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Analysis of Development Planning of *Own Use Gas* Pipeline from Gas Compressor Stations to Gathering Stations in X Field

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Abstract

Trunkline gas network system from Gas Compressor Station (GCS) B to GS.B-GS.B5 has a total distance of ± 18 km. The distance of GS.B4-GS.B5 is 9400 m. Gas is the main fuel for engines at gathering stations. A deadlock was found on the GS.B4-GS.B5 pipeline. The solution to this problem is to plan a pipeline between GS.B4-GS.B5 for optimal gas supply. This study conducted an economic analysis of the planning of pipe construction with the same trunkline diameter. The diameter was selected by looking at the effect of pressure drop and erosional velocity using the Pipesim. Then, a problem-solving approach was taken by building a system using a pig launcher. Based on the research results, in the existing conditions with a distance of 9400 m using a diameter of 6 and 4 inches, there is a high pressure drop. Scenario planning minimizes pressure drop by using equal diameter pipes of 4, 6 and 8 inches. The analysis results show that the selected diameter is 6 inches. Pig launcher is designed with safe specs and design. Calculation of the project's economic indicators with an investment of 505,911 US$M and an oil price of 62.38 US$/bbl. Calculation results obtained Net Present Value (NPV) @12% = 6,022 US$M, Internal Rate of Return (IRR) = 495%, Pay Out Time (POT) = 0.19 years, Profitability Index (PI) = 12.90. Sensitivity analysis by changing assumptions 85%, 115% of the basic assumptions, showed the lowest NPV = 4,725 US$M and the lowest IRR = 393%. Based on the results, this project is profitable and feasible to be developed from an economic perspective.

Keywords

Trunkline; Pressure drop; Pig launcher; Net Present Value (NPV); Internal Rate of Return (IRR)

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1 Introduction

Field X is one of the oil and gas fields in PT Perta X, located in South Sumatra Province, Indonesia. Oil and gas produced from the field will flow to the gathering station to separate water, oil, and gas. Next, oil produced from various collection stations will be collected at the Main Gathering Station (MGS) which will then be transported to the production gathering centre. The produced water will be treated and then the water will be used as injection water. While the gas is sent to the Gas Compressor Station (GCS) to increase the pressure and transport it to the gathering station and the production well as a source of fuel used to drive the engine. Gas in this field is used for personal needs in the field (own use), not for sale. The working principle of the compressor is to increase the pressure of the gas or air by lowering the volume[1]. The gas trunkline network system is supplied from Gas Compressor Station (GSC) and sent through the gas discharge trunkline to GS.B4 and then GS.B5 which has a range of up to ± 18 km. The main problem occurred in the pipeline from GS.B4 to GS.B5 with a distance of 9,400 m. However, in the operation of flowing gas through the trunkline, many possibilities can inhibit the flow rate of the fluid which will affect the pressure drop. Although pipelines are the safest and most efficient transportation, they are not immune to failure, and therefore routine inspection and maintenance are required[2].

The problems in the field are deadlocks at several points in the pipeline which indicate the formation of solid, slugging and liquid at the GS.B4 to GS.B5 facilities. Further knowledge of the problem of the deadlock pipeline and the development of the surface pipeline network is planned. Pipe maintenance in the oil and gas industry is usually carried out by the pigging method, a cylindrical and round tool that runs inside a pipe driven by production fluids[3]. The need for future pipeline maintenance and development planning starts with pipeline analysis which then builds a pig launcher system to clean the internal pipe from accumulated deposits and liquids. The design must be safe and appropriate to international standards, according to American Society of Mechanical Engineers (ASME) code B31.8 "gas transmission and distribution piping system"[4]. To design the right pigging tool, it is crucial to detect where the blockage is occurring and the size of the pipe[5]. After an analysis of the pipeline is carried out, the next step is to calculate the economic value of the pipeline construction plan from SP.B4 to SP.B5 with the aim of whether the pipeline development project is feasible and developed for future production.

2 Methodology

This study used three methods in alternative problem-solving in the supply gas pipeline GS.B4-GS.B5 in X field, namely:

a. Parameters used in selecting pipe sizes are pressure drop, erosional velocity and trunkline diameter sensitivity to the total distance. This study used the Pipesim 2014 simulator to build a single branch-model.
b. In order to prevent the recurrence of the stuck pipe problem, the author's idea to design a pig launcher was carried out by data collection and manual calculations. The parameters used were the design thickness and the corrosion allowance against the wall thickness (Tables 1 and 2).
c. To complete the planning for the construction of this pipeline, an economic feasibility study was carried out on this project using the Production Sharing Contract (PSC). The economic parameters used are Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI) and Pay Out Time (POT).

This research was conducted at PT Perta X in X Field, South Sumatra Province, Indonesia. Data obtained from the company data was related to the study conducted. This research is based on several references such as theories and journals related to research.

3 Results and Discussions

3.1 Pipeline Analysis Using Pipesim Simulator

The first step of the pipeline network design using the Pipesim simulator was preparing data to be simulated. Gas composition data, pipe, and network data are data that will be inputted in the network model. Modeling in Pipesim consists of fluid selection, making a single branch model, and running the process to obtain the simulation results.

Table 1. Pipeline geometry data (Source: Company field data).

Source	Horizontal distance		
	6 inches	4 inches	6 inches
GSC B	500 m	5,700 m	3,200 m

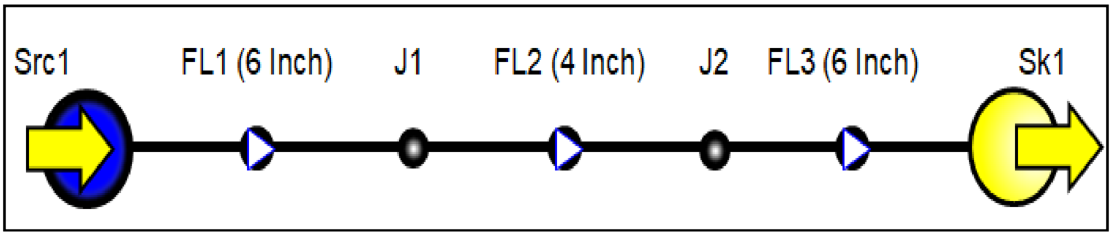
Elevation (m)	Roughness (Inch)	Wall Thickness (Inch)	Ambient Temperature (F°)
0	0.0015	0.5	80

Table 2. Pipesim data input (Source: Company field data).

Operation pressure (Input)	340	Psi
Output pressure	240	Psi
Gas supply	2	MMSCFD
Temperature	89	F°

3.2 Initial Design at Existing Condition

Initial planning in the existing condition has a distance of 9,400 m from GS.B4 to GS.B5. The initial pipeline system uses a variety of pipe diameters ranging from 6 inches and 4-inch schedule 40 as illustrated in Figure 1. The design of the pipeline model uses the Pipesim 2014 simulator which aims to see the amount of pressure loss over the total distance of the pipe.



Note: Src = Source; FL = Flowline; J = Junction; Sk = Sinks

Figure 1. Existing condition at pipeline system model GS.B4-GS.B5.

Input data on this pipeline model was based on actual X field data starting from pipe geometry, gas supply, pressure, and temperature data. The simulation was done by inputting the source with a pressure of 340 psi, the gas supplied is 2 MMSCFD (Million Standard Cubic Feet per Day) with a temperature of 89°F.

Based on the base case model of the supply gas pipeline that has been inputted from the source to the trunkline profile of each series with a total distance of 9400 m, the process of running with the Pipesim simulator was carried out by looking at the effect of a pressure drop that occurs on the difference in the diameter of the pipe in the gas supply pipe network GS.B4-SP.B5, the results of running are presented in Figure 2.

The difference in the diameter of the trunk line in this system has an impact on reducing the pressure and internal problems of the pipeline which can cause losses to the company if this continues. Analysis of this problem needs to be optimized for each pipe diameter that meets the criteria for flowing gas from GS.B4 to GS.B5 so that it can get the optimum gas supply.

3.3 Pipeline Analysis

After observing the problem of pressure drop that occurs in the total distance in the base case above, the authors conducted a sensitivity test of the diameter of the pipe from GS.B4 to GS.B5 using the same size pipe diameter that meets the gas flow rate criteria of 4 MMSCFD with a total distance of 9,400 m.

In the sensitivity test of the diameter of the trunkline, 4,6,8-inch of the pipe diameter (Figure 3) is three comparisons and one that meets the criteria in the pipeline design GS.B4-GS.B5 was chosen. Data input was performed using field data in selecting trunkline diameters capable of meeting the gas flow rate criteria of 4 MMSCFD with a total distance of 9,400 m. The following Figure 4 shows the result of running the Pipesim simulator to monitor the pressure drop over the total distance with the trunkline diameter sensitivity test.

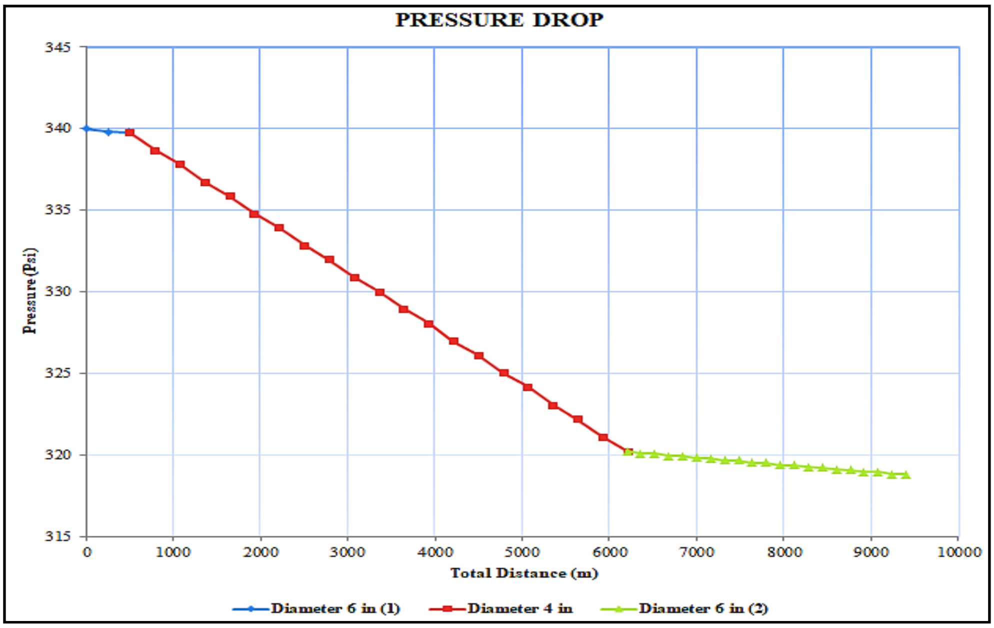
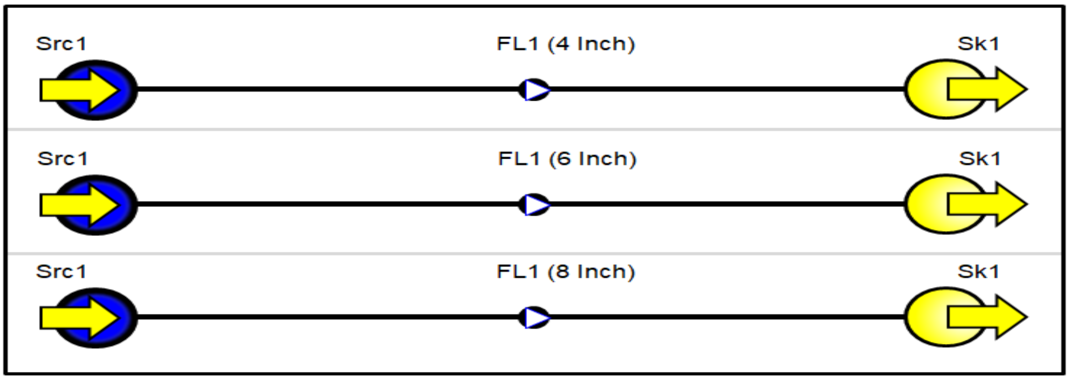


Figure 2. Graph of pressure drop calculation as existing condition.



Note: Src = Source; FL = Flowline; Sk = Sinks

Figure 3. Planning for the same diameter design.

In Figure 4, the 4-inch diameter has decreased in pressure from 340 to 192 psi. The pressure drop in a 4-inch diameter reaches more than 40 psi, so the diameter size does not qualify as the criteria for choosing the diameter size of the pipeline design. Inversely proportional to 6- and 8-inch diameters, the pressure drop that occurs is not too significant, whereby sizes 6 and 8 inches have a pressure loss of no more than 15 psi, so these results indicate that the pipe diameters of 6 and 8 inches meet the criteria in the selection of network diameters pipe GS.B4-GS.B5. A study that analyses pressure drop using "Software Pipe Flow Expert" states that the friction factor in the pipe greatly affects the pressure drop. It can be concluded that the greater the friction factor that occurs, the higher the pressure drop of a pipeline network[6].

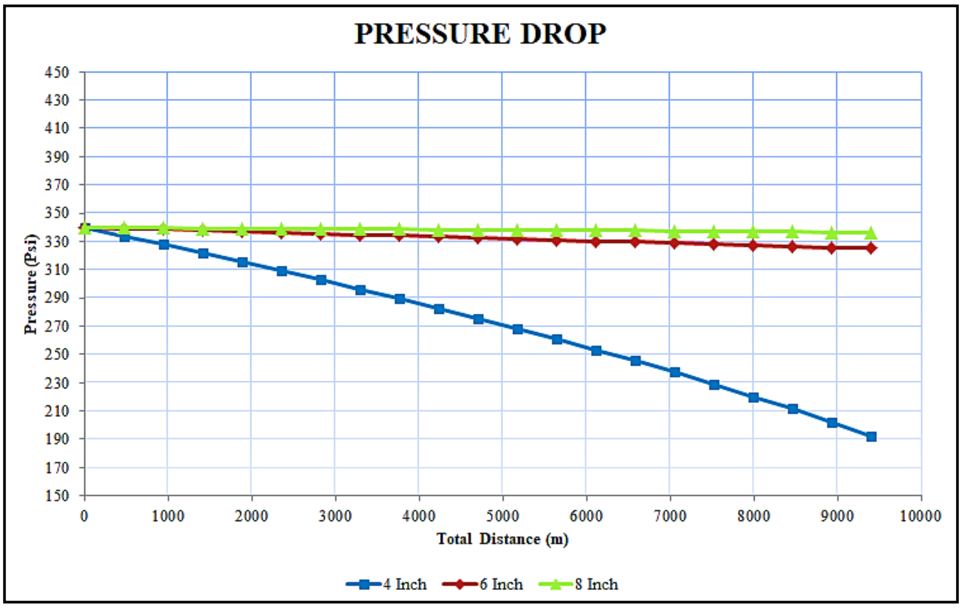


Figure 4. Test results for the sensitivity of trunkline diameter to pressure drop (Sources: Pipesim).

Other parameters in determining the diameter of a pipe that meets the criteria are also seen from the erosional velocity value of the total distance. The result of running for erosion velocity can be seen in Figure 5.

The graph above shows the level of erosion that occurs in each trunkline diameter size tested. For a 4-inch diameter, the erosion rate is high. Inversely proportional to the diameter of 6 and 8 inches, the level of erosion that occurred did not experience a significant increase. The higher the flow rate and the particles contained in the fluid, the higher the erosion rate that occurs due to the erosion of the pipe[7].

The design of the piping system for processing facility needs to consider the effects of pressure loss due to friction and erosion which are influenced by the fluid velocity and the specific gravity of the fluid[8].

Trunkline 6- and 8-inch diameters meet the criteria in selecting the pipe size. In accordance with the initial purpose of designing a pipeline with the same size, one of the two sizes was chosen to enter the criteria. Although the 8-inch size is better than the 6-inch size, with economic considerations, the 6-inch size is more suitable for GS.B4-GS.B5 pipelines. This is because the GS.B4-GS.B5 pipeline network is connected to Gas Compressor Station (GCS) B, whereby the pipe diameter size available from GCS B to GS.B4 is 6 inches so that the pipe size from GCS B to GS.B5 has the same diameter. Another reason related to the choice of a 6-inch diameter is economic considerations. The bigger diameter of the pipe, the cost of purchasing the pipe will also be more expensive. The selection of 6-inch diameter pipes has met the criteria in the technical and economic aspects.

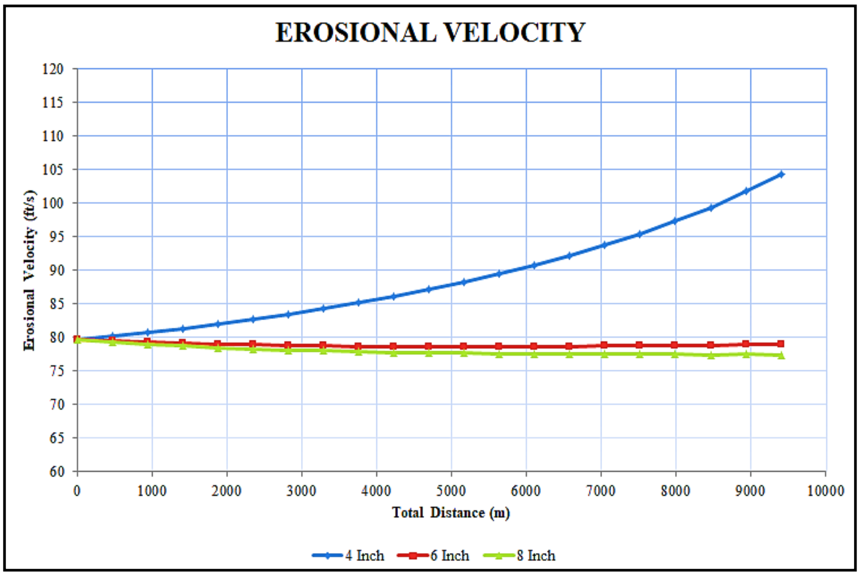


Figure 5. Test results for sensitivity of trunkline diameter to erosional velocity (Sources: Pipesim).

3.4 Pig Launcher Design

After the results of the analysis have been obtained, it is necessary to plan for overcoming problems that occur in gas supply activities by looking at the presence of precipitation, corrosion, water content, and pressure drop in the pipeline GS.B4-GS.B5. Hence, there need to be alternatives for solving problems. One alternative to this problem is to build a system using a pig launcher. Following a statement[9] that pipelines with a diameter less than or equal to 10 inches, the magnification size is 2 inches. The pipeline in this project is 6 inches, so the magnification size is 8 inches. The data used in the design of the pig launcher are as in Table 3.

The assumption data obtained from ASME table B31.8 (Gas Transmission and Distribution Piping Systems) are included in Table 4.

Table 3. Pipeline profile data pig launcher design.

Pressure / temperature (design)	1774.65 Psi	89.6°F
Pressure / temperature (operation)	240 Psi	86.0°F
Material specification	API 5L Gr B	
Operating pipe dimension	6 Inch	Sch 80
Enlargement pipe dimension	8 Inch	Sch 80
Fluid type	Natural gas	
Corrosion allowance	0.9 mm	
Kicker line	6 Inch	Sch 80
Nozzle	2 Inch	Sch 80

Table 4. ASME B31.8 data table.

Location class	2
Design factor (F)	0.60
Longitudinal joint factor (E)	1
Temperature derating factor (T)	1
Specified minimum yield strength (S)	35,000

The design of the pig launcher design which uses manual calculations to determine the thickness of the shell or barrel, followed Mandraguna and Afiff's[4] design of the pig launcher for the gas pipeline in accordance to ASME B31.8 standard with the manual calculation method. The calculations for the pig launcher design are given in Equations 1 and 2 for the major and minor barrel thickness, and Equations 3 and 4 for the nozzle thickness design.

a. Major and minor barrel thickness design

$$t = \frac{P \bullet D}{2S \times F \bullet E \bullet T} \quad (1)$$

$$t\text{ min} = t + \text{Corrosion Allowance} \quad (2)$$

where t = Thickness
P = Pressure design
D = Outside diameter
S = Material allowable stress
F = Design factor
E = Longitudinal joint factor
T = Temperature derating factor

b. Nozzle thickness design

$$\text{trn} = \frac{P \bullet Rn}{S \bullet E - 0.6P} \quad (3)$$

$$t\text{ min} = \text{trn} + \text{Corrosion Allowance} \quad (4)$$

where *t* min = Minimum thickness
trn = Nozzle thickness
Rn = Radius in the nozzle

The results of the calculation of the pig launcher design with a corrosion allowance value of 0.0354 inches are given in Table 5.

Table 5. Calculation result of pig launcher design.

Parameter (+Corrosion allowance)	Design thickness	Wall thickness (Table pipe)	Result
Major barrel 8" Sch 80	0.400	0.500	Safe
Minor barrel 6" Sch 80	0.315	0.432	Safe
Kicker line 6" Sch 80	0.186	0.432	Safe
Nozzle 2" Sch 80	0.086	0.218	Safe

Note: Sch = Schedule Pipe

The safety level of a pipe thickness is whether the thickness design is less than the wall thickness in the table. The minimum thickness of the major barrel and minor barrel at the design pressure obtained is smaller than the wall thickness which is 0.400 (major) and 0.315 (minor). With NPS 8" Sch 80 (major) and NPS 6" Sch 80 (minor), it is safe to be used because the thickness design is below the wall thickness value. Likewise, the thickness of the kicker line design with NPS 6" Sch 80 and nozzle 2" also meet the criteria with values below the wall thickness value of 0.186 (kicker line 6") and 0.086 (nozzle 2").

3.5 Economic Analysis

Measuring the feasibility of a project is not only based on the technical aspects but also the economic aspects.

To reduce the high risk of failure, a cooperation contract between the government and the contractor is needed. The type of contract used in this project is the Production Sharing Contract (PSC) which implements a service contract whereby installation, materials, equipment, and services are all from the contractor. All the costs in this project are included in the capital category and all the costs will be recovered by the government. The investment budget for the pipe replacement project is shown in Table 6.

Table 6. Details of project costs for substitution of pipes.

Pipeline project		
Survey	US$	-
Detail engineering	US$	1,101
Materials	US$	420,379
Fabrication	US$	-
Transportation	US$	-
Installation, hook up and pre-commission	US$	84,430
Sub Total	US$	505,911

The designed trunkline is for gas discharge transportation to the gathering station. The transported gas is not for sale but is needed at the gathering station so that the lifting obtained for economic calculations from oil production from wells is affected by GS.B4 and GS.B5. The first year of production is known to be 1,004.6 barrels of oil per day (BOPD) which was converted into 1 year to 367 MBBLS (Thousand Barrels). For the following year, oil production is carried out using the decline curve analysis forecasting method.

The oil price used in this project uses the average ICP (Indonesian Crude Price) oil price from January to December 2019 obtained from the Ministry of Energy and Mineral Resources data. The average oil price in 2019 is US$ 62.38 / billion barrels (bbl). The fiscal terms of this project are shown in Table 7.

Table 7. Fiscal terms for the pipe replacement project.

Fiscal Term : PSC	
Split after tax (G:C)	85 : 15 %
Split before tax (G:C)	75 : 25 %
OPEX (Operational expenditure), US$/bbl	18.00
FTP (First tranche petroleum)	5%
Discount rate	12%
Tax	40.5%
Decline factor	23%
Oil price (ICP) US$ / bbl	62.38

According to Satriani, Saifudin and Sunarya[10], there are several methods in calculating depreciation, namely straight-line method and decline balance method. The use of different depreciation methods will cause different depreciation costs. This project used the double decline balance and decline balance method. Calculations, domestic market obligation (DMO) and DMO fees were not counted in this project because this analysis only projected counts and not cumulative production. Therefore, after the contractor gets a share, it is immediately taxed to the government. The following Table 8 shows the results of the economic calculations in this project within 5 years.

3.6 Economic Indicator

Profit-sharing according to the PSC is 85%:15% (after-tax). The tax applied to this project is 40.5%, so the split is divided into 75%:25% (before tax), based on the results of economic calculations using PSC contracts, NPV @ 12% = 6,022 US$M; IRR = 495%; POT = 0.19 year; PI = 12.90. The results of the calculation of economic indicators in the pipeline replacement project show a positive NPV value, IRR > MARR (Minimum Attractive Rate of Return), POT < Project age, PI > 1. These results indicate this project is economically valuable and feasible to be developed because all indicators meet the eligibility requirements.

Table 8. Results of calculations on the economy of pipeline projects.

Calculation		Year 1	2	3	4	5	Total
Lifting							
Oil/condensate [MBBLS]		367	291	231	184	146	1,220
Gas [MMCF]		–	–	–	–	–	
Gross revenue [US$M]		2,873	18,173	14,439	11,472	9,115	76,072
First tranche petroleum 5% [US$M]		1,144	909	722	574	456	3,804
Gross revenue after FTP [US$M]		21,729	17,264	13,717	10,899	8,659	72,268
Current year operating costs [US$M]		6,803	5,366	4,239	3,364	2,770	22,541
Depreciation		202	121	73	53	140	589
OPEX		6,600	5,244	4,167	3,311	2,630	21,952
Intangible		–	–	–	–	–	–
Total cost recovery [US$M]		6,803	5,366	4,239	3,364	2,770	22,541
Total recoverable [US$M]		6,803	5,366	4,239	3,364	2,772	22,541
Equity to be split [US$M]		14,926	11,899	9,478	7,535	5,889	49,727
Contractor share	0.25						
Contractor FTP share [US$M]		286	227	180	143	114	951
Contractor Emission Trade System (ETS) share [US$M]		3,732	2,975	2,369	1,884	1,472	12,432
Taxable share [US$M]		4,017	3,202	2,550	2,027	1,586	13,383
Government tax entitlement [US$M]	0.40	1,607	1,281	1,020	811	635	5,353
Net contractor share [US$M]		2,410	1,921	1,530	1,216	952	8,030
Government share	0.75						
Government FTP share [US$M]		858	681	541	430	342	2,853
Government ETS share [US$M]		11,195	8,924	7,108	5,651	4,417	37,296
Government tax entitlement [US$M]	0.40	1,607	1,281	1,020	811	635	5,353
Total government share [US$M]		13,659	10,886	8,670	6,892	5,393	45,501

4 Conclusions

The results of the diameter sensitivity test analysis on the 6- and 8-inch trunkline meet the criteria in pressure drop and erosional velocity except for the 4-inch size which experienced a large pressure loss and a high erosional velocity value, so the 4-inch diameter did not qualify. With economic considerations, the trunkline chosen for GS.B4-GS.B5 is 6-inch diameter. This is because Gas Compressor Station (GCS) B has a 6 inch diameter trunkline to GS.B4. Hence, the pipe sizes from Gas Compressor Station (GCS) B to GS.B4 and GS.B5 have the same diameter, which is 6 inches.

The design of the pig launcher selected safe material used is API 5-L Grade B. The calculation results show the minimum thickness value of major barrels (0.4 inch), minor barrels (0.315 inch), kicker line (0.186 inch), and nozzle (0.086 inch). All components are safe to use because the obtained design thickness value is smaller than the wall thickness.

The results of the economic calculation in the planning of the construction of the pipeline GS.B4-GS.B5 using a PSC contract with an investment cost of 505.91 US$M obtained the results of the NPV @ 12% profit indicator = 6,022 US$M, IRR = 495%, PI = 12.90 and POT = 0.19 year. Based on these results, the GS.B4-GS.B5 gas pipeline replacement project is very feasible because all economic indicators meet the eligibility requirements. Sensitivity analysis shows that the price of oil and the amount of production have the most influence on the value of NPV and IRR.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Methodology: Ariyon, M. & Ramadhan, M.S.
Formal analysis: Ariyon, M. & Ramadhan, M.S.
Visualisation: Ariyon, M. & Ramadhan, M.S.
Software: Ariyon, M. & Ramadhan, M.S.
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Writing (review and editing): Ariyon, M.
Validation: Ariyon, M. & Ramadhan, M.S.
Supervision: Ariyon, M.
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