Preliminary Financial Modelling with Probabilistic Approach for Geothermal Development Project in Indonesia

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Abstract. The right of geothermal field concession in Indonesia is obtained by tender as per Law No. 21/2014 Article 18. In the submitted proposal, the developer candidates shall mention the plan of field development strategy, while available data is limited due to a preliminary survey or preliminary survey and exploration were just performed. Then the developer candidates must be able to formulate the financial condition of the project so that the field utilization not only sustains but also produces appropriate profits. This paper discussed some regulations which are related to the economics of geothermal development project in Indonesia and a simple example of financial modelling with a probabilistic approach using Microsoft Excel Monte Carlo simulation and analysis tool. The input data were some technical assumptions such as installed capacity, steam fraction, steam specific consumption (SSC), well’s capacity, well’s success ratio, and financial assumptions such as well’s price, power plant construction’s cost, operation and maintenance cost, and others. The output of modelling were NPV (Net Present Value), IRR (Internal Rate of Return) and parameters that were sensitive to both values, whether financially or technically. The result of simulation showed from the financial aspect, wells and power plant cost were the most sensitive parameters in IRR calculation, while well’s capacity and steam fraction were the most sensitive parameters from the technical aspect.

1. Introduction
The geothermal business pattern in Indonesia is regulated by Government Regulation No. 7/2017 [1] about “Geothermal for Indirect Use” (Figure 1), where the developer will have the right of a field concession by winning the tender. In the submitted proposal, the developer candidate should mention the plan of development strategy and cost budgeting. However, available data is limited due to a preliminary survey, or preliminary survey, and exploration were just performed. It is not even known whether the field is feasible or not feasible to develop because the feasibility study has not been conducted. Since geothermal development is a long-term project, then the developer candidates must be able to formulate the financial condition of the project so that the field utilization not only sustains but also produces appropriate profits. The technical study, such as numerical simulation, is used to calculate the amount of resource and forecast the field performance so that the production can be sustained as long as the contract period, or more. On the other hand, financial modelling is required to evaluate the
result of technical study whether the chosen strategy will be able to provide appropriate profits. The parameters for evaluating the financial condition of a geothermal project are NPV and IRR [2].

Figure 1. Geothermal business pattern in Indonesia [1].

2. Main Cost Components of Geothermal Project Development

Geothermal development projects require substantial front-end investment and site-specific. Two significant capital costs were well’s drilling and power plant construction. The cost of well’s drilling included exploration wells, production well, and reinjection wells covered 35-46% of total investment cost [3]. Sometimes there were some wells which are not commercially productive. The success ratio of the first well drilled was 50%, then for the first five wells drilled, it was around 59%, then rose to 74% during the development phase and reached 83% for wells drilled at the operation stage [4]. In terms of plant construction, the high investment cost was influenced by the limited number of plant main components suppliers. The combination of three market leaders (Mitsubishi, Toshiba and Fuji) controlled more than 80% of the turbine and generator market share in the world [5]. It is very essential for the developer candidate to understand the risk of a geothermal development project. Figure 2 below shows the breakdown of the main investment components of a geothermal development project in Indonesia. The cost of geothermal development project generally 3-6 million USD per MW installed capacity [6].

Figure 2. Breakdown main investment components of geothermal development project in Indonesia [3].
3. Geothermal Fiscal Policy in Indonesia

Following Indonesia’s fiscal policy were considered in this financial modelling.

3.1. Income Tax

The income tax will be billed to the developers if the cumulative taxable income is already positive. For old concession contract, the income tax rate is 34% based on Ministry of Finance Decree No. 766/KMK.04/1992 [7], which was already updated to Ministry of Finance Regulation No. 90/PMK.02/2017 [8]. In this policy, the value-added tax, tax on land and building, and other levies will be borne by the government. The government also will refund the production bonus which has been issued by the developers. In 2014, Law No.21/2014 [9] about “Geothermal” was issued. There are no specific rules regarding the rate of income tax or other taxes. Then the rate of income tax for a new concession contract will be 25% as per Law No. 36/2008 [10] about “Income Tax”.

3.2. Value Added Tax and Import Tax

According to the Ministry of Finance Decree No. 231/KMK.03/2001 [11], which was already updated became Ministry of Finance Regulation No. 137/PMK.101/2018 [12]. The geothermal developers are exempt from value-added tax and import tax for importing production goods. For domestic goods and service, the value-added tax rate is 10%, based on Law No. 42/2009 [13]. In this paper, the value added tax was already included in investment cost.

3.3. Tax on Land and Building

Tax on Land and Building for geothermal activities during the exploration stage is regulated in Minister of Finance Regulation No. 172/PMK.101/2016 [14]. According to this policy, the tax on land and building during the exploration period is 100% free. In the production period, the tax on land and building rate will be referred to Director General of Tax Regulation No. PER-45/PJ/2013 [15] about “Tax on Land and Building Procedures for Oil, Gas and Geothermal Sector”. Since the value is relatively small, the contribution of tax on land and building was ignored in this paper.

3.4. Tax Incentive

The basis of tax incentives for geothermal activities is Minister of Finance Regulation No. 21/PMK.011/2010 [16]. The incentives obtained included a reduction in net income of 30%, charging for 6 years. Then there is also accelerated depreciation and amortization. The depreciation period for fixed assets is 8 years, with 25% rate and decline balance method. Depreciation was imposed on the tangible cost components, while the intangible components were calculated as expense [17].

3.5. Production Bonus

The production bonus is given to the areas where the geothermal concession is located so that they will have a direct benefit from the geothermal activities. The policy of production bonus is regulated in Minister of Energy and Mineral Resources (MEMR) Regulation No. 23/2017 [18]. Based on this regulation, the amount of production bonus is 1% of steam sales gross revenue or 0.5% of electricity sales gross revenue.

3.6. Fees

There are several fees which have to paid by the developers as per MEMR Regulation No. 14/2015 [19]. The first one is exploration fixed fee, which is related to the area that was used during the exploration period. This fee is imposed since the issuance of the geothermal permit until Commercial Operation Date (COD). The second one is an operation fixed fee, which is related to the area that is used in the operation period. This fee is imposed since the COD of the first unit. The last one is the production fee
(royalty), which is calculated based on electricity sales. In this paper, all those fees were assumed already included in operation and maintenance (O & M) cost.

3.7. Electricity Tariff
In the previous regime, the pricing policy of geothermal electricity was referred to MEMR Regulation No. 17/2014, where the price was determined based on feed-in tariff. However, in the current regime, the electricity price is determined based on the average cost of electricity generation or biaya pokok produksi (BPP) as per MEMR regulation No. 50/2017 [20]. Table 1 dan Table 2 show a comparison of geothermal pricing policy in Indonesia and the electricity price from some geothermal field in Indonesia.

| Table 1. Comparison of geothermal pricing policy in Indonesia (modified after[21]) |
|---------------------------------|----------------------------------|
| **Minister EMR Reg. 17/2014**  | **Ceiling Price, Various Capacity** |
| Region I                        | 15.0 cents/kWh                   |
| Region II                       | 21.9 cents/kWh                   |
| Region III                      | 28.7 cents/kWh                   |
| **API Calculation**             | **Feed in Tariff**               |
| 110 MW                          | 16.2 cents/kWh                   |
| 55 MW                           | 18.8 cents/kWh                   |
| 20 MW                           | 23.1 cents/kWh                   |
| 10 MW                           | 29.7 cents/kWh                   |
| **Minister EMR Reg. 50/2017**   | **100% BPP national or local**   |
| Java-Bali-Sumatera              | 7.59 -17.52 cents/kWh            |
| Sulawesi-West NT                | 7.63-17.52 cents/kWh             |
| East NT-Maluku                  | 11.93-17.52 cents/kWh            |

| Table 2. Electricity price of some geothermal field in Indonesia |
|---------------------------------------------------------------|
| **Power Plant** | **Developer** | **Year of COD** | **Price (Cents USD/kWh)** | **References** |
| Sarulla Unit 1   | SOL           | 2017            | 6.79                       | [22]           |
| Sarulla Unit 2   | SOL           | 2017            | 6.79                       | [22]           |
| Sarulla Unit 3   | SOL           | 2018            | 6.79                       | [22]           |
| Ulubelu Unit 3   | PGE           | 2016            | 7.53                       | [23]           |
| Ulubelu Unit 4   | PGE           | 2017            | 7.53                       | [23]           |
| Kamojang Unit 5  | PGE           | 2015            | 9.4                        | [24]           |
| Lahendong Unit 5 | PGE           | 2016            | 11.42                      | [23]           |
| Lahendong Unit 6 | PGE           | 2016            | 11.42                      | [23]           |
| Karaha Unit 1    | PGE           | 2018            | 8.6                        | [23]           |

4. Methodology
The objectives of financial modelling are to estimate the number of investment costs, to compile cash flow projection, to determine indicators of project profitability and to determine the project financing structure [17]. The main parameters were used in the modelling were revenue, capital, expense, depreciation, tax, cash flow NPV, and IRR. However, since it was still in the tender stage, the input variable for those parameters have some uncertainties. Therefore, the Monte Carlo simulation will be
very beneficial to determine the probabilistic of NPV or IRR value in the financial model calculation. This Monte Carlo simulation and analysis tool can be added to Microsoft Excel. In this facility, the probability assumption for each input variable was defined, then the NPV and IRR value was set as a forecast result. The probability of input variable was set as uniform distribution (min. and max.), triangle distribution (min, max and most likely) or fixed value, depends on the available data. The flow chart of the financial modelling discussed in this paper is shown in Figure 3 below.

![Flowchart of financial modelling.](image)

**Figure 3.** Flowchart of financial modelling.

The first step in financial modelling was determining the input variables for project parameters, technical parameter, and financial parameters. Those variables can vary in each case, depends on data availability. Table 3 shows an example of input variables of financial modelling for 55 MW installed capacity that is summarized from several sources. Some of the variables were assumed by authors team. The calculation for the upstream section was separated from the downstream section. Then, the investment costs were distributed based on the project schedule. The next steps were to calculate the revenue, depreciation, loan, tax up to cash flow each year. Figure 4 shows an example of project scheduling for the geothermal development project.
### Table 3. Example of input variables for financial modelling.

#### Project Parameters

| Input Data                              | Value          |
|-----------------------------------------|----------------|
| Installed Capacity Unit 1 (MW)          | 55             |
| Exploration & Development Period       | Jan 2017 - Sept 2023 |
| Construction Period                     | Jan 2021 - Sept 2023 |
| Utilization Period                      | Oct 2024 - Sept 2053 |
| Power Plant Design                      | Single Flash/Separated Cycle |

#### Technical Assumption

| Input Data                              | Min     | Most/Fix | Max     | Reference            |
|-----------------------------------------|---------|----------|---------|----------------------|
| Capacity Factor                         | 90%     |          | 97%     | [25]                 |
| SSC (Ton/h/MWe)                         | 7.2     | 7.5      | 7.8     | Assumption turbine inlet pressure 6.5 Bar |
| Steam Quality on Gathering System       | 10%     |          | 20%     | Recalculated from [26]|
| Excess Steam                            | 10%     |          |         | Assumption           |
| Output Condensate                       | 20%     |          |         | Assumption           |
| Decline Rate                            | 2%      | 4%       | 6%      | [27]                 |
| Number of Exploration Well              | 3       |          |         | Assumption           |
| Exploration Well Success Ratio          | 50%     |          |         | [4]                  |
| Exploration, Production & Make-Up Well Capacity (MWe) | 3 | 5 | 9 | [28] |
| Production Well Success Ratio           | 74%     |          | 83%     | [4]                  |
| Make Up Well Success Ratio              | 74%     |          | 83%     | [4]                  |
| Injection Well Capacity (Ton/h)         | 430     |          |         | Assumption           |
| Minimum Make-Up Well on a Campaign      | 3       |          |         | Assumption           |

#### Investment Cost Assumption

| Input Data (Steam Field)                | Min (USD) | Most/Fix (USD) | Max (USD) | Reference                |
|-----------------------------------------|-----------|----------------|-----------|--------------------------|
| Capital                                 |           |                |           |                         |
| Land Cost, Environmental Study & Civil Work | 1,000,000 | 1,000,000 | 10,000,000 | [3]                     |
| Exploration Drilling (Per Well)         | 4,000,000 | 6,000,000 | 8,000,000 | [3]                     |
| Development Drilling (Per Well)         | 4,000,000 | 6,000,000 | 8,000,000 | [3]                     |
| Injection Drilling (Per Well)           | 4,000,000 | 6,000,000 | 8,000,000 | [3]                     |
| Make Up Well Drilling (Per Well)        | 4,000,000 | 6,000,000 | 8,000,000 | [3]                     |
| Gathering System (per MW)               | 200,000   | 320,000      | 440,000   | [5]                     |
| Piping & Production Facilities         | 17,325,000 | 19,250,000 | 21,175,000 | Modified from [21]      |
| Support Facilities                     | 1,000,000 |              |           | Assumption               |
| Piping Cost for Make Up Well            | 25% of Capital |          |           | Assumption               |
| Expense                                 |           |                |           |                         |
| Detail 3G Survey                       | 1,000,000 | 2,000,000 | 3,000,000 | [3]                     |
| Core Holes                              |           | 1,000,000 |          | [3]                     |
| Resource Study & Modelling (per MW)     | 100,000   |              |           | [6]                     |
| Feasibility Study (Per MW)              | 100,000   | 140,000     | 200,000   | [3]                     |
| O & M Upstream (Per MW)                 | 100,000   | 140,000     | 200,000   | [3]                     |
| Electricity Price (Cents USD/kWh)       | 8.0       | 9.0         | 10.0      | [20]                    |
## Input Data (Plant)

|                          | Min (USD) | Most/Fix (USD) | Max (USD) | Reference |
|--------------------------|-----------|----------------|-----------|-----------|
| **Capital**              |           |                |           |           |
| Plant EPCC (Per MW)      | 1,360,000 | 1,600,000      | 2,060,000 | [5]       |
| **Expense**              |           |                |           |           |
| Other Cost, Include Adm./Management | 3,000,000 |                |           | [21]      |
| O & M Dowstream (Per MW) | 50,000    |                |           | [29]      |

Cost escalation is negligible

## Financial Parameters

|                          | Min | Most/Fix | Max | Reference |
|--------------------------|-----|----------|-----|-----------|
| Tangible Well Cost       | 44% |          |     | [30]      |
| Depreciation Period (Year)| 8   |          |     | [16]      |
| Depreciation Rate        | 25% |          |     | [16]      |
| Loan Percentage          | 70% |          |     | [27]      |
| Loan Period (Years)      | 20  |          |     | [27]      |
| Interest                 | 4%  |          |     | [27]      |
| Interest During Construction | 4%  | Assumed same as interest | | |
| Income Tax               | 25% |          |     | [10]      |
| Discount Rate            | 10% |          |     | [27]      |
| Investment Tax Allowance | 5%  | of Total Capital for 6 Years | [16] |
| Production Bonus         | 0.5%|          |     | [31]      |

### Figure 4.

Example of geothermal development project scheduling (modified from [5]).
5. NPV and IRR
NPV and IRR are common indicators in determining project feasibility. NPV is the sum of the discounted net amounts (present values) over the project life using a nominated discount rate, while IRR is the discount rate at which the net present value is 0 [27]. An investment is more attractive if the NPV value greater than 0, and the IRR higher than the required rate of return (RRR), for example, 12%. Please be noted that not every input variable can be adjusted to meet a proper NPV or IRR value.

6. Result
Based on financial modelling using Monte Carlo simulation and analysis tool, it was obtained the cumulative frequency of NPV and IRR as per Figure 5 and 6. The P10, P50, and P90 of NPV and IRR value are shown in Table 4 below. The cost of investment per MW installed capacity also can be estimated.

![Figure 5. Cumulative frequency of NPV.](image1)

![Figure 6. Cumulative frequency of IRR.](image2)
Table 4. Result of financial modelling with Monte Carlo probabilistic approach.

| Probability | Investment Cost (USD/MW) | NPV (USD) | IRR (%) |
|-------------|---------------------------|-----------|--------|
| P10         | 4,388,344                 | 8,003,770 | 11.11  |
| P50         | 4,878,819                 | 25,802,481| 13.78  |
| P90         | 5,494,356                 | 42,397,367| 16.41  |

Furthermore, the input variables which were sensitive to IRR value also can be obtained. Those variables were grouped into the technical aspect and financial aspect, as per Figure 7 and 8.

**Figure 7.** Technical input variables which were sensitive to IRR value.

**Figure 8.** Financial input variables which were sensitive to IRR value.
7. Conclusion
The following main conclusions can be made:
• It is very imperative for developers to understand the local regulation and policy in planning geothermal development project.
• Considering the data availability is still limited at the tender stage of the geothermal working area, the Monte Carlo probabilistic approach was very beneficial in evaluating the feasibility of the project.
• Based on financial modelling with Monte Carlo probabilistic approach, the most sensitive input variables to IRR from financial aspect were the electricity selling price, production wells cost, and power plant construction cost. Whereas from the technical aspect, the most sensitive input variables are production wells capacity, stream fraction at the surface facility, and capacity factor.

8. Discussion
The result of financial modelling depends on the quality of input data. Using more detailed and up to date data will improve the accuracy of this modelling.

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