Economic Analysis of LNG Distribution for Power Plant and City Gas in Bali

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Abstract. Indonesia is a country that contains great potential for economic development and it is also impact on increased electricity demand in Indonesia. Ministry of Energy and Mineral Resources stated that increasing demand for electricity in Indonesia have reached 6.9% annually. PT. PLN as the electrical company in Indonesia has designed long term strategic development of power plant to anticipate increasing demand for electricity in Indonesia as documented at “Rencana Usaha Penyediaan Tenaga Listrik” (RUPTL) PT. PLN on 2018-2027[7]. The government has plan to convert the energy that will be used in power plants to become natural gas energy for utilization of power plants in Indonesia. PT. PLN is prioritizing the power plant that will operate by using Liquefied Natural Gas (LNG) as the main energy. PT.PLN also want to build the new Power Plant (PLTGU) in Celuk an Bawang, Bali. The power plant will have 350 MWx2 as the additional power supply to reduce deficit of electrical power in Bali. Analyzing economic indicators is an important point to determined requirement Infrastructure and distribution Natural Gas at every district in Bali. In this study MCDM (Multiple Criteria Decision Making) is applied to model and solve multiple criteria optimization problems in economic process. The AHP method is presented to compare the best alternatives route of distribution LNG, the requirement to construct mini Natural Gas filling station, economical value of the distribution, and supply-demand at every district in Bali. Payback period (PP) and Return of Investment (ROI) calculation must be considered to develop economic value and fulfil the needs at every district by establishing a new mini LNG filling station in certain locations. The result of this research is expected to provide recommendation on best LNG distribution, which will assume lowest gas price at the end user. Accordingly, this will support the program of Bali clean and green.

1. Introduction
Tourism is one of important aspect in Bali Island. The growth expected on January 2018 until December 2019 is 7.100.000, but, the realization on January 2018 – December 2019 is 6.291.141. annually[1], the percentage of increasing tourism in Bali on January 2018-December 2019 is 3.64%. In this situation Bali population in 2018 is 4.292.200, and it grows along every year with an increase the number of tourist each year. This is will affecting the economic value on demand of infrastructure development of industries and hospitality. Increased infrastructure development of industries and hospitality also affecting the increasing demand of electricity in Bali. Bali is one province in Indonesia which has high demand in the electrical power. The increasing demand of electricity in Indonesia also
have reached 6.9% each annually [2]. It is because electrical energy is used for any activity there such as industrial, urban, residential, and tourism, which is resulting on huge demand of electrical power. These electrical power need to be produced by power plants. In the moment, 340 MW electrical power which is used in Bali is still supplied from Java. Nowadays, Bali is only able to supply the electricity into all island with 1300 MW which the power is supplied by four power plant in bali, these power plants are Pesanggaran power plant, Pemaron power plant, Gilimanuk power plant, and Celukan Bawang power plant. Pesanggaran power plant is able to provide 380 MW totally that is 180 MW by PLTG Pesanggaran and 200 MW by PLTDG Pesanggaran. PLTDGU in Celukan Bawang also can provide 350 MW. Pemaron and Gilimanuk power plant role are to ensure the power provided is enough to cover all the additional electrical demand in Bali, such as at the night time. Pemaron and Gilimanuk Power plant counted to be able to provide 80 MW and 130 MW.

In this research, the issue that is being raised is about the inefficiency of natural gas distribution in Bali. In order to maximize the usage of natural gas, efficient distribution scenario and design distribution in Bali need to be improved along with the maximize the economical aspect to calculating best design for increase the capability of power plant, the most efficient scenario to distribute Natural Gas into end user at lowest price which will benefit all the users, and then it may actualize Bali as the Clean and Green Island.

2. Methodology
2.1. Data Collecting
Data that is needed to be gathered in the project can be collected from the power plants, hotel, housing and transportation. Data that collected is about the overall demand of electricity for end user. This data used for analysis including: General information about the demanded from each end user. Data is required to modelling the electrical demand that will visualize the characteristic of electrical demand in Bali based on each district. General information about the electrical power demanded from area which is divided into some region in Bali that can be interpret as the distribution of electrical need. Data of vehicle can be used in the distribution of natural gas between power plants in Bali and to comparing the efficiency use of natural gas as fuel, and also data demand of industries and hospitality in Bali. The data is hopefully can interpret the needs of distribution type in Bali. For the example is in the table below:

| No | Resident / City | Total Demand of Gas for Household in Bali (Thousand) |
|----|----------------|-----------------------------------------------------|
| 1  | Jembrana       | 68.725 MMSCFD 69.150 MMSCFD                          |
| 2  | Tabanan        | 110.250 MMSCFD 110.875 MMSCFD                         |
| 3  | Badung         | 160.875 MMSCFD 164.225 MMSCFD                         |
| 4  | Denpasar       | 228.575 MMSCFD 232.650 MMSCFD                         |
| 5  | Gianyar        | 125.975 MMSCFD 127.025 MMSCFD                         |
| 6  | Klungkung      | 44.350 MMSCFD 44.575 MMSCFD                           |
| 7  | Bangli         | 56.275 MMSCFD 56.550 MMSCFD                           |
| 8  | Karangasem     | 103.200 MMSCFD 103.700 MMSCFD                         |
| 9  | Buleleng       | 163.400 MMSCFD 164.300 MMSCFD                         |
| 10 | Bali           | 1.061.625 MMSCFD 1.073.050 MMSCFD                      |

Source: Ketut Buda Artana.2016 [4]
Table 2. Demand of Gas for Hotel in Bali

| No | Resident/City | Total Demand Gas (Room) | Total Demand Gas (MMSCFD) | 2017 | 2018 |
|----|---------------|-------------------------|---------------------------|------|------|
| 1  | Jembrana      | 119                     | 0,0017                    | 119  | 0,0023 |
| 2  | Tabanan       | 193                     | 0,0087                    | 191  | 0,0090 |
| 3  | Badung        | 58.694                  | 0,6226                    | 44.571 | 0,6758 |
| 4  | Denpasar      | 4.835                   | 0,0935                    | 5.437 | 0,1016 |
| 5  | Gianyar       | 1.135                   | 0,0227                    | 1.221 | 0,0269 |
| 6  | Klungkung     | 263                     | 0,0025                    | 260  | 0,0028 |
| 7  | Bangli        | 0                       | 0                         | 0    | 0     |
| 8  | Karangasem    | 329                     | 0,0078                    | 321  | 0,0094 |
| 9  | Buleleng      | 709                     | 0,0145                    | 807  | 0,0209 |
| 10 | Bali          | 66.277                  | 0,7740                    | 52.927 | 0,8489 |

2.2. Designing Scenario of LNG Distribution

The result of collected data and calculation before, is the one factor that will affect the requirement of LNG distribution scenario in Bali. Designing scenario will be considering some factors such as demand on every district, transporting time, natural gas distribution state whether using pipelines or transportation like truck or barge. In this step it will result in the better distribution mechanism which is fit best to the condition of every district in Bali.

Final scenario will be chosen from the set of distribution scenario and will be checked until the final economical calculation. From the result between scenarios, three scenarios which have the best economical aspect or the most effective will be chosen for the best solution compared to the other choices. The steps that can be applied are:

2.2.1. Input analysis data for designing scenario of LNG distribution plan.

Input economic data such as the initial data requirement for completing the natural gas requirement, power plant capacity, or the demand of each area in Bali.

2.2.2. Getting the result of Long list and Short list design.

The process of choosing the best scenarios results are divided into two steps, the first is making long list scenarios which consist of thirteen scenarios that made from various possibilities of distributing scenarios, then choosing the six best scenario based on basic calculation to determine the most effective scenario from the long list and these six scenarios are short list. From the short list scenarios, three best scenarios will be selected using AHP method to compare the most effective and economical from the short list.

2.2.3. Economical approach calculation

After getting three selected scenarios, some of economic aspects will be calculated on each scenario to compare and finding the most valuable and effective scenario that will be used for distribution scenario of LNG in Bali. Economic aspects will be calculated using NPV (Net Present Value), IRR (Internal Rate Return), PP (Payback Period) method.
3. Result and Discussion

3.1. Long List and Short List

Long list is the list of distribution scenario of developing infrastructure of LNG to distribute Natural Gas in Bali especially into household, transportation, hotel of all regency in Bali. Some scenario of the long list will be chosen to be some scenario short list and from the short list will be choose the best three scenarios using the AHP method and collecting answer from questionnaire. Details of Long List Scenarios and Short List Scenario can be seen in the below:

*Long List Scenario*
1. Truck to all power plants & satellite
2. Barge to all power plants & truck to all satellite
3. Pipeline to all power plants & truck to all satellite

*Celukan Bawang Power Plant as Major Terminal*
4. Pipeline to Gilimanuk PP (Power Plant) & Pemaron PP + Barge to Benoa + truck to all satellite
5. Pipeline to Gilimanuk PP + Barge to Benoa + Truck to Pemaron PP and to all satellite
6. Truck to Gilimanuk PP & Pemaron PP + Barge to Benoa + truck to all satellite

*Gilimanuk Power Plant as Major Terminal*
7. Pipeline to Celukan Bawang PP & Pemaron PP + Barge to Benoa + truck to all satellite
8. Pipeline to Celukan Bawang PP + Barge to Pemaron PP & Benoa + truck to all satellite
9. Pipeline to Celukan Bawang PP + Barge to Benoa + Truck to Pemaron PP and to all satellite
10. Truck to Celukan Bawang PP & Pemaron PP + Barge to Benoa + truck to all satellite

*Benoa (Pesanggaran Powerplant) as Major Terminal*
11. Barge to Gilimanuk PP & Celukan Bawang PP & Pemaron PP + truck to all satellite
12. Pipeline to Gilimanuk PP + Barge to Celukan Bawang PP & Pemaron PP + truck to all satellite
13. Truck to Gilimanuk PP + Barge to Celukan Bawang PP & Pemaron PP + truck to all satellite

*Short List Scenario*
1. Pipeline to all power plants & truck to all satellite
2. Barge to all power plants & truck to all satellite
3. Pipeline to Gilimanuk PP + Barge to Benoa + Truck to Pemaron PP and to all satellite (Celukan Bawang Power Plant as Major Power Plant)
4. Pipeline to Celukan Bawang PP + Barge to Benoa + Truck to Pemaron PP and to all satellite (Gilimanuk as Major Power Plant)
5. Barge to Gilimanuk PP & Celukan Bawang PP & Pemaron PP + truck to all satellite (Benoa as Major Terminal)
6. Pipeline to Gilimanuk PP + Barge to Celukan Bawang PP & Pemaron PP + truck to all satellite (Benoa as Major Terminal)

3.2. Selection Method

3.2.1. AHP (Analytical Hierarchy Process)

The use of AHP in scoring aspects of scenarios with pairwise comparison can help in solving a priority scale problem for a criterion. The final value of scoring scenario aspect is obtained from the geometric mean.
Here are some steps in the processing of data to determine priority scale using AHP:

1. Collecting Data
Collect data from questionnaires, then process these values by entering numerical values into a pairwise comparison matrix on a scale of 1-9.

2. Geometric Mean
Averaging the results of pairwise comparisons with geometric averages because the evaluation involves many people.

\[ G = \sqrt[n]{x_1 \times x_2 \times \cdots \times x_n} \]

3. Data Processing
Data processing from aspect of scenario criteria with AHP method will processed use expert choice software to get the priority scale from the pairwise comparison matrix.

3.2.2. Scoring of Scenario Aspect
The next step of the AHP process is the value of the aspect scenario comparison questionnaire will be used as input data to get a decision which criteria should be prioritized. Pairwise comparison values will be processed using expert choice software. where the expert choice simulation is very helpful in solving problems to determine a determination criteria or an element that must get more priority values. the results of the comparison with this software is to obtain criteria with priority and show that whether the value of this scenario is effective enough to be used.
The best option on selection of the LNG distribution scenario is Social Aspect is safety reason and operational cost, therefore the chosen scenario from the aspect scoring is:
1.) Pipeline to Gilimanuk PP + Barge to Benoa + Truck to Pemaron PP and to all satellite (Celukan Bawang as Major Power Plant).
2.) Pipeline to Celukan Bawang PP + Barge to Benoa + Truck to Pemaron PP and to all satellite (Gilimanuk as Major Power Plant).
3.) Barge to Gilimanuk PP & Celukan Bawang PP & Pemaron PP + truck to all satellite (Benoa as Major Terminal).

3.3. Economical Calculation
The three selected scenarios will be calculated to compare and finding the most valuable and effective scenario that will be used for distribution scenario of LNG in Bali. Economic aspects will be calculated using NPV (Net Present Value), IRR (Internal Rate Return), PP (Payback Period) method.

3.3.1. Capex, Opex, NPV, IRR, Payback Period Calculation
The capital cost (Capex) that needed for LNG storage tank, BOG handling, Vaporizer, LNG Pump, Truck and Storage tank, and Mini LNG filling station after tax 25% from example of one distribution scenario is 9,506,250 US$. While total of operational cost (Opex) is 10,980,000 US$ with the following details below:

| Table 4. Capital Expenditure Cost |
|-----------------------------------|
| ITEM                       | PRICE ($) | Number of Items | Cost ($) |
| LNG Storage Tank            | 500.000   | 3                | 1,500.000 |
| BOG Handling                | 80.000    | 4                | 320.000   |
| Vaporizer                   | 100.000   | 4                | 400.000   |
| Pump                        | 5.000     | 7                | 35.000    |
| Truck and Storage tank      | 200.000   | 20               | 4,000.000 |
| Mini Filling Station        | 150.000   | 9                | 1,350.000 |
| Tax 25% and etc.            |           |                  | 1,901.250 |
| Total Fix Cost              |           |                  | 9,506.250 |

| Table 5. Operational Expenditure Cost |
|---------------------------------------|
| ITEM                          | PRICE ($) | Number of Items | Cost ($) |
| Fuel cost (year)              | 20.000    |                 | 20.000   |
| Management Cost               | 160.000   |                 | 160.000  |
| LNG cost (Once)               | 70.000    | 50              | 3,500.000|
| Maintenance Cost              | 90.000    |                 | 90.000   |
| Crew Cost                     | 700       | 300             | 210.000  |
| LNG Transport by Barge (Year) | 7,000.000 |                 | 7,000.000|
| Total Operational Cost        |           |                 | 10,980.000|

The profit that received annually is multiplication of the amount of gas sold annually multiplied by the profit margin. Detailed calculations can be seen below:
Table 6. Revenue with variants margin

| Item                  | Units | Price ($) |
|-----------------------|-------|-----------|
| Daily Gas Processed   | MMbtu | 8.904,81  |
| Yearly Gas Processed  | MMbtu | 3.250.256 |
| Margin ($)            | 4     | 13.001.023|
| Profit from Gas Selling (Year) | 5     | 16.251.278|
|                       | 6     | 19.501.534|

With an operating cost of 10.980.000 US$/year, the investment will start to be feasible if the profit margin is 5 US$. Because the value of NPV from margin 4 US$ is -2.722617 US$. With a profit margin of 5 US$, capital will return in the 2nd year with NPV value is 12.255.943 US$ (interest 10%). While the profit margin of 6 US$ will return to the 1 year 3rd month with NPV value 27.234.504 US$ (interest 10%).
The payback on margin 4 US$ will be paid back after 3 years but it is not too profitable because the NPV value is negative however the payback on margin 5 US$ is paid back after 2 years and the payback on margin 6 US$ is paid back after 1 year and 3 months. Both the economical calculation scenario margin 5 US$ and margin 6 US$ is profitable and it is good to be implemented.

4. Conclusion
Based on analysis above the following conclusion are obtained:

1. The selected scenario is chosen from the best aspect from selecting method that is safety and operational cost reason. The three selected scenario are:
   a.) Distributing LNG using Pipeline to Gilimanuk PP + Barge to Benoa + Truck to Pemaron PP and to all satellite (Celukan Bawang as Major Power Plant).
   b.) Distributing LNG using Pipeline to Celukan Bawang PP + Barge to Benoa + Truck to Pemaron PP and to all satellite (Gilimanuk as Major Power Plant).
   c.) Distributing LNG using Barge to Gilimanuk PP & Celukan Bawang PP & Pemaron PP + truck to all satellite (Benoa as Major Terminal).

2. From the calculation of economical approach, it can be seen the option that profitable and useable from example of one distribution scenario is scenario with margin US$ 5 and margin US$ 6, because it has positive Net Present Value, positive Internal Rate of Return and Good Payback Period.

5. Suggestion
The calculation can be improved by using more realistic value and realistic schemes that may fit into the actual condition

6. Future Study on Research

There is various aspect for improvement on this research. There are some points that come into thoughts upon the writing of this document regarding the future direction of this research. Finishing the Economic analysis and calculation for the three chosen scenario of LNG distribution in Bali.

References
[1] Bali, B. P. (2019). Provinsi Bali Dalam Angka - Bali Province In Figures. BPS- Statistic of Bali Province
[2] Direktorat Jenderal Minyak dan Gas Bumi. (2018). Neraca Gas Bumi Indonesia 2018-2027. Jakarta: Direktorat Jenderal Minyak dan Gas Bumi, Kementrian Energi dan Sumber Daya Mineral Direktorat Jenderal Minyak dan Gas
[3] ESDM, K. (2013). Pembangunan Jaringan Gas Bumi. 134.
[4] Fakultas Teknologi Kelautan ITS. “Model Cluster Distribusi LNG”, Kerja sama ITS-PGN.
[5] Mineral, K. E. (2012). Pusat Data dan Teknologi Informasi Energi an Sumber Daya Mineral. Kesdm.
[6] PLN, P. (2018). Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) 2018-2027. Jakarta
[7] Pujawan. (2012). Ekonomi Teknik Edisi Kedua. Surabaya.
[8] A. M. F. Katili, K. B. Artana, and A. A. B. D. P., (2017) “Kajian Teknis dan Ekonomis Distribusi Gas Alam dari FSRU Menuju Superblok.”.
[9] Pangestu, J. W. (2018). Design of Natural Gas Distribution Plan in Bali Island Based on Economical Aspect. Surabaya: Department of Marine Engineering, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember.