GOVERNMENT DRILLING PROGRAM FOR GEOTHERMAL EXPLORATION IN INDONESIA

D.N.I. Apriani, J. B. Randle, and A. Paripurna

PT Sarana Multi Infrastruktur (Persero)
Sahid Sudirman Center 47th Floor
Central Jakarta, Indonesia

desak@ptsmi.co.id, jim.pmugeothermal@ptsmi.co.id, adyaksa@ptsmi.co.id

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ABSTRACT

Indonesia is the world's second largest geothermal electricity producer with an installed production capacity of 1,925 MWe (May 2018). The Government of Indonesia aims to increase the production of geothermal energy to 7,200 MW by 2025, making Indonesia the largest geothermal energy producer in the world.

Government can play an important role in accelerating the development of geothermal energy, especially in greenfield areas. Government involvement in the exploration phase is one of the key success factors in countries with high utilization in geothermal energy, such as New Zealand and Iceland, and in fact in most other countries with geothermal developments (with the notable exception of the USA). The exploration phase in a geothermal project remains the highest risk due to the uncertainty of the resource. Because of this high risk, many prospects in Indonesia remain undrilled by developers. In order to solve this issue, the Government of Indonesia in cooperation with The World Bank and the Government of New Zealand, has announced the Indonesia Geothermal Energy Upstream Development Program (GEUDP), in which the Government of Indonesia will undertake the exploration phase, including the drilling activities, before geothermal working areas are tendered to developers.

The focus of this program is to develop geothermal prospects in the more remote areas with difficult terrain, and hence less commercially attractive, especially in Eastern Indonesia. To minimize the financial risk in the exploration phase, the use of the right technologies also plays an important part. Deep slimhole drilling is being encouraged for use in the Government program for geothermal exploration, due to the significantly lower capital cost of both the actual drilling and the infrastructure preparation. Deep slimholes also potentially have a major role in assisting early exploration of those geothermal prospects that are increasingly challenging because of ambiguous surface indications, remote locations, and difficult terrain.

1. INTRODUCTION

The Indonesian energy management paradigm has shifted from supply side management to demand side management (Mappangara and Warokka, 2015). The transformation includes diversification and conservation such as reducing oil dependency, developing and using more renewable energy sources, reducing electricity demand by improving energy efficiency, tariff adjustment for renewable energy sources, and intensifying energy diversification (fuel switching). Public access to energy in Eastern Indonesia is still low. As indicated by PT Perusahaan Listrik Indonesia (PT PLN) in their Electricity Supply Business Plan 2018, the national electrification ratio of Indonesia is at 96.2% and targeted to be fully 100% by 2025. The average growth of national energy consumption is 1.6% per every 1% GDP increase. The national electricity demand increases 10.1% on average per year. Although the national electrification ratio is high, some provinces in Eastern Indonesia is still low. In East Nusa Tenggara, the electrification ratio is at 70%, second lowest province after Papua at 65%. This may happen because Eastern Indonesia still lay on diesel generator to produce electricity and logistic cost is quite high in these locations. Thus, geothermal energy, as a renewable energy source, is expected to have an important role in fulfilling the electricity growth demand, especially in Eastern Indonesia.

Indonesia is situated on the Pacific 'Ring of Fire' which creates a pattern from Sumatera, Java, Bali, Nusa Tenggara, Maluku to the north of Sulawesi and holds significant geothermal power potential. Indonesia is among the largest and most attractive geothermal regions in the world with expected potential about 28 GWe, composed of 11,073 MWe resources and 17,506 MWe reserves (Bertani, 2015). Indonesia has abundant geothermal potential with 331 potential points spread from Sabang to Merauke. After overtaking the Philippines' position as the second largest geothermal power producer in the world after the United States, the Government of Indonesia has a very ambitious target of optimizing and increasing the utilization of renewable energy in the national energy mix from 12% in 2017 to 23% by 2025 and geothermal energy is expected to contribute 7.2 GW or 16% out of the renewable energy share. With the additional installed capacity of geothermal energy power plants from various developers in 2018, it is expected that the utilization of geothermal energy in Indonesia will reach 2,058 MW by the end of the year. This means that Government of Indonesia needs an additional 5,000 MW to reach its target. With this ambitious yet achievable target, the Government projects that Indonesia will become the world's largest geothermal power producer by 2023, beating the United States with a geothermal power capacity of 3,730 MW.

To achieve this target, the Government of Indonesia has provided the necessary breakthroughs in terms of geothermal acceleration. Firstly, special assignments have been issued to state-owned enterprises to develop geothermal concessions without a tender process. Secondly, the government allows for preliminary survey assignments plus exploration. For such preliminary survey assignments and explorations, a company is allowed to commence drilling without a geothermal license once it fulfills the necessary requirements. The third action is simplification of the licensing and permitting process, which has reduced the requirement from 29 to 3 licenses for business entities conducting geothermal operations, by eliminating unnecessary licenses and shortening the length of time needed for their processing.

2. GOVERNMENT SUPPORT IN GEOTHERMAL DEVELOPMENT

As attractive as it may sound to developers, geothermal energy, with its high capital costs and resource uncertainty, is still a high risk business. As a result, only a handful of existing geothermal operations (brownfields) in Indonesia have expanded production over the past decades, and there has been even less development of the newly tendered (greenfield) projects that carry greater risks. The highest risks of geothermal energy development lie within the exploration phase to prove the preliminary data by drilling.

Based on UNFC 2009 definition, a Known Geothermal Energy Resource is discovered when temperature, permeability, and fluid chemistry or other relevant parameters that are important for the planned type of energy extraction are proven by drilling. The first drilling makes a major change on the project risk and cost profile as shown in Figure 1.

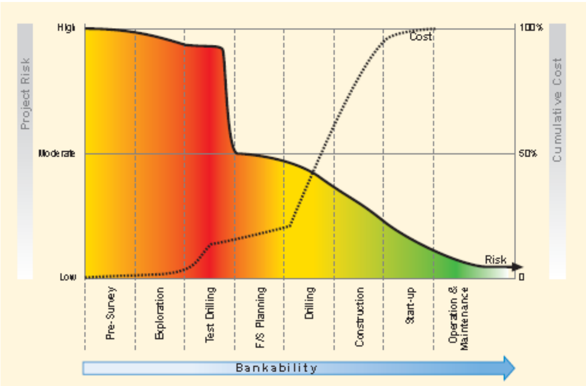

Figure 1: Geothermal Energy Development Risks (ESMAP, 2012).

To further accelerate the development of geothermal energy in Indonesia, the Government of Indonesia, through the Ministry of Finance, has exclusively allocated USD 300 million as a Geothermal Support Fund (GSF) in the national budget for geothermal exploration drilling with Government Drilling and State-Owned Enterprise (SOE) Drilling schemes. PT Sarana Multi Infrastruktur (PT SMI) is a State Owned Enterprise under the Ministry of Finance. It is responsible for management of the Geothermal Support Fund (GSF), a facility to support the exploration and exploitation of geothermal areas as well as the expansion of existing geothermal projects. PT SMI also acts as the project manager for geothermal exploration projects undertaken by the government under the Government Drilling Scheme.

The Government Drilling Scheme is a collaboration between the Ministry of Energy and Mineral Resources (MEMR) and the Ministry of Finance (MOF) as one of the efforts to mitigate exploration risks. Through this facility, the Government, through assignments to PT SMI, will take over the exploration risk from a number of new, unassigned concessions and will drill at least three exploration wells on each to prove the geothermal potential within the area. All concessions that are successfully explored and proven economically developable by PT SMI will then be either tendered to private developers or directly assigned to SOEs, and the winning developers will repay all the exploration costs that have been spent. The revolving funds will then be used for drilling other concessions in the pipeline. This reduces the risk for the private sector at the exploration stage, especially as the main obstacle has been the unwillingness of financial institutions to provide loans at this early stage due to resource uncertainty.

This kind of government support has been implemented in other countries with known success stories of geothermal power utilization. In Mexico, SENER, Nacional Financiera (Mexico's national development bank, also known as Nafinsa), Munich RE, and the IDB have established a revolving fund and third-party guarantee mechanism to reduce geothermal exploration risks for geothermal developers. The goal is to lower the cost of access to capital for geothermal development during the initial stages (IDB, 2014). SENER, IDB, and the Clean Technology Fund (CTF) contributed \$11.4 million, \$54.3 million, and \$54.3 million dollars, respectively, to the program and expected to guarantee up to 300 MW in development. This revolving fund is to ensure sustainability beyond the six-year project duration, by offering insurance mechanisms, providing guarantees, and loans convertible into non-refundable financial support in geothermal energy development (NREL Technical Report, 2017).

In Iceland, a National Energy Fund (NEF) was created to further increase the use of geothermal resources by using cost-sharing scheme in drilling and exploration with convertible loans for unsuccessful drilling costs. This fund was established by merging the former Electricity Fund and the Geothermal Fund in 1967. The NEF has granted numerous loans to companies for geothermal exploration and drilling. Where drilling failed to yield the expected results, loans were converted to grants (Orkustofnun, 2010). Furthermore, the Icelandic government has established The Iceland Deep Drilling Project (IDDP) in 2000 by a consortium of the National Energy Authority of Iceland and four of Iceland's leading energy companies: Hitaveita Sudurnesja (HS), Landsvirkjun, Orkuveita Reykjavíkur and Mannvit Engineering. The consortium is established to conduct a deep drilling project and explore the use of supercritical fluids to increase power output. (Friðleifsson et al, 2012).

New Zealand is also one of the countries with successful government exploration programs since the 1940s. The country's 2 dry years in the 1940s had driven the government to utilize geothermal energy to meet its energy need. The first 170 meters well was drilled at Wairakei in 1949 and the first geothermal power plant in New Zealand and second in the World was built in 1958 (Archer, 2018). This government programme that continued into the 1980s, became the critical success factor and enabler for recent geothermal development in New Zealand.

3. EXPLORATION RISK MITIGATION

There are several reasons why geothermal development in Indonesia has been stagnant these past decades. One of the reasons is Indonesia's limited success in tendering geothermal concessions. Due to limited domestic capacity, poorly executed transactions have led to many concessions being tendered out but almost none achieving financial closure. Despite Indonesia having a vast database of mapped geothermal fields and related information, there is a lack of good quality preliminary information regarding the fields; the credibility of the information being offered is unclear; and many geothermal prospect tenders remain unsuccessful. Other than that, the tenders often do not include a bankable Power Purchase Agreement (PPA) with Perusahaan Listrik Negara (PLN), the national power company and the only electricity off-taker, making it even more of a high risk for developers to conduct exploration activities.

3.1 Regulatory Risk

Indonesia has introduced a special geothermal law and geothermal regulation, recognizing the unique characteristics of geothermal energy and its prominent role in the national economy. Geothermal Law no. 21 of 2014 and Government Regulation no. 7 of 2017 on Geothermal for Indirect Use and other technical regulations. These two regulations change the old mindset that geothermal development can be done in conservation forest areas because it is no longer categorized as a mining business. The existence of a standalone geothermal law, however, is not essential. In many countries, geothermal resources are subject to general mineral extraction or mining laws governing access to land, and exploration and development licensing. Separate legislation often governs environmental and water use permitting procedures. Renewable energy legislation also plays a strong role in supporting geothermal development in many countries.

Since the government drilling program is a new scheme in Indonesia, the GEUDP itself also has to adjust and adapt to the procedures needed to make the program successful. New regulations regarding permitting are important to ensure the smooth coordination between all stakeholders, including central and local government where the geothermal prospects are located. GEUDP is a new program in Indonesia and the regulation or procedures have not been properly in place yet to support the process. This becomes a challenge when certain local permits need to be applied but they cannot be fulfilled because certain requirements are specifically made for business entity and not applicable for a program run by central government.

3.2 Resource Uncertainty Risk

Throughout the exploration and delineation drilling phases of a greenfield geothermal project there is a risk that there is no resource, or that the resource will be too costly to develop, or that the project may not proceed to FID (Financial Investment Decision).

Geoscientific data collected may indicate a significant chance that exploration drilling may or may not find a useful resource. For example, this may be because there are few, if any, strong thermal features, and much of the evidence for a system rests on geochemistry from weakly flowing springs and positive geological and geophysical indications. We see some projects at this stage where the probability of discovering a useful resource may be much less than 50%. Under these circumstances there is a considerable chance that equity invested in exploration and delineation drilling may be lost.

Developers will commonly apply a decision tree process to assess the probability that they will exit the project at each of the main decision gates. At exit, some or all of the cost expended to that point will be lost for no return. If the decision is made to abandon the project based on the results of the first wells, then the best solution for the developers would be to have spent the smallest amount of equity on the drilling campaign (Mackenzie et al, 2017).

3.3 Financial Risk

Although the initial capital costs are high, geothermal energy remains a cheaper source compared to other renewable energy technology for every MWh of electricity produced. Geothermal energy development requires high capital costs in the beginning to cover for the well drilling. Figure 4 below shows that, in the absence of fuel costs and other variable costs for more than 50 years of project life time to generate electricity, geothermal levelized cost of energy remains among the lowest compared to other renewable energy technologies.

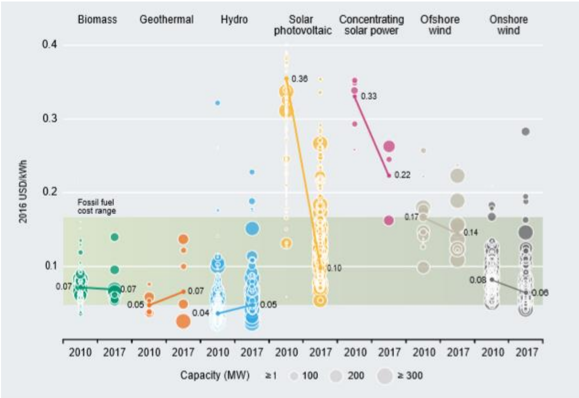

Figure 2. Global Levelized Cost of Electricity from Utility-Scale Renewable Power Generation Technologies (IRENA, 2010-2017).

The ‘extra’ capital costs at the beginning of the projects are often regarded as money advance in substituting the fuel cost that usually exist in other electricity generation projects. With every succeeding stage of a geothermal development project being declared as successful, it will produce positive results and reduce the risk of the uncertainty in the project. Debt financing is usually not available during the exploration phase due to the uncertainty of the resource and hence the risk to the lenders. Therefore, developers have to rely on equity. Once the exploration stage is successful, the geothermal energy project will be able to obtain debt funding from lenders.

In general, finding financial support for a geothermal project is often regarded as one of the significant obstacles to developing new geothermal power project. This is where the government drilling program may be able to narrow down the gap and reduce the risks so that developers are able to develop the projects with debt funding from various financial sources, both commercial and institutional.

4. INDUSTRY CHALLENGES

4.1 Feed-in Tariff

Geothermal development in Indonesia faces challenges from upstream to downstream. According to the new MEMR regulation No. 12/2017 regarding the utilization of renewable energy sources for the provision of electricity, the tariff shall refer to PLN’s regional electricity generating cost (Biaya Pokok Produksi/’BPP’). This BPP will drive the PPA price between the developers and PLN. If the resource is located in Sumatra, Java, or Bali, the developer has a right to negotiate the price using a business to business negotiation with PLN, due to the very low regional BPP in these areas. Most power in these areas is generated from coal or gas fired thermal plant, which has a lower cost of generation. Other than these areas, the PPA value will follow the regional BPP. If the regional BPP is lower than the national BPP, then the PPA may follow the national BPP. This BPP derived value for PPA has become an obstacle in developing renewable energy projects in Indonesia, especially geothermal energy that generally has higher investment costs.

Some geothermal prospects in Indonesia, such as Sumatra, Java and Bali, are located in areas with coal or gas fired thermal power as the main electricity generator, which results in a low BPP. This would mean that the tariff for the electricity generated from geothermal energy would also follow this BPP trend and it will be more difficult for a developer to negotiate a reasonable and bankable price for the project itself in order to obtain financial closure. In Indonesia, the PPA price is negotiated after exploration drilling is finished by the developers and the resource is proven to be feasible and bankable for further development. The uncertainty of the allowable tariff in the PPA for the prospect at the early stages, combined with a low probability of discovery from the prospect has resulted in the hesitation of the developers to conduct exploration drilling.

However, in some of the more remote (Eastern) islands, especially Moluccas and East Nusa Tenggara, BPP are considerably higher due to the prevalence of diesel generation, and hence geothermal feed-in tariffs are more attractive, but so are development costs expected to be higher (Van Campen et al, 2017)

This is the major area where support from the Government is strongly needed, either the exploration risks are undertaken by the government, or PPA incentives are provided for geothermal developers to ensure the electricity purchase by the off-taker, or a revised tariff scheme is introduced that recognizes the long term economic and social benefits of geothermal power.

4.2 Power Plant Technology

Geothermal power plant is a high cost investment. The large, high temperature and vapor-dominated geothermal prospects in Indonesia which are known as the ‘good resources’ have mostly been developed already. Based on the available geoscience data from Badan Geologi, the undeveloped greenfield geothermal prospects in Indonesia nowadays are mostly liquid-dominated with low to intermediate temperature. Any development at these prospects would be expected to use pumped wells in a liquid-fed binary power plant development, which causes a higher investment cost because even at the exploration stage the drilling activities will need to use standard size holes to accommodate downhole pumps. Geothermal binary power plants, which transfer the geothermal heat to a separate working fluid in order to convert thermal into kinetic energy, are not yet in operation for low to intermediate prospects in Indonesia. Although binary power plant in such applications has been proven in other countries, such as United States and New Zealand (see Fig 5), this still remains as a second choice for geothermal development in Indonesia, which in turn causes the low to intermediate prospects to be less attractive for private developers.

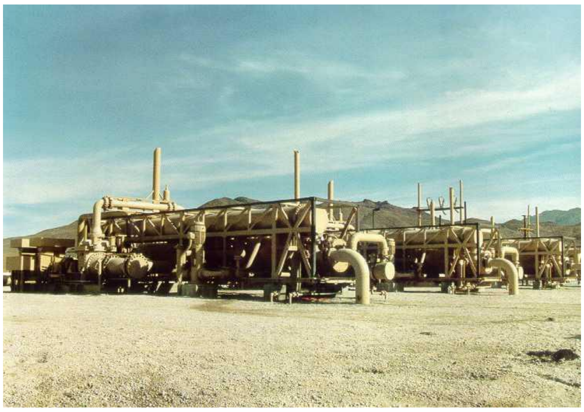

Figure 3. Binary Power Plant in Nevada, United States (Mills, 2018).

This would a very good example of how government drilling and the GSF fund can help the geothermal industry in developing low to intermediate resources, proving the pumped binary power plant technology in Indonesia. Top geothermal developers experienced in binary power plants will likely to attracted to further develop the prospect areas after the resource is proven.

Other than binary power plants, wellhead power plants also provide a solution for small projects in Indonesia or to have a faster initial production in large projects before large scale generators are built. Indonesia’s geothermal projects are scattered all over the islands ranging from small to large resources. For prospects with low market demand, wellhead power plant can be utilized to reduce the investment cost as it is simpler than a conventional single flash condensate power plant. Wellhead power plants have been around for many decades in the geothermal industry, but again have not yet been applied in Indonesia. The modularity and simplicity of wellhead power plants allow for accelerated construction time and a shorter overall period from drilling completion to power production. By using wellhead power plants for each individual well they can all be running at their own optimal pressure and there will be less problems of individual wells becoming unusable because the average system pressure is higher than the shut-in pressure of the individual wells. Costs of wellhead power plant are also similar to a large-scale unit connecting multiple wells. However, the simplicity of the wellhead power plant affects its efficiency and ultimately the utilization of the geothermal resource (Gudmundsson et al, 2016). Wellhead power plants can either be a temporary installation which will be relocated to new wells as conventional larger scale power plant is built or a permanent wellhead power plant. Based on this, developing a field with wellhead instead of a large-scale plant is potentially interesting for developing small scale projects in Indonesia.

Figure 4. Wellhead power plant in Kenya (Mills, 2018).

4.3 Drilling Technology

The capital expenditure required to drill deep geothermal exploration wells to prove any geothermal system can be very substantial particularly if a project is remotely located and requires significant infrastructure works for access and water supply to facilitate the exploration and resource proving process. The cost of drilling a standard size well in Indonesia varies from USD 6-10 million, while the average exploration cost of one well is USD 8-10 million including the civil and infrastructure cost. However, most of these costs depend on the infrastructure and depth of the hole. In more remote areas with less infrastructure such as Eastern Indonesia, the drilling costs are much higher.

In the absence of tariffs commensurate with the risks in exploration drilling, developers are reluctant to embark on high cost drilling, particularly where the probability of successfully finding a resource with the first few wells may be low because of resource uncertainties.

With the high cost of drilling, it is becoming increasingly important to optimize the well targeting, particularly for the first wells in a geothermal system. Where there is uncertainty as to the resource potential, location and extent; or in the location, nature and orientation of permeability, there can be good reasons to use deep slimholes initially rather than jumping on to standard size well (Mackenzie et al, 2017).

Deep slimhole drilling using equipment that is smaller and requires less road and water supply infrastructure can achieve exploration outcomes at lower cost, which would be preferable for conducting any exploration drilling program. The financial risk of unsuccessful exploration drilling would be significantly less than if the exploration is conducted with standard size wells.

Figure 5. Typical slimhole coring rig (Mackenzie et al, 2017)

From the project schedule point of view, the utilization of deep slimholes drilling will also improve due to smaller equipment used and less time for long lead equipment to be manufactured and delivered. Deep slimholes drilling may be possible using a truck-mounted drilling rig that is compact and able to mobilize faster than a standard size drilling land rig.

The use of deep slimholes for exploration drilling reduces the early capital spend on a project, and therefore improves the success-weighted Net Present Value (NPV) of a project, particularly where there is a reduced probability of successfully finding a resource. In combination, the reduced capital and improved scheduling of expenditure plus reduced cost of failure for a project (or for a portfolio of projects), has the ability to reduce the tariff required for geothermal projects in Indonesia (Mackenzie et al, 2017). It may be considered that, since the slimholes are unlikely to achieve production capacity flow, their use represents an additional expenditure over a more conventional development program because the same number of production wells will eventually have to be drilled. However, by starting with deep slimholes, subsequent full-size production wells can be targeted more accurately, thus reducing the risk of dry holes during production drilling and reducing the number of full-size production wells. Furthermore, the overall cash flow profile for the developer is modified, such that his major drilling expenditure occurs later in the project cycle, at a lower risk point, and this itself has a very positive effect on project economics.

Deep slimhole drilling will also reduce early stage environmental and social impacts to the local community affected by the geothermal exploration project. The smaller the diameter of the well, the smaller the infrastructure construction and equipment needed hence the less impact to the environmental and social aspects.

The biggest challenge with using deep slimhole wells for reservoir exploration is achieving the required depth. The relatively small hole size means that there are small tolerances between the drilling string and the hole such that equipment can easily be stuck. Additionally, there are fewer options for adding additional casings in the event of problems. The small diameter tubulars also can face torque issues at deep levels. The solution to these problems, as in fact with most geothermal exploration drilling technical issues, lies in planning and drawing on available geothermal experience with slimhole drilling.

The information secured from drilling deep slimhole wells with full coring capacity is enough to prove whether the geothermal resource exists or not and that is the main objective of conducting any drilling program. With these advantages, slimhole drilling is proven to be one preferred solution for conducting government drilling with reduced financial risk and walkaway costs.

5. GEOTHERMAL ENERGY UPSTREAM DEVELOPMENT PROGRAM

PT SMI, as the implementing agency for the government drilling program in Indonesia, has established a cooperation with The World Bank in co-financing the program through CTF & GEF (see below). The program is called the Geothermal Energy Upstream Development Program (GEUDP). Geothermal energy upstream development program is expected to contribute to a national goal of increasing the installed capacity of geothermal energy to 7,200 MW by 2025. The program is focused on greenfield projects that have not been tendered yet, especially in the eastern part of Indonesia with lower electrification ratio compared to western Indonesia. Eastern Indonesia also presents prospects in more remote areas, with difficult terrain and in some cases smaller off-take market demand, which are less commercially attractive for private developers. This has become one of the goals of the GEUDP program.

The funding for GEUDP projects is by utilizing the Government's GSF fund in the amount of USD 49 million combined with a matching grant from the Clean Technology Fund (CTF) in the amount of USD 49 million and support from the Global Environment Facility (GEF) in the amount of USD 6.25 million to undertake exploration drilling activities aimed at de-risking selected prospects (see figure 2 below).

PT SMI has also received a grant from New Zealand Ministry of Foreign Affairs and Trade (NZ MFAT) in the amount of NZD 2.13 million in the form of technical assistance to help PT SMI building the Geothermal Project Management Unit (PMU) team capacities on the technical side. The technical assistance is provided by Jacobs on behalf of NZ MFAT to provide to PT SMI Exploration Management Consultancy services, which cover geoscientific analysis, civil infrastructure design and planning, as well as well design and drilling program preparation.

Figure 6. PT SMI Collaboration for Government Drilling Scheme in Indonesia

The co-financing collaboration between PT SMI and The World Bank is conducted by providing funds for each geothermal prospect separately. The first pilot project will utilize the CTF grant under The World Bank, while the second project will utilize the GSF fund under PT SMI, and so on. The GEF grant will be utilized for preliminary survey or reprocessing of existing data and for PT SMI Project Management Unit operational costs. Once the prospects have been successfully explored and resources proven, the exploration data will be handed back to MEMR to be tendered to developers for further development and the exploration cost will be repaid by the winning bidder into the revolving fund account for other exploration projects under GEUDP. The winning bidder shall repay all the exploration cost spent by PT SMI, including the management fee margin approved by Ministry of Finance plus the premium risk fee to compensate the exploration risk that have been taken over.

To utilize this facility, MEMR will have to submit a proposal of geothermal prospects to MOF who will verify them and pass the verification results along with the relevant assignments to PT SMI, who will evaluate the preliminary surface data and conduct an initial site screening. Once the evaluation process is finished, PT SMI will issue an evaluation report back to MOF who will then decide the further assignment for exploration drilling of individual prospects that have no fatal flaws identified in the initial screening process.

In the first phase, MEMR has submitted 5 geothermal prospects to MOF to be facilitated under the GEUDP government drilling scheme. Based on MOF Regulation No. 62/PMK.08/2017, PT SMI needs to assess the geothermal prospects and provide evaluation reports, including cost estimate analysis, risk analysis and a recommended drilling strategy, source of funding, and recommendation whether the project is feasible to be developed or if there are any adjustments needed to be made to make the project economically feasible.

Based on PT SMI's evaluation, with the help from Jacobs as the technical assistance from NZ MFAT, those 5 prospects have been prioritized based on a prioritization methodology, focusing on surface preliminary data completeness, probability of discovery, prospective resource capacity, commercial perspective, and project cost estimation. From this methodology, Waesano geothermal prospect has become the first pilot project to be drilled using the government drilling scheme.

6. WAESANO GEOTHERMAL PROSPECT

Currently, Indonesia has 69 geothermal work areas (WKP) which are expected to meet the target of 7,239 MW of power produced by Geothermal Power Plants (PLTP) in 2025. One of the potential areas is Flores Island, which will be defined as Flores Geothermal Island by the Government of Indonesia through the MEMR in the near future.

Flores Island has a geothermal potential of 659 MW and geothermal resources of 745.5 MW. East Nusa Tenggara currently suffers from a low electrification ratio of only 53.1% or the second lowest province after Papua at 52.4% with 1,205 villages have not been electrified yet (Prasetyo, 2018). Among this geothermal potential in Flores Island, Waesano is one of the prospects proposed by MEMR for the GEUDP projects.

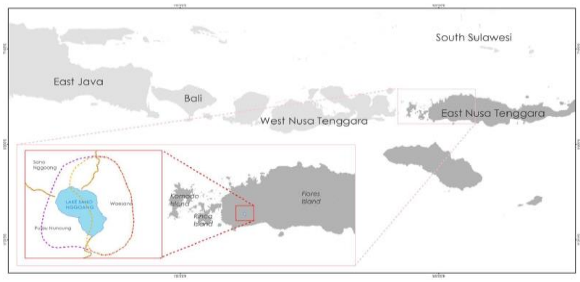

Figure 7. Waesano Prospect in East Nusa Tenggara, Eastern Indonesia (Waesano ESIA, 2017).

The Waesano prospect is centered on 2.5 km diameter Sano Nggoang Crater Lake, in the center of Mt. Waesano on the southwest corner of Flores Island.

Figure 8. Sano Nggoang Crater Lake (Dolovesa Travel, 2015)

Preliminary surveys by the Geological Agency (Badan Geologi) under MEMR, plus some additional geochemistry survey, re-interpretation of the geophysics data, and conceptual model refinement by Jacobs, indicates that there is very likely to be an exploitable geothermal resource in the Waesano area of some 30 MW potential capacity. However, the current interpretation of the geoscientific evidence has to be validated by drilling into the inferred reservoir in order to confirm the subsurface conditions, and especially fluid properties (thermal and chemical) and the permeability of the host formations.

The current proposal is to drill and test two deep (to a depth of 2000 m) slimholes and one standard size (9-5/8" production casing to a depth of 2500 m) exploration wells within the Waesano geothermal prospect to prove the existence of a useful geothermal resource and provide an indication of the resource's development potential with much higher certainty than is possible with present surface exploration data alone. It is expected to undertake the drilling activities in Q2 2019 and finish in Q2 2020.

While these exploration wells may provide some production and reinjection capacity, the principal objective is to provide enough information to confirm the resource quality and better quantify the resource capacity. This will provide the resource information to facilitate commercial tendering or assignation to an SOE to develop a power generation project. All data generated will be provided to Directorate General of New, Renewable Energy and Energy Conservation (EBTKE) under Ministry of Energy and Mineral Resources for this purpose.

There is also included at this stage an option, if the results from the first two deep slimholes are ambiguous, to drill a third deep slimhole prior to drilling the standard size well, in order to improve the probability of success of the standard hole. The requirement for this option will be assessed during the drilling and testing of the first two slimholes. The location of the Phase 2 standard well will be situated proximal to a successful slimhole; however, downhole deviation may be decided to be used for the standard well to increase the overall explored subsurface volume of the drilling campaign.

At Waesano, the Probability of Discovery (POD) may be considered by combining a semi-quantitative assessment of the individual parameters (i.e. the probability of encountering favorable temperature, chemistry, and permeability in a suitably large volume). The estimated probabilities of the various resource parameters and the POD for Waesano are listed in Table 1.

The combined POD of 50% for Waesano is indicative only, not an accurate assessment, but the low value derived from this subjective methodology implies that there is a significant chance that drilling will not discover a useful resource. There is always some risk of not finding a useful reservoir on any greenfield exploration project, but it is important to realize that the risk of failure at Waesano is greater than would have been estimated for some of the prospects that have already been developed in Indonesia. This is mainly because of the possibility of intersecting acidic regions of the reservoir as indicated by the very obvious subsurface flow of acidic fluids into Lake Sano Nggoang, which exhibits a low pH of 2.6.

It is especially important to consider economic strategies when planning exploration campaigns for geothermal prospects with low to moderate PODs, such as Waesano in order to minimize the cost of failure (the potential “walk-away” cost of the project if it is deemed to be sub-commercial). A compromise between cost savings and the effectiveness of the campaign must be tailored to each campaign based on nature and magnitude of the associated project risks.

Table 1. Probability of encountering favorable resource conditions and the combined probability of discovery of a usage geothermal resource at Waesano (Waesano Pre-Feasibility Study Report, 2017).

Parameter	Probability of being favorable	Explanation
Temperature	95%	Springs provide geo-thermometry that is typically reliable and indicate that at least 250˚C exists somewhere feeding the springs.
Permeability	80%	The springs discharging at 600m elevation indicates some lateral limits to permeability.
Chemistry	65%	While the spring chemistry is neutral, the springs have high chloride (with some scaling risk) and the acidity of the lake indicates a significant magmatic input to shallow levels in the system.
Overall POD	50%	Based on an unweighted multiplication of the above factors.

7. CONCLUSION

There are several important things that can accelerate geothermal energy development in Indonesia. The experience of successful countries points to the need for a country to have a dedicated national geothermal exploration and development organization or company capable of managing large-scale infrastructure projects consistent with international and industry standards. The government exploration program plays an important role in accelerating the development of green field geothermal prospect, especially in remote locations with difficult terrain and high cost for civil and infrastructure construction, which are less attractive for private developers to engage.

Other than that, a committed and adequately staffed ministry or similar department of government in charge of the energy sector, whose functions include explicit planning for geothermal energy development, and a capable regulator, especially in the context of a liberalized electricity market, whose functions include the enforcement of the country’s renewable energy policies and balancing the interests of generators and consumers, also play an important role in setting up a conducive geothermal industry atmosphere.

To encounter the exploration risks itself, there are several measures that can be adapted in the government drilling program, such as the use of right-on-target technology that can reduce the financial risks or high cost-of failure when the exploration drilling proves unsuccessful, such as the utilization of deep slimhole drilling in proving the geothermal resource prospect.

Geothermal Energy Upstream Development Program (GEUDP) is the new government drilling scheme in Indonesia designed to mitigate the exploration risk and accelerate the geothermal development in Indonesia. It utilized the revolving fund scheme for the repayment process from winning bidder, allowing it to fund other projects in the future. Waesano is the GEUDP pilot project located in East Nusa Tenggara with a geothermal potential of 30 MW. It is expected to undertake the drilling activities in Q2 2019 and finish in Q2 2020. It has 50% Probability of Discovery (POD) based on unweighted multiplication of several factors, which are temperature, permeability, and chemistry.

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