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Geothermal Exploration Project De-risking: Discussion on Various Schemes

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ABSTRACT

Indonesia is one of the countries with the largest geothermal energy potential in the world which is currently trying to achieve the national geothermal target of 5,800 MWe of installed capacity by 2030. To achieve this target, the Government of Indonesia together with geothermal industry players in Indonesia must carry out exploration activities in various prospect areas spread across various islands in Indonesia. A total of more than 70 prospect areas have been identified by the Government of Indonesia to be explored therefore their feasibility can be assessed for further development.

However, various challenges in realizing geothermal exploration projects have long been the subject of discussion. One of the most obvious challenges is the high exploration risk for investors as a combination of two main factors, namely the high costs that must be incurred for exploration drilling at a time when there is still a high level of uncertainty about the existence of economically viable geothermal resources below the surface. Various countries and financial institutions that have interests in the geothermal industry have conducted various studies and implemented several schemes to overcome this geothermal exploration challenge.

This study aims to map the various schemes currently applied by the geothermal industry around the world through a literature study. These schemes are then discussed and compared to capture the challenges and opportunities if implemented in Indonesia. This paper will also discuss two de-risking schemes that are currently available in Indonesia. This paper, eventually, is expected to trigger more discussion among geothermal industry players in Indonesia regarding the most suitable de-risking schemes for Indonesia to achieve the national geothermal target in 2030.

1. INTRODUCTION

1.1 Geothermal Energy Development Target and Challenges in Indonesia

Government of Indonesia has committed to mitigate the climate change by setting ambitious target to achieve net zero emission by 2060. To achieve this target, the government continues to encourage transition in the energy sector by phasing out the fossil-fueled based power plants and scaling up renewable energy resources in national energy mix. Indonesia which is located at the confluence of three active plates namely Pacific plate, India-Australia plate, and Eurasia plates has been blessed with abundant renewable geothermal resources. Badan Geologi Kementerian ESDM (2023) has estimated that potential geothermal energy in Indonesia is around 23.76 GW making Indonesia has the largest geothermal potential in the world. Therefore, Government of Indonesia has targeted 5,486 MWe of geothermal power plant installed capacity by 2030 (Direktorat Panas Bumi, 2022).

The first geothermal power plant that was successfully commissioning is Kamojang Unit-1 in 1983 with installed capacity of 30 MWe. However, since then the geothermal energy development in Indonesia has been in slow rate as in 2022, the geothermal installed capacity only achieved 2,356 MWe or equivalent to 55 MW/year since first installation (ThinkGeoEnergy, 2023). Even though that Indonesia is currently the second largest installed geothermal capacity in the world after United States, the utilization rate is only around 9.6% of its potential energy. As the comparison with others 1 GW installed geothermal capacity countries, United Stated has used 21% of its geothermal energy potential and New Zealand has utilized 38% of its geothermal potential energy (Asokawaty et al., 2020).

Darma (2016) and Umam et al., (2018) have identified several challenges of geothermal development in Indonesia which is illustrated in **Figure 1**. These various challenges are potentially hindered Indonesia to achieve national geothermal target of 5,800 MW installed capacity in 2030 which is around 7 years from now.

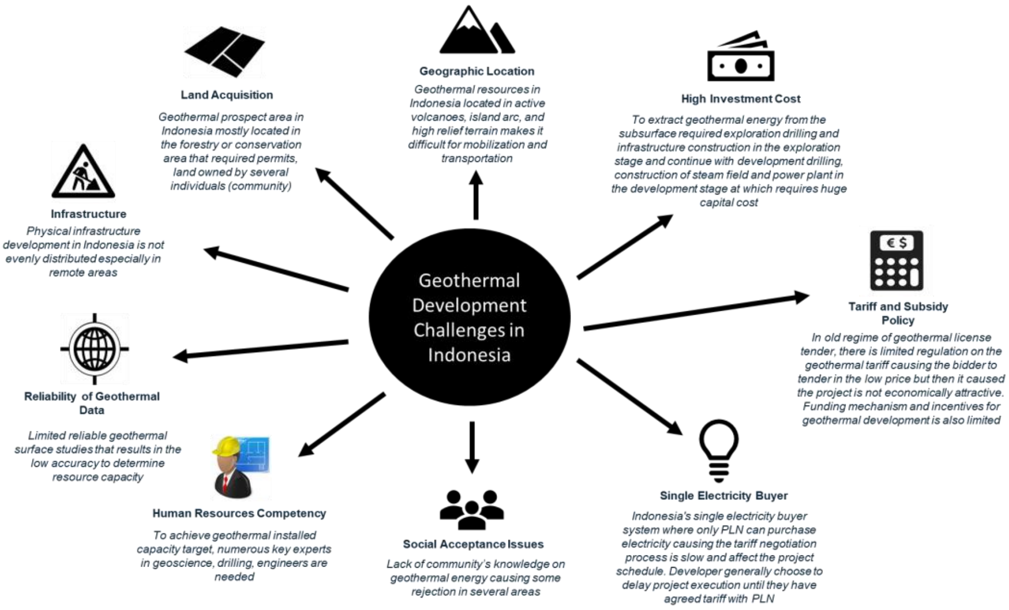


Figure 1: Geothermal Development Challenges in Indonesia

1.2 Geothermal Resource Risk in Exploration Stage

Like other country, a geothermal energy development project in Indonesia typically involves several steps, including preliminary study, exploration, resource assessment, exploitation drilling, steam fields development, and construction of geothermal power plants.

The exploration phase involves identifying areas with potential geothermal resources and conducting surveys to gather information on the geology and geochemistry of the area. This can include drilling test wells, conducting geophysical surveys, and collecting data on the temperature and flow of hot water and steam. Once a viable resource has been identified, the resource assessment phase begins. This includes determining the size of the resource and the potential for energy production. Engineers will also conduct various studies such as environmental impact assessment, social impact assessment, and feasibility study.

One of the main reasons of slow geothermal development in Indonesia is because there are still a lot of geothermal prospect areas that have not been explored yet. **Figure 2** shows the geothermal power plants (marked with red dot) and the prospect areas (marked with yellow and green color) that are still in the preliminary surveys in Indonesia. It can be seen that areas with installed power plant are fewer than area that are still in the exploration stage. By early 2022, there are 63 geothermal working areas (*Wilayah Kerja Panas Bumi*/WKP) and 15 areas of preliminary survey and exploration assignment area (*Wilayah Penugasan Survei Pendahuluan dan Eksplorasi*/WPSPE) in Indonesia (EBTKE, 2022). The total number of geothermal prospect areas and its status can be seen in Table 1.

Table 1: List of Geothermal Prospect Areas (Direktorat Panas Bumi, 2022)

Status of Geothermal Area	Total Number of Area	Total Potential
Area Prospek Wilayah Terbuka (Prospect Area – Open)	17 prospect area	290 MW
Wilayah Penugasan Survei Pendahuluan dan Eksplorasi (Preliminary Survey)	14 PSPE area	920 MW
Persiapan Penawaran WKP dan Government Drilling (Prepared for Tender)	22 WKP	825 MW
WKP Eksplorasi Dengan Rencana Pengembangan (Exploration Area with Development Plan)	20 WKP	1,485 MW
Pembangkit Listrik Tenaga Panas Bumi (Installed Geothermal Power Plant)	17 WKP	2,356 MW

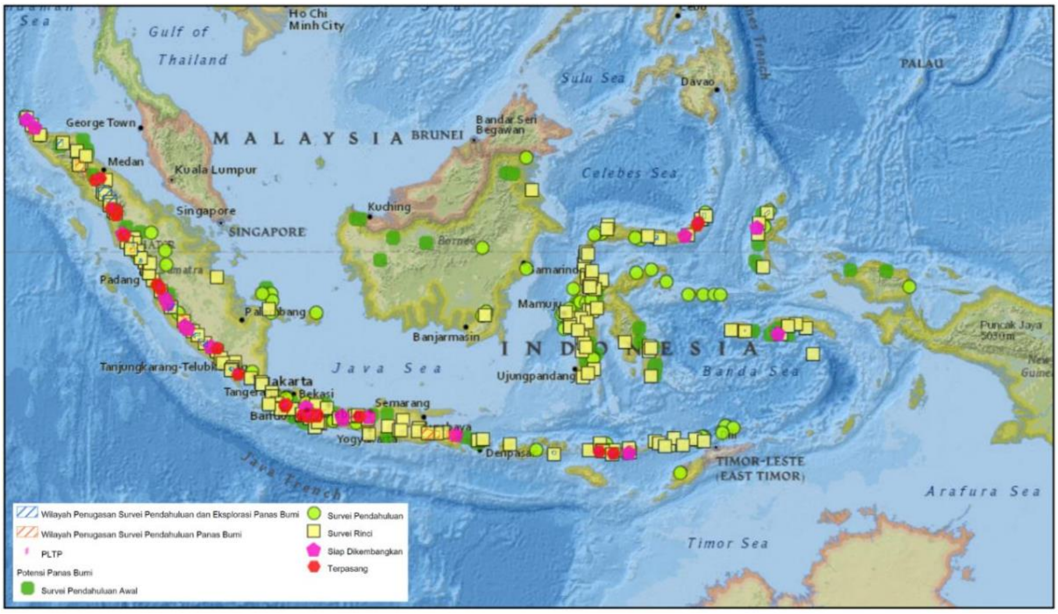


Figure 2: Map of Geothermal Power Plant and Prospect Areas in Indonesia (EBTKE, 2020)

In contrast with other renewable energy resources such as solar, wind, and hydro; geothermal energy is located in the subsurface that required drilling activities to reach the geothermal reservoir. However, this activity is the highest risk of geothermal project development due to the resource uncertainty and high upfront capital cost. Study from (International Finance Corporation, 2013) identified that the success rate of geothermal wells in the exploration stage is only around 50% and the probability will increase to 59% as more wells drilled in the field. This is due to the uncertainty of the resource in the subsurface is still high as it relies on the preliminary surveys (geology, geochemistry, geophysics) that are conducted above surface which still involve human interpretation or it can be called indirect data (D. W. Adityatama, 2020). With that reason, almost all of developers and investors have difficulty in making investment decision in the exploration stage as the capital cost that must be incurred to conduct exploration drilling is high by only relying on the limited data with high uncertainty.

Investment decisions in the exploration stage becomes more difficult because most of developers have to use their own equity considering that financial institutions that are willing to provide loan facilities are rare as the level of project risk is still very high. Most of the lenders would like to make sure that the resource is de-risk and confirmed after exploration drilling and then will follow up by the certain percentage of steam supply prior the financial closure. Thus, in order to accelerate geothermal development in the exploration stage, several countries have introduced several schemes to mitigate the resource risk such as government undertake the risk of exploration drilling before tendering process or providing funding facilities using grant or loan from multilateral/bilateral banks to the public and private business entities. The detail of these schemes will be further explained in the later section.

1.3 Study Objectives

This study will give an overview of typical activities that are conducted in the geothermal exploration project with its cost estimation, duration, and associated risks. Furthermore, this study will discuss in more detail what resource risk is and the exploration strategies used by developer to mitigate the resource risk. As the main part of this study, the detail on the geothermal exploration de-risking schemes that are currently available in the geothermal industry both in worldwide and Indonesia will be further discussed.

Methodology used in this study is literature review combined with interview with several experts that have related experience and background to this study. The main objective of this paper is to trigger more discussion among geothermal industry players in Indonesia and worldwide regarding the most suitable de-risking schemes to be implemented in Indonesia. The research questions that will be explored in the discussion of this paper are:

1. What is the largest portion of the cost in the geothermal exploration project?
2. What are the risks involved in the geothermal exploration project?
3. What are the options available for de-risking geothermal exploration project?
4. What are the pros and cons of each geothermal exploration de-risking options?

2. TYPICAL ACTIVITIES, COST and RISK OF GEOTHERMAL EXPLORATION PROJECT

2.1 Geothermal Exploration in Indonesia

Geothermal development in Indonesia is consisted of several stages as regulated in in Law (*Undang-undang*/UU) No. 21/2014 and Government Regulation (*Peraturan Pemerintah*/PP) No. 7 / 2017 which can be summarized in **Table 2**.

Table 2: Geothermal development stages in Indonesia (modified from Adityatama, 2020)

Geothermal Development Stage	Description	Party who conducts the activity	Duration
Preliminary Survey	Identify areas with potential geothermal resources and conducting surveys to gather information on the geology, geochemistry, and geophysics of the area. The result from the survey is then being integrated to develop conceptual model, resource assessment, and well targeting.	Government/Business Entity/State-Owned Enterprise	1 year
Exploration and Feasibility Study	Proving a geothermal resource exists and proving/delineating sufficient reserves for development. Once a viable resource has been identified, the resource assessment phase begins. This includes determining the size of the resource and the potential for energy production. Engineers will also conduct various studies such as environmental impact assessment, social impact assessment, and feasibility study.	Government/Business Entity/State-Owned Enterprise	5 + 1 + 1 years
Development and Construction	Proving that development of the resource is technically and economically feasible by drilling production and injection wells. Constructing the geothermal facility on specification, on time and on budget.	Business Entity/State-Owned Enterprise	2-4 years
Operation and Maintenance	After the construction of the power plant is finished, it will be operated and maintained. The operators will monitor the power plant's performance, make repairs and improvements as necessary, and ensure that it is operating in compliance with relevant regulations.	Business Entity/State-Owned Enterprise	30 years

For exploration stage in Indonesia, there are several schemes and terminologies that are introduced by government which is summarized in Table 3.

Table 3: Geothermal exploration schemes and terminologies in Indonesia

Wilayah Terbuka (Geothermal Open Area)	An area suspected of having geothermal potential outside the coordinate boundaries of a Geothermal Working Area
Assignment Area	A Geothermal Open Area with certain coordinate boundaries offered to an Other Party for PSP or PSPE
Wilayah Kerja Panas Bumi/WKP (Geothermal Working Area)	An area with defined coordinate boundaries used for the exploitation of Geothermal for Indirect Use (power)
Penugasan Survei Pendahuluan/PSP (Preliminary Survey Assignment)	The assignment given by the Ministry of Energy and Mineral Resources to carry out the Preliminary Survey activity
Penugasan Survei Pendahuluan dan Eksplorasi/PSPE (Preliminary Survey and Exploration Assignment)	The assignment given by the Ministry of Energy and Mineral Resources to carry out the activities of the Preliminary Survey and Exploration
Izin Panas Bumi/IPB (Geothermal License)	Permit to conduct exploration and/or exploitation of Geothermal for Indirect Utilization in certain working areas
Government Drilling	Scheme for government to conduct the early stage of geothermal development (preliminary survey and exploration drilling)

2.2 Typical Cost of Geothermal Exploration in Indonesia

The typical cost of geothermal exploration in Indonesia may varied as it is project specific and highly depends on the exploration drilling strategy that will be used. **Table 4** shows the estimate cost in conducting geothermal exploration drilling.

Table 4: Cost estimate of geothermal exploration drilling

Activity	Geology survey	Geochemistry survey	Geophysical survey	Initial conceptual integration and well targeting	Exploration drilling
Activity Description	Geological mapping on an area of 400 km^2. The work package including pre-field-work study, rock sampling and identification, structural mapping, and reporting.	Work package including a pre-field-work study, liquid and gas sampling from 30 locations, laboratory analysis and reporting.	Work package including pre-field-work study, 100 MT stations and 150 Gravity stations, interpretations and reporting.	Integrate all report from 3G surveys to create several scenarios of conceptual models, including peer review.	Using 3 (three) standard/big hole type or 5 (five) slimhole type. The cost estimate includes infrastructure construction cost to support the drilling operation. The duration estimate includes procurement process, preparation, equipment mobilization, drilling, well testing and demobilization.
Estimated Duration	4-8 months	4-8 months	4-8 months	3-6 months	24 - 36 months
Cost Estimate (USD)	300,000 – 700,000	200,000 – 400,000	1,000,000 – 2,000,000	100,000 – 200,000	15,000,000 – 40,000,000
Considerations	Accuracy might be affected by terrain, weather, and field personnel experiences.	Accuracy might be affected by sampling method (minimize contamination) and laboratory competences.	Accuracy might be affected by noise during data acquisition and data processing method, including personnel interpretation.	Accuracy might be affected by 3G data accuracy and personnel experiences and interpretation.	Allow personnel to acquire downhole data directly from reservoir which is very valuable for more accurate resource assessment but require higher cost and time compared to 3G survey.

2.3 Risks in a Geothermal Exploration Project

Geothermal exploration can be a challenging process, as it involves identifying and assessing the potential for geothermal resources in a specific area. The fundamental objective of a geothermal exploration program is to identify and characterize a geothermal resource which can be economically developed by applying an optimized design based on the exploration results. Nevertheless, it is common for any geothermal developers or investors to face difficulties when making investment decisions in the exploration stage, which is created by the requirement to spend high capital but relying on information that is still very minimal and has a very high level of uncertainty. It should be also remembered that the costs of exploration are not only the cost of drilling, but also costs of supporting infrastructure such as access roads, well pads, and other supporting facilities that are also substantial. Some of the main challenges of geothermal exploration in Indonesia include (Darma, 2016; Umam et al., 2018):

1. Difficulty in locating the “hottest area”: Geothermal resources are not always visible at the surface and can be difficult to locate without conducting detail geological, geochemical, and geophysical (3G) surveys and drilling test wells. This can make it difficult to identify the most promising areas for exploration and increase the risk of drilling dry wells.

2. High exploration costs: Conducting 3G surveys, developing a reliable conceptual model and drilling test wells can be expensive, and there is always the risk that a project will not yield a viable resource. This can make it difficult for developers to secure funding for exploration activities.

3. Complex geology: Geothermal resources in Indonesia are mostly located in volcanic area with complex geological environments, which can make it difficult to understand the subsurface conditions and identify the most promising areas for exploration.

4. Environmental impacts: Exploration activities can have a variety of environmental impacts, such as deforestation and the potential for groundwater contamination. Mitigating these impacts can be costly and time-consuming.

5. Social and community impacts: Exploration activities can also have social and community impacts, such as displacement of local communities and land-use conflicts. Developers need to address these impacts and engage with local communities to ensure their support and minimize the risk of project delays or cancellations.

6. Lack of data: In some cases, there may be a lack of data on the geology and geochemistry of an area, making it difficult to identify potential resources and plan exploration activities.

7. Uncertain regulations: Geothermal exploration is subject to a variety of regulations at the national, regional, and local levels. This can make it difficult for developers to navigate the regulatory environment and can increase the risk of project delays or cancellation.

3. VARIOUS DERISKING SCHEMES On GEOTHERMAL EXPLORATION PROJECT

A geothermal exploration de-risking scheme is a process used to reduce the financial risks associated with exploring for geothermal resources. Conventionally, this can be done through a variety of exploration methods, such as drilling test wells, conducting geophysical surveys, and collecting data on the geology and geochemistry of the area being explored. The goal of a de-risking scheme is to increase the likelihood of a successful geothermal project and to reduce the overall cost of exploration. This can be done by identifying areas with the greatest potential for geothermal resources and by reducing the number of high-risk exploration activities that are needed to confirm the presence of a viable resource.

Despite of the aforementioned methods, financial institution still reluctant to finance geothermal exploration projects due to their lack familiarity of geothermal projects and high risk associated with geothermal resource. Thus, government and donor organizations established programs that aimed at minimizing or substantially reducing financial risks of geothermal exploration project. The risk reduction program can be in the form of government-led exploration, loan guarantee, grants and cooperative agreement, drilling failure insurance, and cost sharing. The following sub-section will describe the various de-risking scheme for geothermal exploration project that are available worldwide.

3.1 Turkey Scheme

3.1.1 Risk Sharing Mechanism (RSM)

The most recent World Bank-supported Turkey Geothermal Development Project is Risk Sharing Mechanism (RSM) implemented by a local bank which will pay out a predetermined fraction of each well that fails to meet predetermined success criteria (40 percent or 60 percent of the well’s drilling targets based on geographical regions). A two-pronged approach will be taken to achieve the goals of the project; an RSM will be established to mitigate the resource risk in the exploration drilling stage and a loan facility will be established to finance project development. The RSM will cover 40 to 60 percent of the cost of exploration wells in case of resource-related failure. This will greatly reduce the risk for project sponsors and help them raise funds for costly exploration drilling projects. The higher coverage provided for projects outside the Aydin, Denizli, and Manisa is intended to stimulate investments in geothermal exploration in the less explored parts of the country (Türkiye Kalkınma ve Yatırım Bankası (TKYB) & The World Bank, 2021).

3.1.2 Government-led Exploration (The Turkish Model)

Government of Turkey also established government-led exploration method which has a slight variation on the Geothermal Development Cooperation (GDC) of Kenya model (Ram & Letvin, 2014). The Government via MTA (General Directorate of Mineral Research and Exploration of Turkey) assumes the exploration risk and the developer takes over at this stage to complete the field development and assume the long-term risk of having the resource throughout the term of the PPA. The mechanism is simple, MTA had been drilling confirmation wells with budget money and thus absorbs the cost of any dry wells. On the other hand, once proven, these resources in a form of licenses are put up for bids and can attract very attractive offers. The Government then collects the money and uses it to finance more exploration drilling and open up new areas. The IPP come into projects which have been “de-risked” to a certain degree and can obtain financing to complete the field development and build the power plants.

3.2 New Zealand Scheme

Most of New Zealand’s geothermal power development was due to government-led exploration (GeothermEX, 2010). A government entity undertakes exploration activities directly or contracts private firms to do so on their behalf. Proven resources are developed by government-owned enterprises or auctioned to private firms. Most of New Zealand’s geothermal development occurred when the country’s utility companies were government-owned. As such, these government utility companies, and in turn the government itself, carried the risk associated with exploration drilling. Although two of the five electricity producers in New Zealand are now private sector companies, much of the country’s geothermal development took place when the government bore the exploration risk, and some of the government-run utilities still undertake geothermal exploration projects today.

3.3 United States Scheme

Unites States (US) Government has introduced several de-risking programs to accelerate the geothermal development in the country especially in the exploration phase. These programs can be broken down as government-led exploration project, grants and cost sharing, and loan guarantee. The list of geothermal exploration risk reduction program can be shown in **Table 5**.

Table 5: List of Geothermal Exploration Risk Reduction Program in United States

Risk Reduction Scheme	Program Name
Government-led exploration	• United States Department of Energy (USDOE) through National Laboratories
Grants and cost sharing	• Industry-Coupled Case Studies Program • User Coupled Confirmation Drilling Program (UCDP) • American Recovery and Reinvestment Act (ARRA)
Loan guarantee	• Geothermal Loan Guarantee Program (GLGP) • Loans for Geothermal Reservoir Confirmation Program

3.3.1 USDOE through National Laboratories Government-led Exploration Project

USDOE through one of the National Laboratories has continued to provide limited financial support which is generally directed to specific technologies, critical component development, resource exploration or demonstrations. Recent solicitations have been directed at for example small power plant demonstrations, critical power plant and well field components e.g. downhole pumps and enhanced evaporative cooling, direct-use applications and enhanced geothermal systems (Lund & Gordon Bloomquist, 2012).

One of the example is the cooperation with Sandia National Laboratories which manages the slimhole drilling program for geothermal exploration. The principal objective of this program is to expand proven geothermal reserves through increased exploration, made possible by lower-cost slimhole drilling. For this to be accepted as a valid exploration method, however, it is necessary to demonstrate that slimholes yield enough data to evaluate a geothermal reservoir, and that is the focus of Sandia's current research (Finger et al., 1997).

3.3.2 Industry-Coupled Case Studies Program

DOE implemented the Industry-Coupled Case Studies Program in 1978 with two main objectives. First, its cost-share mechanism helped facilitate geothermal exploration by offsetting some of the high initial costs and risk of exploration drilling. At the time, little was known about the locations of geothermal resources in the United States (Moore et al., 2010). To encourage exploration, DOE covered 20% to 50% of the exploration and reservoir confirmation costs for participating projects (Bloomquist, 2005). Second, DOE wanted to gather more data on geothermal resources and projects for the purpose of increasing knowledge and thereby aiding in future geothermal power development. Thus, DOE required industry participants to provide the well and drilling data collected during the exploration process. During this program, industry partners evaluated 14 sites, eight of which resulted in geothermal power plants. As of 2010, seven of these plants were operating with a combined capacity of 137 MW (Moore et al., 2010); it is possible more plants have come online since then. The program eventually lost congressional support and is no longer in operation (Speer et al., 2014).

3.3.3 User Coupled Confirmation Drilling Program (UCDP)

UCDP program is a cooperative effort between USDOE and industrial organization to engage industry participation in the early stage of geothermal development mostly for direct use projects but include some electrical generation projects. The program design is to share expenses related to the confirmation of hydrothermal resources activities such as sitting drill holes, drilling, flow testing, reservoir engineering, and drilling of well testing. Through this program, a portion of risk associated in the exploration phase will be absorbed and at the same time experience infrastructure of exploration, reservoir confirmation and utilization engineering consultants, contractors and equipment manufacturers are being developed to further reduce reservoir confirmation risks (Lund & Gordon Bloomquist, 2012).

Even though the program looks like the cost sharing between government and developers, but actually the structure was served as loan guarantee. Thus, the developer may finance the project using their own equity or getting loan from commercial institution by using the UCDP contract as guarantee that the project risk has been reduced. The cost sharing is paid between 20 and 90% of the total project cost based on the formula that has considered well output for planned application. This means that if the project successful, cost share of USDOE is 20% and for the unsuccessful project, the cost share of USDOE is 90%. The program was established in 1980 with the experimental project is Raft River 5 MWe geothermal power plant. However, the program does not actively attract industry participation due to the lack of publication and release of geoscientific data had little impact as most land positions were already well established (Lund & Gordon Bloomquist, 2012).

3.3.4 American Recovery and Reinvestment Act (ARRA)

ARRA program was established in 2009 with objective to boost geothermal Research, Development, and Demonstration Activities (RD&D) and increase geothermal power generation. The allocated projects and program pathways are shown in **Figure 3**.

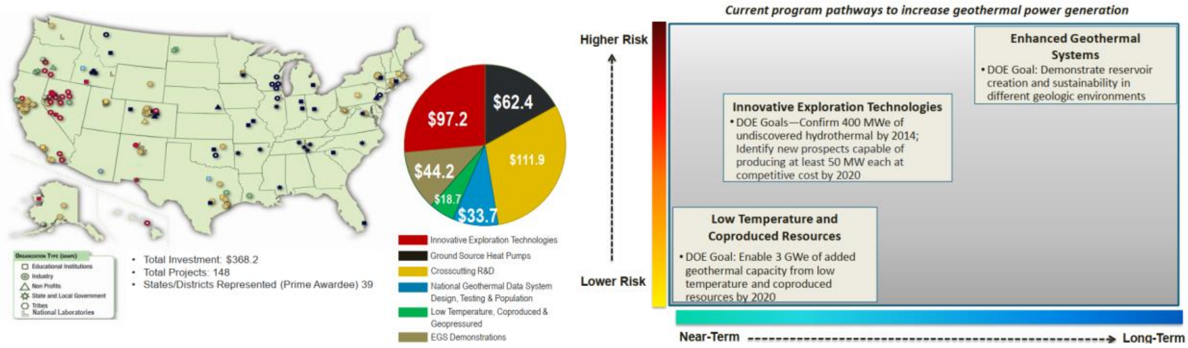


Figure 3: ARRA funding projects and program pathways (US Department of Energy, 2011)

<u>3.3.5 Geothermal Loan Guarantee Program (GLGP)</u>

GLGP was one of the first and well-known geothermal loan program of all the state and Federal programs which established in 1975 (Bloomquist, 2003). The GLGP was designed to accomplish the following objectives:

1. To encourage and assist the private and public sectors to accelerate development of geothermal resources in an environmentally acceptable manner by minimizing a lender's financial risk;

2. To develop normal borrower-lender relationships in order that financing be made available without guarantees at some future date;

3. To enhance competition and encourage new entrants into geothermal markets.

Under terms of the Act, loan guarantees could be granted for up to 75% of the project costs with the Federal government guaranteeing up to 100% of the amount borrowed. The Act was subsequently amended in 1980 to allow for the granting of loans up to 90% of the total aggregate project cost, providing that the applicant was an electric, housing or other cooperative or a municipality. However, loans were limited to $100 million per project and no qualified borrower was to receive more than $200 million in loans (Bloomquist, 2003).

The GLGP was successful in furthering geothermal developments at a number of locations and in bringing both direct use and electrical generation projects on-line. The two most serious deficiencies in the program were that the very severe requirement of loan approval often served to limit the use of the program to those who should have been able to qualify for a conventional loan without the guarantee, and the fact that utilities were unwilling to use the loan guarantee program because default, even on a loan guaranteed by the Federal government, would seriously affect their credit rating. Although successful, the program ended when the U.S. Congress failed to provide further appropriations for the program during the 1980s (Bloomquist, 2003).

<u>3.3.6 Loans for Geothermal Reservoir Confirmation Program</u>

Congress authorized the Loans for Geothermal Reservoir Confirmation Program, a direct loan program, in 1980. It was intended to provide loans to geothermal heat and power projects for surface exploration and drilling (Bloomquist, 2005). Loans could not exceed $3 million and were limited to 50% of project costs for power projects. Despite being passed in the Energy Security Act of 1980 and authorized by the Secretary of Energy, the program never received congressional appropriations (Speer et al., 2014).

3.4 East Africa Scheme

<u>3.4.1 East African Rift Geothermal Development Program (ARGeo)</u>

In partnership with the World Bank and United Nations Environment Programme, the Global Environment Facility established the East African Rift Geothermal Development Program (ARGeo) in late 2009 to provide technical assistance and exploration risk mitigation funding (Mwangi 2010). ARGeo is intended to support operations in six target countries to exploit resources along the seismically active East African Rift that are largely undeveloped.18 The original ARGeo proposal took a dual approach: (1) regional networking facilitation and technical assistance and (2) a drilling risk mitigation fund that exclusively addressed exploration drilling risk. In exchange for a premium paid by the developer, the risk mitigation fund provided up to 85% of eligible drilling expenses in the event that exploration drilling yielded an insufficient resource. This coverage ratio would be reduced for each successive well attempted. The World Bank rescinded its funding for the risk mitigation portion of the project in December 2011, but at the time of writing, the networking and technical assistance portion of the project was still active (Speer et al., 2014).

<u>3.4.2 Geothermal Risk Mitigation Facility for Eastern Africa</u>

After pulling out of the planning process for ARGeo, KfW created a geothermal risk mitigation facility in partnership with the European Union and the African Union in late 2011 (Speer et al., 2014). This program offsets the risk of non-performing exploration wells by providing grants for 80% of the cost of surface studies, 40% of the cost of exploration drilling, and 20% of the cost of required infrastructure improvements (GRMF 2012). Grants are available to both government and private developers. To further incentivize developers, the bank offers an additional financing success fee for projects that secure outside financing for subsequent phases of development (KfW 2011; Muir 2011). Although it offers additional incentives and funding for other activities in addition to exploration drilling, this facility essentially functions in much the same way as the U.S Industry-Coupled Case Studies program: it is a cost-share program with a data collection requirement.

3.5 Indonesia Scheme

Table 6 listed the geothermal exploration de-risking facilities that are currently available in Indonesia.

Table 6: List of geothermal exploration de-risking facilities in Indonesia

Risk Reduction Scheme	Program Name
Government-led exploration	• Geothermal Energy Upstream Development Project (GEUDP) • Government Drilling through Geological Agency
Loan and risk sharing	• Geothermal Resource Risk Mitigation Project (GREM) • State Owned Enterprise (SOE) Drilling

3.4.1 Geothermal Energy Upstream Development Project (GEUDP)

GEUDP is government-sponsored exploration drilling which is a collaboration program between Government of Indonesia and World Bank with main objective to develop greenfield geothermal areas that have not been tendered yet, especially in the remote areas of Indonesia. The project structure and funding source is shown in **Figure 4**.

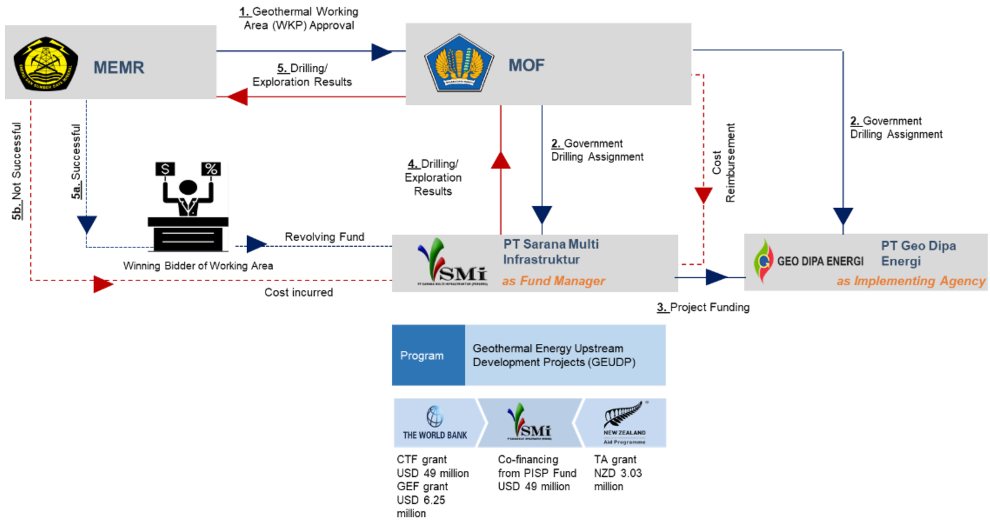


Figure 4: GEUDP Project Structure and Funding Source (PT SMI, 2022)

In this program, government will fully absorb the risk of exploration drilling if the resource is not proven or not economically attractive. If the geothermal resource is feasible to be developed to the electrical generation project, WKP will be tendered along with geothermal data package that are obtained during the exploration drilling. The cost paid by the winning bidder will become revolving fund to finance another government drilling projects. Currently, there are 4 (four) pipeline projects under the program namely Waesano, Jailolo, Nage, and Bittuang with most of them are still in the early stage of exploration activities. Some of the projects also face several issues regarding public acceptance and land utilization status making the project progress slowly.

3.4.2 Government Drilling through Geological Agency

Geological Agency of Indonesia under MEMR also conducted exploration drilling to several geothermal prospect areas in Indonesia with source of fund coming from state budget (APBN) and the risks are covered 100% by government. The activities conducted are preliminary survey, land acquisition, permits, infrastructure construction work, drilling, well testing until updating the pre-FS document. Currently, there are 3 (three) pipeline projects under the program which are Nage, Bittuang, and Cisolok Cisukarame. It is noted that Nage and Bittuang projects coincide with GEUDP sub-projects. This is due to government efforts to accelerate project progress by introducing hybrid financing scheme at which Geological Agency will first conduct early exploration activities until drilling 2 (two) slimhole wells using APBN fund. If the drilling result from Geological Agency cannot conclude and prove the economic geothermal resource, the subsequent activities will be financed under GEUDP program.

3.4.3 Geothermal Resource Risk Mitigation Project (GREM)

GREM was developed by the World Bank and the Government of Indonesia, with PT Sarana Multi Infrastruktur (Persero) as the Project Implementing Entity. GREM is a geothermal exploration financing facility that offers a de-risking scheme for resource risk with targeted applicants are SOE developers/subsidiaries of SOEs called GREM Public Window and private developers called GREM Private Window. For GREM Public Window, the facility will be a combination of blended loan from IBRD/GCF/CTF and de-risking from PISP fund with maximum total limit of USD 30 million. In the GREM Private Window, the facility will be a combination of blended loan from IBRD and financial instrument de-risking from GCF/CTF and the limit of total facility is USD 30 million. The overview of GREM facility is shown in **Figure 5**.

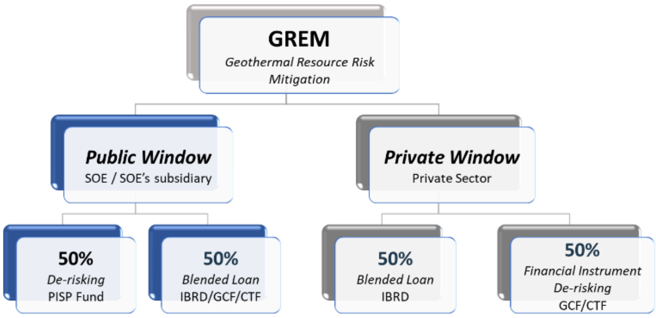


Figure 5: Overview of GREM Facility (PT SMI, 2022)

The total commitment of GREM funding is USD 651.25 million which comes from a combination of multilateral funds (IBRD, GCF, CTF) and PISP funds which is illustrated in **Figure 6**.

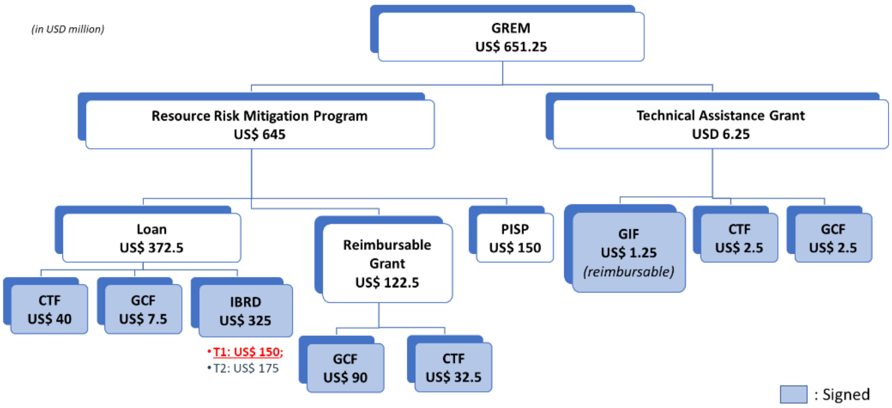
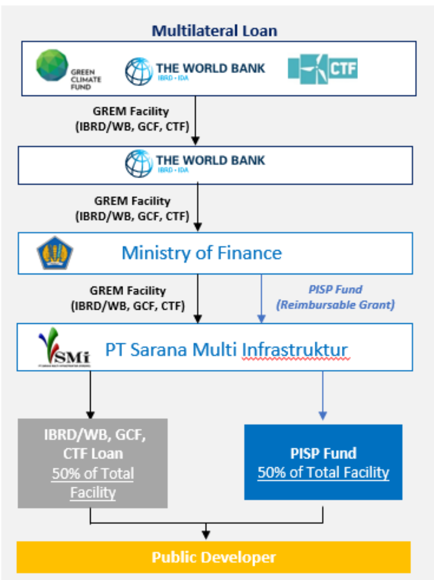


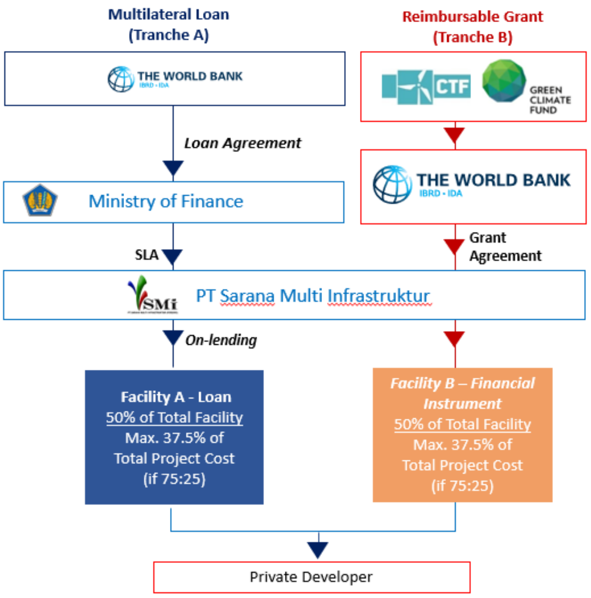
Figure 6: Source of Funding GREM (PT SMI, 2022)

The facility scheme of GREM Public and Private Window along with the summary and general condition of the facility is shown in **Figure 7** and **Figure 8**.



Summary of Standard Indications & General Conditions	
Debtor	SOE/SOE's Subsidiary (majority owned by SOE), IPB license holder
Maximum Facility Limit	USD 30 million
Facility Tenor	Maximum 4 years
Interest Rate	Interest rate is determined by Ministry of Finance
Condition/Criteria	▪ has Geothermal Data and Information obtained from the results of the Preliminary Survey as well as from other activities by the business entity concerned, but the feasibility of the Geothermal Data and Information cannot be concluded; ▪ all or most of the land for exploration purposes in the Working Area has been legally controlled or licensed by the relevant business entity and is not currently the object of a case/dispute in any court; ▪ and other conditions to be determined further
De-risking mechanism	▪ Risk coverage by the Government, in this case the Minister of Finance, is not more than 50% of the total loan value; ▪ Risk Coverage is provided if the following risks occur: a) Exploration Risk b) Political Risk ▪ The implementation of Risk Assurance can be carried out by the Minister of Finance by giving special assignments to PT PII (Persero) based on the applicable laws and regulations
Other criteria	▪ Mandatory to comply with the provisions of World Bank's procurement and safeguards standard

Figure 7: Facility Scheme of GREM Public Window (PT SMI, 2022)



The main feature of GREM Private Window is a financing product which combines Facility A (Loan) and Facility B (Financial Instrument)

- **Facility A (Loan)**

General Terms and Conditions – Facility A (Loan)	
Max. Facility Limit	50% of Total Facility *(Note: Maximum Total Limit for Facility A and Facility B is US$ 30 million)*
Debt-to-Equity Ratio	Max. 75:25 (with the debt portion is the aggregate of both Facility A and B)
Tenor	4 years (bullet payment)
Interest Rate	To be determined by the Minister of Finance

- **Facility B (Financial Instrument)**

General Terms and Conditions – Facility B (Financial Instrument)	
Facility B	Subscription of zero-coupon Financial Instrument (FI) issued by the Issuer to the Investor (PT SMI)
Max. Facility Limit	50% of Total Facility *(Note: Maximum Total Limit for Tranche A and Tranche B is US$ 30 million)*
Debt-to-Equity Ratio	Max. 75:25 (with the debt portion is the aggregate of both Facility A and B)
Repayment or Redemption	All FI issued shall be redeemed in full at the Notional FI Value by the Issuer maximum **5 (five) years** from the date of the first issuance
Feature	• ***Call option:*** Sponsor's right at any time on giving notice to purchase the Fis at a price equal to: ➢ If the Call Option is issued on or before the 4th anniversary → Notional FI Value ➢ If the Call Option is issued after the 4th anniversary → Notional FI Value **or** Share of Participation x Developer Fair Market Value (as elected by the Sponsor) • ***Put option:*** PT SMI's right to sell the FI to the Sponsor at the Notional FI Value, after 4th year from the FI first issuance date under certain circumstances such as if a Call Option is not exercised, or there is an Event of Default, etc.

Figure 8: Facility Scheme of Private Window (PT SMI, 2022)

3.4.3 State Owned Enterprise (SOE) Drilling

SOE Drilling program is particularly similar with GREM Public Window Facility but with funding source is fully coming from PISP fund. The facility is capped at USD 30 million with combination of blended loan and de-risking facility. The application process and eligibility criteria is similar with GREM Public Window which follow provisions in Ministry of Finance Regulation No.80/PMK.08/2022. However, the developer is not obliged to follow World Bank ESS (Environmental Social Safeguards) and Procurement Standards.

4. DISCUSSION

To achieve the national geothermal target, Indonesia must focus on various prospect areas or WKP that are currently in the exploration stage. This can be seen from the target of adding installed capacity of approximately 3,300 MW in 2030, more than 70% is expected to come from geothermal areas or WKPs which are still in the exploration stage. With this understanding, it is very important for all geothermal stakeholders in Indonesia to work together to complete all ongoing and ongoing geothermal exploration projects.

This paper has discussed that one of the major challenges for geothermal exploration projects is the high capital that must be allocated where the level of uncertainty on the economical geothermal resource's availability is still very high. The results of literature studies and interviews with various geothermal experts concluded that the range of funds that must be prepared for a geothermal exploration project in Indonesia ranges from USD 10-50 million with deep well drilling activities being the largest cost component.

Not all geothermal companies in Indonesia have or are willing to allocate their equity to finance geothermal exploration projects due to the high risk of losing all that equity if it turns out that the results of exploration activities conclude the prospects are uneconomical to proceed with. Therefore, it is important to have other funding options available for geothermal exploration activities besides using company equity.

This paper has discussed several de-risking schemes for geothermal exploration project that are established by government and donor organizations around the world. Of course, there is no option that ultimately eliminates the risk of geothermal exploration as a whole, but with the availability of several funding options, it is hoped that geothermal exploration projects in Indonesia can run more quickly.

Of course, there are many aspects that have not been touched on by this paper related to the process of submitting funding for geothermal exploration projects. Therefore, the writing team plans to cover several additional aspects in a separate paper with a more focused discussion on the risks of geothermal resources in the exploration stage.

REFERENCES

Adityatama, D. (2020). Mengenal Tahapan Proyek Panas Bumi di Indonesia. www.enerklaz.com

Adityatama, D. W. (2020). Risiko Utama Pada Fase Eksplorasi Panas Bumi. www.enerklaz.com

Asokawaty, R. F., Purba, D. P., Adityatama, D. W., Muhammad, F., & Umam, M. (2020). Indonesia's Geothermal Development Compare to World Top Geothermal Producers_Asokawaty. 45th Workshop on Geothermal Reservoir Engineering.

Badan Geologi Kementerian ESDM. (2023, January 11). Potensi Pengembangan Panas Bumi di Indonesia. Https://Www.Ebtke.Esdm.Go.Id/Lintas/Id/Investasi-Ebtke/Sektor-Panas-Bumi/Potensi.

Bloomquist, R. G. (2003). United States geothermal policy-Provision of access and encouraging project development.

Bloomquist, R. G. (2005). The Evolution of U.S. Policy Designed to Encourage Geothermal Development Provision of Access and Encouraging Project Development. World Geothermal Congress.

Darma, S. (2016). Indonesia: Vast geothermal potential, modest but growing exploitation. In Geothermal Power Generation: Developments and Innovation (pp. 609–643). Elsevier Inc. https://doi.org/10.1016/B978-0-08-100337-4.00021-8

Direktorat Panas Bumi. (2022). Buku Pintar Umum Panas Bumi.

EBTKE. (2020). Geoportal EBTKE ESDM. Https://Geoportal.Esdm.Go.Id/Ebtke/.

EBTKE. (2022). PENGEMBANGAN PANAS BUMI DI INDONESIA.

Finger, J. T., Jacobson, R. D., Hickox, C. E., & Eaton, R. R. (1997). DRILLING FOR GEOTHERMAL EXPLORATION. 1473–1477.

GeothermEX. (2010). An Assessment of Geothermal Resource Risks in Indonesia. http://www.ppiaf.org/sites/ppiaf.org/files/publication/REPORT_Risk_Mitigation_Options _Indonesia.pdf

International Finance Corporation. (2013). Success of Geothermal Wells: A Global Study.

Lund, J. W., & Gordon Bloomquist, R. (2012, February). DEVELOPMENT OF GEOTHERMAL POLICY IN THE UNITED STATES -WHAT WORKS AND WHAT DOESN'T WORK. PROCEEDINGS, Thirty-Seventh Workshop on Geothermal Reservoir Engineering.

Moore, J., Ross, H., & Wright, P. (2010). Exploration 1976–2006: A History of Geothermal Energy Research and Development in the United States." Washington, DC: U.S. Department of Energy. http://www1.eere.energy.gov/geothermal/pdfs/geothermal_history_1_exploration.pdf

PT SMI. (2022). De-risking of Geothermal Exploration from Lender's Perspective.

Ram, H., & Letvin, A. I. (2014). Using Financial and Policy Tools to Address Exploration/Drilling Risk. In GRC Transactions (Vol. 38).

Speer, B., Economy, R., Lowder, T., Schwabe, P., & Regenthal, S. (2014). Geothermal Exploration Policy Mechanisms: Lessons for the United States from International Applications. www.nrel.gov/publications.

Türkiye Kalkınma ve Yatırım Bankası (TKYB), & The World Bank. (2021). RSM Geothermal Resource Validation - Beneficiary Manual 2.0. https://rpmjeoturkiye.com/en/homepage/

Umam, M. F., Muhammad, F., Adityatama, D. W., & Purba, D. P. (2018). Tantangan Pengembangan Energi Panas Bumi Dalam Perannya terhadap Ketahanan Energi di Indonesia. Swara Patra, 8(3), 48–65. https://www.researchgate.net/publication/331373378

US Department of Energy. (2011). Geothermal Technologies Program. https://www.energy.gov/sites/prod/files/2014/02/f7/gtp_peer_review_plenary_deck_20110606.pdf