INVESTMENT ANALYSIS ON DEVELOPING BINARY POWER PLANT IN GEOTHERMAL FIELD

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ABSTRACT

The conversion energy of Geothermal Power plant usually lower than conventional thermal power plant (coal, gas, nuclear Etc). Geothermal power plants conversion efficiency estimation is based on the enthalpy of the produced geothermal fluid. Most of geothermal fluid consist of two phase fluid, steam and brine, usually only the steam can be used to be utilized to generate electricity, as the brine, it will be reinjected back to geothermal reservoir. This what makes one of the causes of why efficiency in geothermal power plant is low, Due to brine energy is not utilized. In order to increase utilization of brine energy, the binary power plant system is proposed, the system converse heat from brine to generate power, however, although the system has proven, it's not widely used in Indonesia due to reluctancy from geothermal developer as the feasibility to utilize the system is not widely known.

Keywords: Geothermal, Power Generation, Binary Technology, Investment, Sensitivity Analysis

INTRODUCTION

According to the data of the MEMR, as of April 2021, Indonesia has a total installed power capacity of 72,889MW, of which 62,399MW or 85.61% is fossil energy and 10,490MW or 14.39% is new and renewable energy. with 30,980 MW consist of coal fired power plant, making it as the nation backbone of electricity, with the average growth of electricity market by 3.5%. The government of Indonesia has planned to do transition to new and renewable energy, by increasing its portion up to 23% by 2030, compare from present condition which stand at 14.39%. Based on RUPTL 2021-2030, the new and renewable energy will dominate development of power plant where geothermal energy planned to have addition of 3,355 MW of installed capacity, in order to reach the goal, an average of 300 MW of geothermal power plant must be installed per year, however, based on history, the average of additional geothermal power plant per year stand at 57 MW, far below RUPTL target. In order to reach the goal, the government has planned acceleration program which one of main point of the program is to optimizing geothermal resources in geothermal working area that are already in production by developing/expanding and developing small-scale power plants, the binary power plant can be proposed as one of the solution. The binary power plant technology has been used commercially since 1970, this technology can utilize unused brine as source of power, thus has potential to increase power generation in geothermal field, however, at present, the technology just enter the nation market since 2017. The economic feasibility is become one of reason of why investor reluctant to invest in this technology. The scope of this research is limited on existing geothermal working areas that already produced in java island, as for regulated electricity price, refer to Kepmen 169.K/HK.02/MEM.M/2021, the average production cost for electricity price in java island is stand at 0.062 USD/Kwh, thus in order for binary system to be feasible, the production cost must be lower than regulated price..

LITERATURE REVIEW

Financial Management Theory

The basic principle of financial management theory (Damodaran,2011) is as follows:

The investment principle: Invest in assets and projects that yield a return greater than the minimum acceptable hurdle rate. The hurdle rate should be higher for riskier projects and should reflect the financing with owners' funds (equity) or borrowed money (debt). Returns on projects should be measured based on cash flows generated and the timing of these cash flows; they should also consider both positive and negative side effects of these projects.

The Financing Principle: Choose a financing mix (debt and equity) that maximizes the value of the investments made and match the financing to nature of the assets being financed.This part describes the literatures related to the study. It may consists of primary references (grand theory, concept); journal articles (preferable published in the last 10 years); main idea from text book or electronic articles. For empirical study which uses hypotheses development, the literatures aim to strengthen the arguments for variable selection and each proposed hypothesis.

Levelized Cost of Energy (LCOE) Theory

The LCOE is a measurement used to assess and compare alternative methods of energy production. The LCOE of an energy-generating asset can be thought of as the average total cost of building and operating the asset per unit of total electricity generated over an assumed lifetime (EIA,2022), it is used for investment planning and to compare different methods of electricity generation on a consistent basis.

Previous Research

Subroto (2020), conduct a system dynamic modelling for analyzing the growth of geothermal power plant in Indonesia to analyze whether development gap between the targeted and the current installed capacity of the geothermal power plant can be achieved or not and propose relevant scenario that can be implemented to support and expedite the targeted growth based on simulation, the outcome of the research is conclude that the geothermal setting target is not realistic and need some adjustment.

Kristina (2018), conduct analysis of geothermal development & production cost and the impact from geothermal tariff policy in sumatera island, Indonesia to analyze and evaluate cost of development and production of geothermal in region Sumatra for green field area, so it can gives feedback for intervention policy in the future related to electricity tariff in Geothermal industry, the conclusion of the research is the regulated electricity tariff in region sumatera is lower than investor requirement, so the tariff must be negotiated through B2B mechanism.

Rizal (2022), conduct research about favorable business investment and operation methodology in developing geothermal Electricity in Indonesia to explore options of business decisions to enable a generic geothermal firm reaching a fair economic return to its investor under current electricity tariff scheme by PT. PLN, the result is to have fair economic return, investor should add other revenue streams, proposed IPO to lower tax, issue a green bond and making joint venture to optimized financing cost.

METHODOLOGY

Research Variables

There are four main variables in this research that are:

a. Investment cost
   The amount of money spent for the investment, the value of this variable depends on rate of interest and opportunity to used tax exemption when procure goods.
b. Operational and Maintenance Cost
   The cost that must be spend during project lifetime, the variable value depends on brine resources characteristic and size of binary power plant.
c. Fuel Cost
   For binary power plant, the fuel comes in term of production well that must be provided periodically depend on brine resources availability.
d. Revenue
   The gross income returned by an investment, for binary power plant, revenue depend on electricity price and plant capacity factor.

Data Processing and Analysis

After collecting the data, economic feasibility is conducted based on business as usual condition then based on the optimization that can be done to increase economic value for the project such as lowering interest rate, selecting optimum plant size, etc. the outcome of this data is related to IRR and NPV of binary project, if for both scenario the project prove still not economically feasible, then sensitivity analysis is conducted on those 4 variables in order to understand which dominant parameter that affect project feasibility.

FINDINGS AND ARGUMENT

Business as usual scenario

For the business as usual scenario, the assumption parameters that used to do analysis on development of binary power plant is shown below:

Table 1. Assumption parameters for construction cost for Business as Usual Scenario

Item	Unit	Value	Remarks
Unit Size	MW	5	Net value
Purchase Equipment Cost (PEC)	MW	15,000,000	Power Plant only cost
Piping and installation cost	USD	1,500,000	10% of PEC
Instrumentation and control system	USD	750,000	5% of PEC
Construction cost	USD	1,500,000	10% of PEC
Contingencies	USD	1,500,000	10% of PEC
Engineering and Supervision	USD	750,000	5% of PEC
Civil and Structural work	USD	4,500,000	30% of PEC
Working capital and project management		150,000	5% of PEC
Analysis of fluids chemistry, reservoir simulation study and environmental impact assesment	USD	250,000	Constant Value

Total Cost	USD	25,900,000	

Table 2. Assumption parameters for financial unit for Business as Usual Scenario

Item	Unit	Value	Remarks
Equity Portion	Percentage	30	
Loan Portion	Percentage	70	
Interest Rate	Percentage	4.85	Based on bond rate of certain geothermal industry
WACC	Percentage	4.91	Derived from interest rate
Plant Capacity Factor	Percentage	73	Based on PLN data
Project lifetime	Years	30	Based on agreement with PLN
Length of payment	Years	15	
Operation and maintenance cost	Mil USD	0.975	Annual cost
Fuel Cost	Mil USD	34.3	For entire project lifetime

The LCOE value for this scenario stands at 0.10 USD/Kwh, if refer to regulated price that stand at USD 0.062 USD/Kwh, then for this business as usual scenario, the project is not feasible economically, the calculated NPV and IRR value stand at USD (26,506,844) and -24.8% respectively.

Optimization scenario

For the optimization scenario, it utilizes several factors that can increased economic value of the project, these factor are:

- Lower Financing interest: since binary is categorized as green energy, there are lender that willing to financing a project with lower interest compared to conventional project, in this case, an example from Asian Development Bank (ADB) is taken, ADB can provide loan with 2.2% interest rate
- Utilize tax exemption facility : based on government regulation No. 218/PMK.04/2019 related "Exemption from Import Duty on Imported Goods for Geothermal Business Activities" and regulation No 66 of 2015 related "Exemption from Import Duty on Imported Capital Goods in the Context of Development or Development of the Power Generation Industry for Public Interest", with these regulation, the tax for import duty is 7.5%, and the added value tax is 11%, means there is possibility to reduce the cost of imported goods by 18.5%,
- Utilize sustainable unused brine production: For existing water dominated geothermal working area, the brine is not utilized, as its reinjected back to injection well, with this kind of circumstances, the brine can be used as fuel for binary system at free cost, thus diminishing fuel cost, the matter is whether brine volume is sustain enough to be utilized in the binary system over the years, based on author data, is it possible to maintain brine sustainability for binary power plant with plant capacity at 5 MW.
- Increasing CF value to 80%: based on PLN data, the average geothermal CF is stand at 73%, however based on actual operational data, is it possible for geothermal power plant to have CF up to 80%.

Based on several factors above, the assumption parameters that used to do analysis on development of binary power plant for optimization scenario is shown below:

Table 3. Assumption parameters for construction cost for Optimization Scenario

Item	Unit	Value	Remarks
Unit Size	MW	5	Net value
Purchase Equipment Cost (PEC)	MW	12,500,000	Power Plant only cost after tax exemption
Piping and installation cost	USD	1,500,000	10% of PEC
Instrumentation and control system	USD	750,000	5% of PEC
Construction cost	USD	1,500,000	10% of PEC
Contingencies	USD	1,500,000	10% of PEC
Engineering and Supervision	USD	750,000	5% of PEC
Civil and Structural work	USD	4,500,000	30% of PEC
Working capital and project management		150,000	5% of PEC
Analysis of fluids chemistry, reservoir simulation study and environmental impact assesment	USD	250,000	Constant Value
Total Cost	USD	23,650,000	

Table 4. Assumption parameters for financial unit for Optimization Scenario

Item	Unit	Value	Remarks
Equity Portion	Percentage	30	
Loan Portion	Percentage	70	
Interest Rate	Percentage	2.2	Based on Asian Development Bank Rate for green project
WACC	Percentage	4.05	Derived from interest rate
Plant Capacity Factor	Percentage	73	Based on PLN data
Project lifetime	Years	30	Based on agreement with PLN
Length of payment	Years	15	
Operation and maintenance cost	Mil USD	0.975	Annual cost
Fuel Cost	Mil USD	0	Diminish due to utilization of unused brine as fuel

For the optimization scenario, the LCOE value stand at USD 0.056 USD/Kwh, the optimization scenario can provide a value below regulated price, however in term of economic feasibility, the IRR value is stand at 3.5% below WACC value that stand at 4.05%, as result, the NPV generates negative value for the project thus makes project still not feasible.

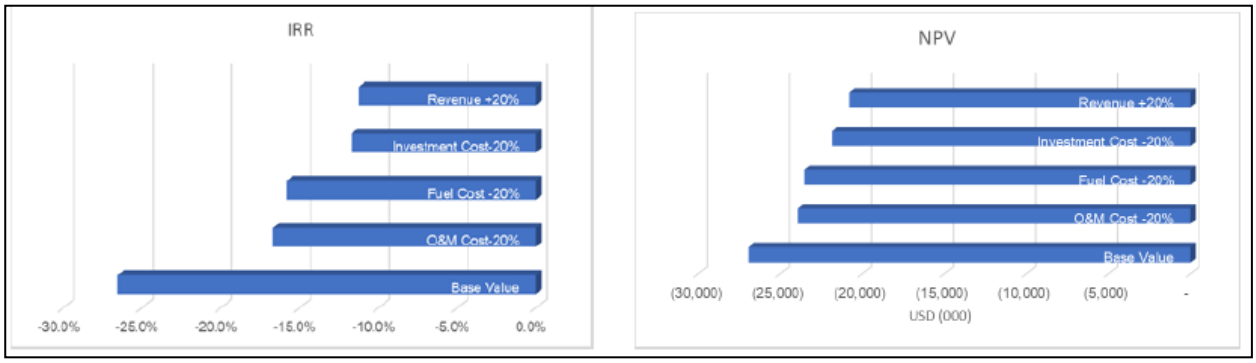
Sensitivity Analysis

As both scenarios is not economically feasible, the sensitivity analysis is conducted with the result as shown below:
a. Sensitivity analysis for business as usual scenario

Table 5. Sensitivity Analysis for Business as Usual Scenario

Variables	IRR	Increment	NPV (USD)	Increment (USD)
Base Value	-26.5%	0.0%	(26,928,615.71)	0
O&M Cost -20%	-16.7%	9.9%	(23,897,797.43)	3,030,818.28
Fuel Cost -20%	-15.8%	10.7%	(23,503,239.59)	3,425,376.11
Investment Cost -20%	-11.7%	14.8%	(21,841,224.02)	5,087,391.69
Revenue +20%	-11.2%	15.3%	(20,770,752.76)	6,157,862.95

Figure 1. Sensitivity Analysis for Business as Usual Scenario

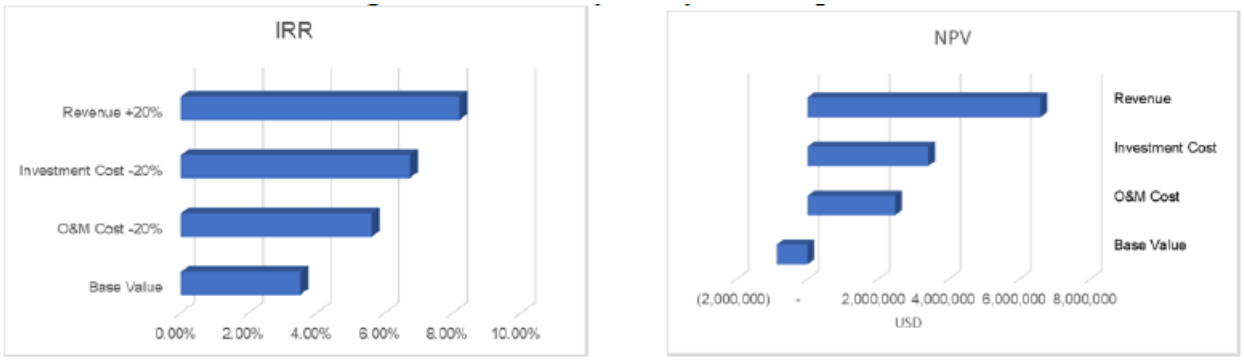


b. Sensitivity analysis for optimization scenario

Table 6. Sensitivity Analysis for Optimization Scenario

Variables	IRR	Increment	NPV (USD)	Increment (USD)
Base Value	3.5%	0.0%	(870,756)	0
O&M Cost -20%	5.6%	2.1%	2,483,237.15	1,612,480.98
Investment Cost -20%	6.72%	3.22%	3,417,318.02	2,546,561.86
Revenue +20%	8.18%	4.68%	6,597,160.11	5,726,403.94

Figure 2. Sensitivity Analysis for Optimization Scenario



Based on the data above, the sensitivity analysis in the optimization scenario gives better result than business as usual scenario, it makes project becomes economically feasible since the IRR value is greater than WACC value thus generated positive NPV Value, the highest IRR can be achieved is at 8.18%, an increase of 4.68% from base value, by adjusting revenue variable to 20%, the NPV value become USD 6,597,160.11, however, even with this value the payback period is in 19.2 years or almost two thirds of project lifetime.

For both scenarios, it shows that revenue variable is affecting IRR value higher than other variables, thus it should become priority for developer when it comes to develop binary project, revenue can be increase by two means, by raising CF value or negotiate electricity price with government, whereas for the least affecting parameter is related to operation and maintenance cost.

CONCLUSIONS

For business as usual scenario, the LCOE cost for binary is stand at 0,10 USD/Kwh, whereas based on MEMR decree no.4/2020 and no.169/2021, the production cost for java island stand at 0.062 USD/Kwh and the tariff ceiling for geothermal is at 100% of production cost. The price gap between LCOE value and tariff ceiling is at 0.038 USD/Kwh or 38%.

Sensitivity analysis that conducted for business as usual scenario shows that, the project will not become feasible economically since the best possible IRR that can be achieved is at -11.2%. means at business as usual condition, the binary project will not economically feasible.

For optimization scenario, it utilizes facility that granted to green energy project, such as lower financing interest and tax exemption, it also increasing revenue based on actual realization of CF in Geothermal power plant.
The result of LCOE for optimization scenario is at 0.056 USD/Kwh, down by 56% compared to LCOE in business as usual scenario, the main factor that reduced LCOE cost is due to diminishing fuel cost, that makes up to 30% of production cost in business as usual scenario. It means that in order to diminish fuel cost, the capacity of the binary plant must not exceed the excess of the brine that produced sustainably in the existing area.

However, even though optimization has been conducted, the LCOE value has become lowered, it still not met its economic value, with price capped at USD 0.062 USD/Kwh, the result of IRR is 3.5%, still under WACC value at 4.05%, thus making NPV value become negative.

Sensitivity analysis that conducted for optimization scenario shows that the best possible IRR that can be achieved is at 8.18% whereas for the lowest possible value is at 5.6%, still above WACC value that stand at 4.05%, thus makes project become economically feasible.

For both scenarios, increasing revenue become dominant factor in increasing IRR Value, so it should be main strategies for developer when it comes to develop binary project. Increasing revenue can be done by two means, by increasing CF Value or by increasing electricity price through negotiation with PLN, by combining those two means the economic value of project will be increased.

REFERENCES

Damodaran, Aswath,.(2014), Applied Corporate Finance (3rd Edition), NYU, John Wiley & Sons
Subroto, R. Wisnu,.(2020), A System Dynamic Modelling for Analyzing The Growth of Geothermal Power Plant in Indonesia.
Kristina, Anggita Dwi,.(2018), Analysis of Geothermal Development & Production cost, and The Impact from Geothermal Tariff Policy in Sumatera Island, Indonesia.
Rizal, Mohamad,.(2022), In Search of Favorable Business Investment and Operation Methodology in Developing Geothermal Electricity in Indonesia.
Yılmaz, Ceyhun.,(2018), Comparison of Thermoeconomic Cost Calculation For A Binary Geothermal Power Plant.
Shamoushaki, M.;Manfrida, G.; Talluri, L.; Niknam,P.H.; Fiaschi, D.,(2021), Different Geothermal Power Cycle Configurations Cost Estimation Models.

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