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Utilization of KB Field Flare Gas for Own Use Gas Fuel and Commercial Sales Gas

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Abstract

PT PHR as an upstream energy company has a vision to become a world-class energy company. The company has a mission to run oil, gas, and new and renewable energy businesses in an integrated manner, based on strong commercial principles. The KB field is part of PT PHR's Zone 4 working area whose main production is crude oil for then sale to a refinery unit in Plaju PLG, The associated gas (asso gas) separated from the gross fluid in the existing condition is burned through the flare stack because the quantity is quite small and the pressure is not able to enter the sales network. In 2023, PT PHR Zona 4 proposed an advanced development plan in the KB field by proposing the drilling of new infill wells and also workover work for existing wells to increase the forecast oil and gas production significantly, this must also be accompanied by the development of production facilities (SP KB) to be able to handle gross fluids that will be processed at SP KB. The author uses a concise structured process to achieve effective research objectives. The author will follow the conceptual framework that has been built. Quantitative data is obtained from existing data within the company, while qualitative data is obtained from brainstorming results. All necessary information and data are further analyzed according to the conceptual framework. To ensure that the recommended operations management strategy is carried out through technical analysis, a mathematical model study is conducted using several proven tools for business strategy.

Keywords
Production Facilities Associated Gas, Gas Flare Utilization, Surface Facilities Operations Management, Upstream Oil, Net Zero Emission.

1. Introduction
The oil and gas industry are one of the most vital industries for the State of Indonesia. The demand for the availability of natural gas for consumption in the South Sumatra region is still very high. These needs, among others, are intended for industrial activities. In terms of meeting this demand, PT PHR as one of the upstream oils & gas industry cooperation contractors in Indonesia carries out exploration and production activities through development in the KB Field (Arnold 2018, Kidnay et al, 2011, Bullin and Krouskop 2009, Liu 2022).

KB Field is one of the crude oil producing fields in PT PHR zone 4. Currently there are 4 producing wells in the KB field which flow to the production facility at SP KB to be separated between liquid and gas fluids. Oil from KB Field will then be sent to the PPP PBM and will be pumped to the refinery unit in Plaju, PLG. In the KB field there is no dedicated gas well but there is associated gas (asso gas) from crude oil produced by wells in the KB field. Because the amount is quite small and the pressure is low, the gas is burned through the flare stack. Because it cannot be used for own used or sales, for fuel gas needs in the KB field currently using gas from SKG 1 LM delivered through SP V

LM with the existing gas pipeline network. The oil and gas transportation flow diagram can be seen from Figure 1 and Figure 2 as follows:

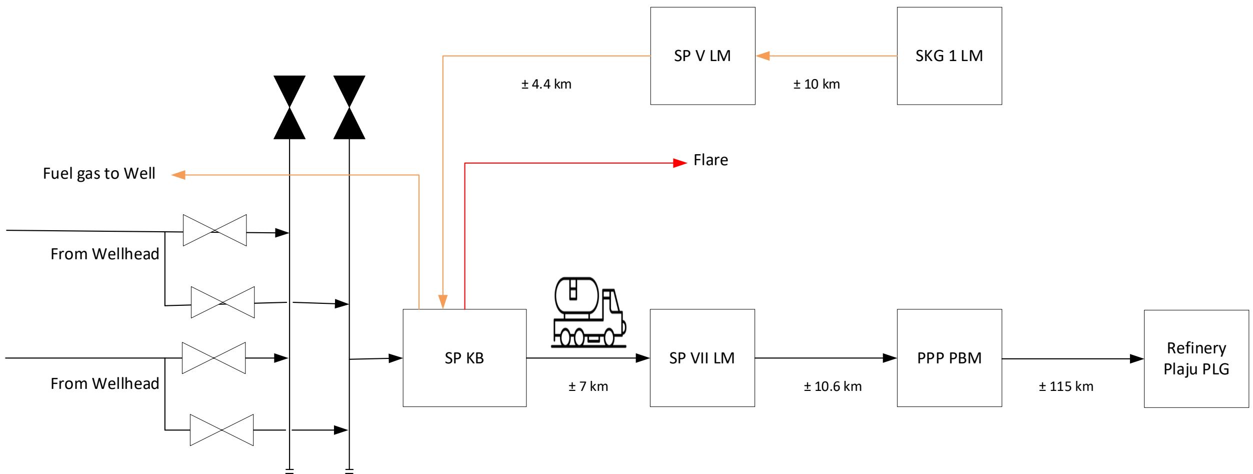


Figure 1. Flow Diagram Oil Transportation.

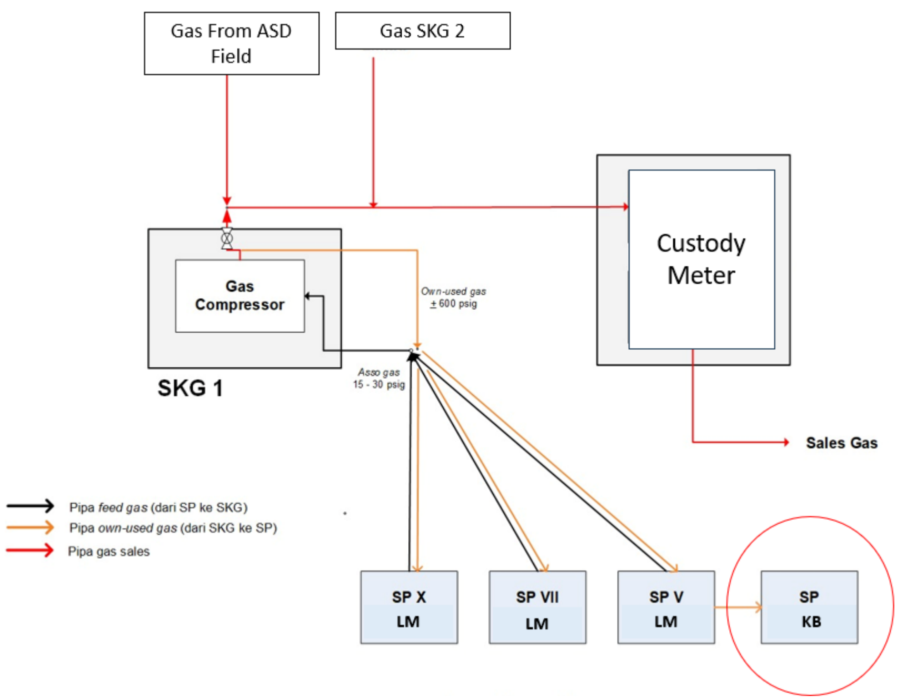
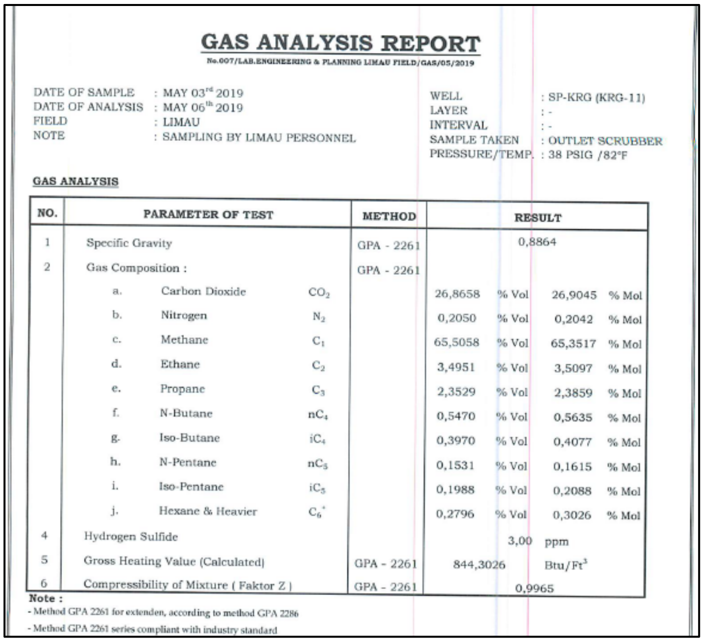


Figure 2. Flow Diagram Gas Transportation.

In the surface facility aspect, The KB field (August 2023 status) has a total of 4 active wells which produce by artificial lift and have 60% water cut. The current oil production rate is 180 BOPD and asso gas is 0.1 MMSCFD.

The next development of PT PHR Zone 4 will drill 18 infill wells and 1 step-out well, so that it will increase the production forecast up to 1700 BOPD oil, and 1.4 MMSCFD gas with 45% water cut, this development will be gradually implemented from 2024-2030.

With the development of the asso gas produced is quite large, this has the potential to be utilized as fuel for own use needs or sold through the gas sales line to get revenue, one of the problems that arises is that the pressure is quite low at SP KB (40 psig) so that it cannot enter the sales network and the CO2 content in the KB Field of 27% mol. KB Gas Analysis can be seen in Figure 3 as follows:



GAS ANALYSIS REPORT

No.007/LAB.ENGINEERING & PLANNING LIMAU FIELD/GAS/05/2019

DATE OF SAMPLE : MAY 03rd 2019
DATE OF ANALYSIS : MAY 06th 2019
FIELD : LIMAU
NOTE : SAMPLING BY LIMAU PERSONNEL

WELL : SP-KRG (KRG-11)
LAYER : -
INTERVAL : -
SAMPLE TAKEN : OUTLET SCRUBBER
PRESSURE/TEMP. : 38 PSIG /82°F

GAS ANALYSIS

NO.	PARAMETER OF TEST			METHOD	RESULT			
1	Specific Gravity			GPA - 2261	0,8864			
2	Gas Composition :			GPA - 2261				
	a.	Carbon Dioxide	CO_2		26,8658	% Vol	26,9045	% Mol
	b.	Nitrogen	N_2		0,2050	% Vol	0,2042	% Mol
	c.	Methane	C_1		65,5058	% Vol	65,3517	% Mol
	d.	Ethane	C_2		3,4951	% Vol	3,5097	% Mol
	e.	Propane	C_3		2,3529	% Vol	2,3859	% Mol
	f.	N-Butane	nC_4		0,5470	% Vol	0,5635	% Mol
	g.	Iso-Butane	iC_4		0,3970	% Vol	0,4077	% Mol
	h.	N-Pentane	nC_5		0,1531	% Vol	0,1615	% Mol
	i.	Iso-Pentane	iC_5		0,1988	% Vol	0,2088	% Mol
	j.	Hexane & Heavier	C_6^+		0,2796	% Vol	0,3026	% Mol
4	Hydrogen Sulfide				3,00 ppm			
5	Gross Heating Value (Calculated)			GPA - 2261	844,3026	Btu/Ft^3		
6	Compressibility of Mixture (Faktor Z)			GPA - 2261	0,9965			

Note :
- Method GPA 2261 for extenden, according to method GPA 2286
- Method GPA 2261 series compliant with industry standard

Figure 3. Gas Analysis Report.

KB Field Gas must meet the gas sale and purchase requirements (PJBG) that must be met. In Table 1, it is stated that the gas properties requirements must be met by PJBG to be used as gas sales.

Table 1 Gas Sales Requirements refer to PJBG

Parameter	Unit	Specification Refer to PJBG
Gas Heating Value, GHV	BTU/SCF	950 - 1200
Specific Gravity, SG	-	0,5 - 0,8
Temperature	°F	60 - 120
Water Content, max	lb/MMSCF	10
N_2, max	%-mole	3
CO_2, max	%-mole	8
C_3, max	%-mole	5
H_2S, max	ppm-v	8

The CO_2 content of the KB field can still be neutralized in the sales pipeline by mixing gas in SKG 1 LM which has a low CO_2 content, with that mixing method CO_2 content at the custody meter is not more than 8% mol so the CO_2 content not exceeds the gas sale and purchase requirements (PJBG) limit.

1.1 Objectives

This study aims to determine the right concept in the utilization of asso gas from oil wells that were originally only burned through flares so that it can be utilized as a revenue enhancer and can also be used for fuel gas needs for own used. In this study will be compared between the existing concept (asso gas remains burn at the flare) which may lead to additional carbon emissions or utilize asso gas with additional investment. The research conducted is based on scientific studies so the results obtained are expected to support operations management in the upstream oil and gas industry, especially for the KB field area at PT PHR Zone 4.

2. Literature Review

The utilization of asso gas from SP KB can be done by increasing the asso gas pressure from SP KB to the sales network, so a gas compressor and gas trunk line from SP KB to SP V LM (4.4 km) is needed so that the gas can then be sent through the existing trunk line from SP V LM to SKG 1 LM. For the selection of gas compressors and trunk line sizing refers to some literature as follows.

2.1 Gas compressor capacity selection analysis

Determination of gas compressor capacity refers to the production forecast issued by the Subsurface Department which is then selected by simulation.

2.2 Gas compressor type selection

The gas compressor type selection based on the gas compressor selection curve in GPSA reference, with the following pressure configuration:

Suction Pressure: 35 psig
Discharge Pressure: 122 psig
Flow: 0.75 MMSCFD

2.3 Trunk line Sizing

The calculation of pressure drop in the gas pipe due to friction is calculated by the following equation as follows:

$$\mathrm{P} = \frac{12.6\ \mathrm{Sg}\ \mathrm{Q}^2\ \mathrm{z}\ \mathrm{T}\ \mathrm{f_m}\ \mathrm{L}}{P\ \mathrm{D}^5}$$

where: ΔP = pressure drop, psi.
f_m = Moody friction factor, dimensionless.
Q = gas flow rate, MMSCFD.
P = fluid pressure at pipe inlet, psia.
T = fluid temperature at pipe inlet.
Z = gas compressibility factor, dimensionless.
Sg = specific gravity of gas, dimensionless.
D = pipe inner diameter, inch.

The selection of gas pipe size should follow the criteria shown in Table 2. For the selection of sizes that do not meet the criteria must be accompanied with certain justifications.

Table 2 Design criteria for gas pipeline

Type of Line	ρv² (lb/ft-s²)	v (ft/s)	ΔP (psi/100ft)
General Criteria :		60	
P ≤ 290 psig	4000		0,5
290 < P ≤ 725 psig	5000		
725 < P ≤ 1160 psig	6700		1,2
1160 < P ≤ 1740 psig	10000		
P > 1740 psig	13400		
Inlet kompresor	General Criteria	60	0,1 – 0,3
Outlet kompresor		60	0,2 – 0,5
Intermittent:		60	N/A
P ≤ 725 psig	6700		
725 < P ≤ 1160 psig	10000		
P > 1160 psig	13400		
Outlet Reboiler	General Criteria		0,18

There is an alternative way to use PIPESIM 2017 software, Steady State Multiphase Flow Simulator is used as a steady state hydraulic analysis to calculate back pressure on the flowline of production wells, trunk line, and fuel gas line. The flowline model used was the "single pipeline / single branch" module.
The following options were used in the simulation:

- Flow Correlation - Vertical Flow (Multiphase): Begs & Brill Revised.
- Flow Correlation - Horizontal Flow (Multiphase): Begs & Brill Revised.
- Flow Correlation - Single Phase: Moody.

3. Methods

The research methods and techniques selected in this study used a combination of qualitative and quantitative modeling methods that apply to surface engineering facilities.

The types of data used are qualitative data and quantitative data. Sources of data used are primary data and secondary data. Some internal and external data will be used as secondary data. Internal data refers to existing data from the company, which is intended to better understand the phenomena that occur in the company and support problem identification and possible solutions. The data are combined through analysis and internal assessments using mathematical models through simulations using software that applies to surface facilities engineering.

4. Data Collection

Sources of information and methods of obtaining data use field data collection methods in the form of laboratory data and internal company data. This data was combined with existing literature, both academic literature and literature from principals in Indonesia, and discussed through brainstorming with several experts at PT. PHR Zone 4.

5. Results and Discussion

Some of the literature on gas sweetening described above can be analyzed regarding the selection of the right technology for the gas utilization in KB Field. The following Figure 4 can be used as a screening tool to make an initial selection of the gas flare utilization equipment. Based on this first initial selection, subsequent screening to determine is the most economical for a given set of parameters. From subsurface studies, gas asso estimates are obtained as shown in Figure 4 as follows:

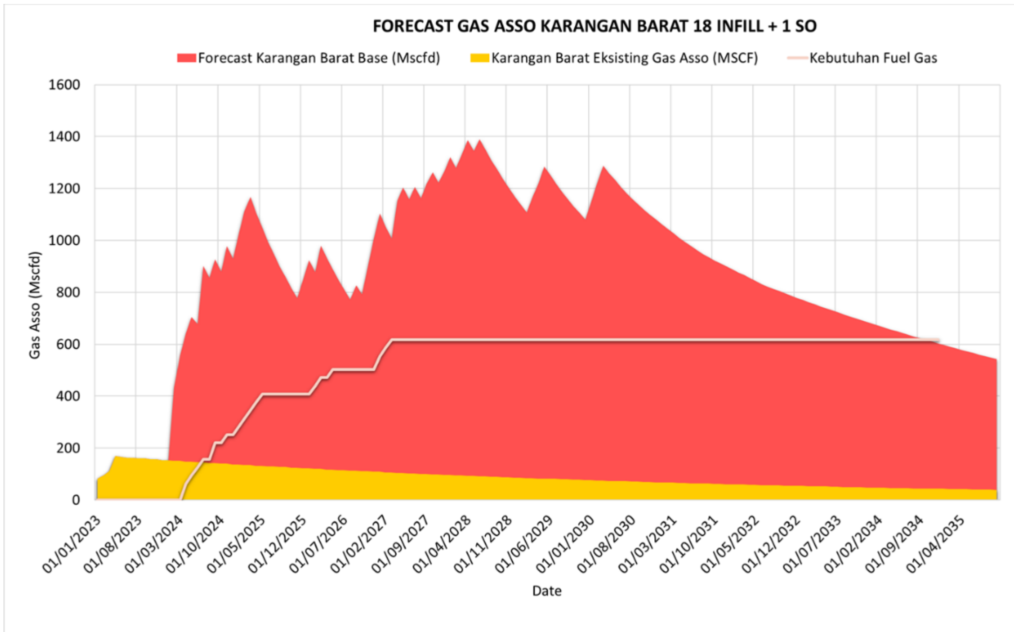


Figure 4. KB Field gas asso forecast

Analysis of gas compressor capacity selection can be seen in Figure 5, by comparing the gas compressor capacity with the annual forecast.

Year	Gas Production [MMSCFD]	Utilization/Train (%)		Remark
		Train 1	Train 2	
2028	1.31	93%	Standby	OK
2029	1.19	85%	Standby	OK
2030	1.18	84%	Standby	OK
2031	1.00	72%	Standby	OK
2032	0.85	61%	Standby	OK
2033	0.74	53%	Standby	OK
2034	0.65	47%	Standby	NOT OK
2035	0.58	41%	Standby	NOT OK

Year	Gas Production [MMSCFD]	Utilization/Train (%)			Remark
		Train 1	Train 2	Train 3	
2028	1.31	93%	93%	Standby	OK
2029	1.19	85%	85%	Standby	OK
2030	1.18	84%	84%	Standby	OK
2031	1.00	72%	72%	Standby	OK
2032	0.85	61%	61%	Standby	OK
2033	0.74	53%	53%	Standby	OK
2034	0.65	93%	Standby	Standby	OK
2035	0.58	82%	Standby	Standby	OK

Figure 5. Analysis of gas compressor capacity selection

Based on the analysis, the selection of 2 unit @1.4 MMSCFD gas compressor is not possible because at the 2034 and 2035 the gas compressor cannot be operated due to efficiency gas compressor under 50%. And once gas compressor cannot be operated there will be a loss of production. Therefore, a capacity of 3 x 0.7 MMSCFD was selected for the purchase of a new gas compressor.

Determination of the type of gas compressor to be used at SP KRG for asso gas in the West KRG field development was carried out using Figure 6. Gas compressor coverage chart is used by plotting the gas flow rate in acfm against discharge pressure in psig. The design gas flow rate used is 0.7 MMSCFD (133.9 acfm) with a discharge pressure of 150 psig.

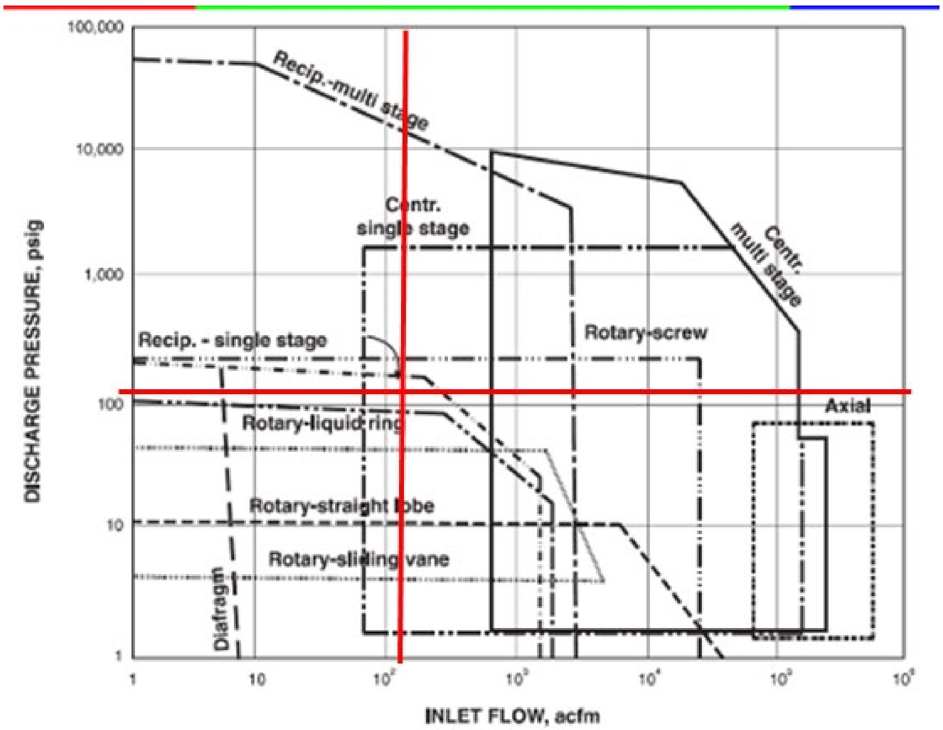


Figure 6. Compressor Type Selection Chart

From the analysis of the gas compressor type selection above, a rotary-screw type was chosen. Determination of sizing gas trunk line from SP KB to SP V LM using Pipesim 2017 software. From the simulation results with a case comparison of 3-inch and 4-inch pipe size, a comparison graph of pressure vs distance and fluid velocity vs distance is obtained which is shown as follows (Figure 7):

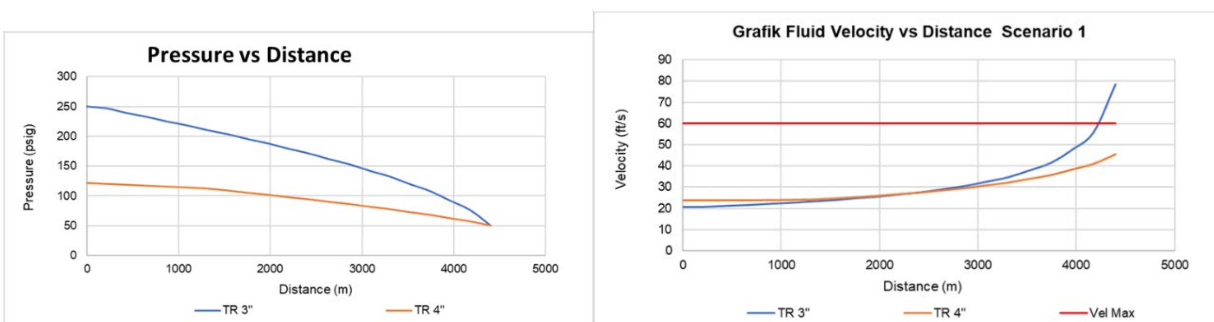


Figure 7. Gas Trunkline Size Selection

For the calculation of the gas trunk line, a 4-inch pipe specification is obtained. Due to the high CO2 content and exceeding the gas sales and purchase agreement (GSPA), the asso gas from the KB field must first be sent to SKG 1 LM to be blended with gas from SP V LM, SP VII LM, and SP X LM so that the CO2 content decreases because the gas from the field has a low CO2 content.

Generally, the economics of using gas flares at the KB field will be influenced by the amount of investment that will be spent on the construction of supporting production facilities, the expected development production facilities flow diagram oil and gas transportation can be seen in Figure 8:

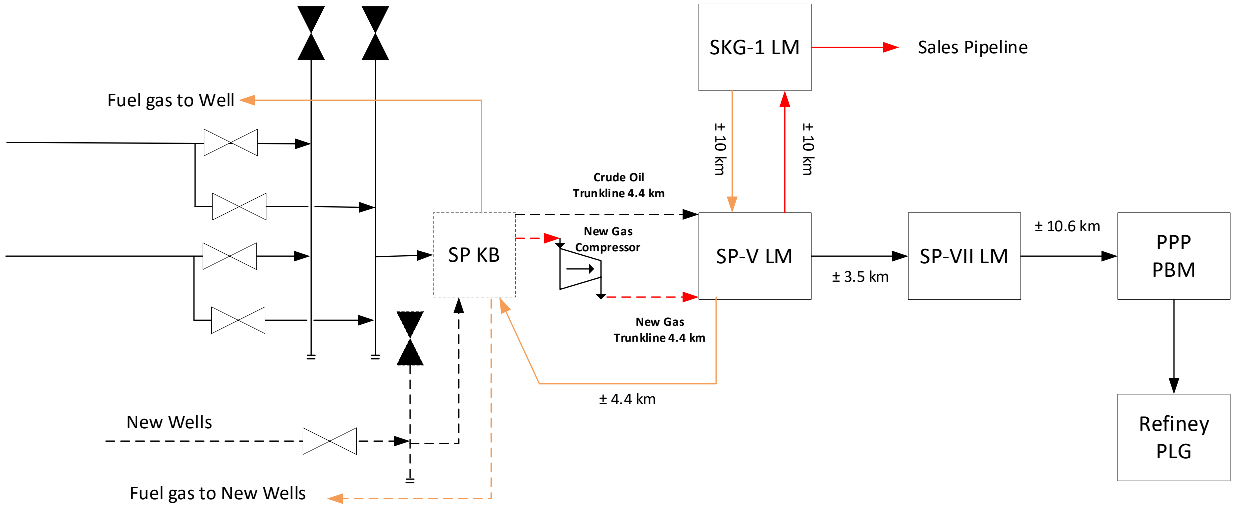


Figure 8. Future Development production facilities SP KB

Qualitative Comparison and Quantitative Comparison based on existing conditions (no facility investment costs) and construction of flare gas utilization facilities will be discussed in the following section Qualitative Comparison

- Qualitative Comparison

The following figure tabulate the qualitative comparison gas flare (existing condition) vs asso gas utilization

No	Aspect	Scale	Gas Flare	Scale	Gas Asso Utilization
1	Capital investment	5	No	3	Medium
2	Maintenance Cost	5	Low	3	Medium
3	Operating Cost	5	Low	3	Medium
4	Environment Impact	1	High	5	Low
5	Hydrcarbon Loses	1	High	5	Low
6	Capital Gain	0	N.A	5	High
7	Schedule/ Instalation Time	5	N.A	3	Medium
	Average Scale Value	3,7		4,5	

Figure 9. Tabulates the Qualitative comparation of gas asso flare vs gas asso utilization

From the aforementioned Figure 9, it was observed that gas asso utilization get the highest qualitative result than burning gas asso.

- Quantitative Comparison (Figure 10)

From the quantitative analysis above, it is obtained that the utilization of asso gas can generate a cumulative cash flow (profit) more than USD 6,290,000 with an Internal Rate of Return (IRR) of 40%.

No	Items		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
1	Investment [MUSD]								
		Gas Compressor	1,801						
		Gas Trunkline	0,643						
		Gas Compressor Accessories & Utility	0,609						
		Site Preparation	0,394						
		Others	1,477						
2	Energy Used								
		Gas Consumption [MMSCFD]	0,0057	0,0057	0,0057	0,0057	0,0057	0,0057	0,0057
		Gas Price [USD/MMBTU]	5,61	5,85	5,84	5,85	5,93	5,78	5,8
		Utility [MUSD]	0,01	0,01	0,01	0,01	0,01	0,01	0,01
3	Maintenance [MUSD]								
		PM	0,18		0,18		0,18		0,18
4	Total Cost [MUSD]		5,12	0,01	0,19	0,01	0,19	0,01	0,19
5	Potential Gas								
		Potential Gas Sales [Average Yearly MMSCFD]	0,76	0,91	0,83	0,82	0,70	0,59	0,52
		Potential LPG sales [Average Yearly MMSCFD]	0,01	0,02	0,02	0,02	0,01	0,00	0,00
		Gas Price [USD/MMBTU]	5,61	5,85	5,84	5,85	5,93	5,78	5,8
		LPG Price [USD/ton]	619	625	626	631	637	640	643
6	Potential Revenue [MUSD]		1,75	2,23	1,99	1,98	1,66	1,32	1,11
		Gas	1,56	1,95	1,76	1,75	1,52	1,25	1,10
		LPG	0,19	0,28	0,22	0,22	0,14	0,07	0,01
7	Cash Flow [MUSD]		- 3,37	2,22	1,79	1,96	1,46	1,31	0,92
8	Cummulative Cash Flow [MUSD]		- 3,37	- 1,15	0,64	2,60	4,07	5,37	6,29

Figure 10. Quantitative Comparison gas asso flare vs gas asso utilization

6. Conclusion

Based on operational problems related to gas flares at SP KB which have not previously been utilized properly, through the analysis of this paper it can be recommended that this gas can be used to increase capital gains by adding production facilities as follows:

- Using asso gas in the KB field can reduce carbon emissions and also increase capital gains in the KB field.
- To utilize asso gas at SP KB, it is necessary to install a gas compressor with a capacity of 3 x 0.7 MMSCFD rotary-screw type and build a 4-inch long gas pipeline for 4.4 km from SP KB to SP V LM.
- Utilization of asso gas provides higher quantitative results (costs) and capital gains compared to burning Asso gas.
- Utilization of asso gas provides the highest qualitative results compared to asso flaring gas from an economic aspect.

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