Situation

2.5.1.1.International Oil Industry Disruption

In the last ten years, the oil and gas industry globally has experienced significant volatility. The sensitivity of oil and gas prices is driven significantly by global geopolitical and economic considerations. One factor that affects oil and gas oversupply is the development of shale technology, especially in the US. In the other hand, decreasing economic growth in some major countries lower oil and gas demand.

Global economic slowdown due to Covid-19 pandemic in Q1-2020 has worsened the condition. World Bank's Commodity Market Outlook (published in April 2020) explained that crude oil prices fell deeply through 2020Q1, dropping 70 per cent between January (the date of the first known human-human transmission) to April. Mitigation of the virus spread has reduced a large proportion of travel globally, with widespread flight cancellations, stay-at-home orders, and reduced global trade all reducing demand for oil. The pandemic has also triggered a deep global recession, which also weakened oil demand.

The decline was compounded by the breakdown of OPEC+ meeting in March, and a new production agreement announced on April failed to boost prices. Following up continued growth in US shale production, in March 2020, OPEC+ met to negotiate to extend or deepening cuts in response to the growing impact of COVID-19 on demand. Nevertheless, the group failed to reach an agreement. Collectively, OPEC oil production in April is likely to have risen by around 1.5 – 2 MB/D, despite the collapse in demand. The oil market has been hit by an unprecedented combination of demand and supply shocks.

Oil prices are projected to average $35/bbl in 2020 before recovering to $42/bbl in 2021, which is substantially lower than the last year forecast of $58/bbl for 2020 and $59/bbl for 2021. From their current lows, oil prices are expected to recover in 2020 before strengthening into next year gradually. The most significant risk is a slower end to the pandemic, particularly if mitigation measures remain in place for longer than expected, which could cause oil demand to be even weaker than anticipated. A more prolonged or deeper global recession would also result in weaker oil demand (World Bank Group, 2020).

2.5.1.2. International Gas Price Fluctuation

As with other commodities, gas prices are also strongly influenced by demand and supply. Gas prices can also be linked to the international crude oil price. The global economic crisis, which reduced the demand for gas, ultimately affected the decline in gas prices.

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As with global crude oil prices, gas prices have also dropped significantly since early 2020 to their history in March. Before the spread of the COVID-19 pandemic, gas prices were affected by LNG oversupply, mild winter in the northern hemisphere, and trade wars between the US and China. Gas demand in China is drastically reduced in the early 2020s when the coronavirus case disrupts industrial activity. This condition affects the decline in global gas prices. Since March, the decline in gas prices has been affected by the impact of lockdowns in several parts of the world. The impact of COVID-19 on the decline in gas prices has increased with the spread of pandemics to other parts of the world. The figure below shows the historical data on gas prices (Henry Hub) in the last one year (Market Insider, 2020).

Figure 2.5. 1-Year Natural Gas (Henry Hub) Historical Price

2.5.2. Indonesia Business Situation

2.5.2.1. Indonesia Oil and Gas Industry

In the oil and gas sector, Indonesia has been active for more than 100 years, since the discovery of the first oil well in Sumatra at the end of the 19th century. Indonesia's oil production has declined in the last decade due to the aging of oil production fields, low reserve replacement rate, and reduced exploration & investment. The figure below shows Indonesia's oil production and consumption trends referring to Indonesia Energy Outlook data (National Energy Council, 2019). The decline in oil production and increased consumption has made Indonesia a net importer.

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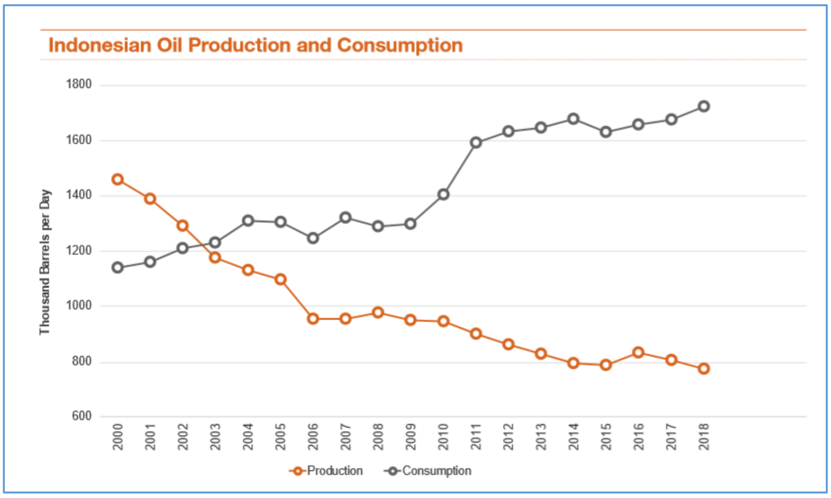

Figure 2.6. Indonesian Oil Production and Consumption (MBOPD)

In Indonesia, the portion of oil production will decrease while gas production will increase for total oil and gas production in the country. The figure below from Indonesia Energy Outlook (National Energy Council, 2019) shows these trends.

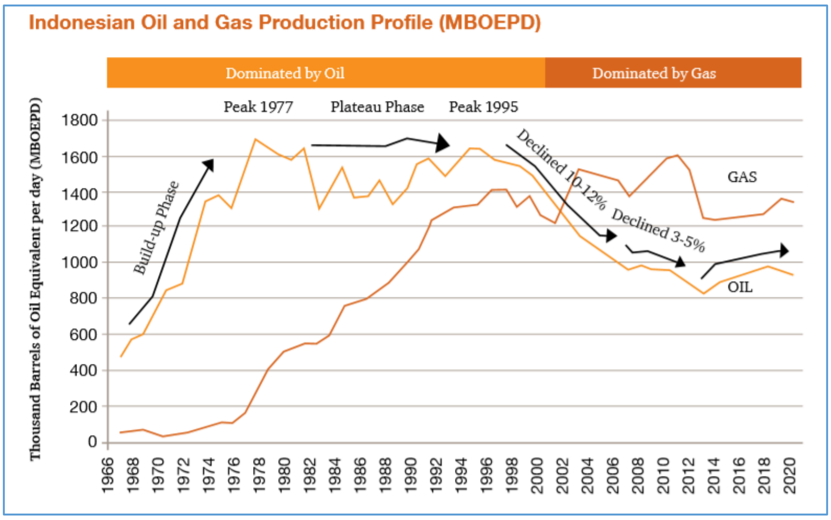

Figure 2.7. Indonesian Oil and Gas Production Profile (MBOEPD)

To promote investors to invest in the upstream oil and gas sector, the government at the end of 2015 revised Government Regulation (GR) No. 79 of 2010 to GR No. 27 of 2017 on Cost Recovery and Taxation in Upstream Business. The revised regulation is intended to create an attractive business climate in the upstream oil and gas sector through tax incentives during the exploration and exploitation period, such as exemption from customs duty, value-added tax and import tax (PWC, 2019).

2.5.2.2. Indonesia Electric Power Generation

In Indonesia, there are various kinds of power generation plants, including coal steam, gas steam, gas, diesel, geothermal, hydro, solar, wind, biomass, biogas, and waste power plants. Currently, more than 50% of electricity in Indonesia is produced from coal steam power plant. The proportion of diesel power plant will decrease in the future, by considering its power generation cost rather than other energy sources such as gas and coal. This portion is replaced by gas and renewable energy.

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CHAPTER 3. BUSINESS SOLUTION

3.1. Working Scheme

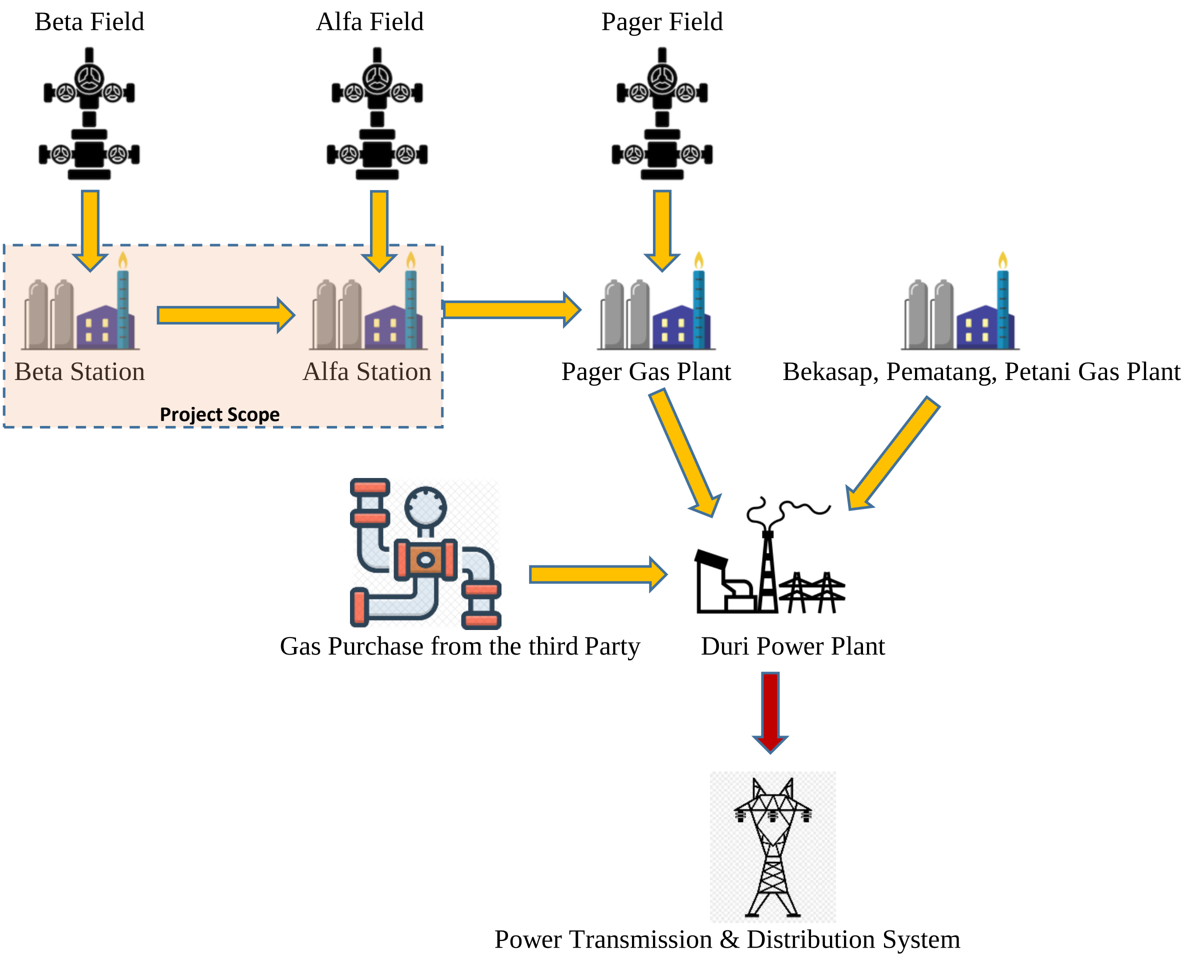

Figure 3.1. Scheme of Alfa and Beta Flare Gas Utilization

As shown in the figure 3.1. above, the gas fuel sources for Duri Power Plant come from the third party and own gas production (Bekasap, Pematang, Petani, and Pager). Through this project, flare gas production from Beta and Alfa station will be utilized to increase Pager gas production. This will increase own gas utilization in Duri Power Plant, that finally will reduce gas purchasing from the third party. Required cost (capital and operational expenditure) for flare gas utilization from Beta and Alfa field will be compared with cost reduction of gas purchasing from the third party.

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3.2. Financial and Operation Assumptions

Financial and operation assumptions in this final project are as shown in the table 3.1 and 3.2 below.

Table 3.1. Financial Assumptions

Description	Assumption
USD to IDR Exchange Rate (IDR/$)	14,400
Discount Rate	10%
Electricity Price ($/KWH)	0.14
Electricity Production Cost without Fuel ($/KWH)	0.0283
Gas Price ($/MMBTU)	5.72

Table 3.2. Operation Assumptions

Description	Assumption
Alfa & Beta Gas Production Decline Rate (Base Scenario)	-20%
Equipment Availability	95%
Third Party Gas BTU (BTU/SCF)	1023
Alfa & Beta Gas BTU (BTU/SCF)	911.5

Below are some references of some assumptions in table 3.1. and 3.2. above :

- Currency exchange rate (IDR/$) refers to currency assumption in 2020 Indonesia's State Budget
- Electricity Price ($/KWH) refers to current PT CPI's data of electric power generation process
- Electricity Production Cost without Fuel ($/KWH) refers to current PT CPI's data of electric power generation process
- Gas Price ($/MMBTU) refers to PT CPI's data of 3rd party gas purchasing
- Gas Production Decline Rate refers to general historical data of associated gas production decline rate in PT CPI
- Equipment availability refers to general historical data of gas compressor availability in PT CPI
- Third party gas BTU refers to specification of third party gas purchasing
- Alfa & Beta gas BTU refers to result of gas composition analysis

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3.2.1. <u>Gas Price Estimate</u>

The historical gas price that was used as a reference in the transaction between PT CPI with the third party within the period 2019-2020 is shown in the figure below.

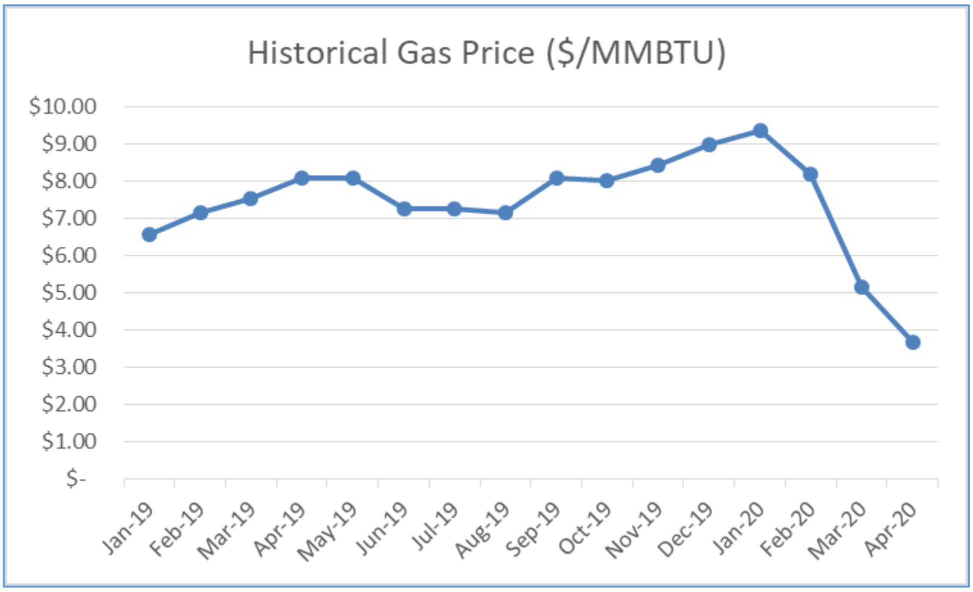

Figure 3.2. Historical Gas Price ($/MMBTU)

For the rest months in 2020, PT CPI set an estimate of gas price on average is $4.65/MMBTU, and the estimated price in 2021 is $5.72/MMBTU. The assumption of gas price in this final project uses 2021 estimate price.

3.3. Production Profile

According to the production variation rule, the oilfield development process can be divided into three phases: build-up, plateau and decline. In the build-up and plateau phases, production is dependent on the designed productive capacity; the production in decline accords with the decline rule, and the decline curve method is generally adopted. The decline curve method extrapolates a trend in the future, assuming that the wells have been produced to a steady-state flow, the factors that influenced the behavior of the well in the past will continue to exert the same influence in future, and the variation out of anticipation will not happen (Kaiser, 2006).

Gas production profile of Alfa and Beta field is developed with an assumption of 20% decline rate per year based on adjusted average historical data. Gas economic value depends on its BTU number, which is different based on its production source. BTU number from own gas production (include Alfa & Beta field) is lower than purchased gas from third party. By considering potential facility shut down for maintenance activities, equipment availability is

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estimated = 95%. Finally, yearly avoidance cost of gas purchasing from the third party is derived from the below calculation :

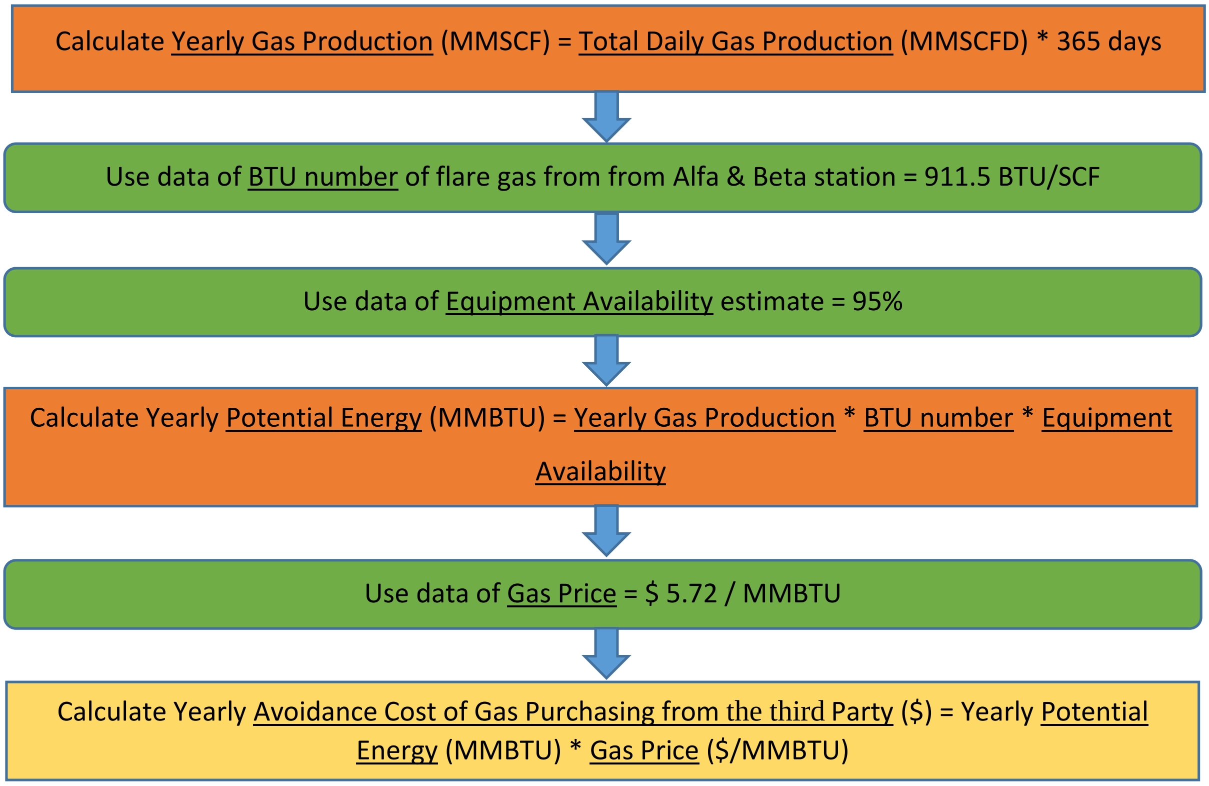

Figure 3.3. Calculation of Yearly Avoidance Cost of Gas Purchasing from The Third Party

Calculation result for 10 years period is shown in table 3.3. below.

Table 3.3. Alfa and Beta Gas Production Profile (2021-2031)

Description	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Bangko Gas Production (MMSCFD)	2.00	1.60	1.28	1.02	0.82	0.66	0.52	0.42	0.34	0.27	0.21
Balam Gas Production (MMSCFD)	1.50	1.20	0.96	0.77	0.61	0.49	0.39	0.31	0.25	0.20	0.16
Total Gas Production (MMSCFD)	3.50	2.80	2.24	1.79	1.43	1.15	0.92	0.73	0.59	0.47	0.38
Yearly Gas Production (MMSCF)	1,278	1,022	818	654	523	419	335	268	214	171	137
Yearly Potential Energy (MMBTU)	1,106,219	884,975	707,980	566,384	453,107	362,486	289,989	231,991	185,593	148,474	118,779
Yearly Avoidance Cost of Gas Purchasing from 3rd Party ($)	6,327,574	5,062,059	4,049,647	3,239,718	2,591,774	2,073,419	1,658,735	1,326,988	1,061,591	849,273	679,418

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Yearly gas production profile over 10 years of study period is shown in the figure below.

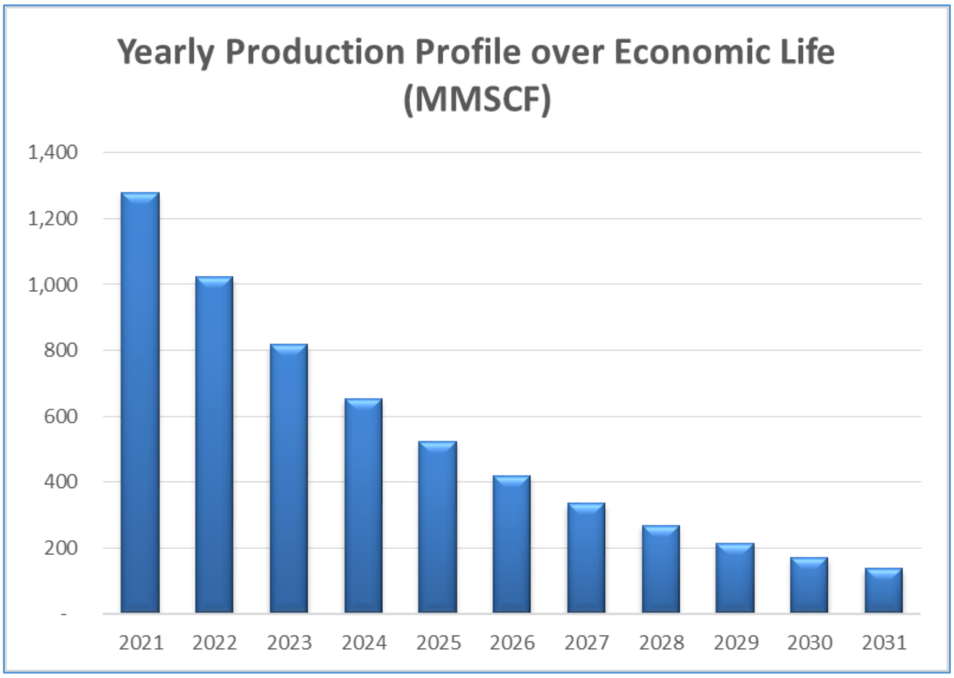

Figure 3.4. Yearly Gas Production Profile over Economic Life

As shown in figure 3.4 above, there is declining of gas production forecast from Alfa and Beta field as impact of natural declining rate (estimate constant 20%).

3.4. Cost

3.4.1. Capital Expenditure (CAPEX) of Alfa & Beta Flare Gas Utilization project

In Alfa and Beta Flare Gas Utilization project, capital expenditure (CAPEX) is required for the installation of new facilities to process flare gas inside plant to be delivered until Pager Gas Plant. The summary of CAPEX is shown in the table below.

Table 3.4. Summary of Capital Expenditure

No	CAPEX Cost ($)	
1	Engineering Design	31,667
2	Material Procurement	2,801,265
3	Construction	1,176,000
4	Construction Management	85,067
5	Project Management	142,912
	Total	**4,236,910**

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Engineering design cost is allocated for manpower charges to develop engineering design and produce deliverables such as construction drawing, and material list. The cost estimate is based on unit price (IDR/working hour) in existing Engineering Company contract in PT CPI, and working hour estimate of each representative personnel in this project. Detail cost estimate for each Alfa and Beta is shown in the table below.

Table 3.5. Detail Cost Estimate of Engineering Design

Item	Unit Rate (IDR/hr)	Working Hours	Budget	
Supervisor	200,000	120	Rp	24,000,000
Drafter	150,000	2880	Rp	432,000,000
Total			Rp	456,000,000
			$	**31,667**

Major equipment for this project are gas compressor, separator, cooler, pump, transformer, MCC, etc. Material procurement cost is allocated also for piping and fitting to connect all those major equipment with existing facilities inside Alfa and Beta GS. Piping and fitting materials are also for off plot gas pipeline installation in Alfa area around 4 km to connect discharge of Alfa gas compressor to an existing gas pipeline from Pinang to Pager. Material procurement cost is also allocated for cable and fitting to connect motor, MCC, transformer, and power distribution line 13.8KV in Alfa and Beta GS. Electrical materials are also for grounding and lighting system. Besides that, material procurement cost is also allocated for instrument and control devices such as a level switch, pressure switch/transmitter, shutdown valve, control valve, etc. The cost estimate is based on the historical unit price of the same or similar material procured by PT CPI previously.

Construction cost is allocated for major equipment installation to Alfa and Beta GS. Construction cost is also allocated for installation of piping and fitting to connect all those major equipment with existing facilities inside Alfa and Beta GS. Cost is also allocated for installation of piping and fitting to connect the discharge of Alfa gas compressor to the existing gas pipeline from Pinang to Pager. Cost is also allocated for installation of cable and fitting to connect motor, MCC, transformer, and power distribution line 13.8KV in Alfa and Beta GS. Cost is also allocated for the installation of the grounding system, lighting system, and instrument & control system. Cost is also allocated for earthwork and civil work, mainly for pilling and concrete foundation. The cost estimate is based on unit price (IDR/work item) in the existing construction work unit rate (WUR) contract in PT CPI.

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Construction management cost is allocated for supervisor, construction representative, QA/QC representative, and HES representative personnel from the third party (Construction Management company) to conduct daily construction supervision at site. The cost estimate is based on unit price (IDR/working hour) in existing Construction Management company contract in PT CPI, and working hour estimate of each representative personnel in this project. Detail cost estimate for each Alfa and Beta is shown in the table below.

Table 3.6. Detail Cost Estimate of Construction Management

Item	Unit Rate (IDR/hr)	Working Hours			Budget
		Month	Working Day/ Month	Working Hours	
Supervisor	300,000	12	22	4	Rp 316,800,000
Construction Reps	220,000	12	22	8	Rp 464,640,000
QA/QC Reps	220,000	6	22	8	Rp 232,320,000
HES Reps	200,000	12	22	4	Rp 211,200,000
Total					Rp 1,224,960,000
					$ 85,067

Project management cost is allocated for charges of some company's personnels that are involved in this project. The cost estimate is based on an estimate salary (IDR/month) and working hour estimate of each company's personnel involved in this project. Detail cost estimate for each Alfa and Beta is shown in the table below.

Table 3.7. Detail Cost Estimate of Project Management

Item	Unit Rate ($/hr)	Working Hours			Work Weight (%)	Budget
		Month	Working Day/ Month	Working Hours		
Project Engineer	55	16	22	8	40	$ 61,952
Project Manager	75	16	22	8	20	$ 42,240
Construction Reps	55	12	22	8	10	$ 11,616
Construction Engineer	55	12	22	8	10	$ 11,616
Cost Engineer	55	16	22	8	10	$ 15,488
Total						**$ 142,912**

3.4.2. Operational Expenditure (OPEX) of Alfa & Beta Flare Gas Utilization project

Operational expenditure or OPEX of proposed alternative is yearly costs required for operation and maintenance of flare gas recovery facilities in Alfa and Beta station and electric power production with BTU number of total gas from Alf and Beta. These OPEX are categorized into several items, include Regular O&M (Operation and Maintenance), Gas Compressor Overhaul, Electricity, Pipeline Maintenance, Chemical Injection, Miscellaneous Cost, and Electricity Production, as shown in the table below.

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Table 3.8. Operational Expenditure (OPEX) of New Proposal (Alfa & Beta Flare Gas Recovery)

Item		2023	2024	2025	2026	2027	2028	2029	2030	2031
Alfa Gas Production	Regular O&M (Operation and Maintenance)	169,467	169,467	169,467	177,940	177,940	177,940	186,837	186,837	186,837
	Gas Compressor Overhaul			233,422					245,093	
	Electricity	155,532	155,532	155,532	155,532	155,532	155,532	155,532	155,532	155,532
	Pipeline Maintenance	410,000	65,000	65,000	65,000	65,000	410,000	65,000	65,000	65,000
	Chemical Injection	25,000	25,000	25,000	26,250	26,250	26,250	27,563	27,563	27,563
	Miscellaneous (Certification, Supporting Equipments, etc)	25,000	25,000	25,000	26,250	26,250	26,250	27,563	27,563	27,563
Beta Gas Production	Regular O&M (Operation and Maintenance)	141,155	141,155	141,155	148,213	148,213	148,213	155,623	155,623	155,623
	Gas Compressor Overhaul			71,257					74,820	
	Electricity	414,295	414,295	414,295	414,295	414,295	175,279	175,279	175,279	175,279
	Pipeline Maintenance	116,000	12,000	12,000	12,000	12,000	116,000	12,000	12,000	12,000
	Chemical Injection	25,000	25,000	25,000	26,250	26,250	26,250	27,563	27,563	27,563
	Miscellaneous (Certification, Supporting Equipments, etc)	25,000	25,000	25,000	26,250	26,250	26,250	27,563	27,563	27,563
Electricity Production	Electricty Production Cost ($)	1,179,967	943,974	755,179	604,143	483,315	386,652	309,321	247,457	197,966

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3.4.2.1. Regular O&M (Operation and Maintenance)

It is assumed that the contractor company will conduct the operation and maintenance of new facilities for flare gas recovery in Alfa and Beta through contract development. Contractor company will be paid monthly for their operation and maintenance services. With this scenario, there is no requirement of the company's operation and maintenance team personnel addition due to the installation of these new facilities in Alfa and Beta station.

The cost estimate is based on the current contract in PT CPI for operating and maintaining similar facilities. Project startup estimate is the end of Q4 2022 so that spending plan of regular O&M (Operation and Maintenance) is started in 2023. It is also assumed that contract duration is three years, and there will be a 5% cost adjustment every contract renewal.

3.4.2.2. Gas Compressor Overhaul

It is assumed that the gas compressor overhaul in Alfa and Beta station will be conducted every five years. The cost estimate is based on a current contract in PT CPI for an overhaul of similar equipment. Cost estimate for an overhaul of gas compressor in Alfa station (gas engine compressor) is $240,814 as shown in the table below.

Table 3.9. Gas Compressor Overhaul (Alfa station)

Monthly O&M Cost (Alfa)				
Manpower				
Certified Technician	1	Lot	162,000,000	162,000,000
Technician	1	Lot	90,000,000	90,000,000
Material				
OH Material Engine	1	Lot	2,056,379,951	2,056,379,951
OH Material Compressor	1	Lot	1,159,336,762	1,159,336,762
Total				**Rp 3,467,716,713**

Cost estimate for overhaul of gas compressors in Beta station (electrically driven compressor) is $73,514 as shown in table below.

Table 3.10. Gas Compressor Overhaul (Beta station)

Monthly O&M Cost (Beta)				
Manpower				
Certified Technician	1	Lot	125,000,000	125,000,000
Technician	1	Lot	170,000,000	170,000,000
Material				
OH Material GC01	1	Lot	176,500,000	176,500,000
OH Material GC02	1	Lot	587,100,000	587,100,000
Total				**Rp 1,058,600,000**

It is assumed that cost estimate of overhaul will increase 5% from the last same activities.

3.4.2.3. Electricity

Major equipment (gas compressor) in Alfa flare gas recovery facilities is engine-driven compressor while supporting equipment (pump, cooler, air compressor, etc.) are electrically driven. Total required power is 170 HP ~ 127 KW. Major equipment (gas compressor) and supporting equipment (pump, cooler, air compressor, etc.) in Beta flare gas recovery facilities are electrically driven. The total required power is 500 HP ~ 373 KW.

It's assumed that electricity price is $0.14/KWH (based on 2020 electricity price in PT CPI) and remain the same during 10 years of study period until 2031. The yearly cost estimate is derived from the multiplication of total required power above with electricity price x 24 hours x 365 days. Spending plan is started in Jan 2023. Considering the declining trend of production profile in Beta station, it's assumed that required quantity of running the gas compressor in Beta station is two units until 2027, while since 2028, the required quantity of running gas compressor is only 1 unit and 1 unit as spare. This reduces the estimate of electric power requirement in Beta station in period 2028 until 2031.

3.4.2.4. Pipeline Maintenance

Component of pipeline maintenance include :

- In-Line Inspection to assess pipe integrity condition, conducted every five years.
- Regular pigging to clean pipeline from any substance that may cause pipe corrosion, conducted 4x in a year.
- Corrective maintenance to repair leak pipeline segment.

The cost estimate is based on a current contract in PT CPI for conducting the same scope as explained above. Spending plan is started in Jan 2023.

3.4.2.5. Chemical Injection

Chemical injection costs during the operating period is allocated for injection chemical material to a pipeline, in order to maintain pipe integrity of those segment. Those chemicals are corrosion inhibitor and H2S scavenger. When injected to the pipeline, the corrosion inhibitor has a function to decrease the corrosion rate of pipe material that comes into contact with the fluid. H2S scavenger has a function to eliminate or reduce H2S content of gas that

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enters the pipeline in order to minimize potential pipe corrosion. The cost estimate is based on a current contract in PT CPI to provide chemical material. Spending plan is started in Jan 2023.

3.4.2.6. *Miscellaneous (Certification, Supporting Equipments, etc)*

Miscellaneous costs during the operating period is allocated for several purposes such as equipment certification (PSV, vessel, gas compressor, transformer, etc.), corrective maintenance of supporting facilities both process equipment and also utility equipment, etc. The cost estimate is based on historical data of the same scopes. Spending plan is started in Jan 2023.

3.4.2.7. *Electricity Production*

Electricity production cost is derived from below calculation :

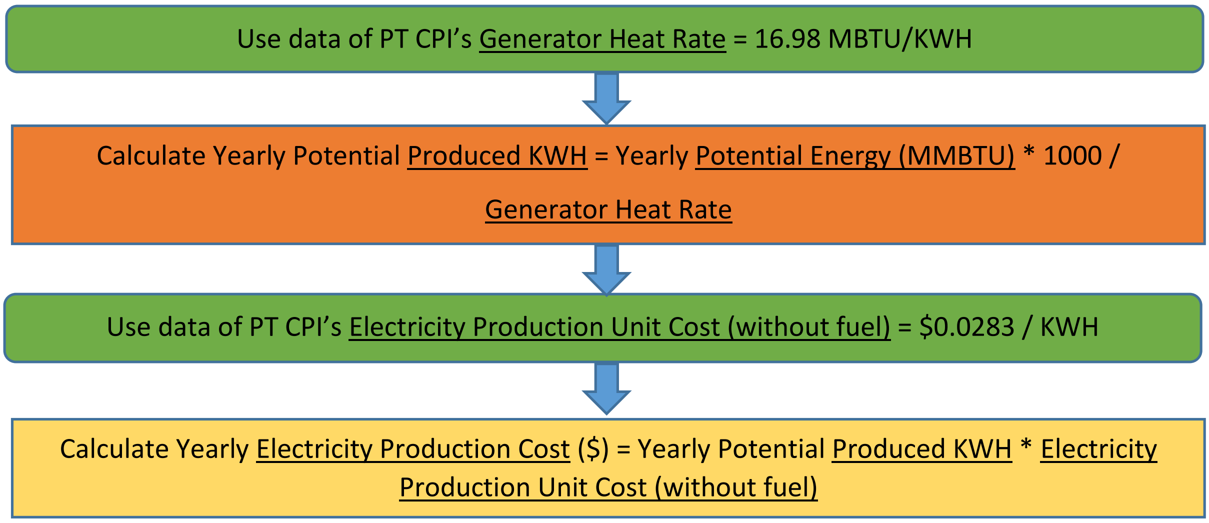

Figure 3.5. Calculation of Electricity Production Cost

Spending plan of electricity production cost is shown in table 3.11. below.

Table 3.11. Electricity Production Cost (2021-2031)

Description	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Yearly Potential Energy (MMBTU)	1,106,219	884,975	707,980	566,384	453,107	362,486	289,989	231,991	185,593	148,474	118,779
Yearly Potential Produced KWH	65,148,362	52,118,690	41,694,952	33,355,961	26,684,769	21,347,815	17,078,252	13,662,602	10,930,081	8,744,065	6,995,252
Yearly Electricty Production Cost ($)	1,843,699	1,474,959	1,179,967	943,974	755,179	604,143	483,315	386,652	309,321	247,457	197,966

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3.5. Cost Saving

This final project calculates cost-saving if the existing condition (purchasing gas from 3rd party) is replaced by executing new proposal (utilizing flare gas from Alfa and Beta station). Cost-saving calculation start since 2023 when Alfa & Beta flare gas recovery facilities starts to operate after complete construction stage in 2022. Present value (PV) of yearly cost spending plan until 2031 is calculated as a basis to calculate NPV. Figures 3.11 below shows cost spending of the existing condition that refers to the calculation in section 3.3 above.

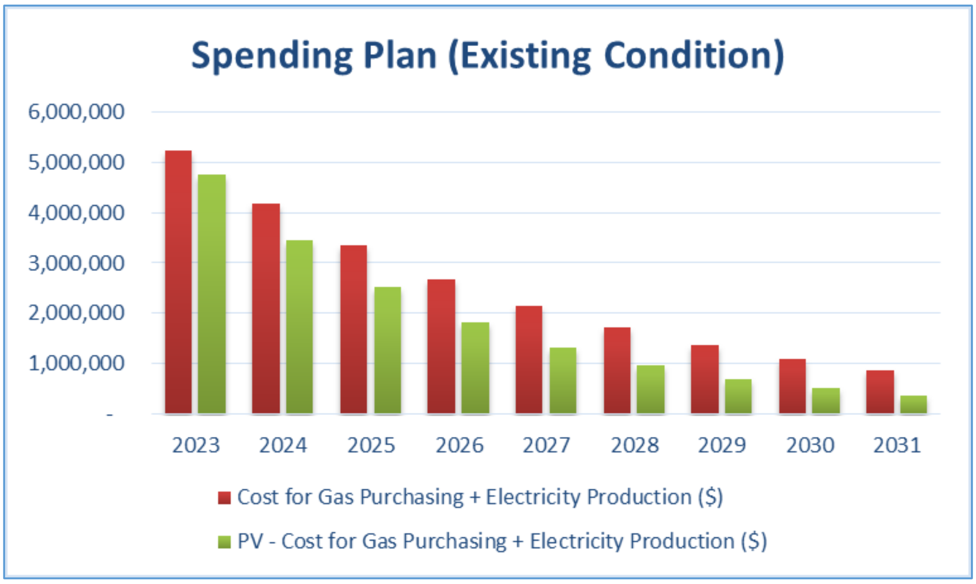

Figure 3.6. Spending Plan of Existing Condition

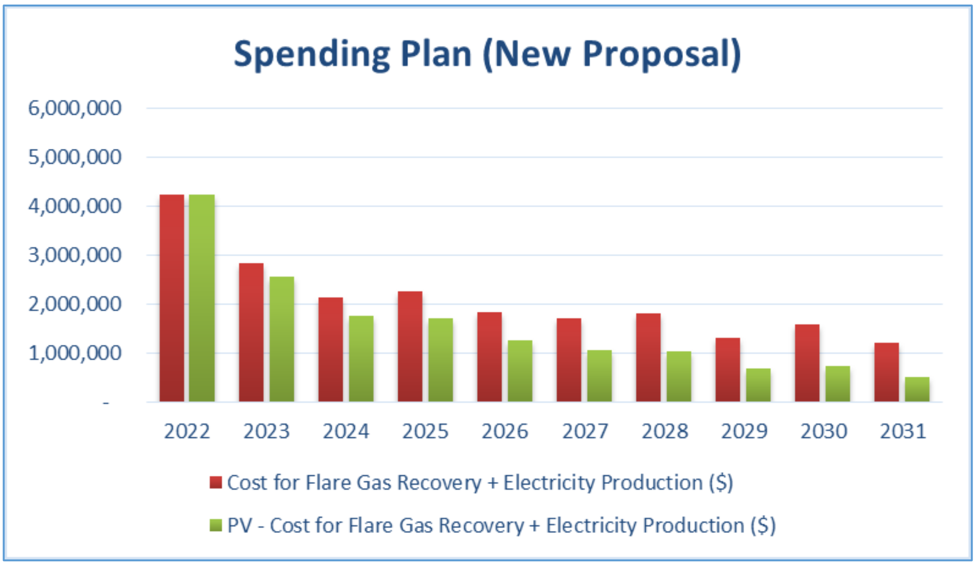

Figure 3.7. Spending Plan of Alfa & Beta Flare Gas Utilization

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Figure 3.12 above shows cost spending of new proposal that refer to calculation at section 3.4.1 and 3.4.2 above. Cost spending in 2022 is used for project capital expenditure of facilities installation. Cost spending from 2023 until 2031 is used for operating expenditure, both operation and maintenance activities. In general, cost spending decline from 2023 to 2031.

Generally, spending plan of new proposal during study period is lower than existing condition. With current condition, total OPEX (2023-2031) is $ 22,638,537. With new proposal, total investment (CAPEX) in this project is $2,102,800, with total OPEX (2023-2031) is $ 15,379,399.

3.6. Financial Analysis

3.6.1. NPV (Net Present Value)

PV (Present Value) of total required cost (capital & operating) to recover flare gas from Alfa and Beta station as fuel in the existing power plant is compared with PV of total required cost to purchase gas from the third party for fuel.

PV of total required cost with existing condition is $ 16,439,791. PV of total required cost with new proposal is $15,523,405. From comparison of those PV, by executing new proposal, there is cost-saving = $916,386. It can be concluded that, new proposal of Alfa & Beta flare gas utilization is economically feasible to be implemented.

3.6.2. Payback Period and IRR (Internal Rate of Return)

Net cash flow or cost-saving between existing condition (purchase gas from the third party) and new proposal (Alfa & Beta flare gas utilization) is shown in table 3.12 below. It also includes one-time investment cost in 2022. Data in table 3.12 is used to calculate payback period and IRR (Internal Rate of Return).

Table 3.12. Operation Cost Spending Comparison (2022-2031)

Description	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Capital Investment Cost	-4,236,910									
Cost Saving		2,408,362	2,047,433	1,085,162	853,861	439,178	-102,553	52,412	-489,950	-329,760

As shown in table 3.14, initial investment from this project is -$4,236,910 in 2022. In 2023, there is cost saving $2,408,362, and in 2024, there is cost saving 2,047,433. It means that investment payback is achieved less than 2 year.

$$Payback\ Period = 642\ days = 1{,}8\ years$$

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Payback period of this project is achieved in 642 days or 1,8 years. This payback period is a good result because the investment will reach break-even point less than two year, very long before the end of contract life. Calculated IRR (Internal Rate of Return) is 23%. It means that when this percentage applied as a discount rate, cost-saving PV will be zero.

3.7. Sensitivity Analysis

Sensitivity analysis is conducted to identify the impact of specific parameters on the results of economic analysis. From the sensitivity analysis results, parameters that most affecting project saving could be identified.

There are three parameters or variables as input in this analysis. Those are gas production (% decline rate), gas price ($/MMBTU), and capital expenditure ($). Sensitivity analysis is performed by changing the evaluated parameter to the upper or lower assumption, while other parameters remain on the base assumption. Detail variable information in 3 scenarios is shown in table 3.13 below. Increase of decline rate assumption will decrease gas production forecast over the operation period. The low scenario of gas production forecast is high decline rate assumption (30%), and the high scenario is low decline rate assumption (10%). The low scenario of gas price is 80% of the base case, while the high scenario is 120% of the base case. The low scenario of capital expenditure is 120% of the base case, while the high scenario is 80% of the base case.

Table 3.13. Sensitivity Analysis Input Scenario

Parameter	Scenario		
	Low	Base	High
Gas Production (% Decline Rate)	30%	20%	10%
Gas Price ($/MMBTU)	4.58	5.72	6.87
Capital Expenditure ($)	5,084,292	4,236,910	3,389,528

This sensitivity analysis assess impact of parameter change above on cost saving as shown in table 3.14 below.

Table 3.14. Sensitivity Analysis Output

	Saving ($)		
	Low	High	Base
Capital Expenditure	$ 69,004	$ 1,763,768	$ 916,386
Gas Price	$ (1,620,802)	$ 3,475,830	
Gas Production	$ (3,895,626)	$ 9,901,857	

The sensitivity analysis result is shown in the figure 3.8. below.

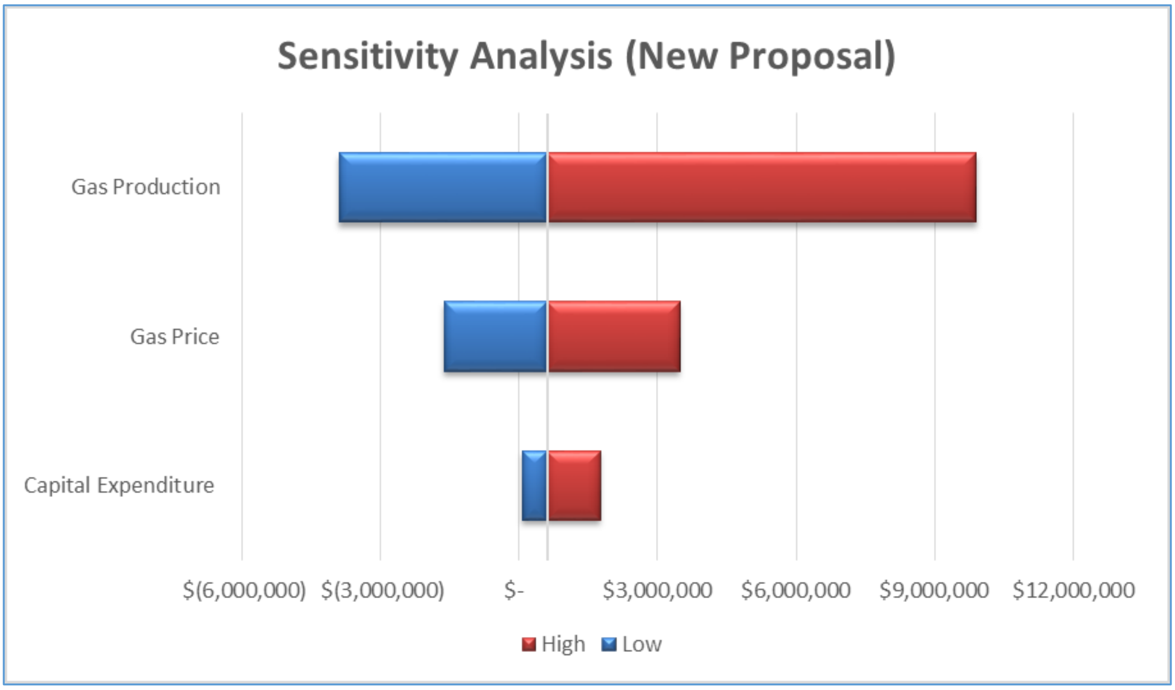

Figure 3.8. Sensitivity Analysis Result

Above table and chart indicates that in 4 scenarios, cost-saving is positive, and only in 2 scenarios (pessimistic scenario of gas production forecast [decline rate is 30%] and pessimistic scenario of gas price [$4.58/MMBTU]), cost-saving is negative. This project is more sensitive to the changes of gas production rate, continued by gas price, and then capital expenditure. To anticipate potential financial risk, it's recommended to validate flare gas production forecast and gas price forecast before project is decided to be executed.

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CHAPTER 4. CONCLUSION AND RECOMMENDATION

4.1. Conclusion

Based on result of this study, it can be concluded as follows:

1. Based on the calculation of economic feasibility, proposal of Alfa & Beta flare gas utilization as fuel gas of existing company's power plant is feasible to be implemented by the company with cost saving = $916,386; IRR = 23%; and payback period = 1,8 years.
2. Utilization of Alfa and Beta flare gas as fuel gas of power plant will increase the value of Alfa & Beta flare gas economically, as well as achieving government regulation, and protecting environment & public health.
3. Based on sensitivity analysis, gas production forecasts play the most critical role in influencing economic benefit. It is continued by variation of gas price and capital expenditure.

4.2. Recommendation

As result of study conclusion, we recommend as follows:

1. Execute Alfa & Beta Flare Gas Recovery project when Rokan block has been handed over from PT CPI to PT PTM in 2021.
2. In order to maximize economic benefit of Alfa & Beta Flare Gas Recovey project, recovered gas production should be maximized by conducting gas well exploration and exploitation, and also oil well drilling or workover in Alfa dan Beta field.

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APPENDIX

Appendix 1. CAPEX (Material Procurement) of Alfa & Beta Flare Gas Utilization Project

No	Category	Item Name	Qty	UOM	Unit Price	Total Price	Remarks
1	Main Equipment	Compressor 1	1	PC	0	-	Ex Libo SEL 17
2	Main Equipment	Compressor 2	1	PC	0	-	Ex Pinang GP
3	Main Equipment	Cooler, Gas/OIl	1	PC	0	-	Ex Libo SEL 17
4	Main Equipment	Cooler, Water	1	PC	0	-	Ex Pinang GP
5	Main Equipment	Cooler, Pre Cooler	1	PC	0	-	Ex Minas
6	Main Equipment	Cooler, After Cooler	1	PC	0	-	Ex Minas
7	Main Equipment	Vessel, Primary Scrubber	1	PC	0	-	Ex Bekasap GS
8	Main Equipment	Vessel, Inlet Scrubber	1	PC	0	-	Ex Libo SEL 17
9	Main Equipment	Vessel, Oil Separator	1	PC	0	-	Ex Libo SEL 17
10	Main Equipment	Vessel, Final Scrubber	1	PC	0	-	Ex Minas
11	Main Equipment	Vessel, Liquid Acummulator	1	PC	0	-	Ex Bekasap GS
12	Main Equipment	Pump, Condensate Pump 1	1	PC	0	-	Ex Libo SEL 17
13	Main Equipment	Pump, Condensate Pump 2	1	PC	0	-	Ex Shipping Pump from
14	Main Equipment	Pump, Water Pump 1	1	PC	0	-	Ex Water Pump Pinang GP
15	Main Equipment	Pump, Water Pump 2	1	PC	0	-	Ex Circulating Pump Kerang GS
16	Main Equipment	Pump, Lube Oil	1	PC	0	-	Ex Pinang GP
17	Main Equipment	Tank, Lube Oil	1	PC	0	-	Ex Pinang GP
18	Piping & Mechanical	Pipe 1"	8	JT	28.9	231.20	
19	Piping & Mechanical	Pipe 2"	20	JT	47	940.00	
20	Piping & Mechanical	Pipe 3"	15.5	JT	187.78	2,910.59	
21	Piping & Mechanical	Pipe 4"	11	JT	267.46	2,942.06	
22	Piping & Mechanical	Pipe 6"	26	JT	427.97	11,127.22	
23	Piping & Mechanical	Pipe 8"	6	JT	729.65	4,377.90	
24	Piping & Mechanical	Elbow 1", 90DEG	10	PC	3.75	37.50	
25	Piping & Mechanical	Elbow 2", 90DEG	22	PC	4.5	99.00	
26	Piping & Mechanical	Elbow 3", 90DEG	12	PC	13.5	162.00	
27	Piping & Mechanical	Elbow 4", 90DEG	14	PC	25.75	360.50	
28	Piping & Mechanical	Elbow 6", 90DEG	14	PC	57.2	800.80	
29	Piping & Mechanical	Elbow 8", 90DEG	4	PC	95.52	382.08	
30	Piping & Mechanical	Flange 2", #150	43	PC	18.35	789.05	
31	Piping & Mechanical	Flange 3", #150	31	PC	31.5	976.50	
32	Piping & Mechanical	Flange 4", #150	15	PC	48.8	732.00	
33	Piping & Mechanical	Flange 6", #150	32	PC	74.5	2,384.00	
34	Piping & Mechanical	Flange 8", #150	14	PC	90	1,260.00	
35	Piping & Mechanical	Flange 10", #150	8	PC	170	1,360.00	
36	Piping & Mechanical	Flange 12", #150	1	PC	245.12	245.12	
37	Piping & Mechanical	Blind Flange 2", #150	2	PC	14.5	29.00	
38	Piping & Mechanical	Blind Flange 3", #150	1	PC	22.5	22.50	
39	Piping & Mechanical	Blind Flange 4", #150	1	PC	32.24	32.24	

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40	Piping & Mechanical	Weldolet 2"x1/2"	14	PC	2.49	34.86	
41	Piping & Mechanical	Weldolet 6"x1/2"	7	PC	3.41	23.87	
42	Piping & Mechanical	Weldolet 8"x1/2"	5	PC	3.41	17.05	
43	Piping & Mechanical	Weldolet 10"x1/2"	11	PC	3.38	37.18	
44	Piping & Mechanical	Weldolet 4"x1"	1	PC	2.69	2.69	
45	Piping & Mechanical	Weldolet 10"x1"	2	PC	2.69	5.38	
46	Piping & Mechanical	Weldolet 4"x2"	1	PC	3.39	3.39	
47	Piping & Mechanical	Weldolet 6"x2"	3	PC	11.5	34.50	
48	Piping & Mechanical	Weldolet 8"x2"	1	PC	11.5	11.50	
49	Piping & Mechanical	Weldolet 6"x3"	1	PC	37.28	37.28	
50	Piping & Mechanical	Weldolet 8"x3"	1	PC	37.28	37.28	
51	Piping & Mechanical	Weldolet 10"x4"	1	PC	185	185.00	
52	Piping & Mechanical	Weldolet 10"x6"	2	PC	185	370.00	
53	Piping & Mechanical	Reducer 2"x1"	2	PC	2.75	5.50	
54	Piping & Mechanical	Reducer 3"x2"	1	PC	2.76	2.76	
55	Piping & Mechanical	Reducer 6"x3"	2	PC	8.76	17.52	
56	Piping & Mechanical	Reducer 6"x4"	3	PC	28.61	85.83	
57	Piping & Mechanical	Reducer 8"x4"	2	PC	20.62	41.24	
58	Piping & Mechanical	Reducer 8"x6"	3	PC	36.95	110.85	
59	Piping & Mechanical	Reducer 10"x6"	4	PC	101.98	407.92	
60	Piping & Mechanical	Reducer 12"x10"	1	PC	29.04	29.04	
61	Piping & Mechanical	Reducing Tee, 3"x3"x2"	1	PC	6.24	6.24	
62	Piping & Mechanical	Reducing Tee, 4"x4"x3"	1	PC	35.85	35.85	
63	Piping & Mechanical	Reducing Tee, 6"x6"x4"	3	PC	76	228.00	
64	Piping & Mechanical	Reducing Tee, 10"x10"x8"	1	PC	215.49	215.49	
65	Piping & Mechanical	Tee 1"	1	PC	6	6.00	
66	Piping & Mechanical	Tee 2"	7	PC	10.15	71.05	
67	Piping & Mechanical	Tee 3"	1	PC	10.84	10.84	
68	Piping & Mechanical	Tee 4"	2	PC	47.9	95.80	
69	Piping & Mechanical	Tee 6"	2	PC	73.95	147.90	
70	Piping & Mechanical	Tee 8"	2	PC	138.5	277.00	
71	Piping & Mechanical	Gate Valve 1/2", #150	25	PC	27	675.00	
72	Piping & Mechanical	Gate Valve 3/4", #150	2	PC	40	80.00	
73	Piping & Mechanical	Gate Valve 1", #150	8	PC	45.6	364.80	
74	Piping & Mechanical	Gate Valve 2", #150	25	PC	151	3,775.00	
75	Piping & Mechanical	Gate Valve 3", #150	10	PC	245.46	2,454.60	
76	Piping & Mechanical	Gate Valve 4", #150	5	PC	335	1,675.00	
77	Piping & Mechanical	Gate Valve 6", #150	10	PC	600.91	6,009.10	
78	Piping & Mechanical	Gate Valve 8", #150	5	PC	700	3,500.00	
79	Piping & Mechanical	Gate Valve 10", #150	3	PC	880.35	2,641.05	
80	Piping & Mechanical	Check Valve 2", #150	1	PC	115	115.00	
81	Piping & Mechanical	Check Valve 3", #150	3	PC	158.87	476.61	
82	Piping & Mechanical	Check Valve 4", #150	2	PC	251.21	502.42	
83	Piping & Mechanical	Check Valve 6", #150	2	PC	350	700.00	
84	Piping & Mechanical	Check Valve 8", #150	1	PC	450	450.00	

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85	Piping & Mechanical	Pressure Safety Valve (PSV) - 1	2	PC	3000	6,000.00	
86	Piping & Mechanical	Pressure Safety Valve (PSV) - 2	2	PC	3500	7,000.00	
87	Piping & Mechanical	Pressure Safety Valve (PSV) - 3	2	PC	4000	8,000.00	
88	Piping & Mechanical	Gasket 2", #150	43	PC	1.29	55.47	
89	Piping & Mechanical	Gasket 3", #150	31	PC	2.27	70.37	
90	Piping & Mechanical	Gasket 4", #150	15	PC	2.81	42.15	
91	Piping & Mechanical	Gasket 6", #150	32	PC	4.05	129.60	
92	Piping & Mechanical	Gasket 8", #150	14	PC	6	84.00	
93	Piping & Mechanical	Gasket 10", #150	8	PC	7.48	59.84	
94	Piping & Mechanical	Gasket 12", #150	1	PC	11.05	11.05	
95	Electrical	Transformer 1	1	PC	0	-	Ex Libo SEL 17
96	Electrical	Transformer 2	1	PC	0	-	Ex Pinang GP
97	Electrical	Main Breaker 1	1	PC	0	-	Ex Libo SEL 17
98	Electrical	MCC Compressor 1	1	PC	0	-	Ex Libo SEL 17
99	Electrical	Switchgear Compressor 2	1	PC	0	-	Ex Pinang GP
100	Electrical	MCC Compressor 2	1	PC	0	-	Ex Pinang GP
101	Electrical	MCC Gas Cooler, Compressor 1	1	PC	0	-	Ex Libo SEL 17
102	Electrical	MCC Water Cooler, Compressor 2	1	PC	0	-	Ex Pinang GP
103	Electrical	MCC Pre Cooler	1	PC	0	-	Ex Minas
104	Electrical	MCC After Cooler	1	PC	0	-	Ex Minas
105	Electrical	MCC Condensate Pump 1	1	PC	0	-	Ex Libo SEL 17
106	Electrical	MCC Condensate Pump 2	1	PC	0	-	Ex Waduk GS
107	Electrical	MCC Water Pump 1	1	PC	0	-	Ex Waduk GS
108	Electrical	MCC Water Pump 2	1	PC	0	-	Ex Waduk GS
109	Electrical	Load Center	1	PC	0	-	Ex Libo SEL 17
110	Electrical	3C #250 MCM, 600V	210	FT	20.53	4,311.30	
111	Electrical	3C #2 AWG, 600V	30	FT	5.93	177.90	
112	Electrical	3C #8 AWG, 600V	90	FT	2.55	229.50	
113	Electrical	3C #10 AWG, 600V	120	FT	2.93	351.60	
114	Electrical	3C #12 AWG, 600V	880	FT	1.41	1,240.80	
115	Electrical	3C #350 MCM, 5KV	180	FT	48	8,640.00	
116	Electrical	12C #14AWG	150	FT	2.46	369.00	
117	Electrical	Cable Terminator TMCX 6206	4	PC	124.86	499.44	
118	Electrical	Cable Terminator 1/2"	102	PC	23.32	2,378.64	
119	Electrical	Cable Terminator 3/4"	10	PC	51.71	517.10	
120	Electrical	Cable Terminator 350MCM	4	PC	100	400.00	
121	Electrical	Myer Hub 1/2"	51	PC	6.3	321.30	
122	Electrical	Myer Hub 3/4"	10	PC	6.92	69.20	
123	Instrument	Pressure Control Valve (PCV) - 1	2	PC	7500	15,000.00	
124	Instrument	Pressure Control Valve (PCV) - 2	1	PC	6000	6,000.00	
125	Instrument	Pressure Control Valve (PCV) - 3	1	PC	5000	5,000.00	
126	Instrument	Level Control Valve (LCV) - 1	1	PC	5000	5,000.00	
127	Instrument	Level Control Valve (LCV) - 2	1	PC	6000	6,000.00	
128	Instrument	Emergency Shutdown (ESD)	1	PC	7000	7,000.00	
129	Instrument	Pressure Transmitter	4	PC	2500	10,000.00	

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130	Instrument	Level Transmitter	1	PC	2500	2,500.00	
131	Instrument	Pressure Controller	1	PC	2000	2,000.00	
132	Instrument	Level Controller	1	PC	2000	2,000.00	
133	Instrument	Pressure Gauge 0-30 psi	4	PC	69.4	277.60	
134	Instrument	Pressure Gauge 0-100 psi	7	PC	67.1	469.70	
135	Instrument	Temperature Gauge	5	PC	255	1,275.00	
136	Instrument	Level Gauge	4	PC	2000	8,000.00	
137	Instrument	Level Switch	6	PC	553.64	3,321.84	
138	Instrument	Pressure Switch	7	PC	346.2	2,423.40	
139	Instrument	Temperature Switch	2	PC	800	1,600.00	
140	Instrument	Vibration Switch	4	PC	82.06	328.24	
141	Instrument	Oil Filter	1	PC	2500	2,500.00	
					TOTAL	**179,868.69**	

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Appendix 2. CAPEX (Construction) of Alfa & Beta Flare Gas Utilization Project

Description	Unit	Unit Rate Remote	Quantity	Total Price	
PIPING ON PLOT					
Install Steel Pipe Line					14,000
Install Steel Pipe Line <= 2	Meter	Rp 70,380	168	Rp 11,823,840	$ 844.56
Install Steel Pipe Line 3" 0.216	Meter	Rp 72,680	186	Rp 13,518,480	$ 965.61
Install Steel Pipe Line 4" 0.237	Meter	Rp 76,245	132	Rp 10,064,340	$ 718.88
Install Steel Pipe Line 6" 0.280	Meter	Rp 96,140	312	Rp 29,995,680	$ 2,142.55
Install Steel Pipe Line 8" 0.375	Meter	Rp 258,750	72	Rp 18,630,000	$ 1,330.71
Install Steel Elbow					
Install Steel Elbow <= 2" All Thickness	Each	Rp 187,680	32	Rp 6,005,760	$ 428.98
Install Steel Elbow 3" 0.216	Each	Rp 210,220	12	Rp 2,522,640	$ 180.19
Install Steel Elbow 4" 0.237	Each	Rp 1,407,600	14	Rp 19,706,400	$ 1,407.60
Install Steel Elbow 6" 0.280	Each	Rp 402,155	14	Rp 5,630,170	$ 402.16
Install Steel Elbow 8" 0.375	Each	Rp 728,985	4	Rp 2,915,940	$ 208.28
Install Blind Flange					
Install Blind Flange 2" Class 150	Each	Rp 160,770	2	Rp 321,540	$ 22.97
Install Blind Flange 3" Class 150	Each	Rp 196,880	1	Rp 196,880	$ 14.06
Install Blind Flange 4" Class 150	Each	Rp 240,695	1	Rp 240,695	$ 17.19
Install Reducer					
Install Reducer 2"	Each	Rp 415,150	2	Rp 830,300	$ 59.31
Install Reducer 3"	Each	Rp 442,865	1	Rp 442,865	$ 31.63
Install Reducer 6"	Each	Rp 695,635	5	Rp 3,478,175	$ 248.44
Install Reducer 8"	Each	Rp 900,450	5	Rp 4,502,250	$ 321.59
Install Reducer 10"	Each	Rp 1,092,845	4	Rp 4,371,380	$ 312.24
Install Reducer 12"	Each	Rp 1,508,915	1	Rp 1,508,915	$ 107.78
Install Weldolet					
Install Threadolet/Sockolet/Weldolet <= 2" All Thickness	Each	Rp 175,950	45	Rp 7,917,750	$ 565.55
Install Threadolet/Sockolet/Weldolet 3" All Thickness	Each	Rp 188,600	2	Rp 377,200	$ 26.94
Install Threadolet/Sockolet/Weldolet 4" All Thickness	Each	Rp 249,320	2	Rp 498,640	$ 35.62
Install Threadolet/Sockolet/Weldolet 6" All Thickness	Each	Rp 307,395	2	Rp 614,790	$ 43.91
Install Tee/Tee Reducer					
Install Tee/Tee Reducer 2" 0.154	Each	Rp 246,330	8	Rp 1,970,640	$ 140.76
Install Tee/Tee Reducer 3"	Each	Rp 265,995	2	Rp 531,990	$ 38.00
Install Tee/Tee Reducer 4"	Each	Rp 362,135	3	Rp 1,086,405	$ 77.60
Install Tee/Tee Reducer 6" 0.280	Each	Rp 536,820	5	Rp 2,684,100	$ 191.72
Install Tee/Tee Reducer 8"	Each	Rp 730,825	2	Rp 1,461,650	$ 104.40
Install Tee/Tee Reducer 10"	Each	Rp 920,920	1	Rp 920,920	$ 65.78
Install Valve/Control Valve					
Install Valve/Control Valve <= 2" All Class	Each	Rp 207,000	63	Rp 13,041,000	$ 931.50

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Install Valve/Control Valve 3" Class 150	Each	Rp 222,870	15	Rp 3,343,050	$ 238.79
Install Valve/Control Valve 4" Class 150	Each	Rp 258,060	9	Rp 2,322,540	$ 165.90
Install Valve/Control Valve 6" Class 150	Each	Rp 321,885	12	Rp 3,862,620	$ 275.90
Install Valve/Control Valve 8" Class 150	Each	Rp 401,350	6	Rp 2,408,100	$ 172.01
Install Valve/Control Valve 10" Class 150	Each	Rp 538,890	3	Rp 1,616,670	$ 115.48
Install Nipple					
Install Nipple <= 2" All Thickness	Each	Rp 317,400	20	Rp 6,348,000	$ 453.43
Supply and Apply Painting (without abrassive blasting)					
Supply and Apply Painting (without abrassive blasting) on existing installed Pipe Line (on-line/off-line) <= 2"	Meter	Rp 21,390	168	Rp 3,593,520	$ 256.68
Supply and Apply Painting (without abrassive blasting) on existing installed Pipe Line (on-line/off-line) 3"	Meter	Rp 31,510	186	Rp 5,860,860	$ 418.63
Supply and Apply Painting (without abrassive blasting) on existing installed Pipe Line (on-line/off-line) 4"	Meter	Rp 40,595	132	Rp 5,358,540	$ 382.75
Supply and Apply Painting (without abrassive blasting) on existing installed Pipe Line (on-line/off-line) 6"	Meter	Rp 58,650	312	Rp 18,298,800	$ 1,307.06
Supply and Apply Painting (without abrassive blasting) on existing installed Pipe Line (on-line/off-line) 8"	Meter	Rp 76,820	72	Rp 5,531,040	$ 395.07
Hot Tap Work					
Hot Tap Work 3" All Thickness & Class	Package	Rp 7,428,540	1	Rp 7,428,540	$ 530.61
Hydrostatic Test for holding time <= 12 hours					
Hydrostatic Test for holding time <= 12 hours Hydrostatic Test for cummulative length up to 100 Meter < 8"	Package	Rp 1,809,180	3	Rp 5,427,540	$ 387.68
Non Pressure tested Clossure Weld (Golden Weld)					
Non Pressure tested Clossure Weld (Golden Weld) 10"	Joint	Rp 3,407,220	1	Rp 3,407,220	$ 243.37
Install Steel Flange					
Install Flange <= 2" All Class	Each	Rp 187,680	43	Rp 8,070,240	$ 576.45
Install Flange 3" Class 150	Each	Rp 212,175	31	Rp 6,577,425	$ 469.82
Install Flange 4" Class 150	Each	Rp 985,320	15	Rp 14,779,800	$ 1,055.70
Install Flange 6" Class 150	Each	Rp 382,260	32	Rp 12,232,320	$ 873.74
Install Flange 8" Class 150	Each	Rp 604,670	14	Rp 8,465,380	$ 604.67
Install Flange 10" Class 150	Each	Rp 3,049,800	8	Rp 24,398,400	$ 1,742.74
Install Flange 12" Class 150	Each	Rp 3,632,275	1	Rp 3,632,275	$ 259.45
PIPING OFF PLOT					

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Supply and Apply Painting (without abrasive blasting)					
Supply and Apply Painting (without abrasive blasting) on existing installed Pipe Line (on-line/off-line) 10"	Meter	Rp 79,235	10000	Rp 792,350,000	$ 56,596.43
PIPE SUPPORT & PILLING					
Install Steel Pipe Pile					
Install Steel Pipe Pile 8"	Meter	Rp 115,345	120	Rp 13,841,400	$ 988.67
Fabricate and Install Pipe Support					
Fabricate and Install Pipe Support Type I 8"	Meter	Rp 414,000	40	Rp 16,560,000	$ 1,182.86
ELECTRICAL					
Install and Termination Cable					
Fabricate & Install Termination for <= 1000 Volt; 14 AWG - 10 AWG (size 2 - 5.75 mm2)	Each	Rp 109,480	102	Rp 11,166,960	$ 797.64
Fabricate & Install Termination for <= 1000 Volt; 8 AWG - 4 AWG (size 8.36 - 21.1 mm2)	Each	Rp 142,830	10	Rp 1,428,300	$ 102.02
Fabricate & Install Termination for <= 1000 Volt; 250 MCM - 350 MCM (127 - 177 mm2)	Each	Rp 386,285	8	Rp 3,090,280	$ 220.73
Install Power and Control Cable - (Above /Under Ground, Single Core/Multi Core Cable); Up to 600V, Overall Diameter 6 - 25 mm	Meter	Rp 44,505	381	Rp 16,956,405	$ 1,211.17
Install Power and Control Cable - (Above /Under Ground, Single Core/Multi Core Cable); Up to 600V, Overall Diameter Above 35 mm	Meter	Rp 31,740	117	Rp 3,713,580	$ 265.26
Install Electrical Equipment					$ -
Install Switchgear Panel, above 480V up to 4160V	Each	Rp 5,979,195	1	Rp 5,979,195	$ 427.09
Install MCC (Motor Control Center) 480 V MCC	Cu. Meter	Rp 2,150,500	9	Rp 19,354,500	$ 1,382.46
Install Electrical Panelboard/Load Center	Each	Rp 858,590	2	Rp 1,717,180	$ 122.66
Install Electrical Control Panel (Local Control Panels, Annunciator Panels, Supervisory Panel, Electrical Power center and other similar control panel) size up to 1 cubic meter	Cu. Meter	Rp 1,592,520	2	Rp 3,185,040	$ 227.50
Install Power Transformer; Distribution Class Pad Mounted <= 2,500 KVA	Each	Rp 10,350,000	2	Rp 20,700,000	$ 1,478.57
Install Electrical Apparatus					
Install Switchrack	Section	Rp 1,105,955	6	Rp 6,635,730	$ 473.98
Install Junction Box (all size & type)	Each	Rp 1,322,500	1	Rp 1,322,500	$ 94.46
Install Horn & Alarm Beacon	Each	Rp 323,150	1	Rp 323,150	$ 23.08
Install Lighting Fixture	Each	Rp 264,500	2	Rp 529,000	$ 37.79
Install Electrical Switch/Breaker					
Install Load Break / Disconnecting Switch	Each	Rp 2,128,420	1	Rp 2,128,420	$ 152.03
Install Grounding Systems					

Install Grounding Pipe	Meter	Rp 182,160	2	Rp 364,320	$ 26.02
Install Grounding Rod	Meter	Rp 103,385	1	Rp 103,385	$ 7.38
Install Grounding Bare Copper	Meter	Rp 165,255	40	Rp 6,610,200	$ 472.16
Install Grounding Systems - Bonding (Exothermic)	Each	Rp 677,120	15	Rp 10,156,800	$ 725.49
Install Electric Motor and Starter					$ -
Install Electric Motor - Low Voltage 120 V - 480 V; up to 10 HP	Each	Rp 1,286,965	5	Rp 6,434,825	$ 459.63
Install Electric Motor - Low Voltage 120 V - 480 V; 11-50 HP	Each	Rp 2,517,925	3	Rp 7,553,775	$ 539.56
Install Electric Motor - Low Voltage 120 V - 480 V; 101-500 HP	Each	Rp 4,476,375	1	Rp 4,476,375	$ 319.74
Install Cable Connector and Accessories					
Install Myer Hub or equivalent; Any size	Each	Rp 30,935	61	Rp 1,887,035	$ 134.79
Install Bus Duct					$ -
Install Bus duct <= 1000V	Meter	Rp 497,260	3	Rp 1,491,780	$ 106.56
Dismantle Electrical Work					
Dismantle Switchgear Panel, above 480V up to 4160V	Each	Rp 3,967,500	1	Rp 3,967,500	$ 283.39
Dismantle Electrical 480 V MCC 3-500 HP	Each	Rp 1,594,360	9	Rp 14,349,240	$ 1,024.95
Dismantle Electrical Panelboard/Load Center	Each	Rp 618,585	2	Rp 1,237,170	$ 88.37
Dismantle Electrical Control Panel (Local Control Panels, Annunciator Panels, Supervisory Panel, Electrical Power center and other similar control panel) size up to 1 cubic meter	Cu. Meter	Rp 2,108,410	1	Rp 2,108,410	$ 150.60
Dismantle Electrical Switchrack	Section	Rp 789,935	6	Rp 4,739,610	$ 338.54
Dismantle junction box	Each	Rp 674,475	1	Rp 674,475	$ 48.18
Dismantle Electrical Load Break / Disconnect Switch	Each	Rp 1,532,490	1	Rp 1,532,490	$ 109.46
Dismantle Electric Motor - Low Voltage 120 V - 480 V; 1/4-10HP	Each	Rp 600,875	5	Rp 3,004,375	$ 214.60
Dismantle Electric Motor - Low Voltage 120 V - 480 V; 10-50 HP	Each	Rp 1,459,465	3	Rp 4,378,395	$ 312.74
Dismantle Electric Motor - Low Voltage 120 V - 480 V; 100-500 HP	Each	Rp 4,959,375	1	Rp 4,959,375	$ 354.24
Dismantle Power Transformer; Distribution Class Pad Mounted <= 2,500 KVA	Each	Rp 3,059,920	2	Rp 6,119,840	$ 437.13
INSTRUMENTATION					
Install Instrument Equipment					
Install Instrument - Pressure Gauge	Each	Rp 104,650	11	Rp 1,151,150	$ 82.23
Install Instrument - Pressure Switch	Each	Rp 468,855	7	Rp 3,281,985	$ 234.43
Install Instrument - Transmitter	Each	Rp 643,425	4	Rp 2,573,700	$ 183.84
Install Instrument - Temperature Gauge	Each	Rp 104,650	5	Rp 523,250	$ 37.38
Install Instrument - RTD/Thermocouple	Each	Rp 174,570	5	Rp 872,850	$ 62.35
Install Instrument - Level Gauge	Feet	Rp 69,805	4	Rp 279,220	$ 19.94

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	Install Instrument - Level Switch	Each	Rp	305,785	6	Rp	1,834,710	$	131.05
	Install Instrument - Accessories & Connections (pneumatic) of a Control Valve	Each	Rp	514,050	1	Rp	514,050	$	36.72
	Install Instrument - Vibration Switch	Each	Rp	284,395	4	Rp	1,137,580	$	81.26
	Install Instrument - Control Station (S/S, H-O-A, Indicating Lamp)	Each	Rp	921,840	10	Rp	9,218,400	$	658.46
	Install PLC (include Dismantle, Installation, Programming, Rewiring)	LOT	Rp345,000,000		1	Rp	345,000,000	$	24,642.86
Install Instrument Line									
	Install Instrument Line - Tubing; < 2", include connector, accessories, etc	Meter	Rp	49,105	10	Rp	491,050	$	35.08
EARTHWORK & CIVIL									
Earthworks									
	Earthworks Compaction	Sq. Meter	Rp	4,600	1000	Rp	4,600,000	$	328.57
	Manual Excavation	Sq. Meter	Rp	316,480	200	Rp	63,296,000	$	4,521.14
Concrete Works for On Plot									
	Supply and Install Sand Bedding	Cu. Meter	Rp	428,260	20	Rp	8,565,200	$	611.80
	Supply and Install Lean Concrete	Cu. Meter	Rp	2,836,360	20	Rp	56,727,200	$	4,051.94
	Supply and Pouring Concrete - K225	Cu. Meter	Rp	3,020,590	50	Rp	151,029,500	$	10,787.82
	Concrete Formwork	Sq. Meter	Rp	2,041,020	145	Rp	295,947,900	$	21,139.14
	Supply and Install Anchor Bolt	Kilogram	Rp	157,435	100	Rp	15,743,500	$	1,124.54
	Supply, Fabricate & Install Concrete Cable Marker	Each	Rp	52,440	20	Rp	1,048,800	$	74.91
	Supply, Fabricate & Install Concrete Cable Tile	Each	Rp	20,240	100	Rp	2,024,000	$	144.57
	Supply and Install Grouting Non Shrinkage	Cu. Meter	Rp	17,687,920	1	Rp	17,687,920	$	1,263.42
Structural Steel Works									
	Supply, Fabricate & Install Structural Steel	Kilogram	Rp	42,780	1000	Rp	42,780,000	$	3,055.71
MECHANICAL									
Install Mechanical Equipment									
	Install Vessel (Separator, Softener, Scrubber, Pig Facility, Waterseal Drum, Cooling Drum, etc) Volume < 100 bbls	Bbls	Rp	293,250	300	Rp	87,975,000	$	6,283.93
	Install Centrifugal Pump Capacity <= 50 gpm	Unit	Rp	9,005,190	9	Rp	81,046,710	$	5,789.05
	Install Skidded Packaged Equipment	Kilogram	Rp	21,965	1000	Rp	21,965,000	$	1,568.93
Dismantle Work									
	Dismantle Vessel (Separator, Softener, Scrubber, Pig Facility, Waterseal Drum, Cooling Drum, etc) Volume < 100 bbls	Bbls	Rp	274,850	300	Rp	82,455,000	$	5,889.64
	Dismantle Centrifugal Pump Capacity < 50 gpm	Unit	Rp	10,160,825	9	Rp	91,447,425	$	6,531.96
	Dismantle Skidded Packaged Equipment	Kilogram	Rp	28,060	1000	Rp	28,060,000	$	2,004.29
SUPPORT & TESTING									
Scaffolding Work									
	Supply and Install Steel Pipe/Tubular Tower Scaffolding (<100 Cu.Meter)	Cu.Meter.Day	Rp	80,960	375	Rp	30,360,000	$	2,168.57

OTHER					
Equipment Repair					
Equipment Repair	LOT	Rp 50,000,000	6	Rp 300,000,000	$ 21,428.57
TOTAL				**Rp 3,077,542,330**	**$ 219,824.45**

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Appendix 3. OPEX (Monthly Operation & Maintenance Contract) – Alfa GS

No	Description	Est Qty	Unit	Price (IDR)		
				Material	Labor	Total
1	Operator	120	Mday		650,000	78,000,000
2	Maintenance Technician	4	Mday		3,000,000	12,000,000
3	Electrical or Mechanical Specialist	2	Mday		3,500,000	7,000,000
4	Lube Oil	4	drum	8,000,000		32,000,000
5	Spare Parts of Gas Compressors	1	lot	35,800,000		35,800,000
6	Spare Part of Peripheral Equipments	1	lot	20,000,000		20,000,000
7	Predictive Maintenance	1	lot	25,000,000		25,000,000
	TOTAL					209,800,000

Yearly cost = 12 * 209,800,000 / 14,400 = $174,833

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Appendix 4. OPEX (Monthly Operation & Maintenance Contract) – Beta GS

No	Description	Est Qty	Unit	Price (IDR)		
				Material	Labor	Total
1	Operator	120	Mday		650,000	78,000,000
2	Maintenance Technician	4	Mday		3,000,000	12,000,000
3	Electrical or Mechanical Specialist	2	Mday		3,500,000	7,000,000
4	Lube Oil GC 01	3	drum	8,000,000		24,000,000
5	Lube Oil GC 02	0.25	drum	85,000,000		21,250,000
6	Spare Part	1	lot	32,500,000		32,500,000
	TOTAL					174,750,000

Yearly cost = 12 * 174,750,000 / 14,400 = $145,625

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Koleksi digital milik UPT Perpustakaan ITB untuk keperluan pendidikan dan penelitian

Appendix 5. OPEX (Overhaul) – Alfa GS

Manpower				
Certified Technician	1	Lot	162,000,000	162,000,000
Technician	1	Lot	90,000,000	90,000,000
Material				
OH Material Engine	1	Lot	2,056,379,951	2,056,379,951
OH Material Compressor	1	Lot	1,159,336,762	1,159,336,762
Total				**3,467,716,713**

OH Material Engine :

	GASKET SET			-	-	
1e.3.1	BASIC GSKT SET PN G-900-1025	1	PC	32,964,489	-	32,964,489
1e.3.2	TOP OH GSKT ST PN G-979-266	1	PC	22,680,995	-	22,680,995
1e.3.3	HEAD ASM., CYL (SERVICE) PN DA204702R	12	PC	52,704,348	-	632,452,176
1e.3.4	BUSHING, ROCKER ARM PN 167480G	48	PC	103,076	-	4,947,648
1e.3.5	BUSHING, ROCKER ARM PN 167480H	12	PC	179,832	-	2,157,984
1e.3.6	SCREW R A ADJ ASM PN A153889C	48	PC	516,641	-	24,798,768
1e.3.7	NUT,HEX JAM,.625-18 UNF PN 21227	48	PC	4,098	-	196,704
1e.3.8	SCREW,HYD LIFTER ADJ PN 169080W	24	PC	238,147	-	5,715,528
1e.3.9	INSERT PN 169669A	12	PC	36,408	-	436,896
1e.3.10	RETAINER, BALL PN 169690B	12	PC	177,940	-	2,135,280
1e.3.11	BALL, TAPPET PN 168998F	12	PC	188,815	-	2,265,780
1e.3.12	O RING,.25X.38X.06,VITON PN 166580M	48	PC	4,098	-	196,704
	PUSH ROD			-	-	
1e.3.13	ROD, PUSH, ASM. PN A153754U	24	PC	1,772,940	-	42,550,560
	OIL COOLER			-	-	
1e.3.14	VALVE PRESS REG ASM PN G169871	1	PC	12,431,701	-	12,431,701
1e.3.15	CONN,MALE,CHI,24X24 PN 164922U	6	PC	2,438,837	-	14,633,022
1e.3.16	STRAINER,OIL PN 153462P	1	PC	1,760,332	-	1,760,332
1e.3.17	NUTESTOP,.50-20 PN 157635	1	PC	14,500	-	14,500
1e.3.18	WASHER,NYL 1.78X2.25X.03 PN 116861B	1	PC	56,266	-	56,266

	PISTON, LINER & CONNECTING RODS			-	-	
1e.3.19	SNGL SLVE KIT PN G-932-182	12	PC	35,425,234	-	425,102,808
1e.3.20	BEARING,CONN ROD PN A205210	12	PC	3,178,179	-	38,138,148
1e.3.21	NBL BUSHING,PISTON PIN PN 47108F	24	PC	526,886	-	12,645,264
1e.3.22	NBL CAPSCREW, CONN. ROD PN 28587D	48	PC	572,120	-	27,461,760
	CRANKCASE & CRANKSHAFT			-	-	
1e.3.23	VHP 12, MAINS STD.T-DRILLED PN G-918-344	1	PC	29,395,440	-	29,395,440
1e.3.24	STRIP, TIMING FLYWHL PN 211638B	2	PC	97,717	-	195,434
1e.3.25	WASHER, MED LOCK .50 PN 21054	4	PC	2,049	-	8,196
1e.3.26	HXHDSCR,.50-13X 2.00 PN 21435	4	PC	8,038	-	32,152
1e.3.27	NBL STUD MAIN BRG. CAP. PN 168514B	28	PC	750,060	-	21,001,680
1e.3.28	NUT,ELASTI STP ,.75-16 PN 28245	28	PC	77,386	-	2,166,808
1e.3.29	NUTCYLHD, .75-16X.81 PN 118091B	1	PC	893,168	-	893,168
1e.3.30	WASHER..781X1.359X.134 PN B2239	1	PC	36,723	-	36,723
1e.3.31	WASHER,.76X2.25X.38 PN 153751A	1	PC	741,391	-	741,391
1e.3.32	BUSHING BRONZE PN 145029A	1	PC	621,766	-	621,766
1e.3.33	SPINDLE,O.P. IDLER PN 153063E	1	PC	6,537,609	-	6,537,609
1e.3.34	STRAINER,LUBE OIL,ASM PN A153707L	1	PC	19,790,136	-	19,790,136
	IGNITION			-	-	
1e.3.35	SPARK PLUG ASM PN 69512A	12	PC	743,755	-	8,925,060
	CAMSHAFT			-	-	
1e.3.36	CAM BSHG SET PN G-927-7	1	PC	8,969,196	-	8,969,196
1e.3.37	THRUST RING, CMSHFT FRNT BRG PN 153032	2	PC	1,525,967	-	3,051,934
1e.3.38	PIN,ROLL,.19X.50 LG PN 26730	2	PC	9,299	-	18,598
1e.3.39	GUIDE,TAPPET PN 153003C	24	PC	3,371,408	-	80,913,792
1e.3.40	VALVE TAPPET LUBE OIL UPDATE PN G-962-518	1	PC	146,125,799	-	146,125,799
1e.3.41	BEARING,BALL PN 78391	2	PC	1,658,516	-	3,317,032
1e.3.42	BEARING,BALL PN 78390	2	PC	229,478	-	458,956
	GOVERNOR LINKAGE			-	-	
1e.3.43	ROD ASM.GOVERNOR PN AA209615B	1	PC	8,088,005	-	8,088,005
	INTAKE MANIFOLD			-	-	
1e.3.44	VALVE, BUTTERFLY PN 119060K	2	PC	1,534,321	-	3,068,642

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1e.3.45	SHAFT REGULATING PN 156476C	2	PC	1,515,880	-	3,031,760
1e.3.46	SHAFT B V PN 168510	2	PC	886,707	-	1,773,414
1e.3.47	LEVER,CROSS SHAFT PN 153267C	1	PC	1,944,261	-	1,944,261
1e.3.48	BUSHING,.62NOMX .5LG PN 168290B	4	PC	35,304	-	141,216
1e.3.49	DISC UNIV JOINT PN 153272A	4	PC	238,147	-	952,588
1e.3.50	SPIDER, UNIVERSAL JOINT (.501" REAM) PN 153271B	2	PC	1,182,380	-	2,364,760
1e.3.51	COVER CROSS SHAFT PN 168899	4	PC	208,674	-	834,696
1e.3.52	SPIDER UNIV JOINT (.635" REAM) PN 153271	6	PC	1,173,712	-	7,042,272
	EXHAUST MANIFOLD			-	-	
1e.3.53	PILOT EXH MANIFOLD PN 168055	8	PC	1,386,957	-	11,095,656
1e.3.54	PILOT EXH MANIFOLD PN 168055A	2	PC	1,386,957	-	2,773,914
1e.3.55	STRIP,INSULATION PN 199942	8	PC	175,418	-	1,403,344
1e.3.56	STRIP,INSULATION PN 199942A	2	PC	194,962	-	389,924
1e.3.57	CLAMP,HOSE 5.12-6.0 PN 41236E	10	PC	43,342	-	433,420
	FILTER LUB OIL			-	-	
1e.3.58	ELEMENT FILT LUB OIL PN 168660B	7	PC	333,658	-	2,335,606
1e.3.59	O RING,17.0X17.5X.25,NITRILE PN 168922N	1	PC	221,913	-	221,913
	MAIN WATER PUMP			-	-	
1e.3.60	PUMP ASM., WATER PN AH200960D	1	PC	58,078,804	-	58,078,804
1e.3.61	BELT SET(2).88X69.75 PN A209617	1	PC	1,482,310	-	1,482,310
	AUXILIARY WATER PUMP			-	-	
1e.3.62	PUMP OC WATER PN 208540D	1	PC	36,268,440	-	36,268,440
1e.3.63	BELT SET PN A199868	1	PC	487,168	-	487,168

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	BREATHER			-	-	
1e.3.64	SEPARATOR, OIL PN 166420B	1	PC	1,742,679	-	1,742,679
1e.3.65	SEPARATOR, OIL PN 161541F	1	PC	9,222,788	-	9,222,788
1e.3.66	TUBE VAC. VA. ASM. PN A208898A	1	PC	5,963,913	-	5,963,913
	THERMOSTAT HOUSING			-	-	-
1e.3.67	THERMOSTAT,165 DEG. F. PN 211887A	1	PC	841,473	-	841,473
1e.3.68	THERMOSTAT,170 DEG. F. PN 211887B	5	PC	667,788	-	3,338,940
1e.3.69	CPLG,38 DRESS,3 PIPE PN 159991E	2	PC	1,296,804	-	2,593,608
	ELEMENT AIR FILTER			-	-	-
1e.3.70	ELEMENT, AIR FILTER PN 169180L	2	PC	1,085,293	-	2,170,586
1e.3.71	ELEMENT,PRE-CLEANER PN 208349	2	PC	250,283	-	500,566
1e.3.72	INDICATOR, RESTRICTION PN 153789	2	PC	325,304	-	650,608
1e.3.73	ELEMENT, RESTRICTOR PN 153790	2	PC	91,413	-	182,826
1e.3.74	CLAMP,HOSE 5.12-6.0 PN 41236E	4	PC	43,342	-	173,368
	OIL PUMP			-	-	-
1e.3.75	OIL PUMP CONVERSION KIT PN G-962-402	1	PC	123,835,516	-	123,835,516
	GAS REGULATOR			-	-	-
1e.3.76	REGULATOR GAS PN 214517	2	PC	45,716,609	-	91,433,218
	CARBURETOR			-	-	-
1e.3.77	CARBURETOR, R.H. PN 59018	1	PC	15,206,245	-	15,206,245
1e.3.78	CARBURETOR-LH PN 59018A	1	PC	15,367,321	-	15,367,321

OH Material Compressor :

1e.4.1	O-RING,VT, 6.395 O.D. X .210 PN A-0031	8	PC	139,484	-	1,115,872
1e.4.2	THUMB SCREW,NYLON,1/4-20 X 3/4 PN A-0145	8	PC	4,728	-	37,824
1e.4.3	PISTON RING, 13JG:A:R:H:J:RJ PN A-0156	2	PC	1,234,864	-	2,469,728
1e.4.4	O-RING,VT,12.395 O.D. X .210 PN A-0653	1	PC	757,940	-	757,940
1e.4.5	STL GASKET, 6.448 X 6.147 X30 PN A-0655	8	PC	130,815	-	1,046,520
1e.4.6	LOCKNUT, DRAKE 5/8-18 PN A-1369	8	PC	310,174	-	2,481,392
1e.4.7	SUC VLV,145R1 PN B-0266-G	4	PC	15,753,935	-	63,015,740
1e.4.8	DIS VLV,145R1 ,STD PN B-0267-G	4	PC	15,753,935	-	63,015,740
1e.4.9	GSKT,RND,16, X 1/64, 16 HOLES PN B-0369	1	PC	173,054	-	173,054
1e.4.10	RBLD KIT,PIST ROD PKG,2.000 PN B-0807-K	1	PC	7,574,201	-	7,574,201
1e.4.11	RBLD KIT,WIPER PKG,2.000,BD PN B-0809-K	1	PC	3,247,054	-	3,247,054
1e.4.12	PISTON COLLAR,JGH:E:ET PN B-0846	1	PC	2,935,304	-	2,935,304
1e.4.13	PISTON NUT,JGH:E:ET PN B-0847	1	PC	5,250,261	-	5,250,261
1e.4.14	CUP PT.SET-SCREW,5/16-24 X 1 PN FS0405DG	2	PC	9,772	-	19,544
1e.4.15	STAT-O-SEAL,VT,75DUR. 3/4 DIA PN FW0550ID	1	PC	221,913	-	221,913
	C18280 9-3/4H			-	-	-
1e.4.16	O-RING,VT, 4.645 O.D. X .210 PN A-0036	8	PC	80,380	-	643,040
1e.4.17	THUMB SCREW,NYLON,1/4-20 X 3/4 PN A-0145	8	PC	4,728	-	37,824
1e.4.18	STL GASKET,10.188 X 9.875 X 60 PN A-0483	1	PC	377,158	-	377,158
1e.4.19	STL GASKET, 4.640 X 4.406 X30 PN A-0484	8	PC	214,190	-	1,713,520
1e.4.20	CHK VLV,DBL BALL,SS,1/4TX1/8P PN A-0942	1	PC	1,172,293	-	1,172,293
1e.4.21	PISTON RING, 9-1/4H PN A-3411	3	PC	1,049,359	-	3,148,077
1e.4.22	GSKT,RND,16, X 1/64, 16 HOLES PN B-0369	1	PC	173,054	-	173,054
1e.4.23	RBLD KIT,WIPER PKG,2.000,BD PN B-0809-K	1	PC	3,247,054	-	3,247,054
1e.4.24	RBLD KIT,PIST ROD PKG,2.000 PN B-0810-K	1	PC	8,156,250	-	8,156,250
1e.4.25	PISTON COLLAR,JGH:E:ET PN B-0846	1	PC	2,935,304	-	2,935,304
1e.4.26	PISTON NUT,JGH:E:ET PN B-0847	1	PC	5,250,261	-	5,250,261
1e.4.27	SUC VLV,105RO PN B-0886-E	4	PC	10,502,571	-	42,010,284
1e.4.28	DIS VLV,105RO ,STD PN B-0887-F	4	PC	10,502,571	-	42,010,284
1e.4.29	CUP PT.SET-SCREW,5/16-24 X 1 PN FS0405DG	2	PC	9,772	-	19,544
1e.4.30	STAT-O-SEAL,VT,75DUR. 3/4 DIA PN FW0550ID	1	PC	221,913	-	221,913

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	C41283 19-1/2E			-	-	-
1e.4.31	THUMB SCREW,NYLON,1/4-20 X 3/4 PN A-0145	8	PC	4,728	-	37,824
1e.4.32	MACHINE SCREW PLUG,PL, 1/2-13 PN A-0256	1	PC	5,989	-	5,989
1e.4.33	O-RING,VT, 7.395 O.D. X .210 PN A-0715	12	PC	166,277	-	1,995,324
1e.4.34	STL GASKET, 7.310 X 6.965 X30 PN A-0716	12	PC	156,190	-	1,874,280
1e.4.35	O-RING,VT, 6.645 O.D. X .210 PN A-0724	4	PC	150,989	-	603,956
1e.4.36	O-RING,VT,19.375 O.D. X .210 PN A-0796	1	PC	570,701	-	570,701
1e.4.37	THUMB SCREW,NYLON,1/4-20 X 1 PN A-2695	8	PC	4,728	-	37,824
1e.4.38	RIDER RING,19-1/2R:H:E:ET PN A-3437	1	PC	9,031,924	-	9,031,924
1e.4.39	CHK. VLV.KIT,DBL,RETRO A-18496 PN A-3780	2	PC	2,373,114	-	4,746,228
1e.4.40	GSKT,RND,16, X 1/64, 16 HOLES PN B-0369	1	PC	173,054	-	173,054
1e.4.41	PISTON COLLAR,JGH:E:ET PN B-0846	1	PC	2,935,304	-	2,935,304
1e.4.42	PISTON NUT,JGH:E:ET PN B-0847	1	PC	5,250,261	-	5,250,261
1e.4.43	SUC VLV,168CT ,NYX PN B-1504-T	6	PC	23,864,321	-	143,185,926
1e.4.44	RBLD KIT,PIST ROD PKG,BTS,2.000 PN B-1582-K	1	PC	7,532,435	-	7,532,435
1e.4.45	RBLD KIT,WIPER PKG,2.0,WAT PN B-1687-K	1	PC	8,184,147	-	8,184,147
1e.4.46	DIS VLV,168CT ,MTX PN B-1724-N	6	PC	21,425,641	-	128,553,846
1e.4.47	CUP PT.SET-SCREW,5/16-24 X 1 PN FS0405DG	2	PC	9,772	-	19,544

	C41284 19-1/2E			-	-	-
1e.4.48	THUMB SCREW,NYLON,1/4-20 X 3/4 PN A-0145	8	PC	4,728	-	37,824
1e.4.49	MACHINE SCREW PLUG,PL, 1/2-13 PN A-0256	1	PC	5,989	-	5,989
1e.4.50	O-RING,VT, 7.395 O.D. X .210 PN A-0715	12	PC	166,277	-	1,995,324
1e.4.51	STL GASKET, 7.310 X 6.965 X30 PN A-0716	12	PC	156,190	-	1,874,280
1e.4.52	O-RING,VT, 6.645 O.D. X .210 PN A-0724	4	PC	150,989	-	603,956
1e.4.53	O-RING,VT,19.375 O.D. X .210 PN A-0796	1	PC	570,701	-	570,701
1e.4.54	THUMB SCREW,NYLON,1/4-20 X 1 PN A-2695	8	PC	4,728	-	37,824
1e.4.55	RIDER RING,19-1/2R:H:E:ET PN A-3437	1	PC	9,031,924	-	9,031,924
1e.4.56	CHK.VLV.KIT,DBL,RETRO A-18496 PN A-3780	2	PC	2,373,114	-	4,746,228
1e.4.57	GSKT,RND,16, X 1/64, 16 HOLES PN B-0369	1	PC	173,054	-	173,054
1e.4.58	PISTON COLLAR,JGH:E:ET PN B-0846	1	PC	2,935,304	-	2,935,304
1e.4.59	PISTON NUT,JGH:E:ET PN B-0847	1	PC	5,250,261	-	5,250,261
1e.4.60	SUC VLV,168CT ,NYX PN B-1504-T	6	PC	23,864,321	-	143,185,926
1e.4.61	RBLD KIT,PIST ROD PKG,BTS,2.000 PN B-1582-K	1	PC	7,532,435	-	7,532,435
1e.4.62	RBLD KIT,WIPER PKG,2.0,WAT PN B-1687-K	1	PC	8,184,147	-	8,184,147
1e.4.63	DIS VLV,168CT ,MTX PN B-1724-N	6	PC	21,425,641	-	128,553,846

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1e.4.64	CUP PT.SET-SCREW,5/16-24 X 1 PN FS0405DG	2	PC	9,772	-	19,544
	F07294 JGE/4			-	-	-
1e.4.65	O-RING,VT, 2.637 O.D. X .139 PN A-0010	1	PC	36,092	-	36,092
1e.4.66	O-RING,VT, 1.637 O.D. X .139 PN A-0030	1	PC	14,027	-	14,027
1e.4.67	BLOW-OUT ASSY,SPECIFY DISC. PN A-0080	2	PC	272,663	-	545,326
1e.4.68	MACHINE SCREW PLUG,PL, 7/16-14 PN A-0109	8	PC	14,973	-	119,784
1e.4.69	DUST SEAL,TFE,JGH:E:K:T,J/6 PN A-0245-B	1	PC	4,187,505	-	4,187,505
1e.4.70	CHK VLV,DBL BALL,SS,1/4TX1/8P PN A-0281	1	PC	1,172,293	-	1,172,293
1e.4.71	SPKT,41-1 X 15T, 0.500 BORE PN A-0523	1	PC	675,826	-	675,826
1e.4.72	SWING CHECK VALVE, 1/2NPT PN A-0564	1	PC	21,357,712	-	21,357,712
1e.4.73	LO FILTER ELEMENT,SPIN-ON PN A-0661	3	PC	236,886	-	710,658
1e.4.74	O-RING,VT, 2.756 O.D. X .103 PN A-0745	1	PC	19,071	-	19,071
1e.4.75	GSKT,ARL DBL LUBE BOX CVR,1/32 PN A-2349	1	PC	42,397	-	42,397
1e.4.76	HSG BRG FF LUBE BOX RH PN A-2361	1	PC	2,404,005	-	2,404,005
1e.4.77	O-RING,VT, 2.012 O.D. X .139 PN A-3507	2	PC	30,891	-	61,782
1e.4.78	O-RING,VT, 2.762 O.D. X .139 PN A-3508	2	PC	57,370	-	114,740
1e.4.79	O-RING,VT, 1.318 O.D. X .103 PN A-3512	12	PC	8,826	-	105,912
1e.4.80	12 PT, 1/2-20 X 10 G8 PN A-3869	4	PC	984,109	-	3,936,436
1e.4.81	SPKT,40-1 X 24T, 2.125 BORE PN A-3872	1	PC	1,810,136	-	1,810,136
1e.4.82	SPKT,40-1 X 28T, 0.502 BORE PN A-3873	1	PC	1,611,549	-	1,611,549
1e.4.83	GSKT,RND,12-13/16, X 1/32 PN A-3875	1	PC	452,967	-	452,967
1e.4.84	CHAIN,40-1 X 114 PN A-3884	1	PC	620,978	-	620,978

1e.4.85	SHAFT OIL SEAL 1/2S PN A-3911	1	PC	146,576	-	146,576
1e.4.86	SPKT,40-1 X 21T, 0.751 BORE PN A-3918	1	PC	1,096,957	-	1,096,957
1e.4.87	SIGHT GLASS,2-1/4"LENS PN A-5374	1	PC	150,359	-	150,359
1e.4.88	GSKT,RND,2-1/4,X 1/32,INNER PN A-5375	1	PC	135,701	-	135,701
1e.4.89	GSKT,RND,2-1/4 X 1/8,OUTER PN A-5376	1	PC	173,054	-	173,054
1e.4.90	PACKING KIT, PRIMING PUMP PN B-0425-K	1	PC	258,636	-	258,636
1e.4.91	SLEEVE BRG,H/S,MAIN,H:E:K:T PN B-0770	16	PC	3,346,348	-	53,541,568
1e.4.92	BUSHING,BZ,ROD,H:E:K:T PN B-0772	4	PC	7,549,299	-	30,197,196
1e.4.93	CROSSHEAD PIN,JGH:E:K:T PN B-0773	4	PC	11,683,533	-	46,734,132
1e.4.94	THRUST PLATE,BZ,JGH:E:K:T PN B-0776	2	PC	10,435,587	-	20,871,174
1e.4.95	GSKT,SQ,5-15/16X5-15/16X1/32 PN B-0779	1	PC	151,620	-	151,620
1e.4.96	BUSHING,BZ,XHD,EKT ELP PN B-0787	12	PC	3,834,147	-	46,009,764
1e.4.97	GSKT,RET,15-5/16X10-13/16X1/32 PN B-0832	8	PC	452,967	-	3,623,736
1e.4.98	GSKT,RET,10-13/16X7-3/4X1/32 PN B-0834	8	PC	264,467	-	2,115,736
1e.4.99	GSKT,NST,17-3/4 X15-7/8X1/64 PN B-0835	4	PC	399,223	-	1,596,892
1e.4.100	GSKT,RET,23-1/2X20-5/16X1/32 PN B-0844	2	PC	847,147	-	1,694,294
1e.4.101	GSKT,RET,77-5/8 X20-3/8X1/32 PN C-0645	1	PC	3,602,935	-	3,602,935
1e.4.102	HEX HD CAP, 1/2-20 X 3-1/4 G5 PN FC0107GP	1	PC	28,685	-	28,685
1e.4.103	WOODRUFF KEY,#204,1/2D X 1/16 PN FK0360AA	1	PC	4,728	-	4,728
1e.4.104	SQR KEY,3/16 X 1"LG PN FK0361EG	1	PC	26,163	-	26,163
1e.4.105	NYLON INSERT LOCKNUT, 1/2-20 PN FN0461GA	4	PC	14,342	-	57,368
1e.4.106	DOWEL PIN, 1/4 X 3/4 +.0002 PN FP0500FE	1	PC	11,033	-	11,033

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1e.4.107	DOWEL PIN,5/16 X 3/4 +.0002 PN FP0500GE	1	PC	12,766	-	12,766
1e.4.108	DOWEL PIN,5/16 X 1" +.0002 PN FP0500GG	4	PC	14,342	-	57,368
1e.4.109	ROLL PIN, 1/8 X 3/4 PN FP0505CE	1	PC	1,261	-	1,261
1e.4.110	THD.TAPER PIN,#4 X 1"LG PN FP0512EF	2	PC	107,332	-	214,664
1e.4.111	THD.TAPER PIN,#5 X 1-1/2LG PN FP0512FH	2	PC	136,647	-	273,294
1e.4.112	THD.TAPER PIN,#5 X 2"LG PN FP0512FJ	2	PC	148,152	-	296,304
1e.4.113	CUP PT.S-SCRW,NY,5/16-24 X 1 PN FS0455DG	2	PC	73,130	-	146,260
1e.4.114	CUP PT.S-SCRW,NY,5/16-24X1-1/4 PN FS0455DH	1	PC	74,391	-	74,391
1e.4.115	STAT-O-SEAL, 1/2 DIA., BLACK PN FW0550GA	1	PC	16,864	-	16,864
1e.4.116	STAT-O-SEAL, 3/4 DIA., NITRILE PN FW0550IA	8	PC	27,424	-	219,392
	U06965			-	-	-
1e.4.117	MACHINE SCREW PLUG,PL, 1/2-13 PN A-0256	1	PC	5,989	-	5,989
1e.4.118	O-RING,VT,13.395 O.D. X .210 PN A-0469	1	PC	411,674	-	411,674
1e.4.119	V PACKING, UNL PN A-0639	1	PC	375,266	-	375,266
1e.4.120	BELLOWS, UNL.THREAD PROTECTOR PN A-0641	1	PC	1,542,832	-	1,542,832
1e.4.121	STL GASKET,13.938 X 13.625 X60 PN A-0654	1	PC	541,701	-	541,701
1e.4.122	UNL.PISTON RING,11-1/4 O.D. PN A-0700	1	PC	3,506,478	-	3,506,478
	U06966			-	-	-
1e.4.123	MACHINE SCREW PLUG,PL, 1/2-13 PN A-0256	1	PC	5,989	-	5,989
1e.4.124	O-RING,VT, 9.145 O.D. X .210 PN A-0473	1	PC	309,701	-	309,701
1e.4.125	UNL.PISTON RING, 7-1/2 O.D. PN A-0477	1	PC	2,834,277	-	2,834,277
1e.4.126	STL GASKET,10.188 X 9.875 X 60 PN A-0483	1	PC	377,158	-	377,158
1e.4.127	V PACKING, UNL PN A-0639	1	PC	375,266	-	375,266
1e.4.128	BELLOWS, UNL.THREAD PROTECTOR PN A-0641	1	PC	1,542,832	-	1,542,832
1e.4.129	WOODRUFF KEY,#808,1 D X 1/4 PN FK0360OA	1	PC	12,451	-	12,451

Appendix 6. OPEX (Overhaul) – Beta GS

Manpower				
Certified Technician	1	Lot	125,000,000	125,000,000
Technician	1	Lot	170,000,000	170,000,000
Material				
OH Material GC01	1	Lot	176,500,000	176,500,000
OH Material GC02	1	Lot	587,100,000	587,100,000
Total				**1,058,600,000**

1b.3	**OH Material GC01 (Screw Type)**					
1b.3.1	Coalescing Filters	1	PC	22,000,000		22,000,000
1b.3.2	Oil Filter	1	Set	7,500,000		7,500,000
1b.3.3	Lube Oil Summit Oil PGS 150 or Equal	1	Drum	85,000,000		85,000,000
1b.3.4	Mechanical Seal	1	Set	12,000,000		12,000,000
1b.3.5	Others (V-Belt, Instruments etc)	1	Lot	50,000,000		50,000,000

1b.4	**OH Material GC02 (Sliding Vane 23D)**					
1b.4.1	SF SEAL 3.500" SHAFT PN 16-242-090-006	1	Set	39,000,000		39,000,000
1b.4.2	CYL HEAD GASKET 23 DURA .016" PN 16-242-326-580	2	PC	18,000,000		36,000,000
1b.4.3	CYL HEAD GASKET 23 DURA .031" PN 16-242-326-579	2	PC	14,400,000		28,800,000
1b.4.4	GASKET, CYL.HEAD, 23, .062" TK PN 16-242-326-578	2	PC	14,400,000		28,800,000
1b.4.5	ROTOR BLADE SET 23D REFRIG PN 16-136-475-809	1	Set	404,500,000		404,500,000
1b.4.6	Others (V-Belt, Instruments etc)	1	Lot	50,000,000		50,000,000

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Appendix 7. OPEX (Electricity Cost)

- Alfa GS

No	Equipment	Power (HP)	Power (KW)	Running Hours/Day	Yearly Electricicty Cost ($)
1	Gas Compressor	30	22.38	24	26,074
2	Interstage Cooler 1	15	11.19	24	13,037
3	Interstage Cooler 2	15	14.92	24	17,383
4	Pre Cooler 1	20	14.92	24	17,383
5	Pre Cooler 2	20	14.92	24	17,383
6	Lube Oil Pump	2	1.49	24	1,738
7	Air Compressor 1	10	7.46	12	4,346
8	Air Compressor 2	10	7.46	12	4,346
9	Control Panel		20.00	24	23,302
10	Condensate Pump	15	11.14	22	11,892
11	Accumulator Pump	10	7.46	22	7,967
12	Lighting	5	3.73	11	1,992
13	Containment Pump	10	7.46	24	8,691
	TOTAL		**128.77**		155,535

- Beta GS

No	Equipment	Power (HP)	Power (KW)	Running Hours/Day	Yearly Electricicty Cost ($)	
					GC 1 & 2 operating	GC 1 only operating
1	Gas Compressor - 1	150	111.90	24	130,372	130,372
2	Gas Compressor - 2	250	186.50	24	217,287	
3	Gas Cooler	10	7.46	24	8,691	8,691
4	Condensate Pump 1	5	3.73	4	724	724
5	Water Jacket Cooler	5	3.73	24	4,346	
6	Pre Cooler A	15	11.19	24	13,037	13,037
7	Pre Cooler B	15	11.19	24	13,037	13,037
8	After Cooler A	7.5	5.60	24	6,519	
9	After Cooler B	7.5	5.60	24	6,519	
10	Water Pump 1	5	3.73	4	724	724
11	Condensate Pump 2	15	11.19	4	2,173	2,173
12	Air Compressor	5	3.73	12	2,173	2,173
13	Water Pump 2	5	3.73	24	4,346	
14	Control Panel	5	3.73	24	4,346	4,346
	TOTAL		**373.00**		414,295	175,279

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Appendix 8. Avoidance Cost for 3rd Party Gas Purchasing

Flare Gas Production (Decline Rate = 20%)												
Description	Formula	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Bangko Gas Production (MMSCFD)	A	2.00	1.60	1.28	1.02	0.82	0.66	0.52	0.42	0.34	0.27	0.21
Balam Gas Production (MMSCFD)	B	1.50	1.20	0.96	0.77	0.61	0.49	0.39	0.31	0.25	0.20	0.16
Total Gas Production (MMSCFD)	C = A+B	3.50	2.80	2.24	1.79	1.43	1.15	0.92	0.73	0.59	0.47	0.38
Yearly Gas Production (MMSCF)	**D = C*365**	1,278	1,022	818	654	523	419	335	268	214	171	137
BTU (Own Gas) = 911.5 BTU/SCF	E											
Production Reliability = 95%	G											
Yearly Potential Energy (MMBTU)	**H = D*E*G**	1,106,219	884,975	707,980	566,384	453,107	362,486	289,989	231,991	185,593	148,474	118,779
Gas Price = 5.72 $/MMBTU --> Base case	I											
Yearly Avoidance Cost of Gas Purchasing from 3rd Party ($)	**J = H*I**	6,327,574	5,062,059	4,049,647	3,239,718	2,591,774	2,073,419	1,658,735	1,326,988	1,061,591	849,273	679,418
PT. CPI's Generator Heat Rate = 16.98 MBTU/KWH	K											
Yearly Potential Produced KWH	**L = H*1000/K**	65,148,362	52,118,690	41,694,952	33,355,961	26,684,769	21,347,815	17,078,252	13,662,602	10,930,081	8,744,065	6,995,252
Electricity Production (without fuel) Unit Cost = $0.0283/ KWH	M											
Yearly Electricty Production Cost ($)	**N = L*M**	1,843,699	1,474,959	1,179,967	943,974	755,179	604,143	483,315	386,652	309,321	247,457	197,966
Gas Price = 4.58 $/MMBTU --> Low Gas Price Case	O											
Gas Price = 6.87 $/MMBTU --> High Gas Price Case	P											
Yearly Avoidance Cost ($) --> Low Gas Price Case	**Q = H*O**	5,066,484	4,053,187	3,242,550	2,594,040	2,075,232	1,660,185	1,328,148	1,062,519	850,015	680,012	544,010
Yearly Avoidance Cost ($) --> High Gas Price Case	**R = H*P**	7,599,726	6,079,781	4,863,825	3,891,060	3,112,848	2,490,278	1,992,223	1,593,778	1,275,022	1,020,018	816,014

Flare Gas Production (Decline Rate = 30%)											
Description	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Bangko Gas Production (MMSCFD)	2.00	1.40	0.98	0.69	0.48	0.34	0.24	0.16	0.12	0.08	0.06
Balam Gas Production (MMSCFD)	1.50	1.05	0.74	0.51	0.36	0.25	0.18	0.12	0.09	0.06	0.04
Total Gas Production (MMSCFD)	3.50	2.45	1.72	1.20	0.84	0.59	0.41	0.29	0.20	0.14	0.10
Yearly Gas Production (MMSCF)	1,278	894	626	438	307	215	150	105	74	52	36
BTU (Own Gas) = 911.5 BTU/SCF											
Production Reliability = 95%											
Yearly Potential Energy (MMBTU)	1,106,219	774,353	542,047	379,433	265,603	185,922	130,146	91,102	63,771	44,640	31,248
Gas Price = 5.72 $/MMBTU											
Yearly Avoidance Cost ($)	6,327,574	4,429,302	3,100,511	2,170,358	1,519,250	1,063,475	744,433	521,103	364,772	255,340	178,738
PT. CPI's Generator Heat Rate = 16.98 MBTU/KWH											
Yearly Potential Produced KWH	65,148,362	45,603,853	31,922,697	22,345,888	15,642,122	10,949,485	7,664,640	5,365,248	3,755,673	2,628,971	1,840,280
Electricity Production (without fuel) Unit Cost = $0.0283/ KWH											
Electricty Production Cost ($)	1,843,699	1,290,589	903,412	632,389	442,672	309,870	216,909	151,837	106,286	74,400	52,080
Gas Price = 4.58 $/MMBTU --> Low Gas Price Case											
Gas Price = 6.87 $/MMBTU --> High Gas Price Case											
Yearly Avoidance Cost ($) --> Low Gas Price Case	5,066,484	3,546,539	2,482,577	1,737,804	1,216,463	851,524	596,067	417,247	292,073	204,451	143,116
Yearly Avoidance Cost ($) --> High Gas Price Case	7,599,726	5,319,808	3,723,866	2,606,706	1,824,694	1,277,286	894,100	625,870	438,109	306,676	214,673

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Flare Gas Production (Decline Rate = 10%)											
Description	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Bangko Gas Production (MMSCFD)	2.00	1.80	1.62	1.46	1.31	1.18	1.06	0.96	0.86	0.77	0.70
Balam Gas Production (MMSCFD)	1.50	1.35	1.22	1.09	0.98	0.89	0.80	0.72	0.65	0.58	0.52
Total Gas Production (MMSCFD)	3.50	3.15	2.84	2.55	2.30	2.07	1.86	1.67	1.51	1.36	1.22
Yearly Gas Production (MMSCF)	1,278	1,150	1,035	931	838	754	679	611	550	495	445
BTU (Own Gas) = 911.5 BTU/SCF											
Production Reliability = 95%											
Yearly Potential Energy (MMBTU)	1,106,219	995,597	896,038	806,434	725,790	653,211	587,890	529,101	476,191	428,572	385,715
Gas Price = 5.72 $/MMBTU											
Yearly Avoidance Cost ($)	6,327,574	5,694,816	5,125,335	4,612,801	4,151,521	3,736,369	3,362,732	3,026,459	2,723,813	2,451,432	2,206,289
PT. CPI's Generator Heat Rate = 16.98 MBTU/KWH											
Yearly Potential Produced KWH	65,148,362	58,633,526	52,770,173	47,493,156	42,743,840	38,469,456	34,622,511	31,160,260	28,044,234	25,239,810	22,715,829
Electricity Production (without fuel) Unit Cost = $0.0283/ KWH											
Electricty Production Cost ($)	1,843,699	1,659,329	1,493,396	1,344,056	1,209,651	1,088,686	979,817	881,835	793,652	714,287	642,858
Gas Price = 4.58 $/MMBTU --> Low Gas Price Case											
Gas Price = 6.87 $/MMBTU --> High Gas Price Case											
Yearly Avoidance Cost ($) --> Low Gas Price Case	5,066,484	4,559,835	4,103,852	3,693,467	3,324,120	2,991,708	2,692,537	2,423,284	2,180,955	1,962,860	1,766,574
Yearly Avoidance Cost ($) --> High Gas Price Case	7,599,726	6,839,753	6,155,778	5,540,200	4,986,180	4,487,562	4,038,806	3,634,925	3,271,433	2,944,289	2,649,861

Appendix 9. Financial Analysis – Base Case

	Description	Formula	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
EXISTING CONDITION GAS PURCHASING FROM 3RD PARTY	Cost for Gas Purchasing + Electricity Production ($)	A			5,229,614	4,183,691	3,346,953	2,677,563	2,142,050	1,713,640	1,370,912	1,096,730	877,384
	Discount Factor = 10%	B											
	PV - Cost for Gas Purchasing + Electricity Production ($)	C = A / (1+B)^(Year-2022)			4,754,195	3,457,596	2,514,615	1,828,811	1,330,045	967,305	703,495	511,632	372,096
	NPV	D = sum C (2022-2031)	**16,439,791**		Sum	22,638,537							
					Avg	2,515,393							

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
NEW PROPOSAL USE FLARE GAS AS FUEL IN EXISTING POWER GENERATOR	Cost for Flare Gas Recovery + Electricity Production ($)	E		4,236,910	2,821,252	2,136,259	2,261,792	1,823,701	1,702,872	1,816,193	1,318,500	1,586,679	1,207,144
	Discount Factor = 10%	F											
	PV - Cost for Flare Gas Recovery + Electricity Production ($)	G = E / (1+F)^(Year-2022)		4,236,910	2,564,775	1,765,503	1,699,317	1,245,612	1,057,350	1,025,194	676,599	740,198	511,947
	NPV	H = sum G (2022-2031)	**15,523,405**		Sum	16,674,392							
	Saving / Benefit (ALT 1 compared to Existing Condition)	I = D - H	**916,386**		Avg	1,852,710							

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
IRR	Capital Investment Cost			(4,236,910)									
	Net Cash Flow	O = A - G			2,408,362	2,047,433	1,085,162	853,861	439,178	(102,553)	52,412	(489,950)	(329,760)
	IRR		**23%**										

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Appendix 10. Financial Analysis – Gas Production Low

	Description	Formula	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
EXISTING CONDITION GAS PURCHASE FROM 3RD PARTY	Cost for Gas Purchasing + Electricity Production ($)	A			4,003,923	2,802,746	1,961,923	1,373,346	961,342	672,939	471,058	329,740	230,818
	Discount Factor = 10%	B											
	PV - Cost for Gas Purchasing + + Electricity Production ($)	C = A / (1+B)^(Year-2022)			3,639,930	2,316,319	1,474,021	938,014	596,918	379,857	241,727	153,826	97,889
	NPV	D = sum C (2022-2031)	**9,838,502**										

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
NEW PROPOSAL USE FLARE GAS AS FUEL IN EXISTING POWER GENERATOR	Total Cost	E		4,236,910	2,494,697	1,774,674	1,899,285	1,476,928	1,383,967	1,528,878	1,060,339	1,358,497	1,006,133
	Discount Factor = 10%	F											
	PV (Total Cost)	G = E / (1+F)^(Year-2022)		4,236,910	2,267,907	1,466,672	1,426,961	1,008,762	859,335	863,012	544,122	633,749	426,699
	NPV	H = sum G (2022-2031)	**13,734,128**										
	Saving / Benefit (ALT 1 compared to Existing Condition)	I = D - H	**(3,895,626)**										

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
IRR	Capital Investment Cost			(4,236,910)									
	Net Cash Flow	O = A - G			1,509,226	1,028,073	62,638	(103,583)	(422,625)	(855,939)	(589,281)	(1,028,757)	(775,315)
	IRR		**#NUM!**										

Appendix 11. Financial Analysis – Gas Production High

	Description	Formula	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
EXISTING CONDITION GAS PURCHASE FROM 3RD PARTY	Cost for Gas Purchasing + Electricity Production ($)	A			6,618,731	5,956,858	5,361,172	4,825,055	4,342,549	3,908,294	3,517,465	3,165,718	2,849,147
	Discount Factor = 10%	B											
	PV - Cost for Gas Purchasing + + Electricity Production ($)	C = A / (1+B)^(Year-2022)			6,017,028	4,923,023	4,027,928	3,295,577	2,696,381	2,206,130	1,805,016	1,476,831	1,208,316
	NPV	D = sum C (2022-2031)	**27,656,230**										

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
NEW PROPOSAL USE FLARE GAS AS FUEL IN EXISTING POWER GENERATOR	Total Cost	E		4,236,910	3,084,681	2,486,341	2,666,263	2,255,744	2,146,875	2,258,877	1,747,705	1,998,384	1,596,911
	Discount Factor = 10%	F											
	PV (Total Cost)	G = E / (1+F)^(Year-2022)		4,236,910	2,804,255	2,054,828	2,003,203	1,540,703	1,333,040	1,275,077	896,849	932,261	677,246
	NPV	H = sum G (2022-2031)	**17,754,373**										
	Saving / Benefit (ALT 1 compared to Existing Condition)	I = D - H	**9,901,857**										

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
IRR	Capital Investment Cost			(4,236,910)									
	Net Cash Flow	O = A - G			3,534,050	3,470,516	2,694,909	2,569,311	2,195,674	1,649,417	1,769,760	1,167,334	1,252,235
	IRR		**74%**										

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Appendix 12. Financial Analysis – Gas Price Low

	Description	Formula	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
EXISTING CONDITION GAS PURCHASE FROM 3RD PARTY	Cost for Gas Purchasing + Electricity Production ($)	A			4,422,517	3,538,013	2,830,411	2,264,329	1,811,463	1,449,170	1,159,336	927,469	741,975
	Discount Factor = 10%	B											
	PV - Cost for Gas Purchasing + + Electricity Production ($)	C = A / (1+B)^(Year-2022)			4,020,470	2,923,978	2,126,529	1,546,567	1,124,776	818,019	594,923	432,671	314,670
	NPV	D = sum C (2022-2031)	**13,902,603**										

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
NEW PROPOSAL USE FLARE GAS AS FUEL IN EXISTING POWER GENERATOR	Total Cost	E		4,236,910	2,821,252	2,136,259	2,261,792	1,823,701	1,702,872	1,816,193	1,318,500	1,586,679	1,207,144
	Discount Factor = 10%	F											
	PV (Total Cost)	G = E / (1+F)^(Year-2022)		4,236,910	2,564,775	1,765,503	1,699,317	1,245,612	1,057,350	1,025,194	676,599	740,198	511,947
	NPV	H = sum G (2022-2031)	**15,523,405**										
	Saving / Benefit (ALT 1 compared to Existing Condition)	I = D - H	**(1,620,802)**										

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
IRR	Capital Investment Cost			(4,236,910)									
	Net Cash Flow	O = A - G			1,601,265	1,401,755	568,619	440,627	108,590	(367,023)	(159,163)	(659,210)	(465,169)
	IRR		**#NUM!**										

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Appendix 13. Financial Analysis – Gas Price High

	Description	Formula	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
EXISTING CONDITION GAS PURCHASE FROM 3RD PARTY	Cost for Gas Purchasing + Electricity Production ($)	A			6,043,792	4,835,033	3,868,027	3,094,421	2,475,537	1,980,430	1,584,344	1,267,475	1,013,980
	Discount Factor = 10%	B											
	PV - Cost for Gas Purchasing + + Electricity Production ($)	C = A / (1+B)^(Year-2022)			5,494,356	3,995,895	2,906,106	2,113,531	1,537,114	1,117,901	813,019	591,286	430,026
	NPV	D = sum C (2022-2031)	**18,999,235**										

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
NEW PROPOSAL USE FLARE GAS AS FUEL IN EXISTING POWER GENERATOR	Total Cost	E		4,236,910	2,821,252	2,136,259	2,261,792	1,823,701	1,702,872	1,816,193	1,318,500	1,586,679	1,207,144
	Discount Factor = 10%	F											
	PV (Total Cost)	G = E / (1+F)^(Year-2022)		4,236,910	2,564,775	1,765,503	1,699,317	1,245,612	1,057,350	1,025,194	676,599	740,198	511,947
	NPV	H = sum G (2022-2031)	**15,523,405**										
	Saving / Benefit (ALT 1 compared to Existing Condition)	I = D - H	**3,475,830**										

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
IRR	Capital Investment Cost			(4,236,910)									
	Net Cash Flow	O = A - G			3,222,539	2,698,775	1,606,235	1,270,720	772,665	164,236	265,844	(319,204)	(193,164)
	IRR		**49%**										

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Appendix 14. Financial Analysis – CAPEX High

	Description	Formula	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
EXISTING CONDITION GAS PURCHASE FROM 3RD PARTY	Cost for Gas Purchasing + Electricity Production ($)	A			5,229,614	4,183,691	3,346,953	2,677,563	2,142,050	1,713,640	1,370,912	1,096,730	877,384
	Discount Factor = 10%	B											
	PV - Cost for Gas Purchasing + + Electricity Production ($)	C = A / (1+B)^(Year-2022)			4,754,195	3,457,596	2,514,615	1,828,811	1,330,045	967,305	703,495	511,632	372,096
	NPV	D = sum C (2022-2031)	**16,439,791**										

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
NEW PROPOSAL USE FLARE GAS AS FUEL IN EXISTING POWER GENERATOR	Total Cost	E		5,084,292	2,821,252	2,136,259	2,261,792	1,823,701	1,702,872	1,816,193	1,318,500	1,586,679	1,207,144
	Discount Factor = 10%	F											
	PV (Total Cost)	G = E / (1+F)^(Year-2022)		5,084,292	2,564,775	1,765,503	1,699,317	1,245,612	1,057,350	1,025,194	676,599	740,198	511,947
	NPV	H = sum G (2022-2031)	**16,370,787**										
	Saving / Benefit (ALT 1 compared to Existing Condition)	I = D - H	**69,004**										

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
IRR	Capital Investment Cost			(5,084,292)									
	Net Cash Flow	O = A - G			2,408,362	2,047,433	1,085,162	853,861	439,178	(102,553)	52,412	(489,950)	(329,760)
	IRR		**11%**										

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Appendix 15. Financial Analysis – CAPEX Low

	Description	Formula	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
EXISTING CONDITION GAS PURCHASE FROM 3RD PARTY	Cost for Gas Purchasing + Electricity Production ($)	A			5,229,614	4,183,691	3,346,953	2,677,563	2,142,050	1,713,640	1,370,912	1,096,730	877,384
	Discount Factor = 10%	B											
	PV - Cost for Gas Purchasing + + Electricity Production ($)	C = A / (1+B)^(Year-2022)			4,754,195	3,457,596	2,514,615	1,828,811	1,330,045	967,305	703,495	511,632	372,096
	NPV	D = sum C (2022-2031)	**16,439,791**										

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
NEW PROPOSAL USE FLARE GAS AS FUEL IN EXISTING POWER GENERATOR	Total Cost	E		3,389,528	2,821,252	2,136,259	2,261,792	1,823,701	1,702,872	1,816,193	1,318,500	1,586,679	1,207,144
	Discount Factor = 10%	F											
	PV (Total Cost)	G = E / (1+F)^(Year-2022)		3,389,528	2,564,775	1,765,503	1,699,317	1,245,612	1,057,350	1,025,194	676,599	740,198	511,947
	NPV	H = sum G (2022-2031)	**14,676,023**										
	Saving / Benefit (ALT 1 compared to Existing Condition)	I = D - H	**1,763,768**										

	Description		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
IRR	Capital Investment Cost			(3,389,528)									
	Net Cash Flow	O = A - G			2,408,362	2,047,433	1,085,162	853,861	439,178	(102,553)	52,412	(489,950)	(329,760)
	IRR		**40%**										

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