BACHELOR THESIS & COLLOQUIUM – ME184841

# *SIMULATION OF COLD ENERGY RECOVERY TECHNOLOGY APPLICATION FOR POWER GENERATION ON FLOATING STORAGE AND REGASIFICATION UNIT (FSRU) JAWA BARAT*

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DOUBLE DEGREE PROGRAM
DEPARTMENT OF MARINE ENGINEERING
FACULTY OF MARINE TECHNOLOGY
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SURABAYA
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**SKRIPSI – ME184841**

# SIMULASI APLIKASI TEKNOLOGI PEMULIHAN ENERGI DINGIN UNTUK PEMBANGKIT LISTRIK PADA UNIT PENYIMPANAN DAN REGASIFIKASI TERAPUNG (FSRU) JAWA BARAT

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SURABAYA

2020

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## ENDORSEMENT PAGE

# SIMULATION OF COLD ENERGY RECOVERY TECHNOLOGY APPLICATION FOR POWER GENERATION ON FLOATING STORAGE AND REGASIFICATION UNIT (FSRU) JAWA BARAT

## BACHELOR THESIS

Submitted to fulfill one of the requirements for obtaining a Bachelor Engineering Degree in the field of study of Marine Machinery and System (MMS)

Programs study of Double Degree Bachelor Engineering (S-1) of

Department Marine Enineering

Faculty of Ocean Technology

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**JANUARY 2020**

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## DECLARATION OF HONOR

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hereby declare and certify in my honor that this bachelor thesis has been written and developed independently without any act of plagiarism.

Should be there any dispute in the future regarding this matter, it will be under my full responsibility and according to the regulation in ITS I am willing to receive any penalties given.

Surabaya, January 2020

Hilman Diri Aji Eka Wijaya

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# SIMULATION OF COLD ENERGY RECOVERY TECHNOLOGY APPLICATION FOR POWER GENERATION ON FLOATING STORAGE AND REGASIFICATION UNIT (FSRU) JAWA BARAT


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## ABSTRACT


Unused potential exergy accompanying heat transfer in regasification process onboard FSRU can still be extracted and converted into another useful form of energy. The extracted energy can then be utilized to increase the overall efficiency of the FSRU while sparing fuel needed to generate electricity. The exergy from the regasification system can be extracted by modifying the old system and incorporating an organic Rankine cycle coupled with an intermediate fluid evaporator into it. The old system is modified by installing a 5,2MW-expander generator, PCHE heat exchanger with total duty of 45,9 MW, and plate heat exchanger with total duty of 49,6 MW. To analyze the performance of the modified system and how it influences the overall efficiency, a simulation is done to the modified system without changing the system input and output. The result of simulation is that the system could produce daily an additional electrical energy of 73,9 MWh which reflects the 7,5% of exergic efficiency. The energy contributes to an 8,16% overall efficiency increase and will bring annual economic benefit of Rp.14.369.544.840. Based on these findings, the modified system is confirmed to be able to extract some exergy from the system, increase the overall efficiency, and bringing economical benefit to the FSRU operation.



*Keywords – Exergy, LNG, Organic Rankine Cycle.*

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# SIMULASI APLIKASI TEKNOLOGI PEMULIHAN ENERGI DINGIN UNTUK PEMBANGKIT LISTRIK PADA UNIT PENYIMPANAN DAN REGASIFIKASI TERAPUNG (FSRU) JAWA BARAT


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## ABSTRAK


Exergi pendamping perpindahan panas pada proses regasifikasi pada FSRU memiliki potensi untuk diekstraksi dan diubah menjadi bentuk energi lain yang lebih berguna. Energi yang berhasil diekstrak dapat digunakan untuk meningkatkan efisiensi dari FSRU dengan cara menghemat kebutuhan bahan bakar yang digunakan untuk membangkitkan tenaga listrik. Exergi dapat diekstraksi dari sistem dengan memodifikasi sistem lama dan menambahkan siklus Rankine organik kedalamnya. Sistem lama dimodifikasi dengan menambahkan sebuah expander-generator dengan kapasitas 5,2 MW, penukar panas PCHE dengan kapasitas 45,9 MW, dan penukar panas tipe plat dengan kapasitas 49,6 MW. Untuk menganalisa kinerja dari sistem yang telah dimodifikasi dan bagaimana pengaruh sistem tersebut terhadap efisiensi, maka sebuah simulasi dilakukan tanpa merubah input dan output dari sistem. Hasil dari simulasi tersebut adalah sistem dapat menghasilkan energi listrik sebesar 73,9 MWh setiap hari yang mencerminkan 7,5% dari efisiensi exergis. Energi ini berkontribusi terhadap peningkatan efisiensi umm sebesar 8,16% dan mengakibatkan keuntungan ekonomis sebesar Rp.14.369.544.840 per tahun. Berdasarkan temuan ini, dapat disimpulkan bahwa modifikasi sistem dapat mengekstraksi sebagian eksergi, meningkatkan efisiensi umum, dan mengakibatkan keuntungan ekonomis pada operasi FSRU.



*Kata Kunci – Exergi, LNG, Siklus Rankine Organik.*

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# PREFACE

Praise be to Allah SWT, for his blessings and guidance that has been given until the author can finish the "Bachelor Thesis Project" in time. This report was a part of the fulfillment of graduation requirements to obtain the Bachelor of Engineering title from Institut Teknologi Sepuluh Nopember, Surabaya and titled "Simulation of Cold Energy Recovery Technology Application for Power Generation on Floating Storage And Regasification Unit (FSRU) Jawa Barat". The research for this project was done in the Marine Machinery and System Laboratory ITS with an intensive support from PT. Nusantara Regas from July 2019 until February 2020.

Author would firstly thank Author's parents, for they have given all the love and support so the thesis can be finished. Second in place would be the supervisor of this thesis, Ir. Alam Baheramsyah, M. Sc and Mr. Sutopo Purwono Fitri, S.T., M. Eng., Ph.D., for they have given the author guidance, directions, and feedbacks, which are very helpful and assisting, during the research and writing process of this thesis. Further gratitude is given to PT. Nusantara Regas, for they have kindly assist the author in data gathering process. Finally, are all friends and people that are directly and indirectly involved in the process, that the author cannot individually mention.

Lastly, the author apologizes for any imperfection that may be missed during writing and editing process and hopefully this thesis can add more knowledge about the cold energy and exergy and in turn be useful for the reader and future research about similar or relatable topics.

Surabaya, January 10th 2020

Author

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# GLOSSARY

| | |
|---|---|
| AAV | : Ambient Air Vaporizer |
| BOG | : Boil Off Gas |
| C3_1 | : Phase, Liquid propane after LNG Evaporator |
| C3_2 | : Phase, Liquid propane before propane pump |
| C3_3 | : Phase, Liquid propane before propane evaporator |
| C3_4 | : Phase, Propane gas before expander |
| C3_5 | : Phase, Propane gas after expander |
| C3_6 | : Phase, Propane gas after reheater |
| DEC | : Direct Expansion Cycle |
| FSRU | : Floating Storage and Regasification Unit |
| ICP | : Indonesian Crude Price |
| IFV | : Intermediate Fluid Vaporizer |
| LNG | : Liquefied Natural Gas |
| LNG_IN | : LNG flow goes into the system |
| MMBTU | : Million British Thermal Unit |
| MW | : Megawatts |
| NG | : Natural Gas |
| NG_OUT | : Natural gas flow output from the system |
| NGL | : Natural Gas Liquefaction |
| ORC | : Organic Rankine Cycle |
| ORV | : Open Rack Vaporizer |
| $P_{mech}$ | : Net Power Output |
| PFD | : Plant Flow Diagram |
| PID | : Piping Instrument Diagram |
| PLN | : Perusahaan Listrik Negara |
| RUPTL | : Rencana Usaha Pengembangan Tenaga Listrik |
| SCV | : Submerge Combustion Vaporizer |
| SOR | : Send Out Rate |
| STV | : Shell and Tube Vaporizer |
| SW_IN_C3_EVAP | : Seawater flow input to the propane evaporator |

SW_IN_C3_REHT : Seawatr input flow to propane reheater
SW_IN : Seawater flow input to the system
SW_OUT_C3_EVAP : Seawater output flow from the propane evaporator
SW_OUT_C3_REHT : Seawater ouput flow from the propane reheater
SW_OUT : Seawater flow output from the system
$W_{IN}$ : Work needed by the system
$W_{OUT}$ : Work produced by the system
Wturbine : Expander power output

# CHAPTER I : INTRODUCTION

## 1.1. Background

LNG demand in Indonesia is increasing and get a bigger portion on national energy mix each year. According to the RUPTL (Rencana Usaha Pengembangan Tenaga Listrik) issued by PT. PLN under the authority of Energy and Mineral Source ministry, it is stated that the portion of LNG in the national energy mix will reach 19,4% in 2026.

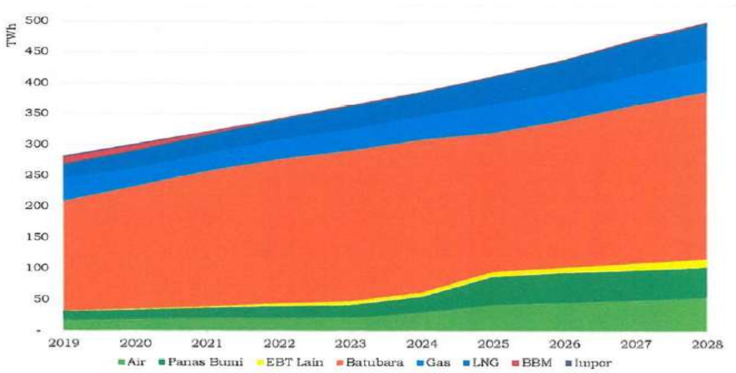


Figure 1.1. Energy Mix Projection 2019-2028 [1]

This electricity development plan is a solid commitment from the government to reduce the portion of coal and fuel oil in national energy mix for power generation. It leads to many projects of power plant fuel shift or new gas-powered power plants. Newbuilt projects of gas powerplant are located on the middle of Indonesia and mostly have small to moderate power capacity. These government-backed projects will ensure LNG demand growth across Indonesia.

The increasing LNG demand across Indonesia increases also the need of supporting infrastructures of gas processing. For instance, the LNG regasification terminal which purpose is to store and revert LNG to its gas form. Indonesia tend to utilize FSRU as their LNG regasification terminal than onshore terminal. Currently, there are 2 operating FSRUs in Indonesia, one is used to support the gas need of power plants in Jakarta area, while the other is stationed in South Sumatera. There are more upcoming FSRUs to support Indonesia's ambition to provide electricity for all Indonesian people.

The FSRUs is a floating facility which needs to produce its own electrical energy to operate. FSRU Jawa Barat, for example, consumes daily an enormous 18 MW of electricity produced by two steam turbine generators to supply maximum 500 MMSCFD gas flow to the power plants [2]. This huge energy consumption has reduced the amount of gas distributed to the power plant and in turn reduced the company's profit or making the electricity cost higher. The power plant onboard the terminal consumes on average 1% of the total gas production of the terminal.

For a long time, the regasification process onboard FSRUs around Indonesia uses conventional method which neglect the possibility of exergy recovery in the system. Generally, the regasification process of LNG can be concluded as follows,

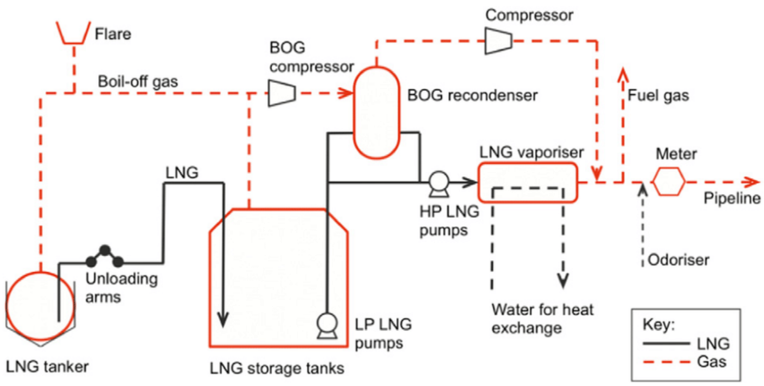


Figure 1.2. General Regasification Process [3]

The process begins with pumping the LNG out of the storage tanks in the FSRU. It goes through a booster pump to obtain desired output pressure of the NG. It flows firstly to the BOG recondenser where some of its cold is used to recondense natural gas resulted by natural heat exchange in the tanks. The LNG is the vaporized in the LNG vaporizer fully into gas phase using the heat supplied mainly from the seawater. The high temperature gradient of LNG (-160°C) and seawater (25-30°C) expose the possibility of exergy extraction from low temperature LNG. The required action is only to introduce reversible heat cycle so the exergy can be converted into work.

Exergy is defined as the possible work to be extracted from the system for it to be in the same condition with its ambient environment. Since the LNG has a temperature far below 0°C, there is a huge amount of exergy available to be recovered into work from it. The exergy recovery scheme or widely known as cold energy recovery has been implemented in some developed country such as Japan. The work extracted from exergy recovery scheme of LNG regasification processes can be utilized in wide applications such as power generation, $CO_2$ capture, air separation, emission control, NGL recovery, etc [4]. Lee and Choi [5] have designed a combined regasification system that utilizes LNG cold as cooling medium to increase efficiency. In the research, an amount of 9,72 MW exergy is recovered in form of electricity.

The object of this thesis (FSRU Jawa Barat) need an enormous 45,6 MW of heat to be supplied into the LNG in the regasification process. And according to the initial exergy analysis, there is an enormous 53,26 MW of exergy available to be extracted from the regasification system. The application of exergy recovery will have a positive impact on energy efficiency and in turn economic aspects.

The most applicable way to extract this exergy is by introducing reversible heat cycle to the system. And the most common and mature heat cycle in the world is the organic Rankine cycle. The organic Rankine cycle is used in this research to change exergy into work by designing it to adapt to the existing system. The work obtained will be converted into electricity and hopefully will increase the overall performance efficiency of the FSRU. The increase in performance and efficiency on the FSRU will profit the operator economically.

In accordance with Indonesia's long-term energy plan, there will be a huge possibility of savings, additional income, and even cheaper LNG regasification fee if the technology of exergy or cold energy recovery can be applied in Indonesian's FSRU. Therefore, an explicit and specific study of exergy recovery application in FSRU should be conducted.

## 1.2. Problem Statements

1. How is the design of ORC cycle and its layout to recover exergy in the system?
2. How much electrical power generated, and efficiency increase are obtained from the modified system?
3. How the modified system impacts economically?

## 1.3. Problem Limitation

The problems in this thesis are limited as follows,

1. The maximum send-out rate (SOR) of the designed system is 250 MMSCFD for one train replacement.
2. The layout of the new system is limited only in PID layout.
3. Economic impact studies are limited only on saving from operational cost reduction.
4. The system input and output are taken as the same as existing system.

## 1.4. Objectives

The objectives of this thesis are as follows,

1. To design an ORC cycle and its layout to recover exergy in the system.
2. To estimate generated electrical power and efficiency increase from the modified system.
3. To analyze the economic impact of modified system application.

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# CHAPTER II : LITERATURE STUDY

## 2.1. General Overview

LNG is becoming the fastest growing business related to fossil fuels and clean energy soon. It is supported by the fact that natural gas is the cheapest and cleanest fossil fuel there is and the distance between NG producer and consumer is usually far apart. Therefore, a need of reliable mode of transportation such as conversion into LNG is inevitable. In practices, the liquefaction of LNG in LNG plant needs a huge amount of energy and by the time it is regasified in the terminal, this huge amount of thermal gradient is simply wasted into the environment. This present an opportunity to develop a technology that could take advantage of this huge thermal gradient instead of just being thrown away. The cold potential energy is also called cold energy or exergy of cold is an amount of energy that is stored within the matter that could be converted into work. The conversion of this exergy into work cannot be done using the conventional method, but by introducing reversible thermal cycles such as Rankine and Brayton cycles.

Some companies around the world have already implement the recovery of cold exergy. For instance, the Japanese has already built a cryogenic power plant that could generate about 6 MW electrical power from this recovery process. another example is brazil which already applied exergy recovery to separate air and capture loose $CO_2$ in the air for emission control and industrial stock.

All the systems that are built in the world are integrated into the LNG terminal and got their power form the potential cold energy in the regasified LNG. These applications have proved that cold exergy recovery system could increase overall system efficiency, reducing wasted energy, and increasing economy of the system through energy savings and/or valuable byproducts. Thus, this make the study and application of this technology very interesting.

## 2.2. LNG Regasification System

### 2.2.1. Vaporizers

In the LNG terminal, LNG will be reverted to its original gas form. The original form is achieved by adding heat from outside into the LNG to increase its temperature. There are various ways to add heat into the LNG, but the most common way is to use vaporizer. The vaporizer acts as a heat exchanger in the system and has various types, which are,

1. Open Rack Vaporizer

ORV is a heat exchanger type utilizing water as heat source. The water used by this vaporizer is usually seawater, because LNG terminals are located mostly on sea or near the shoreline. The performance of heat exchanger varies dependent on the water condition which is taken into the system. This vaporizer is very common on LNG terminals, due to its simple design, low cost heat source, simple maintenance, no moving parts, and excellent reliability.

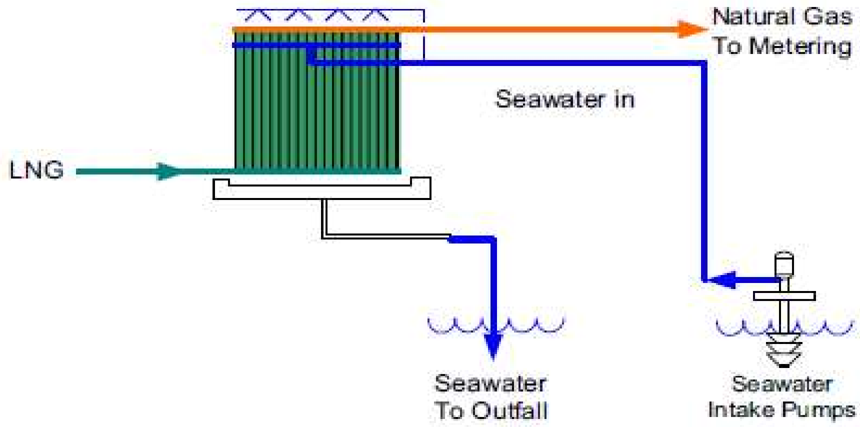


Figure 2.1. ORV Schematic [6]

2. Submerged Combustion Vaporizer

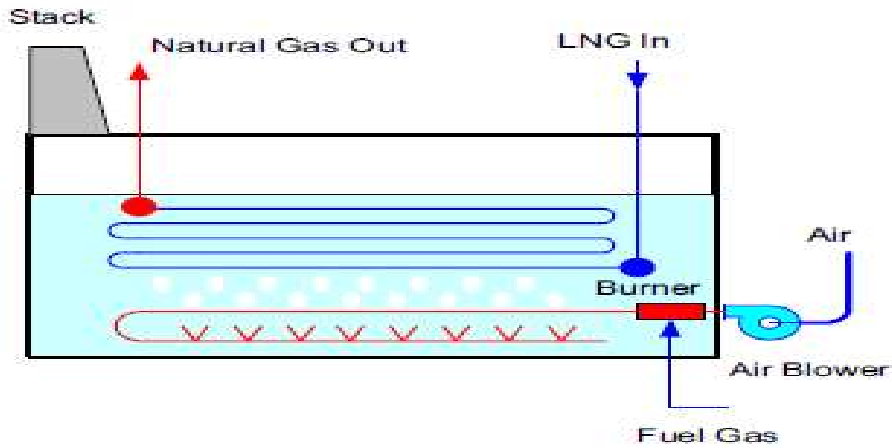


Figure 2.2. SCV Schematic

SCV uses heat emitted from a burner as its heat source. It consumes about 1,5% of total natural gas as fuel. This vaporizer type is used only when there is no other heat source available. The LNG flow is submerged into a water bath heated by a burner which burn some of the gas.

3. Ambient Air Vaporizer

AAV uses direct contact, long, vertical heat exchanger that facilitates downward air draft. This vaporizer is considered the eco-friendliest because it generates less pollution to the environment, hence are much easier to permit. This vaporizer is standalone which mean it does not require seawater and other fluids except ambient air. However, this vaporizer needs to be defrosted every 4 to 8 hours due to ice buildup on the surface of the heat exchanger. This ice buildup can prevent heat exchange and reduce the performance of the overall system.

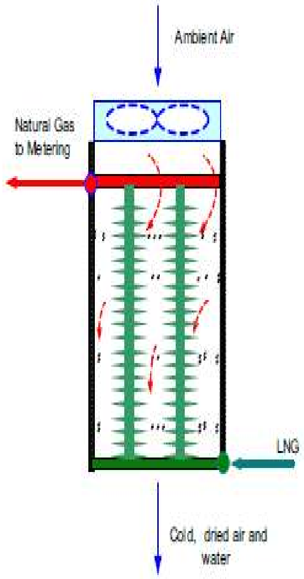


Figure 2.3. AAV Schematic [6]

4. Intermediate Fluid Vaporizer

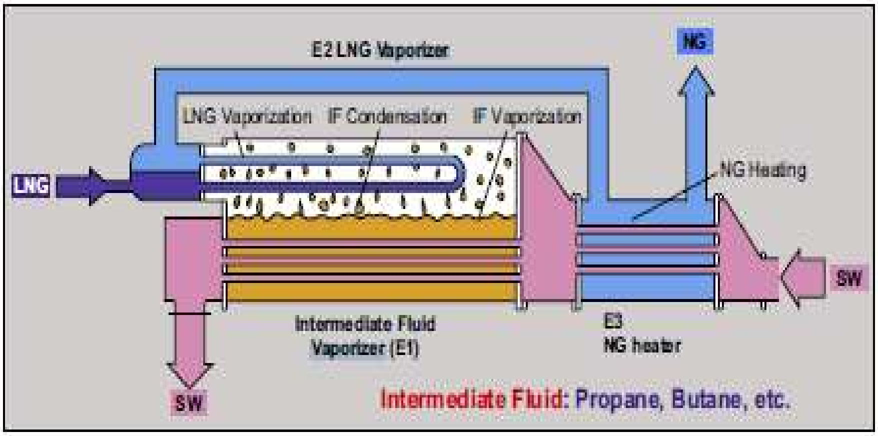


Figure 2.4. IFV Schematic

IFV uses intermediate fluid in a closed loop to transfer heat from heat source to LNG. There are many fluids that can be used for the purpose such as Propane, Ethylene Glycol, other low-freezing fluids that are suitable for cryogenic operation, but until now only water-glycol and propane which is feasible for IFV usage [7]. The IFV is very flexible and can accommodate multiple heat sources in one cycle. The performance of this vaporizer is highly affected by the fluid type used in the system. Many researches are based on this vaporizer type due to its flexibility.

5. Shell and Tube Vaporizer

STV is like another shell and tube heat exchanger. The difference is only this heat exchanger is adapted to cryogenic temperature and high temperature gradient. This vaporizer can be operated either in open loop or closed loop configuration. SCV in open loop configuration is like ORV, but the heat exchanger configuration is shell and tube type. The material cost of this heat exchanger is expensive, but it has compact size which may useful in limited space application such as in FSRU.

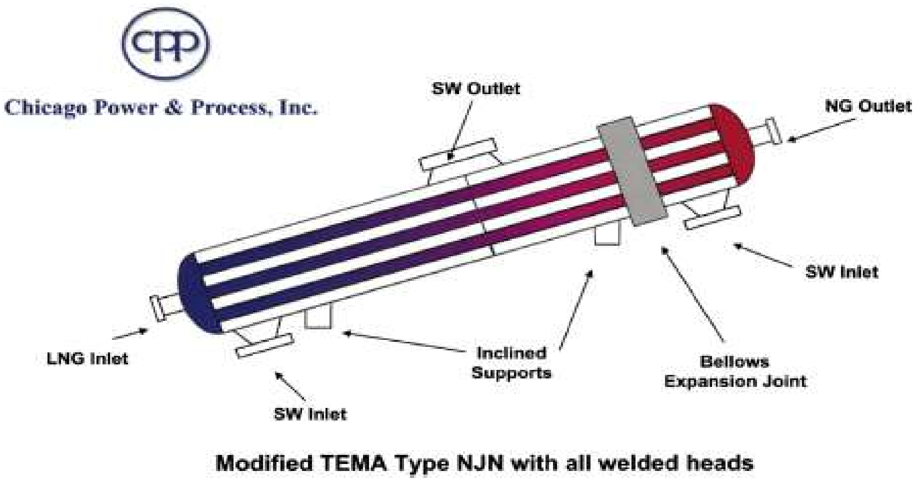


Figure 2.5. STV Vaporizers

Most of these vaporizers are direct heat transfer type, which operates without a heat cycle and supply heat directly to the LNG. The downside of direct vaporizer is that no potential work (thermal exergy) can be extracted from the system. Special for IFV type, there is a possibility of exergy extraction since it utilizes intermediate fluid to transfer the heat from LNG to seawater.

### 2.2.2. Onboard regasification system

FSRU Jawa Barat has an onboard regasification unit which uses intermediate fluid vaporizer (IFV) to do its job. The LNG will pass through the regasification system to obtain heat supplied by the seawater with help from propane as an intermediary fluid. It uses three loops that are working together to achieve the goal to regasify the LNG. These working loops work individually and influencing one another. The fluid used as a heating medium in the Intermediate fluid vaporizer is pure propane ($C_3H_8$). The regasification system onboard the ship is represented by the following PID drawing,

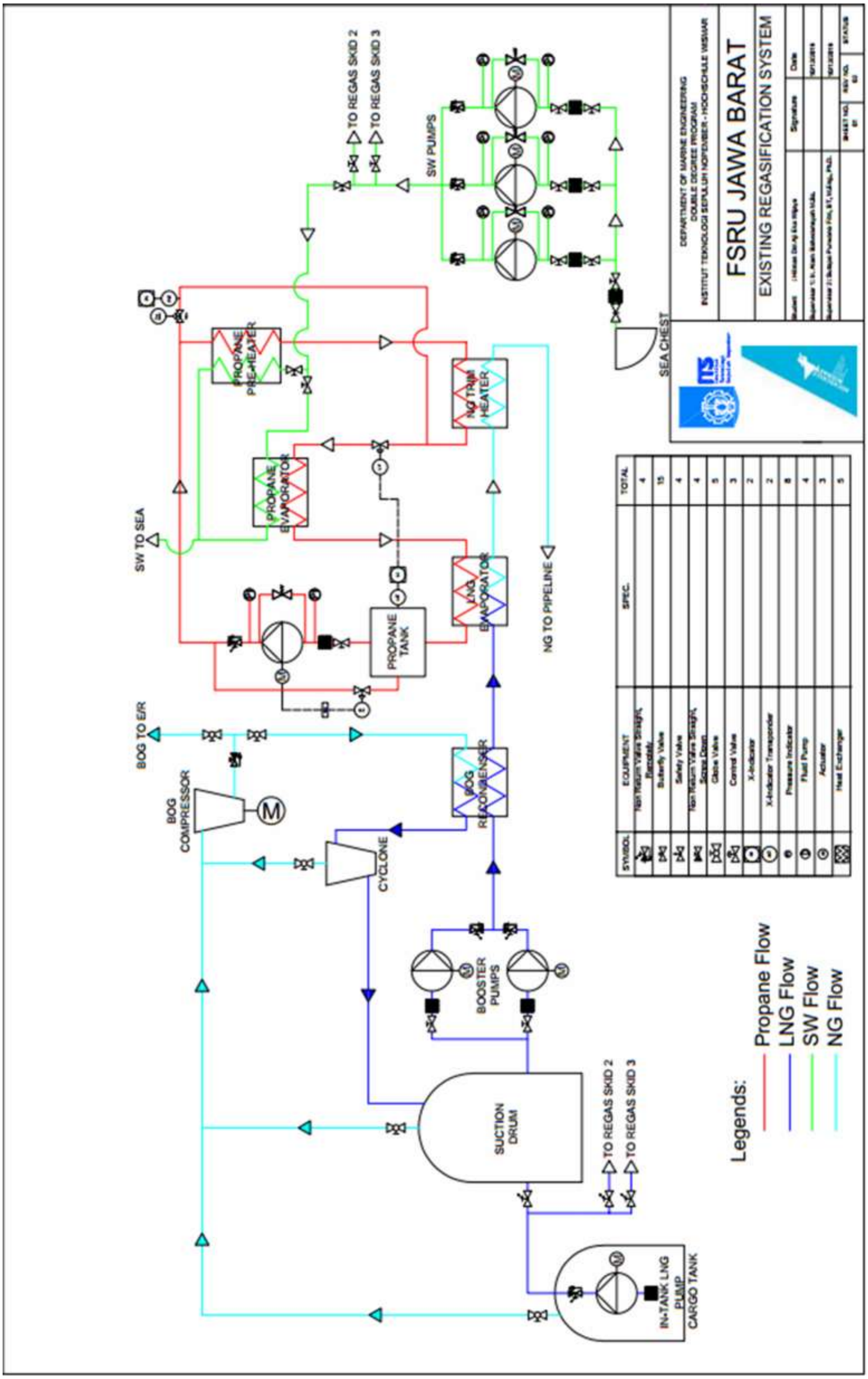


Figure 2.6. Onboard regasfication system PID drawing

The regasification system consists of several working loops which are categorized based on the fluid working or flowing in the loop. Practically, there are three loops which are the LNG, propane, and seawater loop.

1. LNG Loop


Figure 2.7. LNG Loop [8]

The LNG flow starts at the LNG storage tank in the FSRU. The LNG is pumped through cryogenic cargo pump submerged in the tank. This LNG is then transferred to the suction drum for vapor-liquid separation. The vapor is separated and vented out the suction drum into the BOG Compressor. The liquid LNG is then pumped out from the suction drum using booster pumps. These pumps pressurize the LNG to meet specified requirement. The pressurized LNG is going through the first heat exchanger which is the Re-condenser. The purpose of this re-condenser is to condense the BOG so that these BOG can be liquid again and flows through the system as a liquid. In this state, the flow consists of two phase, gas and liquid. This flow goes into the second heat exchanger which is Evaporator. The LNG is heated up and converted fully into gas form. The heat is obtained from propane gas (intermediary heating medium). After converted fully into gas form, the NG flows through the third heat exchanger. In this heater the NG is heated to meet pre-specified requirement.

2. Propane Loop


Figure 2.8. Propane Loop [8]

Propane is the intermediary heating medium used in the FSRU Jawa Barat. The purpose of the propane use as intermediary heating medium is to prevent icing, O2 system leak, and clogging. The propane flow starts from the propane tank. The propane stored in the tank in the form of liquid. This liquid is pumped to the pre-heater. In this heat exchanger, the propane is heated to gas form using seawater. The propane gas flows to the LNG Trim Heater, this heater heats up the NG produced from the LNG Vaporizer and turns propane gas into liquid propane. The liquid propane goes through propane evaporator to be evaporated back into gas form. The propane gas then goes into LNG vaporizer to heat LNG and turn it into gas form. The liquid propane resulted from previous process is transferred back to the propane tank.

3. Seawater Loop

Seawater is used as the main heat source in the regasification process onboard the FSRU. The seawater is used because the LNG has a very low temperature and does not require high temperature heat source. The seawater pass through the heat exchanger and directly dumped back into the ocean. The detailed loop can be seen below,


Figure 2.9. Seawater Loop [8]

The seawater is supplied to the regasification plant at a pressure of about 2,2 bar. The seawater system has no control loop but utilize the seawater at whatever temperature it has. The seawater flows in parallel to the propane evaporators and the propane pre-heater.

Heat from the seawater is used to vaporize propane in the evaporators and to pre-heat the propane in the pre-heater prior entering the natural gas trim heater. external filters shall prevent any debris to enter the propane evaporators and the propane pre-heater. Filtration grade shall be of maximum aperture 2 mm according to equipment supplier's recommendation. The loop of seawater is as follows,

### 2.3. Exergy

Generally, exergy is defined as the maximum potential work that can be converted into work from a matter by bringing it into equilibrium with its environment or respective environment [8]. Exergy, as defined by Rant [10], is a part of energy together with anergy ($E = Ex + A$). The difference of anergy and exergy is that the anergy is referred to the part of energy which cannot be converted into work. During heat transfer processes, some part of exergy is converted into anergy, while the amount of energy is constant following the 1st law of thermodynamic. So, in the transfer of energy between two bodies as a result in temperature difference (heat), there is a transfer of exergy as well as anergy happening.

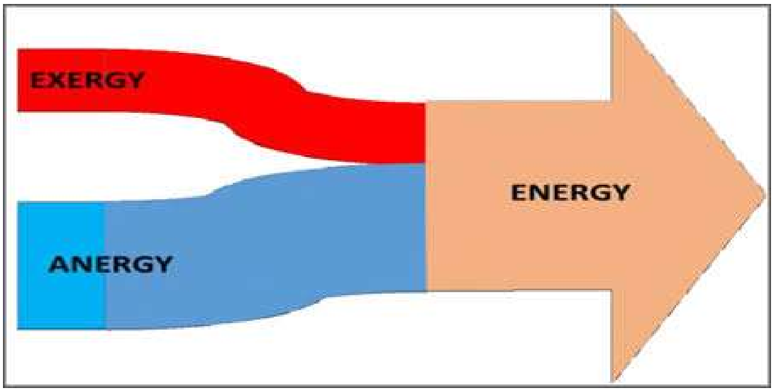


Figure 2.10. Energy Composition [11]

The ratio between available exergy (Ex) and transferred heat energy (Q) is defined as exergy factor (fex). This factor is often called as quality factor or exergetic quality factor [12]. It is giving a clear picture of the work potential per unit heat, which indicates its quality. There are two types of exergy that is commonly used. These two types come from different extreme of an ambient reference temperature. The first type of exergy is the heat exergy or exergy of heat which indicates the maximum work that can be obtained by bringing the heat in thermal equilibrium with the environment using a reversible process or reversible cycle. The second type is the exergy of cold or commonly known as cold energy which indicates the maximum work obtainable by bringing the cold into thermal equilibrium with ambient reference temperature using reversible cycle.

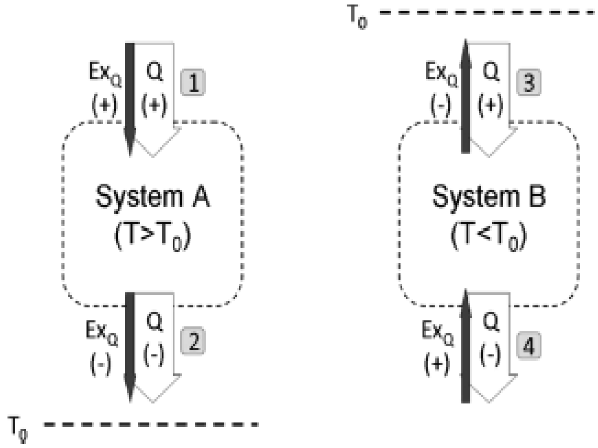


Figure 2.11.Exergy accompanying heat transfer dependent on system and respective environment temperature [9]

The direction of exergy flows can differ from energy flow direction, while anergy always have the same direction as energy flow. The heat transfer spontaneously occurs from hotter to colder bodies, whereas the cold bodies are referred to those with temperature lower than the ambient or environment temperature while hot bodies referred as those with higher temperature than environmental reference. The direction of exergy flow depends from the temperature standpoint of system in respective to its respective environment as shown in Figure 2.11.

The general equation for determining exergy accompanying heat transfer can be expressed using following formula,

$$Ex_Q = Q.\left(1 - \frac{T_0}{T}\right) \quad (1)$$

Where,

| | | | |
|---|---|---|---|
| $Ex_Q$ | = | Exergy accompanying heat transfer | (J) |
| $Q$ | = | Heat being transferred | (J) |
| $T_0$ | = | Reference temperature | ($^{O}$C) |
| $T$ | = | System Temperature (Hot/Cold) | ($^{O}$C) |

According the Equation 1, the exergy factor is given by the factor $\left(1 - \frac{T_0}{T}\right)$ and the result of the calculation using this factor and an ambient reference temperature 25ºC is shown in the following figure,

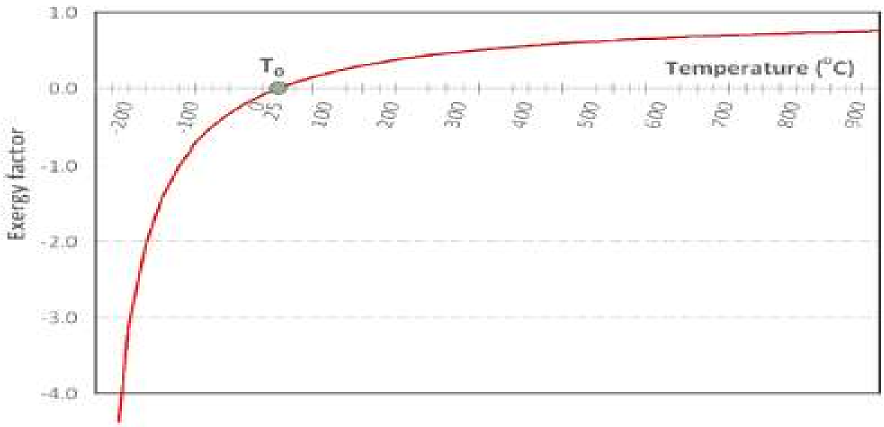


Figure 2.12. Exergy factor at given $T_0$ of 25ºC [9]

According to Figure 2.12, when the temperature approaches infinity or exergy of heat (T>T0), the exergy factor becomes unity. This means that in a very high temperature, all available exergy could be theoretically be converted into work. In the other hand, the exergy of cold or cold energy (T< T0), the negative value of factor $\frac{T_0}{T}$ makes the quality factor possible to be more than unity. It means that the exergy will have a greater value than the available cold. Theoretically, it is possible to extract more work than available exergy because the heat supplied to the cold system via reversible cycle is unlimited while the cold source is limited. So, the heat supply by the environment adjust in a way that $\frac{Q_H}{-Q_C} = \frac{T_H}{T_C}$ thus resulting in a larger amount of exergy than available cold.

The exergy inside a matter cannot be extracted if the heat transfer happens naturally. In this case is if there is a direct heat transfer between the LNG and its heating medium, which is seawater. The heat transfer between the system (LNG) and its reference environment (seawater) should be done using a reversible heat cycle in order to extract work from the system. There are three known reversible cycle that are commonly used in thermal exergy extraction especially in LNG regasification process. These cycles are,

1. Organic Rankine Cycle (ORC)

Organic Rankine Cycle uses working fluid with low boiling temperature to recover LNG cold energy. Working fluid will be condensed in the main LNG evaporator and then later vaporized by heat source in vaporizer. The heat source used is usually seawater or ambient air. Just like in the normal steam Rankine cycle, the working fluid goes through compression, evaporation, expansion and back to condensation. The difference is only the heat source that could use ambient temperature medium such as seawater or ambient air due to the cryogenic heat sink and low boiling temperature working fluid. The working fluid used is usually refrigerant or hydrocarbon derivatives such as propane and butane.

2. Brayton Cycle

Brayton cycle uses cold energy to reduce the gas inlet temperature of the compressor. Temperature reduction of gas inlet will increase the net power output of the turbine. Between the compressor and turbine, the gas is usually heated to increase its enthalpy, so more power can be extracted.

3. Kalina Cycle

Kalina cycle is a development of Rankine cycle. Instead of using refrigerant or other hydrocarbon gas, it uses ammonia-water solution. It has greater exergy efficiency than Rankine cycle due to temperature-varying evaporation of the working fluid. Shi and Che [13] used a combination of DEC and Kalina cycle to obtain a net power output of 1,25 MW per kg of ammonia-water. However, the Kalina cycle is controversial due to the nature of ammonia which is toxic and environmentally unfriendly [7].

From this literature study about exergy that accompanying heat transfer, it is concluded that there is a possibility of greater work being extracted from a reversible cycle where the cold source is limited. However, not all exergy can be extracted from the system. In the other words there is also a measure of efficiency in exergy extraction. This efficiency is called exergic efficiency and is formulated as,

$$Exergic\ Efficiency = \frac{Exergy\ Extracted}{Exergy\ Available} \tag{2}$$

## 2.4. Organic Rankine Cycle (ORC)

Organic rankine cycle (ORC) is one of reversible power systems available to extract potential thermal exergy in the system. It is categorized as a steam system, but tin case of ORC the working fluid is replaced by hydrocarbons or hydrocarbon derivations. The usage of hydrocarbon as working fluid enables steam cycle to be applied in low or mid temperature heat configuration since the boiling temperature of these fluids are usually located at a lower temperature than water. The ORC technology is commonly used as an alternative solution for clean, waste heat, or cryogenic power generation. The large application (>400 kW) of this technology are already available, while its smaller counterparts are still in development. The application of this technology using hydrocarbons and its derivatives as working fluid allows the down scaling of conventional power plants. The ORC technology has some inseparable advantages such as,

1. Modular and adaptive to various heat resources
2. Mature and proven technology

3. Simple and less maintenance required
4. Scalable and distributed generation system
5. Commercially available

The different of ORC cycle and conventional Rankine cycle is only on the working fluid. This difference affects all downstream parameters and system behavior while maintaining the system configuration.

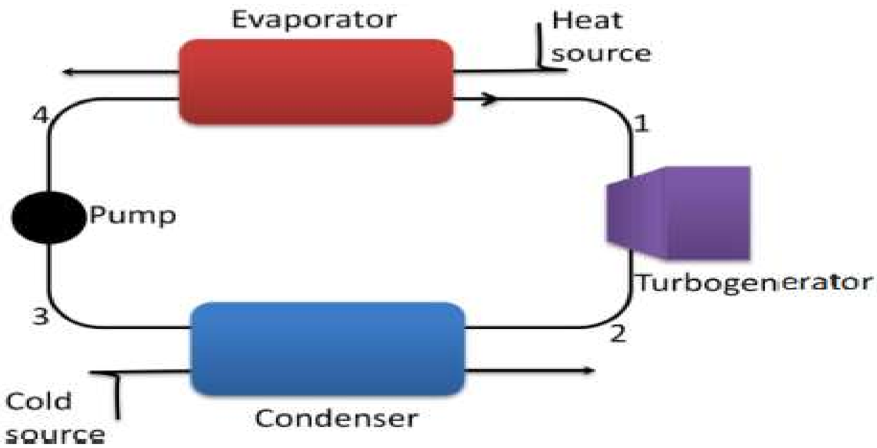


Figure 2.13. ORC Schematic [14]

ORC is made of mainly four components as shown in Figure 2.13: expander, pump, evaporator, and a condenser. The working principle of the system is as follows,

1. (4-1) The working fluid is heated by a heat source in the evaporator. This heating process change the phase of the working fluid into gas. Different from normal Rankine cycle, the working process of heating in ORC which consists of heating, boiling, and superheating can be done in a single evaporator due to lower boiling and superheating temperature of hydrocarbon derivation that is being used as the working fluid.

   Further development in expander material technology enables the usage of supercritical working fluid to be used. It enables a higher cycle efficiency than normal subcritical fluid cycle.

2. (1-2) The high pressure, gas formed working fluid expands the turbine which can be coupled with various application. The working fluid will lose some of its energy and being reduced in temperature and pressure. Depending on the expander equipment used, the phase of the output working fluid can be saturated gas or wet gas.
3. (2-3) The low-pressure working fluid rejects heat using temperature gradient in the condenser and change its phase into liquid form.

4. (3-4) The working fluid is pumped to increase its pressure back to the evaporator. For supercritical system, the fluid is pumped to exceed critical point of the fluid, while subcritical system stays below the critical point.

The ORC cycle can operate in two different design scheme, super- and subcritical. This make the critical point of the working fluid become an important design parameter. The advantage of supercritical design scheme is that it has higher efficiency, while having a possibility of turbine blade damage and fast wear due to supercritical fluid behavior.

The mechanical power produced by the cycle can be calculated using following formula,

$$P_{mech} = W_{OUT} - W_{IN}$$

$$P_{mech} = \dot{m}_{ORC}[(h_1 - h_2) - (h_4 - h_3)] \tag{3}$$

While the heat flow to the cycle is,

$$\dot{Q}_{ORC} = \dot{m}.(h_{in} - h_{out}) = \dot{m}.c_P.(T_{in} - T_{out}) \tag{4}$$

Using the Equation (3) and (4), the efficiency of the ORC cycle can be defined as,

$$\eta_{ORC} = P_{mech}/Q_{ORC} \tag{5}$$

Where,

$h_j$ $(j = 1,2,3,4,)$ = Specific enthalpy for each condition

$\dot{m}_{ORC}$ = Mass flow of the working fluid

$\dot{m}_{HS}$ = Mass flow of the heat carrier

$T_{in}$ = Inlet temperature of heat carrier

$T_{out}$ = Outlet temperature of heat carrier

$c_P$ = Specific heat of heat source medium

The ORC can be designed following the steps proposed by Budisulistyo [15] which are,

1. Selection of heat source
2. Selection of working fluid
3. Selection of component types
4. Selection of cycle design
5. Determination of design parameters

## 2.5. Economic Analysis

Economic analysis is a broad method to determine the feasibility of a project to be carried out by the company. This step is important and has a significant impact on projects.

The economic analysis can use several approaches, one of them is the economical saving approach. This approach gives an insight about the saving that could be a result from implementing or doing a certain project. According to the modified regasification system, the saving resulted from the system implementation can be quantified by multiplying the power produced by the modified system and the energy price used to power the whole FSRU.

The formula to determine the energy price is taken from the formula that is being used by the company to determine the average gas buying price for fuel. The information is obtained in an interview with company supervisor during internship in PT. Nusantara Regas. The formula was stated as follows,

$$Gas\ Price\left(\frac{\$}{MMBTU}\right) = ICP \times 11\% \tag{6}$$

Where,

$ICP$ = Indonesian Crude Oil Price

$MMBTU$ = Million British Thermal Unit

This value is multiplied with the amount of energy produced by the system.

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# CHAPTER III : METHODOLOGY

## 3.1. Study Location

This bachelor thesis will be using data of an existing FSRU vessel owned by PT. Nusantara Regas. The data are taken directly from the company and for further analysis and calculation, will be done in the Laboratory of Marine Machinery and System (MMS) of Marine Engineering Department FTK-ITS.

## 3.2. Research Scheme

The research consists of one main and two sb flowcharts. The main flowchart will guide the researcher to do the general research while sub flowcharts will guide the researcher to do the two more specific parts in the research which is ORC design and system modelling and simulation.

### 3.2.1. Main research flowchart

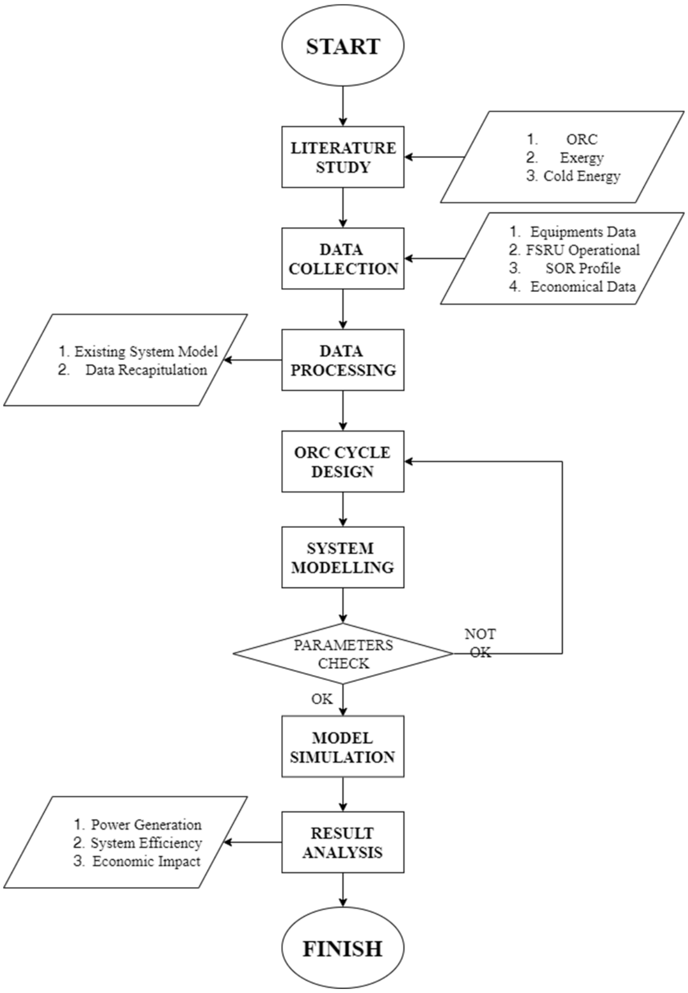


Figure 3.1. Main Research Flowchart

### 3.2.2. Sub research flowcharts

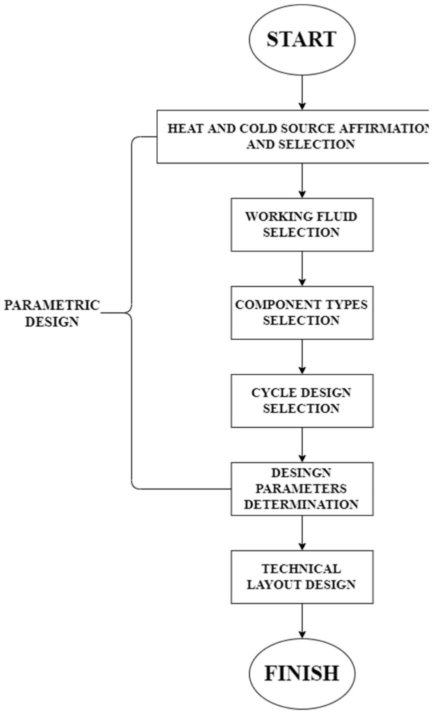


Figure 3.2. ORC design flowchart

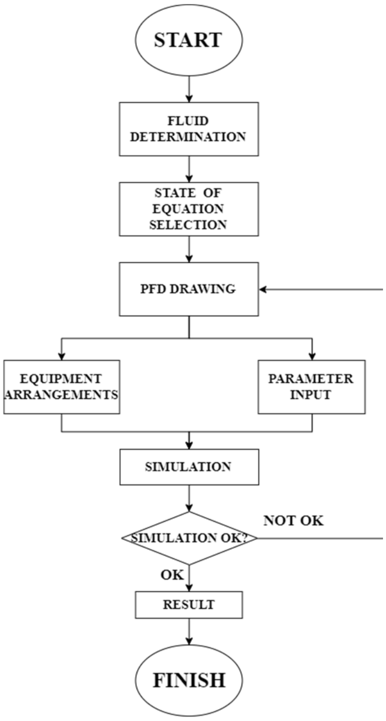


Figure 3.3. Modelling and Simulation Flowchart

## 3.3. Literature Study

Literature study is done to obtain the recent state-of-art of the technology and gives both fundamental and advance knowledge regarding the study material of this thesis, including theories, key variables, phenomena, and methodology of several studies regarding the study material. The literature study was done using scientific approach by reading and summarizing the journals, handbooks, textbooks, company database, and other thesis. There are also discussions between the author and the supervisors which provides different point of views regarding the studies, including their experienced perspectives in their focus field. The literature study is mainly focused in three main concern of this thesis, which are,

1. Organic Rankine Cycle (ORC
2. Exergy Analysis
3. Cold-energy Recovery

## 3.4. Data Collection

Data collection is one of the most important of this study, because it gives the author the steppingstones to complete the whole study. It will be conducted by using conventional method of discussion, literature search, internet surfing, and company data lease. This study needs various data sourced from many entities. The data required for the completion in this thesis are summarized below,

- PID and PFD of the regasification system of the FSRU
- Company daily operational report
- Send-out rate profile
- Equipment data
- Economic data

The gathered data will be further processed in order to be suitable for the research process.

### 3.5. Data Processing

The obtained data will be processed to gives a more comprehensive view of the problem in this thesis. The raw data and its aim will be shown in the table below,

Table 3.1. Raw data and its objectives

| No. | Raw Data | Objectives |
|---|---|---|
| 1. | PID & PFD of regasification system | Initial PFD system model and layout of existing system.<br>Information about input and output to the system. |
| 2. | Company daily operational report | Send-out rate profile and average LNG composition. |
| 3. | Equipment data | Assist in system layout modelling and |
| 4. | Economic data | Assist in economic impact analysis. |

### 3.6. ORC Cycle Design

The ORC cycle design for the system consists of two parts, parametric and layout design. Since the thesis talk about application in the object of the research, then the thesis will also discuss about the layout design and equipment selection.

#### 3.6.1. Parametric design

Parametric design has a purpose to design system parameters on the ORC cycle. The designed parameter will be in a close contact and work parallelly with the layout design. The parametric design process, consist of a set of sub-process, which are,

1. Heat and cold source affirmation and selection
2. Working fluid selection
3. Selection of component types

4. Selection cycle design
5. Determination of design parameters

#### 3.6.2. System layout design

System layout design is the physical design of the system. It is only limited to the PID drawing, which consists of system technical drawing including all its equipment, fittings, and material.

### 3.7. System Modelling

The system simulation is the next step of this process in which the result from parametric and system layout design are put together in form of a model. The system will be modeled using the information from parametric and system layout design with help from a software. The software will verify the parametric and system layout design and if there is a mistake in designing process the software will gives a hint and recommendation.

If there is a mistake in the parameter determination, then the design process will revert to the determination of design parameters step. If the parameters are ok, then the research process can continue to the next step.

### 3.8. System Simulation

The simulation process is an inseparable process of system modelling, because this step is done automatically after the system modelling. The simulation will give us a hint about many parameters such as, power generated, unknown parameters, effect of various changes in the system, etc.

### 3.9. Result Analysis

The results generated from the simulation will be studied and compared with initial values of the existing system to obtain several answers for problem statements such as generated power, system efficiency, and economic aspect.

#### 3.9.1. Power generation

The power generated by the simulated system will be the main result of this thesis. The amount of power generated will be observed for various regasification rate. Moreover, its working fluid flow will be considered and compared to the send-out rate profile to determine the amount of energy produced from this system.

#### 3.9.2. Efficiency

The efficiency is a byproduct from power generation. The expected efficiency to be presented in this result will be exergy efficiency and overall system efficiency.

#### 3.9.3. Economic aspect

The economic aspect will be derived from the system and mainly discussed about how much savings that could be done from implementing this technology onboard an LNG terminal. The economic aspect will be presented in annual saving.

# CHAPTER IV : DISCUSSION AND RESULT

## 4.1. Processed Data

The data are collected from various sources with secondary data source from the operator of FSRU Jawa Barat in form of daily operational data taken between February to June 2019. The data are further processed to obtain usable data ready to be used in the research.

### 4.1.1. Fluid Component

The fluid component poses a significant role in the research due to the variation of LNG processed in the plant. The data are obtained from the plant daily operational report and processed to get the average value of processed LNG. The result of fluid properties as follows,

Table 4.1. LNG Composition

| LNG Composition (%) | |
|---|---|
| Methane | 94,14422799 |
| Ethane | 3,146522136 |
| Propane | 1,710933528 |
| i-Butane | 0,410617692 |
| n-Butane | 0,51025924 |
| i-Pentane | 0,021255709 |
| n-Pentane | 0,00716623 |
| n-Hexane | 0 |
| Nitrogen | 0,025576407 |
| $CO_2$ | 0,009226252 |
| Water | 0,000316667 |
| Total | 99,98615828 |

The fluid used as the intermediate fluid in the existing system is pure (100%) propane. This information of fluids will be used as reference in the system design process.

### 4.1.2. Existing Parameter Data

The parameter derived from existing system's data are as follows,

Table 4.2. Existing System Parameter Data-1

| General Data | |
|---|---|
| Ambient Air Temperature Range | 7 – 65ºC |
| Seawater Temperature Range | 15 – 35ºC |
| Humidity Average | 95% |
| Barometric Pressure | 0,95 – 1,04 bar |
| **Gas Send-out Rates** | |
| Nominal | 200 – 400 MMSCFD |
| Peak | 500 MMSCFD |
| **Gas Send-out Pressures** | |
| Maximum | 59 bar @ 15ºC |
| Nominal | 55 bar |
| **Gas Temperature** | Above 0ºC at Gas Control Station |
| **LNG** | |
| **LNG Feed** | |
| Temperature | -160ºC |
| Pressure | 5 bar |
| Max Mass Flow Rate | 464 ton/h |
| **LNG Before Evaporator** | |
| Temperature | -150ºC |
| Pressure | 74 barg |
| **NG** | |
| **NG After LNG Evaporator (Before Trim Heater)** | |
| Temperature | -20 ºC |
| Pressure | 63 barg |
| **NG After Trim Heater** | |
| Temperature | 17,5 ºC |
| Pressure | 55 barg |

Table 4.3. Existing System Parameter Data-2

| **Propane** | |
|---|---|
| **Propane Before LNG Evaporator** | |
| Pressure | 3 bar |
| Temperature | -1,7°C |
| Max Liquid Fraction | 30% |
| **Propane After LNG Evaporator** | |
| Temperature | -20°C |
| Pressure | 1,5 bar |
| **Propane After Pump** | |
| Pressure | 10 bar |
| Temperature | -20°C |
| **Propane After Pre-Heater** | |
| Temperature | 26 °C |
| Pressure | 10 bar |
| **Propane After NG Trim Heater** | |
| Temperature | 4 °C |
| Pressure | 7,5 bar |
| **Propane After Throttling Valve** | |
| Temperature | 1,7 °C |
| Pressure | 3,5 bar |

The input and output parameters of heat and cold source will be taken as the existing system. This means the data of LNG before and after LNG evaporator and seawater before and after propane heater will be taken as the same value with existing system.

### 4.1.3. Send-out Rate Profile

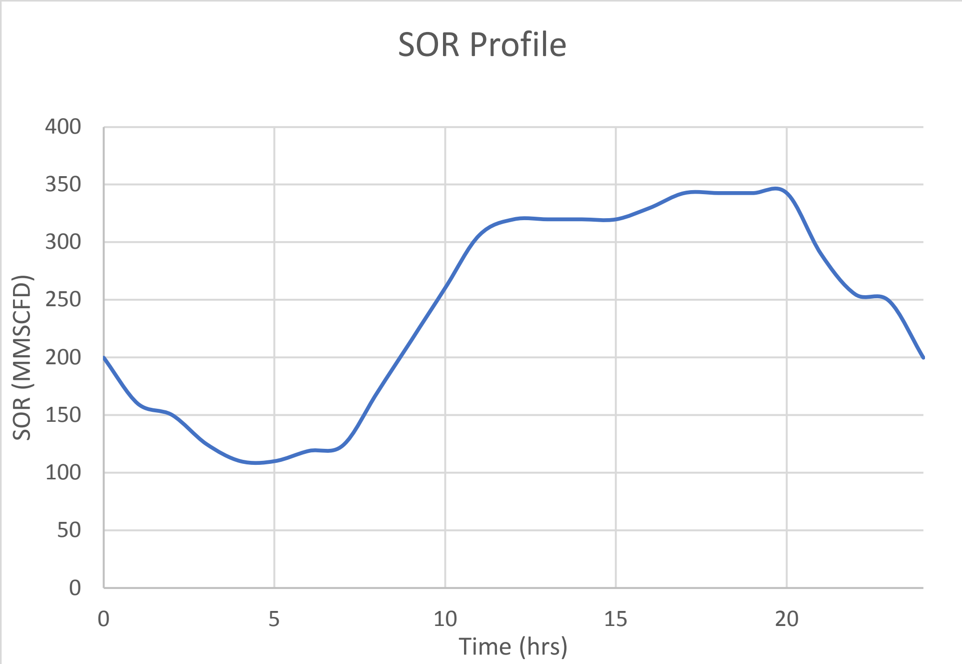


Figure 4.1. SOR Profile of FSRU

The send-out rate profile is the profile of regasification rate throughout the day. The data is taken from the company's file dated back in April 2014. This data will be used to determine the optimum operation time of the designed system. The send-out rate profile has the maximum regasification rate of 342,8 MMSCFD while the minimum rate is at 110 MMSCFD and has a highest ramp of 45,6 MMSCFD/hr in 4 hours.

### 4.1.4. Economic Data

The economic data used to determine the economic impact of the system's modification is based on the oil and gas price and consumed gas to generate the power needed for FSRU operation. The result of data gathering regarding this information is as follows,

1. Indonesian Crude Price

Indonesian crude price or ICP is taken as the reference to determine gas price per MMBTU. The gas price per MMBTU is equal as 11% of the ICP. According to the ICP on September 2019, the price of gas per MMBTU is calculated using the Equation 6 as follows,

$$Gas\ Price\left(\frac{\$}{MMBTU}\right) = ICP \times 11\%$$

$$Gas\ Price\left(\frac{\$}{MMBTU}\right) = \$63{,}26 \times 11\%$$

$$Gas\ Price\left(\frac{\$}{MMBTU}\right) = \$6{,}96$$

Therefore, the reference price for gas is taken as \$6,69 per MMBTU.

2. Gas Consumption

The existing steam boiler consumes 3.718,4 MMBTU/day gas. This gas is consumed to generate power of 18 MW to power the operation onboard the FSRU.

## 4.2. ORC Cycle Design

### 4.2.1. Heat and cold source affirmation and selection

Heat and cold source should be selected and calculated to ensure the cycle can be properly applied.

The cold source of this system is the LNG cold after the BOG re-condenser which has a mass flow rate of 60,41 kg/s, pressure of 74 barg and temperature of -150ºC. the cold source will be heated to a temperature of 17,5 ºC and pressure of 55 barg. According to the information, using the general form of Equation 4 the available cold can be calculated as follows,

$$Q_{COLD} = \dot{m}_{COLD}.(h_{out} - h_{in})$$

$$Q_{COLD} = 60.09\ kg/s.\left((-4477\frac{kJ}{kg}) - (-5234\frac{kJ}{kg})\right)$$

$$Q_{COLD} = 45{,}9\ MW$$

The heat source of the system is the heat from seawater taken from the open sea. The seawater is taken into the system with a temperature of 27ºC and pressure of 2,2 bar. The available heat is theoretically unlimited due to abundant heat resource.

According to the exergy analysis, there is an extractable work in the system in form of exergy. Using the Equation 1, the available exergy on the system can be calculated as follows,

$$Ex_Q = Q.\left(1 - \frac{T_0}{T}\right)\ (1)$$

$$Ex_Q = 45{,}9\ MW.\left(1 - \frac{27^oC}{(-150^oC)}\right)$$

$$Ex_Q = 45.9\ MW.\left(1 - \frac{27^oC}{(-150^oC)}\right)$$

$$Ex_Q = 54{,}16\ MW$$

The obtained result of 54,16 MW is the theoretical exergy available in the system when LNG is selected as cold source. The exergy could be bigger than the actual cold requirement due to unlimited heat provided by seawater acting as the heat source in the system.

Therefore, the LNG is selected as the only cold source in the system and seawater as the main heat source.

### 4.2.2. Working fluid selection

The working fluid selected in the process should come from organic materials. There are various possible working fluids to be used in the system, but the working fluid of propane ($C_3H_8$) is selected due to several reasons, such as:

1. Similarity with recent intermediate fluid.

A similar working fluid in the system will ease the crew and system adaptation process to the modification. It will also ensure the system to be easily integrated with the existing regasification system. The crew will not require additional training to accommodate the new system.

2. Abundant supply and relative cheaper price.

Propane is resulted from ordinary crude oil fractional distillation process. Therefore, it has a relatively cheaper price in comparison with other possible working fluid such as organic refrigerants due to further chemical modifications needed by these organic refrigerants to obtain specified material properties.

3. The natural component of LNG

Propane is a natural component of LNG with a fraction of 1%-2% of the whole LNG component. It also has a low boiling temperature of -40$^{o}$C, which is suitable for cryogenic application. The concern of propane usage as a working fluid is that in the event of propane leak into the LNG system, there will be no worry of natural gas output contamination of foreign gases.

Therefore, propane ($C_3H_8$) is selected as the working fluid in this system with 100% purity.

### 4.2.3. Component type selection

In the designed ORC cycle, there are 4 major components that should be selected. These components are pump, expander, evaporator and condenser.

1. Pump

The type of pump selected for the application in the ORC cycle is the pot-mounted single stage centrifugal cryogenic pump. The pot-mounted criterion is chosen to further decrease the possibility of the impeller working on two different fluid phases. The pot has a gas escape nozzle to prevent cavitation in cryogenic liquid such as propane that is prone to temperature increase.

2. Expander

The expander type chosen for this design process is the turbomachine type which has an advantage in large ORC units in comparison with positive displacement type. The turbomachine has greater efficiency but is limited by the fluid or gas flow rate that flow through it. The expander will be coupled with a generator in order to directly convert the obtained mechanical work into electrical power. The expander and electric generator will be connected by a power shaft incorporated into a gearbox to reduce the speed of the power shaft. The gearbox output will be connected to the generator's shaft to produce electrical power.

3. Evaporator

The working fluid evaporator is chosen to be plate type due to relatively lower operating pressure, lower temperature different, and indirect influence on the main flow of LNG. Furthermore, the plate heat exchanger is deemed relatively cheaper than the heat exchanger used in the condenser (LNG evaporator).

4. Condenser

The condenser (LNG evaporator) used in the system comes from PCHE (Printed Circuit Heat Exchanger) type which allow high duty heat exchange in high pressure to take place and has a significant smaller unit size in comparation to the conventional shell and tube heat exchangers. This condenser type is chosen due to high cooling duty to be performed in order to regasify the LNG with limited space. The compact heat exchanger is made from tough material using high welding technique to ensure structural toughness so that it can be operated under high load and pressure while maintaining compact size. It has become a choice since the conventional plate and frame heat exchanger with the same heat duty are far bigger and heavier in size.

### 4.2.4. Cycle design selection

There are four available cycle design type to be chosen. These design types are sub-critical without recuperator, sub-critical with recuperator, super-critical without recuperator, and super-critical with recuperator. For this ORC design process, the sub-critical without recuperator is chosen as the cycle design type due to the limitation of selected equipment, specifically the expander that can only be operated under the critical point of the fluid.

### 4.2.5. Design parameter determination

To design the parameter used in the system the conventional approach using pressure-enthalpy diagram is used. The limitation of the design process is as follows,

1. The system should be designed as subcritical, non-recuperated system.
2. The input and output parameter of cold reservoir (LNG) should be the same value as existing system.
3. The condition of hot reservoir (seawater) should be the same value as the existing system.

According to above mentioned limitations, the cycle is designed as following block diagram.

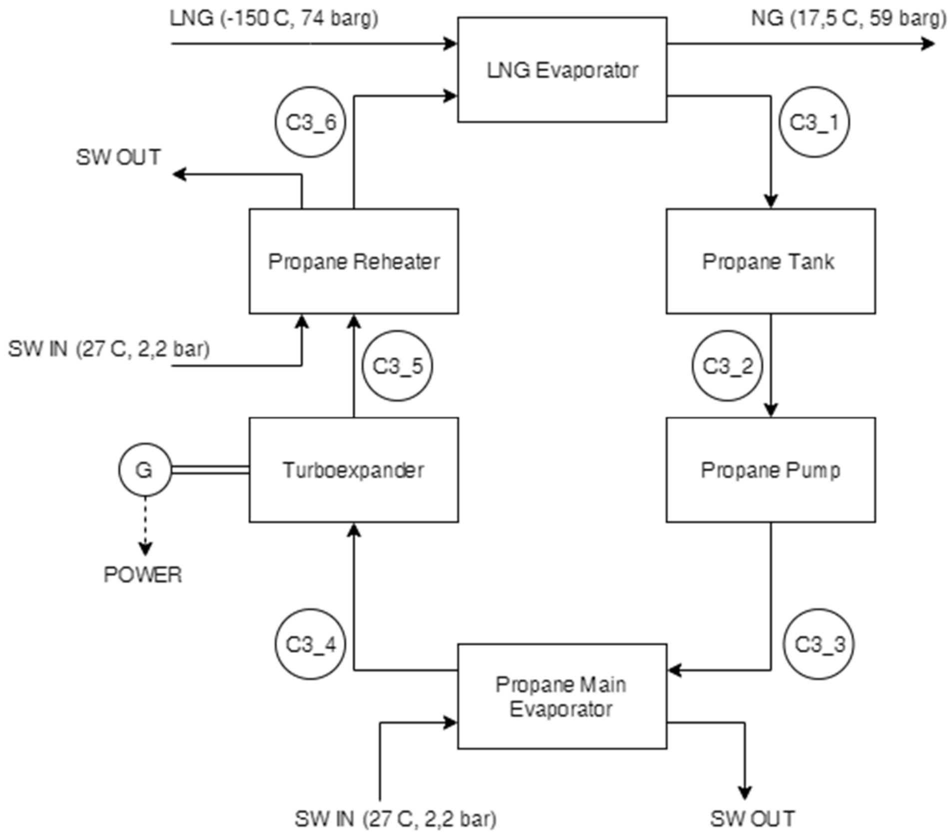


Figure 4.2. System Block Diagram

The C3_X parameters are parameter of the fluid in respective conditions in each cycle phase. The detail of these parameter naming are as follows,

1. C3_1 = Liquid propane after LNG evaporator.
2. C3_2 = Liquid propane before propane pump.
3. C3_3 = Liquid propane before propane evaporator.
4. C3_4 = Propane gas before expander.
5. C3_5 = Propane gas after expander.
6. C3_6 = Propane gas after propane reheater.

The naming of these parameters is for naming purpose only thus do not correlate with the parameter conditions.

The parameters are designed and presented in the following pressure-enthalpy diagram,

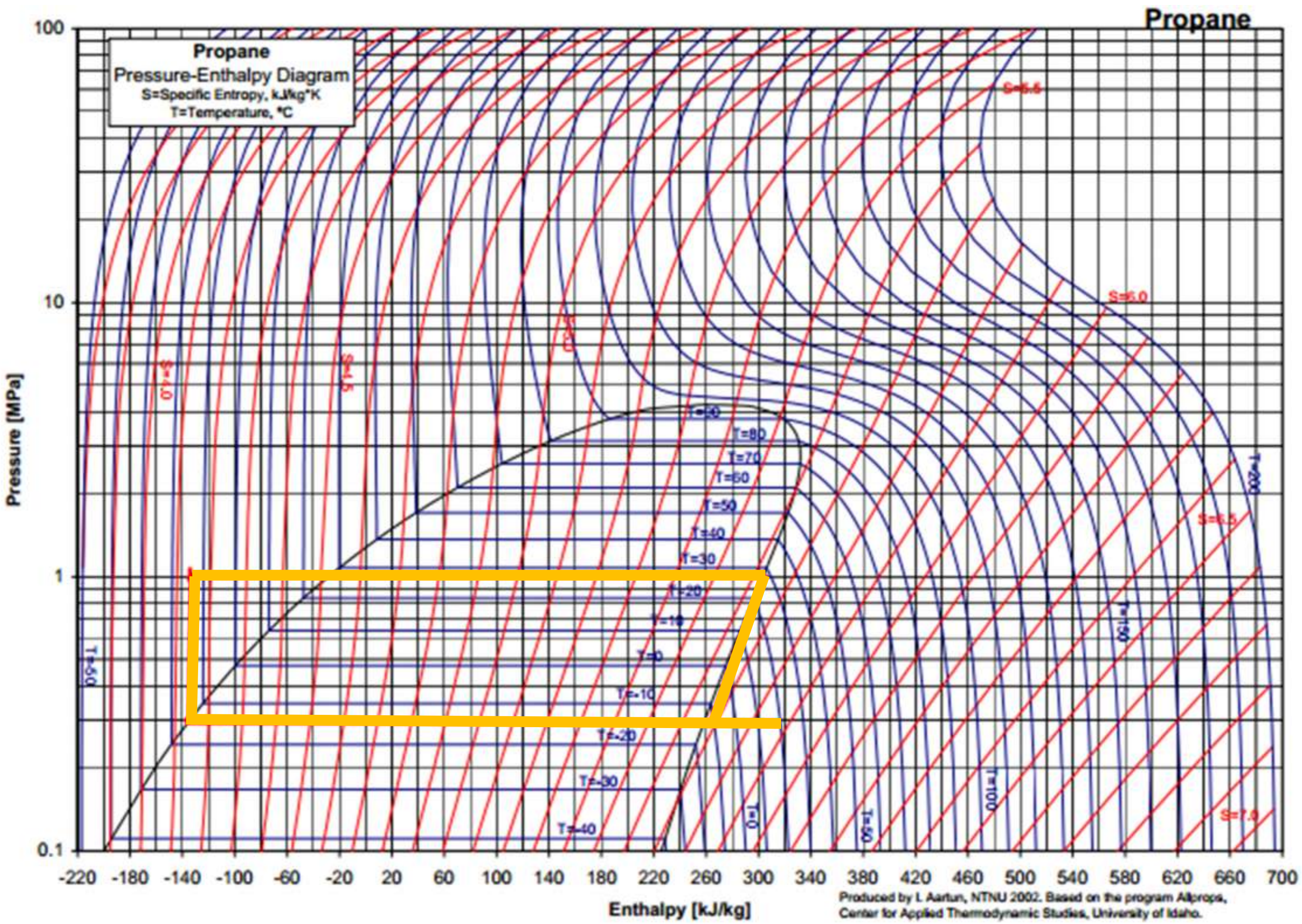


Figure 4.3. Pressure-Enthalpy diagram of the designed ORC

Detailed parameters for each position in the block diagram are shown in the table below,

Table 4.4. Designed ORC Parameters

| Designed Parameters | |
|---|---|
| **C3_1** | |
| Temperature | -15,2°C |
| Pressure | 2,89 bar |
| Mass Flow Rate | 100,4 kg/s |
| **C3_2** | |
| Temperature | -15,2°C |
| Pressure | 2,89 bar |
| Mass Flow Rate | 100,4 kg/s |
| **C3_3** | |
| Temperature | -14,6°C |
| Pressure | 10 bar |
| Mass Flow Rate | 100,4 kg/s |
| **C3_4** | |
| Temperature | 27°C |
| Pressure | 10 bar |
| Mass Flow Rate | 100,4 kg/s |
| **C3_5** | |
| Temperature | -11,3°C |
| Pressure | 2,9 bar |
| Mass Flow Rate | 100,4 kg/s |
| **C3_6** | |
| Temperature | 19,6°C |
| Pressure | 2,89 bar |
| Mass Flow Rate | 100,4 kg/s |

### 4.2.6. Technical layout design

The regasification system onboards the FSRU is modified. The modification adds an expander-generator in order to extract and convert potential exergy into electrical power. The generator and the expander are connected via a metal shaft. The shaft is connected to a variable gearbox to reduce the turning speed. The shaft and the gearbox are assumed to have 98% of efficiency while the generator is assumed to have 85% efficiency in converting mechanical to electrical power. Some other changes are also made such as the elimination of natural gas trim heater and the addition of another plate heat exchanger.

The plate heat exchanger will be called as the propane reheater. Its duty is to reheat the propane after it gone through the expander and losing a significant amount of temperature. The reheating process is necessary to achieve the 17,5ºC output temperature of the natural gas. The number of units needed to be installed is not specified, only the total duty that is specified. This ensures the user's freedom to determine due to different situation, build condition, and economical aspect of consideration.

The trim heater in the other side is eliminated and its duty is integrated into the LNG evaporator to simplify the system while maintaining its functionality.

The flow, tank level control system, and pump power control are now integrated using automatic controller. The control system is connected to a controller. This controller will have three input which are the tank level, flow speed, and pump power. The controller also has additional input from the ship officer on the bridge. The integration of these controller is essential because they are influencing one another and should be controlled simultaneously.

The modified system will need the same input as the old system while maintaining the same output of the old system. Therefore, there is no need to change any input or output in case of the modified system's application.

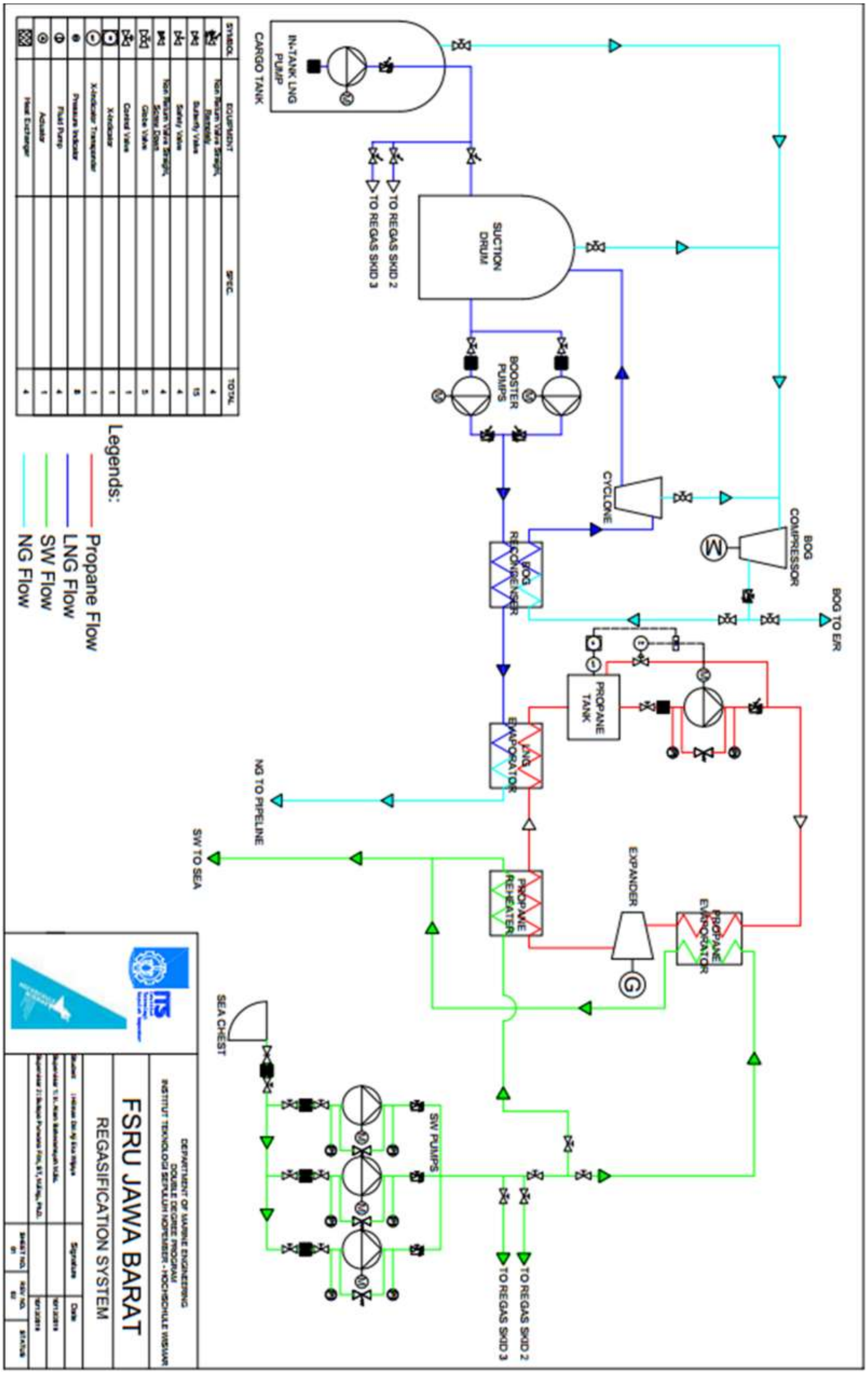


Figure 4.4. Modified System PID

The equipment planned to be used in the system are stated in the table below,

1. Propane Pump

Table 4.5. Propane pump specification

| PROPANE CIRCULATING PUMP | | |
|---|---|---|
| Brand | Nikkiso | |
| Type | 60446L1P326F | |
| Capacity | 1000 | $m^3/h$ |
| Head | 162 | M |
| Power | 326 | kW |
| Speed | 1800 | RPM |
| ELECTRIC MOTOR | | |
| Voltage | 6600 | V |
| Frequency | 60 | Hz |
| DIMENSION | | |
| Diameter | 540 | mm |
| Height | 1909 | mm |

2. Propane Evaporator and Reheater

Table 4.6. Propane evaporator specification

| PROPANE EVAPORATOR | | |
|---|---|---|
| Brand | APV | |
| Type | PFHE: LR9GN | |
| Designed Temp. | -40 to 200°C | |
| Duty | 44,5 | MW |
| DIMENSION | | |
| Height | 2150 | mm |
| Width | 804 | mm |

3. LNG Evaporator

Table 4.7. LNG evaporator specification

| LNG EVAPORATOR | | |
|---|---|---|
| Brand | Heatric | |
| Type | Printed Circuit Heat Exchanger | |
| Designed Temp. | -45 to 70°C | |
| Duty | 45,9 | MW |
| DIMENSION | | |
| Height | 600 | mm |
| Width | 600 | mm |
| Length | 1500 | mm |

4. Expander

Table 4.8. Expander specification

| EXPANDER GENERATOR | | |
|---|---|---|
| Brand | Atlas Copco | |
| Type | ECOTS Expander | |
| Expansion Ratio | 5 | |
| Max Inlet Pressure | 82 | bar |
| Inlet Temp. | -129 to 93 | °C |
| Gas Handled | Natural Gas | |
| Max Speed | 50000 | RPM |
| Max Shaft Power | 5,2 | MW |

The equipment will be installed on fore of the ship. the system will complement other two regasification skids that are already installed onboard the ship. the equipment will be installed in vertical manner since the bow area of the ship is limited. The vertical installation will be using additional platform that are vertically stacked. The height of the platforms will be legally allowed by the classification society since the ship is immobile and only used as a terminal. The equipment will be installed considering its weight and space available onboard the ship. Heavy equipment will be installed first on lower platform to maintain ship stability. The ship stability is also considered undisturbed since the ship is permanently moored to a dolphin mooring platform, thus providing more freedom in equipment installation.

## 4.3. System Modelling and Simulation

### 4.3.1. Fluid specification

The fluid used as the heat sink in the system modelling is LNG with mole fraction quality as stated in Table 4.1 in this research. The fluid used as the heat source is the seawater which is represent by $H_2O$ with mole fraction quality of 1 (pure water) due to the limitation of the software. The fluid used as the working fluid is propane with mole fraction quality of 1 (pure propane). These three fluids are incorporated into one fluid components consisting of all the mole fraction elements of each fluid.

### 4.3.2. State of equation selection

The state of equation is important to predict and calculate the properties of fluids in thermodynamic. It is relating the state variables of matter under given condition such as temperature, pressure, volume, and internal energy. For this study, the state of equation stated by Peng-Robinson is used.

### 4.3.3. PFD drawing input

The PFD of the system should be inputted in order to simulate the system. The PFD were made based on the block diagram and designed parameters in Section 4.2.5. and technical layout in Section 4.2.6. the drawing input is as follows,

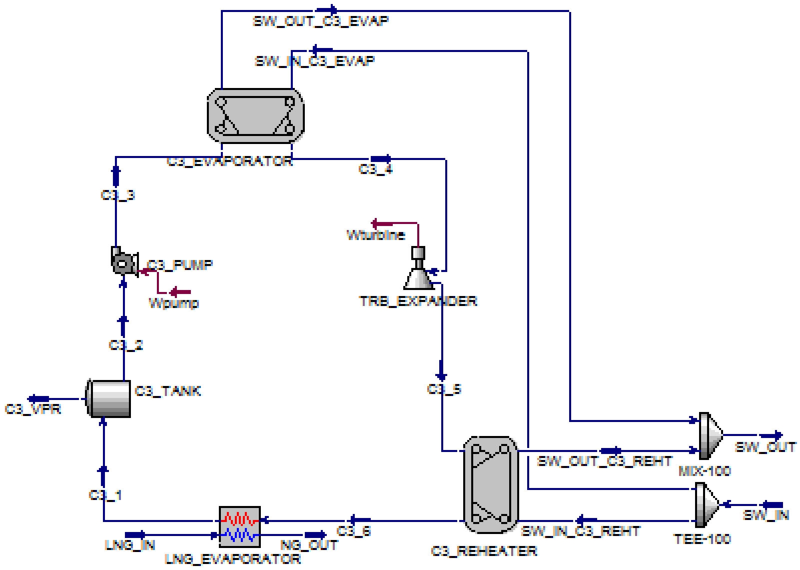


Figure 4.5. PFD drawing of the system

### 4.3.4. Simulation result

The simulation is done by varying the send-out rate of FSRU per 50 MMSCFD from 0 to 250 MMSCFD. The result of this simulation is shown in the table on following pages.

Table 4.9. Simulation Result on Working Fluid at 250 MMSCFD

| | Unit | LNG_IN | NG_OUT | SW_IN | SW_OUT | C3_1 | C3_2 | C3_3 |
|---|---|---|---|---|---|---|---|---|
| **Vapour Fraction** | | 0,00 | 1,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **Temperature** | ***C*** | -150,00 | 17,50 | 27,00 | 18,18 | -15,20 | -15,20 | -14,64 |
| **Pressure** | ***bar*** | 75,01 | 56,01 | 2,20 | 2,20 | 2,89 | 2,89 | 10,00 |
| **Molar Flow** | ***MMSCFD*** | 250,00 | 250,00 | 5230,25 | 5230,25 | 164,50 | 164,50 | 164,50 |
| **Mass Flow** | ***kg/s*** | 60,09 | 60,09 | 1303,61 | 1303,61 | 100,36 | 100,36 | 100,36 |
| **Liquid Volume Flow** | ***m3/h*** | 692,13 | 692,13 | 4702,47 | 4702,47 | 713,08 | 713,08 | 713,08 |
| **Heat Flow** | ***MW*** | -314,54 | -269,02 | -20700,15 | -20749,75 | -283,66 | -283,66 | -283,49 |

| | Unit | C3_4 | C3_5 | C3_6 | SW_IN_C3_EVAP | SW_IN_C3_REHT | SW_OUT_C3_EVAP | SW_OUT_C3_REHT |
|---|---|---|---|---|---|---|---|---|
| **Vapour Fraction** | | 1,00 | 1,00 | 1,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **Temperature** | ***C*** | 27,00 | -11,34 | 19,60 | 27,00 | 27,00 | 18,44 | 15,00 |
| **Pressure** | ***bar*** | 10,00 | 2,90 | 2,89 | 2,20 | 2,20 | 2,20 | 2,20 |
| **Molar Flow** | ***MMSCFD*** | 164,50 | 164,50 | 164,50 | 4831,78 | 398,48 | 4831,78 | 398,48 |
| **Mass Flow** | ***kg/s*** | 100,36 | 100,36 | 100,36 | 1204,29 | 99,32 | 1204,29 | 99,32 |
| **Liquid Volume Flow** | ***m3/h*** | 713,08 | 713,08 | 713,08 | 4344,20 | 358,27 | 4344,20 | 358,27 |
| **Heat Flow** | ***MW*** | -239,04 | -243,28 | -238,14 | -19123,06 | -1577,08 | -19167,52 | -1582,22 |

Table 4.10. Simulation Result on Working Fluid at 200 MMSCFD

| | **Unit** | **LNG_IN** | **NG_OUT** | **SW_IN** | **SW_OUT** | **C3_1** | **C3_2** | **C3_3** |
|---|---|---|---|---|---|---|---|---|
| **Vapour Fraction** | | 0,00 | 1,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **Temperature** | ***C*** | -150,00 | 17,50 | 27,00 | 19,94 | -15,20 | -15,20 | -14,64 |
| **Pressure** | ***bar*** | 75,01 | 56,01 | 2,20 | 2,20 | 2,89 | 2,89 | 10,00 |
| **Molar Flow** | ***MMSCFD*** | 200,00 | 200,00 | 5230,25 | 5230,25 | 131,60 | 131,60 | 131,60 |
| **Mass Flow** | ***kg/s*** | 48,07 | 48,07 | 1303,61 | 1303,61 | 80,29 | 80,29 | 80,29 |
| **Liquid Volume Flow** | ***m3/h*** | 553,70 | 553,70 | 4702,47 | 4702,47 | 570,47 | 570,47 | 570,47 |
| **Heat Flow** | ***MW*** | -251,63 | -215,21 | -20700,15 | -20739,83 | -226,93 | -226,93 | -226,79 |

| | **Unit** | **C3_4** | **C3_5** | **C3_6** | **SW_IN_C3_EVAP** | **SW_IN_C3_REHT** | **SW_OUT_C3_EVAP** | **SW_OUT_C3_REHT** |
|---|---|---|---|---|---|---|---|---|
| **Vapour Fraction** | | 1,00 | 1,00 | 1,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **Temperature** | ***C*** | 27,00 | -11,34 | 19,60 | 27,00 | 27,00 | 20,26 | 15,00 |
| **Pressure** | ***bar*** | 10,00 | 2,90 | 2,89 | 2,20 | 2,20 | 2,20 | 2,20 |
| **Molar Flow** | ***MMSCFD*** | 131,60 | 131,60 | 131,60 | 4911,47 | 318,78 | 4911,47 | 318,78 |
| **Mass Flow** | ***kg/s*** | 80,29 | 80,29 | 80,29 | 1224,16 | 79,45 | 1224,16 | 79,45 |
| **Liquid Volume Flow** | ***m3/h*** | 570,47 | 570,47 | 570,47 | 4415,86 | 286,61 | 4415,86 | 286,61 |
| **Heat Flow** | ***MW*** | -191,23 | -194,62 | -190,51 | -19438,48 | -1261,67 | -19474,05 | -1265,78 |

Table 4.11. Simulation Result on Working Fluid at 150 MMSCFD

| | Unit | LNG_IN | NG_OUT | SW_IN | SW_OUT | C3_1 | C3_2 | C3_3 |
|---|---|---|---|---|---|---|---|---|
| Vapour Fraction | | 0,00 | 1,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Temperature | C | -150,00 | 17,50 | 27,00 | 21,71 | -15,20 | -15,20 | -14,64 |
| Pressure | bar | 75,01 | 56,01 | 2,20 | 2,20 | 2,89 | 2,89 | 10,00 |
| Molar Flow | MMSCFD | 150,00 | 150,00 | 5230,25 | 5230,25 | 98,70 | 98,70 | 98,70 |
| Mass Flow | kg/s | 36,05 | 36,05 | 1303,61 | 1303,61 | 60,22 | 60,22 | 60,22 |
| Liquid Volume Flow | m3/h | 415,28 | 415,28 | 4702,47 | 4702,47 | 427,85 | 427,85 | 427,85 |
| Heat Flow | MW | -188,73 | -161,41 | -20700,15 | -20729,91 | -170,20 | -170,20 | -170,09 |

| | Unit | C3_4 | C3_5 | C3_6 | SW_IN_C3_EVAP | SW_IN_C3_REHT | SW_OUT_C3_EVAP | SW_OUT_C3_REHT |
|---|---|---|---|---|---|---|---|---|
| Vapour Fraction | | 1,00 | 1,00 | 1,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Temperature | C | 27,00 | -11,34 | 19,60 | 27,00 | 27,00 | 22,03 | 15,00 |
| Pressure | bar | 10,00 | 2,90 | 2,89 | 2,20 | 2,20 | 2,20 | 2,20 |
| Molar Flow | MMSCFD | 98,70 | 98,70 | 98,70 | 4991,17 | 239,09 | 4991,17 | 239,09 |
| Mass Flow | kg/s | 60,22 | 60,22 | 60,22 | 1244,02 | 59,59 | 1244,02 | 59,59 |
| Liquid Volume Flow | m3/h | 427,85 | 427,85 | 427,85 | 4487,51 | 214,96 | 4487,51 | 214,96 |
| Heat Flow | MW | -143,42 | -145,97 | -142,88 | -19753,90 | -946,25 | -19780,57 | -949,33 |

Table 4.12. Simulation Result on Working Fluid at 100 MMSCFD

| | Unit | LNG_IN | NG_OUT | SW_IN | SW_OUT | C3_1 | C3_2 | C3_3 |
|---|---|---|---|---|---|---|---|---|
| Vapour Fraction | | 0,00 | 1,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Temperature | C | -150,00 | 17,50 | 27,00 | 23,47 | -15,20 | -15,20 | -14,64 |
| Pressure | bar | 75,01 | 56,01 | 2,20 | 2,20 | 2,89 | 2,89 | 10,00 |
| Molar Flow | MMSCFD | 100,00 | 100,00 | 5230,25 | 5230,25 | 65,80 | 65,80 | 65,80 |
| Mass Flow | kg/s | 24,04 | 24,04 | 1303,61 | 1303,61 | 40,14 | 40,14 | 40,14 |
| Liquid Volume Flow | m3/h | 276,85 | 276,85 | 4702,47 | 4702,47 | 285,23 | 285,23 | 285,23 |
| Heat Flow | MW | -125,82 | -107,61 | -20700,15 | -20719,99 | -113,47 | -113,47 | -113,40 |

| | Unit | C3_4 | C3_5 | C3_6 | SW_IN_C3_EVAP | SW_IN_C3_REHT | SW_OUT_C3_EVAP | SW_OUT_C3_REHT |
|---|---|---|---|---|---|---|---|---|
| Vapour Fraction | | 1,00 | 1,00 | 1,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Temperature | C | 27,00 | -11,34 | 19,60 | 27,00 | 27,00 | 23,74 | 15,00 |
| Pressure | bar | 10,00 | 2,90 | 2,89 | 2,20 | 2,20 | 2,20 | 2,20 |
| Molar Flow | MMSCFD | 65,80 | 65,80 | 65,80 | 5070,86 | 159,39 | 5070,86 | 159,39 |
| Mass Flow | kg/s | 40,14 | 40,14 | 40,14 | 1263,88 | 39,73 | 1263,88 | 39,73 |
| Liquid Volume Flow | m3/h | 285,23 | 285,23 | 285,23 | 4559,16 | 143,31 | 4559,16 | 143,31 |
| Heat Flow | MW | -95,61 | -97,31 | -95,26 | -20069,31 | -630,83 | -20087,10 | -632,89 |

Table 4.13. Simulation Result on Working Fluid at 50 MMSCFD

| | Unit | LNG_IN | NG_OUT | SW_IN | SW_OUT | C3_1 | C3_2 | C3_3 |
|---|---|---|---|---|---|---|---|---|
| Vapour Fraction | | 0,00 | 1,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Temperature | C | -150,00 | 17,50 | 27,00 | 25,24 | -15,20 | -15,20 | -14,64 |
| Pressure | bar | 75,01 | 56,01 | 2,20 | 2,20 | 2,89 | 2,89 | 10,00 |
| Molar Flow | MMSCFD | 50,00 | 50,00 | 5230,25 | 5230,25 | 32,90 | 32,90 | 32,90 |
| Mass Flow | kg/s | 12,02 | 12,02 | 1303,61 | 1303,61 | 20,07 | 20,07 | 20,07 |
| Liquid Volume Flow | m3/h | 138,43 | 138,43 | 4702,47 | 4702,47 | 142,62 | 142,62 | 142,62 |
| Heat Flow | MW | -62,91 | -53,80 | - 20700,15 | -20710,07 | -56,73 | -56,73 | -56,70 |

| | Unit | C3_4 | C3_5 | C3_6 | SW_IN_C3_EVAP | SW_IN_C3_REHT | SW_OUT_C3_EVAP | SW_OUT_C3_REHT |
|---|---|---|---|---|---|---|---|---|
| Vapour Fraction | | 1,00 | 1,00 | 1,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Temperature | C | 27,00 | -11,34 | 19,60 | 27,00 | 27,00 | 25,39 | 15,00 |
| Pressure | bar | 10,00 | 2,90 | 2,89 | 2,20 | 2,20 | 2,20 | 2,20 |
| Molar Flow | MMSCFD | 32,90 | 32,90 | 32,90 | 5150,56 | 79,70 | 5150,56 | 79,70 |
| Mass Flow | kg/s | 20,07 | 20,07 | 20,07 | 1283,75 | 19,86 | 1283,75 | 19,86 |
| Liquid Volume Flow | m3/h | 142,62 | 142,62 | 142,62 | 4630,82 | 71,65 | 4630,82 | 71,65 |
| Heat Flow | MW | -47,81 | -48,66 | -47,63 | -20384,73 | -315,42 | -20393,62 | -316,44 |

Table 4.14. Simulation Result on Electrical Power

| SOR | Unit | Power Output (kW) | Electrical Power (kWe) |
|---|---|---|---|
| **0** | **MMSCFD** | 0 | 0 |
| **50** | **MMSCFD** | 848,9 | 707,1337 |
| **100** | **MMSCFD** | 1698 | 1414,434 |
| **150** | **MMSCFD** | 2547 | 2121,651 |
| **200** | **MMSCFD** | 3395 | 2828,035 |
| **250** | **MMSCFD** | 4244 | 3535,252 |

The simulation gave out result that the system could produce maximum 4,24 MW mechanical power with maximum system pressure of 10 bar and lower system pressure of 2,9 bar. Furthermore, at its maximum generation capacity it could supply a natural gas send-out rate of 250 MMSCFD and has a maximum working fluid molar flow of 183.600 Nm3/h or 98.7 MMSCFD.

### 4.3.5. Simulation result analysis

Complement to this simulation result, the simulation software also analyzes the effect of the independent to the dependent parameters. The analyzed independent parameters are,

1. Molar flow of NG_OUT (Gas send-out rate)
2. Pressure of C3_3 (Fluid phase before propane evaporator)
3. Pressure of C3_5 (Fluid phase after expander)
4. Temperature of C3_6 (Fluid phase after propane reheater)

While the analyzed dependent parameters are,

1. Expander power output (Wturbine)
2. Molar flow of the propane (C3_4)

The result of simulation is analyzed using the simulation and analysis software. The result of this analysis is as follows,

1. Effect of send-out rate of natural gas to the turbine power output

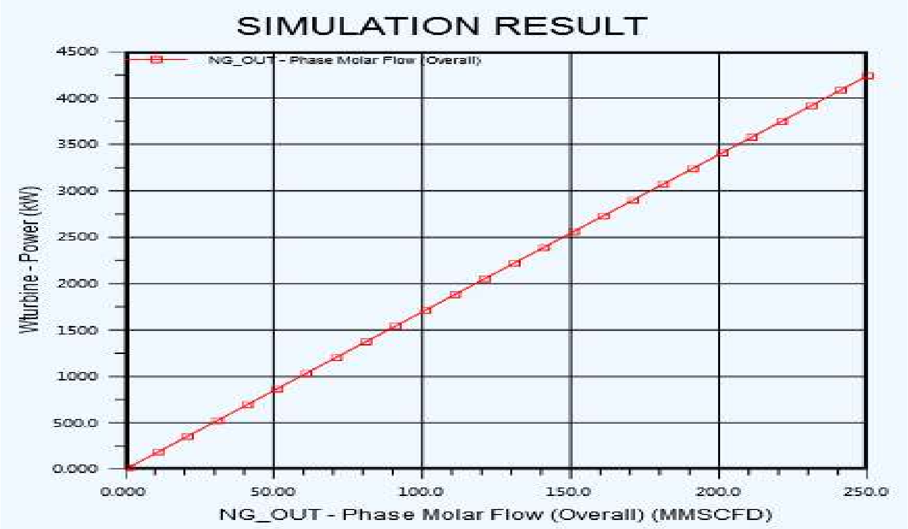


Figure 4.6. Turbine Power vs FSRU Send-out Rate

According to the simulation result obtained from the system's PFD model, the turbine power has a proportional relationship with the SOR (Send-out Rate) of the natural gas produced by the FSRU. The power of the turbine goes up in a linear manner together with the increase of send-out rate of the FSRU. The linear relationship between the two can be obtained by holding the parameters in a still condition for which the molar flow of the intermediate fluid should be adjusted properly for each SORs of the FSRU. This relation between the SOR of the natural gas and the intermediate fluid can be shown in the diagram below,

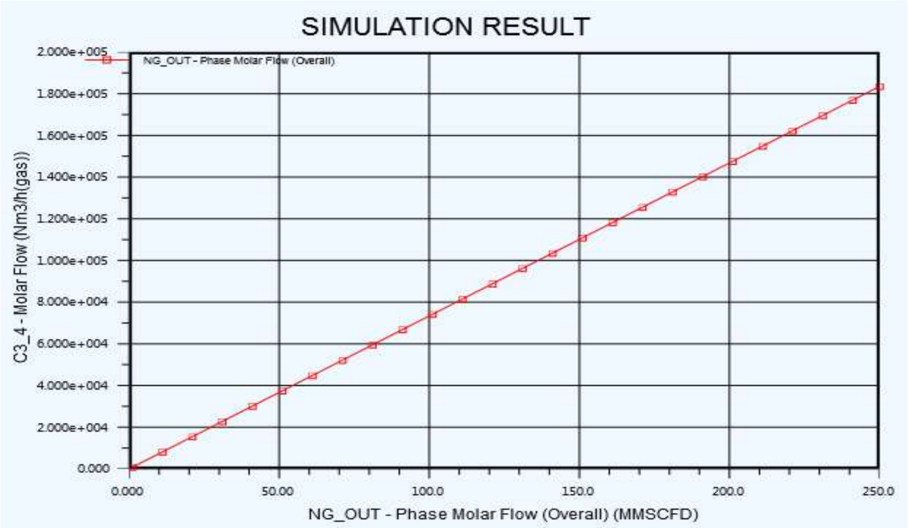


Figure 4.7. Intermediate Fluid Molar Flow vs FSRU Send-out Rate

2. The significant parameters in the system

There are many parameters that are embedded into the system especially in the ORC system. These parameters are determined using the pressure-enthalpy diagram as shown in the section 4.2.5 of this study. The simulation results in a detailed analysis of which parameter has significant effect to the output power from the expander. The parameters which are analyzed are the parameter which are given or specified by the system designer with assumption that the other calculated parameters depend on these parameters. The first parameter to be observed is the effect of the C3_3 (Fluid before expander)'s pressure to the power output from the system.

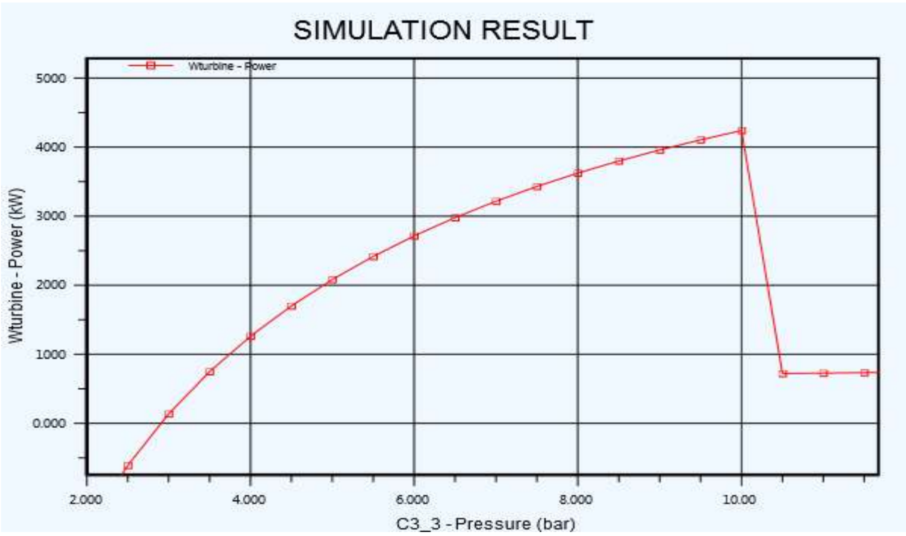


Figure 4.8. Pressure before expander vs power output

From figure 4.8, it can be clearly seen that the pressure before the expander has a significant effect on the power output. The power output increases as the pressure on phase C3_3 increases. But it stopped in 10 bar pressure and experience a dramatic decrease of power output. The decrease of power beyond 10 bar is likely due to the phase of the fluid becoming partly liquid in the given temperature and pressure. The highest pressure that can be achieved in this system is limited to 10 bar due to the heat source (in this case sea water) capability which is set to has temperature of 27°C. the pressure should be lower or equal to the seawater temperature otherwise temperature cross will happen in the heat exchanger or another heat source with higher temperature is needed.

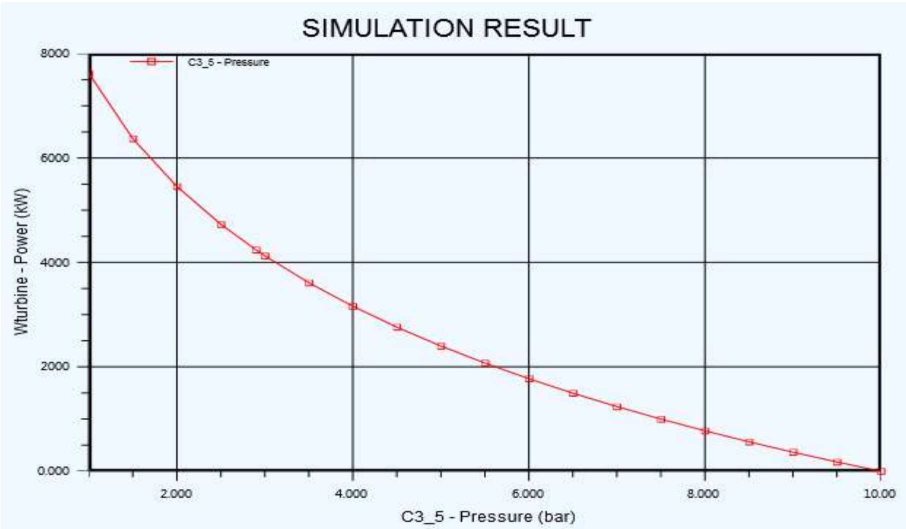


Figure 4.9. Pressure after expander vs power output

From Figure 4.9, the power output decreases as the pressure after the expander increases. From these two figures, a tendency is to be observed in which the turbine power is greatly dependent on the pressure difference of before and after expander, while in this system, the upper limit of the intermediate fluid pressure (10 bar) is limited by the condition of heat source and the lower limit of pressure is limited by the molar flow of the fluid itself.

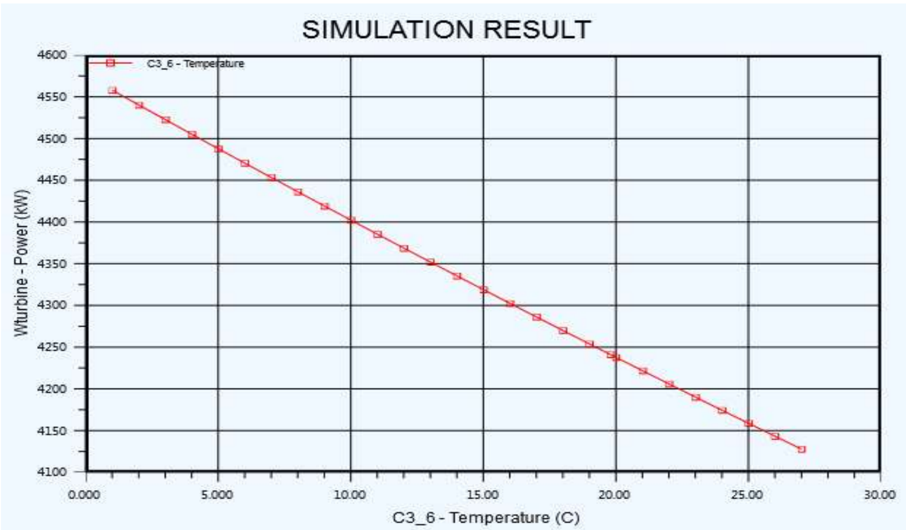


Figure 4.10. Temperature after reheater vs power output

Another parameter that has a significant effect on the power output is the temperature of the working fluid after the reheater (C3_6). It can be seen from the Figure 4.10, that the power output decreases as the temperature after the reheater increases. The higher power output couldn't be reached because the temperature of

C3_6 should be higher than 17,5ºC, otherwise a temperature cross will happen in the LNG evaporator.

According to these simulation results, there are three parameters that are taken as significant values in the system. These parameters are,

1. Pressure difference in the expander.
2. Temperature after reheater.

## 4.4. Analysis

### 4.4.1. Total Power Production Analysis

The total power produced from system modification can be calculated by summing the total electrical power production throughout the day. The power production will fluctuate in parallel to the send-out-ratio of the FSRU. Therefore, a power graph should be derived using SOR profile shown previously in Figure 4.1 of this report. The power produced profile is shown below,

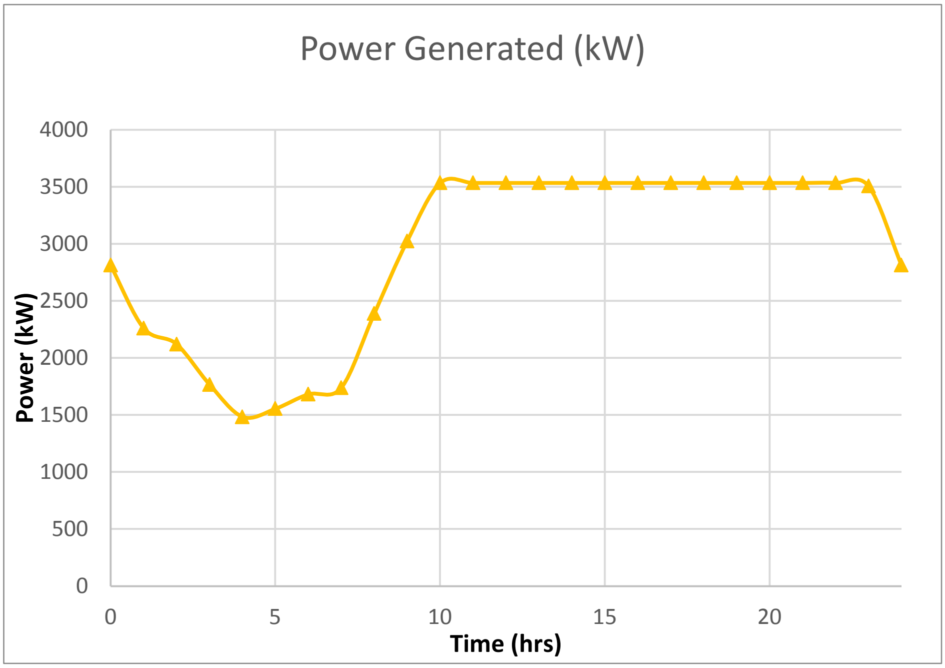


Figure 4.11. Daily generated power profile

Using the integration principle, the area under the graph or the total power generated from the modified system is 73,9 MWh or equal as 252,1573 MMBTU.

### 4.4.2. Efficiency Analysis

1. Exergic Efficiency

The exergic efficiency can be calculated using Eq. 2, in which the extracted exergy is the power output from the system and the available exergy is already calculated in section 4.2.1. The net power output of the system can be calculated using Equation (3) as,

$$P_{mech} = W_{OUT} - W_{IN}$$

$$P_{mech} = 4{,}24\ MW - 0{,}173\ MW$$

$$P_{mech} = 4{,}06\ MW$$

Using the net power output as extracted exergy, the exergy efficiency can be calculated using the Equation 5 as follows,

$$Exergic\ Efficiency = \frac{Exergy\ Extracted}{Exergy\ Available}$$

$$Exergic\ Efficiency = \frac{4{,}06\ MW}{54{,}16\ MW}$$

$$Exergic\ Efficiency = 7{,}5\%$$

The exergic efficiency is calculated as 7,5% of total exergy that can be extracted if the value of $W_{IN}$ uses the needed work as resulted from the simulation. However, if the work of designed equipment is used, then the exergic efficiency is reduced to be 7% of overall exergy.

The efficiency obtained can be categorized as normal due to the lower heat source used in the ORC cycle. The value is categorized as normal since it is in the range of 5%-10%.

2. Overall efficiency

The boiler generator in the FSRU currently generating as big as 18 MW of electricity by consuming about 3.718,4 MMBTU/day. Using a conversion factor of 0,012 MMBTU/(day.MW), the overall efficiency of the system is 40,34% following the calculation below,

$$\eta = \frac{energy\ output}{energy\ input}$$

$$\eta = \frac{18\ MW \times \frac{1000 MMBTU}{12\quad MW.d}}{3718{,}4 \frac{MMBTU}{day}}$$

$$\eta = 40{,}34\%$$

The additional electrical energy from the ORC system will increase the overall efficiency of the system. The additional energy that comes from the modified system is convertible to the amount of energy used to generate the power. the 252 MMBTU additional energy is divided by current system's efficiency to obtain 625 MMBTU. The 625 MMBTU energy will reduce the amount of energy needed for power generation thus increasing the overall efficiency. Taking the maximum electrical output of the system, the overall efficiency of the system will increase to 48,5% following below calculation,

$$\eta = \frac{energy\ output}{energy\ input} = \frac{18\ MW \times \frac{1000 MMBTU}{12\ \ MW.d}}{\left(3718{,}4\frac{MMBTU}{d} - 625\frac{MMBTU}{day}\right)}$$

$$\eta = 48{,}5\%$$

The overall system efficiency will increase by 8,16% after the implementation of one modified regasification system.

### 4.4.3. Economic Analysis

The economic analysis will explain about how much the system affect the operational cost of the system economically. It will show the saving that comes from implementation of this modification into the system by calculating the electric power price of the generated electricity based on the power price of existing system. The power price of the existing system will be derived from the daily consumption of boiler to produce the onboard electricity.

1. Power price derivation

The power price is derived from the power consumption information on the existing FSRU and the power price which depends on the ICP price. The company has set a formula of determining gas price to be consumed in the FSRU. The formula used is stated in the Equation 6. According to this formula, the gas price can be calculated as follows,

$$Gas\ Price\left(\frac{\$}{MMBTU}\right) = ICP \times 11\% = \$63{,}26 \times 11\% = \$6{,}96$$

The gas price is calculated using ICP price which is \$63,26 on November 2019 and results in gas price of \$ 6,96/MMBTU.

2. Economical saving calculation

The economical saving can be calculated by multiplying the amount of energy and the energy price/rate. The amount of energy should be firstly converted into MMBTU unit. The converted energy unit is then multiplied by the energy price rate which at \$6,69/MMBTU to obtain the daily saving rate if the modified is applied onboard the regasification system in FSRU. The calculation proceeds as follows,

$$\frac{Savings}{day} = Gas\ Price\left(\frac{\$}{MMBTU}\right) \times Energy = 6{,}69\ \times 252{,}1573 = \$1686{,}9$$

$$Annual\ saving = \$1686{,}9 \times 365 = \$\ 615.718{,}5\ \approx \boldsymbol{Rp.8.620.05\ 9000}$$

3. Additional revenue from idle gas calculation

Gas that are initially used to power the FSRU is now available for selling. The amount of energy which is available for sell can be calculated by dividing the power generated (73,9 MWh) by the initial or the old system's efficiency which is at 40,34%. The amount of energy is then multiplied by the gas selling price, whose component consists of regasification fee ($1,8/MMBTU). The calculation proceeds as follows,

$$Daily\ Revenue = Sell\ Price\ \left(\frac{\$}{MMBTU}\right) \times \frac{Energy}{Efficiency} = \frac{\$1{,}8}{\text{MMBTU}} \times \frac{252{,}1573\ MMBTU}{40{,}34\%}$$

$$Daily\ Revenue = \frac{\$1{,}8}{\text{MMBTU}} \times 625{,}08\ MMBTU = \$1125{,}1$$

$$Annual\ Revenue = \$1125{,}1 \times 365 = \$410.677{,}6 = \boldsymbol{Rp.5.7\ 4\ .9\!\!4\ 8584\ 0}$$

According to the economical saving and additional revenue calculation, the total benefit resulted from the application of the modified system is Rp.14.369.544.840 anually.

# CHAPTER V : CONCLUSION AND SUGGESTION

## 5.1. Conclusion

From the research conducted to complete this study, several conclusions can be made from the analysis of modified regasification system onboard FSRU Jawa Barat. These conclusions are presented in the following:

1. The regasification system is modified by adding an Atlas Copco expander with a power generation capacity of 5,2 MW and a Plate and Frame reheater with a duty of 5,12 MW in the working fluid flow to extract potential exergy. The reheater is needed since the expander exhaust working fluid is in lower temperature than the grid temperature of the natural gas. The system also applies integrated automatic pump power and working fluid flow control using control valve and controller.
2. The modified regasification system manages to extract an amount of 4,06 MW of mechanical power from an enormous 54,16 MW of exergy accompanying heat transfer in the regasification process. This amount equals to approximately 7,5% exergic efficiency. From this mechanical power the system is expected to deliver a maximum 3,5 MW electrical power at its peak SOR. Coupled with its SOR profile, the system can generate daily a total energy of 73,9 MWh. The produced energy contributes to the overall energy efficiency increase of 3,75%. The pressure difference in expander and temperature after reheater affects the performance of the system greatly.
3. The total benefit resulted from the modified system’s application is Rp.14.369.544.840 anually. This benefit consists of the economical saving Rp.8.620.059.000 and additional revenue from the idle gas sell $Rp.$5.749.485.840.

## 5.2. Suggestion

1. The lack of data about the cryogenic equipment specifically about its detailed specification and price has unfortunately affected this study’s result. The more exact economic impact analysis such cost-benefit analysis cannot be done. Future research regarding this matter is possible.
2. A more comprehensive supporting software for system modelling should be used. The recent software has flaws especially in the availability of chosen equipment and limitations.

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# BIBLIOGRAPHY


[1] PT. PLN (Persero), Rencana Usaha Penyediaan Tenaga Listrik, 2019.

[2] Golar LNG Ltd., Terminal Operation Manual: Nusantara Regas Satu, 2012.

[3] M. I. Khan, “Comparative Well-to-Tank energy use and greenhouse gas assessment of natural gas as a transportation fuel in Pakistan,” *Energy For Sustainable Development,* vol. 43, pp. 38-59, 2018.

[4] F. Zhang dan X.-m. Yu, “LNG Cold Energy Recovery and Power Generation,” *IEEE,* 2009.

[5] S. Lee dan B. C. Choi, “Thermodynamic Assessment of Integrated Heat Recovery System Combining Exhaust-gas Heat and Cold Energy for LNG Regasification Process in FSRU Vessel,” *Journal of Mechanical Science and Technology,* vol. 3, no. 30, pp. 1389-1398, 2016.

[6] S. Mokhatab, J. Y. Mak, J. V. Valappil dan D. A. Wood, Handbook of Liquefied Natural Gas, 1st penyunt., Oxford: Elsevier, 2014.

[7] F. Xue, Y. Chen dan Y. Ju, “A review of cryogenic power generation cycles with liquefied natural gas cold energy utilization,” *Frontiers in Energy,* 2016.

[8] Darsono, Penulis, *Introduksi Bisnis Regasifikasi LNG.* [Performance]. PT Nusantara Regas, 2019.

[9] S. Jansen dan N. Wondstra, “Understanding the exergy of cold: theory and practical examples,” *International Journal of Exergy,* vol. 7, no. 6, pp. 693-713, 2010.

[10] Z. Rant, “Exergie, ein neues Wort für technische Arbeitsfähigkeit,” *Forschung Inginieur Wesen,* vol. 22, no. 1, pp. 36-37, 1956.

[11] H. Norman, “Quora,” 2018. [Online]. Available: https://www.quora.com/What-is-the-difference-between-anergy-and-entropy. [Diakses 9 10 2019].

[12] I. Dincer dan M. A. Rosen, Exergy Energy, Environment and Sustainable Development, Amsterdam: Elsevier, 2007.

[13] X. Shi dan D. Che, “A combined power cycle utilizing low-temperature waste heat and LNG cold energy,” *Applied Thermal Engineering 2013,* vol. 490, no. 7, p. 59, 2013.

[14] B. F. Tchance, P. Loonis, M. Petrissans dan H. Ramenah, “Organic Rankine Cycle Systems: Principles, opportunities and challenges,” *IEEE,* 2013.

[15] D. Budisulistyo dan S. Krumsdieck, “A review of cryogenic power generation cycles with liquefied natural gas cold energy utilzation,” dalam *New Zealand Geothermal Workshop*, Auckland, 2016.

[16] T. He, Z. R. Chong, J. Zheng, Y. Ju dan P. Linga, “LNG cold energy utilization: Prospects and challenges,” *Elsevier,* vol. 170, pp. 557-568, 2019.

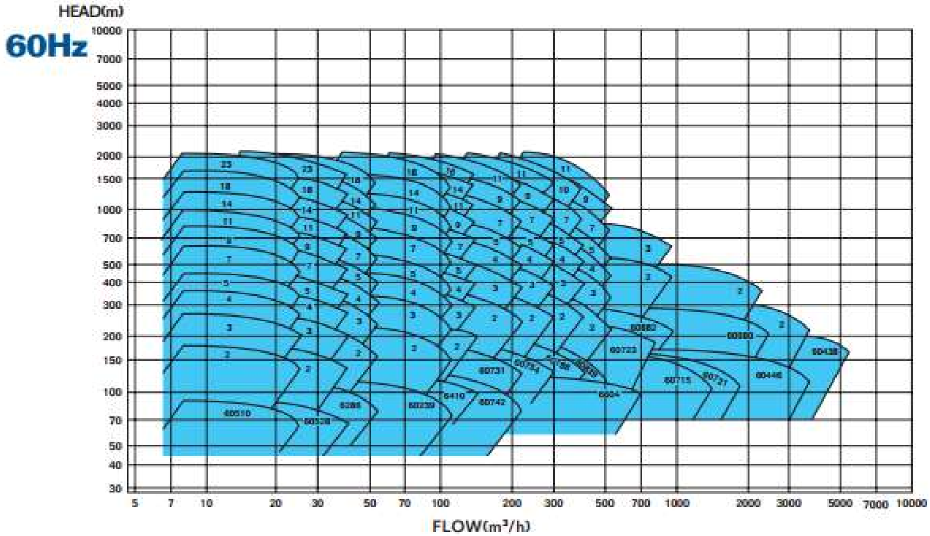
[17] Y. Hisayumi, Y. Yamasaki dan S. Sugiyama, “Proposal for a high efficiency LNG power-generation system utilizing waste heat from the combined cycle,” *Applied Energy,* pp. 169-182, 1998.

[18] Y. A. Cengel, Heat Transfer 2nd Edition, 2nd penyunt., Nevada: McGraw-Hill, 2002.

# APPENDICES

# APPENDIX 1. CHOSEN EQUIPMENT SPECIFICATION

PROPANE CIRCULATION PUMP




## MOTOR SELECTION - FEATURES AND OPTIONS

**Type:** Submerged, 3 -phase induction motor
**Frequency:** 50/60Hz
**Voltage:** 200/400/3000/3300/6000/6600V, etc.
**No. of Poles:** 2/4
**Time Rating:** Continuous

**Windings:** Formed wound/random wound.
**Insulation:** Vacuum pressure impregnation using special cryogenic varnish, class F.
**Starting:** Full voltage start (standard)

# EXPANDER

| | | | |
|---|---|---|---|
| Maximum inlet pressure | 200 bar(a)/2900 psia | Up to 200 bar(a)/2900 psia | Up to 82 bar(a)/1200 psia |
| Expansion ratio (per stage) | 18 (depending on process fluid) | 18 (depending on process fluid) | 5 |
| Inlet temperature | -220 °C to +200 °C/-365 °F to +400°F | -220 °C to +500 °C/-365 °F to +930 °F | Expander: -129 °C to +93 °C<br>-200 °F to +200 °F<br>Compressor: -29 °C to +93 °C<br>-20 °F to +200 °F |
| Inlet flow range | 10000 to 1000000 Nm³/h<br>6000 to 600000 SCFM | 10000 to 1000000 Nm³/h<br>6000 to 600000 SCFM | Plant flow up to 470800 Nm³/h<br>up to 400 MMSCFD |
| Maximum number of stages | 1 | 1 to 6 | 1 |
| Gases handled | All industrial gases and hydrocarbon gas mixtures | All industrial gases and hydrocarbon gas mixtures | Natural gas |
| Shaft | | | |
| Maximum impeller speed (RPM) | 100000 | 50000 | 50000 |
| Maximum shaft power | Up to 22500 kW<br>30000 HP | Up to 50000 kW<br>67000 HP | 5200 kW<br>7000 HP |
| Seals | | | |
| Labyrinth | • | • | • |
| Carbon ring | | • | |
| Oil-lubricated | | • | |
| Dynamic dry-gas | | • | |
| Capacity control | | | |
| Variable inlet guide vanes (IGVs) | Expander only | • | Expander only |
| API | Atlas Copco Standard; API 617; Customer specification | Manufacturers Standard; API 617 | Atlas Copco Standard |
| Axial thrust compensation | Bidirectional thrust bearings with Automatic Thrust Balancing control and monitoring system. | Bidirectional thrust bearings or thrust collars on pinions; bidirectional thrust bearings on gear shaft. | Bidirectional thrust bearings with Automatic Thrust Balancing control and monitoring system. |
| Oil system | Atlas Copco Standard; API 614; Customer specifications | Atlas Copco Standard; API 614; Customer specifications | Atlas Copco Standard |
| Test code | API 617, ASME PTC-10 Class II | API 617, ASME PTC-10 Class II | Atlas Copco Standard |

[1] Loaded compressor available with oil bearings or active magnetic bearings
[2] Available with fluid brake for small power ranges
[3] Combination of expander and compressor stages on one gearbox

PCHE HEAT EXCHANGER

| Technical data |
|---|
| Core |
| 316 or 304 |
| Diffusion bonded |

| Headers and connections |
|---|
| 304, 316, Duplex, Super Duplex |
| Codes – ASME VIII Div. 1 and PED 2014/68/EU + applicable national codes |

| Design pressure |
|---|
| Full vacuum to 1000 bar (14,500 psi) |

| Design temperature |
|---|
| -196°C to 800°C (-321°F to 1,472°F) |

PLATE AND FRAME HEAT EXCHANGER

| MATERIALS | | |
|---|---|---|
| PLATES | GASKETS | PORT RINGS |
| AISI 316, AISI 904L, 254 SMO, Hastelloy, C2000, Titanium and Nickel | NBR, EPDM, FPM, CR, CSP, TFEP | PTFE lined option |

| WORKING CONDITIONS | | |
|---|---|---|
| MAX. TEMPERATURE | MIN. TEMPERATURE | MAX. DESIGN PRESSURE |
| Up to 200°C (392°F) | Down to -38°C (-36°F) | 30 bar (435 psi) |

| TYPE | HEIGHT IN (MM) | WIDTH IN (MM) | CONNECTION IN (MM) |
|---|---|---|---|
| LR2 | 1,070 (42) | 395 (16) | 65 (3) |
| LR4 | 1,490 (59) | 574 (23) | 125 (5) |
| LR9GL | 1,717 (68) | 804 (32) | 200 (8) |
| LR9GN | 2,150 (85) | 804 (32) | 200 (8) |
| LR9AV | 2,597 (102) | 804 (32) | 200 (8) |
| LR9AL | 3,029 (119) | 804 (32) | 200 (8) |
| B063 | 1,843 (73) | 980 (39) | 300 (12) |
| B110L | 2,323 (91) | 980 (39) | 300 (12) |
| B134L | 2,670 (105) | 980 (39) | 300 (12) |
| B158L | 2,910 (115) | 980 (39) | 300 (12) |
| B205L | 3,390 (133) | 980 (39) | 300 (12) |

# APPENDIX 2. OPERATIONAL DATA

| OPERATIONAL DATA | | |
|---|---|---|
| ***SW Temperature Range*** | 15-35 | C |
| ***Humidity Average*** | 95% | |
| ***Barometric Pressure*** | 0,95 - 1,04 | bar |
| ***Feed LNG from In-Tank Pumps*** | 464 | ton/h |
| | -160 | C |
| | 5 | bar |
| ***NG to Shore (2 regas train)*** | 464 | ton/h |
| | 17,5 | C |
| | 45-64 | bar |
| ***SW Inlet*** | 9386 | ton/h |
| | 27 | C |
| | 2,2 | bar |
| ***Gas SOR*** | 200-400 | MMSCFD |
| ***Gas SOP*** | 59 | bar @15 C (max) |
| | 55 | bar (nominal) |
| ***BOG Compressor*** | 10 | m3/h LNG |

# APPENDIX 2. GAS COMPOSITION DATA

| No | Tanggal | KOMPOSISI GAS # 620 % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Jan-19 | 96,7293 | 2,3418 | 0,4645 | 0,0877 | 0,1089 | 0,0208 | 0 | 0 | 0,2355 | 0,0034 | 0 | 99,9919 |
| 2 | 02-Jan-19 | 96,7234 | 2,3808 | 0,4675 | 0,0915 | 0,1117 | 0,0148 | 0,001 | 0 | 0,1943 | 0 | 0 | 99,985 |
| 3 | 03-Jan-19 | 96,7135 | 2,3636 | 0,4715 | 0,0891 | 0,1117 | 0,0127 | 0,0128 | 0 | 0,1837 | 0,0046 | 0 | 99,9632 |
| 4 | 04-Jan-19 | 96,7079 | 2,4382 | 0,4885 | 0,0952 | 0,1152 | 0,0194 | 0,0047 | 0 | 0,1151 | 0,0047 | 0 | 99,9889 |
| 5 | 05-Jan-19 | 96,6991 | 2,4289 | 0,4772 | 0,0931 | 0,1155 | 0,0148 | 0,0119 | 0 | 0,1453 | 0,0058 | 0 | 99,9916 |
| 6 | 06-Jan-19 | 94,0039 | 3,0095 | 1,8984 | 0,4429 | 0,5439 | 0,0164 | 0,0075 | 0 | 0,0448 | 0 | 0 | 99,9673 |
| 7 | 07-Jan-19 | 93,8635 | 3,0683 | 1,9676 | 0,4629 | 0,5691 | 0,0188 | 0,0044 | 0 | 0,0305 | 0 | 0 | 99,9851 |
| 8 | 08-Jan-19 | 93,6917 | 3,1864 | 2,0319 | 0,4733 | 0,587 | 0,0068 | 0,0076 | 0 | 0,0096 | 0 | 0 | 99,9943 |
| 9 | 09-Jan-19 | 93,7611 | 3,153 | 2,0032 | 0,4679 | 0,5769 | 0,0191 | 0,0034 | 0 | 0,0117 | 0 | 0 | 99,9963 |
| 10 | 10-Jan-19 | 93,7719 | 3,1313 | 1,9856 | 0,4609 | 0,5731 | 0,0187 | 0,0067 | 0 | 0,0106 | 0,0105 | 0 | 99,9693 |
| 11 | 11-Jan-19 | 93,9196 | 3,1513 | 1,8912 | 0,4363 | 0,5445 | 0,0139 | 0,0044 | 0 | 0,016 | 0,0031 | 0 | 99,9803 |
| 12 | 12-Jan-19 | 93,8636 | 3,1227 | 1,9396 | 0,4467 | 0,5526 | 0,0225 | 0,004 | 0 | 0,0197 | 0,0112 | 0 | 99,9826 |
| 13 | 13-Jan-19 | 93,7174 | 3,2144 | 1,9843 | 0,4583 | 0,5675 | 0,0194 | 0,0049 | 0 | 0,0206 | 0 | 0 | 99,9868 |
| 14 | 14-Jan-19 | 94,1308 | 3,1293 | 1,756 | 0,4033 | 0,5009 | 0,0229 | 0,0056 | 0 | 0,0187 | 0,0141 | 0 | 99,9816 |
| 15 | 15-Jan-19 | 96,2346 | 2,5213 | 0,7088 | 0,1499 | 0,1879 | 0,0162 | 0,0006 | 0 | 0,1586 | 0,0058 | 0 | 99,9837 |
| 16 | 16-Jan-19 | 96,7265 | 2,3408 | 0,4601 | 0,0895 | 0,1138 | 0,0072 | 0,0112 | 0 | 0,22 | 0,0034 | 0 | 99,9725 |
| 17 | 17-Jan-19 | 96,6528 | 2,3805 | 0,4993 | 0,1013 | 0,1242 | 0,0135 | 0,0091 | 0 | 0,1954 | 0 | 0 | 99,9761 |
| 18 | 18-Jan-19 | 96,6711 | 2,3924 | 0,5071 | 0,1026 | 0,1263 | 0,0083 | 0,0016 | 0 | 0,1871 | 0 | 0 | 99,9965 |
| 19 | 19-Jan-19 | 96,6614 | 2,3752 | 0,486 | 0,0983 | 0,1188 | 0,013 | 0,002 | 0 | 0,2089 | 0,0047 | 0 | 99,9683 |
| 20 | 20-Jan-19 | 96,7015 | 2,337 | 0,4859 | 0,0966 | 0,1202 | 0,0043 | 0,0054 | 0 | 0,2393 | 0,0035 | 0 | 99,9937 |
| 21 | 21-Jan-19 | 96,713 | 2,3664 | 0,4747 | 0,0938 | 0,1193 | 0,0135 | 0,0056 | 0 | 0,2101 | 0 | 0 | 99,9964 |
| 22 | 22-Jan-19 | 96,6765 | 2,3938 | 0,4833 | 0,095 | 0,1215 | 0,0088 | 0,0062 | 0 | 0,2002 | 0,0027 | 0 | 99,988 |
| 23 | 23-Jan-19 | 96,6948 | 2,4126 | 0,4923 | 0,0986 | 0,1231 | 0,0201 | 0 | 0 | 0,1539 | 0 | 0 | 99,9954 |
| 24 | 24-Jan-19 | 93,9819 | 3,0441 | 1,8746 | 0,4473 | 0,5682 | 0,0218 | 0,0037 | 0 | 0,054 | 0,0017 | 0 | 99,9973 |
| 25 | 25-Jan-19 | 93,8104 | 3,1381 | 1,9517 | 0,4696 | 0,5861 | 0,0144 | 0,0077 | 0 | 0,0118 | 0 | 0 | 99,9898 |
| 26 | 26-Jan-19 | 93,8423 | 3,1223 | 1,9306 | 0,4664 | 0,587 | 0,0188 | 0,0039 | 0 | 0,0129 | 0,0035 | 0 | 99,9877 |
| 27 | 27-Jan-19 | 93,7378 | 3,193 | 1,953 | 0,4726 | 0,5964 | 0,0305 | 0 | 0 | 0,0141 | 0 | 0 | 99,9974 |
| 28 | 28-Jan-19 | 93,8333 | 3,149 | 1,9162 | 0,4636 | 0,5811 | 0,0192 | 0,0023 | 0 | 0,0107 | 0,0011 | 0 | 99,9765 |
| 29 | 29-Jan-19 | 93,8258 | 3,1608 | 1,9154 | 0,4611 | 0,5862 | 0,018 | 0,0034 | 0 | 0,0191 | 0 | 0 | 99,9898 |
| 30 | 30-Jan-19 | 93,8449 | 3,1796 | 1,89 | 0,4548 | 0,571 | 0,029 | 0,0094 | 0 | 0,0145 | 0 | 0 | 99,9932 |
| 31 | 31-Jan-19 | 94,064 | 3,0882 | 1,8225 | 0,435 | 0,5455 | 0,0164 | 0 | 0 | 0,0166 | 0,0025 | 0 | 99,9907 |
| **TOTAL JANUARI 2019** | | **95,12804194** | **2,797245161** | **1,279951613** | **0,293712903** | **0,366293548** | **0,016580645** | **0,004870968** | **0** | **0,096235484** | **0,002783871** | **0** | **99,98571613** |

| No | Tanggal | KOMPOSISI GAS # 350, % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Jan-19 | 95 | 3 | 0,8386 | 0,1648 | 0,2092 | 0,035 | 0,024 | 0 | 0,2721 | 0,4751 | 0 | 99,9959 |
| 2 | 02-Jan-19 | 97 | 2 | 0,4859 | 0,093 | 0,1154 | 0,011 | 0,0024 | 0 | 0,1205 | 0,005 | 0 | 99,994 |
| 3 | 03-Jan-19 | 97 | 2 | 0,4827 | 0,0932 | 0,1141 | 0,0068 | 0,001 | 0 | 0,1131 | 0 | 0 | 100 |
| 4 | 04-Jan-19 | 97 | 3 | 0,5042 | 0,097 | 0,1187 | 0,012 | 0,0057 | 0 | 0,0753 | 0,007 | 0 | 99,9876 |
| 5 | 05-Jan-19 | 97 | 3 | 0,5074 | 0,0995 | 0,1213 | 0,0132 | 0 | 0 | 0,0754 | 0,0089 | 0 | 100,0001 |
| 6 | 06-Jan-19 | 97 | 3 | 0,5529 | 0,1069 | 0,1316 | 0,014 | 0,005 | 0 | 0,0841 | 0,0486 | 0 | 99,9953 |
| 7 | 07-Jan-19 | 94 | 3 | 2 | 0,4659 | 0,5831 | 0,014 | 0 | 0 | 0,0082 | 0 | 0 | 99,4169 |
| 8 | 08-Jan-19 | 94 | 3 | 2 | 0,4825 | 0,5987 | 0,0179 | 0,0042 | 0 | 0 | 0 | 0 | 99,998 |
| 9 | 09-Jan-19 | 94 | 3 | 2 | 0,4767 | 0,5906 | 0,0175 | 0,0033 | 0 | 0 | 0 | 0 | 99,9935 |
| 10 | 10-Jan-19 | 94 | 3 | 2 | 0,4753 | 0,5869 | 0,0181 | 0 | 0 | 0 | 0 | 0 | 99,9999 |
| 11 | 11-Jan-19 | 94 | 3 | 2 | 0,4427 | 0,5522 | 0,0172 | 0,0023 | 0 | 0 | 0 | 0 | 99,9966 |
| 12 | 12-Jan-19 | 94 | 3 | 2 | 0,4563 | 0,5668 | 0,0152 | 0,002 | 0 | 0 | 0 | 0 | 99,9999 |
| 13 | 13-Jan-19 | 94 | 3 | 2 | 0,4693 | 0,5838 | 0,0134 | 0,004 | 0 | 0 | 0 | 0 | 99,9999 |
| 14 | 14-Jan-19 | 94 | 3 | 2 | 0,4132 | 0,515 | 0,0144 | 0,0008 | 0 | 0 | 0 | 0 | 99,9839 |
| 15 | 15-Jan-19 | 96 | 3 | 0,725 | 0,1525 | 0,1924 | 0,0128 | 0,0069 | 0 | 0,1091 | 0,0126 | 0 | 99,9833 |
| 16 | 16-Jan-19 | 97 | 2 | 0,468 | 0,0916 | 0,1175 | 0,0125 | 0,0037 | 0 | 0,1638 | 0 | 0 | 99,9899 |
| 17 | 17-Jan-19 | 96,73 | 2 | 0,468 | 0,0916 | 0,1175 | 0,0125 | 0,0037 | 0 | 0,1638 | 0 | 0 | 99,9899 |
| 18 | 18-Jan-19 | 97 | 2 | 0,5078 | 0,1023 | 0,1294 | 0,011 | 0 | 0 | 0,144 | 0 | 0 | 99,9833 |
| 19 | 19-Jan-19 | 97 | 2 | 0,4954 | 0,0988 | 0,1243 | 0,0046 | 0,002 | 0 | 0,1518 | 0 | 0 | 99,9945 |
| 20 | 20-Jan-19 | 97 | 2 | 0,4884 | 0,098 | 0,1224 | 0,0131 | 0 | 0 | 0,1837 | 0 | 0 | 99,9999 |
| 21 | 21-Jan-19 | 97 | 2 | 0,4921 | 0,0973 | 0,122 | 0,0101 | 0 | 0 | 0,1583 | 0,0054 | 0 | 99,985 |
| 22 | 22-Jan-19 | 97 | 2 | 0,4749 | 0,0939 | 0,0056 | 0,0134 | 0,0056 | 0 | 0,145 | 0,0036 | 0 | 99,8472 |
| 23 | 23-Jan-19 | 97 | 2 | 0,5048 | 0,0994 | 0,1257 | 0,0043 | 0,0016 | 0 | 0,1057 | 0 | 0 | 99,9933 |
| 24 | 24-Jan-19 | 94 | 3 | 2 | 0,4614 | 0,5833 | 0,0134 | 0 | 0 | 0,0229 | 0 | 0 | 99,9907 |
| 25 | 25-Jan-19 | 94 | 3 | 2 | 0,4775 | 0,6037 | 0,0143 | 0,0067 | 0 | 0 | 0 | 0 | 99,9916 |
| 26 | 26-Jan-19 | 94 | 3 | 2 | 0,4779 | 0,6041 | 0,0151 | 0,0055 | 0 | 0 | 0 | 0 | 99,9942 |
| 27 | 27-Jan-19 | 94 | 3 | 2 | 0,4764 | 0,6051 | 0,0159 | 0 | 0 | 0 | 0 | 0 | 99,996 |
| 28 | 28-Jan-19 | 94 | 3 | 2 | 0,4677 | 0,5899 | 0,014 | 0,0093 | 0 | 0 | 0 | 0 | 99,999 |
| 29 | 29-Jan-19 | 94 | 3 | 2 | 0,4701 | 0,5871 | 0,0222 | 0,0029 | 0 | 0 | 0 | 0 | 99,985 |
| 30 | 30-Jan-19 | 94 | 3 | 2 | 0,4597 | 0,5811 | 0,0202 | 0,0089 | 0 | 0 | 0 | 0 | 99,9922 |
| 31 | 31-Jan-19 | 94 | 3 | 2 | 0,4397 | 0,5537 | 0,0147 | 0,0032 | 0 | 0 | 0 | 0 | 100 |
| **TOTAL JANUARI 2019** | | **95,1033516** | **2,85933226** | **1,2726** | **0,29006774** | **0,35230333** | **0,01431613** | **0,0037** | **0** | **0,06763871** | **0,01826452** | **0** | **99,9702097** |

| No | Tanggal | KOMPOSISI GAS # IP - TP % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Jan-19 | 96,8877 | 2,2296 | 0,4532 | 0,0875 | 0,1064 | 0,0113 | 0,0026 | 0 | 0,2185 | 0,0032 | 0 | 100 |
| 2 | 02-Jan-19 | 96,9156 | 2,2418 | 0,4566 | 0,088 | 0,1063 | 0,011 | 0,0004 | 0 | 0,1784 | 0,0019 | 0 | 100 |
| 3 | 03-Jan-19 | 96,8955 | 2,2629 | 0,4628 | 0,0887 | 0,1088 | 0,0103 | 0,0006 | 0 | 0,1674 | 0,0029 | 0 | 99,9999 |
| 4 | 04-Jan-19 | 96,869 | 2,3379 | 0,4747 | 0,0919 | 0,1116 | 0,105 | 0,0014 | 0 | 0,1003 | 0,0027 | 0 | 100,0945 |
| 5 | 05-Jan-19 | 96,884 | 2,2988 | 0,4689 | 0,0902 | 0,11 | 0,0092 | 0,0028 | 0 | 0,133 | 0,003 | 0 | 99,9999 |
| 6 | 06-Jan-19 | 94,2212 | 2,9114 | 1,8489 | 0,4333 | 0,5317 | 0,0125 | 0,0026 | 0 | 0,0375 | 0 | 0 | 99,9991 |
| 7 | 07-Jan-19 | 93,991 | 3,02 | 1,945 | 0,4523 | 0,555 | 0,0117 | 0 | 0 | 0,0227 | 0 | 0 | 99,9977 |
| 8 | 08-Jan-19 | 93,9256 | 3,0567 | 1,9721 | 0,4609 | 0,5632 | 0,0132 | 0,0026 | 0 | 0,0056 | 0 | 0 | 99,9999 |
| 9 | 09-Jan-19 | 93,9698 | 3,046 | 1,9409 | 0,4572 | 0,5639 | 0,013 | 0,0027 | 0 | 0,0065 | 0 | 0 | 100 |
| 10 | 10-Jan-19 | 94,0237 | 3,0237 | 1,92 | 0,4516 | 0,5558 | 0,0125 | 0,0026 | 0 | 0,0064 | 0 | 0 | 99,9963 |
| 11 | 11-Jan-19 | 94,1308 | 3,0246 | 1,8551 | 0,4318 | 0,5323 | 0,0125 | 0,003 | 0 | 0,0096 | 0,0002 | 0 | 99,9999 |
| 12 | 12-Jan-19 | 94,1535 | 2,9927 | 1,8538 | 0,4361 | 0,5353 | 0,0118 | 0,0042 | 0 | 0,0126 | 0 | 0 | 100 |
| 13 | 13-Jan-19 | 93,9331 | 3,107 | 1,9291 | 0,4491 | 0,5517 | 0,0137 | 0,0024 | 0 | 0,014 | 0 | 0 | 100,0001 |
| 14 | 14-Jan-19 | 94,4356 | 2,982 | 1,6895 | 0,3899 | 0,4769 | 0,0122 | 0,0027 | 0 | 0,0112 | 0 | 0 | 100 |
| 15 | 15-Jan-19 | 96,4183 | 2,4078 | 0,6917 | 0,1464 | 0,1835 | 0,006 | 0 | 0 | 0,1457 | 0,0005 | 0 | 99,9999 |
| 16 | 16-Jan-19 | 96,9008 | 2,2385 | 0,4453 | 0,0892 | 0,1115 | 0,0059 | 0 | 0 | 0,2088 | 0 | 0 | 100 |
| 17 | 17-Jan-19 | 96,8251 | 2,2826 | 0,4845 | 0,0984 | 0,1226 | 0,005 | 0 | 0 | 0,1813 | 0,0005 | 0 | 100 |
| 18 | 18-Jan-19 | 96,8098 | 2,298 | 0,4919 | 0,0991 | 0,1249 | 0,0051 | 0 | 0 | 0,171 | 0,0003 | 0 | 100,0001 |
| 19 | 19-Jan-19 | 96,8607 | 2,2605 | 0,4694 | 0,0947 | 0,1177 | 0,0055 | 0 | 0 | 0,1915 | 0 | 0 | 100 |
| 20 | 20-Jan-19 | 96,8491 | 2,254 | 0,4685 | 0,0951 | 0,1181 | 0,0055 | 0 | 0 | 0,2094 | 0,0005 | 0 | 100,0002 |
| 21 | 21-Jan-19 | 96,8302 | 2,2877 | 0,4671 | 0,094 | 0,1172 | 0,0069 | 0 | 0 | 0,1963 | 0,0006 | 0 | 100 |
| 22 | 22-Jan-19 | 96,879 | 2,2479 | 0,466 | 0,0937 | 0,117 | 0,0065 | 0 | 0 | 0,1893 | 0,0005 | 0 | 99,9999 |
| 23 | 23-Jan-19 | 96,8647 | 2,3014 | 0,4729 | 0,0952 | 0,1185 | 0,0065 | 0 | 0 | 0,1403 | 0,0006 | 0 | 100,0001 |
| 24 | 24-Jan-19 | 94,105 | 3,0005 | 1,8352 | 0,4449 | 0,5584 | 0,0103 | 0 | 0 | 0,0455 | 0 | 0 | 99,9998 |
| 25 | 25-Jan-19 | 94,0117 | 3,0506 | 1,8856 | 0,4607 | 0,573 | 0,0105 | 0 | 0 | 0,0078 | 0 | 0 | 99,9999 |
| 26 | 26-Jan-19 | 94,0241 | 3,0465 | 1,8816 | 0,4569 | 0,571 | 0,0108 | 0 | 0 | 0,0091 | 0 | 0 | 100 |
| 27 | 27-Jan-19 | 93,9682 | 3,0799 | 1,8922 | 0,4629 | 0,5777 | 0,0102 | 0 | 0 | 0,0088 | 0,0001 | 0 | 100 |
| 28 | 28-Jan-19 | 94,0527 | 3,0603 | 1,852 | 0,4541 | 0,5611 | 0,0115 | 0 | 0 | 0,0083 | 0 | 0 | 100 |
| 29 | 29-Jan-19 | 94,0922 | 3,025 | 1,8483 | 0,4495 | 0,5625 | 0,011 | 0 | 0 | 0,0116 | 0 | 0 | 100,0001 |
| 30 | 30-Jan-19 | 94,0364 | 3,1069 | 1,8355 | 0,4456 | 0,5555 | 0,0116 | 0 | 0 | 0,0084 | 0 | 0 | 99,9999 |
| 31 | 31-Jan-19 | 94,325 | 2,9798 | 1,717 | 0,4254 | 0,531 | 0,0108 | 0 | 0 | 0,011 | 0 | 0 | 100 |
| **TOTAL JANUARI 2019** | | **95,3254548** | **2,69235484** | **1,24113871** | **0,28755806** | **0,35580968** | **0,0128871** | **0,0009871** | **0** | **0,08605806** | **0,00056452** | **0** | **100,002813** |

| No | Tanggal | KOMPOSISI GAS # PERTAGAS - MTW % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Jan-19 | 96,776 | 2,3227 | 0,4562 | 0,09 | 0,1091 | 0,0153 | 0 | 0 | 0,2306 | 0 | 0 | 99,9999 |
| 2 | 02-Jan-19 | 96,7376 | 2,3417 | 0,4644 | 0,0877 | 0,1089 | 0,0207 | 0 | 0 | 0,2355 | 0,0034 | 0 | 99,9999 |
| 3 | 03-Jan-19 | 96,7379 | 2,381 | 0,4676 | 0,0915 | 0,1117 | 0,0148 | 0,001 | 0 | 0,1945 | 0 | 0 | 100 |
| 4 | 04-Jan-19 | 96,749 | 2,3646 | 0,4717 | 0,0892 | 0,1117 | 0,0127 | 0,0127 | 0 | 0,1838 | 0,0046 | 0 | 100 |
| 5 | 05-Jan-19 | 96,719 | 2,4378 | 0,4884 | 0,0952 | 0,1152 | 0,0193 | 0,0048 | 0 | 0,1157 | 0,0047 | 0 | 100,0001 |
| 6 | 06-Jan-19 | 96,7073 | 2,4292 | 0,4773 | 0,0931 | 0,1155 | 0,0148 | 0,0119 | 0 | 0,1451 | 0,0058 | 0 | 100 |
| 7 | 07-Jan-19 | 94,0511 | 3,0071 | 1,8903 | 0,4408 | 0,5414 | 0,0164 | 0,0075 | 0 | 0,0454 | 0 | 0 | 100 |
| 8 | 08-Jan-19 | 93,8802 | 3,0678 | 1,9667 | 0,4626 | 0,5687 | 0,0188 | 0,0045 | 0 | 0,0308 | 0 | 0 | 100,0001 |
| 9 | 09-Jan-19 | 93,6986 | 3,1856 | 2,0315 | 0,4732 | 0,5869 | 0,0069 | 0,0076 | 0 | 0,0098 | 0 | 0 | 100,0001 |
| 10 | 10-Jan-19 | 93,7612 | 3,1535 | 2,0036 | 0,468 | 0,5797 | 0,0189 | 0,0035 | 0 | 0,0117 | 0 | 0 | 100,0001 |
| 11 | 11-Jan-19 | 93,8004 | 3,1324 | 1,9864 | 0,4611 | 0,5733 | 0,0187 | 0,0067 | 0 | 0,0106 | 0,0104 | 0 | 100 |
| 12 | 12-Jan-19 | 93,9373 | 3,1518 | 1,8921 | 0,4365 | 0,5448 | 0,0139 | 0,0044 | 0 | 0,016 | 0,0031 | 0 | 99,9999 |
| 13 | 13-Jan-19 | 93,8803 | 3,1234 | 1,9397 | 0,4467 | 0,5527 | 0,0225 | 0,004 | 0 | 0,0197 | 0,0112 | 0 | 100,0002 |
| 14 | 14-Jan-19 | 93,7204 | 3,2139 | 1,984 | 0,4582 | 0,5674 | 0,0194 | 0,0049 | 0 | 0,0206 | 0,0112 | 0 | 100 |
| 15 | 15-Jan-19 | 94,1446 | 3,1306 | 1,7582 | 0,4038 | 0,5016 | 0,0229 | 0,0056 | 0 | 0,0187 | 0,0141 | 0 | 100,0001 |
| 16 | 16-Jan-19 | 96,235 | 2,526 | 0,7165 | 0,1518 | 0,1903 | 0,0163 | 0,0006 | 0 | 0,1577 | 0,0059 | 0 | 100,0001 |
| 17 | 17-Jan-19 | 96,7446 | 2,3445 | 0,4644 | 0,0906 | 0,1151 | 0,0074 | 0,011 | 0 | 0,219 | 0,0034 | 0 | 100 |
| 18 | 18-Jan-19 | 96,6764 | 2,3809 | 0,4992 | 0,1013 | 0,1242 | 0,0135 | 0,0091 | 0 | 0,1956 | 0 | 0 | 100,0002 |
| 19 | 19-Jan-19 | 96,6745 | 2,3924 | 0,5071 | 0,1026 | 0,1263 | 0,0084 | 0,0017 | 0 | 0,1872 | 0 | 0 | 100,0002 |
| 20 | 20-Jan-19 | 96,6918 | 2,3762 | 0,4864 | 0,098 | 0,1224 | 0,0131 | 0 | 0 | 0,1837 | 0 | 0 | 99,9716 |
| 21 | 21-Jan-19 | 96,7074 | 2,3377 | 0,4859 | 0,0966 | 0,1202 | 0,0044 | 0,0054 | 0 | 0,2389 | 0,0035 | 0 | 100 |
| 22 | 22-Jan-19 | 96,7164 | 2,366 | 0,4749 | 0,0939 | 0,0056 | 0,0134 | 0,0056 | 0 | 0,2106 | 0,0001 | 0 | 99,8865 |
| 23 | 23-Jan-19 | 96,6883 | 2,3939 | 0,4833 | 0,095 | 0,1215 | 0,0088 | 0,0062 | 0 | 0,2003 | 0,0027 | 0 | 100 |
| 24 | 24-Jan-19 | 96,6992 | 2,4126 | 0,4923 | 0,0986 | 0,1231 | 0,02 | 0,0001 | 0 | 0,1543 | 0 | 0 | 100,0002 |
| 25 | 25-Jan-19 | 94,0124 | 3,0379 | 1,8605 | 0,4436 | 0,5635 | 0,0218 | 0,0037 | 0 | 0,0549 | 0,0017 | 0 | 100 |
| 26 | 26-Jan-19 | 93,8217 | 3,1374 | 1,9511 | 0,4694 | 0,586 | 0,0145 | 0,0077 | 0 | 0,0122 | 0 | 0 | 100 |
| 27 | 27-Jan-19 | 93,8537 | 3,1228 | 1,9309 | 0,4665 | 0,5871 | 0,0188 | 0,0039 | 0 | 0,0129 | 0,0035 | 0 | 100,0001 |
| 28 | 28-Jan-19 | 93,7409 | 3,1927 | 1,9529 | 0,4726 | 0,5964 | 0,0304 | 0 | 0 | 0,0141 | 0 | 0 | 100 |
| 29 | 29-Jan-19 | 93,8543 | 3,1501 | 1,917 | 0,4638 | 0,5814 | 0,0193 | 0,0023 | 0 | 0,0107 | 0,0011 | 0 | 100 |
| 30 | 30-Jan-19 | 93,8354 | 3,1611 | 1,9156 | 0,4612 | 0,5863 | 0,018 | 0,0034 | 0 | 0,0191 | 0 | 0 | 100,0001 |
| 31 | 31-Jan-19 | 93,8512 | 3,1797 | 1,8903 | 0,4549 | 0,5711 | 0,0289 | 0,0094 | 0 | 0,0145 | 0 | 0 | 100 |
| **TOTAL JANUARI 2019** | | **95,2291645** | **2,77274194** | **1,23569032** | **0,28251613** | **0,34868065** | **0,01654839** | **0,0048129** | **0** | **0,10239355** | **0,00291613** | **0** | **99,9954645** |

| No | Tanggal | KOMPOSISI GAS # 620 % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Feb-19 | 93,9641 | 3,0976 | 1,87 | 0,4483 | 0,5624 | 0,0176 | 0,0063 | 0 | 0,0159 | 0,0006 | 0 | 99,9907 |
| 2 | 02-Feb-19 | 93,9524 | 3,1677 | 1,8173 | 0,4361 | 0,5494 | 0,0224 | 0,0023 | 0 | 0,0109 | 0 | 0 | 99,9585 |
| 3 | 03-Feb-19 | 93,94 | 3,1388 | 1,8588 | 0,4479 | 0,5642 | 0,0164 | 0 | 0 | 0,0143 | 0,0039 | 0 | 99,9843 |
| 4 | 04-Feb-19 | 93,9426 | 3,0779 | 1,8875 | 0,4626 | 0,5827 | 0,0173 | 0,003 | 0 | 0,0097 | 0 | 0 | 99,9833 |
| 5 | 05-Feb-19 | 93,7086 | 3,293 | 1,9218 | 0,4588 | 0,5728 | 0,0191 | 0,0041 | 0 | 0,0173 | 0 | 0 | 99,9955 |
| 6 | 06-Feb-19 | 93,6723 | 3,2661 | 1,9081 | 0,4651 | 0,5781 | 0,0131 | 0,0051 | 0 | 0 | 0,0257 | 0 | 99,9336 |
| 7 | 07-Feb-19 | 93,5798 | 3,3821 | 1,9508 | 0,4733 | 0,5823 | 0,0212 | 0,0044 | 0 | 0 | 0 | 0 | 99,9939 |
| 8 | 08-Feb-19 | 93,6503 | 3,3392 | 1,9342 | 0,4701 | 0,5769 | 0,0096 | 0,0086 | 0 | 0,0079 | 0 | 0 | 99,9968 |
| 9 | 09-Feb-19 | 93,5942 | 3,3724 | 1,9397 | 0,4701 | 0,5824 | 0,0264 | 0,0148 | 0 | 0 | 0 | 0 | 100 |
| 10 | 10-Feb-19 | 93,5398 | 3,4051 | 1,9758 | 0,4721 | 0,5886 | 0,0174 | 0 | 0 | 0 | 0,0012 | 0 | 100 |
| 11 | 11-Feb-19 | 93,5622 | 3,3426 | 1,9749 | 0,4657 | 0,5917 | 0,0196 | 0 | 0 | 0 | 0,0405 | 0 | 99,9972 |
| 12 | 12-Feb-19 | 93,5248 | 3,3821 | 1,981 | 0,4739 | 0,5992 | 0,0315 | 0,0046 | 0 | 0 | 0 | 0 | 99,9971 |
| 13 | 13-Feb-19 | 93,705 | 3,2751 | 1,9951 | 0,4437 | 0,5586 | 0,0173 | 0 | 0 | 0,0046 | 0 | 0 | 99,9994 |
| 14 | 14-Feb-19 | 93,5306 | 3,3541 | 2,0691 | 0,4574 | 0,5598 | 0,0208 | 0,0047 | 0 | 0 | 0 | 0 | 99,9965 |
| 15 | 15-Feb-19 | 93,2251 | 3,4908 | 2,1568 | 0,4574 | 0,5989 | 0,0178 | 0,0023 | 0 | 0 | 0,0022 | 0 | 99,9513 |
| 16 | 16-Feb-19 | 93,5415 | 3,3191 | 2,0171 | 0,4609 | 0,5645 | 0,0225 | 0,0063 | 0 | 0,0147 | 0 | 0 | 99,9466 |
| 17 | 17-Feb-19 | 93,4381 | 3,3758 | 2,0291 | 0,449 | 0,5735 | 0,0143 | 0,0034 | 0 | 0,0293 | 0 | 0 | 99,9125 |
| 18 | 18-Feb-19 | 93,4808 | 3,3735 | 2,0688 | 0,461 | 0,5702 | 0,0181 | 0,0077 | 0 | 0,0035 | 0,0163 | 0 | 99,9999 |
| 19 | 19-Feb-19 | 93,5629 | 3,3155 | 2,0612 | 0,4554 | 0,5677 | 0,0221 | 0,0152 | 0 | 0 | 0 | 0 | 100 |
| 20 | 20-Feb-19 | 93,5201 | 3,3319 | 2,0424 | 0,4564 | 0,5603 | 0,0187 | 0,0072 | 0 | 0 | 0,0631 | 0 | 100,0001 |
| 21 | 21-Feb-19 | 93,374 | 3,4251 | 2,104 | 0,4661 | 0,5783 | 0,0173 | 0,0173 | 0 | 0 | 0,0179 | 0 | 100 |
| 22 | 22-Feb-19 | 93,7347 | 3,2605 | 1,9566 | 0,4509 | 0,5653 | 0,0197 | 0,0034 | 0 | 0 | 0,0089 | 0 | 100 |
| 23 | 23-Feb-19 | 93,785 | 3,2321 | 1,9465 | 0,4429 | 0,5588 | 0,022 | 0,0054 | 0 | 0 | 0,0055 | 0 | 99,9982 |
| 24 | 24-Feb-19 | 93,2961 | 3,4766 | 2,129 | 0,4618 | 0,5704 | 0,0093 | 0 | 0 | 0 | 0 | 0 | 99,9432 |
| 25 | 25-Feb-19 | 93,6636 | 3,2827 | 1,9752 | 0,4559 | 0,5727 | 0,0295 | 0,0133 | 0 | 0 | 0,0043 | 0 | 99,9972 |
| 26 | 26-Feb-19 | 93,7285 | 3,2593 | 1,967 | 0,4531 | 0,5685 | 0,016 | 0,0047 | 0 | 0 | 0 | 0 | 99,9971 |
| 27 | 27-Feb-19 | 93,6285 | 3,3017 | 1,9721 | 0,4499 | 0,5764 | 0,0325 | 0,0064 | 0 | 0,0119 | 0,0155 | 0 | 99,9949 |
| 28 | 28-Feb-19 | 93,6357 | 3,2632 | 1,9587 | 0,4545 | 0,5681 | 0,0231 | 0,0127 | 0 | 0 | 0,0244 | 0 | 99,9404 |
| 29 | | | | | | | | | | | | | 0 |
| 30 | | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | | |
| OTAL FEBRUARI 201 | | 93,62433214 | 3,3072 | 1,981021429 | 0,457867857 | 0,572953571 | 0,019735714 | 0,005828571 | 0 | 0,005 | 0,008214286 | 0 | 99,98243571 |

| No | Tanggal | KOMPOSISI GAS # 350, % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Feb-19 | 94 | 3 | 2 | 0,4531 | 0,5732 | 0,0175 | 0,0076 | 0 | 0 | 0 | 0 | 100,0942 |
| 2 | 02-Feb-19 | 94 | 3 | 2 | 0,4451 | 0,5587 | 0,0133 | 0 | 0 | 0 | 0 | 0 | 99,9963 |
| 3 | 03-Feb-19 | 94 | 3 | 2 | 0,4599 | 0,5762 | 0,0138 | 0,003 | 0 | 0 | 0 | 0 | 99,9988 |
| 4 | 04-Feb-19 | 94 | 3 | 2 | 0,4728 | 0,5922 | 0,022 | 0,0048 | 0 | 0 | 0,0014 | 0 | 99,9977 |
| 5 | 05-Feb-19 | 94 | 3 | 2 | 0,4804 | 0,6001 | 0,0148 | 0,0011 | 0 | 0 | 0 | 0 | 99,9693 |
| 6 | 06-Feb-19 | 94 | 3 | 2 | 0,4724 | 0,5983 | 0,0198 | 0,0069 | 0 | 0 | 0 | 0 | 99,9948 |
| 7 | 07-Feb-19 | 94 | 3 | 2 | 0,476 | 0,5989 | 0,0177 | 0,0062 | 0 | 0 | 0 | 0 | 99,9918 |
| 8 | 08-Feb-19 | 94 | 3 | 2 | 0,4803 | 0,6055 | 0,0156 | 0,0083 | 0 | 0 | 0 | 0 | 100 |
| 9 | 09-Feb-19 | 94 | 3 | 2 | 0,4821 | 0,6063 | 0,0153 | 0,0057 | 0 | 0 | 0 | 0 | 100 |
| 10 | 10-Feb-19 | 94 | 3 | 2 | 0,4888 | 0,6184 | 0,014 | 0,0046 | 0 | 0 | 0 | 0 | 100 |
| 11 | 11-Feb-19 | 94 | 3 | 2 | 0,4867 | 0,6137 | 0,0132 | 0,0006 | 0 | 0 | 0 | 0 | 100 |
| 12 | 12-Feb-19 | 93 | 3 | 2 | 0,4925 | 0,621 | 0,009 | 0,0047 | 0 | 0 | 0 | 0 | 99,9994 |
| 13 | 13-Feb-19 | 94 | 3 | 2 | 0,4667 | 0,5838 | 0,0157 | 0,0022 | 0 | 0 | 0 | 0 | 99,9911 |
| 14 | 14-Feb-19 | 94 | 3 | 2 | 0,4745 | 0,5888 | 0,0158 | 0,0018 | 0 | 0 | 0 | 0 | 99,9952 |
| 15 | 15-Feb-19 | 93 | 3 | 2 | 0,4834 | 0,6056 | 0,0181 | 0,0015 | 0 | 0 | 0 | 0 | 99,9962 |
| 16 | 16-Feb-19 | 94 | 3,29 | 2 | 0,4747 | 0,5861 | 0,0106 | 0 | 0 | 0 | 0 | 0 | 99,9862 |
| 17 | 17-Feb-19 | 94 | 3 | 2 | 0,4725 | 0,5884 | 0,0212 | 0,0065 | 0 | 0 | 0 | 0 | 99,9822 |
| 18 | 18-Feb-19 | 94 | 3 | 2 | 0,4751 | 0,5932 | 0,0205 | 0,0055 | 0 | 0 | 0 | 0 | 99,9844 |
| 19 | 19-Feb-19 | 93 | 3 | 2 | 0,4716 | 0,5924 | 0,018 | 0,0053 | 0 | 0 | 0,0038 | 0 | 100 |
| 20 | 20-Feb-19 | 94 | 3 | 2 | 0,471 | 0,5865 | 0,0146 | 0 | 0 | 0 | 0 | 0 | 99,9878 |
| 21 | 21-Feb-19 | 93 | 3 | 2 | 0,4791 | 0,6012 | 0,018 | 0,0008 | 0 | 0 | 0 | 0 | 99,9891 |
| 22 | 22-Feb-19 | 94 | 3 | 2 | 0,464 | 0,5838 | 0,0154 | 0,0051 | 0 | 0 | 0 | 0 | 99,9999 |
| 23 | 23-Feb-19 | 94 | 3 | 2 | 0,4645 | 0,5813 | 0,0195 | 0,0053 | 0 | 0 | 0 | 0 | 99,984 |
| 24 | 24-Feb-19 | 93,3533 | 3,433 | 2,1275 | 0,4811 | 0,5842 | 0,0069 | 0,0084 | 0 | 0 | 0 | 0 | 99,9944 |
| 25 | 25-Feb-19 | 93,6888 | 3,2239 | 1,9954 | 0,4742 | 0,5902 | 0,0203 | 0,0073 | 0 | 0 | 0 | 0 | 100,0001 |
| 26 | 26-Feb-19 | 93,6871 | 3,2286 | 2,0007 | 0,4688 | 0,5909 | 0,0228 | 0,0012 | 0 | 0 | 0 | 0 | 100,0001 |
| 27 | 27-Feb-19 | 93,6479 | 3,2511 | 2,0028 | 0,4781 | 0,5939 | 0,0196 | 0 | 0 | 0 | 0 | 0 | 99,9934 |
| 28 | 28-Feb-19 | 93,7252 | 3,209 | 1,985 | 0,4705 | 0,5858 | 0,0242 | 0,0003 | 0 | 0 | 0 | 0 | 100 |
| 29 | | | | | | | | | | | | | 0 |
| 30 | | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | | |
| TOTAL FEBRUARI 2019 | | 93,6168393 | 3,27562857 | 2,01791786 | 0,47356786 | 0,59280714 | 0,01668571 | 0,00373929 | 0 | 0 | 0,00018571 | 0 | 96,5491862 |

| No | Tanggal | KOMPOSISI GAS # IP - TP % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Feb-19 | 94,1868 | 2,9984 | 1,8069 | 0,4403 | 0,5478 | 0,0104 | 0 | 0 | 0,0094 | 0 | 0 | 100 |
| 2 | 02-Feb-19 | 94,2422 | 3,026 | 1,7542 | 0,4284 | 0,5305 | 0,0106 | 0 | 0 | 0,0081 | 0 | 0 | 100 |
| 3 | 03-Feb-19 | 94,1324 | 3,0579 | 1,7999 | 0,4406 | 0,5518 | 0,0104 | 0 | 0 | 0,007 | 0 | 0 | 100 |
| 4 | 04-Feb-19 | 94,0895 | 3,0398 | 1,8379 | 0,4527 | 0,5645 | 0,009 | 0 | 0 | 0,0065 | 0 | 0 | 99,9999 |
| 5 | 05-Feb-19 | 94,0789 | 3,0384 | 1,8412 | 0,4552 | 0,5702 | 0,0098 | 0 | 0 | 0,0063 | 0 | 0 | 100 |
| 6 | 06-Feb-19 | 94,0415 | 3,0734 | 1,8426 | 0,4577 | 0,5694 | 0,0099 | 0 | 0 | 0,0055 | 0 | 0 | 100 |
| 7 | 07-Feb-19 | 93,9824 | 3,0939 | 1,876 | 0,4597 | 0,5734 | 0,0098 | 0 | 0 | 0,0049 | 0 | 0 | 100,0001 |
| 8 | 08-Feb-19 | 93,9512 | 3,1183 | 1,8758 | 0,459 | 0,581 | 0,0096 | 0 | 0 | 0,0052 | 0 | 0 | 100,0001 |
| 9 | 09-Feb-19 | 93,912 | 3,1226 | 1,9046 | 0,4668 | 0,5802 | 0,0097 | 0 | 0 | 0,0041 | 0 | 0 | 100 |
| 10 | 10-Feb-19 | 93,8492 | 3,1666 | 1,9189 | 0,4692 | 0,5821 | 0,0105 | 0 | 0 | 0,0034 | 0 | 0 | 99,9999 |
| 11 | 11-Feb-19 | 93,8873 | 3,1346 | 1,9119 | 0,4685 | 0,585 | 0,0091 | 0 | 0 | 0,0037 | 0 | 0 | 100,0001 |
| 12 | 12-Feb-19 | 93,7688 | 3,1902 | 1,9411 | 0,4831 | 0,6002 | 0,0136 | 0 | 0 | 0,003 | 0 | 0 | 100 |
| 13 | 13-Feb-19 | 93,9794 | 3,0598 | 1,9162 | 0,458 | 0,564 | 0,014 | 0 | 0 | 0,0086 | 0 | 0 | 100 |
| 14 | 14-Feb-19 | 93,8646 | 3,1139 | 1,972 | 0,4617 | 0,569 | 0,0142 | 0 | 0 | 0,0046 | 0 | 0 | 100 |
| 15 | 15-Feb-19 | 93,6813 | 3,2091 | 2,031 | 0,4704 | 0,5888 | 0,0148 | 0 | 0 | 0,0045 | 0 | 0 | 99,9999 |
| 16 | 16-Feb-19 | 93,8743 | 3,1158 | 1,9578 | 0,4603 | 0,57 | 0,0149 | 0 | 0 | 0,0066 | 0 | 0 | 99,9997 |
| 17 | 17-Feb-19 | 93,8953 | 3,0944 | 1,9659 | 0,4588 | 0,5661 | 0,0142 | 0 | 0 | 0,0053 | 0 | 0 | 100 |
| 18 | 18-Feb-19 | 93,8566 | 3,1095 | 1,9805 | 0,4641 | 0,5705 | 0,0137 | 0 | 0 | 0,0049 | 0,0002 | 0 | 100 |
| 19 | 19-Feb-19 | 93,8265 | 3,1408 | 1,9735 | 0,466 | 0,5733 | 0,0147 | 0 | 0 | 0,0052 | 0 | 0 | 100 |
| 20 | 20-Feb-19 | 93,8905 | 3,1074 | 1,9619 | 0,4574 | 0,5644 | 0,0132 | 0 | 0 | 0,0052 | 0 | 0 | 100 |
| 21 | 21-Feb-19 | 93,707 | 3,19 | 2,025 | 0,4761 | 0,5824 | 0,0148 | 0 | 0 | 0,0047 | 0 | 0 | 100 |
| 22 | 22-Feb-19 | 94,063 | 3,0193 | 1,875 | 0,4558 | 0,5607 | 0,0202 | 0 | 0 | 0,006 | 0 | 0 | 100 |
| 23 | 23-Feb-19 | 94,1856 | 2,954 | 1,8235 | 0,4512 | 0,5571 | 0,02 | 0 | 0 | 0,0087 | 0 | 0 | 100,0001 |
| 24 | 24-Feb-19 | 93,5337 | 3,2588 | 2,1204 | 0,4858 | 0,5845 | 0,0088 | 0,0018 | 0 | 0,0062 | 0 | 0 | 100 |
| 25 | 25-Feb-19 | 94,0739 | 2,9984 | 1,8713 | 0,4605 | 0,5719 | 0,0193 | 0 | 0 | 0,0047 | 0 | 0 | 100 |
| 26 | 26-Feb-19 | 94,0802 | 3,007 | 1,8665 | 0,456 | 0,5669 | 0,0188 | 0 | 0 | 0,0046 | 0 | 0 | 100 |
| 27 | 27-Feb-19 | 93,9701 | 3,0617 | 1,9029 | 0,464 | 0,5748 | 0,0202 | 0 | 0 | 0,0063 | 0 | 0 | 100 |
| 28 | 28-Feb-19 | 94,1266 | 2,9836 | 1,8435 | 0,4565 | 0,564 | 0,02 | 0 | 0 | 0,0059 | 0 | 0 | 100,0001 |
| 29 | | | | | | | | | | | | | 0 |
| 30 | | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | | |
| **TOTAL FEBRUARI 2019** | | **93,9546714** | **3,0887** | **1,90706786** | **0,46013571** | **0,57016071** | **0,01350714** | **6,4286E-05** | **0** | **0,00568214** | **7,1429E-06** | **0** | **96,5517207** |

| No | Tanggal | KOMPOSISI GAS # PERTAGAS - MTW % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Feb-19 | 94,0714 | 3,089 | 1,8231 | 0,4352 | 0,5457 | 0,0165 | 0,0001 | 0 | 0,0166 | 0,0025 | 0 | 100,0001 |
| 2 | 02-Feb-19 | 93,9817 | 3,098 | 1,8696 | 0,4482 | 0,5322 | 0,0176 | 0,0062 | 0 | 0,0159 | 0,0006 | 0 | 99,97 |
| 3 | 03-Feb-19 | 93,9913 | 3,1682 | 1,8187 | 0,4364 | 0,5498 | 0,0224 | 0,0024 | 0 | 0,011 | 0 | 0 | 100,0002 |
| 4 | 04-Feb-19 | 93,9551 | 3,1396 | 1,8587 | 0,4479 | 0,5642 | 0,0165 | 0 | 0 | 0,0143 | 0,0039 | 0 | 100,0002 |
| 5 | 05-Feb-19 | 93,9583 | 3,0791 | 1,8875 | 0,4625 | 0,5826 | 0,0173 | 0,003 | 0 | 0,0098 | 0 | 0 | 100,0001 |
| 6 | 06-Feb-19 | 93,7145 | 3,2917 | 1,9217 | 0,4589 | 0,5729 | 0,0191 | 0,0041 | 0 | 0,0173 | 0 | 0 | 100,0002 |
| 7 | 07-Feb-19 | 93,7348 | 3,2686 | 1,9095 | 0,4647 | 0,5784 | 0,0132 | 0,0051 | 0 | 0,0002 | 0,0254 | 0 | 99,9999 |
| 8 | 08-Feb-19 | 93,5627 | 3,3807 | 1,9501 | 0,4732 | 0,5822 | 0,0211 | 0,0044 | 0 | 0 | 0,0257 | 0 | 100,0001 |
| 9 | 09-Feb-19 | 93,651 | 3,3395 | 1,9343 | 0,4701 | 0,5769 | 0,0116 | 0,0086 | 0 | 0,0079 | 0,0002 | 0 | 100,0001 |
| 10 | 10-Feb-19 | 93,5939 | 3,3722 | 1,9397 | 0,4701 | 0,5831 | 0,0263 | 0,0148 | 0 | 0,0001 | 0 | 0 | 100,0002 |
| 11 | 11-Feb-19 | 93,5401 | 3,4049 | 1,9756 | 0,4721 | 0,5886 | 0,0175 | 0,0001 | 0 | 0 | 0,0012 | 0 | 100,0001 |
| 12 | 12-Feb-19 | 93,5648 | 3,3431 | 1,975 | 0,4658 | 0,5917 | 0,0196 | 0 | 0 | 0 | 0,0401 | 0 | 100,0001 |
| 13 | 13-Feb-19 | 93,528 | 3,3817 | 1,981 | 0,4738 | 0,5591 | 0,0314 | 0,0045 | 0 | 0 | 0,0005 | 0 | 99,96 |
| 14 | 14-Feb-19 | 93,7041 | 3,2756 | 1,9954 | 0,444 | 0,559 | 0,0174 | 0 | 0 | 0,0046 | 0 | 0 | 100,0001 |
| 15 | 15-Feb-19 | 93,661 | 3,2884 | 2,0284 | 0,4484 | 0,5489 | 0,0204 | 0,0046 | 0 | 0 | 0 | 0 | 100,0001 |
| 16 | 16-Feb-19 | 93,2786 | 3,4883 | 2,1552 | 0,4574 | 0,5982 | 0,0179 | 0,0024 | 0 | 0 | 0,0022 | 0 | 100,0002 |
| 17 | 17-Feb-19 | 93,5891 | 3,3221 | 2,0192 | 0,4611 | 0,5651 | 0,0225 | 0,0063 | 0 | 0,0146 | 0 | 0 | 100 |
| 18 | 18-Feb-19 | 93,5204 | 3,3783 | 2,0308 | 0,4495 | 0,5739 | 0,0144 | 0,0034 | 0 | 0,0292 | 0 | 0 | 99,9999 |
| 19 | 19-Feb-19 | 93,4822 | 3,3731 | 2,0682 | 0,4608 | 0,5702 | 0,0181 | 0,0077 | 0 | 0,0037 | 0,0162 | 0 | 100,0002 |
| 20 | 20-Feb-19 | 93,5625 | 3,3158 | 2,0612 | 0,4554 | 0,5677 | 0,0221 | 0,0152 | 0 | 0 | 0,0001 | 0 | 100 |
| 21 | 21-Feb-19 | 93,5204 | 3,3318 | 2,0426 | 0,4564 | 0,5604 | 0,0187 | 0,0073 | 0 | 0 | 0,0626 | 0 | 100,0002 |
| 22 | 22-Feb-19 | 93,3748 | 3,4244 | 2,1037 | 0,4662 | 0,5781 | 0,0173 | 0,0172 | 0 | 0 | 0,0182 | 0 | 99,9999 |
| 23 | 23-Feb-19 | 93,7322 | 3,2616 | 1,9577 | 0,451 | 0,5654 | 0,451 | 0,0035 | 0 | 0 | 0,009 | 0 | 100,4314 |
| 24 | 24-Feb-19 | 93,4945 | 3,2387 | 2,1243 | 0,5105 | 0,6193 | 0,008 | 0,001 | 0 | 0,0039 | 0 | 0 | 100,0002 |
| 25 | 25-Feb-19 | 93,7917 | 3,2039 | 1,9065 | 0,4468 | 0,5659 | 0,0214 | 0,0069 | 0 | 0,0058 | 0,0511 | 0 | 100 |
| 26 | 26-Feb-19 | 93,4815 | 3,2757 | 1,9709 | 0,6531 | 0,5715 | 0,0294 | 0,0132 | 0 | 0 | 0,0046 | | 99,9999 |
| 27 | 27-Feb-19 | 93,7294 | 3,2595 | 1,9671 | 0,4546 | 0,5685 | 0,0161 | 0,0048 | 0 | 0 | 0,0003 | 0 | 100,0003 |
| 28 | 28-Feb-19 | 93,6339 | 3,3016 | 1,9722 | 0,45 | 0,5764 | 0,0324 | 0,0064 | 0 | 0,0118 | 0,0154 | 0 | 100,0001 |
| 29 | | | | | | | | | | | | | 0 |
| 30 | | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | | |
| **TOTAL FEBRUARI 2019** | | **93,6572821** | **3,28911071** | **1,97313929** | **0,46586071** | **0,57128214** | **0,0349** | **0,00547143** | **0** | **0,00595357** | **0,00999286** | **0** | **96,564269** |

| No | Tanggal | KOMPOSISI GAS # 620 % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Mar-19 | 93,6381 | 3,3055 | 1,9789 | 0,4625 | 0,5769 | 0,0221 | 0,0056 | 0 | 0 | 0,0104 | 0 | 100 |
| 2 | 02-Mar-19 | 93,6873 | 3,2665 | 1,9811 | 0,4555 | 0,575 | 0,0259 | 0,0069 | 0 | 0 | 0,0018 | 0 | 100 |
| 3 | 03-Mar-19 | 93,7882 | 3,2454 | 1,9242 | 0,4484 | 0,545 | 0,018 | 0 | 0 | 0 | 0 | 0 | 99,9692 |
| 4 | 04-Mar-19 | 93,6362 | 3,2764 | 1,9412 | 0,4484 | 0,5598 | 0,0192 | 0,0082 | 0 | 0 | 0,0536 | 0 | 99,943 |
| 5 | 05-Mar-19 | 93,6582 | 3,2991 | 1,9652 | 0,4609 | 0,573 | 0,0239 | 0,0034 | 0 | 0,0043 | 0,0121 | 0 | 100,0001 |
| 6 | 06-Mar-19 | 93,7221 | 3,2732 | 1,9586 | 0,4531 | 0,5619 | 0,0246 | 0 | 0 | 0 | 0 | 0 | 99,9935 |
| 7 | 07-Mar-19 | 93,7368 | 3,2511 | 1,9467 | 0,45 | 0,5616 | 0,0215 | 0,0195 | 0 | 0 | 0,0081 | 0 | 99,9953 |
| 8 | 08-Mar-19 | 93,7939 | 3,2509 | 1,9081 | 0,442 | 0,569 | 0,0298 | 0,0047 | 0 | 0 | 0 | 0 | 99,9984 |
| 9 | 09-Mar-19 | 94,0469 | 3,1724 | 1,8008 | 0,4228 | 0,5196 | 0,02 | 0,0061 | 0 | 0,0115 | 0 | 0 | 100,0001 |
| 10 | 10-Mar-19 | 94,8071 | 3,0251 | 1,3791 | 0,3132 | 0,3904 | 0,0214 | 0,0023 | 0 | 0,0531 | 0,006 | 0 | 99,9977 |
| 11 | 11-Mar-19 | 94,2855 | 3,0693 | 1,6821 | 0,388 | 0,4805 | 0,0162 | 0 | 0 | 0,0233 | 0 | 0 | 99,9449 |
| 12 | 12-Mar-19 | 94,2521 | 3,2251 | 1,6309 | 0,373 | 0,4764 | 0,0159 | 0 | 0 | 0,0267 | 0 | 0 | 100,0001 |
| 13 | 13-Mar-19 | 93,8174 | 3,2596 | 1,8927 | 0,4472 | 0,5637 | 0,0125 | 0,0037 | 0 | 0 | 0 | 0 | 99,9968 |
| 14 | 14-Mar-19 | 93,6956 | 3,2562 | 1,9067 | 0,4587 | 0,5722 | 0,0146 | 0,0098 | 0 | 0 | 0,0257 | 0 | 99,9395 |
| 15 | 15-Mar-19 | 93,7563 | 3,2700 | 1,9154 | 0,4517 | 0,5709 | 0,0205 | 0,0152 | 0 | 0 | 0 | 0 | 100 |
| 16 | 16-Mar-19 | 93,671 | 3,3334 | 1,895 | 0,4579 | 0,5682 | 0,02 | 0,0023 | 0 | 0 | 0 | 0 | 99,9478 |
| 17 | 17-Mar-19 | 93,8048 | 3,2676 | 1,8617 | 0,4478 | 0,5688 | 0,0181 | 0 | 0 | 0 | 0 | 0 | 99,9688 |
| 18 | 18-Mar-19 | 93,756 | 3,2274 | 1,8979 | 0,4531 | 0,5598 | 0,0331 | 0 | 0 | 0 | 0,0727 | 0 | 100 |
| 19 | 19-Mar-19 | 93,7966 | 3,2573 | 1,8833 | 0,4452 | 0,5578 | 0,0178 | 0,001 | 0 | 0 | 0,0411 | 0 | 100,0001 |
| 20 | 20-Mar-19 | 93,6307 | 3,3372 | 1,9535 | 0,4673 | 0,5857 | 0,0198 | 0 | 0 | 0 | 0 | 0 | 99,9942 |
| 21 | 21-Mar-19 | 93,7289 | 3,2848 | 1,9021 | 0,4558 | 0,5735 | 0,03 | 0,0064 | 0 | 0 | 0 | 0 | 99,9815 |
| 22 | 22-Mar-19 | | | | | | | | | | | | 0 |
| 23 | 23-Mar-19 | 93,9454 | 3,1903 | 1,8187 | 0,4402 | 0,5517 | 0,0182 | 0,0038 | 0 | 0 | 0,0309 | 0 | 99,9992 |
| 24 | 24-Mar-19 | 93,7828 | 3,2654 | 1,9039 | 0,4677 | 0,5524 | 0,0213 | 0,0009 | 0 | 0 | 0,0056 | 0 | 100 |
| 25 | 25-Mar-19 | 93,6969 | 3,2364 | 1,8922 | 0,4593 | 0,583 | 0,0264 | 0,2 | 0 | 0 | 0,0857 | 0 | 100,1799 |
| 26 | 26-Mar-19 | 93,57 | 3,3597 | 1,9495 | 0,459 | 0,6042 | 0,0177 | 0 | 0 | 0,0217 | 0,0182 | 0 | 100 |
| 27 | 27-Mar-19 | 93,824 | 3,2067 | 1,8538 | 0,45 | 0,5605 | 0,0134 | 0,0055 | 0 | 0 | 0,0862 | 0 | 100,0001 |
| 28 | 28-Mar-19 | 93,7846 | 3,2562 | 1,8851 | 0,4453 | 0,574 | 0,027 | 0,0116 | 0 | 0,0037 | 0 | 0 | 99,9875 |
| 29 | 29-Mar-19 | 93,7897 | 3,2538 | 1,8983 | 0,4576 | 0,5755 | 0,0208 | 0,0013 | 0 | 0 | 0 | 0 | 99,997 |
| 30 | 30-Mar-19 | 93,7464 | 3,2954 | 1,8953 | 0,4575 | 0,5573 | 0,015 | 0,0101 | 0 | 0 | 0 | 0 | 99,977 |
| 31 | 31-Mar-19 | 93,7175 | 3,3103 | 1,897 | 0,4614 | 0,5755 | 0,0234 | 0 | 0 | 0,0062 | 0 | 0 | 99,9913 |
| **TOTAL MARET 2019** | | **93,8189** | **3,250923333** | **1,8733** | **0,44335** | **0,554793333** | **0,020936667** | **0,010943333** | **0** | **0,005016667** | **0,01527** | **0** | **99,99343333** |

| No | Tanggal | KOMPOSISI GAS # 350, % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Mar-19 | 93,5779 | 3,2856 | 2,0196 | 0,4801 | 0,6011 | 0,0223 | 0,0062 | 0 | 0 | 0 | 0 | 99,9928 |
| 2 | 02-Mar-19 | 93,6087 | 3,2632 | 2,0138 | 0,4751 | 0,5949 | 0,0271 | 0,0036 | 0 | 0 | 0 | 0 | 99,9864 |
| 3 | 03-Mar-19 | 93,789 | 3,1914 | 1,9533 | 0,4663 | 0,5752 | 0,0166 | 0,0081 | 0 | 0 | 0 | 0 | 99,9999 |
| 4 | 04-Mar-19 | 93,7292 | 3,192 | 2,0016 | 0,4701 | 0,5829 | 0,0185 | 0 | 0 | 0 | 0,0009 | 0 | 99,9952 |
| 5 | 05-Mar-19 | 93,7277 | 3,2176 | 1,9758 | 0,4741 | 0,5857 | 0,0164 | 0,0027 | 0 | 0 | 0 | 0 | 100 |
| 6 | 06-Mar-19 | 93,8105 | 3,151 | 1,9725 | 0,4693 | 0,5801 | 0,0166 | 0 | 0 | 0 | 0 | 0 | 100 |
| 7 | 07-Mar-19 | 93,7411 | 3,2174 | 1,9692 | 0,4709 | 0,581 | 0,0193 | 0,0011 | 0 | 0 | 0 | 0 | 100 |
| 8 | 08-Mar-19 | 93,7763 | 3,1819 | 1,9576 | 0,4672 | 0,5823 | 0,0213 | 0,0047 | 0 | 0 | 0 | 0 | 99,9913 |
| 9 | 09-Mar-19 | 94,0112 | 3,1212 | 1,8472 | 0,4372 | 0,5429 | 0,0163 | 0,0044 | 0 | 0,0082 | 0 | 0 | 99,9886 |
| 10 | 10-Mar-19 | 94,8503 | 2,9424 | 1,398 | 0,3243 | 0,4031 | 0,0176 | 0,007 | 0 | 0,0501 | 0,0006 | 0 | 99,9934 |
| 11 | 11-Mar-19 | 94,2461 | 3,0949 | 1,7132 | 0,4041 | 0,4975 | 0,0153 | 0,0058 | 0 | 0,0209 | 0 | 0 | 99,9978 |
| 12 | 12-Mar-19 | 94,2897 | 3,1051 | 1,6842 | 0,3969 | 0,4912 | 0,0154 | 0,0013 | 0 | 0,0153 | 0 | 0 | 99,9991 |
| 13 | 13-Mar-19 | 93,8296 | 3,1517 | 1,9465 | 0,467 | 0,5791 | 0,0182 | 0,0061 | 0 | 0 | 0,0018 | 0 | 100 |
| 14 | 14-Mar-19 | 93,7688 | 3,1795 | 1,9543 | 0,4754 | 0,5895 | 0,0168 | 0 | 0 | 0 | 0 | 0 | 99,9843 |
| 15 | 15-Mar-19 | 93,7435 | 3,1819 | 1,9751 | 0,4743 | 0,5883 | 0,0218 | 0,0037 | 0 | 0 | 0,0012 | 0 | 99,9898 |
| 16 | 16-Mar-19 | 93,7563 | 3,2699 | 1,9154 | 0,4518 | 0,5709 | 0,0205 | 0,0152 | 0 | 0 | 0,0002 | 0 | 100,0002 |
| 17 | 17-Mar-19 | 93,8559 | 3,1525 | 1,9343 | 0,4646 | 0,5765 | 0,0107 | 0,0054 | 0 | 0 | 0 | 0 | 99,9999 |
| 18 | 18-Mar-19 | 93,7974 | 3,1576 | 1,8626 | 0,4481 | 0,569 | 0,0173 | 0 | 0 | 0 | 0 | 0 | 99,852 |
| 19 | 19-Mar-19 | 93,8435 | 3,1566 | 1,9429 | 0,4595 | 0,5769 | 0,0142 | 0,0014 | 0 | 0 | 0 | 0 | 99,995 |
| 20 | 20-Mar-19 | 93,6451 | 3,2472 | 1,9965 | 0,4803 | 0,5992 | 0,0157 | 0,0006 | 0 | 0 | 0 | 0 | 99,9846 |
| 21 | 21-Mar-19 | 93,7675 | 3,2025 | 1,9486 | 0,4745 | 0,5869 | 0,0186 | 0,0014 | 0 | 0 | 0 | 0 | 100 |
| 22 | 22-Mar-19 | | | | | | | | | | | | 0 |
| 23 | 23-Mar-19 | 93,9938 | 3,0678 | 1,8854 | 0,4609 | 0,5727 | 0,0156 | 0,0026 | 0 | 0 | 0 | 0 | 99,9988 |
| 24 | 24-Mar-19 | 93,8933 | 3,1276 | 1,9047 | 0,4724 | 0,5884 | 0,0135 | 0 | 0 | 0 | 0 | 0 | 99,9999 |
| 25 | 25-Mar-19 | 93,7932 | 3,1642 | 1,957 | 0,4786 | 0,5921 | 0,0127 | 0 | 0 | 0 | 0 | 0 | 99,9978 |
| 26 | 26-Mar-19 | 93,7374 | 3,1628 | 1,9831 | 0,4863 | 0,6084 | 0,0128 | 0,0026 | 0 | 0 | 0 | 0 | 99,9934 |
| 27 | 27-Mar-19 | 93,9365 | 3,0799 | 1,9198 | 0,4655 | 0,5791 | 0,0192 | 0 | 0 | 0 | 0 | 0 | 100 |
| 28 | 28-Mar-19 | 93,8466 | 3,1332 | 1,9357 | 0,4682 | 0,5853 | 0,0139 | 0,0103 | 0 | 0 | 0 | 0 | 99,9932 |
| 29 | 29-Mar-19 | 93,8191 | 3,117 | 1,962 | 0,4778 | 0,5983 | 0,0172 | 0,005 | 0 | 0 | 0 | 0 | 99,9964 |
| 30 | 30-Mar-19 | 93,7772 | 3,1543 | 1,9682 | 0,4774 | 0,5985 | 0,0182 | 0,0039 | 0 | 0 | 0 | 0 | 99,9977 |
| 31 | 31-Mar-19 | 93,705 | 3,2029 | 1,9791 | 0,4807 | 0,5988 | 0,0216 | 0 | 0 | 0 | 0 | 0 | 99,9881 |
| **TOTAL MARET 2019** | | **93,85558** | **3,16242667** | **1,91590667** | **0,45996333** | **0,57252667** | **0,01737333** | **0,00343667** | **0** | **0,00315** | **0,00015667** | **0** | **96,7650194** |

| No | Tanggal | KOMPOSISI GAS # IP - TP % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Mar-19 | 94,0029 | 3,0532 | 1,8802 | 0,4652 | 0,5736 | 0,0205 | 0 | 0 | 0,0044 | 0 | 0 | 100 |
| 2 | 02-Mar-19 | 93,9869 | 3,0603 | 1,8898 | 0,4648 | 0,5739 | 0,0193 | 0 | 0 | 0,005 | 0 | 0 | 100 |
| 3 | 03-Mar-19 | 94,1508 | 2,9774 | 1,8414 | 0,4529 | 0,5527 | 0,0187 | 0 | 0 | 0,0061 | 0 | 0 | 100 |
| 4 | 04-Mar-19 | 94,081 | 3,007 | 1,8652 | 0,4603 | 0,5642 | 0,0178 | 0 | 0 | 0,0045 | 0 | 0 | 100 |
| 5 | 05-Mar-19 | 94,0581 | 3,0182 | 1,8704 | 0,4612 | 0,5702 | 0,0178 | 0 | 0 | 0,0042 | 0 | 0 | 100,0001 |
| 6 | 06-Mar-19 | 94,07 | 3,0363 | 1,8505 | 0,46 | 0,5597 | 0,019 | 0 | 0 | 0,0044 | 0 | 0 | 99,9999 |
| 7 | 07-Mar-19 | 94,1529 | 2,9723 | 1,8383 | 0,4538 | 0,5585 | 0,0179 | 0 | 0 | 0,0063 | 0 | 0 | 100 |
| 8 | 08-Mar-19 | 94,1693 | 2,9659 | 1,831 | 0,4524 | 0,5565 | 0,0184 | 0 | 0 | 0,0063 | 0 | 0 | 99,9998 |
| 9 | 09-Mar-19 | 94,3653 | 2,9151 | 1,733 | 0,4252 | 0,5222 | 0,0187 | 0 | 0 | 0,0205 | 0 | 0 | 100 |
| 10 | 10-Mar-19 | 95,0995 | 2,7682 | 1,3317 | 0,3192 | 0,392 | 0,016 | 0 | 0 | 0,0734 | 0 | 0 | 100 |
| 11 | 11-Mar-19 | 94,5896 | 2,8979 | 1,5866 | 0,393 | 0,4762 | 0,017 | 0 | 0 | 0,0397 | 0 | 0 | 100 |
| 12 | 12-Mar-19 | 94,5083 | 2,9572 | 1,6215 | 0,386 | 0,4773 | 0,0179 | 0 | 0 | 0,0317 | 0 | 0 | 99,9999 |
| 13 | 13-Mar-19 | 94,0955 | 3,0053 | 1,8588 | 0,4505 | 0,5618 | 0,0164 | 0 | 0 | 0,0118 | 0 | 0 | 100,0001 |
| 14 | 14-Mar-19 | 93,9943 | 3,0476 | 1,9022 | 0,4624 | 0,5722 | 0,0169 | 0 | 0 | 0,0044 | 0 | 0 | 100 |
| 15 | 15-Mar-19 | 94,0357 | 3,0337 | 1,8821 | 0,4586 | 0,5683 | 0,0169 | 0 | 0 | 0,0047 | 0 | 0 | 100 |
| 16 | 16-Mar-19 | 94,0145 | 3,0391 | 1,8942 | 0,4605 | 0,569 | 0,0181 | 0 | 0 | 0,0047 | 0 | 0 | 100,0001 |
| 17 | 17-Mar-19 | 94,1009 | 3,0175 | 1,8518 | 0,4504 | 0,5539 | 0,0181 | 0 | 0 | 0,0074 | 0 | 0 | 100 |
| 18 | 18-Mar-19 | 94,0461 | 3,0309 | 1,874 | 0,459 | 0,565 | 0,0184 | 0 | 0 | 0,0066 | 0 | 0 | 100 |
| 19 | 19-Mar-19 | 94,0943 | 3,0038 | 1,8649 | 0,4541 | 0,5591 | 0,0163 | 0 | 0 | 0,0076 | 0 | 0 | 100,0001 |
| 20 | 20-Mar-19 | 93,9506 | 3,074 | 1,9143 | 0,4656 | 0,5737 | 0,0174 | 0 | 0 | 0,0044 | 0 | 0 | 100 |
| 21 | 21-Mar-19 | 93,9691 | 3,0709 | 1,9021 | 0,4627 | 0,5721 | 0,0179 | 0 | 0 | 0,0051 | 0 | 0 | 99,9999 |
| 22 | 22-Mar-19 | | | | | | | | | | | | 0 |
| 23 | 23-Mar-19 | 94,1376 | 2,9657 | 1,8537 | 0,4565 | 0,5642 | 0,0158 | 0 | 0 | 0,0065 | 0 | 0 | 100 |
| 24 | 24-Mar-19 | 94,0778 | 2,9969 | 1,8716 | 0,463 | 0,571 | 0,0152 | 0 | 0 | 0,0044 | 0 | 0 | 99,9999 |
| 25 | 25-Mar-19 | 94,1289 | 2,9719 | 1,8571 | 0,4577 | 0,5649 | 0,0154 | 0 | 0 | 0,0042 | 0 | 0 | 100,0001 |
| 26 | 26-Mar-19 | 93,9622 | 3,0448 | 1,9093 | 0,4736 | 0,5897 | 0,0165 | 0 | 0 | 0,004 | 0 | 0 | 100,0001 |
| 27 | 27-Mar-19 | 94,1256 | 2,9764 | 1,8526 | 0,4572 | 0,5658 | 0,0157 | 0 | 0 | 0,0067 | 0 | 0 | 100 |
| 28 | 28-Mar-19 | 94,1246 | 2,9679 | 1,8613 | 0,4573 | 0,5683 | 0,015 | 0 | 0 | 0,0056 | 0 | 0 | 100 |
| 29 | 29-Mar-19 | 94,038 | 3,0157 | 1,8845 | 0,4661 | 0,5751 | 0,0155 | 0 | 0 | 0,0052 | 0 | 0 | 100,0001 |
| 30 | 30-Mar-19 | 94,0203 | 3,0268 | 1,8889 | 0,4666 | 0,5784 | 0,0148 | 0 | 0 | 0,0043 | 0 | 0 | 100,0001 |
| 31 | 31-Mar-19 | 93,916 | 3,0716 | 1,9266 | 0,4761 | 0,5886 | 0,017 | 0 | 0 | 0,0041 | 0 | 0 | 100 |
| **TOTAL MARET 2019** | | **94,1355533** | **2,99965** | **1,83298667** | **0,44973** | **0,55460333** | **0,01721** | **0** | **0** | **0,01027333** | **0** | **0** | **96,7742** |

| No | Tanggal | KOMPOSISI GAS # PERTAGAS - MTW % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Mar-19 | 93,6911 | 3,2654 | 1,96 | 0,4547 | 0,5685 | 0,0232 | 0,0127 | 0 | 0,0001 | 0,0244 | 0 | 100,0001 |
| 2 | 02-Mar-19 | 93,6384 | 3,3053 | 1,9788 | 0,4625 | 0,5768 | 0,0221 | 0,0057 | 0 | 0 | 0,0105 | 0 | 100,0001 |
| 3 | 03-Mar-19 | 93,6873 | 3,2665 | 1,9811 | 0,4555 | 0,575 | 0,0259 | 0,0069 | 0 | 0 | 0,0018 | 0 | 100 |
| 4 | 04-Mar-19 | 93,8152 | 3,2466 | 1,9253 | 0,4493 | 0,5454 | 0,0181 | 0,0001 | 0 | 0 | 0 | 0 | 100 |
| 5 | 05-Mar-19 | 93,6903 | 3,2781 | 1,9422 | 0,4487 | 0,56 | 0,0192 | 0,0082 | 0 | 0 | 0,0534 | 0 | 100,0001 |
| 6 | 06-Mar-19 | 93,6583 | 3,299 | 1,9651 | 0,4608 | 0,5729 | 0,0239 | 0,0034 | 0 | 0,0043 | 0,0124 | 0 | 100,0001 |
| 7 | 07-Mar-19 | 93,7278 | 3,2736 | 1,9588 | 0,4532 | 0,562 | 0,0246 | 0 | 0 | 0 | 0,0001 | 0 | 100,0001 |
| 8 | 08-Mar-19 | 93,7411 | 3,2514 | 1,9469 | 0,45 | 0,5616 | 0,0215 | 0,0194 | 0 | 0 | 0,008 | 0 | 99,9999 |
| 9 | 09-Mar-19 | 93,7949 | 3,251 | 1,9085 | 0,4421 | 0,5689 | 0,0297 | 0,0049 | 0 | 0 | 0,0001 | 0 | 100,0001 |
| 10 | 10-Mar-19 | 94,0452 | 3,1729 | 1,8015 | 0,4229 | 0,5199 | 0,0201 | 0,0061 | 0 | 0,0114 | 0 | 0 | 100 |
| 11 | 11-Mar-19 | 94,8047 | 3,026 | 1,3816 | 0,3139 | 0,3912 | 0,0214 | 0,0023 | 0 | 0,0529 | 0,006 | 0 | 100 |
| 12 | 12-Mar-19 | 94,3421 | 3,0706 | 1,6801 | 0,3875 | 0,4799 | 0,0163 | 0 | 0 | 0,0236 | 0,0001 | 0 | 100,0002 |
| 13 | 13-Mar-19 | 94,2526 | 3,224 | 1,6313 | 0,3731 | 0,4764 | 0,0159 | 0 | 0 | 0,0267 | 0 | 0 | 100 |
| 14 | 14-Mar-19 | 93,8266 | 3,2592 | 1,8891 | 0,4462 | 0,5625 | 0,0126 | 0,0037 | 0 | 0,0004 | 0 | 0 | 100,0003 |
| 15 | 15-Mar-19 | 93,7527 | 3,2582 | 1,9078 | 0,4589 | 0,5725 | 0,0146 | 0,0098 | 0 | 0 | 0,0256 | 0 | 100,0001 |
| 16 | 16-Mar-19 | 93,7563 | 3,2699 | 1,9154 | 0,4518 | 0,5709 | 0,0205 | 0,0152 | 0 | 0 | 0,0002 | 0 | 100,0002 |
| 17 | 17-Mar-19 | 93,7202 | 3,3347 | 1,8961 | 0,4581 | 0,5685 | 0,02 | 0,0024 | 0 | 0 | 0 | 0 | 100 |
| 18 | 18-Mar-19 | 93,8329 | 3,2693 | 1,8626 | 0,4481 | 0,569 | 0,0181 | 0 | 0 | 0 | 0 | 0 | 100 |
| 19 | 19-Mar-19 | 93,7571 | 3,228 | 1,8974 | 0,453 | 0,5599 | 0,0329 | 0 | 0 | 0 | 0,0717 | 0 | 100 |
| 20 | 20-Mar-19 | 93,7964 | 3,2572 | 188,34 | 0,4452 | 0,5578 | 0,0179 | 0,001 | 0 | 0 | 0,0412 | 0 | 286,4567 |
| 21 | 21-Mar-19 | 93,6377 | 3,3366 | 1,9529 | 0,4671 | 0,5855 | 0,0198 | 0 | 0 | 0 | 0,0004 | 0 | 100 |
| 22 | 22-Mar-19 | | | | | | | | | | | | 0 |
| 23 | 23-Mar-19 | 93,529 | 3,3944 | 1,9656 | 0,4909 | 0,5883 | 0,0203 | 0 | 0 | 0 | 0,0115 | 0 | 100 |
| 24 | 24-Mar-19 | 93,9442 | 3,1913 | 1,8194 | 0,4405 | 0,5519 | 0,0182 | 0,0038 | 0 | 0 | 0,0308 | 0 | 100,0001 |
| 25 | 25-Mar-19 | 93,7837 | 3,265 | 1,9035 | 0,4676 | 0,5524 | 0,0213 | 0,009 | 0 | 0 | 0,0057 | 0 | 100,0082 |
| 26 | 26-Mar-19 | 93,6974 | 3,2366 | 1,8923 | 1,8923 | 0,4593 | 0,0264 | 0,0199 | 0 | 0 | 0,0853 | 0 | 101,3095 |
| 27 | 27-Mar-19 | 93,5708 | 3,3589 | 1,9491 | 0,459 | 0,6041 | 0,0178 | 0,0001 | 0 | 0,0216 | 0,0186 | 0 | 100 |
| 28 | 28-Mar-19 | 93,8225 | 3,2075 | 1,8543 | 0,4501 | 0,5608 | 0,0134 | 0,0055 | 0 | 0,0001 | 0,0858 | 0 | 100 |
| 29 | 29-Mar-19 | 93,7966 | 3,2562 | 1,8851 | 0,4454 | 0,574 | 0,0269 | 0,0116 | 0 | 0,0037 | 0,0007 | 0 | 100,0002 |
| 30 | 30-Mar-19 | 93,7926 | 3,2539 | 1,8982 | 0,4575 | 0,5755 | 0,0209 | 0,0014 | 0 | 0 | 0 | 0 | 100 |
| 31 | 31-Mar-19 | 93,7496 | 3,2952 | 1,8954 | 0,4575 | 0,5773 | 0,0151 | 0,01 | 0 | 0 | 0 | 0 | 100,0001 |
| **TOTAL MARET 2019** | | **93,8218433** | **3,25341667** | **8,09284667** | **0,49211333** | **0,55162333** | **0,02062** | **0,00543667** | **0** | **0,00482667** | **0,01647667** | **0** | **102,831487** |

| No | Tanggal | KOMPOSISI GAS # 620, % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Apr-19 | 93,7912 | 3,2476 | 1,8571 | 0,4615 | 0,5694 | 0,0146 | 0,0068 | 0 | 0 | 0 | 0 | 99,9482 |
| 2 | 02-Apr-19 | 93,6405 | 3,3318 | 1,9004 | 0,461 | 0,602 | 0,0168 | 0 | 0 | 0 | 0 | 0 | 99,9525 |
| 3 | 03-Apr-19 | 93,5889 | 3,3282 | 1,9413 | 0,4713 | 0,5863 | 0,0201 | 0,0047 | 0 | 0 | 0 | 0 | 99,9408 |
| 4 | 04-Apr-19 | 93,9571 | 3,1967 | 1,8201 | 0,4434 | 0,5616 | 0,0173 | 0,0038 | 0 | 0 | 0 | 0 | 100 |
| 5 | 05-Apr-19 | 93,828 | 3,2538 | 1,8521 | 0,4534 | 0,5824 | 0,022 | 0,0045 | 0 | 0 | 0 | 0 | 99,9962 |
| 6 | 06-Apr-19 | 93,774 | 3,2782 | 1,8784 | 0,4601 | 0,5851 | 0,0193 | 0 | 0 | 0,0049 | 0 | 0 | 100 |
| 7 | 07-Apr-19 | 93,7542 | 3,2744 | 1,8747 | 0,4576 | 0,5688 | 0,0185 | 0,0043 | 0 | 0 | 0 | 0 | 99,9525 |
| 8 | 08-Apr-19 | 93,8447 | 3,237 | 1,8372 | 0,4532 | 0,5723 | 0,0255 | 0,0041 | 0 | 0,0259 | 0 | 0 | 99,9999 |
| 9 | 09-Apr-19 | 93,779 | 3,2823 | 1,8727 | 0,4577 | 0,5841 | 0,0181 | 0,0019 | 0 | 0 | 0 | 0 | 99,9958 |
| 10 | 10-Apr-19 | 94,3162 | 3,1187 | 1,622 | 0,3907 | 0,4981 | 0,0187 | 0,0094 | 0 | 0,0236 | 0 | 0 | 99,9974 |
| 11 | 11-Apr-19 | 94 | 3,2442 | 1,7527 | 0,4377 | 0,5397 | 0,0215 | 0,0114 | 0 | 0,0084 | 0 | 0 | 99,9979 |
| 12 | 12-Apr-19 | 94,7138 | 3,088 | 1,3226 | 0,3091 | 0,3938 | 0,0206 | 0,0054 | 0 | 0,0194 | 0,088 | 0 | 99,9607 |
| 13 | 13-Apr-19 | 95,2016 | 2,9866 | 1,1409 | 0,2637 | 0,3313 | 0,0213 | 0,0066 | 0 | 0,048 | 0 | 0 | 100 |
| 14 | 14-Apr-19 | 95,5276 | 2,8706 | 0,9613 | 0,2197 | 0,2769 | 0,016 | 0,0108 | 0 | 0,079 | 0,0381 | 0 | 100 |
| 15 | 15-Apr-19 | 96 | 2,8706 | 0,9613 | 0,2197 | 0,2769 | 0,016 | 0,0108 | 0 | 0,079 | 0,0381 | 0 | 100 |
| 16 | 16-Apr-19 | 95,9933 | 2,6567 | 0,823 | 0,1887 | 0,2188 | 0,0247 | 0,0046 | 0 | 0,0838 | 0 | 0 | 99,9936 |
| 17 | 17-Apr-19 | 95,9809 | 2,7602 | 0,7912 | 0,1781 | 0,2182 | 0,0121 | 0,0066 | 0 | 0,0475 | 0 | 0,0475 | 100,0423 |
| 18 | 18-Apr-19 | 94 | 3,0551 | 1,6886 | 0,4284 | 0,5206 | 0,0296 | 0,0051 | 0 | 0,0171 | 0,0223 | 0 | 99,9959 |
| 19 | 19-Apr-19 | 94 | 3,095 | 2 | 0,4472 | 0,5478 | 0,0254 | 0,0009 | 0 | 0 | 0 | 0 | 99,9999 |
| 20 | 20-Apr-19 | 93,8777 | 3,141 | 1,8763 | 0,4708 | 0,5881 | 0,0294 | 0 | 0 | 0 | 0 | 0 | 99,9833 |
| 21 | 21-Apr-19 | 93,9367 | 3,1584 | 1,8329 | 0,4573 | 0,5629 | 0,0326 | 0,0044 | 0 | 0 | 0 | 0 | 99,9852 |
| 22 | 22-Apr-19 | 94,031 | 3,1459 | 1,7698 | 0,4437 | 0,5445 | 0,0277 | 0,0211 | 0 | 0 | 0 | 0 | 99,9837 |
| 23 | 23-Apr-19 | 94 | 3 | 1,7981 | 0,45 | 0,5498 | 0,0315 | 0,0018 | 0 | 0,0114 | 0,0552 | 0 | 100 |
| 24 | 24-Apr-19 | 94,1778 | 3,1144 | 1,7055 | 0,4276 | 0,5233 | 0,0257 | 0,0072 | 0 | 0 | 0 | 0 | 99,9815 |
| 25 | 25-Apr-19 | 93,742 | 3,1819 | 1,7967 | 0,4543 | 0,5485 | 0,0475 | 0,0159 | 0 | 0 | 0,0843 | 0 | 99,8711 |
| 26 | 26-Apr-19 | 94,0049 | 3,1938 | 1,7691 | 0,4436 | 0,5494 | 0,0284 | 0,0024 | 0 | 0 | 0 | 0 | 99,9916 |
| 27 | 27-Apr-19 | 93,9929 | 3,1839 | 1,7745 | 0,4671 | 0,5462 | 0,0243 | 0,0063 | 0 | 0 | 0,0047 | 0 | 99,9999 |
| 28 | 28-Apr-19 | 93,9361 | 3,2354 | 1,7807 | 0,453 | 0,5655 | 0,0264 | 0,0029 | 0 | 0 | 0 | 0 | 100 |
| 29 | 29-Apr-19 | 93,9801 | 3,1669 | 1,8049 | 0,4603 | 0,5587 | 0,0232 | 0,0059 | 0 | 0 | 0 | 0 | 100 |
| 30 | 30-Apr-19 | 93,8989 | 3,2024 | 1,79 | 0,4539 | 0,5635 | 0,023 | 0,0056 | 0 | 0 | 0,0494 | 0 | 99,9867 |
| 31 | | | | | | | | | | | | | |
| **TOTAL APRIL 2019** | | **94,23719** | **3,133176667** | **1,645956667** | **0,406126667** | **0,504483333** | **0,02326** | **0,00584** | **0** | **0,014933333** | **0,01267** | **0,001583333** | **99,98522** |

| No | Tanggal | KOMPOSISI GAS # 350, % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Apr-19 | 93,7914 | 3,1852 | 1,9389 | 0,4737 | 0,5878 | 0,0146 | 0,0073 | 0 | 0 | 0 | 0 | 99,9989 |
| 2 | 02-Apr-19 | 93,6111 | 3,2684 | 1,9906 | 0,4871 | 0,608 | 0,0212 | 0,0049 | 0 | 0 | 0 | 0 | 99,9913 |
| 3 | 03-Apr-19 | 93,6959 | 3,195 | 2,0029 | 0,488 | 0,6043 | 0,012 | 0,0011 | 0 | 0 | 0 | 0 | 99,9992 |
| 4 | 04-Apr-19 | 94,0051 | 3,0469 | 1,8779 | 0,465 | 0,5798 | 0,0208 | 0 | 0 | 0 | 0 | 0 | 99,9955 |
| 5 | 05-Apr-19 | 93,9542 | 3,1979 | 1,8212 | 0,4437 | 0,5618 | 0,0173 | 0,0038 | 0 | 0 | 0 | 0 | 99,9999 |
| 6 | 06-Apr-19 | 93,8457 | 3,1254 | 1,93 | 0,4729 | 0,5976 | 0,0223 | 0,0051 | 0 | 0 | 0,0009 | 0 | 99,9999 |
| 7 | 07-Apr-19 | 93,8448 | 3,1392 | 1,9273 | 0,4741 | 0,5922 | 0,0191 | 0,0033 | 0 | 0 | 0 | 0 | 100 |
| 8 | 08-Apr-19 | 93,8358 | 3,1346 | 1,9346 | 0,473 | 0,6023 | 0,0195 | 0 | 0 | 0 | 0 | | 99,9998 |
| 9 | 09-Apr-19 | 93,8779 | 3,0994 | 1,9246 | 0,4712 | 0,596 | 0,0192 | 0 | 0 | 0 | 0 | 0 | 99,9883 |
| 10 | 10-Apr-19 | 94,3267 | 3,0156 | 1,6761 | 0,4067 | 0,5154 | 0,0171 | 0,0017 | 0 | 0,0243 | 0 | 0 | 99,9836 |
| 11 | 11-Apr-19 | 94,0511 | 3,0997 | 1,8052 | 0,4481 | 0,5594 | 0,0149 | 0,0015 | 0 | 0,0043 | 0,0019 | 0 | 99,9861 |
| 12 | 12-Apr-19 | 94,8925 | 2,9539 | 1,3524 | 0,325 | 0,4029 | 0,0173 | 0,0008 | 0 | 0,034 | 0,0067 | 0 | 99,9855 |
| 13 | 13-Apr-19 | 94,7464 | 2,9569 | 1,4575 | 0,3452 | 0,4362 | 0,0195 | 0,0062 | 0 | 0,0288 | 0 | 0 | 99,9967 |
| 14 | 14-Apr-19 | | | | | | | | | | | | 0 |
| 15 | 15-Apr-19 | 95,6213 | 2,7047 | 1,0432 | 0,2407 | 0,3003 | 0,0125 | 0 | 0 | 0,0724 | 0 | 0 | 99,9951 |
| 16 | 16-Apr-19 | 95,5505 | 2,7466 | 1,0472 | 0,2426 | 0,3043 | 0,017 | 0,0027 | 0 | 0,0732 | 0,0096 | 0 | 99,9937 |
| 17 | 17-Apr-19 | 95,1726 | 2,8221 | 1,1481 | 0,2604 | 0,3275 | 0,0271 | 0,0072 | 0 | 0,0941 | 0,1314 | 0 | 99,9905 |
| 18 | 18-Apr-19 | 94,2674 | 2,988 | 1,7226 | 0,1782 | 0,2182 | 0,0122 | 0,0066 | 0 | 0,0477 | 0 | 0 | 99,4409 |
| 19 | 19-Apr-19 | 93,9903 | 3,0906 | 1,8502 | 0,4649 | 0,5785 | 146 | 0,001 | 0 | 0,0085 | 0 | 0 | 245,984 |
| 20 | 20-Apr-19 | 94,0099 | 3,1169 | 1,8155 | 0,4583 | 0,5643 | 0,0237 | 0,0054 | 0 | 0 | 0 | | 99,994 |
| 21 | 21-Apr-19 | 93,8917 | 3,1484 | 1,8663 | 0,472 | 0,5859 | 0,0245 | 0,0007 | 0 | 0 | 0 | 0 | 99,9895 |
| 22 | 22-Apr-19 | 94,0279 | 3,1151 | 1,798 | 0,4556 | 0,5708 | 0,0271 | 0 | 0 | 0 | 0 | 0 | 99,9945 |
| 23 | 23-Apr-19 | 93,8916 | 3,1492 | 1,8631 | 0,4616 | 0,5802 | 0,0285 | 0,0072 | 0 | 0 | 0 | 0 | 99,9814 |
| 24 | 24-Apr-19 | 94,1141 | 3,0909 | 1,7666 | 0,442 | 0,555 | 0,0247 | 0,0068 | 0 | 0 | 0 | 0 | 100,0001 |
| 25 | 25-Apr-19 | 93,9396 | 3,1621 | 1,8304 | 0,4616 | 0,5799 | 0,0215 | 0,0039 | 0 | 0 | 0 | 0 | 99,999 |
| 26 | 26-Apr-19 | 93,9233 | 3,1592 | 1,8475 | 0,4601 | 0,5762 | 0,0265 | 0,0028 | 0 | 0 | 0 | 0 | 99,9956 |
| 27 | 27-Apr-19 | 93,8933 | 3,1758 | 1,8525 | 0,4608 | 0,5718 | 0,0349 | 0,0053 | 0 | 0 | 0 | 0 | 99,9944 |
| 28 | 28-Apr-19 | 93,8672 | 3,1967 | 1,8505 | 0,4672 | 0,5841 | 0,0265 | 0 | 0 | 0 | 0 | 0 | 99,9922 |
| 29 | 29-Apr-19 | 93,9896 | 3,0915 | 1,822 | 0,4732 | 0,5882 | 0,0242 | 0 | 0 | 0 | 0 | 0 | 99,9887 |
| 30 | 30-Apr-19 | 93,935 | 3,1591 | 1,8345 | 0,4658 | 0,5777 | 0,0216 | 0,0045 | 0 | 0 | 0 | 0 | 99,9982 |
| 31 | | | | | | | | | | | | | 0 |
| **TOTAL APRIL 2019** | | | | | | | | | | | | | 98,2340806 |

| No | Tanggal | KOMPOSISI GAS # IP - TP % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Apr-19 | 94,1051 | 2,9859 | 1,8629 | 0,4589 | 0,5678 | 0,0141 | 0 | 0 | 0,0052 | 0 | 0 | 99,9999 |
| 2 | 02-Apr-19 | 93,9428 | 3,0658 | 1,9169 | 0,4707 | 0,5845 | 0,0156 | 0 | 0 | 0,0037 | 0 | 0 | 100 |
| 3 | 03-Apr-19 | 93,9196 | 3,0905 | 1,9099 | 0,4747 | 0,5869 | 0,0149 | 0 | 0 | 0,0036 | 0 | 0 | 100,0001 |
| 4 | 04-Apr-19 | 94,2639 | 2,908 | 1,7916 | 0,4528 | 0,5617 | 0,0162 | 0 | 0 | 0,0057 | 0 | 0 | 99,9999 |
| 5 | 05-Apr-19 | 94,1473 | 2,9528 | 1,8422 | 0,4595 | 0,5574 | 0,0169 | 0 | 0 | 0,0038 | 0 | 0 | 99,9799 |
| 6 | 06-Apr-19 | 94,0588 | 3,0007 | 1,8721 | 0,466 | 0,5818 | 0,017 | 0 | 0 | 0,0036 | 0 | 0 | 100 |
| 7 | 07-Apr-19 | 94,1448 | 2,967 | 1,8356 | 0,4578 | 0,5708 | 0,0175 | 0 | 0 | 0,0059 | 0 | 0 | 99,9994 |
| 8 | 08-Apr-19 | 94,1917 | 2,9415 | 1,8215 | 0,4543 | 0,5677 | 0,0165 | 0 | 0 | 0,0069 | 0 | 0 | 100,0001 |
| 9 | 09-Apr-19 | 94,1508 | 2,9619 | 1,8336 | 0,4597 | 0,5721 | 0,0166 | 0 | 0 | 0,0053 | 0 | 0 | 100 |
| 10 | 10-Apr-19 | 94,57 | 2,859 | 1,6197 | 0,3987 | 0,4965 | 0,0151 | 0 | 0 | 0,0409 | 0 | 0 | 99,9999 |
| 11 | 11-Apr-19 | 94,28 | 2,9702 | 1,7493 | 0,4335 | 0,5344 | 0,0173 | 0 | 0 | 0,0153 | 0 | 0 | 100 |
| 12 | 12-Apr-19 | 95,1556 | 3,088 | 1,3226 | 0,3091 | 0,3938 | 0,0206 | 0,0054 | 0 | 0,0194 | 0,0836 | 0 | 100,3981 |
| 13 | 13-Apr-19 | 95,5369 | 2,6574 | 1,1253 | 0,2663 | 0,3292 | 0,0147 | 0 | 0 | 0,0701 | 0 | 0 | 99,9999 |
| 14 | 14-Apr-19 | | | | | | | | | | | | 0 |
| 15 | 15-Apr-19 | 95,8583 | 2,5716 | 0,9634 | 0,2198 | 0,2761 | 0,0122 | 0 | 0 | 0 | 0 | 0 | 99,9014 |
| 16 | 16-Apr-19 | 96,2103 | 2,4524 | 0,8074 | 0,1808 | 0,225 | 0,0108 | 0 | 0 | 0,1135 | 0 | 0 | 100,0002 |
| 17 | 17-Apr-19 | 96,2658 | 2,4916 | 0,7723 | 0,1711 | 0,2144 | 0,0116 | 0 | 0 | 0,0731 | 0 | 0 | 99,9999 |
| 18 | 18-Apr-19 | 94,5296 | 2,8284 | 1,6521 | 0,4197 | 0,5199 | 0,0216 | 0,0216 | 0 | 0,0288 | 0 | 0 | 100,0217 |
| 19 | 19-Apr-19 | 94,3435 | 2,8874 | 1,7375 | 0,4419 | 0,5458 | 0,0223 | 0 | 0 | 0,0216 | 0 | 0 | 100 |
| 20 | 20-Apr-19 | 94,2052 | 2,9502 | 1,7952 | 0,4535 | 0,564 | 0,0243 | 0 | 0 | 0,0076 | 0 | 0 | 100 |
| 21 | 21-Apr-19 | 94,1926 | 2,955 | 1,8053 | 0,4508 | 0,5655 | 0,0235 | 0 | 0 | 0,0072 | 0 | 0 | 99,9999 |
| 22 | 22-Apr-19 | 94,3464 | 2,9079 | 1,729 | 0,4372 | 0,5467 | 0,0237 | 0 | 0 | 0,0092 | 0 | 0 | 100,0001 |
| 23 | 23-Apr-19 | 94,3497 | 2,8968 | 1,7367 | 0,4381 | 0,5469 | 0,0232 | 0 | 0 | 0,0086 | 0 | 0 | 100 |
| 24 | 24-Apr-19 | 94,3983 | 2,9016 | 1,7049 | 0,4294 | 0,5335 | 0,0222 | 0 | 0 | 0,0101 | 0 | 0 | 100 |
| 25 | 25-Apr-19 | 94,2625 | 2,9521 | 1,7615 | 0,444 | 0,5499 | 0,0235 | 0 | 0 | 0,0065 | 0 | 0 | 100 |
| 26 | 26-Apr-19 | 94,3062 | 2,9373 | 1,7397 | 0,4401 | 0,5456 | 0,0233 | 0 | 0 | 0,0081 | 0 | 0 | 100,0003 |
| 27 | 27-Apr-19 | 93,6285 | 3,1233 | 2,1435 | 0,4877 | 0,5991 | 0,0088 | 0,0027 | 0 | 0,0064 | 0 | 0 | 100 |
| 28 | 28-Apr-19 | 94,1948 | 3,0082 | 1,7666 | 0,4473 | 0,556 | 0,0221 | 0,0051 | 0 | 0 | 0 | 0 | 100,0001 |
| 29 | 29-Apr-19 | 94,1959 | 2,9739 | 1,7817 | 0,4576 | 0,5671 | 0,0195 | 0 | 0 | 0,0042 | 0 | 0 | 99,9999 |
| 30 | 30-Apr-19 | 94,2993 | 2,935 | 1,7421 | 0,4482 | 0,5512 | 0,0195 | 0 | 0 | 0,0046 | 0 | 0 | 99,9999 |
| 31 | | | | | | | | | | | | | 0 |
| TOTAL APRIL 2019 | | | | | | | | | | | | | 93,5580839 |

| No | Tanggal | KOMPOSISI GAS # PERTAGAS - MTW % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Apr-19 | 93,7258 | 3,3105 | 1,8972 | 0,4614 | 0,5756 | 0,0233 | 0,0001 | 0 | 0,0062 | 0 | 0 | 100,0001 |
| 2 | 02-Apr-19 | 93,8391 | 3,2497 | 1,8583 | 0,4617 | 0,5697 | 0,0147 | 0,0068 | 0 | 0 | 0 | 0 | 100 |
| 3 | 03-Apr-19 | 93,6857 | 3,333 | 1,9011 | 0,4612 | 0,6021 | 0,0168 | 0 | 0 | 0 | 0 | 0 | 99,9999 |
| 4 | 04-Apr-19 | 93,6445 | 3,3302 | 1,9423 | 0,4715 | 0,5867 | 0,0201 | 0,0047 | 0 | 0 | 0 | 0 | 100 |
| 5 | 05-Apr-19 | 93,7008 | 3,0867 | 2,0913 | 0,5004 | 0,6093 | 0,0069 | 0,0004 | 0 | 0,0047 | 0 | -0,0003 | 100,0002 |
| 6 | 06-Apr-19 | 93,8339 | 3,2529 | 1,8516 | 0,4532 | 0,582 | 0,0219 | 0,0045 | 0 | 0 | 0 | 0 | 100 |
| 7 | 07-Apr-19 | 93,7747 | 3,2779 | 1,8781 | 0,46 | 0,5851 | 0,0193 | 0,0001 | 0 | 0 | 0 | 0 | 99,9952 |
| 8 | 08-Apr-19 | 93,7985 | 3,276 | 1,8756 | 0,4578 | 0,5692 | 0,0185 | 0,0043 | 0 | 0 | 0 | 0 | 99,9999 |
| 9 | 09-Apr-19 | 93,8443 | 3,2374 | 1,8376 | 0,4533 | 0,5723 | 0,0254 | 0,0041 | 0 | 0,0256 | 0 | 0 | 100 |
| 10 | 10-Apr-19 | 93,7836 | 3,282 | 1,8724 | 0,4577 | 0,584 | 0,0182 | 0,0019 | 0 | 0,0003 | 0 | 0 | 100,0001 |
| 11 | 11-Apr-19 | 94,0511 | 3,0997 | 1,6235 | 0,3911 | 0,4986 | 0,0187 | 0,0094 | 0 | 0,0235 | 0 | 0 | 99,7156 |
| 12 | 12-Apr-19 | 93,9863 | 3,2435 | 1,752 | 0,4374 | 0,5395 | 0,0215 | 0,0114 | 0 | 0,0085 | 0 | 0 | 100,0001 |
| 13 | 13-Apr-19 | 94,743 | 3,0918 | 1,33 | 0,3113 | 0,3963 | 0,0206 | 0,0055 | 0 | 0,0192 | 0,0823 | 0 | 100 |
| 14 | 14-Apr-19 | | | | | | | | | | | | 0 |
| 15 | 15-Apr-19 | 95,033 | 3,0131 | 1,208 | 0,2885 | 0,3612 | 0,0171 | 0,0035 | 0 | 0,0755 | 0 | 0 | 99,9999 |
| 16 | 16-Apr-19 | 95,5234 | 2,8718 | 0,9634 | 0,2203 | 0,2776 | 0,0107 | 0,0107 | 0 | 0,079 | 0,0378 | 0 | 99,9947 |
| 17 | 17-Apr-19 | 95,9933 | 2,6596 | 0,8249 | 0,1891 | 0,2196 | 0,0246 | 0,0072 | 0 | 0,0837 | 0,0005 | 0 | 100,0025 |
| 18 | 18-Apr-19 | 95,986 | 2,7597 | 0,7915 | 0,01782 | 0,2182 | 0,0122 | 0,0066 | 0 | 0,0477 | 0 | 0 | 99,83972 |
| 19 | 19-Apr-19 | 94,2429 | 3,0536 | 1,6836 | 0,427 | 0,5189 | 0,0295 | 0,0051 | 0 | 0,0173 | 0,0222 | 0 | 100,0001 |
| 20 | 20-Apr-19 | 94,1034 | 3,0943 | 1,781 | 0,4469 | 0,5473 | 0,0255 | 0,001 | 0 | 0,0003 | 0,0004 | 0 | 100,0001 |
| 21 | 21-Apr-19 | 94,0168 | 3,1168 | 1,8151 | 0,4582 | 0,5641 | 0,0237 | 0,0053 | 0 | 0 | 0 | 0 | 100 |
| 22 | 22-Apr-19 | 93,9511 | 3,1586 | 1,8331 | 0,4574 | 0,563 | 0,0325 | 0,0044 | 0 | 0 | 0 | 0 | 100,0001 |
| 23 | 23-Apr-19 | 94,0456 | 3,1465 | 1,7706 | 0,4439 | 0,5448 | 0,0278 | 0,021 | 0 | 0 | 0 | 0 | 100,0002 |
| 24 | 24-Apr-19 | 94,0072 | 3,0964 | 1,7977 | 0,4499 | 0,5497 | 0,0314 | 0,0021 | 0 | 0,0112 | 0,0544 | 0 | 100 |
| 25 | 25-Apr-19 | 94,1807 | 3,1144 | 1,7063 | 0,4278 | 0,5235 | 0,0258 | 0,0072 | 0 | 0,0001 | 0,0144 | 0 | 100,0002 |
| 26 | 26-Apr-19 | 93,8695 | 3,1846 | 1,7971 | 0,4543 | 0,5487 | 0,0471 | 0,0157 | 0 | 0 | 0,083 | 0 | 100 |
| 27 | 27-Apr-19 | 94,0113 | 3,194 | 1,7696 | 0,4438 | 0,5494 | 0,0286 | 0,0026 | 0 | 0 | 0 | 0 | 99,9993 |
| 28 | 28-Apr-19 | 93,9932 | 3,184 | 1,7745 | 0,4668 | 0,5462 | 0,0244 | 0,0063 | 0 | 0 | 0 | | 99,9954 |
| 29 | 29-Apr-19 | 93,9366 | 3,2349 | 1,7806 | 0,4531 | 0,5653 | 0,0264 | 0,0029 | 0 | 0 | 0 | 0 | 99,9998 |
| 30 | 30-Apr-19 | 93,9798 | 3,1674 | 1,8047 | 0,4603 | 0,5588 | 0,0232 | 0,0059 | 0 | 0 | 0 | 0 | 100,0001 |
| 31 | | | | | | | | | | | | | 0 |
| TOTAL APRIL 2019 | | | | | | | | | | | | | 93,5336523 |

| No | Tanggal | KOMPOSISI GAS # 350, % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Mei-19 | 93,9041 | 3,2211 | 1,8093 | 0,462 | 0,559 | 0,0179 | 0,0265 | 0 | 0 | 0 | 0 | 99,9999 |
| 2 | 02-Mei-19 | 93,873 | 3,2159 | 1,8226 | 0,4589 | 0,5663 | 0,0238 | 0,0091 | 0 | 0,0039 | 0 | 0 | 99,9735 |
| 3 | 03-Mei-19 | 93,8749 | 3,2017 | 1,7719 | 0,4474 | 0,5483 | 0,0229 | 0,0034 | 0 | 0 | 0 | 0 | 99,8705 |
| 4 | 04-Mei-19 | 93,958 | 3,1964 | 1,7551 | 0,4574 | 0,5596 | 0,0267 | 0,0072 | 0 | 0 | 0,0379 | 0 | 99,9983 |
| 5 | 05-Mei-19 | 94,0386 | 3,1603 | 1,7759 | 0,4427 | 0,5559 | 0,0222 | 0,0043 | 0 | 0 | 0 | 0 | 99,9999 |
| 6 | 06-Mei-19 | 93,9047 | 3,2249 | 1,7934 | 0,4524 | 0,5642 | 0,0235 | 0,0056 | 0 | 0 | 0,0047 | 0 | 99,9734 |
| 7 | 07-Mei-19 | 93,7016 | 3,2696 | 1,8211 | 0,4615 | 0,563 | 0,0251 | 0,0027 | 0 | 0,0242 | 0,0081 | 0 | 99,8769 |
| 8 | 08-Mei-19 | | | | | | | | | | | | 0 |
| 9 | 09-Mei-19 | 93,8506 | 3,2314 | 1,808 | 0,47 | 0,5639 | 0,019 | 0,0095 | 0 | 0 | 0 | 0 | 99,9524 |
| 10 | 10-Mei-19 | 96,0914 | 2,7129 | 0,7071 | 0,1424 | 0,1766 | 0,0186 | 0,0117 | 0 | 0,1349 | 0 | 0 | 99,9956 |
| 11 | 11-Mei-19 | 94 | 3,2262 | 1,8219 | 0,4586 | 0,5618 | 0,0219 | 0,0127 | 0 | 0,0045 | 0 | 0 | 99,9959 |
| 12 | 12-Mei-19 | 93,8459 | 3,2077 | 1,797 | 0,4516 | 0,5635 | 0,0285 | 0,0043 | 0 | 0 | 0,0151 | 0 | 99,9136 |
| 13 | 13-Mei-19 | 93,8189 | 3,261 | 1,8365 | 0,4636 | 0,5704 | 0,0287 | 0,0021 | 0 | 0,0032 | 0 | 0 | 99,9844 |
| 14 | 14-Mei-19 | 93,7693 | 3,2624 | 1,8448 | 0,484 | 0,5983 | 0,0278 | 0,0091 | 0 | 0 | 0,0568 | 0 | 100,0525 |
| 15 | 15-Mei-19 | 94 | 3,3293 | 1,8394 | 0,4599 | 0,5657 | 0,0192 | 0,0099 | 0 | 0 | 0 | 0 | 99,9958 |
| 16 | 16-Mei-19 | | | | | | | | | | | | 0 |
| 17 | 17-Mei-19 | 93,8181 | 3,303 | 1,8083 | 0,4656 | 0,5701 | 0,0228 | 0,0081 | 0 | 0 | 0 | 0 | 99,996 |
| 18 | 18-Mei-19 | 94 | 3,2071 | 1,7454 | 0,4527 | 0,5517 | 0,0251 | 0,0204 | 0 | 0,0097 | 0 | 0 | 99,9999 |
| 19 | 19-Mei-19 | 94 | 3,2395 | 2 | 0,4591 | 0,5599 | 0,02 | 0,0059 | 0 | 0,0054 | 0 | 0 | 99,9977 |
| 20 | 20-Mei-19 | 93,75 | 3,308 | 1,8478 | 0,4682 | 0,5757 | 0,0397 | 0,0107 | 0 | 0 | 0 | 0 | 100,0001 |
| 21 | 21-Mei-19 | 93,7747 | 3,2786 | 1,8431 | 0,4738 | 0,5733 | 0,0385 | 0 | 0 | 0 | 0,0179 | 0 | 99,9999 |
| 22 | 22-Mei-19 | 93,749 | 3,3441 | 1,8381 | 0,4705 | 0,5668 | 0,0315 | 0 | 0 | 0 | 0 | 0 | 100 |
| 23 | 23-Mei-19 | 94 | 3 | 1,8396 | 0,4668 | 0,5684 | 0,0324 | 0,0036 | 0 | 0 | 0 | 0 | 100 |
| 24 | 24-Mei-19 | 93,8909 | 3,2325 | 1,8147 | 0,4584 | 0,5735 | 0,021 | 0,009 | 0 | 0 | 0 | 0 | 100 |
| 25 | 25-Mei-19 | 93,752 | 3,316 | 1,8366 | 0,4709 | 0,5774 | 0,0402 | 0,0033 | 0 | 0 | 0 | 0 | 99,9964 |
| 26 | 26-Mei-19 | 93,7574 | 3,3243 | 1,8355 | 0,4707 | 0,5718 | 0,0205 | 0,0199 | 0 | 0 | 0 | 0 | 100,0001 |
| 27 | 27-Mei-19 | 93,7197 | 3,3476 | 1,8412 | 0,4785 | 0,5732 | 0,0247 | 0,0023 | 0 | 0 | 0 | 0 | 99,9872 |
| 28 | 28-Mei-19 | 93,7747 | 3,2659 | 1,8023 | 0,4664 | 0,5703 | 0,0404 | 0,0041 | 0 | 0,0043 | 0,0681 | 0 | 99,9965 |
| 29 | 29-Mei-19 | 93,7778 | 3,3065 | 1,8159 | 0,4766 | 0,5653 | 0,0232 | 0,0273 | 0 | 0,0041 | 0 | 0 | 99,9967 |
| 30 | 30-Mei-19 | 93,8427 | 3,2948 | 1,8169 | 0,4602 | 0,5597 | 0,0182 | 0,0051 | 0 | 0 | 0 | 0 | 99,9976 |
| 31 | 31-Mei-19 | 93,9227 | 3,2471 | 1,7727 | 0,4581 | 0,5568 | 0,0232 | 0,0043 | 0 | 0 | 0 | 0 | 99,9849 |
| **TOTAL MEI 2019** | | **93,91267586** | **3,244065517** | **1,774437931** | **0,452031034** | **0,552772414** | **0,025765517** | **0,008348276** | **0** | **0,006696552** | **0,007193103** | **0** | **99,98398621** |

| No | Tanggal | KOMPOSISI GAS # 350, % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Mei-19 | 93,8203 | 3,2007 | 1,8814 | 0,4755 | 0,5927 | 0,0224 | 0,0061 | 0 | 0 | 0 | 0 | 99,9991 |
| 2 | 02-Mei-19 | 93,875 | 3,1761 | 1,8636 | 0,4746 | 0,5908 | 0,0199 | 0 | 0 | 0 | 0 | 0 | 100 |
| 3 | 03-Mei-19 | 93,9867 | 3,1402 | 1,8091 | 0,4618 | 0,5771 | 0,0242 | 0,0009 | 0 | 0 | 0 | 0 | 100 |
| 4 | 04-Mei-19 | 93,9106 | 3,1287 | 1,8633 | 0,4713 | 0,5912 | 0,0256 | 0 | 0 | 0 | 0 | 0 | 99,9907 |
| 5 | 05-Mei-19 | 93,9963 | 3,155 | 1,7171 | 0,4301 | 0,5335 | 0,0297 | 0 | 0 | 0 | 0 | 0 | 99,8617 |
| 6 | 06-Mei-19 | 93,8693 | 3,186 | 1,8536 | 0,471 | 0,5861 | 0,0239 | 0,0017 | 0 | 0 | 0 | 0 | 99,9916 |
| 7 | 07-Mei-19 | 93,8203 | 3,2169 | 1,8535 | 0,476 | 0,5962 | 0,0231 | 0 | 0 | 0 | 0 | 0 | 99,986 |
| 8 | 08-Mei-19 | | | | | | | | | | | | 0 |
| 9 | 09-Mei-19 | 93,8835 | 3,1343 | 1,8875 | 0,4765 | 0,5962 | 0,0159 | 0 | 0 | 0 | 0 | 0 | 99,9939 |
| 10 | 10-Mei-19 | 96,1808 | 2,6262 | 0,7242 | 0,1469 | 0,182 | 0,0149 | 0,0054 | 0 | 0,1195 | 0 | 0 | 99,9999 |
| 11 | 11-Mei-19 | 93,8543 | 3,1627 | 1,8825 | 0,4748 | 0,5941 | 0,0236 | 0,008 | 0 | 0 | 0,0019 | 0 | 100,0019 |
| 12 | 12-Mei-19 | 93,8194 | 3,1652 | 1,8452 | 0,4721 | 0,5917 | 0,0241 | 0,005 | 0 | 0 | 0,0008 | 0 | 99,9235 |
| 13 | 13-Mei-19 | 93,807 | 3,2035 | 1,8945 | 0,4781 | 0,5965 | 0,02 | 0 | 0 | 0 | 0 | 0 | 99,9996 |
| 14 | 14-Mei-19 | 93,7454 | 3,2108 | 1,9104 | 0,484 | 0,5983 | 0,0278 | 0,0091 | 0 | 0 | 0 | 0 | 99,9858 |
| 15 | 15-Mei-19 | 93,7279 | 3,2465 | 1,8952 | 0,4859 | 0,6062 | 0,0215 | 0,0005 | 0 | 0 | 0 | 0 | 99,9837 |
| 16 | 16-Mei-19 | | | | | | | | | | | | 0 |
| 17 | 17-Mei-19 | 93,9054 | 3,1449 | 1,8493 | 0,4785 | 0,5909 | 0,0229 | 0,0081 | 0 | 0 | 0 | 0 | 100 |
| 18 | 18-Mei-19 | 93,8143 | 3,1879 | 1,8775 | 0,4826 | 0,5976 | 0,0218 | 0,0067 | 0 | 0 | 0,0012 | 0 | 99,9896 |
| 19 | 19-Mei-19 | 93,8723 | 3,1713 | 1,8598 | 0,4752 | 0,5894 | 0,0192 | 0,0077 | 0 | 0 | 0 | 0 | 99,9949 |
| 20 | 20-Mei-19 | 93,7427 | 3,2447 | 1,8849 | 0,4904 | 0,6034 | 0,0213 | 0,0053 | 0 | 0 | 0 | 0 | 99,9927 |
| 21 | 21-Mei-19 | 93,7555 | 3,234 | 1,8912 | 0,4858 | 0,6 | 0,0222 | 0,0049 | 0 | 0 | 0 | 0 | 99,9936 |
| 22 | 22-Mei-19 | 93,7679 | 3,2339 | 1,8885 | 0,44 | 0,6005 | 0,0193 | 0 | 0 | 0 | 0 | 0 | 99,9501 |
| 23 | 23-Mei-19 | 93,7299 | 3,2421 | 1,9179 | 0,4889 | 0,6044 | 0,014 | 0,0027 | 0 | 0 | 0 | 0 | 99,9999 |
| 24 | 24-Mei-19 | 93,8273 | 3,2102 | 1,8468 | 0,4817 | 0,5997 | 0,0194 | 0,0004 | 0 | 0 | 0 | 0 | 99,9855 |
| 25 | 25-Mei-19 | 93,7814 | 3,2204 | 1,723 | 0,474 | 0,06023 | 0,0211 | 0,0062 | 0 | 0 | 0 | 0 | 99,28633 |
| 26 | 26-Mei-19 | 93,7769 | 3,2277 | 1,879 | 0,4852 | 0,6064 | 0,0193 | 0,0025 | 0 | 0 | 0 | 0 | 99,997 |
| 27 | 27-Mei-19 | 93,7382 | 3,2488 | 1,8925 | 0,4917 | 0,606 | 0,0155 | 0 | 0 | 0 | 0 | 0 | 99,9927 |
| 28 | 28-Mei-19 | 93,8046 | 3,2164 | 1,8659 | 0,4871 | 0,599 | 0,019 | 0,006 | 0 | 0 | 0 | -0,0003 | 99,9977 |
| 29 | 29-Mei-19 | 93,6714 | 3,2827 | 1,9023 | 0,4965 | 0,6159 | 0,0184 | 0,0064 | 0 | 0 | 0 | 0 | 99,9936 |
| 30 | 30-Mei-19 | 93,389 | 3,3223 | 1,9669 | 0,506 | 0,6316 | 0,0325 | 0,0066 | 0 | 0,0075 | 0,1286 | 0 | 99,991 |
| 31 | 31-Mei-19 | 94,2532 | 2,9745 | 1,7279 | 0,4571 | 0,5641 | 0,0154 | 0 | 0 | 0,007 | 0 | 0 | 99,9992 |
| **TOTAL MEI 2019** | | **93,9009241** | **3,17636552** | **1,82256897** | **0,4654931** | **0,56212862** | **0,0213069** | **0,00345517** | **0** | **0,00462069** | **0,00456897** | **-1,034E-05** | **93,5122977** |

| No | Tanggal | KOMPOSISI GAS # IP - TP % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Mei-19 | 94,2326 | 2,9619 | 1,7622 | 0,4561 | 0,5646 | 0,0188 | 0 | 0 | 0,0038 | 0 | 0 | 100 |
| 2 | 02-Mei-19 | 94,2236 | 2,9635 | 1,7703 | 0,4554 | 0,5629 | 0,202 | 0 | 0 | 0,0041 | 0 | 0 | 100,1818 |
| 3 | 03-Mei-19 | 94,3496 | 2,9258 | 1,7719 | 0,4376 | 0,5452 | 0,0196 | 0 | 0 | 0,0062 | 0 | 0 | 100,0559 |
| 4 | 04-Mei-19 | 94,2573 | 2,9501 | 1,7595 | 0,4502 | 0,557 | 0,0202 | 0 | 0 | 0,0057 | 0 | 0 | 100 |
| 5 | 05-Mei-19 | 94,4119 | 2,9224 | 1,6798 | 0,4287 | 0,5311 | 0,02 | 0 | 0 | 0,0062 | 0 | 0 | 100,0001 |
| 6 | 06-Mei-19 | 94,203 | 2,9957 | 1,7566 | 0,4548 | 0,5645 | 0,0203 | 0 | 0 | 0,005 | 0 | 0 | 99,9999 |
| 7 | 07-Mei-19 | 94,174 | 3,0122 | 1,7697 | 0,4543 | 0,564 | 0,0213 | 0 | 0 | 0,0045 | 0 | 0 | 100 |
| 8 | 08-Mei-19 | | | | | | | | | | | | 0 |
| 9 | 09-Mei-19 | 94,2209 | 2,984 | 1,7562 | 0,4551 | 0,5609 | 0,0184 | 0 | 0 | 0,0044 | 0 | 0 | 99,9999 |
| 10 | 10-Mei-19 | 96,3507 | 2,4437 | 0,7042 | 0,1421 | 0,175 | 0,0143 | 0,0031 | 0 | 0,1668 | 0 | 0 | 99,9999 |
| 11 | 11-Mei-19 | 94,2409 | 2,967 | 1,7497 | 0,4508 | 0,5675 | 0,0188 | 0 | 0 | 0,0051 | 0 | 0 | 99,9998 |
| 12 | 12-Mei-19 | 94,2558 | 2,957 | 1,7559 | 0,4484 | 0,5589 | 0,0185 | 0 | 0 | 0,0054 | 0 | 0 | 99,9999 |
| 13 | 13-Mei-19 | 94,1753 | 2,9841 | 1,7919 | 0,4576 | 0,5686 | 0,018 | 0 | 0 | 0,0046 | 0 | 0 | 100,0001 |
| 14 | 14-Mei-19 | 94,1505 | 3,0156 | 1,7795 | 0,4599 | 0,5715 | 0,0186 | 0 | 0 | 0,0045 | 0 | 0 | 100,0001 |
| 15 | 15-Mei-19 | 94,1034 | 3,0279 | 1,805 | 0,4655 | 0,5746 | 0,0197 | 0 | 0 | 0,0039 | 0 | 0 | 100 |
| 16 | 16-Mei-19 | | | | | | | | | | | | 0 |
| 17 | 17-Mei-19 | 94,1203 | 3,042 | 1,7795 | 0,4655 | 0,5704 | 0,0156 | 0 | 0 | 0,0066 | 0 | 0 | 99,9999 |
| 18 | 18-Mei-19 | 94,2612 | 2,9766 | 1,7242 | 0,4556 | 0,5563 | 0,016 | 0 | 0 | 0,01 | 0 | 0 | 99,9999 |
| 19 | 19-Mei-19 | 94,0937 | 3,0625 | 1,7802 | 0,4686 | 0,5725 | 0,0154 | 0 | 0 | 0,0072 | 0 | 0 | 100,0001 |
| 20 | 20-Mei-19 | 94,0489 | 3,0841 | 1,7949 | 0,4725 | 0,5768 | 0,017 | 0 | 0 | 0,0057 | 0 | 0 | 99,9999 |
| 21 | 21-Mei-19 | 94,0369 | 3,0954 | 1,7999 | 0,4697 | 0,5775 | 0,0156 | 0 | 0 | 0,005 | 0 | 0 | 100 |
| 22 | 22-Mei-19 | 94,0685 | 3,0812 | 1,7806 | 0,4708 | 0,5773 | 0,0166 | 0 | 0 | 0,005 | 0 | 0 | 100 |
| 23 | 23-Mei-19 | 94,0733 | 3,0703 | 1,7893 | 0,4715 | 0,5746 | 0,0166 | 0 | 0 | 0,0044 | 0 | 0 | 100 |
| 24 | 24-Mei-19 | 94,1621 | 3,0167 | 1,7644 | 0,4629 | 0,5725 | 0,0158 | 0 | 0 | 0,0058 | 0 | 0 | 100,0002 |
| 25 | 25-Mei-19 | 94,1264 | 3,0564 | 1,7458 | 0,472 | 0,5781 | 0,0159 | 0 | 0 | 0,0054 | 0 | 0 | 100 |
| 26 | 26-Mei-19 | 94,0981 | 3,0455 | 1,7829 | 0,472 | 0,5782 | 0,0167 | 0 | 0 | 0,0066 | 0 | 0 | 100 |
| 27 | 27-Mei-19 | 94,0613 | 3,0679 | 1,7919 | 0,4757 | 0,58 | 0,0161 | 0 | 0 | 0,0071 | 0 | 0 | 100 |
| 28 | 28-Mei-19 | 94,1436 | 3,041 | 1,7564 | 0,4645 | 0,5736 | 0,0152 | 0 | 0 | 0,0058 | 0 | 0 | 100,0001 |
| 29 | 29-Mei-19 | 94,1495 | 3,0301 | 1,7597 | 0,4679 | 0,5704 | 0,0153 | 0 | 0 | 0,0071 | 0 | 0 | 100 |
| 30 | 30-Mei-19 | 94,2161 | 2,996 | 1,742 | 0,4609 | 0,5618 | 0,0153 | 0 | 0 | 0,0078 | 0 | 0 | 99,9999 |
| 31 | 31-Mei-19 | 94,2532 | 2,9745 | 1,7279 | 0,4571 | 0,5641 | 0,0154 | 0 | 0 | 0,0078 | 0 | 0 | 100 |
| **TOTAL MEI 2019** | | **94,2504345** | **2,99141724** | **1,72868966** | **0,4490931** | **0,55346207** | **0,02368966** | **0,0001069** | **0** | **0,0112931** | **0** | **0** | **93,5560452** |

| No | Tanggal | KOMPOSISI GAS # PERTAGAS - MTW % Mol | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Methane | Ethane | Propane | i-Butane | n-Butane | i-Pentane | n-Pentane | n-Hexane | Nitrogen | CO2 | Water | % TOTAL |
| 1 | 01-Mei-19 | 93,9121 | 3,2025 | 1,7904 | 0,454 | 0,5635 | 0,023 | 0,0056 | 0 | 0 | 0,049 | 0 | 100,0001 |
| 2 | 02-Mei-19 | 93,9043 | 3,2209 | 1,8091 | 0,4619 | 0,559 | 0,018 | 0,0263 | 0 | 0 | 0,0004 | 0 | 99,9999 |
| 3 | 03-Mei-19 | 93,8979 | 3,2168 | 1,823 | 0,4591 | 0,5664 | 0,0238 | 0,0093 | 0 | 0,0039 | 0 | 0 | 100,0002 |
| 4 | 04-Mei-19 | 93,9954 | 3,206 | 1,7748 | 0,4481 | 0,5492 | 0,0229 | 0,0035 | 0 | 0,0001 | 0 | 0 | 100 |
| 5 | 05-Mei-19 | 93,9599 | 3,1965 | 1,7553 | 0,4573 | 0,5595 | 0,0267 | 0,0072 | 0 | 0 | 0,0376 | 0 | 100 |
| 6 | 06-Mei-19 | 93,9962 | 3,1552 | 1,7173 | 0,4302 | 0,5336 | 0,0297 | 0,0013 | 0 | 0 | 0,1365 | 0 | 100 |
| 7 | 07-Mei-19 | 93,9307 | 3,2248 | 1,7929 | 0,4522 | 0,5639 | 0,0236 | 0,0055 | 0 | 0 | 0 | 0 | 99,9936 |
| 8 | 08-Mei-19 | | | | | | | | | | | | 0 |
| 9 | 09-Mei-19 | 94,0289 | 3,1672 | 1,7684 | 0,4479 | 0,5509 | 0,0238 | 0,0061 | 0 | 0,0066 | 0,0001 | 0 | 99,9999 |
| 10 | 10-Mei-19 | 93,8183 | 3,0784 | 2,0206 | 0,4798 | 0,5481 | 0,0076 | 0,0054 | 0 | 0,0109 | 0 | 0 | 99,9691 |
| 11 | 11-Mei-19 | 94,0402 | 3,042 | 1,8069 | 0,4837 | 0,6005 | 0,0205 | 0,0015 | 0 | 0,0051 | 0 | -0,0003 | 100,0001 |
| 12 | 12-Mei-19 | 94,0885 | 3,0222 | 1,7893 | 0,4783 | 0,5938 | 0,0204 | 0,0015 | 0 | 0,0065 | 0 | -0,0003 | 100,0002 |
| 13 | 13-Mei-19 | 94,0295 | 3,049 | 1,8093 | 0,484 | 0,6008 | 0,0206 | 0,0015 | 0 | 0,0057 | 0 | 0 | 100,0004 |
| 14 | 14-Mei-19 | 94,00636 | 3,06028 | 1,81704 | 0,48598 | 0,60323 | 0,02056 | 0,00152 | 0 | 0,00535 | 0 | -0,0003 | 100,00002 |
| 15 | 15-Mei-19 | 93,9668 | 3,0797 | 1,83 | 0,4894 | 0,6074 | 0,0206 | 0,0015 | 0 | 0,0049 | 0 | 0 | 100,0003 |
| 16 | 16-Mei-19 | | | | | | | | | | | | 0 |
| 17 | 17-Mei-19 | 93,9956 | 3,0696 | 1,8159 | 0,4888 | 0,0015 | 0,0193 | 0,0015 | 0 | 0,0055 | 0 | 0 | 99,3977 |
| 18 | 18-Mei-19 | 94,0231 | 3,0592 | 1,8005 | 0,4892 | 0,601 | 0,0178 | 0,0014 | 0 | 0,0082 | 0 | -0,0003 | 100,0001 |
| 19 | 19-Mei-19 | 94,0932 | 3,027 | 1,7781 | 0,4826 | 0,5928 | 0,0175 | 0,0013 | 0 | 0,0078 | 0 | -0,0003 | 100 |
| 20 | 20-Mei-19 | 93,9699 | 3,0883 | 1,8164 | 0,4935 | 0,6064 | 0,0178 | 0,0013 | 0 | 0,0067 | 0 | -0,00032 | 99,99998 |
| 21 | 21-Mei-19 | 93,9641 | 3,0929 | 1,8172 | 0,4942 | 0,607 | 0,0178 | 0,0013 | 0 | 0,006 | 0 | -0,00033 | 100,00017 |
| 22 | 22-Mei-19 | 94,0032 | 3,0737 | 1,8048 | 0,4909 | 0,6028 | 0,0176 | 0,0013 | 0 | 0,0061 | 0 | -0,0003 | 100,0001 |
| 23 | 23-Mei-19 | 93,9608 | 3,096 | 1,8175 | 0,4943 | 0,607 | 0,0178 | 0,0013 | 0 | 0,0059 | 0 | -0,0003 | 100,0003 |
| 24 | 24-Mei-19 | 93,9698 | 3,0897 | 1,8146 | 0,4942 | 0,6075 | 0,0177 | 0,0013 | 0 | 0,0055 | 0 | -0,0003 | 100 |
| 25 | 25-Mei-19 | 94,0652 | 3,0384 | 1,7819 | 0,4881 | 0,6023 | 0,017 | 0,0011 | 0 | 0,00655 | 0 | -0,0003 | 100,00025 |
| 26 | 26-Mei-19 | 94,0169 | 3,0653 | 1,795 | 0,4913 | 0,6064 | 0,017 | 0,0011 | 0 | 0,0074 | 0 | -0,0003 | 100,0001 |
| 27 | 27-Mei-19 | 93,946 | 3,0983 | 1,8181 | 0,4983 | 0,6151 | 0,0173 | 0,0011 | 0 | 0,0063 | 0 | -0,0003 | 100,0002 |
| 28 | 28-Mei-19 | 93,9831 | 3,0828 | 1,8066 | 0,494 | 0,6092 | 0,0172 | 0,0011 | 0 | 0,0064 | 0 | -0,0003 | 100,0001 |
| 29 | 29-Mei-19 | 94,0273 | 3,0581 | 1,7932 | 0,4911 | 0,606 | 0,017 | 0,0011 | 0 | 0,0065 | 0 | -0,0003 | 100 |
| 30 | 30-Mei-19 | 94,1131 | 3,0148 | 1,7675 | 0,4833 | 0,5962 | 0,0168 | 0,0011 | 0 | 0,0077 | 0 | -0,00032 | 100,00018 |
| 31 | 31-Mei-19 | 94,1209 | 3,013 | 1,7642 | 0,4821 | 0,5945 | 0,0168 | 0,0011 | 0,0133 | 0,0078 | 0 | -0,0003 | 100,0134 |
| **TOTAL MEI 2019** | | **93,9940434** | **3,09960621** | **1,80330483** | **0,47819931** | **0,56743207** | **0,01945379** | **0,00331448** | **0,00045862** | **0,00515172** | **0,00771034** | **-0,0001783** | **93,528271** |

# APPENDIX 3. SOR PROFILE &PRODUCED POWER

| SEND-OUT RATE PROFILE | | |
|---|---|---|
| MINIMUM | 110 | MMSCFD |
| MAXIMUM | 342.8 | MMSCFD |
| HIGHEST RAMP | 45,6 | MMSCFD/H |

| SOR PROFILE | | | Mech. Power (kW) | El. Power (kW) |
|---|---|---|---|---|
| 0 | 200 | MMSCFD | 3378,426798 | 2814,229522 |
| 1 | 160 | MMSCFD | 2716,323053 | 2262,697103 |
| 2 | 150 | MMSCFD | 2546,552863 | 2121,278534 |
| 3 | 125 | MMSCFD | 2122,127385 | 1767,732112 |
| 4 | 105 | MMSCFD | 1782,587004 | 1484,894974 |
| 5 | 110 | MMSCFD | 1867,472099 | 1555,604259 |
| 6 | 119 | MMSCFD | 2020,265271 | 1682,880971 |
| 7 | 123,7 | MMSCFD | 2088,173347 | 1739,448398 |
| 8 | 169,3 | MMSCFD | 2869,116225 | 2389,973816 |
| 9 | 214,9 | MMSCFD | 3633,082084 | 3026,357376 |
| 10 | 260,5 | MMSCFD | 4244,254771 | 3535,464224 |
| 11 | 306,4 | MMSCFD | 4244,254771 | 3535,464224 |
| 12 | 320 | MMSCFD | 4244,254771 | 3535,464224 |
| 13 | 320 | MMSCFD | 4244,254771 | 3535,464224 |
| 14 | 320 | MMSCFD | 4244,254771 | 3535,464224 |
| 15 | 320 | MMSCFD | 4244,254771 | 3535,464224 |
| 16 | 330 | MMSCFD | 4244,254771 | 3535,464224 |
| 17 | 342,8 | MMSCFD | 4244,254771 | 3535,464224 |
| 18 | 342,8 | MMSCFD | 4244,254771 | 3535,464224 |
| 19 | 342,8 | MMSCFD | 4244,254771 | 3535,464224 |
| 20 | 342,8 | MMSCFD | 4244,254771 | 3535,464224 |
| 21 | 290 | MMSCFD | 4244,254771 | 3535,464224 |
| 22 | 255 | MMSCFD | 4244,254771 | 3535,464224 |
| 23 | 249 | MMSCFD | 4210,300733 | 3507,18051 |
| 24 | 200 | MMSCFD | 3378,426798 | 2814,229522 |

## AUTOBIOGRAPHY

**Hilman Diri Aji Eka Wijaya** is the author of this bachelor thesis. He is the firstborn of three sibling and was born in Malang, East Java on 15th November 1996. He started his education in an Islamic elementary school in Cirebon, SDI Al-Azhar 03 Cirebon, and graduated in 2008 with excellent result. He continued his educational journey to SMP Negeri 1 Bogor and again graduated in 2011 with remarkable result, while following his father's duty as a ranked officer in the military. The he moved to a boarding school, SMA Taruna Nusantara in Magelang, to get his high school education. In this school he was known as one of the bright students among his friends and graduated in top 5 position. He took 1-year education in RWTH Aachen University, Germany before he took the Indonesian higher education recruitment test to get into Institut Teknologi Sepuluh Nopember (ITS), Surabaya.

In his college, he was active in many social, and entrepreneurial activities. He was actively involved in Rumah Bahasa Project of Surabaya as a volunteer German language teacher. He also interested in business and entrepreneurial activities such as building a product and stock trading.

With everlasting fighting spirit and high motivation, the author have finished this thesis, which titled "SIMULATION OF COLD ENERGY RECOVERY TECHNOLOGY APPLICATION FOR POWER GENERATION ON FLOATING STORAGE AND REGASIFICATION UNIT (FSRU) JAWA BARAT" and hopefully it will be useful for anyone who reads it and the technology development in marine engineering.