Incentivizing geothermal energy business with G20 collaboration

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Abstract. Indonesia has an abundance of geothermal energy potential (29 GWe) and becomes the second-largest geothermal power plant installed capacity after the United States. Geothermal is the most reliable renewable energy due to its highest capacity factor. It works as the base load in the electric grid. Unfortunately, the installed geothermal power plant was only approximately 6.3 % in 2018. Although the Government of Indonesia (GoI) has already given and supported in terms of financial incentives, regulation, technical assistance, it could not boost geothermal development significantly. Recent geothermal based electricity generation cost is rising, especially for the greenfield, caused by rising exploration cost could lead to geothermal development unfavorable, especially for affordability policy in Indonesia energy. All the incentives could not yet accelerate geothermal development significantly due to the risk and cost of geothermal exploration. Facing the fact that exploration cost tends to rise over time, G20 collaboration should be able to reduce the risk and cost associated with geothermal exploration with effective incentives. This paper aims to provide solutions and recommendations regarding exploration cost reduction through geothermal technology research and development with an emphasis on cost and risk reduction among G20 collaboration. The proposed incentives are then constructed for Indonesia's requirement to meet geothermal conditions and requirement from the trilemma energy aspect, especially for geothermal technology to reduce exploration cost and risk. The proposed incentives also deal with human resource development for improvement in learning rates to have better technology adoption and acquisition by using SWOT and Policy Gap Analysis.

Keywords: Geothermal Power Plant, Effective Incentives, Learning Rate, Policy Gap Analysis, SWOT Analysis, Technology Adoption, and Acquisition

1. Introduction

Geothermal energy, especially for electric power generation, is known as the most reliable renewable energy with the highest capacity factor. This high capacity power makes Geothermal Power Plant (GPP) suitable to baseload in the electricity grid. Indonesia, fortunately, lies in the ring of fire with abundant geothermal energy [1]. In RUPTL 2019-2029 (General Planning Electricity Power Plant), the blueprint of Indonesia electricity development, PLN, as Indonesia state-owned electric operator, has a high target for an installed capacity of GPP to reach 7.2 GW, although the existing installed capacity of GPP in
2019 is approximately 2 GW only. It is a great opportunity to delve into the project with such large market expansion.

Unfortunately, besides its high factor capacity, GPP has significant disadvantages. The most crucial factor is the exploration cost and risk are still high. Early-stage, which consists of preparation and exploration risk, is the highest. Figure 1 shows the risks and costs at different stages of GPP below.

![Figure 1. Geothermal Risks and Costs. Gehringer et al., IBRD (2012)](image1.png)

The risk related to GPP development rises proportionally to the capacity of the proven reserve, meaning it is harder to scale up and reach an installed capacity of the GPP target. Figure 2 shows the relation between productivity and probability of failure below.

![Figure 2. Productivity and Probability Failure of GPP (IFC, 2012)](image2.png)

In Indonesia, the electricity generation cost of GPP tends to rise [2]. This trend will jeopardize the target since Indonesia puts affordability as the priority [3] and power purchase regarding local BPP (electricity generation cost), as stated in GoI regulation [4]. The rising electricity generation cost is in Figure 3
below. It rises when the cost gas and diesel power plant decline, cause more burden for PLN as the single grid operator.

![Figure 3. PLN Electricity Generation Cost 1985-2018 (PLN Statistics, 2018)](image)

All the incentives could not reduce electricity generation costs and risks. The rising electricity generation cost from GPP, as mentioned above, is still dangerous to develop such abundant energy resources. The most important thing to deal with is exploration cost and risk, which correlates the deployment of technology and human resources. This paper aims to construct the model of effective incentives for GPP development, especially for the deployment of technology, which set on field suitability and empowerment of human resources related to the learning process.

2. Literature Review

It is clear that GPP potency is so high, but the disadvantages such as exploration of high risk and cost halt its progress. There are some references to mitigate those disadvantages by improving the skill and technology, which in turn decreases the risk and cost theoretically. In microeconomic theory, the cost of production could be lowered by skillful labor, which has had experiences through undergoing working in the field of manufacturing or services. Figure 4 shows that more output and less cost will prevail when such knowledge and technology have been acquired and adopted. The more hours of labor spent, the more output produced.

![Figure 4. Cumulative Output produced (Pindyck and Rubinfeld, 2013)](image)
The learning process for production factors such as labor is also the decisive factor to sustain the business by becoming more efficient (less cost per output unit, when the firm reaches its economies of scale as shown by AC1 and AC2 cost function curve in Figure 5 below. Learning could shift the cost more downward more effectively [5].

![Figure 5. Learning Effect on Economies of Scale [5].](image)

In the Indonesian geothermal industry, it is interesting that although the risk increases proportionally to proven reserve, the cost of electricity cost decreases, regardless of the spending of such investment [6]. Table 1 shows the relationship between well capacity WC/proven reserve (MW) and electricity cost P ($/kWh), below. This finding confirms the learning rate above that the higher geothermal well explored, which needs the expertise and experiences more, the lower the cost of output per unit.

Table 1. Well Capacity and Electricity Generation Cost [6].

| WC (MW) | N_DW | M_DW | IDW + IMW (US Million) | OC_U (US Million/year) | IPF (US Million) | P (power) US cents $/kWh |
|---------|------|------|------------------------|------------------------|------------------|------------------------|
| 5       | 28   | 22   | 115                    | 2                      | 10               | 7.1                    |
| 10      | 12   | 12   | 54                     | 1.2                    | 6                | 5.3                    |
| 15      | 7    | 8    | 33.5                   | 0.9                    | 4.5              | 4.8                    |
| 20      | 5    | 6    | 24.5                   | 0.8                    | 4                | 4.5                    |

In conducting SWOT (Strength Weakness Opportunity Threat) analysis for energy research [7], there are three considerations as follows:

1. Science and Technology such as RD and D, Technology advancement
2. Market and Industry such as potential market and supporting industry
3. Policy and Measures such as price/tariff, Renewable Energy Rank

The research conducted in the Geothermal Technology Office finds that with more aggressive and easier regulations and action such as streamlined regulations and reduced permitting timelines, the USA could double its installed capacity. Under EGS technology and other technology improvements, which predicted will be commercially viable in 2030, the USA could escalate its installed capacity more than 20 folds, or it could share 8.5 % of all electricity generation, compared to 0.4% in 2019 [8]. It is important for Indonesia because hydrothermal well could experience higher costs due to regulatory reforms and new exploration technologies and techniques to increase successfully proven reserve ratio [8].

In large renewable energy share of the electric grid, GPP as the baseload could serve as a spinning reserve as well and become the integrator of variable renewable energy such as wind and solar PV [9]. GPP could become flexible by using its geologic thermal energy storage [10]. It is very important
because of intermittency could reduce electric grid stability in terms of frequency [11] and voltage stability [12]. GPP, hydropower, and other thermal power generations could serve as flexible power generations to serve large variable renewable in the electric grid with further modifications on the turbines, boilers (thermal), controls [13]. Indonesia has to make new relevant electricity codes to implement large renewable energy shares in the electric grid [14].

Meanwhile in G20 collaborations, especially for geothermal resources, Indonesia still put much attention on investment or grant/loan such as Climate Fund or Geothermal Fund and other conventional schemes such as collaboration with UNU-GTP (United Nations University for Geothermal Resources) since 1982 but the requirement for human resource for GPP is not enough yet (Umam and Nugraha, 2019).

Recent 35 GW electricity power plant program with lower growth of predicted electric energy demand and the slow progress of transmission and distributions for renewable energy to absorb generated energy also become the threat for GPP besides rising geothermal electricity generation cost. Indonesia, however, has already launched PSPE (Preliminary Assignment and Survey) to ease geothermal exploration, since 2017 to have better data and information for GPP. GoI has also given incentives in forms of tax incentives, but the GPP still finds difficulties for low Power Purchase Agreement, which is backed up by the bank. Hence, it is important to have effective incentives in G20 collaboration in terms of reducing the risk and cost of geothermal exploration with existing incentives.

3. Analysis

The SWOT and Policy Gap Analysis is as follows

| Table 2. SWOT and Policy Gap Analysis |
|---------------------------------------|
| **Strength**                          |
| **Science & Technology**              |
| Abundant potential, technology allows flexible technology besides baseload as well, side income such as heat energy |
| **Market and Industry**               |
| Huge market                           |
| **Policies and Measures**             |
| G20 backup                            |
| **Gap Analysis**                      |
| Fewer incentives and related regulation on GPP, EGS technology-related collaboration or other forms of technologies |
| Fewer incentives to boost GPP         |
| Less effective coordination and collaboration |

| **Weakness**                          |
| **Science & Technology**              |
| Less transmission in GPP locations, poor Geothermal Exploration Data |
| **Market and Industry**               |
| No Direct use or local supporting industry |
| **Policies and Measures**             |
| Discrete Policy                       |
| **Gap Analysis**                      |
| Lack of incentives for transmission development and exploration phase (PSPE still in progress) |
| Lack of collaboration among GPP stakeholders |
| Changing policy causes instability    |

| **Opportunity**                       |
| **Science & Technology**              |
| Higher market share and the backbone for renewable energy |
| **Market and Industry**               |
| Higher market share for industries and residential |
| **Policies and Measures**             |
| G20 collaboration                     |
| **Gap Analysis**                      |
| Lack of human resources availability  |
| Lack of collaboration for new technology development and direct heat use |
| Patent and capabilities issues        |
### 4. Solutions, Recommendations and The Way Forward

- PSPE and G20 based incentives in terms of Human Resource Development from GPP stakeholders such as developers, academics and regulators must be done properly and fairly to guarantee proven reserve for GPP development.
- Human Resource must be managed by top management since there it is the key for GPP development.
- Incentives and regulation should direct to G20-Indonesia collaboration on:
  - Hydrothermal-EGS transitional-technology adaption
  - Big data for geothermal model collaboration
  - Joint-Exploration collaboration
  - Transmission and Grid empowerment
  - Cost-Effective Program Research

#### Recommendations

- Building comprehensive ToT (Transfer of Technology) legal umbrella
- Scholarship link to G20 collaboration on the reduction of geothermal cost and risk

#### The Way Forward

- Extension on government authority to support GPP in terms of funding and full guarantor, provided by reformed regulations as the legal umbrella
- Legal umbrella for transmission and distribution reimbursement

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