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Techno Economic of CNG & GTG Technology Applied in Gas Flare Management

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Abstract

Our environment is being endangered by greenhouse gases from gas flaring processes. Approximately 4 mmscfd is contributed by flare gas from JWB field. The flare gas would be concentrated to become the most economic value and prevent the greenhouse effect. The analysis of economic value is getting the fastest investment return and the most annual profit. This Study would discuss a techno-economic aspect of flare gas utilization technology. In this paper, two methods of compressed natural gas (CNG) and gas to wire (GTW) was combined with CNG would be introduced and applied in this field. For both methods are introduced and compared to the best method from an economic standpoint identified. According to the results, the production of the CNG method of flare gas utilization is the most economical technology; with has a greater ROR, an annual profit of about $3.65 million, and a payback period of 2.09 years. Economic analysis shows there improved gas flare value and improvement environmental protection.

INTRODUCTION SECTION

After another record years, global demand for natural gas has growing until now, and driven by consumption energy for growing Asian economies, and supported by the continued development of the international gas trade (IEA, 2019).

After another record years, global demand for natural gas has grown until now, and driven by consumption energy for growing Asian economies, and supported by the continued development of the international gas trade (IEA, 2019). Natural gas is gaining more important. This growth was driven by some factors; such as an abundant resource base, growing energy demand, environmental responsibility, improved technologies, transportation and conversion of natural gas. Most economic of the world are diversifying from oil to gas as energy. (Salami, Daskareem, & Oladipo, 2013).

Energy is the ability to wok out an action. If energy is seen from the source, Energy sources can be categorized as renewable or nonrenewable. Renewable energy an energy source that can be been easily replenished; such as solar energy, geothermal energy, wind energy, biomass, hydro power, etc. Nonrenewable energy is an energy source that cannot be easily replenished; such as hydrocarbon product, coal, nuclear energy, etc (IEA, 2019).

Natural gas comes from reservoirs; mixed with crude oil is called associated gas, and from unmixed is called non-associated gas. Gas is separated in oil and gas collection facilities, and the results are used as fuel, CNG, LPG, LNG and, etc (Deri, 2016). However, Some energy wasn't useless, for example is gas flares. Gas flare is a product of natural gas, which is forced to be burned into the environment. Flaring gas is wasted due to flaring and or venting as a result lack of processing facilities. About 5% of world gas is discharged through flares. Causing 300 million tons of CO2 per year and cause environmental pollution (Emeka, Chike, & Nwabueze, 2016). Flare was colleted for three categories, from upstream sites, from upstream site, downstream site and the remaining operational flaring site (D.Elvidge, et al., 2012). Although, the purpose of flaring system is to ensure the plant is safe of safety accidents, including overpressure in the gas streams and fires,

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burning in the flare tower produces some products which are transformed to CO2 and H2O (Mohabbat, Vahid, & Hossein, 2017).

There are no doubts about the environmental, health and economic implications of gas flaring. Gas flaring began of environmental degradation, which significantly impacts to local populations, with economic production and health issues. The soot and carbon monoxide was resulting the incomplete combustion of natural gas into air pollution. Gas flaring releases carbon dioxide (CO2) and carbon monoxide (CO), and other pollutants, such as volatile organic compounds (VOC). And suprosingly impact of premature death, respiratory illnesses, cancers, asthma attacks and others (Ikechukwu, Musa, Ashem, & Mukaila, 2013).

The Indonesian government regulate of gas flaring since the Minister of Energy and Mineral Resources regulation number 31 of 2012; about the limitation of flare gas. This regulation to limit and regulated oil and gas company flare gas; which maximum 5 mmscfd, or maximum 3% feed gas for oil field, etc (Ministry of Energy and Mineral Resources, 2012)

Furthermore, Minister of Energy and Mineral Resources regulation number 32 of 2017; about pricing of flare gas, the government tried to attach of investors to utilize of flare gas. In this regulation also shows several gas flaring gas utilization (Ministry of Energy and Mineral Resources, 2017).

Gas transportation that is used to deliver natural gas from source to be accepted by consumers. The method is used are physically changing the natural gas, such as pipeline, CNG, LNG, and GTS. There are also methods that are chemically changing the natural gas, such as GTL, GTW and GTC (Gunard, 2012).

In oil and gas fields, early production used to accelerate production; when completion of other development wells. For more positive is generating revenue with minimized investment. Early production also provided a valuable mitigation problem for development phase when completion of the permanent production facilities and wells are still produced (Wilson, 2016). In Other Case, Operator India was applied to quick production facilities (QPF) for quick relocation with skid-mounted, plug and play, and easily commission which in multiple fields. QPF also present by the services company using an economic, flexible, and reliable QPF. For more challenge related to the flow assurance, limited infrastructure, and compliance with India Directorate General of Mines Safety (DGMS) Challenge (Amol, Milind, Zaharia, & Sunil, 2015). Due to the short duration of early production, utilization of flaring gas was seldom applied, because short-term gas is not economical. This paper purpose, flare gas for a short-term lifetime would be applied for mobile and flexible transportation; and got economic value.

Flare Gas Process

Flare gas usually comes from the upstream and downstream oil & gas company. Basically, flare installation is a safety system from a gas. Aside from being a safety measure, combustion of gas flares aims to minimize environmental pollution. If the gas is discharged into the air without burning, it has a negative impact for the most greenhouse gases. Heating value of methane emissions are more dangerous than carbon dioxide; So the gas must be burned into carbon dioxide; and discharged into the atmosphere. Methane also as greenhouse effect more labour than carbon dioxide, because in atmosphere, methane can't decompose faster than carbon dioxide. Indirectly from economic value, flaring gas also result that loss of potential economic value. Some impact of gas flaring was found, such as acidity impact, thermal impact, heat radiation impact, photochemical effect, health impact, agriculture impact (Mohammad, Angineh, Mohammad, & Eugenia, 2016). Flaring from associated petroleum gas (APG) was considered a considered global problem to lead large climate

gas emission; and gas flaring is waste of energy and reduce Russian potential revenue from its use of hydrocarbon resources (S.P.Loe & Olga, 2012)

In a lot of countries regulation have been made to minimize of flare gas. Although flaring could be permitted in some case, for example when accidental break down of machinery and pipeline, and over pressure vessel (Emeka, Chike, & Nwabueze, 2016). Some flaring gas due to following reasons, such as over capacity of demand or customer, over production of gas well, vapour that is collected from tank & vessel, shut down of plant, plant maintenance, equipment changeover, etc

Supply and Demand of Gas

In specifical accordance with "neraca gas bumi nasional" at West Java, was estimated gas supply and demand in their area. As per supply in 2018, natural gas supply was estimated at 1300 mmscfd @ 1000btu/scf. Gas supply has decreased from the previous year. However, different from demand trend, demand recorded has insignificantly increased from previous year. Demand required approximately 1670 mmscfd @1000btu/scf. This trend analysis shows that there was found deficit of natural gas supply, and would be continued for next year (Downstream Oil and Gas Regulatory Republic Indonesia, 2019).

RESEARCH AND METHODS

Gas utilization technology had been introduced by several researchers, which is classified as following:

Liquefied Natural Gas (LNG)

Gas utilization technology had been introduced by several researchers, which is classified as following: 2.1 Liquefied Natural Gas (LNG) Liquefied Natural Gas (LNG) is liquefied natural gas with -162 degC at a atmospheric pressure. LNG has a density about 45% lighter than water, reaching volume up to 1/600 of gas at room temperature. The main purpose of liquefying natural gas easily brings with transportation liquid phase from supplier to the consumer. LNG's compositions were dominant of 85-90% mole of methane & ethane. The actual composition of LNG depends on gas sources and processes technology.

LNG was estimated for range distances more than 1000 km, and for this range is more economical than gas pipelines. The ideal distance is around 500-2500 nautical miles, for gas volume around 500-800 mmscfd. Some already operating small-scale liquefaction plant is introduced and had most economic value. (Mohammad, Angineh, Mohammad, & Eugenia, 2016)

Compressed natural gas (CNG)

Compressed Natural Gas (CNG) is natural gas that is compressed at a high pressure. The volume of natural gas will be 1/133 times when pressed to 1400 psig and 1/280 time when pressed to 2850 psig. The purpose of this compression is to obtain a greater volume of natural gas to carry than without the process liquefaction. The composition must meet commercial gas specifications such as maximum water, CO2 and heavy hydrocarbon content limits. In addition, storing gas at a very high pressures requires strict limits on water content and heavy hydrocarbons to prevent condensation and formation of hydrates. CNG technology is suitable for land transport over short distance and has the potential to become the preferred method in offshore platforms. Since CNG is land transportable, it can be used in fields with relatively short production horizons. Thus, CNG is used primarily as a transport fuel and on small scales transport road projects (Ernest, 2015).

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Gas To Wire (GTW)

Gas-to-Wire (GTW) is a strategy of using natural gas to generate electricity. The Basic natural gas-fired electric generation consists of a steam generation unit, in which fossil fuels are burned in a boiler to heat water and produce steam that turns a turbine to generate electricity. This process of generating electricity through steam boiler with efficiency in that only 33 to 35 percent of the thermal energy. Gas turbines and combustion engines are also used to generate electricity (Ernest, 2015). An electric utility power used some technology, such as turbine, engine, water wheel or other machines to drive an electric generator (M.R.Rahimpour, et al., 2012). Natural gas was converted into electric is more cheap, from maintenance than for liquid phase (Emeka, Chike, & Nwabueze, 2018). For more technology was intoduced for burning mixture of the flare gas and a conventional fueld in combustion chamber can be used or modified and get more economic value (Mohammad, Abtin, & Mohammad Hoseini, 2016).

Liquefied Petroleum Gas

LPG (liquefied petroleum gas) consists of a main mixture of propane (C3H8) and butane (C4H10) and some lighter C2 fractions and heavier C5. LPG is a mixture of hydrocarbons in the form of gas at atmospheric pressure but can be condensed into a liquid form at normal temperature, with a large enough pressure. Even though it is used as a gas, but for the convenience, stored and transported inside liquid form with a certain pressure. Liquid LPG evaporated to form gas with a volume into about 250 times.

Pipeline Gas

Gas pipeline flows natural gas to the user. Gas pipelines can be connected between regions, between islands, and between countries. The ideal distance of a gas pipeline is around 0-600 nautical miles or 0.1 to 1000 km. The ideal gas flow volume is around 0 to 1000 mmscfd. Pipeline or pipeline is the cheapest and easiest method for transport natural gas. But pipeline gas would be a problem if unconnected pipeline route around oil and gas field. More investigation is needed to connect potential gas to the existed pipeline.

In other utilization media, natural gas can be converted in other forms. As for some other converts like Gas to Solid (GTS), Changing gas into a form of solid or known as natural gas hydrate. Gas to Liquid (GTL), Converting gas into the liquid. Usually used to replace diesel fuel. The famous technology in making GTL is Fischer-Tropsch.Gas to Chemical (GTC), Changing gas into chemicals such as methanol. The product can be reduced to a variety of other chemicals (Odumugbo, 2010). Odumogbo illustrated and figured the gas flare utilization currently used and discussed in Figure 1

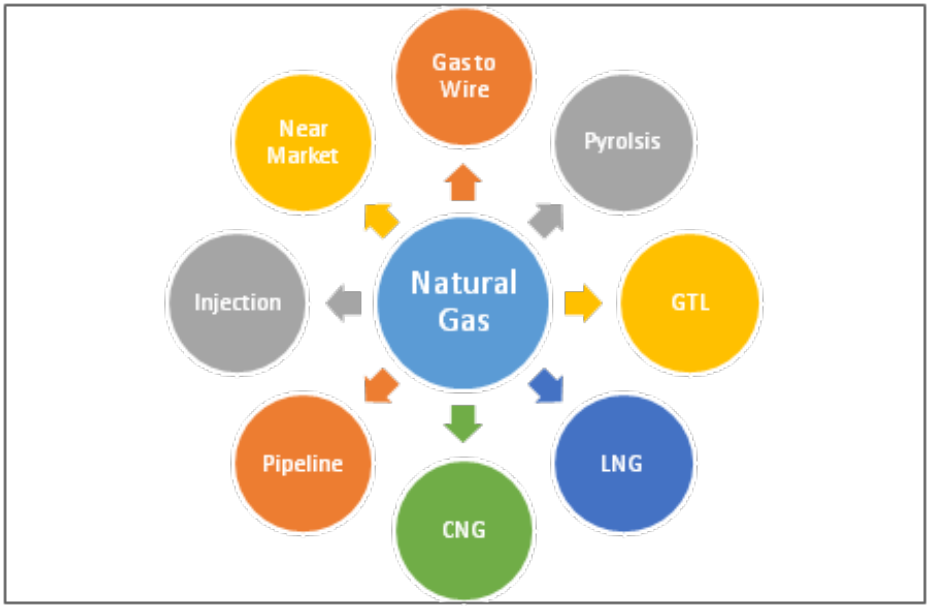

Figure 1. Natural gas transport and development alternative

RESULT AND DISCUSSION

From several fields that use early production, JWB field was chosen because this facility is ready and will be produced.But due to the lack of gas flare utilization, JWB field wants to applied gas utilization of there potential gas flare and found faster turn over of investment.

This section identified the results of case studies. This includes the amount of gas produced, used and burned. Initial processing, CNG and GTW have similar gas purification process, transportation and storage; but end of the product, GTW would be utilized with mobile gas turbines generator to produced electric power. And the last stage, CNG and GTW would be compared to there economic value.

Gas Processing & Purification.

Feed Gas would be fed from Flare gas, which is obtained from associated gas and non associated gas, both of them be adjusted the pressure and be mixed by the mixer. After mixing of the feed gas, gas is called feed gas. Feed gas had a pressure of 625 psi, a temperature of 131 degF, a flow rate of 4.03 mmscfd. Gas specification and composition is figured in Table 1.

However, before the application of gas utilization technology, the gas must be ensured that the gas has met the minimum standards. The minimum standards used are several references, such as gas to wire uses the minimum general gas generator specifications (example: Kohler type 1000REZCK), and CNG follows the standards of the General of Oil and Gas Republik Indonesia regulation No. 247.K / 10 / DHM.T / 2011, regarding the CNG specifications for transportation fuels (Directorate General of Oil and Gas, 2011).

Feed gas contained a carbon dioxide composition of 15.4%. it can cause interference with the storage process and engine performance. therefore it had to the purification of the feed gas, to control carbon dioxide contained to the minimum allowed specifications.

Gas purification is carried out based on the specifications and composition of the gas feed. in this case, Gas purification is focused on the CO2 content in feed gas. The CO2 content in the Feed Gas of 15.4%, which the initial purification is needed CO2 & H2S Removal. The target CO2

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content must be reduced into <0.005 mol% or below 50 ppmv. This process uses the simulation of UNISIM. Feed gas would be streamed to the absorber column from the bottom column. But instead, absorber (MEA, MDEA & H2O) streamed from the top of the column. Furthermore, the absorber did through each tray and; the gas directly enters and contacts the absorber. After contact between the gas and the absorber, CO2 would be absorbed by the absorber, and the gas pass through the tray/column on condenser. Gas output from the tray column is called sweet gas. As a result of this process, CO2 gas is reduced from 15.4% to 0.0454% or equivalent with of 45.4 ppmv.

Table 1. Feed Gas Composition

Composition	Mole Fraction (%mol)
H_2S	0
CO_2	15.4025
N_2	0.8325
Methane	69.03
Ethane	5.92
Propane	5.1075
i-Butane	1.1525
n-Butane	1.3125
i-Pentane	0.4475
n-Pentane	0.315
Hexane +	0.48

However, water in the amine process contained water composition in sweet gas; so there is a water content gained into 61.3 lb / mmscf. To meet sweet gas specification, water have to reduce into 7 lb / mmscf, and to decrease, Dehydration unit is needed in this process. In the Dehydration column is used contactor column, too; But the difference with amine process; absorber used Triethylene glycol (TEG). Sweet gas was streamed to bottom coloum, and TEG to top coloum. Both of fluid would be contact and water would be absorbed to TEG, and sweet gas was found decrease from 61.3 lb / mmscf to 5.26 lb / mmscf. Sweet gas after dehydration unit is called sales gas.

Sales gas in pipeline can be sold. But application pipeline method didn't meet with early production aplication. And also, gas price of pipeline method is lower than CNG and GTW Product. In regulation of President of Republik Indonesia Regulation was set maximum sales gas price of 6 usd/mmbtu (Widodo, 2016)

In the last stage, CNG composition has to dominant with methane and ethane, and the sales gas will be separated with other hydrocarbon composition. In the first distillation column, stage one used depropanizer, which separated propane gas to pass condenser. To separate propane, comp fraction was set to minimum propane contained 0.001 or 0.1% in the condenser. But also, methane is monitored to pass the boiler in the bottom distillation column. To monitored, methane was set to minimum methane contained of 0.001 or 0.1% in the reboiler column. Furthermore, Ethane was found in reboiler output line, then the process is needed to separate ethane used deetanizer. Deethanizer was set to monitored propane gas to condensed in the condenser. To set of propane contained, deetanizer was set to minimum propane contained 0.001 or 0.1% Propane.

For those process, gas was separated into methane & ethane dominant, and propane & heavier gas (NGLs). Two types of gas products is called CNG and NGLs. CNG product obtained of 3,204 mmscfd, the temperature of 35.56 degC and a pressure of 2901 psia. And NGLs product obtained flow rate of 131.2 bbls / day, the temperature of 33.33 degC and a pressure of 104 psia. Both composition could be seen as Table 2.

Summary of those process, process is needed 4 step purification, such as Compression, Acid Gas Removal Unit (AGRU), Dehydration Unit, dan Hydrocarbon Recovery. Which can be seen in Figure 2.

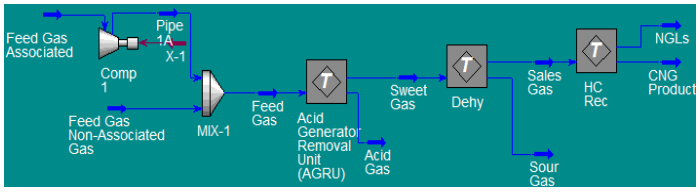

Figure 2. JWB Gas Purification Process

For package of Gases, gas is needed 16 module truck CNG per day, wich capacity of 0.176mmscf, which moved every day. And NGLs would be filling in 4 tank truck, with the capacity of 223.5 bbl. NGLs would be sold to the potential customer, CNG would be sold or convert to electric power.

Table 2. CNG & NGLs Composition

Composition	Mole Fraction of CNG (mol%)	Mole Fraction of NGLs (mol%)
H_2S	0	0
CO_2	0.0644	0.0003
N_2	1.14	0
Methane	87.66	0.0021
Ethane	10.1	0.81
Propane	1	50.22
i-Butane	0	14.44
n-Butane	0	17.28
i-Pentane	0	6.16
n-Pentane	0	4.36
Hexane +	0	6.72
H_2O	0.017	0.0356

Economic analysis of CNG Technology

Summary of CNG Process starts from production well/feed gas, and was streamed to production process facility, then was filled to CNG module and transported to potential client, and be sold with CNG price. The overall process of CNG would be figured in Figure 3.

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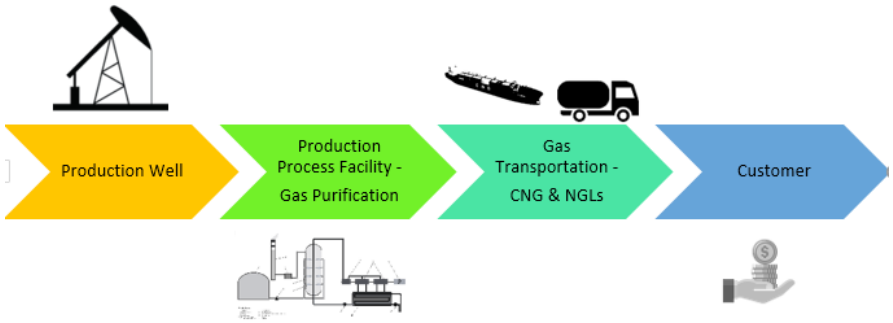

Figure 3. CNG Process

Based on the gas feed capacity of approximately 4mmscfd, 10 years (360 days of operation/ year) of the well will be taken into account and constant gas production is assumed. With the assumption and economic basis using the gas feed price of 3.57 usd / mmbtu (after deducting the correction value). Then from the income, it is assumed the price of CNG products is 11 USD / MMBTU, and NGLs with a value of 4.62 USD / MMBtu. Component of investment is obtained from construction and transportation. Investment component was found from the interview, quotation, and reference research. Construction cost of $ 534.121,43 and transportation cost of $5.951.016,1. From facility rent cost is estimated for gas processing, hydrocarbon & condensate recovery unit, gas metering, flare, condensate process, CNG compression system, power system, lighting, equipment support, HSE & safety protection system and personnel cost, that cost of $ 9.809,5 per day. The results obtained in Table 3.

Table 3. CNG Technology Economic Analysis

Name	Value
Capacity of CNG Product	2970 mmbtu per day
Income of CNG Product	$32.224,2 per day
Capacity of NGLs	$131.21 bbl per day
Income of NGLs	$7764.86 per day
Total Daily income	$39.986,1 per day
Feed Cost	$15.216,54 per day
Total Direct Gas Plant Cost	$8,927.98 per day
Total Production Cost	$26,835.44 per day
Tax Rate	25%
Total Investment	$6.485.137.51
NPV	$14,428,799.87
IRR @12%	56%
PBP	2.09 years
Annual Profit	$3,659,235.98

Economic analysis of GTW Technology (Combined with CNG Transporation)

This Method, to handle on mobile potential gas supply, investment focus to mobile gas transportation, which CNG is selected to transport Sales gas to Gas Generator. This method, GTW

used 13 unit Gas Generator; for this study is referred to Gas Generator Kohler with series number 1000REZCK, to accomode mobility when generator was moved. Gas generator show in Table 4.

Table 4. Gas Generator Spesification

Name	Specification
Series or Model	1000REZCK
Daya Continues Max.	1030-1200 KW
Voltage / Amp	143-1239 Amp
Pressure Inlet	8-15 kpa
Type Fuel	Natural Gas
Fuel supply	- DN80 / min CH4 75% - Impurities max 5% - C4+ max 2%

After the gas was transported, the gas would be converted to be electric power with Gas Generator. For overall process GTW combined with CNG, figure in Figure 4.

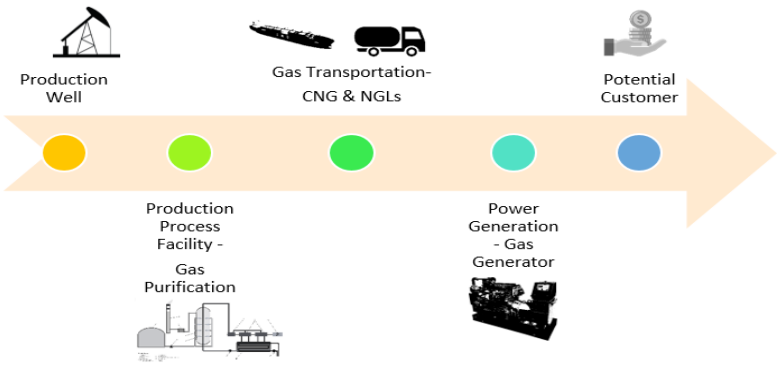

Figure 4. GTW combined CNG Process & Tranportation

Component of investment is obtained from construction and transportation. Construction cost of $ 667.157,14 and transportation cost the same with CNG. From the facility, rent cost is estimated for gas processing, hydrocarbon & condensate recovery unit, gas metering, flare, condensate process, CNG compression system, power system for 16 Unit Gas Generator, lighting, equipment support, HSE & safety protection system and personnel cost, that cost of $ 14.048,67 per day. This cost was added power generation system to convert gas to electric.

Based on the gas feed capacity same condition with CNG. Then from the income, it is assumed the price of electric power is 0.11 USD/kwh. The results obtained in Table 5.

Table 5. GTW Combined CNG Technology Economic Analysis

Name	Value
Capacity of Electric Product	308.758.03 kwh per day
Income of Electric Product	$30,515.34 per day

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Name	Value
Capacity of NGLs	131.21 bbl per day
Income of NGLs	$7764.86 per day
Total Daily income	$38,280.20 per day
Feed Cost	$15.216,54 per day
Total Direct Gas Plant Cost	$10,057.98 per day
Total Production Cost	$27,138.91 per day
Tax Rate	25%
Total Investment	$ 6.618.173.23
NPV	$8,751,795.20
IRR @12%	35%
PBP	3.51 years
Annual Profit	$3,032,190.12

From the two analyzes, was compered of the economic value of flare gas utilization; which is figured in Figure 5.

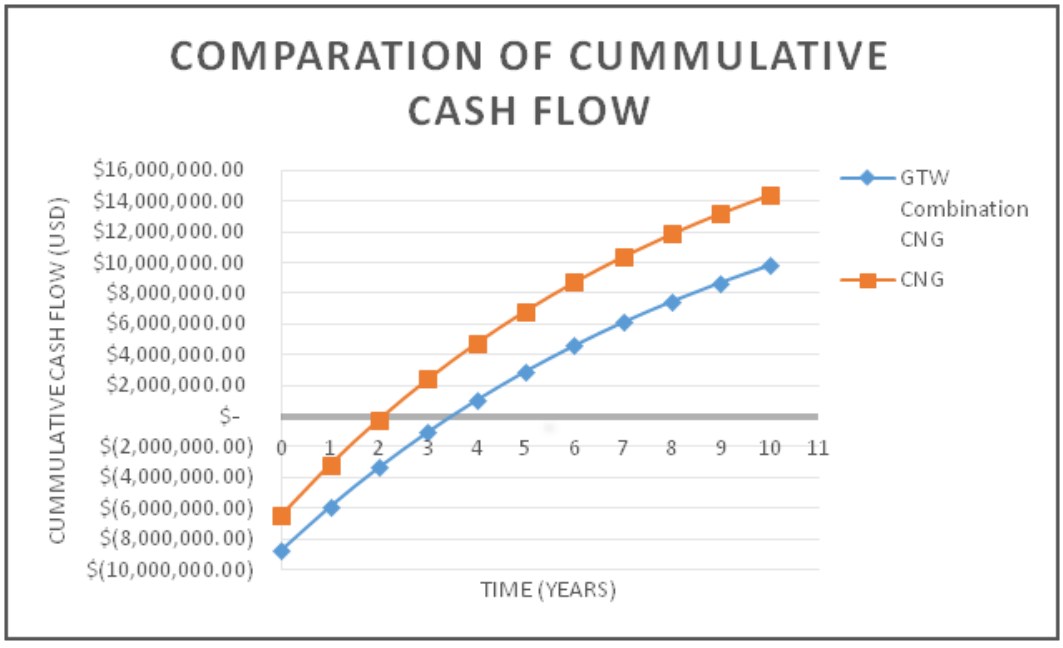

Figure 5. Comparation of Cummulative Cash Flow

And last of analysis, is compared of IRR. The result, CNG Technology is getting more IRR than GTW combination CNG, which is figured in Figure 6.

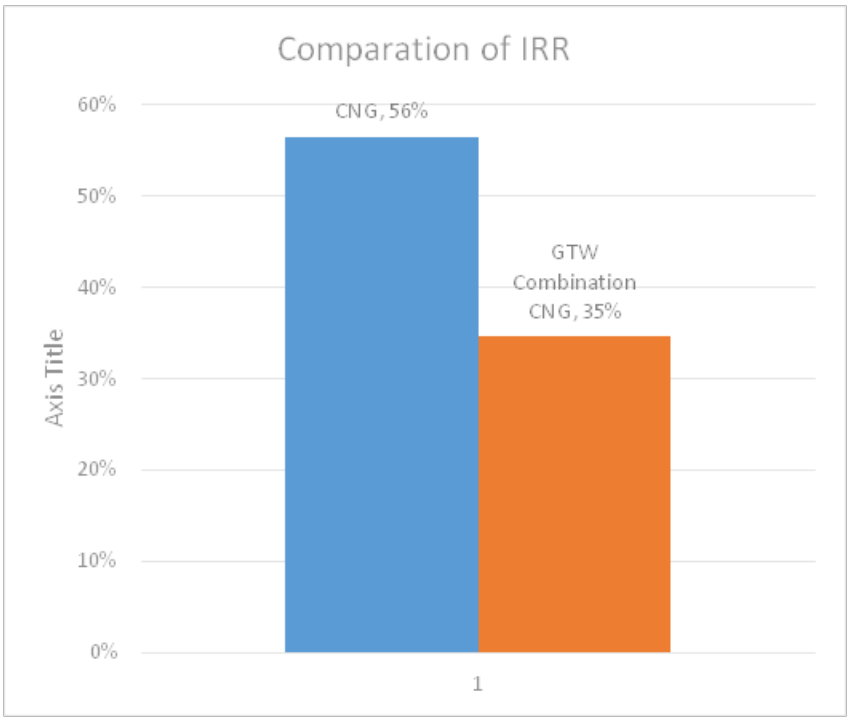

Figure 6. Comparation of IRR

CONCLUSION

The development of the flare gas facility must be considered as an option to minimize the gas deficit, focused West Java in the next years. In the CNG profile, gas flares archived 2,970.16 MMBtu per day and other products; that is, NGLs produce 131.21 bbls/day. In the form of CNG, operational costs are less than GTW. From financial analysis, net present value has been obtained an annual profit of $3.65 million, ROR is 56% and the payback period of 2.09 years. From this analysis, it can be concluded that CNG is more economically applied in this field. But also, GTW combination with CNG would be applied when electic deficit area.

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