Determination of Geothermal Electricity Tariff

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Abstract— The most significant utilization of geothermal energy is currently by processing to electricity. One of the geothermal projects developed in Indonesia is at the Lahendong Area owned by PT. Pertamina Geothermal Energy with a generating capacity of 1 X 20 MW. Therefore, an economic study was conducted on this project to measure its annual Net Present Value (NPV), the Internal Rate of Return (IRR), and Pay Out Time (POT) using basic input data obtained from PT. Pertamina Geothermal Energy and the Indonesian Geothermal Association (API). The results showed this field is not feasible for development and based on the simulation of parameters conducted to achieve a decent economy, the selling price (tariff), drilling costs, and Engineering, Procurement, Construction, Commissioning (EPPCC) of the project were observed to require some adjustments. In this study, the selling price for Generation Cost of Supply (BPP) of Lahendong Area was set by the Indonesian Ministry of Energy and Mineral Resources at a rate of US$ 13.46 cents/kWh and the project was discovered to not feasible. Therefore, adjustments must be made to achieve a feasible economy for the generation of 1 X 20 MW capacity in North Sulawesi province.

Index Terms—Economic Analysis, Tariff, Geothermal Development Project

1 Introduction

GEOTHERMAL energy is defined in the Law Number 27 of the year 2003 as a source of heat energy contained in hot water, steam, and rock associated with minerals and other gases which are inseparable from the geothermal system and requiring drilling for it to be utilized [5]. Currently, this energy is primarily and indirectly used as a power plant to maintain sustainability and national energy security. This is due to the need to increase generation with respect to rapid economic growth [1]. It was also implemented to reduce dependence on fossil obtained from coal and petroleum. These are currently the most abundant sources of energy with the ability to produce substantial CO_2 emissions compared to geothermal plants. This is because the geothermal plant (PLTP) is a closed generating system producing no wastes such as coal, gas and oil [4]. Geothermal energy therefore is more environmentally friendly and renewable when compared to fossil, which is widely used as a power plant. Indonesia is in a tectonic framework region that forms a volcanic path called the Ring of Fire, where the Indo-Australian and the Pacific plates are under the Eurasian plate and this makes the country has abundant geothermal energy potential. When the plate reaches an approximately 100 km depth, the rocks are transformed into magma under high temperature and the magma rises to the surface at 76 active volcanic eruption sites spread all over the country. This means Indonesia has great potential for geothermal energy and one of the highest any country could have [3]. Moreover, according to the data provided by the Ministry of Energy and Mineral Resources, the current potential is 11,073 MW of 17,506 MW[8]. In Indonesia, the search for geothermal energy sources was first conducted in the Kamojang area in 1918. Geothermal development was stalled due to the occurrence of world war and the Indonesian independence war, and resumed again in 1972 by surveying the country's territory. This has led to the identification of 325 geothermal prospects in 2018 by the Indonesian Government. More than 90 of them are already developed as geothermal working areas (WKP) which has air production, exploration status, tendered right or ready to tend. Moreover, the Indonesian National Energy Policy of 2014 set a target of 23% in the Energy Mix by 2025, with the heat generation capacity targeted to reach 7,100 MW [16].

Therefore, this paper aimed to conduct economic research on Lahendong Area, one of the geothermal projects developed in Indonesia, owned by PT. Pertamina Geothermal Energy with a generating capacity of 1X20 MW to determine its feasibility based on Indonesia Government's 2018 Cost of Generation.

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2 Method

In modeling the geothermal project, the 20 MW capacity field was determined using the economic scenario with the intention to meet the electricity needs of the Sulawesi region, especially for the surrounding areas and also to increase revenue from the Lahendong area. The project was planned to start by February 1, 2019, and the Commercial Operation Date (COD) was set at February 1, 2026, with the supporting infrastructure expected to be developed within seven years. The field is expected to have a total electricity production of 4,993,200 MWh, 30 years of operation, and an electricity selling price of US$ 13.46 cents/kWh based on 2018 Cost of Generation for the North Sulawesi region. Moreover, the assumed discount rate or Weighted Average Cost of Capital (WACC) or MARR, to be applied to the economic calculation was 10.36%.

2.1 Development of the Economic Model

In this study, the Discounted Cash Flow method was used for valuation and it is one of the most popular methods used by companies, financial institutions, and market analysts even though it has a high degree of uncertainty. The method was applied because the geothermal investment is generally long-term and requires an extended period for cash flow projections. The inputs for the calculation, however, include technical, commercial, financial, fiscal, and other data. The research started with field data collection and details of costs according to the provisions of the Indonesian Geothermal Association (API) and followed by data processing and economic calculations. The feasibility of the project was determined by a positive NPV and an IRR value above the 10.36% set for the WACC or MARR. However, if the economic parameters such as NPV and IRR are found not to be economical. Therefore, a sensitivity analysis conducted on the costs incurred during the geothermal project. The cost of developing geothermal projects includes investment, operational, and government tax calculation costs. Moreover, the investment includes upstream and downstream investment, operational covers subsurface and surface equipment, and the total amount of tax paid to the government. The upstream cost includes several activities such as steps taken to identify, produce, and transport hot steam to make it useable as an energy source by the power plant (PLTP). In geothermal field development projects, all funds are spent to build a power plant which includes preparation of access roads, land acquisition and leveling, detailed planning, and building construction works such as power generation facilities, offices, laboratories, public facilities, as well as assembly and installation of equipment. Furthermore, the calculation of Operational Expenditure (OPEX) involves operational and maintenance (O&M) costs incurred to maintain production levels such as steam field and power generation per-kWh, and major overhaul costs for each overhaul. This fee needs to be issued even if the equipment at the power plant is not operational. The costs are further divided into two parts, cost of operating and maintaining the facilities which are also known as the detailed costs and the labour costs [6]. They are the routine cost of maintaining the productivity level of the geothermal power plant. Moreover, the production revenue of the project was also calculated for each year and the results were based on the generation capacity in Mega Watt Electric units. Besides, the value of profits earned each year after COD was also calculated in US$. After the calculation of the costs and investment for the project, depreciation was calculated using the straight-line method. This involves setting the same value for depreciation every year and the factors considered include the age of well assets (upstream), power plant age, and an asset life of SAGS, each of which has 8 years. Calculation of the tax expense for the government depends on differences in regime policies and it can be divided into two which involve payments based on regulations of the old regime where the production working area contract (WKP) has been signed before Law No. 27 of 2003 (existing) and on a new regime after the law involving holders of Geothermal/IPB Permit. The WKPs with or without IPB holders are obliged to pay fixed tariffs as stipulated in Law No. 21 of 2014, while existing WKP is required to pay Government Deposit (SBP) of 34% of the Company's Net Operating Income (NOI) after relevant production costs have been deducted [2] and this study made use of this second format. The economic aspects of the geothermal project's feasibility were analyzed objectively to aid the decision making through the use of the following indicators.

A. NPV (Net Present Value)

This is the amount of net profit assessed calculated at a particular time based on a certain interest rate. A positive value shows the project is feasible and able to provide benefits while a negative value shows non-feasibility and economic losses. Moreover, NPV=0 indicates the investment only produces the Internal Rate of Return (IRR), without any interest or losses. The Net Present Value can be calculated using the following equation:

$$\mathrm{NPV} = \sum_{t=0}^{N} \left(\frac{\mathrm{Rt}}{(1+\mathrm{i})^{t}}\right) \qquad \text{(II.1)}$$

Where:

n = the time of the cash flow
i = the discount rate
Rt = the net cash flow i.e. cash inflow – cash outflow

B. IRR (Internal Rate of Return)

Internal Rate of Return (IRR) is defined as the interest which makes all cash inflows to be similar to outflows if the cash flow is discounted for at a certain time. Therefore, IRR is the interest rate which makes NPV = 0. IRR is represented using the following equation:

$$\sum_{t=0}^{N} \left(\frac{\mathrm{Rt}}{(1+\mathrm{IRR})^{t}}\right) = 0 \qquad \text{(II.2)}$$

Where:

t = the time of the cash flow
i = the discount rate
R_t = the net cash flow, i.e. cash inflow – cash outflow

IRR is generally calculated using trial and error approach and it involves determining NPV at several discount levels up to when a negative and positive value is obtained, which is usually followed by an interpolation to have a zero value. However, its disadvantage is the inability to consider risks explicitly, provide information about the number of costs involved in the project, and the payout time [10].

C. POT (Pay Out Time)

This is the length of time up to when there is a return on investment. Investors usually want the invested capital to return quickly, which indicates a shorter POT for a particular project. However, due to the inability of this indicator to provide information after it has been achieved, it is rarely used as the main parameter in project selection but only as an additional consideration [10]. POT also indirectly affects the speed at which the government obtains revenue through taxes because it is impossible to tax business without profit.

3 Result & Discussion

The cash flow is calculated based on the results of corporate expenses issued divided into two, cash in-flow and cash out-flow. The results obtained from the calculation as well as the final values of NPV (Net Present Value) and IRR (Internal Rate of Return) were used in determining the feasibility of a project and to decide on whether it should be developed or not.

TABLE 1
CASHFLOW

CASHFLOW	COST (USD)
Revenue	672084,72
OPEX	153194,76
Depreciation	153062,75
NOI	365827,19
Tax	124381,24
NIAT	241445,94
Add Back Depreciation	153062,75
Capital	153062,75
NCF	241445,94
Rate DCF	20,737464
DCI	672084,72
DCO	277576,01
DCF	-10380,69
DCumCF	-10380,69

TABLE2
RESULTS OF INITIAL FEASIBILITY CALCULATION

Price	IRR	NPV (US$X1000)
6	-1,97%	-111.252
7	0,38%	-97.006
8	2,30%	-82.760
9	3,97%	-68.514
10	5,48%	-54.268
11	6,87%	-40.022
12	8,08%	-26.953
13	9,09%	-15.494
13,46	9,52%	-10.381
14	10,00%	-4.438
14,40	10,36%	0
15	10,87%	6.568
16	11,71%	17.573
17	12,50%	28.578
18	13,27%	39.584
19	14,02%	50.589
20	14,74%	61.594
21	15,44%	72.600
22	16,12%	83.605
23	16,78%	94.611
24	17,43%	105.616
25	18,06%	116.621

The data used in calculating the NPV and IRR values include Revenue or income, Operating Expenditure (OPEX), total depreciation value, total NOI or Net Operating Income which is the depreciated revenue value reduced by OPEX costs, tax or taxes in case of 34% Government Share (SBP), NIAT or Net Income After Tax which is NOI reduced by the 34% SBP tax, Add Back Depreciation, Capital, NCF or Net Cash Flow , Discounted Cash In , Discounted Cash Out , Discounted Cash Flow , and Discounted Cumulative Cash Flow .

3.1 Feasibility Determination

Determination of the feasibility level of the project was based on the calculated economic parameters. A project is said to be feasible if the Net Present Value (NPV) is >0 or positive and Internal Rate of Return (IRR) value is above the Discounted Factor of 10.36% stated for the Weighted Average Cost of Capital. Based on the economic modeling scenario compiled from the data obtained, the final results revealed it is not feasible to develop the project as observed from the values of NPV and IRR. The NPV or Net Present Value was obtained from the total amount of Discounted Cash Flow during the project's 30 years lifetime to be -US$ 10.381 million. Besides, the project's feasibility was also determined based on the IRR value. This was calculated from the Net Cash Flow cost to obtain only 9.52%. Therefore, these two results showed the development of the field would be uneconomical due to the negative NPV value and a smaller IRR value compared to the specified 10.36% for WACC.

3.2 Sensitivity Analysis of Generation BPP Rates

In analyzing the BPP generation prices, the calculation for the North Sulawesi region, especially Manado, was initially based on the BPP Generation 2018 value of US$ 13.46 cents/kWh. The results showed an NPV value of -US$ 10.381 million and an IRR value of 9.52% which means the field is not feasible for development. Therefore, sensitivity analysis for the tariff value was conducted by increasing the rate by US$ 1 cents/kWh to obtain an amount needed to modify the NPV and IRR values allowing the field to be feasible. This modification led to a purchase rate of US$ 14.40 cents/kWh with NPV at 0 and IRR above 10.36%. Therefore, this project with a capacity of 1X20 MW can be feasible for development if the selling price for PLN is set at a minimum price of US$ 15 cents/kWh leading to NPV at US$ 6.568 million and IRR value greater than the WACC value of 10.87%.

TABLE 3
RESULTS OF TARIFF SENSITIVITY

PARAMETER	UNIT	VALUE
NPV	(US$x1000)	-10,381
IRR	%	9,52%
POT (*Pay Out Time*)	Year	7,53

4 CONCLUSION

The results of the analysis conducted on PT. Pertamina Geothermal Energy and the Indonesian Geothermal Association (API) showed the Net Present Value (NPV) to be very small and the Internal Rate of Return (IRR) not to have the ability to reach the targeted value of -US $ 10,381,000 for NPV with 9.52%. This means the project is uneconomical and would generate no profits for the developer up to the end of the contract. However, sensitivity analysis conducted based on the tariff showed the valued selling price to be US$ 15 cents/kWh. However, developers are not expected to sell electricity at this price due to its far exceeding value compared to the benchmark of US$ 13.46 cents/kWh set in 2018 Cost of Generation.

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REFERENCES

[1] Azhar, M., and Suhartoyo (2017Legal Aspects of GeothermalPolicyinIndonesia,LawReform,**11**(1),123.https://doi.org/10.14710/lr.v11i1.15761
[2] DJPK Kementerian Keuangan (2017): Allocation of NaturalResourcesRevenueSharingFunds,Https://Www.Kemenkeu.Go.Id/Sites/Default/Files/Dbh%20Sda.Pdf.
[3] Fan, K., and Sang, N. (2018): Accelerating Geothermal Development in Indonesia : A Case Study in the Underutilization of Geothermal Energy, Consilience: The Journal of Sustainable Development, 19(1), 103–129.
[4] Fandari, A. El, Daryanto, A., and Suprayitno, G. (2014): Sustainable Geothermal Energy Development, Teknika Universe Scientific Journal, 17(1), 68–82. https://doi.org/doi: 10.1016/j.ygyno.2008.08.036
[5] Farduwin, A., and Yuliansyah, Z. (2011): Geothermal Development, The 11TH Annual Indonesian Geothermal Association Meeting & Conference, 1–6.
[6] Ginting, A. M., Nusantara, G., Setjen, L., and Ri, D. P. R. (2014): DYNAMICS OF POLICY AND DETERMINATION OF GEOTHERMAL ELECTRICITY RATES: CASE STUDY SIBAYAK PLTP * (Policies Dynamics and Determination of Geothermal Electricity Tariff : Case Study at the PLTP of Sibayak) A ., 211–224.

[7] Ministry of Energy and Mineral Resources (2017): PERMEN ESDM No. 50 Tahun 2017.
[8] Ministry of Energy and Mineral Resources (2018): Doing Business In Geothermal, retrieved from internet: https://www.google.com/url?sa=t&source=web&rct=j&url=http://igis.esdm.go.id/igis/img/Proses_Bisnis.pdf&ved=2ahUKEwjzmNzxjcjgAhUFX30KHUw8AtUQFjABegQIARAB&usg=AOvVaw0vW0fhjWQVjybiD3-HPm74.
[9] Ministry of Energy and Mineral Resources (2019): Kepmen ESDM 55 Tahun 2019.
[10] Lubiantara, B. (2012): Oil and Gas Economy: Overview of the Commercial Aspects of Oil and Gas Contracts, Grasindo, xv, 260 p. : ill.; 22 cm.
[11] Lubiantara, B., and Lubis, B. (ed. . (2014): Dynamics of the Oil and Gas Industry: Analyst Records OPEC, Petromindo.com, Jakarta.
[12] Rakhmanto, P. A. (2016): Economics of Geothermal Electricity.
[13] Rozaq, K., Rahayu, D., and Bramantio, B. (2015): Development of Geothermal in Indonesia - PGE, World Geothermal Congress 2015, (April), 7.
[14] Saptadji, N. (2008): Overview of Geothermal Energy, ITB: Bandung.
[15] Saptadji, N. M. (2001): Geothermal Technical, 1–306.
[16] Wahjosoedibjo, A. S., and Hasan, M. (2018): Indonesia's Geothermal Development: Where is it Going?