Feasibility Study of City Gas Distribution Network in Kelapa Gading, North Jakarta

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Abstract. Kelapa Gading is one of the densely populated areas in DKI Jakarta with population density of 16,122 people/km² that tends to increase every year. With increasing of population, the energy needs are likely to increase to meet household and commercial needs, such as restaurants. One of the alternative energies that can be used for daily needs is besides LPG is natural gas. Compared to LPG, natural gas is more affordable, has abundant availability, and is environmentally friendly. The gas needed for the area is 4,326,856 m³/year with a route of 41,122.25 m using a combination of MDPE SDR 11 pipe and API 5L Grade B pipe. The capital expenditure is calculated to be IDR 70,511,737,825 with operational costs of IDR 4,141,071,275/year and project lifetime of 20 years. Based on the economic analysis, this project is feasible with households’ gas selling price of IDR 7,200/m³ and commercials’ gas selling price of IDR 8,400/m³, where the calculated NPV is IDR 5,303,138,979 with 12,29% of IRR and payback period time of 7 years.

Keywords: Gas Distribution Network, City Gas, Kelapa Gading, Natural Gas, Energy

1. Introduction

Indonesia’s gas production and consumption showing an increase every year along with increase in population. According to the Ministry of Energy and Mineral Resources of Indonesia, the largest national energy needs used for household purposes, reaching 382.94 million BOE [1]. Generally, the energy used for households’ daily needs is LPG for heating media. In the other hand, this uses tend to be inefficient due to high prices and is not always available. Therefore, national energy needs must be fulfilled in a way that ensures energy security and sovereignty. One of the strategies to fulfil the needs is increasing natural gas uses to contribute 23% of Indonesia’s total energy supply in 2025. Natural gas plays a major role in global energy supply as a source of clean energy with low carbon intensity. Compared to LPG, natural gas has lower costs, abundant in availability, and environmentally friendly.

The development of city gas distribution network in densely populated areas are needed to increase interest and accessibility to the use of natural gas, which one of the dense area is located in Kelapa Gading, North Jakarta. Kelapa Gading has a population of 140,735 people with 3.71% of population growth rate [2]. As the population in Kelapa Gading tends to increase every year, consumption and energy requirements will also increase, especially in the household and commercial sectors. Thus, it’s needed to have natural gas infrastructure to increase natural gas accessibility and consumption.

2. Method

The research starts with problem identifications and defining problem boundaries, then continued with collecting and analysing demand data and existing distribution pipe network. City gas network route should reach all customers, have least hazard and obstacles in the area, ease to construct and to
permit, and economically feasible with tapping point location is determined by ease of tapping and have a short distance from supply to the customers. The determined supply, demand, and pipe route become the basis for hydraulic simulation using PipelineStudio to get pipeline components specification, referring to design standard ASME B31.8. Simulation is done using trial and error method until optimal operating condition is obtained, where the gas velocity shouldn’t less than 10 – 15 ft/s to prevent liquid formation in pipe and shouldn’t exceed 40 – 60 ft/s to prevent pipe erosion [3]. The obtained pipeline components specification is proceeded into isometric design drawings and material take off which become the basis to estimate project’s investment cost. Economic analysis is done by evaluating net present value (NPV), internal rate of return (IRR), and payback period (PBP) as parameter of feasibility. Project will be feasible to develop if its NPV is positive, IRR greater than MARR, and PBP below 10 years. After that, risk analysis is done using risk matrix referring to AS IEC 61882 to find the risk score so that mitigation could be done to reduce risks that will occur.

3. Results and Discussions

Total city gas demand for the system is based on calculation of customers’ gas requirement in a peak hour condition to meet pipeline’s safety aspects where the pipe would be able to be used during these conditions. This calculation refers to Minister of Energy and Mineral Resources Regulation 6/2016. The gas requirement for households is set at 0.2 m³/h and for commercials is set at 1.5 m³/h. total gas demand is shown in table 1.

| Customer  | Units | City Gas Demand |
|-----------|-------|-----------------|
|           |       | m³/h            |
|           |       | m³/day          |
|           |       | m³/year         |
| Households| 6,119 | 1,223.8         |
|           |       | 9,790.4         |
|           |       | 3,573,496       |
| Commercials | 172   | 258             |
|           |       | 2,064           |
|           |       | 753,360         |
| Total     | 6,291 | 1,481.8         |
|           |       | 11,854.4        |
|           |       | 4,326,856       |

Tapping point is set to be near Taman Jogging 2 Kelapa Gading on Jl. Boulevard Timur with upstream gas pressure is 16 bar that will be reduced to 4 bar using MR/S P2 150# G.250 4/4-27/5-4/1-2005/805-G250. The route will be developed using a combination of SCH 40 API 5L grade B steel pipe and MDPE 80 SDR 11 pipe. Carbon steel pipes are used to deliver gas from tapping point to MR/S with high pressure range and polyethylene pipes are used to deliver gas from R/S to customers in much lower gas pressure range. There will be 2 clusters in the system, namely cluster A and B. In each of the clusters, there will be one R/S P3 #150 G.160 2/2-4/2-1/0.3-515/267-G160 to reduce gas pressure from 4 bar to 0.4 bar. The system will be running using a tree network system. The optimum operating system conditions are obtained by simulation and shown in table 2 and pipe material size and requirement are shown in table 3.

| Operating System Conditions | Value |
|-----------------------------|-------|
| Velocity at farthest backbone pipe (ft/s) | 25.48 |
| Pressure at farthest point (barg) | 0.69 |
| Supply flow rate (m³/h) | 1,488 |

| Pipe Material | Pipe Size | Pipe Required (m) |
|---------------|-----------|-------------------|
| API 5L Grade B | 2 inch | 12 |
|               | 4 inch | 124.34 |
|               | 6 inch | 34.36 |
| MDPE 80 SDR 11 | 63 mm | 36177.3 |
|               | 90 mm | 3508.6 |
After the route and technical specification are obtained through simulation results, isometric design drawings are done using AutoCAD. There are 3 types of isometric designs made, namely the design of a city gas distribution network from tapping points to distribution pipes in each cluster, a typical piping system from distribution pipes to each household customer, and a typical piping system from distribution pipes to each small customer. The materials needed for typical piping requirement are shown in table 4.

Through isometric drawings, material take-off (MTO) is obtained and uses as the basis for estimating investment costs. Its then processed into bill of materials (BOM). Project investment costs are divided into capital expenditure (CAPEX) and operational expenditure (OPEX). Estimated total capital expenditure is obtained by adding the cost of work with 10% of VAT and insurance by 2.5%, so that the total project’s capital expenditure is IDR 70,511,737,825. Based on the calculation results, required capital cost required for one household customer is IDR 7,478,304 and IDR 28,377,802 for one commercial customer. Total capital expenditure is shown in table 5.
Table 4. Typical piping requirements from main pipe to customers (a) For households (b) For commercials

| Materials                        | Units | Amount |
|----------------------------------|-------|--------|
| PE 80 pipe SDR 11 Ø 20mm         | m     | 7      |
| Galvanic pipe Ø ¾” m             |       | 1,25   |
| Tapping saddle Ø 63x20mm         | EA    | 1      |
| Coupler Ø 20mm                   | EA    | 1      |
| Female Transition Coupler Ø 32mm | EA    | 1      |
| Pipe clamp                       | EA    | 1      |
| Ball valve Ø ¾”                   | EA    | 1      |
| Botchen 90 Ø ¾”                   | EA    | 1      |
| Double nipple Ø ¾”                | EA    | 1      |
| Seal tape                        | EA    | 1      |
| Gas meter G1.6                   | EA    | 1      |
| Regulator service                | EA    | 1      |

(b)

| Materials                        | Units | Amount |
|----------------------------------|-------|--------|
| PE 80 pipe SDR 11 Ø 32mm         | m     | 7      |
| Galvanic pipe Ø 1” m             |       | 1,25   |
| Tapping saddle Ø 125x32mm        | EA    | 1      |
| Coupler Ø 32mm                   | EA    | 1      |
| Female Transition Coupler Ø 32mm | EA    | 1      |
| Pipe clamp                       | EA    | 1      |
| Ball valve Ø 1”                   | EA    | 1      |
| Botchen 90 Ø 1”                   | EA    | 1      |
| Double nipple Ø 1”                | EA    | 1      |
| Seal tape                        | EA    | 1      |
| Gas meter G1.6                   | EA    | 1      |
| Regulator service                | EA    | 1      |

Table 5. Capital expenditure

| No | Components                        | Total costs (million IDR) |
|----|-----------------------------------|---------------------------|
| 1  | Materials                         | 25,785                    |
| 2  | Preparatory work                  | 2,26                      |
| 3  | Excavation demolition work        | 851.152                   |
| 4  | Installation work                 | 3,492                     |
| 5  | Special work and completion       | 12,575                    |
| 6  | Excavation repairs work           | 4,064                     |
| 7  | Testing and cleaning work         | 800.005                   |
| 8  | Final completion work             | 588.569                   |

Total Work Fees: 50,424
Total Work Fees + VAT + Insurance: 70,511

Operational expenditure is assumed to be 5% of total capital expenditure. Operational costs will have an escalation of 1.66% each year referring to BPH Migas Regulation number 22/2011, so that total operational costs needed for 20 years of lifetime is IDR 82,821,425,491.

Table 6. Operational expenditure

| Year- | OPEX (million IDR) | Escalation (million IDR) |
|-------|--------------------|--------------------------|
| 0     | 0                  | 0                        |
| 1     | 3,525              | 58.524                   |
| 2     | 3,584              | 59.496                   |
| 3     | 3,643              | 60.483                   |
| 4     | 3,704              | 61.487                   |
| 5     | 3,765              | 62.508                   |
| 6     | 3,828              | 63.546                   |
| 7     | 3,891              | 64.601                   |
| 8     | 3,956              | 65.673                   |
| 9     | 4,021              | 66.763                   |
| 10    | 4,088              | 67.871                   |
| 11    | 4,156              | 68.889                   |
After obtaining initial investment costs, cash flow calculation is performed to evaluate project’s economic viability. The economic evaluation is carried out based on feasibility approach of capital costs, operational costs, the selling price of city gas, depreciation, and determined taxes calculation. The depreciation method used is straight line method, rupiah exchange rate used at the time of calculation was exchange rate on March 1, 2020 in the amount of IDR 13,976, gas upstream purchase price of $ 6.40/MMBtu with a toll fee of $1.50/MSCFD, making the final purchase price of gas obtained is $ 0.28/m³ or IDR 3,912 and income tax of 20%. The amount of gas needed each year is 4,326,856 m³ with project lifetime set of 20 years. Project will be feasible if it meets parameters of positive NPV, IRR is greater than MARR with MARR set at 11%, and PBP is less than 10 years. According to BPH Migas (Regulatory Agency for Downstream Oil and Gas) regulations number 22/2011, gas price for middle to high income households (namely RT-2) is set as low as the gas price for low to middle households (namely RT-1) of IDR 2,618/m³ with maximum selling price for middle to high income household and commercial sector is IDR 5,236/m³.

In this condition, the project isn’t feasible enough to execute with NPV of -51 billion IDR, and unknown IRR and PBP. A trial and error method is conducted to see its feasibility. Project is feasible with minimum gas selling price of IDR 7,200/m³ for household customers and IDR 8,400/m³ for commercial customers, with NPV of 5,1 billion IDR, IRR of 12.29%, and PBP in 7 years. Sensitivity analysis is performed to see the effects of gas purchase price, gas selling price, addition of customers, and total capital cost to economic parameters with ± 40% deviation and stains per 10%. Based on the sensitivity results, the selling price of gas for household customers, the addition of commercial customers, and the purchase price of gas have a significant effect. The higher gas selling price for household customers and more household customers, NPV will become positive, IRR will increase, and PBP will be lower. Meanwhile, if gas purchase price gets higher, NPV will be negative, IRR will decrease, and PBP will increase.

|  |  |
|---|---|
|  |  |
| Total operational costs | 82,821 |
| Average OPEX/year | 4,141 |

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Since the proposed gas selling price is higher than BPH Migas regulation, another funding scheme is needed to subsidize the selling price of gas for households and commercial markets in Kelapa Gading. The funding scheme that is used is a funding scheme between business entity, government, and developer of area that is shown in table 7.

**Table 7.** Funding scheme between business entity, government, and area developer

| Scheme | Business Entity | Government | Area Developer |
|--------|-----------------|------------|---------------|
|        | CAPEX | OPEX | CAPEX | OPEX | CAPEX | OPEX |
| 1      | 100%  | 100% | 0%    | 0%   | 0%    | 0%   |
| 2      | 90%   | 100% | 10%   | 0%   | 0%    | 0%   |
| 3      | 80%   | 100% | 20%   | 0%   | 0%    | 0%   |
| 4      | 70%   | 100% | 30%   | 0%   | 0%    | 0%   |
| 5      | 60%   | 100% | 40%   | 0%   | 0%    | 0%   |
| 6      | 51%   | 100% | 49%   | 0%   | 0%    | 0%   |
| 7      | 40%   | 100% | 49%   | 0%   | 11%   | 0%   |
| 8      | 35%   | 100% | 30%   | 0%   | 35%   | 0%   |
| 9      | 30%   | 100% | 30%   | 0%   | 40%   | 0%   |
| 10     | 25%   | 100% | 30%   | 0%   | 45%   | 0%   |

Smaller business entity’s CAPEX share, NPV of project will be even greater. NPV shows a positive value in funding scheme number 8 with business entity’s CAPEX share of 35%, funding scheme number 9 with a share of 30%, and funding scheme number 10 with a share of 25%. It’s known that the project will be feasible when business entity’s CAPEX share is 35% or IDR 24,679,108,238 or smaller than that. The smaller the capital costs incurred by business entities, the greater the NPV and IRR of the project, the faster the PBP.
Figure 3. Sensitivity analysis of funding scheme (a) Effects of business entity funding share to NPV (b) Effects of business entity funding share to IRR (c) Effects of business entity funding share to PBP

The usage of gas and LPG per month using proposed gas price is compared in table 8, resulting that gas will be more affordable than LPG.

| Product   | Price (IDR/m³) | Usage (m³/month) | Total cost (IDR/month) |
|-----------|----------------|------------------|------------------------|
|           |                | Households       | Commercials            | Households      | Commercials |
| LPG       | 9,700          | 15               | 500                    | 145,500         | 4,850,000   |
| City Gas  | 7,200          | 15               | 500                    | 108,000         | 4,200,000   |
| Price comparisons (IDR) | 37,500         | 650,000          |

Based on the risk analysis using 5x5 risk matrix, there are 5 low to medium risks, 2 medium risks, and 1 medium to high risk that gets more attention, namely the failure of work due to material specification errors by the contractor with a risk level of 10. This risk has likelihood level of 2, where the risk is rare but it’s possible to happen with impact level of 5, which if this event occurs it will cause a large threat of damage. The risk can be caused by the selection of an inexperienced contractor or vendor, unavailable materials in the market, and lack of coordination between contractor and business entities. To prevent this risk, the mitigations that could be implemented are to coordinate projects related to the required material specifications and existing conditions, determining qualified vendor, and regular coordination meetings between vendor, contractor, and business entities.

In conclusion, the city gas distribution network in Kelapa Gading can be developed using combinations of API 5 L Grade B pipes and MDPE 80 SDR 11 pipes. The gas demand in developed area is 4,326,856 m³/year, with proposed household selling gas price of IDR 7,200/m³ and commercial selling gas price of IDR 8,400/m³. Capital expenditure for this project is IDR 70,511,737,825 and operational expenditure of IDR 82,821,425,491 with 20 years lifetime. The project will be developed using financial funding schemes between business entities, governments, and regional developers, with
capital cost shares between business entities, governments, and developers being varied with maximum share of business entities at 35%. There are 5 low to medium risks, 2 medium risks, and 1 medium to high risk. From the results of this analysis, the project does not require much mitigation and is feasible to develop.

4. References

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