GREENING FLARING PROCESS IN OIL AND GAS INDUSTRIES

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ABSTRACT

The process of burning excess natural gas in the atmosphere is known as gas flaring in the oil and gas industry. It occurs at the onshore and offshore oil and gas production platforms, as well as the processing plant. As a result, a significant proportion of natural gas is squandered. It would be ideal to recover energy from flared natural gas and use it to generate electricity, particularly in an offshore area when electricity is scarce. As a result, more attention should be paid to the efficient use of flared natural gas in offshore oil and gas installations. The energy recovery system, as one of the promising approaches for generating power from flared natural gas in the Central Processing Platform 1, has gotten a lot of attention (CPP1).

Through greenhouse gases and other pollutants, gas flaring is one of the most serious environmental issues. These emissions contribute to climate change by having a high global warming potential. Flared gas and its emissions must be measured, and this has proven to be a difficult task. The reduction and recovery of flare gases is a high priority since it satisfies both environmental and economic efficiency goals. In industry, there are several different forms of FGRS, including gas collection and compression, gas-to-liquid, and power generation. A variety of technical problems have hampered FGRS, including a combination of extremely variable flow rates and composition, poor heating value, and low pressure of waste gases. FGRS has enhanced noise and thermal radiation reduction, operating and maintenance expenses, air pollution and gas emission reduction, and reduced fuel gas and steam usage due to environmental and economic concerns.

Therefore, in this study, a simulation model was created using the HYSYS simulation software to anticipate the potential energy in terms of power generated from gas flaring in DCPP using a microturbine. The focus has been on recovering and evaluating potential energy from gas flaring, with the case study taking place at the Central Processing

Platform 1, the total amount of gas burned at CPP1 is currently 1.48MMscf/d. With the help of the simulation model, a total of 245kW of power may be created. Based on the amount of energy generated and the money required to set up the system, a complete economic analysis was conducted. It is found that the energy recovery system is extremely desirable, with a potential annual savings of RM217,344 during a 7-year payback time. To make use of the gas flaring, it is recommended that an energy recovery system consisting of a microturbine be placed in the Central Processing Platform 1.

Keywords: natural gas, flaring, generate electricity, microturbine, energy recovery

PROSES PEMBAKARAN HIJAU DALAM INDUSTRI MINYAK DAN GAS

ABSTRAK

Proses pembakaran gas asli berlebihan di atmosfera dikenali sebagai pembakaran gas di industri minyak dan gas. Ia berlaku di platform pengeluaran minyak dan gas darat dan luar pesisir, serta kilang pemprosesan. Akibatnya, sebilangan besar gas asli terbuang. Sangat sesuai untuk mendapatkan semula tenaga dari gas asli yang menyala dan menggunakannya untuk menjana elektrik, terutamanya di kawasan luar pesisir ketika elektrik kekurangan. Akibatnya, perhatian lebih harus diberikan kepada penggunaan gas asli yang menyala secara efisien dalam pemasangan minyak dan gas luar pesisir. Sistem pemulihan tenaga, sebagai salah satu pendekatan yang menjanjikan untuk menghasilkan tenaga dari gas asli yang menyala di Pusat Pemprosesan Pusat 1, telah mendapat banyak perhatian (CPP1).

Melalui gas rumah hijau dan pencemaran lain, pembakaran gas adalah salah satu masalah alam sekitar yang paling serius. Pelepasan ini menyumbang kepada perubahan iklim dengan mempunyai potensi pemanasan global yang tinggi. Gas yang menyala dan pelepasannya mesti diukur, dan ini terbukti menjadi tugas yang sukar. Pengurangan dan pemulihan gas suar adalah keutamaan tinggi kerana memenuhi kedua-dua tujuan kecekapan alam sekitar dan ekonomi. Dalam industri, terdapat beberapa bentuk FGRS yang berbeza, termasuk pengumpulan dan pemampatan gas, gas ke cecair, dan penjanaan tenaga. Berbagai masalah teknikal telah merintangi FGRS, termasuk kombinasi kadar aliran dan komposisi yang sangat berubah-ubah, nilai pemanasan yang buruk, dan tekanan rendah gas buangan. FGRS telah meningkatkan pengurangan kebisingan dan radiasi termal, perbelanjaan operasi dan penyelenggaraan, pencemaran udara dan pengurangan pelepasan gas, dan

pengurangan penggunaan bahan bakar gas dan wap kerana masalah lingkungan dan ekonomi.

Oleh itu, dalam kajian ini, model simulasi dibuat menggunakan perisian simulasi HYSYS untuk menjangkakan potensi tenaga dari segi daya yang dihasilkan dari pembakaran gas di DCPP menggunakan mikroturbin. Tumpuannya adalah untuk memulihkan dan menilai tenaga berpotensi dari pembakaran gas, dengan kajian kes yang berlaku di Platform Pemprosesan Pusat 1, jumlah keseluruhan gas yang dibakar pada CPP1 saat ini adalah 1.48MMscf / d. Dengan bantuan model simulasi, sebanyak 245kW kuasa dapat dibuat. Berdasarkan jumlah tenaga yang dihasilkan dan wang yang diperlukan untuk mengatur sistem, analisis ekonomi yang lengkap telah dilakukan. Didapati bahawa sistem pemulihan tenaga sangat diinginkan, dengan potensi penjimatan tahunan sebanyak RM217,344 dalam tempoh pembayaran balik selama 7 tahun. Untuk memanfaatkan pembakaran gas, disarankan agar sistem pemulihan tenaga yang terdiri dari mikropurbin ditempatkan di Platform Pemprosesan Pusat 1.

Kata Kunci: gas asli, penyalaan, penjanaan elektrik, mikroturbin, pemulihan tenaga

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LIST OF SYMBOLS AND ABBREVIATIONS

API	:	American Petroleum Institute
AGRU	:	Acid Gas Remover Unit
CO_2	:	Carbon Dioxide
CH_4	:	Methane
DPP A	:	Drilling Platform A
EOY	:	End Of Year
GHG	:	Green House Gas
GTL	:	Gas To Liquid
HP	:	High Pressure
H_2	:	Hydrogen gas
H_2S	:	Hydrogen Sulfide
HHV	:	Higher Heating Value
IRR	:	Internal Rate of Return
LP	:	Low Pressure
MARR	:	Minimum Attractive Rate of Return
N_2	:	Nitrogen gas
NO_2	:	Nitrogen Dioxide
NO	:	Nitrogen Oxide
ORC	:	Organic Rankine Cycles
PW	:	Present Worth
SPDC	:	Shell Petroleum Development Company
SRC	:	Steam Rankine Cycles
VOC	:	Volatile Organic Compound

CHAPTER 1: INTRODUCTION

1.1 Background

Gas flaring is now being referred to as a "multibillion-dollar waste and an impending environmental disaster" (Umukoro and Ismail, 2017). It is, nevertheless, still commonly utilized today as a method of removing related gas from oil production, particularly where there is no reason to use it. This is because the eruption blocks ventilation twice and might be eaten quickly. Problems with natural gas emission are frequently described in terms of efficiency and emanation. An eruption can be wasteful, especially due to the impact of ambient breezes on the fire and a variety of other signs that suggest a lack of fire. As a result, it is undeniable that "an eruption is not only a waste of immense useful energy, but also a source of climate change through the emission of hazardous toxins" (Heidari, Ataei et al. Rakhdar, 2016; Williard, 2019).

Carbon dioxide (CO_2) is the primary source of any greenhouse gases that contribute to increased pollution as the earth warms. According to data, consumption of petroleum products accounts for around 75% of all anthropogenic CO_2 emissions. This massive sum generates a plethora of natural maintainability results all around the planet (Heidari, Ataei et al. Rakhdar, 2016; Williard, 2019). As a result, in terms of the above criteria, reducing greenhouse gas emissions is a difficulty. Sequestration (carbon capture and storage) is one method for lowering CO_2 emissions. It involves removing CO_2 from emission sources and storing it in a controlled environment. The challenge of managing hydrocarbon sources has received a lot of attention in recent years. Pollution of the main source is costly and harmful, as it limits the quantity of innovation and, in most cases, leads to the breakdown of key hydrocarbon bonds. Hydrocarbon destruction can be minimized with a smoke capture approach that allows recovered assets to be repurposed in a processing plant (Heidari, Ataei et al. Rakhdar, 2016; Williard, 2019).

Flare the gas and flare the environment is a common strategy for reducing gas emissions quickly. Given the challenges of gas eruptions, emissions, and climatic consequences, as well as the difficulty of giving more accurate and uniform estimates around the world, caution should be given in the methodologies employed. Inaccurate sensors or information on gas emissions and subsequent emissions, which are detailed from time to time, have no actual impact on the oil and gas industry's climate goals. Exploring various techniques will be critical in the future in order to combat environmental corruption in this multibillion-dollar business (Cheremisinoff, 2009).

The use of flare gas has significant ramifications for several countries around the world, with two benefits and a reduction in air. Furthermore, converting flare gas to gaseous gasoline, which is created in abundance, is a complimentary alternative to directing and converting flare gas to gaseous gasoline, which is combusted mostly indoors at start-up. The demand for natural gasoline has recently risen dramatically. When demand fluctuates, gas bills tend to rise. By trapping flare gases, this treatment plant replaces the (Flare Gas Recovery) FGR cage for closing leaks. They're moderate to the point of becoming torch able. In this example, the flare gas fills the reduction chamber, which is then processed in the concentrator gas chamber. The blower is used to boost the compressible fluid's compression ratio. The pressure in the channel can range from near vacuum to substantially positive. The supply pressure element might be anything from harmful to the environment to considerable, costing thousands of pounds per square inch. Flare is seen as a highly visible loss warning (Alcazar, Amilio, 1984; Reed, 1981; Straitz and John, 1978) investigated the relationship between assets and pollution from oil, gas, and petrochemical plants. According to new research, “an ecologically responsive framework will postpone the existence of foldable tips, reflecting the substantial support expenses connected with the shutdown, in addition to replacing the tour.” This eliminates the need for an infinite supply of gas to be discharged to oil and gas facilities. The frame will reduce CO_2 and NO_2 emissions by displacing gas. Backlighting is considered as a waste of impression sources and pollution in genuine backlighting. The flash will be extinguished in the normal course of business. The frame is environmentally friendly and will increase the life of flare tips by protecting them from power surges while detaching and replacing flare tips. A flare header outlet, detached or potentially dynamic gas recovery, control logic, and a dependable startup method are all included in the model. This skill was demonstrated on a variety of maritime boats as well as land-based establishments during the procedure (Zadakbar, Karimpur and Zadakbar, 2006).

The liquid ring blower prompts and begins to fill the flare gas when the pressure in the flare manifold reaches the predetermined value of the projected ultimate compression ratio. To complete the operation of pressurizing the recovered gas, water is employed as an effluent liquid. The gas is released by the blower into a three-phase separator, which separates the process fluid from the flare gas, then the consolidated hydrocarbons from the process fluid. To deliver fuel gas to the plant, compact gases are made accessible. The American Petroleum Institute (API) 521 is a common plan designation, and it relates to pressure reduction and smoke pressure reduction frames. Although it was designed with refineries in mind, it can also be utilized in petrochemical plants, gas plants, and gasoline fused gas plants. The information supplied is meant to assist in the selection of a structure that is extremely well suited to the flaws and conditions connected with different plants. The hybrid line was used for superfluous gas recovery, while the slide's supporter was used for dynamic gas recovery. The structure of the flare header output, the structure of the recovery of both dynamic and inactive gas, the reason for control, and a dependable launch structure must all be considered in this process. Onshore, stockpiling and offloading, staged or offshore operations are all different types of oil and gas plants. As a result, this ability must be fine-tuned. Gas will be rationed, and CO_2 and NO_2 emissions will be reduced. Gas interaction recovery, gas shaping, and gas transformation are all things that can be done with gas. At the end of the day, the cost of changing the flare tip or closure is no longer necessary, thus the associations will save a significant amount of money while also benefiting from the green environment.

Through greenhouse gases and other pollutants, gas flaring is one of the most serious environmental issues. These emissions contribute to climate change by having a high global warming potential. Flared gas and its emissions must be measured, and this has proven to be a difficult task. Reduced flare gas emissions is a top focus since it satisfies both environmental and economic efficiency goals. In industry, there are several different forms of Flare Gas Recovery System (FGRS), including gas collection and compression, gas-to-liquid, and power generation. A variety of technical problems have hampered FGRS, including a combination of extremely variable flow rates and composition, poor heating value, and low pressure of waste gases. Gas collection and compression into pipelines for processing and sale is a tried-and-true method of reducing flaring and venting. FGRS has enhanced noise and thermal radiation reduction, operating and maintenance expenses, air pollution and gas emission reduction, and reduced fuel gas and steam usage due to environmental and economic concerns.

1.2 Problem Statement

As the globe grapples with global warming concerns caused by rising carbon dioxide and greenhouse gas (GHG) concentrations in the atmosphere, gas flaring has become a major concern. As a result, HALLIBURTON and other major oil and gas companies across the world are working to reduce CO_2 emissions by lowering gas flaring at their exploration and production facilities. The importance of this endeavor stems from the same rationale. The case study chosen for this research will focus on the gas flaring operations on one of HALLIBURTON gas platforms, the Central Processing Platform, on Malaysia's east coast. Data from the Central Processing Platform, or more specifically the Central Processing Platform was acquired and assessed for its recovery potential in this study. On a daily average basis, the total gas flared in the Central Processing Platform is roughly 1.48 MMscf/d. This is a significant waste of unused energy that could have been used to generate power. This study aims to investigate and assess the energy potential of the facility's gas flaring operation.

1.3 Research Questions

The following are the research questions:

i. What are the current flaring method used by the industry?
ii. What are the different possible green strategy of flare gas recovery systems?
iii. What is the economic viability of the greener flare gas recovery system?

1.4 Aim of the study

The project's aim is to show that converting otherwise flared and wasted natural gas into power for the Central Processing Platform is commercially viable.

1.5 Objectives of the study

The objective of the study is:

I. To identify the current flaring method and improve into greener method.
II. To identify different possible green strategy of flare gas recovery systems.
III. To evaluate the economic viability of the greener flare gas recovery system

1.6 Scope of the study

The data for the pilot flare from the Haliburton Gas Platform called Central Processing Platform 1 inside the Gas Complex, situated offshore, was collected for this study. The gas for this platform comes from the Drilling Platform A (DDP-A), which is located inside the complex. The gas will be separated at the Receiving facility before being mixed with gas from DDP-A after the low pressure (LP) and high pressure (HP) knock out drums and routed to the flare boom. Simultaneously, the Gas Complex's facilities use gas as a fuel gas to power up the existing gas turbine generator.

1.7 Significant of the study

The project's significance is to prove that converting otherwise flared and wasted natural gas into power for the Central Processing Platform 1 is commercially viable. To begin, this research will assess and investigate the utilisation of flare gas for electricity generation. The recycled energy also has the advantage of being produced on manufacturing locations, where the majority of their electric load is used. Furthermore, using flared gas will aid in the conservation of vital energy resources, improve the oil and gas industry's environmental responsibility, and improve overall air quality.

1.8 Dissertation outline

In nutshell, this study consist of 5 chapters as follows:

i. Chapter 1 – Introduction

   This chapter covers the background of the research on flaring in the oil and gas industry. It also covers the recent advances on flaring technology in the industry. Besides, this chapter discusses problem statement, aim and objectives of the study and scope of the study.

ii. Chapter 2 – Literature review

This chapter discusses previous and current findings on gas flaring in the oil and gas industry. It introduces flaring, the flaring gas composition and its associated environmental impacts. Apart from that, this chapter discusses about the reduction and recovery of gas flaring done all around the world. Moreover, this chapter discusses gas flaring collection and compression. Finally, it highlights how the recovery of flare gas leads to electricity production.

iii. Chapter 3 – Research Methodology

This chapter describes the different strategies and methods utilised to collect data and information important to this research. This research will illustrate the process of generating energy from natural gas using the HYSYS process modelling software. The programme will assist in predicting the quantity of electric power that can be generated from flared gas on the Central Processing Platform.

iv. Chapter 4 – Results and Discussion

The two primary findings will be discussed in this chapter. The first portion examines the economics of extracting energy from natural gas flared in the CPP1 using a microturbine. The review would demonstrate the energy recovery program's commercial viability. The second segment would assess the energy recovery potential of platforms providing gas to CPP1. In Chapter 4, the economic analysis was thoroughly explored, with economic instruments such as the present worth method, internal rate of return, and payback time being used.

v. Chapter 5 – Conclusion and Recommendation

This chapter summarizes the overall findings and looks at the energy potential of flare gases in oil and gas plants, with an emphasis on the CPP1. The microturbine was chosen to convert natural gas energy into electricity, along with gas conditioning operations. Another section of this chapter will focus on suggestions and recommendations for future studies.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Gas flaring is the act of burning off associated gas from wells, hydrocarbon processing plants, or refineries as a means of disposal or to alleviate pressure (Ghadyanlou, 2015). It is currently acknowledged as a serious environmental issue, with an estimated 150 billion m3 of natural gas flared annually throughout the world, polluting the environment with 400 Mt CO_2 (Andersen, 2012). Flare losses account for most losses in many industrial activities, including oil and gas extraction, refineries, chemical plants, the coal sector, and landfills. Process gases, fuel gas, steam, nitrogen, and natural gas are among the wastes or losses to the flare. Flaring systems can be deployed in a variety of locations, including producing fields onshore and offshore, transport ships and port facilities, storage tank farms, and distribution pipes.

Gas flaring is one of the world's most difficult energy and environmental issues today. One of the most pressing challenges confronting the globe now is global warming. An increase in CO_2, CH_4, and other greenhouse gases (GHG) emissions in the atmosphere might be the source of this problem. Flared gas, on the other hand, has a composition that is very comparable to natural gas and is a cleaner source of energy than other commercial fossil fuels (Andersen, 2012). Since 2005, as gas prices have risen and worries about the shortage of oil and gas supplies have grown, flare gas has become more popular, and the quantity of gas wasted has been studied. The quantity of gas released, for example, could possibly provide 50% of Africa's energy demands (Andersen, 2012).

As a result, conserving energy and lowering emissions has become a global necessity for all countries. Furthermore, minimizing flaring and boosting fuel gas use contributes directly to energy efficiency and climate change mitigation (Deo, 2010). The goal of this study is to provide an overview of gas flaring in industry based on the following criteria: Industry gas flaring and its composition, environmental effects by researching government regulations, flow meter difficulties, measurement technologies, and various ways of flare gas recovery systems (FGRS), such as gas collection and compression, power production, and gas to liquid, measurement methodologies may be learned.

2.2 Gas flaring

The Canadian Association of Petroleum Producers defines gas flaring as the controlled burning of natural gas that cannot be processed for sale or use for technical or economic reasons. The combustion devices designed to safely and effectively eliminate waste gases generated in a facility during normal operation are also known as gas flaring. It comes from a variety of areas, including related gas, gas plants, well testing, and other places.

It is gathered in pipe headers and safely disposed of in a flare system. Multiple flares are used in a flare system to remediate waste gases from diverse sources (Sangsaraki, 2015). Most of the flaring occurs at the top of the stack, when gases are burned with a visible flame. The height of the flame is determined by the amount of expelled gas, while the brightness and color are determined by the composition. Onshore and offshore platforms, producing fields, transport ships and port facilities, storage tank farms, and distribution pipelines all have gas flaring systems installed. A full flare system comprises of the flare stack or boom and pipelines that collect the gases to be flared. The flare tip at the end of the stack or boom is meant to aid air entrainment into the flare, resulting in increased burn efficiency. A vessel at the foot of the stack collects and conserves any liquids from the gas flowing to the flare, and seals in the stack prevent the flame from flashing back. One or more flares may be required at a process site, depending on the design.

Flares are often visible and produce both noise and heat. The burnt gas produces mostly water vapor and CO_2 during flaring. The absence of liquids and adequate mixing between the fuel gas and air (or steam) are required for efficient combustion in the flame. When hydrocarbon liquids are discharged into the flare system, low pressure pipe flares are not designed to handle liquids and function poorly (Duck, 2011). When hydrocarbon liquids are discharged into the flare system, this happens inexorably (Duck, 2011). Emergency flaring, process flaring, and production flaring are the three types of flaring processes. Emergency flaring can occur in the event of a fire, a valve failure, or a compressor failure. As a result, a huge volume of gas with a high velocity is burnt in a short period of time. Process flaring generally has a lower rate, such as when waste gases are extracted from the production stream and flared during the petrochemical process.

Flared gas volumes at such operations can range from a few m^3 /hr to thousands m^3 /hr during normal operation and plant failures, respectively. Production flaring happens in the oil and gas industry's exploration and production sector. During the evaluation of a gas-oil potential test, large amounts of gas will be combusted as an indicator of the well's production capability.

2.3 General gas flaring composition

In most cases, the gas flaring will be a combination of various gases. The composition will be determined by the gas supply for the flare system. Natural gas makes up most of the associated gases produced during oil and gas production. Natural gas is mostly methane (CH_4), with a minor quantity of ethane and other hydrocarbons; inert gases like N_2 and CO_2 may also be present. A combination of hydrocarbons and, in certain circumstances, H_2 is routinely flared from refineries and other industrial activities. Landfill gas, biogas, and digester gas, on the other hand, is a combination of CH_4 and CO_2 with trace quantities of other inert gases. Because there is no standard composition for gas flaring, it is essential to identify a group of gas flaring based on the gas's real properties. The heat transmission capacities of the gas will be affected by changing gas composition, as would the performance of the flow meter measurement.

Table 2.1 Waste gas composition at a typical gas plant

Gas flaring constituent	Gas Composition	MIN	MAX	AVG
Methane	CH_4	7.17	82	43.6
Ethane	C_2H_6	0.55	13.1	3.66
Propane	C_3H_8	2.04	64.2	20.3
n-Butane	C_4H_{10}	0.199	28.3	2.78
Isobutane	C_5H_{12}	1.33	57.6	14.3
n-Pentane	C_5H_{12}	0.008	3.39	0.226
Isopentane	C_5H_{12}	0.096	4.71	0.530
neo-pentane	C_5H_{12}	0	0.342	0.017
n-Hexane	C_6H_{14}	0.026	3.53	0.635
Ethylene	C_2H_4	0.081	3.2	1.05
Propylene	C_3H_6	0	42.5	2.73
1 -Butene	C_4H_8	0	14.7	0.696
Carbon monoxide	CO	0	0.932	0.186
Carbon dioxide	CO_2	0.023	2.85	0.713
Hydrogen sulfide	H_2S	0	3.8	0.256
Hydrogen	H_2	0	37.6	5.54
Oxygen	O_2	0.019	5.43	0.357
Nitrogen	N_2	0.073	32.2	1.3
Water	H_2O	0	14.7	1.14

The worth of a gas is largely determined by its ability to heat. The composition of flared gas is critical for determining its economic worth and matching it to an appropriate treatment or disposal method. The H_2S concentration of the gas, for example, is a critical factor for transmission in the upstream pipeline network. If a gas contains 10 mol/kmol H_2S or higher, it is classified as sour (Johnson and Coderre, 2012).

2.4 Environmental impacts from the flaring of gas

Gas flaring is one of the world's most difficult energy and environmental issues today. The environmental effects of gas flaring have a significant influence on local communities, frequently resulting in serious health problems. In most cases, gas flaring is visible and produces both noise and heat. Using commercial flare software, Ghadyanlou and Vatani estimated the heat radiation and noise intensity as a function of distance from the flare. Table 2.2 summarizes the findings.

Table 2.2 Thermal and noise emissions from flaring

Distance (m)	**Thermal radiation,** kW/m^2	**Noise level** dB
10	5.66	86.3
20	5.87	86.19
30	6.04	86.02
40	6.14	85.78
50	6.17	85.5
60	6.14	85.18
70	6.04	84.83
80	5.88	84.46
90	5.67	84.08
100	5.42	83.68

The technology to handle the problem of gas flaring already exists, and the necessary legislative requirements are well known. Global gas flaring emissions account for more than half of the yearly Certified Emission Reductions (624 Mt CO_2) presently provided under the Kyoto Clean Development Mechanisms. Flaring, on the other hand, is seen to be far safer than just releasing gases to the atmosphere. Table 2.3 summarizes flare pollutants and their health effects.

Table 2.3 Health effects of pollutants released by the flare

Chemical name	Health effect
Ozone in land	Low densities excite the eye, while excessive densities, particularly in infants and adults, induce respiratory issues.
Sulfide hydrogen	It has an effect on the eye and nose at low densities, causing sleeplessness and headaches.
Dioxide nitrogen	It has an effect on the depth of the lungs and respiratory tubes, aggravating asthma symptoms. Meta-hemoglobin is produced at high concentrations, which stops blood from absorbing oxygen.
Particles matter	There is a widespread belief that it will lead to cancer and a heart attack.
Sulfur Dioxide	It will stimulate the respiratory system, exacerbating asthma and bronchitis.
Alkanes: Methane, Ethane, Propane	In low densities, it causes swelling, itching, and inflammation; in high densities, it causes eczema and acute lung swelling.
Alkenes: Ethylene, Propylene	It will cause weakness, nausea, and vomiting.
Aromatics: Benzene, Toluene, Xylene	It is toxic and carcinogenic. It has an effect on the nervous system, and at low densities, it causes blood abnormalities, stimulates the skin, and causes depression.

CO_2 and CH_4 are greenhouse gases (GHGs) that trap heat in the atmosphere when discharged directly into the sky. The impact on the environment is apparent, implying a significant contribution to global GHG emissions. For example, everyday flared gas releases roughly 45.8 billion kW of heat into the atmosphere in the Niger Delta (Abdulhakeem, 2014). Gas flaring has risen temperatures and left huge regions uninhabitable as a result of the environment. Flaring produces a lot of CO_2, which has a lot of global warming potential and contributes to climate change. Only roughly 75% of CO_2 emissions arise from the burning of fossil fuels (Sangasaraki, 2015). In fact, CH_4 is more hazardous than CO_2. On a mass basis, it has roughly 25 times the global warming potential of CO_2 (Johnson, 2012). It's also more common in flares with a lower efficiency of combustion (Abdulhakeem, 2014). As a result, there are worries regarding the release of CH_4 and other volatile organic compounds from various processes. Other pollutants produced by flaring include Sulphur oxides (SO_2), nitrogen oxides (NO_2), and volatile organic compounds (VOC) (Wilk,2010). In the Bay Area Management District, Ezersky and Lips investigated emissions from a variety of oil refinery flare systems (California).

They found that total organic compound emissions varied from 2.5 to 55 tonnes per day, while SO_2 emissions ranged from 6 to 55 tonnes per day. As a result, flare emissions might account for a considerable portion of overall SO_2 and VOC emissions. Furthermore, once discharged into the atmosphere, gaseous pollutants such as SO_2 have no limitations and become uncontrolled, resulting in acid deposition. Several toxicological/epidemiological studies conducted over the last few decades have revealed that this gas has a severe effect. Acid rain and fog are caused mostly by SO_2 and NO_2, which affect the natural environment and human life (Mohantyb, 2009). Also, ozone has been shown to be harmful. The photochemical interaction of VOC and NO_2, the primary components of the oxidant, also produces ozone. The oxidant speeds up the conversion of harmful sulfuric and nitric acids from SO_2 and NO_2. To lower the concentration of ozone, it is critical to remove VOC and NO (Mochida, 2000). A smoldering flare, on the other hand, may be a major source to total particle emissions (Ezersky and Guy, 2003). Because most flared gas isn't treated or cleaned, it can cause condensation, fouling (because to the build-up of paraffin wax and asphaltene deposits), corrosion (due to the presence of H2S, moisture, or some air), and perhaps abrasion (due to debris, dust, and corrosion products in the piping). The number of emissions produced by flaring is proportional to the combustion efficiency. The quantity of hydrocarbon transformed to CO_2 is simply the combustion efficiency given as a percentage. In other words, a flare's combustion efficiency is a measurement of how well it converts all the carbon in the fuel to CO_2. The heating value, velocity of gases entering the flare, climatic circumstances, and their impact on the flame size are all elements that influence the effectiveness of the combustion process in flares (Mcmahon, 1994). Properly operated flares achieve at least 98 percent combustion efficiency in the flare plume, implying that hydrocarbon and CO emissions account for less than 2% of species in the gas stream, demonstrating that industrial flares are extremely efficient when properly planned and managed. Many studies have found that flares have efficiency ranging from 62 to 99 percent (Leahey, 2001). In flares, steam or air is utilized as an aid to enhance combustion efficiency by creating turbulent mixing and greater interaction between carbon and oxygen. Excess air has an impact on emissions, particularly when it comes to the production of NO_2.

The presence of more nitrogen in the air, as well as the increased heat necessary to sustain combustion temperatures, are ideal circumstances for the production of thermal NO. Furthermore, while more surplus air produces less CO_2, it also results in higher heat loss. As a result of the above, gas flaring has a substantial environmental effect due to the potential existence of several hazardous chemicals. The magnitude of the impact is determined on the nature of the flared gas.

The impacts of flare emissions can be concluded as the following:

- the low-quality gas that is flared releases many impurities and toxic particles into the atmosphere,
- harmful effects on human health associated with exposure to these pollutants and the ecosystems.
- products of combustion can be hazardous when present in high amounts,
- the waste gas contains CO_2 and H_2S, which are both weakly acidic gases and become corrosive in the presence of water,
- acidic rain, caused by SO_2 in the atmosphere, is one of the main environmental hazards,
- acid rains wreak havoc on the environment destroying crops, roofs and impacting human health,
- CO causes reduction in oxygen-carrying capacity of the blood, which may lead to death,
- Uncontrolled NO_2 emission could be injurious to health

- when NO_2 reacts with O_2 in the air, the result is ground-level ozone which has very negative effects on the respiratory system and can cause inflammation of the airways, lung cancer etc.

2.5 Gas flaring reducing and recovery

Flare gas recovery is becoming more popular due to environmental and economic concerns. Flaring gas reduction systems (FGRS) have been developed to reduce the quantity of gas flared. Gas that has been flared can be recovered. Noise and heat radiation are reduced, as are operating and maintenance expenses, air pollution, and gas emissions. It emits less pollution and uses less fuel gas and steam.

Flared gas losses can be reduced by a variety of measures, including appropriate flare operation and maintenance, as well as changes to start-up and shut-down processes. Flare losses can also be reduced by removing leaking valves, making effective use of the fuel gases necessary for optimum flare operation, and improving steam management to ensure smokeless burning. Recovery technologies can also be used to reduce the environmental and financial costs of burning flare gas. Several technologies in flare tip design have recently been discovered to give the greatest decrease in flare loss. Even in the most sophisticated nations, FGRS has only been around for a decade, thus the process is still relatively new for use with refinery wastes. The United States, Italy, the Netherlands, and Switzerland are among the nations involved in FGRS. The majority of FGRS have been installed largely for economic reasons, where the equipment's payback period was short enough to justify the initial expenditure. These systems were designed to collect the majority of waste gases, but not all of them. The transitory spikes of high gas flows are often relatively uncommon, thus collecting the highest waste gas flows is usually not economically justifiable due to their irregular nature. However, there is a growing interest in minimizing flaring for environmental reasons rather than commercial reasons (Peterson, 2007).

There are several ways for reducing and recovering flaring, which may be described as follows:

1. Collection, compression, and injection/reinjection

- Into oil fields for enhanced oil recovery.
- Into wet gas fields for maximum liquid recovery;
- Into an aquifer.
- Into refinery pipelines;
- Collection and delivery to a nearby gas-gathering system;
- Shipping the collected flared gas to treatment plants before use;
- Using as an onsite fuel source.
- Using as a feedstock for petrochemical production

2. Electricity generation

The decision to flare or process gas is influenced by gas pricing. Gas flaring would be processed and sold if prices remained high for a long time, and the necessary infrastructure for gas processing and transportation could be developed (Anderson, 2012). Operators, on the other hand, must have a thorough grasp of how flare gases are created, dispersed, and best utilized within the production plant in order to pick the optimum technique for flared gas recovery and reduction. A variety of technical difficulties (Peterson,2007) have hampered FGRS, including a combination of highly variable flow rates and composition, poor heating value, and low pressure of waste gases. Gas-to-liquid (GTL) conversion of related flared gas into more valuable and easily transportable liquid fuels, or the manufacture of liquefied natural gas (LNG) to ease transportation to distant markets, are viable solutions (Bachu, 2005). Both GTL and LNG need significant infrastructure expenditures and must process extremely large amounts of gas to be economically viable.

Gas flaring is unlikely to be permitted in the near future, given the growing awareness of the environmental effect and the adoption of the Kyoto Protocol by the majority of member nations (Sangasaraki, 2015). This will necessitate major modifications in present oil and gas production techniques, as well as other operations (Bjrondalen, 2005). According to the World Bank (2005), the economic feasibility of flare gas recovery projects in many countries is limited, owing to high project development costs, a lack of finance, and a lack of distribution infrastructure. Several FGRS concepts and technologies have been proved and widely used in offshore oil and gas production sectors in Norway (Cristiansen,2001). In the Oseberg field in Norway, for example, gas flaring is piped back down into the reservoir to maintain the pressure and flow rate of the oil being produced (Anderson,2012). They are able to recover a significantly larger proportion of oil when they reintroduce flared gas into the oil production business than if they merely inject water. In accordance with the growing government attention on flare reduction and the company's goal to minimize emissions and carbon footprint, Qatargas has achieved great progress flaring from its LNG trains. Between 2004 and 2011, Qatargas' older, conventional LNG trains effectively decreased flaring by more than 70% (Bawazir, 2014) thanks to improved acid gas recovery and operational excellence initiatives on source reduction and plant dependability. Figure 2.1 (Bawazir, 2014) shows an overview of Qatargas engineering projects, together with projected flare reductions and execution dates.

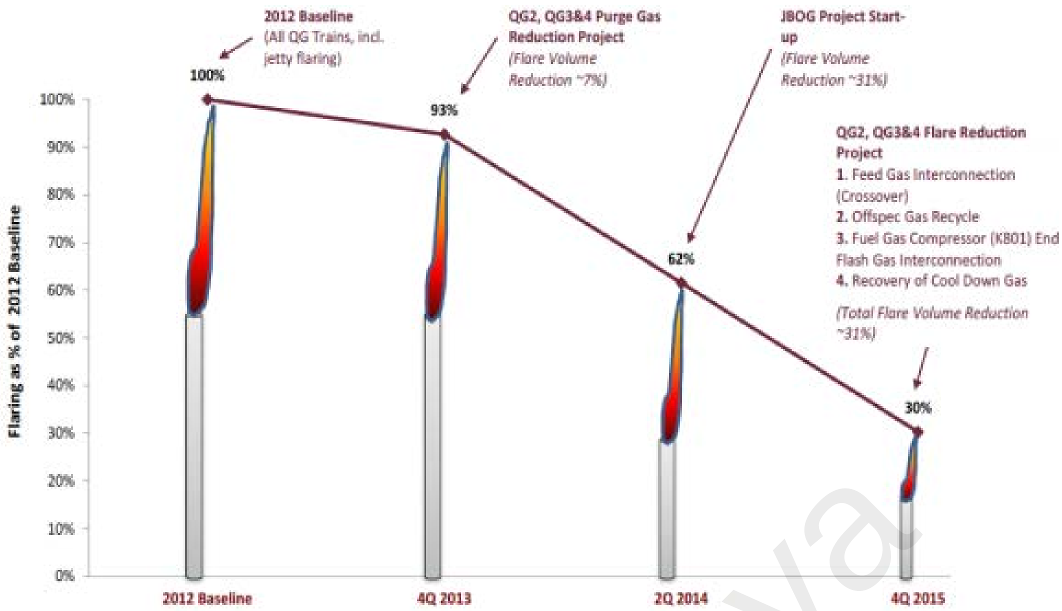

Figure 2.1 Summary of Qatargas flare reduction projects

Several attempts have been undertaken in Nigeria to decrease gas flaring, including the construction of a liquefied natural gas plant, the construction of a pipeline to carry gas to certain neighboring countries, and legislative steps to control the oil and gas business (Ibitoye, 2014). According to Al-Blaies, Nigeria flared 15.2 billion m3 of gas in 2010, making it the world's second largest (Al-Blaise, 2011). When compared to 2005, there has been a 29 percent drop in gas flaring in Nigeria, owing mostly to the deployment of various flare control programs (Al-Blaise, 2011). Even yet, the amount of gas flared in Nigeria is significant, and the country is still one of the worst offenders when it comes to natural gas flaring, second only to Russia (Al-Blaise, 2011). as of 2010. Since 2000, Nigeria's Shell Petroleum Development Company (SPDC) has been working on a multiyear project to install gas collection technology at its facilities. Between 2002 and 2011, overall SPDC flaring decreased by more than 60%, from approximately 0.6 billion ft3 /day to under 0.2 billion ft3 /day (Abdulhakeem, 2014).

2.6 Gas flaring collection and compression

Flared gas is collected and compressed for transit via pipelines or other methods for processing and sale, which is a well-established and proven method of reducing flaring and venting. Several initiatives in Iran have incorporated the collection of related gases in recent years (Zadakbar, 2008). In Alberta, roughly 72 percent of the 9.72 billion m^3 of associated gas generated during oil and heavy oil production was collected and sold into pipelines in 2008. An extra 21% was utilized on-site as fuel (such as for process heaters or to drive natural gas fired compressors). The 0.69 billion m^3 of gas that remained was flared or released. In the refinery case study, Tahouni et al. integrated flared gas streams with waste and fuel gas streams to the fuel gas network. Fuel gases were gathered from multiple source streams, mixed optimally, and delivered to various fuel sinks such as furnaces, boilers, turbines, and so on through a fuel gas network. Using flared gas stream to the network, this study demonstrated that the ideal fuel gas network may minimize energy expenditures and flaring emissions.

Due to environmental and economic concerns, the usage of FGRS to collect gases for other use has grown. A gas compression and recovery system (FGRS) can be utilized to minimize the volume of flared gases by utilizing modern technologies in this sector. A generic perspective of a FGRS (Tahouni, 2014) is shown in Figure 2.2. After collecting from the flare header, flared gas is directed to the FGRS downstream of the knock-out drum via a liquid seal vessel and then compressed. After that, the compressed gas is pumped into a mixed phase separator. The substance is liquid is pushed via a heat exchanger and returned to the compressor's service liquid inlet. The liquid is separated from the compressed gas, which is then routed to the plant's fuel gas header or any other suitable place. Control signals depending on the intake flare gas pressure are used to regulate the compressor recycling valve. This maintains positive pressure in the flare header at all times. If the FGRS's flow capacity is surpassed, the liquid seal vessel will allow the waste gas to travel to the flare, where it will be safely burnt (Duck, 2011). Compressed gases are utilized as a feed or fuel in refineries and similar units. Heat exchangers are employed if necessary to bring the entry gas temperature to FGRS and the exterior gas temperature from this unit to an optional temperature.

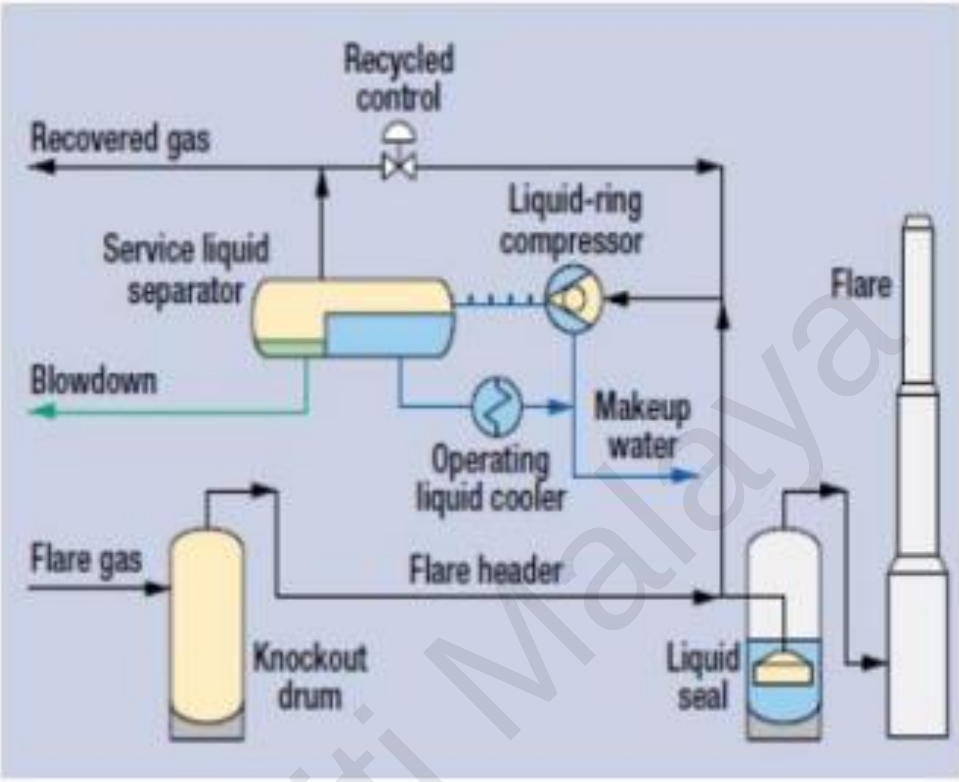

Figure 2.2 Flare recovery system

2.7 Electricity production

Power is one of the most utilized types of energy and is a fundamental component of nature. It is derived by the conversion of a variety of energy sources, including coal, natural gas, oil, nuclear power, and other natural sources. Natural gas provided roughly 16 percent of the electricity (Razak, 2007). Reduce thermal emissions from a variety of industries, including petrochemicals, industrial gases, synthetic organic fibers, and agricultural chemicals, where high-temperature exhaust can be recovered for power production. The conversion of flare gas as a major source of energy is the other FGRS technique. A turbine, engine, water wheel, or other similar equipment are used to power an electric generator at an electric power station. The kinetic energy of a flowing fluid (liquid or gas) is converted into mechanical energy by a turbine. When there is a significant demand for electricity, gas turbines are often employed (Razak, 2007). Gas flaring can be burnt to generate hot combustion gases that flow straight into a turbine, rotating the turbine blades to generate electricity. The 4.176 MMSCFD of gas discharged from the Farashband gas refinery in Iran is used to generate 25 MW of power using a gas turbine (Rahimpour, 2012). Gas flaring may also be utilized to generate electricity in gas-fired turbines known as "microturbines," which can be used to power industrial processes such as pumping, compression machines, and gas processing. If they don't need all of it, the power can even be sold (Bott, 2007). The creation of electrical power from flared gas is presented in two scenarios (Heydari, 2007). In the first scenario, a gas turbine operating on a basic Brayton cycle simulates power generation. To increase efficiency, the second scenario adds Fog cooling to the incoming air of a simple cycle gas turbine.

The results show that the second scenario has a superior power generation condition, while the first scenario is more economically justifiable. The first and second scenarios generate 38.5 MW and 40.25 MW of electricity, respectively, with payback times of 3.32 and 3.48 years. It should also be noted that a compressor with a 90% efficiency is utilized to boost the fuel pressure from 6 bar to 23.7 bar.

There are various ways to create electricity. The most popular technique for generating electricity from waste heat is the Steam Rankine Cycle (SRC), which uses the heat to produce steam in a waste heat boiler, which then powers a steam turbine. One of the oldest and most flexible primary mover technologies is steam turbines. ORC heat engines employ organic Rankine Cycles (ORC) and other working fluids that have higher efficiency at lower heat source temperatures. In comparison to water, ORCs employ an organic working fluid with a lower boiling point, greater vapor pressure, larger molecular mass, and higher mass flow. As a result, ORC turbine efficiencies are greater than SRC turbine efficiencies. Furthermore, ORC systems may use waste heat sources as low as 148 degrees Celsius, whereas steam systems are limited to heat sources larger than 260 degrees Celsius. ORCs are frequently employed in geothermal power plants to generate electricity, and more recently in pipeline compressor heat recovery applications.

2.8 Alternative method to reduce flaring

Many writers looked at the many FGRS methods for reducing emissions from various sectors, as well as fuel prices, visible flame, smells, and supplementary flare utilities like steam. Mourad et al. studied the recovery of flared gas using a multistage separation with intermediate feeds to stabilize crude oil. Xu et al. used plant-wide dynamic simulation to examine a universal flare reduction approach for chemical plant start-up operations. Ghadyanlou and Vatani studied techniques for recovering flare gases in olefin plants and thereby reducing gas flaring. According to the example study, considerable volumes of ethylene (about 43.3 Mt/hr) and fuel gas (approximately 10.8 Mt/hr) may be recovered. In addition, around $ 9 million in valuable gases is returned to the plant each year, and the FGRU's investment expenses are repaid after about three years of operation. Flare emissions and the loss of salable liquid petroleum products to the fuel gas system are reduced when new ecologically friendly technologies are used. In a refinery context, new waste heat refrigeration systems are helpful for utilizing low temperature waste heat to generate sub-zero refrigeration temperatures with dual temperature loads. These devices are used to condense salable liquid hydrocarbon products from the refinery's fuel gas composition streams (Brant, 1998).

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2.9. Importance of Green Technology to the Oil and Gas Industry

Whether it is the backbone of global monetary progress or not, the oil and gas industry is notorious for wreaking havoc on the climate, destroying land, and disrupting commercial networks in the areas where it operates. Operational problems, as well as an increasing focus on oil as a non-renewable energy source, have piqued attention in manageability concerns. Executives of gasoline firms situated in the United States of America are increasingly using exercise connected to maintainability difficulties such as natural recovery and current energy, according to a new report (Verdantix, 2014). Regardless, such cost increases do not reflect deliberate attempts to implement maintainability, particularly when new financially informed techniques to eliminate unconventional solutions combat climate change and make sustainable energy less of a threat (Lozanova, 2014). Furthermore, oil and gas companies have been accused of greening their advertising and corporate reporting in recent years (Pulver, 2007), raising questions about their approaches and support techniques. Because of the dwindling benefits, several oil and gas behemoths have substantially lowered their high-capitalized clean energy costs (solar and wind) to zero through higher-return speculation, such as biofuel research and cleaner petroleum product use methods that are far from green (Webb, 2009).This makes sense in terms of "helpless maintainability," which minimizes the impact on natural qualities and social fairness while exaggerating the relevance of resource efficiency (Ball and Milne, 2005). Given humanity's reliance on clean energy, which is why oil as an industry exists, any effort to reduce the negative effects of a particularly harmful sector, no matter how modest, should not be undermined. As a result, in order to handle the larger business impact, the organization's ability to sustain maintainability must be increased further. As shown by rising administrative pressure and the advancement of deliberate granular support from non-legislative organizations, some congregations have been strong in this attitude. 8 People have the right to age, assessment, and misuse data that can thoroughly highlight essential duties and functional status changes if the governance system is effective (Otley, 2001). A leadership structure view can lead to positive changes in culture, structures, and energy cycles by leveraging a wide range of data types and focusing on past performance as it works with performance goal setting, asset allocation and focus, analysis of current exercises, and presentation of the consequences of consensus building targets (Amaratunga and Baldry, 2002).

2.9 Literature Review Summary

The act of burning associated gas from wells, hydrocarbon processing plants, or refineries as a form of disposal or to relieve pressure is known as gas flaring. It is gathered in pipe headers and safely disposed of in a flare system. Multiple flares are used in a flare system to remediate waste gases from diverse sources. The process of gas flaring is discussed thoroughly in this chapter. This chapter also discusses the general composition of gases found during flaring. The environmental impacts from the flaring of gas is also discussed in this chapter. Moreover, the health effects of the pollutants released by the flare is also discussed in this chapter along with the impacts of flare emissions. Furthermore, techniques that are used worldwide for efficient gas flaring and recovery is also discussed in this chapter. Gas flaring collection and compression is also discussed briefly in this chapter. Other than that, methods used for electricity production from the flare gas is discussed in this chapter. Alternative method to reduce flaring is also discussed in this chapter. Finally, the importance of green technology to the oil and gas industry were discussed.

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CHAPTER 3: METHODOLOGY

3.1 Introduction

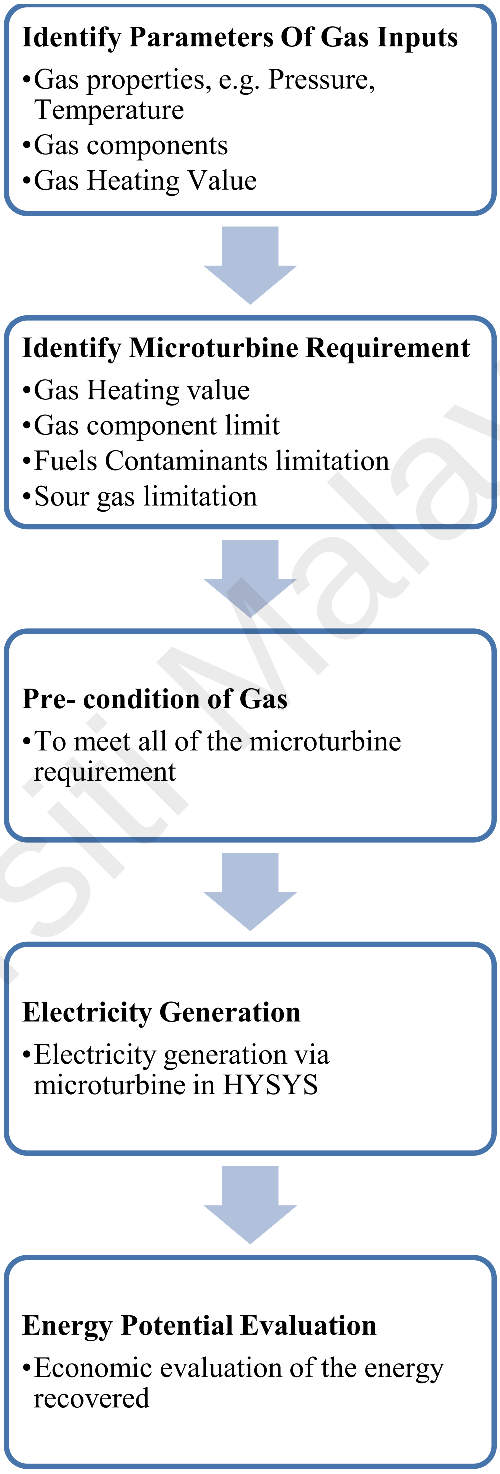


Figure 3.1 Process flow of energy evaluation from gas flaring

This chapter is broken into two pieces and discusses the methodology of this project in detail. The first section will define the microturbine's gas input and fuel gas requirements, including gas heating value, gas component limit, pollutants limit, and sour gas limit. The simulation portion is the second component, and it is used to measure the energy potential of flare gas and, as a result, to assess the project's economic feasibility if it is executed.

The information on natural gas properties collected from the Central Processing Platform 1(CPP1), specifically from a tapping point on CPP1 shortly before the natural gas is transported to the flare stack, is the starting point for this investigation. An engineer from CPP1 identified the tap position as suitable for this study. Before passing through the electricity generation portion, the flare gas must travel through the gas pre-conditioning section to meet the microturbine criteria.

The HYSYS software would be used to mimic the processes involved in power generation in order to determine the amount of energy that could be recovered. Finally, economic tools would be employed to assess the project's viability.

3.1.1 Gas Input Parameters for Microturbine Simulation in HYSYS

It is vital to understand gas parameters such as natural gas qualities. Before it can be utilized as a fuel in the furnace, it must first be broken down into its constituents and given a heating value. To create electricity, a microturbine is used.

The following are the natural gas characteristics and gas components identified in this study from the CPP1 tapping point:

Table 3.1 Gas properties from the tapping point of CPP1

Pressure	1007kPa
Flow rate	1.48 MMscf/d
Temperature	39.16 C
Heat Flow	5.445 x 10^6 kj/h
Higher Heating Value (HHV)	1028.39 Btu/sf^3

Table 3.2 Gas component from the tapping point of CPP1

Component	**Mass fraction**
Methane	86.5587
Ethane	9.645874
Propane	1.856985
n-butane	0.545659
i-butane	0.646842
n-pentane	0.465685
i-pentane	0.054875
Hexane	0.004587
Heptanes	0.045871
Octane	0.098546
Nonane	0.00044
Carbon dioxide, CO_2	4.965412

Nitrogen, N_2	0.96541
Water, H2O	0.007854
Hydrogen sulfide, H_2S	0.00001

The phase of identifying gas input characteristics serves as the foundation for this investigation, with the properties and gas components of present and forecast gas flaring assumed to be constant.

3.1.2 Microturbine Requirement Identification for simulation in HYSYS

To avoid difficulties that may influence equipment performance, life, reliability, warranty, and most importantly, safety, it is crucial to identify and comply with the microturbine requirement. In this study, a Capstone Turbine Corporation (Capstone) CR200 model microturbine will be used to convert potential energy in natural gas, with fuel need data extracted from its technical reference.

3.1.3 Gas Heating Value Requirement Identification

Table 3.3 Gas Heating Value Requirement

Fuels Type	**Gas Heating Value (HHV)**	
	Calorific Value btu/ft^3(MJ/m^3)	
	LSL	**USL**
Natural Gas	825(32.5)	1275(50.2)

The amount of fuel consumed per kilowatt-hour of power generated is influenced by the gas heating value; a low gas heating value will necessitate huge volumetric flows, which can be uneconomical. To put it another way, while employing a low gas heating value as a fuel, a modification of the existing microturbine is required to make the microturbine run smoothly.

The Higher Heating Value (HHV) was calculated as follows:

HHV of natural gas = $\sum_{i=0}^{n} x_i HHV_I$ Where: HHV_I = Higher Heating Value of gas component i, in Btu/ft3 x_i = mole fraction of gas component i

Table 3.4 HHV calculation from the tapping point of CPP1

Component	Mass fraction	Mole Fraction	HHV (Btu/ft^3)	x*HHV (Btu/ft^3)
Methane	86.5587	0.818	1020	834.00
Ethane	9.645874	0.091	1700	154.90
Propane	1.856985	0.018	2514	44.10
n-butane	0.545659	0.005	3200	16.49
i-butane	0.646842	0.006	3214	19.64
n-pentane	0.465685	0.004	3999	17.59
i-pentane	0.054875	0.001	4005	2.08
Hexane	0.004587	0.000	4690	0.20
Heptane	0.045871	0.000	5499	2.38
Octane	0.098546	0.001	6259	5.83
Nonane	0.00044	0.000	6887	0.03
Carbon dioxide, CO_2	4.965412	0.047	0	0.00
Nitrogen, N_2	0.96541	0.009	0	0.00
Water, H_2O	0.007854	0.000	0	0.00
Hydrogen sulfide, H_2S	0.00001	0.000	549	0.00
	Sum	1.000		1097.24

The calculated HHV, which is 1097.24, is within the turbine's fuel need limit. As a result, the microturbine can run on gas.

3.1.3.1 Major Gas Components Limits Requirements for Microturbine

Methane (C1), Ethane (C2), Propane (C3), Butane (C4), Pentane (C5), Hexane (C6), Heptanes (C7), Octane (C8), Nonane (C9), Carbon Dioxide (CO_2), Nitrogen (N_2), Water (H2O), and Hydrogen Sulphide (H_2S) are commonly evaluated in the fuel using gas chromatography according to ASTM D1945. The microturbine's maximal power and efficiency will be determined by the major gas components.

Table 3.5 Major Gas Components Limits Requirements

Fuels Type	**Major Gas Components Limits (vol%)**													
	C1		C2		C3		C4		C5	C6	N2	CO_2		O_2
	LSL	USL	LSL	USL	LSL	USL	LSL	USL	USL	USL	USL	LSL	USL	USL
Natural Gas	50	100	0	14	0	9	0	4	1	1	22	0	11	6

3.1.3.2 Fuels Contaminants Limitations Requirements

Table 3.6 Gas input contaminants limitations

Contaminant	Units	USL	Test Method
Lubricant Oil	ppm, mass	2	
Particulate Size	microns	10	
Particulate Qty	ppm, mass	20	
Water	% mass liquid	0	ASTM D5454

The pollutants limitations listed in the table above must be followed when supplying gas. Contaminants such as water, lubricating oil droplets, and dust will have a negative impact on the microturbine's long-term performance and may shorten its lifespan.

3.1.3.3 Requirement on Sour Gas Limitations

For hydrogen sulphide, microturbine operating on gaseous fuel may have limits (H_2S). Gaseous fuels with fewer than five parts-per-million by volume (ppmv) are commonly referred to as "Sweet," whilst fuels with more than 5 ppmv are referred to as "Sour." The hydrogen sulphide upper specification limit for the CR200 model is 5000ppmv.

3.1.4 Pre-Conditioning of Gas Input for Microturbine

Gas reception facilities, acid gas removal and disposal section, hydrogen sulphide (H_2S) scrubber, gas dehydration, particle filtering, and mercury removal are all common components of microturbine gas treatment. Despite the fact that there is no mercury in the DCPP data, the negative effects of mercury make mercury removal mandatory as a precaution in the gas treatment facility. The gas receiving facilities section was designed to eliminate liquid entrainment in the system caused by condensation and fluid pressure reduction (Joule Thomson effect). The gas inlet pressure is adjusted in this area to fulfil the gas turbine's requirements.

- To remove acid gases (CO_2 components) from the supply gas, a section for acid gas removal and disposal is provided. The specification and requirement of the microturbine, as stated in the microturbine requirement section, impact the extent of removal.
- Water is removed from the feed gas in the dehydration portion. To avoid corrosion and water hammer, water vapor must be eliminated.
- The mercury removal phase removes traces of mercury in the feed gas, which can damage pipelines and equipment constructed of aluminum and aluminum compounds. Filtration of the gas stream through the mercury removal unit is required to prevent particles from entering the microturbine unit and causing damage to the equipment.

3.1.5 Electricity Generation

As previously stated, the CR200 microturbine model from Capstone will be used to generate electricity in this investigation. The process of converting electrical energy from other types of energy, in this case natural gas as the fuel, is known as electricity production. In the microturbine, chemical energy held in natural gas and oxygen from the air is transferred to thermal energy, mechanical energy, and finally electrical energy. The compression, combustion, and exhaust stages are all included in the microturbine process. The HYSYS program is used to model these processes, and the result, which is the energy recovered, is evaluated.

3.1.6 Energy Potential Evaluation

The return that a given project will or should create should be considered in all engineering economy analyses of capital projects. Because of the significant capital costs involved, economic analysis is frequently used before a project is implemented. It is necessary to quantify the potential energy generated by the microturbine before doing an economic analysis. The energy generated from natural gas that would otherwise be flared will be an essential factor in determining the project's overall feasibility. Three quantitative methods were employed to assess the energy recovery project's economic profitability: the Present Worth (PW) method, the Internal Rate of Return (IRR) method, and the payback time method. The first approach calculates the current equivalent worth using a ten percent interest rate known as the Minimum Attractive Rate of Return (MARR). The IRR technique, which is the second way, calculates yearly rates of return based on the initial capital required and is compared to the MARR. Finally, the payback period is used to determine how quickly an investment is repaid by the annual savings it generates. The final metric is equally significant in complementing the previous two measures.

3.2 Simulation Modeling in HYSYS

Process simulation software is now a necessary tool in the process industries. Simulation software does, in fact, play an important part in the development of processes to examine, for example. Process options, feasibility analysis, and preliminary project economics design to optimize hardware selection, equipment and operating cost estimation, and Examine feedstock flexibility and plant operations to reduce energy use and boost output. a higher yield and better pollution management. The suggested energy recovery scheme's process components are analyzed using HYSYS 3.2 simulation software, which is based on the chemical reactions of the natural gas components in the mixer and combustion chamber.

3.2.1 Assumption

A few assumptions have been made, such as the simulation's process being steady state, the usage of a splitter to represent the acid gas removal unit, and an H_2S scrubber with a 100% efficiency. A steady state condition was employed to simplify the simulation and save processing time. The software already has a big database of pure body components, which simplifies the simulation process.

3.2.2 Simulation Algorithm

Pure components that are involved in the process (e.g., Methane, Ethane, and so on) were introduced to the Simulation Basis Manager at the start of the simulation (e.g., Methane, Ethane, and so on) with their matching mass fraction.

The following are the gas inlet conditions into the microturbine that may be anticipated in the process.

Table 3.7 Gas inlet conditions

Conditions	Value	Specifications of gas inlet for micro gas turbine
Temperature©	39.16	
Pressure (kPa)	1007	517-552
Molar flow (kgmol/h)	79.86	
Mass flow(kg/h)	1402	
Std ideal liq.vol.flow (m^3/h)	4.123	
Molar enthalphy (KJ/kjmol)	8.004e+04	
Molar entropy (KJ/kgmol C)	169.2	
Heat flow (KJ/h)	5.445e+06	2.4e+06

3.2.3 Simulation of Microturbine

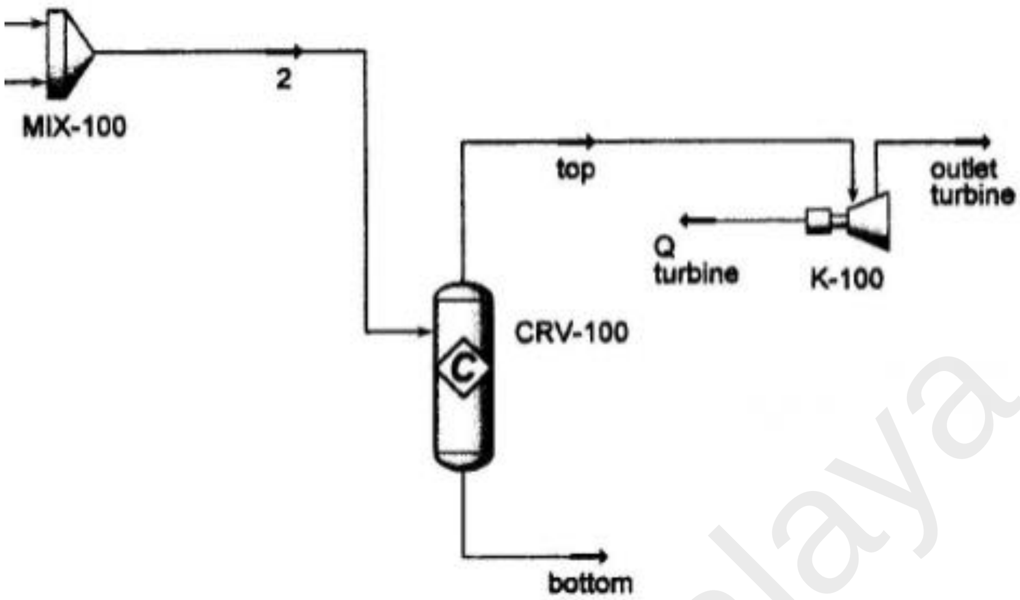


Figure 3.2 HYSYS components that represents a gas turbine

Three components were required to model the process in the microturbine in HYSYS: a mixer to mix the air with the gas, a combustion chamber, and a turbine to generate power.

3.2.3.1 Combustion chamber

In order to model the process that occurs in the gas combustion chamber, an assumption was made. It's because the combustion chamber's efficiency was 90%. In other words, the ratio of the output of the combustion chamber to the input, expressed as a percentage.

3.2.3.2 Microturbine engine – Adiabatic efficiency for compressor

Another assumption is that the microturbine's compressor has a 75 percent adiabatic efficiency. When the word adiabatic efficiency is used, it refers to the fact that elements outside the turbine have no effect on those inside. Although the turbine is supposed to be a separate and autonomous entity, the fact that it is nevertheless influenced by natural external factors by 75% reveals that natural external forces still play a significant role. Looking at it from a granular level, the research anticipates the concept being put into practice rather than being limited to theoretical comprehension.

3.2.3.3 Acid Gas Remover Unit (AGRU)

Natural gas typically contains CO_2, H_2S, and other sulfur components, also known as acid gas, which poses significant environmental risks when released into the atmosphere and damages processing facility equipment. As a result, these undesired components must be removed, which is referred to as the gas sweetening process. Chemical solvents, physical solvents, adsorption methods, hybrid solvents, and physical separation are among the several acid gas treating processes for CO_2 removal (membrane). In the oil and gas business, chemical and physical solvents are commonly used. The presence of carbon dioxide in natural gas must be reduced in order to improve the gas's heating value and prevent pipeline and gas processing equipment corrosion. To remove the acidic components from the gas input, an acid gas remover unit, or AGRU, is required. It's just a vessel with a water sprayer on the top. The acidic component will dissolve in the water and be removed at the bottom outlet. The splitter with 100 percent efficiency has been used to represent this component in HYSYS. It signifies that all acidic gases have been completely removed.

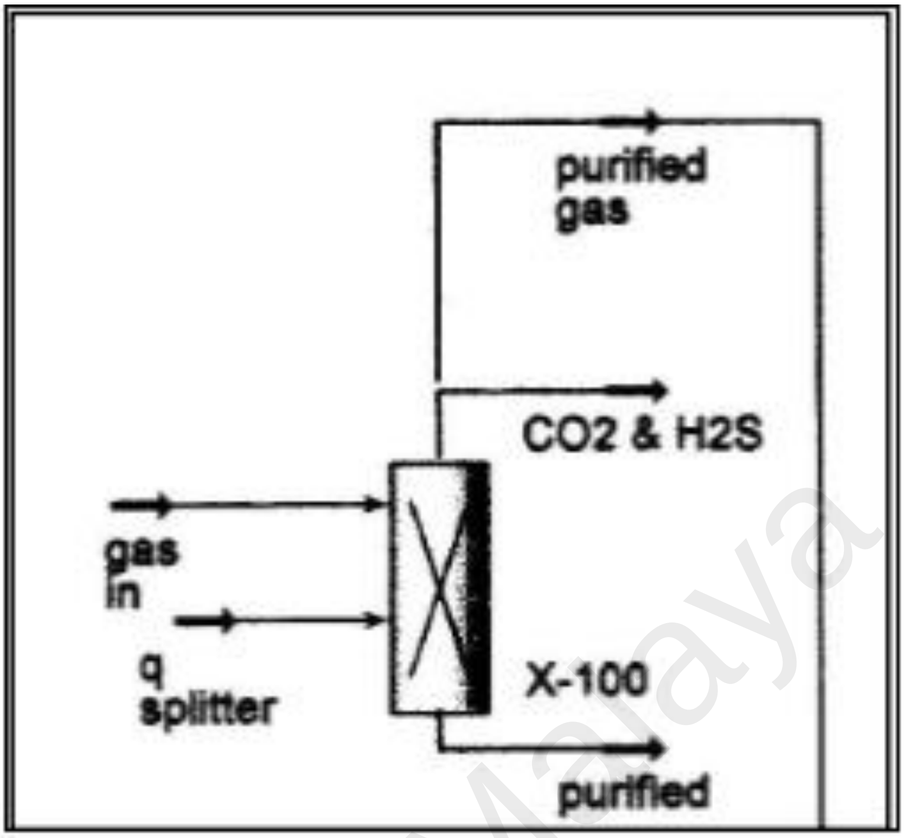


Figure 3.3 Acid Gas Remover Unit (AGRU) splitter

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Introduction

As the globe grapples with global warming concerns caused by rising carbon dioxide and greenhouse gas (GHG) concentrations in the atmosphere, gas flaring has become a major concern. As a result, company X and other major oil and gas companies across the world are working to reduce CO_2 emissions by decreasing gas flaring at their exploration and production facilities. On a daily average basis, the total gas flared in the gas platform is roughly 1.48 MMscf/d. This is a significant waste of unused energy that could have been used to generate power. This study aims to investigate and assess the energy potential of the facility's gas flaring operation. The data for the pilot flare from the companies Gas Platform called Central Processing Platform inside the Gas Complex, situated offshore Terengganu, was collected for this study. The gas is supplied by Drilling Platform A (DDP-A), which is located within the complex. The gas from the gas c0omplex will be separated at the receiving facility before being mixed with gas from DDP-A after the low pressure (LP) and high pressure (HP) knock out drums and routed to the flare boom. The energy conversion process from microturbine will be simulated using HYSYS version 3.2 simulation software.

The information on natural gas characteristics received from the Central Processing Platform (CPP), especially from a tapping point on DCPP immediately before the natural gas is transported to the flare stack, is the starting point for this investigation. An engineer from DCPP determined the tap location as suitable for this investigation. Before passing through the electricity generating portion, the flare gas must travel through the gas pre-conditioning section to meet the microturbine criteria. The HYSYS software would be used to model the processes involved in power generation in order to determine the amount of energy that might be recovered. Finally, economic methods would be employed to assess the project's viability.

4.2 Alternative green strategy for flare gas recovery system

One of the most difficult energy and environmental issues facing the globe today is associated gas flaring. Environmental deterioration caused by gas flaring has a substantial impact on local communities, frequently leading in job losses and serious health problems. Flare reduction is a chance for producing governments to add value to a wasted resource, allowing for more access to energy, improved environmental conditions, and economic growth for local communities. Local communities, provincial and national governments, and the entire planet will benefit from successful measures to minimize flaring. Given the potential and contents of flare gas, as well as their influence, there are numerous benefits to reducing flare gas for the company's eco-efficiency. However, if related gas is used for 70 percent of the time, efficiency is achieved.

The following are a few examples of Gas Flare Recovery (Anejionu,2015).

- Reinjection. This approach is commonly employed in EOR activities to retain the presence of gas for future usage and to improve the efficiency of oil production (enhance oil recovery). This is a typical method for companies with limited gas capacity.
- G.T.G. (Gas turbine generator). The resultant gas will be utilized to fuel a power plant that will serve both the industry and the general public. According to research conducted in Argentina, burning 0.45 m3 of gas may generate 40 MW of power.
- Papua New Guinea (PNG) (Pipeline natural gas). Gas pipeline installations cost an average of 1-5 USD depending on the topography, however this method may be utilized to minimize combustion of the connected gas, even if it is regarded uneconomical, especially for pipelines from offshore to onshore.

- LPG (Liquid Petroleum Gas) (Liquefied petroleum gas). Because of the convenience of storing and transporting local markets, this technique is frequently employed. However, eliminating the contaminants (water vapour, CO_2, mercury vapour, and H2S) makes related gas processing less cost-effective. However, in order to enhance the economic worth of the associated gas, several businesses have created equipment to treat solely the LPG component.
- LNG (Liquefied Natural Gas) (Liquefied natural gas). At room temperature, LNG has a volume of 1/600 that of gas and requires greater large-scale investment. A large gas reservoir with a capacity of >85 bscm (billion standard cubic meters) requires a one-billion-dollar investment. One cost-effective aspect of LNG processing is the lengthy process of removing gas contaminants, cooling to a liquid at -1620C, and regasification.
- CNG (Compressed Natural Gas) (Compressed natural gas). CNG is nearly identical to LNG, however compression does not take place before the liquid phase. As a result, no regasification is necessary. At room temperature, the volume produced is higher than 1/1200 of the volume of gas.
- NGH (Natural gas hydrates). At -200 C, the gas is hydrated to crystallize and stabilize. This technology might potentially be used to collect related gas that has a higher economic value than LNG.
- Gas to ethylene (GTE) and methanol ammonia are the products. As a substance of DME (Dimethyl ether) and olefin (ethylene and propylene) used in reactors with standard systems in catalyst manufacturing, methane gas from associated gas and natural gas may be converted to methanol products. Methane may also be used as a fertilizer source material by being converted to ammonia. While ethylene is a byproduct of the thermal breakdown of hydrocarbon compounds,

it is particularly important in the generation of NGLs and the accompanying outcomes of petroleum fractionation. Ethylene is widely used to make LDPE (low-density polyethylene) and HDPE (high-density polyethylene) (high-density polyethylene).

- GTL is a slang term for " (Gas to liquid). Gasoline, diesel, and wax are the items in question. Liquid fuels now offer a transportation and storage advantage (Zolfaghari,2017). GTL is typically produced solely using natural gas, however Chevron Nigeria Limited began manufacturing GTL 70% and naphthalene 30% (mid-2014) with 15% flare gas, a capacity of 34,000 barrels per day, and is required to sustain a production capacity of about 9.6 MMSCMD in Nigeria (million standard cubic meters per day).
- Olefin units - Olefin units are among the most profitable plants in the petrochemicals industry. Due to the nature of these units, there is a good potential for using FGRUs during startups to reduce emissions and recover capital. Given the expanding number of olefin units in the world today, with flaring an integral part of the factories, large amounts of energy and capital are lost. Therefore, it makes good sense to consider more deeply the use of FGRUs with such units.

The success stories of the flare reduction initiative are listed below.

4.2.1 Russia - Jenbacher gas engines reduce flare gas emissions and generate power.

GE Energy is delivering 12 Jenbacher gas engines to Monolit LLC, a Russian oil and gas company, as part of an initiative to cut emissions at a Western Siberian production plant by repurposing previously flared gas. The waste gas will be separated at the plant into liquefied natural gas and other “transportable” products for the chemical sector (such as propane, butane, and ethane). Monolit will reduce the need to transport diesel fuel over long distances by using gas from neighboring drilling resources at Shapinskoe for onsite power generation, resulting in considerable environmental advantages.

4.2.2 Kazakhstan - Sour gas re-injection

If sour gas or natural gas with high amounts of H2S is distributed into the air, it can be fatal. GE has developed technology to manage the high-pressure, high-sulfur gas produced by the oil fields of Karachaganak, Tengiz, and Kashagan. To sequester the poisonous gas while enhancing oil recovery, the associated gas is collected, compressed, and re-injected into the formations. The BCL300 family of centrifugal compressors from GE are used in this method. Since its introduction in 2000, this GE technology for gas re-injection has averted the release of more than 49 million tonnes of CO_2 into the atmosphere each year, the equivalent of around 10 million typical automobiles' yearly CO_2 emissions.

4.2.3 Aeroderivative power generating in Argentina

REPSOL YPF Argentina commissioned GE Energy to build the Chihuido Power Plant. The project uses GE's LM2500 gas turbine, which is designed to run on low-BTU fuel. From the.45 million cubic meters per day of gas that was previously flared, the facility generates roughly 40 MW of power.

1. Nigeria - Projects to compress natural gas and generate electricity on a fast schedule

Compression island approaches are being developed by GE Oil and Gas for several flow stations in the Niger Delta. These reciprocating compressor machines will compress natural gas in preparation for transmission to local power plants or pipelines. For redelivery into the pipeline grid, the Ebocha compression project collects low and high-pressure gas from the oil and gas separation units. Another Nigerian project, the Crawford Channel LPG and related gas-gathering project, uses GE aeroderivative technology, including LM2500 gas turbines.

4.2.4 India- Reliance refinery at Jamnagar

In November 2003, India's largest refinery installed a flare gas recovery system with in-house design and minor assistance from Shell Global Solution Netherlands. This method decreased hydrocarbon flaring from 53 to 10 tons per day, lowering pollution levels in the environment. To determine the flaring quantity (by nitrogen balance) from individual plants and decrease leakages, a technique of injecting measured amounts of nitrogen into the flare header of each plant and analyzing flare gases (before and after nitrogen injection) at the plant battery limit was utilized. All of these efforts resulted in a flare loss of around 45 TPD. Flare loss from the best-performing refineries has been recorded as low as 0.03 percent. The network's required purging accounted for roughly 0.05 percent of the refinery's total intake.

4.3 Recuperated and Unrecuperated microturbine

Microturbines are a relatively recent technique for energy generation. A microturbine is a combustion turbine that generates heat as well as electricity. Microturbine generators provide a number of benefits over reciprocating engine generators, including better power density (in terms of size and weight), extremely low emissions, and few, if any, moving parts. Microturbines additionally benefit from the fact that the bulk of their waste heat is confined in their relatively high temperature exhaust, whereas reciprocating engines' waste heat is divided between the exhaust and cooling system. Reciprocal engine generators, on the other hand, are faster to respond to changes in output power requirements and are typically somewhat more efficient, but microturbine efficiency is improving. Microturbines may run on a variety of commercial and renewable fuels, including gasoline, natural gas, propane, diesel, and kerosene. A single stage radial compressor, a single stage radial turbine, and a recuperator are typical components of microturbine designs. There are two types of microturbine generators: recuperated and unrecuperated microturbines. Compressed air is combined with fuel and burnt under constant pressure circumstances in an unrecuperated microturbine. To do work, the heated gas is allowed to expand through a turbine. Microturbines with a simple cycle have a low efficiency of up to 15%. Unrecuperated microturbines, on the other hand, are less expensive, more reliable, and have more heat available for cogeneration applications than recuperated microturbines. Recuperated microturbines, on the other hand, employ a sheet-metal exchanger to recover part of the heat from an exhaust stream and transfer it to the incoming air stream, increasing the temperature of the air supply to the combustor. In a cogeneration arrangement, more exhaust heat recovery may be employed. Microturbines that have been recovered can have an efficiency of up to 80%. In this study, the microturbine is chosen as the alternative green technology to minimize flare gas.

4.4 Energy conversion process from Microturbine using HYSYS

The sophisticated program HyproTech HYSYS 3.2 will be used to simulate and analyze the potential energy of the flaring gas. It may be used to simulate processes in both stable and dynamic states. It contains tools for estimating physical characteristics and liquid-vapor phase equilibrium, heat and material balances, process design, and process equipment optimization. The application is based on tried-and-true technology that have been providing process simulation tools to the oil and gas sectors for more than two decades. HYSYS is a versatile and interactive process modelling software that allows engineers, students, and researchers to create, monitor, debug, and optimize process operations and asset management. The plant's productivity, dependability, decision-making, and profitability will all improve as a result.

The fluid package in HYSYS contains the essential information for pure components flash and physical properties calculations. Choosing the correct fluid package for a specific component and situation, on the other hand, is critical. As a starting point for effective process modelling, proper selection of thermodynamic models during process simulation is also required If the process simulation is based on erroneous fluid package and thermodynamics models, a process that is otherwise perfectly optimized in terms of equipment selection and setup might be rendered useless and recommends the Peng-Robinson fluid package for energy recovery from flaring gas simulations because of its precision and usability. Once the fluid package and thermodynamics model equations have been chosen, the simulation environment may now be used to create the detailed process flow diagram. In HYSYS, stream to stream connections are impossible, therefore components like mixers and splitters are used to create an acceptable model, even if this has little or no influence on the correctness of the process being studied. The simulation of the built process flow diagram is accomplished by providing some important physical, thermodynamics, and transport data to the stream and equipment involved. This is done until all of the units and streams are solved and converged, as indicated by the green color on the stream and equipment. The most significant input parameters for streams to solve are the temperature, pressure, and flow rate of the stream, which are all required by HYSYS. These data are taken from the tapping point of CPP1.

The capacity of the HYSYS software to work on both steady state and dynamic simulation processes was previously highlighted. Because this project relies on simulation results that are backed up by other people's work, it's crucial to get everything right from the start. The study included some research on steady state modelling of a chemical plant's startup operation using an anticipated set of steady state operating points to project the system's dynamic response. The technique, however, was discovered to be deficient due to a missing component between two neighboring steady state operating points, leaving it unable to direct essential process control and operation. The steady state simulation was chosen for this project because it is comparatively easy in comparison to the inherent complexity of the plantwide dynamic simulation. Furthermore, the nature of the offshore platform differs from that of a chemical factory, where shutting down is not a frequent practice. However, further work on dynamic modelling is still needed to account for external operational variables that impact the process.

4.4 Economic Evaluation of Energy Recovery in CPP1

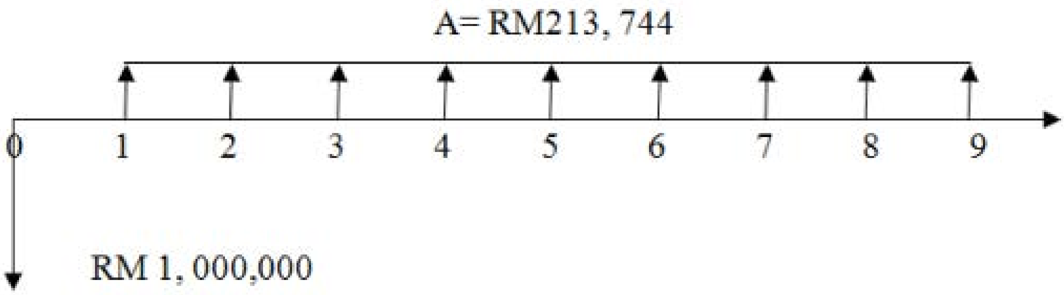
In the table below, the simulation model was used to analyze the energy potential of CPP and estimate the amount of power that may be generated on the platform.

Table 4.1 CPP1 electric generation summary

Power Generated (kW)	245-320
Adiabatic efficiency (%)	75
Usage percentage of gas supplied (%)	100
Input gas flow rate (MMscf/d)	1.48-2.0

With an input gas of 1.48 - 2 MMscf/d, the energy recovery system could yield a total power of 245 to 320 kW. Microturbines were identified as a suitable gas turbine for energy generation based on the power generated, with an estimated cost of RM900,000 (Capstone CR200 model).

When the price of a unit of power is taken into account, RM0.10/kWh, with a total capital outlay of roughly RM 1 million. an expected amount of money, including the cost of the microturbine, installation, and piping works RM 213,744 might be saved yearly over the microturbine's lifetime.



Calculation for electricity generated in term of Ringgit Malaysia (RM):

RM 0.10/kWh X 244 kW X 24h/ day X 365 days = RM 213, 744

Figure 4.1 Potential annual savings calculation

4.4.1 Minimum Attractive Rate of Return (MARR) for economic viability

Because the quantity of money available for investment is constantly limited, the Minimum Attractive Rate of Return (MARR) is usually a policy established by top management of a firm. The MARR, also known as the hurdle rate, should be chosen to maximize an organization's economic well-being. The opportunity cost is a typical method for determining a MARR. Simply defined, the profit that could have been made if the money had been invested in other viable vehicles or projects. Throughout the study period, a MARR of 10% was chosen in the process of evaluating the energy potential from the electricity generated by the microturbine.

4.4.2 Present Worth (PW) Method to determine economic viability

The PW technique is founded on the idea that all cash flows have the same value relative to a starting point in time called the present, or simply year zero. That is, all cash inflows and outflows are discounted to the present moment in time using the MARR as the interest rate. An investment project's positive PW is the amount of profit that exceeds the minimal quantity expected by investors. The cash created by the alternative is expected to be available for other purposes that earn interest at the same rate as the MARR.

To get the PW with a MARR of 10%, for example, i= 10%, it is essential to discount future sums to the present using a 10% interest rate.

Since F1=F2=F3=F4=F5=F6=F7=F9, F1 (1+i)1+F2(1+i)2…+F9(1+i)9

= A (P/A, 10%, 9) Hence, PW (10%)

= F0 (1+i)0 + A (P/A, 10%, 9)

= -RM1, 000,000 (1+0.1)0+ RM 213,744 (5.7590)

= RM 230,951.60

With a MARR of 10% per year, the plan of installing a microturbine rather than continuing gas flaring activities will add RM230,951.60 to the platform cash flow in 9 years. As a result, the installation of a microturbine to generate energy from gas flaring is a wise investment.

4.4.3 Internal Rate of Return (IRR) Method to evaluate economic viability

For engineering economy analyses, the IRR approach is the most extensively utilized rate-of-return method. It's also referred to as the profitability index or the discounted cash-flow approach. This method compares the equivalent worth of a project's cash inflows (savings) to the equivalent worth of the project's cash outflows (expenditures, including investment cost), where the equal worth can be computed using the current worth method. When the IRR is more than the MARR, the project is economically justified, according to the IRR determination rule.

IRR can be computed as follows:

PW = 0 = -1 000, 000 +213744 (P/A, i'%, 9) i'% (1)

= IRR Solve using the linear interpolation

At i'%= 15%, PW

= -1 000, 000 +213744 (P/A, 15%, 9)

= -1 000, 000 +213744 (7.1078)

= 519249.6 At i'%= 18%, PW

= -1 000, 000 +213744 (P/A, 18%, 9)

= -1 000, 000 +213744 (4.3030)

= -80259.6 The IRR is between the range of 15-18%, e.g.: (IRR= 15 %< i')

Because the project's IRR (17.59%) is higher than its MARR (10%), the project is considered economically viable.

4.4.4 Payback Period Method

The simple payout approach, often known as the payback period method, is used to determine a project's liquidity rather than its profitability. Because liquidity is concerned with how quickly an investment may be returned, the payback technique has traditionally been employed as a measure of a project's risk. In this analysis, it's also crucial to figure out how quickly the initial investment can be recouped. To put it another way, the payback technique determines how long it will take for cash inflows to equal cash outflows.

Table 4.2 Calculation of the Simple Payback Period and the Discounted Payback

End of Year (EOY), k	Net Cash Flow	Cumulative PW at i= 0%/yr through year k	PW of cash flow at i= 10%/yr	Cumulative PW at i=10%/yr through year k
0	-1000000	-1000000	-1000000	-1000000
1	213744	-786256	194315	-805685
2	213744	-572512	176638	-629047
3	213744	-358768	160589	-468461
4	213744	-145024	145988	-322474
5	213744	68720	132714	-189761
6	213744	282464	120659	-69103
7	213744	496208	109694	40592
8	213744	709952	99712	140303
9	213744	923696	90649	230952

Figure above depicts the simple and discounted cash flow during the microturbine installation project at CPP1. The capital invested, which is RM1, 000,000, is represented by the figures in the first row or at year zero, e.g., k=0, and the subsequent numbers in column 2 are the annual savings over the expected microturbine lifespan of 9 years.

The number of years for yearly savings to equal the capital invested in the basic payback period technique is at the end of year 5, e.g., EOY 5, because the cumulative balance turns positive at EOY 5. Similarly, the number of years it takes for yearly savings to equal the capital invested is at the end of year 7, e.g., EOY 7 at a 10% interest rate, i=10 percent.

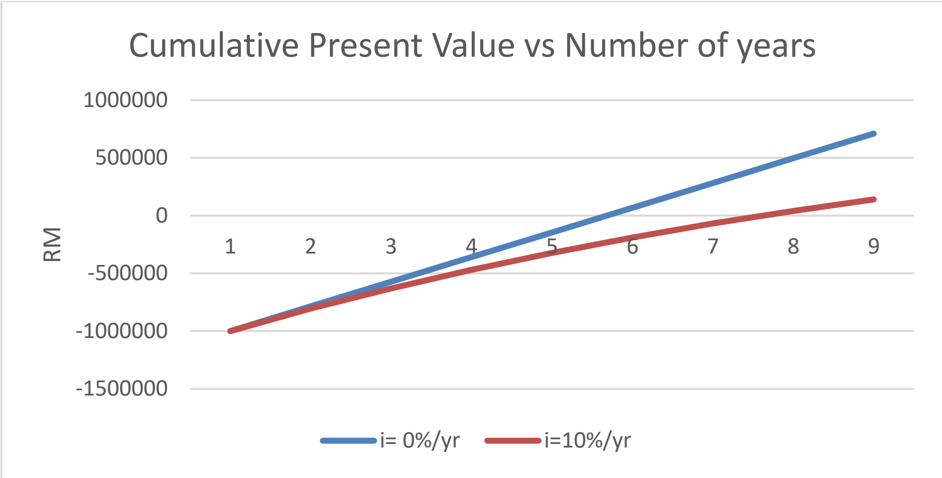


Figure 4.2 Graph of cumulative pw vs number of years for microturbine installation at CPP1

The blue trend line in Figure 4.2 clearly shows that using a simple payback time technique, such as interest rate, i=0 percent, will result in a payback period of 5 years.

Simply said, it takes 5 years for cash inflows, which means annual savings from the microturbine installation, to accumulate and equal the invested capital with no interest. Similarly, the repayment term is longer for discounted payback periods, such as interest rate, i=10 percent, as illustrated by the orange trend line, than for simple payback periods, where the line crosses the horizontal axis after 6 years. In other words, it takes 7 years for cash inflows or annual savings from the microturbine installation to collect and equalize the invested capital at a 10% interest rate.

The proposal to install the microturbine is an attractive alternative because the payback term is less than the microturbine lifespan, according to both simple and discounted payback periods. Furthermore, if the microturbine is installed, the predicted ongoing savings after the payback period is a plus.

4.5 Summary

The commercial viability of CPP1's energy potential has been demonstrated. It's crucial to see if the same technology can be used to the other two gas-supply platforms for CPP1, namely CPP2 and CPP3 The available natural gas flow rate and gas characteristics in the two platforms were equivalent to CPP1. The gas compositions from the two platforms were incorporated into the simulation, and the following is a summary of the power generated:

Table 4.3 Comparison of Power Generated in Nearby Platform with the Main Gas

Gas Components	Mass Fraction		
	CPP1	**CPP2**	**CPP3**
Methane	86.5587	76.89	91.22
Ethane	9.64587	8.22	7.33
Propane	1.85699	1.23	1
n-butane	0.54566	0.43	0.12
Power Generated	245	223	258

It can be said that methane is the most abundant gas component in natural gas.is the primary source of electricity generated. This explains the conclusion. In his work, Farzana shows how the thermal efficiency of the Brayton cycle can be increased. As the concentration of methane in the atmosphere grew, the maximum point was reached.

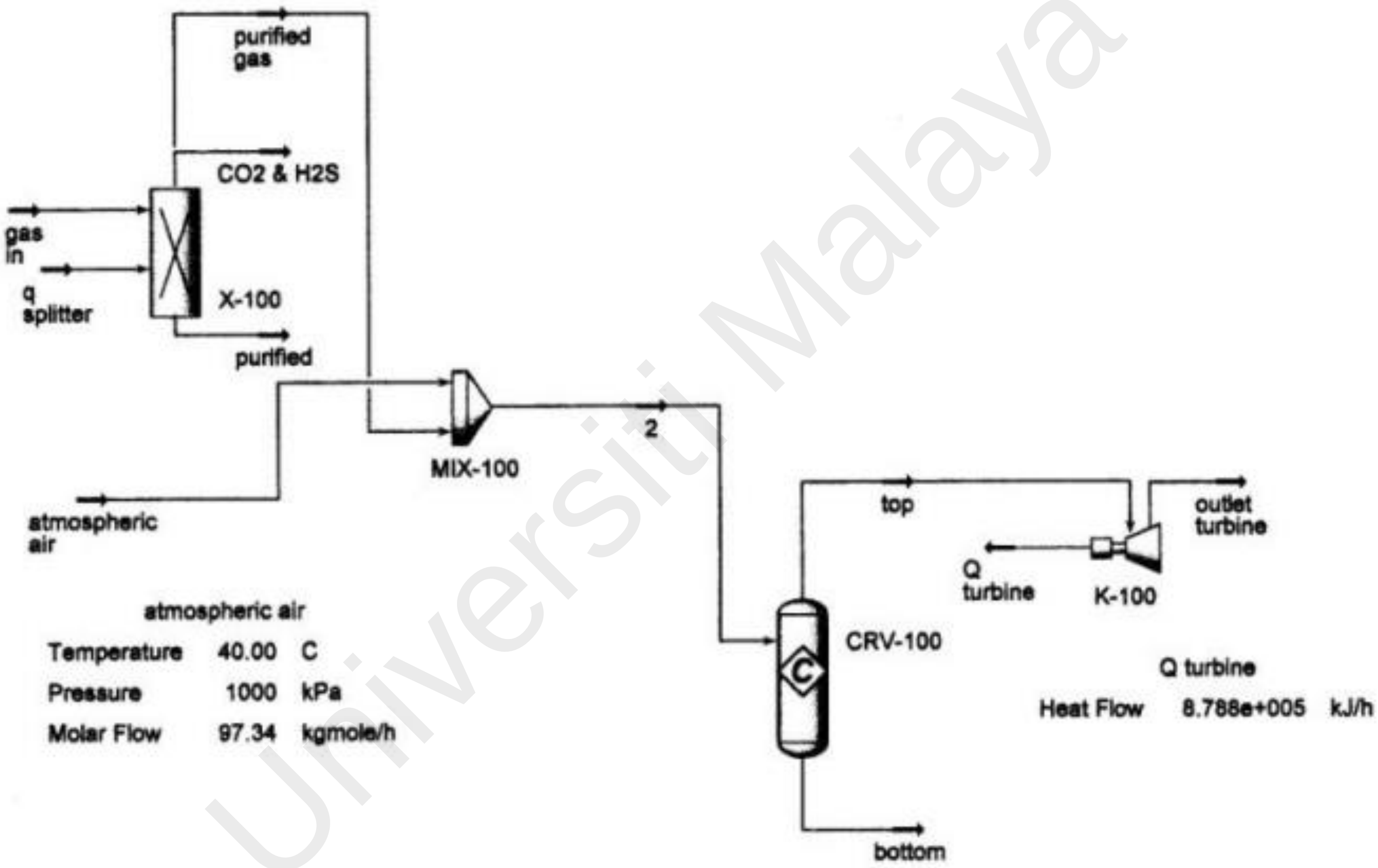


Figure 4.3 Complete Process Flow Diagram for Electricity Generation by Using microturbine

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Many industrial activities, such as oil-gas extraction, refineries, chemical plants, coal industries, and landfills, use gas flaring as a combustion device to burn related, undesired, or surplus gases and liquids generated during normal or unexpected over-pressuring operations. Flaring of natural gas is a significant cause of pollution. It also produces noise and heat, as well as rendering huge regions uninhabitable. According to the World Bank, between 150 and 170 billion m^3 of gases are flared or vented yearly, amounting to roughly $ 30.6 billion, or one-quarter of the United States' gas consumption or 30% of the European Union's gas use. Reducing or recovering gas flaring is critical. Environmental limitations in developing nations are characterized by a number of factors, including population expansion, inefficient technology, weak governance, a bad health sector, low per capita income, poverty, and so on. Growth would take precedence over environmental concerns. This may be true, but the faster the development, consumption, and use of natural capital resources, the more waste is produced, and the greater the risk of environmental deterioration and depletion. As a result, economic expansion is likely to trump environmental concerns, putting the environment on the back burner while the focus is on accumulating riches. There is a pressing need to measure flared gas in order to determine its composition, distribution, and volume, as well as to use the appropriate flare gas recovery or disposal method. According to the modelling presented in Chapter 3, the volume of natural gas now flared, which is 1.48 MMscf/d, could generate 244kW of electrical power. When the gas inflow is at its highest, which is 2.0MMscf/d, this amount of energy might reach a peak of 325kW. Furthermore, the energy potential of the flare gases on the platform was assessed in this study. The economic examination was discussed in full in Chapter 4 using economic instruments such as the current worth approach, internal rate of return, and payback time. The conclusion is that employing a microturbine to recover energy from flare gases is a good investment.

5.2 Recommendation

HYSYS software simulation set in steady state mode, the energy recovery potential was examined in this thesis. However, because natural gas volume and composition vary over time, it is recommended that these impacts be studied in real time using dynamic model functions of simulators. The electricity generated has been anticipated to be required on the platform in this analysis. Because a project of this nature necessitates a large sum of money, it is vital to properly analyze the need for electricity.

Currently, several methods exist to capture gas that would otherwise be wasted and transform it into usable products or for onsite usage to enhance manufacturing. While there is technology for this that are commercially accessible. When market circumstances fail, these solutions are not used, such as collecting and monetizing flared gas to provide a cost-effective alternative to low-cost flaring and venting during normal field operations production.

Compressing natural gas and transporting it short distances for use as a fuel for oilfield activities, extracting natural gas liquids from the flare gas stream to minimize the flared amount, and converting the gas to power using small scale generators are all commercial alternatives to flaring. While a concentrated network of technologies and infrastructure exists to capture and monetize natural gas at various petroleum refineries and chemical plants, as producing regions evolve, a distributed network of technologies and infrastructure is required to effectively reduce daily venting and flaring volumes. These distributed technology solutions to minimize flared quantities are frequently not cost-competitive at this time, necessitating significant R&D and infrastructure improvements.

Developing cost-effective solutions for lowering flared gas volumes by capturing related gas and converting it to value-added goods might be extremely beneficial. These options would benefit from technologies that are low-cost to develop and run, as well as those that can be transported from one well pad to another. These technologies would be more successful and efficient if they were operationally independent of collection systems and capable of converting a wide variety of gas flow rates and chemical compositions into products with market value on-site or nearby.

Some other recommendations to reduce flaring is as below:

- Natural gas can be collected and compressed (CNG) on the well pad before being trucked to a gas processing facility or a fueling station. At wells adjacent to a processing facility or other site where gas may join the pipeline system, this technique may be economically feasible (20 to 25 miles, or fewer). It may also be cost-effective if compressed gas can be utilised to power equipment in the production area.
- Natural gas may be converted to chemicals or fuels, and some of these systems have been marketed to reduce flaring. As shown by their lack of broad deployment, several features of these systems have not been modified, scaled, or optimized for use in Malaysian flaring circumstances. To demonstrate technical and economic capabilities, new combinations of current technological pieces must be created and tested. Researchers will develop ways to convert flare gas into compounds that are useful in industry. There may also be a possibility to combine research into solid oxide fuel cell technology with chemical upgrading.

- For local power generation, a number of technologies are available, ranging from reciprocating engines and gas turbines to electricity generators. When utilising lean related gas, local load systems perform well (e.g., the residual gas after NGL recovery). All of these techniques require a continual nearby demand for electric power or the ability to sell electricity to the local grid in order to be economically viable.
- Through small-scale combined heat and power systems, captured natural gas may be utilized for onsite power production, space heating, and other uses. This approach is unlikely to be cost-effective due to the gap between the amounts of gas released and the volumes required for such end applications. While several onsite technology solutions have been tested and proven to function, many have not been extensively used, owing to negative economics as compared to flaring. The installation (or rental) expenses, as well as the operating costs, do not appear to support widespread use of these solutions currently.

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