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Institutionalized Public-Private Partnership for Geothermal Power Generation in Indonesia: A Real Option Analysis

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ABSTRACT

Recent portfolio of energy generation in Indonesia is mostly based on fossil fuels, and the growing of energy consumption go on opposite direction of the government's goal for climate change mitigation. Indonesian government plans to achieve 23% share of renewables in national energy mix in 2025 where geothermal power as one of the largest contributor. As single off taker, PLN expects to develop geothermal power plant in close collaboration with the private sector, not only in a contractor-supplier relation but also in deep partnership where both PLN and the private sector have substantial responsibilities in managing and running the business. This model is acknowledged as institutionalized public–private partnership (iPPP)/ joint venture. This work will look at structure of how the risk is allocated, transferred and managed in PLN Geothermal iPPP Initiative to develop its Geothermal Working Areas (up to 400 MW). Portfolio construction is simulated to assess risk reduction benefit and its impact on project feasibility by implementing this scheme. In order to value and manage the project, Real Option Analysis (ROA) is undertaken. The sequence and interconnection of available Real Option are developed to assure flexibility of the project.

1. INTRODUCTION

In COP 21, it is set that in 2027 the target for emission for Indonesia is 1,200 Mt. CO2 equivalent. To achieve this objective and to provide cushion to support system economics when fossil energy prices increases, geothermal energy need to be developed in Indonesia. In 2027, the national generation capacity will be 500 TWh where 20% will be supplied by renewables including 10% by geothermal energy. Nevertheless, in order to accomplish this energy mix target, especially in geothermal sector, technical and pricing policy challenges need to be addressed.

Technical challenges include insufficient data in bidding stage, lack of competency and less equity fund of developer. According to Castlerock (2009), the pricing policy includes four areas for attention, namely

1. Exploration (upfront) risk
2. Segmented pricing framework
3. Fund to incremental cost gap
4. New Geothermal Working Area tender process

Nonetheless, to accelerate the development of geothermal energy is slightly of an enormous task due to the aforementioned obstacles.

This paper will present preliminary approach of PLN initiative to address first and second pricing policy issues by promoting institutionalized public-private partnership (iPPP)/ joint-venture. First, the paper will clarify the concept and rationale of iPPPs. Their benefits, pointing out the risks allocation. The economics behind geothermal power plants is also addressed, identifying the key success factors and making a deeper investigation on the risk sharing scheme adopted for the development of geothermal power plants. A general overview of the geothermal electricity sector will be presented, dividing the value-chain into its main components and identifying the key stakeholders in each sub-system, as well as the respective industrial organization model. A public selection procedure for a package of 360 MW geothermal capacity is discussed next, focusing on the process of selection of the private partner, on the risk sharing scheme adopted and on the portfolio construction.

2. IPPP ARRANGEMENTS IN THE GEOTHERMAL ENERGY SECTOR

2.1 iPPP Definition

The importance of the geothermal sector for climate protection and electricity price cushion is driving PLN as public utility to seek innovative approaches to harnessing private sector upstream management skills and investment capabilities, i.e. institutionalized Public-Private Partnership (iPPP).

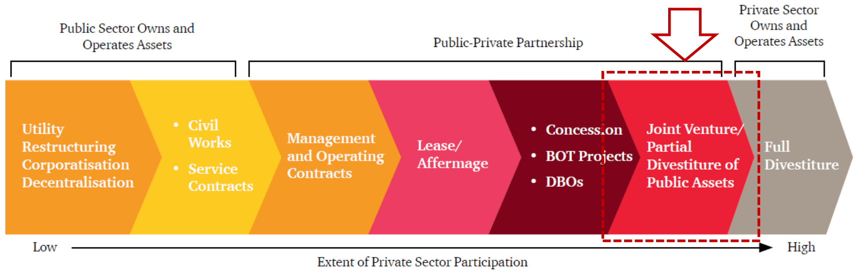

Figure 1: iPPP/ Joint Venture position (dashed square) in public-private project spectrum (World Bank).

An iPPP operates like a share corporation in terms of governance and autonomy. In an iPPP, the public partner (i.e. PLN) will create a new company and can retain the majority share while a private operator with the capacity to optimize the processes and improve efficiency, or multiple private investors joined with the operator, hold the minority share – and vice versa. In addition, the private partner enters into a management contract with the public partner for day-to-day operations. A joint-venture (JV) in the geothermal sector has specific features that complicate the provision and management of services. These include a monopoly market with location-based pricing, the high cost of entry, and exploration risk. The iPPP model can help mitigate major risks by drawing on the strengths of both the public and private partners.

2.2 Benefit of Using iPPP Model

Public party prefer to take a substantial stake in a project company or maintain a substantial stake in a utility involved in an iPPP. However, as the public and private sectors work in very different manners and have different processes and priorities, in practice this can cause challenges. Benefit of this model are (World Bank, 2013):

- Access to different sources of finance
- Public party can exercise some degree of control over day to day operations or at least key decisions (at board and shareholder level)
- Transparency (accounts and finances presented to board)
- Public perception – this is not privatization or private provision of a service
- Sustainability – continuity of partners – even if private partner changes
- Share of profits

However, as share ownership alone does not necessarily guarantee these advantages, attention needs to be given to the shareholder agreement. Indeed, a private party can achieve a number of these advantages with 49% shareholding if the structure is properly designed which will be described later in case study analysis.

This model is mainly intended to address the fact that renewable energy still has a higher cost than traditional sources, and financing mechanisms need to be found to overcome this gap, and foster the development of these technologies (Yue et al., 2001).

It is clear that currently the political priority given to geothermal power development to PLN as single off-taker. In fact, the investments in this field are being used by the government as a representation of the country's ability to transform and deal with future challenges of renewable energy provision.

This leads to the discussion on the risk-sharing assumptions of the contract. The risk-sharing matrix shows a large majority of risks being entirely (or mostly) assumed by the joint venture. This is a desirable principle for a successful iPPP, but, unfortunately, may not always achieved. Nevertheless, the demand risk is not completely removed from the public sector (PLN), since in case of a grid failure the energy produced would be paid but not sold.

With regard to approach local BPP, one of the main benefit of iPPP is that the public entity can provide access to low-cost, public financing for the joint venture that would otherwise not be available to a private entity. On the other hand, PLN will have access to best geothermal expertise on the market, joining two benefits of public and private entities. The advantage is quantified and presented in Figure 3. Main assumptions used in the simulation are:

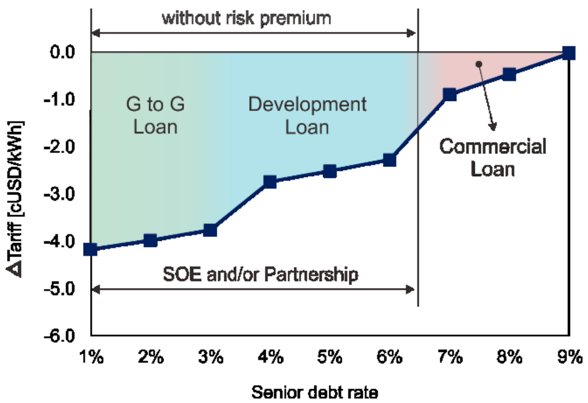

Figure 1: Tariff reduction sensitivity to senior debt rate.

- Reservoir temperature of 240 °C
- Steam water ratio of 5.4 (dryness of 84%)
- Wellhead, incremental, single-flash condensing generation units
- Investment cost of 4,400 $/kW (55 MW)
- Debt to Equity ratio of 70:30
- Tenor between 20 years for G to G loan;
- 15 years for SOE soft loan; and 10 years for commercial loan.

From Figure 3, it can be shown that development and G to G loan lowering the tariff by 2.2 – 4.1 cUSD/kWh corresponds to senior debt rate of 6.5% to 1%. Nevertheless, time-lagging due to long processing time of low-cost financing is not included yet in the simulation.

2.3 Comparison between iPPPs and Traditional Models

iPPP arrangements, as a development model, should be compared with the traditional development methods to ensure that value for money is delivered. This means comparing the cost of developing the project under an iPPP scheme, with the hypothetical risk-adjusted cost of the project if developed solely by the public sector (Devapriya, 2006). It is then necessary to estimate the cost of construction and maintaining the installation (investment and O&M expenses) along with the risk entirely assumed by the public sector, contrasting to iPPP projects where risks are allocated to the private sector. If the value for money delivered by the iPPP solution is higher, then this development model should be adopted. In the case of geothermal power generation this question does exist because energy production is now carried out mostly by contractual PPP (cPPP) with independent private companies. The third alternative to geothermal energy project delivery is under a traditional model of public works, where can be extended to the development and management of the steam-field is private, but the power-plant is public (PLN).

3. GEOTHERMAL PARTNERSHIP SCHEME

3.1 Geothermal Fields

As aforementioned described, iPPP model enables access to different sources of finance. The public partner can provide the political influence to help access low-cost, public financing for the joint venture that would otherwise not be accessible to a private operator. Contrarily, the private partner may be able to help access market finance that the public partner's credit rating would otherwise not allow (at least not on favorable terms), and help to win the confidence of International Financial Institutions (IFIs) (Castro V. et al., 2011). This correlates to the fact that in order to meet power-system economics (local BPP), low-rate loan is required by the developer.

Therefore, the iPPP initiative is expected to answer the above requirement. As Currently, PLN has been assigned 11 Geothermal Working Areas (GWAs) with total capacity of 360 MW, which is listed in Table 1.

Table 1 PLN Geothermal Working Areas.

System	GWA	COD	Capacity
Java	Tangkuban Parahu	2024/25	60
	Ungaran	2024	55
Sumatera	Kepahiang	2024	110
	Danau Ranau	2030	20
Non - Java Sumatera	Tulehu	2021/22	20
	Ulumbu 5/6	2021/23	40
	Mataloko 2	2023	20
	Atadei	2023	10
	Songa Wayaua	2023	10
	Oka Ile Ange	2030	10
	Gn. Sirung	2028	5

Tariff should meet system economics, if not governmental support will be required to compensate power production cost (BPP) increase. There is trade-off between system and project economics. Factors that affect tariff can be categorized into two main components:

1. Controllable, such as infrastructure, study & investigation, drilling success ratio & cost, well capacity, FCRS & power-plant, project financing
2. Uncontrollable, such as regulation, social, etc.

Power-system economics, i.e. local BPP is regulated in Ministry of Energy and Mineral Resources (MEMR) Decree No. 50/2017. The local BPP values are stated in MEMR Act No. 1404 K/20/MEM/2017.

3.2 Selecting the Private Partner

For the evaluation of selections to phase A, the following technical 5 criteria were used: (A) Resource study; (B) Drilling; (C) Reservoir management; (D) EPC and (E) O&M. To each criteria was attributed a weight of 40%, 35%, 25%, 5% and 5%, respectively. Given the criteria weights for this public selection, the economic and financial factors were valued 60%, while the technical had a relative weight of 40%. This means that PLN strongly preferred the creation of an upstream capability (a weight of 90% given to the upstream experiences). In financial criteria, at least a working capital of 20% of total project cost must be provided to attract equity investment to the project.

3.3 Risk Sharing

Risk in iPPP projects is a critical matter for the success of this model, and its correct allocation is essential to ensure a better value for money than traditional scheme, i.e. public work, upstream - downstream, cPPP (IPP) models.

The joint-venture (JV) is entrusted with the responsibility of construction, financing and managing the power plant, but this does not mean, however, that it bears all the associated risks. With this type of development the aim is that each partner does what it is best fitted and prepared to, ensuring that services and infrastructure are provided as efficiently as possible. Although complex, a generally accepted principle for risk sharing is that each agent should bear the risk that is best capable of dealing with the risks associated with geothermal. The geothermal contract does not have a risk matrix or a study discriminating all the risks involved in a geothermal project. But this is the best methodology to identify, evaluate and allocate them, as mentioned in Table 2. As one might expect, in a iPPP contract the risks are mainly shared between the public and the private sectors, except for the risk of legal, price, force majeure, demand and competition risks. The risks most likely to occur are those related to the safety issue of workers, the accessibility to geothermal sites, operation and maintenance, the party performance, and after all those risks, the ones associated to the financial aspect.

Table 2 Main risks at PLN geothermal iPPP partnership.

Risk type	Risk description	Risk allocation		Probability	Impact level
		PLN	Private		
Financial	• Risk of insolvency of lenders • Uncertainty about rising inflation • Evolution of the financial burden • Amendment of conditions of tariff by the regulatory authorities	x	x	Medium	High
Legal	• Likelihood of new legislation with an impact on the structure cost • Stricter regulations	x		Low	High
Price	• Electricity production cost volatility (opportunity cost)	x		High	High
Demand and competition	• Location and displacement of enterprises • Threat about the coming of new competitors into the business	x		Low	High
Performance	• Uncertainty about the quality of service for drilling and power-plant maintenance • Increasing demand in service quality	To Be Determined*		Medium	Medium
Environmental	• Obtaining the environmental impact study • Location of geothermal power plant on protected forest area	x	x	Low	Medium
Accessibility	• Risk of damage of current roads • Risk of occupation of private property	x	x	Medium	Medium
Grid failure	• Risk of a failure in the distribution grid, affecting energy usage	x		Low	High
Grid connection	• Risk of non-generation of power pre-agreed • Loss of entitlement to power not available	x		Low	High
Security	• Accidents during the exploration, construction and operation stages	x	x	Medium	Medium
Licenses	• Acceptance of expropriation • Obtaining licenses for construction and operation	x	x	Low	Medium
Planning and design	• Definition of projects outputs • Adequacy of construction projects as defined in specific design	x	x	Low	Medium
Exploration	• Risk of failure of geothermal resource • Uncertainty about geological and environmental conditions	PT SMI – SOE Drilling *	x	Medium	High
Construction	• Delays in the commissioning of the geothermal power plant • Equipment damages during operation or during the installation • Difficulty in providing material	x	x	Low	Medium
Operation and maintenance	• Uncertainty of the availability of steam/brine (losses caused by well damage, failures of income) • Facilities state • System reliability • Availability of equipment • Uncertainty about the quality of maintenance services • Risk of availability of infrastructures	x	x	Medium	High
Force majeure	• Natural disasters, vandalism, war, epidemics	x		Low	High

The sequence of project development can be described as follows, first IPB issuance, followed by partner selection. By default, equity for exploration should be provided by private partner. Nevertheless, Ministry of Finance, PT SMI is now preparing the so called geothermal exploration fund. There are two exploration fund windows that can be employed in this partnership scheme (i) PISP fund and (ii) private. Forgiveness scenario will be applied in this financing scheme, e.g. up to 50% of exploration fund will be forgiven in case of unfeasible project as government compensation. After exploration is successful, exploration fund will be recognized as 51:49 PLN-Partner equity shares, and further JV shares. After completion of development drilling the funding can be sourced from other sources, such as PT Sarana Multi Infrastruktur (SMI), World Bank, Japan International Cooperation Agency (JICA), Kreditanstalt fuer Wiederaufbau (KfW), Asian Infrastructure Investment Bank (AIIB), Agence Française de Développement (AFD), etc.

4. DESCRIPTION OF THE DECISION PROCESS

The geothermal project that we analyze below is synthetic case study that represents typical Indonesia high-enthalpy geothermal field circumstances. The decisional pathway featured in the project as well as the parameters associated with the technical uncertainty surrounding the amount of recoverable reserves, the cost and impact on the resolution of technical uncertainty of exploratory and appraisal tests, the capital expenditure (CAPEX) costs, operational expenditure (OPEX) costs, decline rates and economic life of power plants were all provided from literatures.

The point of departure is that of a geothermal prospect which, due to its promising geologic characteristics, is deemed to warrant exploration. A sequence of 3G (Geochemistry, Geology, and Geophysics) surveys followed by the drilling of three exploratory wells, will have to be successfully performed until a specific location of reservoir is found for sure. Once such reservoir location has been identified, the private partner will form JV Company with PLN, and may proceed immediately with a sunk investment in an expensive development drilling and power plant installation or, alternatively, drill delineation/ confirmation well to appraise the quantity of available reserves before making such an investment. This decision is relevant because the optimal size of a power plant depends on the actual amount of recoverable reserves in the site within at least the lifetime. For simplicity, we assume that there are only two possible levels of recoverable reserves – which we designate as expected and smaller geothermal reserves – and two corresponding power plant sizes – an expected power plant (EP) and a smaller power plant (SP). The a SP is a less costly installation but unable to utilize larger reserve capacity as expected; if it turns out that the site is highly productive enough to provide expected capacity, additional power plant will have to be installed to supplement the SP (incremental development scenario, e.g. well-head unit). By drilling delineation/ confirmation wells (CW) and delaying the investment in a power plant until the results from such drilling become known, a better match between power plant size and reserve size is achieved. Nevertheless, this approach delays revenue of JV Company which turns to decrease Return on Equity (ROE) of the shareholders.

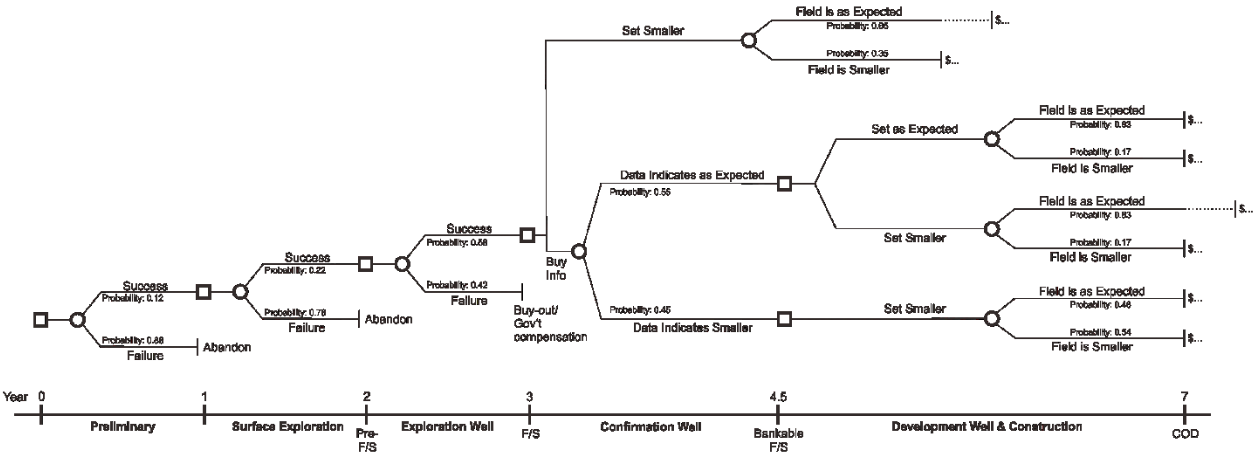

Figure 2: Geothermal field development decision tree.

This setup encompasses learning options, development options and abandonment options. During the exploratory phase, management decides on whether to perform a sequence of tests to learn about the existence of geothermal system in the prospect. Failure in any of the exploratory tests triggers the immediate abandonment of the project; success, on the other hand, prompts management to probe the prospect further with a more localized, accurate and expensive survey. The successful completion of the three exploration wells confirms the existence of geothermal system in a particular site within the prospect. Management may then proceed to make an immediate choice between a EP and a SP or drill a delineation/ confirmation well (CW) to improve its information about the volume of reserves available in the site before committing itself to a power plant size, thereby delaying the choice of power plant for one a half year. Once an investment in a power plant is made, the power plant becomes operational two and a half year later, extracting the available reserves thereafter over a 25-year period according to a Geothermal Power Production Agreement (GPPA), i.e., without any production flexibility being available to it.

The tree depicting the decisional path of the project is shown in Figure 2. The represented time steps are 1 – 2.5 year; the squares reflect decision nodes whereas the circles represent the resolution of technical uncertainty. Notice that the tree considers the possibility of project abandonment after successful outcomes from exploration activities due to low success ratio. We want to leave that possibility open since extreme decrease of the success ratio may optimally lead to the abandonment of a project whose technical uncertainty is being resolved satisfactorily.

The parameters governing the technical uncertainty of the project are reported in Table 3. Inspection of the table shows that upon successful completion of the exploratory phase, the probabilities of finding an expected or a smaller capacity of geothermal reserves are 65% and 35%, respectively. The delineation/ confirmation well (CW) yields a binary signal on reserve size with a reliability of 70% with probability 55% the binary signal indicates an expected reserve size and with 45% probability indicates smaller reserve size. Based on these numbers, the posterior probability of an expected geothermal reservoir finding following the appraisal test rises to 82.73% upon observing a favorable outcome of the delineation well, and declines to 45.56% upon the observation of unfavorable outcome.

Table 3 Project technical uncertainty.

Input parameters technical uncertainty	
Probability of success of preliminary survey	12,00%
Probability of failure of preliminary survey	88,00%
Probability of success of surface survey conditional on success in preliminary survey	22,00%
Probability of failure of surface survey conditional on success in preliminary survey	78,00%
Probability of success of exploratory well (EW) conditional on success in surface survey	58,00%
Probability of failure of exploratory well (EW) conditional on success in surface survey	42,00%
Cumulative success probability of the initial 3 phases	1,53%
Capacity of geothermal reserves	
As expected geothermal reserves (in MW)	110,00
Smaller geothermal reserves (in MW)	55,00
As expected geothermal probability after successfully completing exploration phase	65,00%
Smaller geothermal probability after successfully completing exploration phase	35,00%
Accuracy of the information provided by delineation/ confirmation well	
Probability delineation/ confirmation well quantity indication is correct	70,00%
Probability delineation/ confirmation well quantity indication is not correct	30,00%
Revised probabilities after running delineation/ confirmation well	
Outcome delineation/ confirmation well data indicates as expected capacity	
Probability of as expected geothermal capacity	83,00%
Probability of smaller geothermal capacity	17,00%
Branch probability	55,00%
Outcome delineation/ confirmation well data indicates smaller capacity	
Probability of as expected geothermal capacity	46,00%
Probability of smaller geothermal capacity	54,00%
Branch probability	45,00%

Table 4 Project cost data.

Power plant lifetime	
Lifetime of power plant (years)	30
Depreciation scheme	Double-decline
Investment and platform structures CAPEX	
Preliminary survey	$ 300.000
Surface survey	$ 741.000
Exploration well drilling	$ 38.373.000
Delineation/ confirmation well (CW) drilling	$ 20.305.500
Expected (110 MW) power plant (including development drilling)	$ 348.508.000
Smaller (80 MW) power plant (including development drilling)	$ 142.996.500
OPEX	
Make-up well including workover (USD per 3 years, levelized)	$ 10.614.000
Variable O&M (USD per year, levelized)	$ 12.493.000
Exploration risk	
Government compensation	50%
PLN buy-out	50%
Tax and rates	
Risk-free rate	3,40%
Inflation rate	2,00%
Convenience yield rate	
Royalty (after Net Operating Income)	2,50%
Production bonus	0,50%
Corporate tax	25,00%
JV Company discount rate	8,00%

The cost data of the project is summarized in Table 4. We can see that exploration tests are increasingly more costly: exploration wells are costlier than surface survey, e.g. geophysics, which in turn is costlier than preliminary survey, e.g. geological mapping, geochemical analysis. As expected power plants (110 MW) are more expensive to install than smaller power plants (55 MW); they are also more expensive to operate (on a per kWh basis) when the capacity is small; they are, however, cheaper to operate when the capacity is larger. The electricity production over the 25-year contract of a power plant is between 868 GWh to 434 GWh for 110 MW and 55 MW, respectively.

5. VALUE OF PROJECT

5.1 Value of Newly Installed Power Plant

The (net present) value of a new power plant (including production and injection wells) installed in year 7 ranges between 28 million USD (install expected size power plant/ as expected geothermal reserve finding) and 17 million USD (install smaller power plant/ smaller geothermal reserve finding). If installed in year 4, the value of a new power plant ranges between 19 million USD (smaller, incremental power plant/ as expected geothermal finding) and 4.5 million USD (smaller power plant/ smaller geothermal finding). Keep in mind that these are extreme power plant values resulting from similar electricity price outcomes. Please note that the electricity ceiling price is fixed at 7.45 cUSD/kWh which is determined in advance.

5.2 Value of Project at Initial Date

The complete tree with the value of the project at each node, presenting already optimal set of decisions is contained in Figure 2. The value of the project at the initial node of the tree is 166 thousand USD. The tree shows a rich optimal decisional pathway, driven by the resolution of technical information. The key features can be summarized as follows:

- During the exploration phase, it is generally optimal to continue with exploration following a successful exploration activity. The exceptions occur at year 2 and in year 3 when the predicted average success ratio drops to below SR=0.5. In these cases, the optimal decision is to immediately let PLN purchase (buy-out) the project, or abandon;
- After successful completion of the exploratory phase (i.e., after it has been confirmed a location containing geothermal reserves), the choice between proceeding immediately to install a power plant, drill delineation/ confirmation well to appraise the quantity of available reserves, sell (PLN buy-out) the project for good, or let government compensates partially the drilling expense depend on the (average) success ratio:
  - For large probability of expected resources size ($P \geq 60\%$), the best decision is to install immediately a smaller power plant and further develop incrementally if the resources size is as expected;
  - For lower size probability ($P < 60\%$) and predicted success ratio is higher than SR=0.5, the best decision is to drill delineation/ confirmation well and delay the installation decision for year 4;
  - Finally, for lower size probability ($P < 60\%$) and predicted success ratio is lower than SR=0.5, the best decision is to sell the project to PLN or abandon;
- If the drilling of delineation/ confirmation wells is chosen in year 3, then the general rule in year 4.5 is to install a smaller power plant and develop further incrementally. The exception occurs when success ratio become very low (lower than SR=0.35), in which case the best option is to abandon in year 4.5 regardless of the data revealed by the delineation/ confirmation well. The corresponding tree for the project also depicted in Figure 2, yields a value for the project of 166 thousand USD (higher than zero) denotes feasibility of the project.

6. VALUE OF FLEXIBILITY

The flexibility to the project value can be estimated by valuing the project under the assumption that there are no real options available to management during the project lifetime and then computing the difference between this no-flexibility benchmark and the project's value under full flexibility calculated earlier.

The valuation of an inflexible project considers three mutually exclusive cases, namely, the irreversible commitment, at year 0, to install an expected size, centralized power plant, to install a smaller, incremental power plant or to drill delineation/ confirmation well in year 3, regardless of exploration outcomes (these alternatives are illustrated in Figure 2). The underlying assumption to our “no flexibility” reference is that, for technical reasons, the three exploration phases – preliminary survey, surface survey, and the drilling of exploration well – are required before delineation/ confirmation well may be drilled or a power plant installed, a constraint that holds even if exploration fails to reveal the existence of geothermal reservoir. We also assume that failure in any exploration phase entails failure in all subsequent phases, implying that no geothermal reservoir is found/ found but not feasible in year 3; in such not-feasible-geothermal-is-found scenario, the project advances to one of the three mutually exclusive alternatives, which in the case of establishing a power plant in year 3 results on the immediate relinquishment of the asset once installation is completed (i.e., in year 4.5).

The paths and the end nodes payoffs of these mutually exclusive alternatives can be seen in Figure 2. The best of the “no flexibility” alternatives considered is the pre-commitment to acquire additional information in year three that yield a negative NPV, indicating that a project without flexibility should be rejected by management (both PLN and private partner). We conclude that managerial flexibility adds significant value to the project, which is an economically important result, given the initial investment of $166 thousand.

7. CONCLUSIONS

Overall, iPPP appears to be positive effort to accelerate geothermal development in Indonesia. While not conclusive, there are opportunity that iPPPs have ability to improve operational efficiency in regulatory regimes and contractual specificities. A strong public partner like PLN (as off-taker with enormous financial profile) can lead to a power balance between partners in a public-private joint venture. Appealing in iPPP arrangements, PLN attempts to pursue an opportunity of developing large, massive investments with minimum public expenditure, bringing the expertise and profit-oriented approach of the private sector, to geothermal projects of public service delivery.

This paper presents a preliminary approach of an institutionalized PPP applied to geothermal power plants, in Indonesia. This was the first iPPP attempted to be carried out in this sector, and it is clear the political commitment in promoting the development of this sector in Indonesia using private leverage to induce growth. Confirmation can be found in the evaluation factors under the partner selection procedure that 90% of technical weight given to the upstream skills and partner should provide 20% of total project cost, which is commonly recognized as exploration cost portion. There are still some barriers regarding the development of this sector related to the cost per unit of power. In fact, from an economic perspective, there is an extra cost (risk) related with this energy type, when compared to more conventional energy sources. This work focuses into two main objectives: the first comprised in the analysis of an iPPP arrangement for geothermal energy projects, focusing on understanding the factors of access and competition aspects related to a business of this nature, and the second considered the analysis of the risks related with this sector, including Real Option Analysis (ROA) of a project.

This study illustrates the application of ROA to a geothermal field development iPPP project. This valuation technique allows the identification and consideration of the project's applied options, turning a project destined to rejection into a project with positive economic value. The difficulty is due in large part to the option to sell (PLN buy-out) or abandon, which allows for project exit when exploration and appraisal activities yield poor outcomes or the success ratio, becomes excessively low. This exit strategy gives more flexibility which increases project value for private sector.

We discussed in the paper that ROA can only be of value to practitioners if a clinical approach is taken with respect to the methodology. In other words, ROA has to be tailored to the specifics of the project under analysis to represent its specific characteristics in terms of the applied options. In this paper we attempted to develop a realistic but at the same time manageable and informative application of ROA to a geothermal iPPP project by taking typical characteristic of high-enthalpy, 110 MW geothermal projects in Indonesia. The application provides an illustration of how a real options approach can be of use in an applied setting, helping a company identify the main sources of flexibility in a specific project and map their optimal exploitation across possible state variables' scenarios, thereby improving the project's commercial.

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