ISSN 2541-223X
Volume 4 2022

# SORIK MARAPI POWER PLANT DISASTER PREPAREDNESS LEVEL

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**Abstract.**
Sorik Marapi Geothermal Power (SMGP) is one of the largest developing geothermal projects in Indonesia. This project is located in Mandailing Natal Regency, North Sumatera Province. KS ORKA acquired the majority shares of the company in mid-2016 and since then the project has completed drilling program for 18 wells and confirmed at least 55 MW of proven resources. The project aims to connect 240 MW power to The PT PLN grid. The Steam field Diagram Options (SAGS) conceptual design based on the wellpad separation concept with the separated fluids running the Well Head Units (WHU) installed within the production well pad. This SAGS concept is a decentralized system with shorter pipelines per plant. The SAGS concept has the advantage of a faster time to see its development compared to the traditional concept. High risk of that could occurs during geothermal exploration and development activities identifying risks of geohazard in early phase of geothermal development plan might cause some problems and catastrophic events such as damages on infrastructure, well pad, road access, pipeline, well leaks or broken, impairment of power plant facilities, and following cessation of electricity production. Moreover, these events also could affect the nature or environment surrounding the field and results fatality or loss of human lives. Therefore, it is very critical to have a well - structured and comprehensive method as a guide to identify and mitigate the geohazard risks. The aim of this study is to gathers and reviews disaster preparedness level in SMGP Project area especially geohazard such as earthquake and landslide. Evaluation of existing building using FEMA P-154 and ASCE 41-17 Tier 1 and 2 also explained on this study.

***Keywords*:** Sorik Marapi, Disaster Preparedness Level, Geothermal Power

## 1. INTRODUCTION

Geothermal energy represents one of the alternative options for Indonesia to achieve a comprehensive approach to national energy development. It is a source of clean, renewable and environmentally friendly energy to getting power generation. The Government of Indonesia has put major efforts into promoting its development with initiatives such as the Roadmap of Geothermal Development 2012–2025, the National Energy Policy 2014, the issuance of a new geothermal tariff in 2014 and the Geothermal Law No. 21 of 2014. Participation from all stakeholders, public sector as well as private sector, is essential to raise awareness of the role of geothermal power in the national energy strategy.

KS ORKA is one of the most ambitious geothermal developers in the country, with projects led by the most experienced geothermal experts and power project developers with over 30 years of experience in some of the most significant geothermal development

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DOI: https://doi.org/10.20885/icsbe.vol4.art31

projects in the world. Applying the innovative Incremental business model, KS Orka develops and accelerates geothermal power projects, with a target of up to 1,000 MW in Indonesia by 2024. The technology allows KS Orka to develop geothermal resources in a more cost-efficient and environmentally friendly manner. See Figure 1 for KS ORKA Project Location in Indonesia.

Sorik Marapi Geothermal Power, a subsidiary company of KS Orka Renewables Pte. Ltd. is developing a geothermal power plant project at the Sorik Marapi Geothermal Work Area ("Wilayah Kerja Panas Bumi–WKP") in Mandailing Natal Regency of North Sumatra Province in Indonesia. KSO entered the Indonesian geothermal market with the aim of accelerating the development of this local resource. The Sorik Marapi Geothermal Power Plant Project designed as a closed-loop system with 100% water reinjection into its original formation. This technology ensures the most environment protecting renewable energy experience. It is implementing "One Well - One Plant" concept where power plants could be commissioned within 6 months from ordering. Thus, wellhead units manufactured immediately after testing of new wells, instead of waiting for long gestation period as is the case for bigger and more conventional central turbine units.

Sorik Marapi is located in North Sumatera, Indonesia, approximately 590 km south of the city of Medan. It is within the Mandailing Natal Regency and the nearest major town is Panyabungan. Sorik Marapi has a total area of 629 km2. It encompasses more than 50 km of the Sumatra Fault Zone, which is the major geologic tectonic structure that runs the length of Sumatra and controls the location of most of the volcanic and geothermal activity on the island.

Disaster preparedness and earthquake engineering are necessary for Indonesia, as history shows that Indonesian people suffered due to the disasters. Measuring its preparedness level might be an advantage to face the future disasters. At the same time, SMGP also need to measure its employee's level of preparedness in terms of disaster including their facility resistance. SMGP has to ensure that its employees and facility are prepared for disaster's threats. SMGP currently running 90 MW (2x45 MW) from total 240 MW commitment in Sorik Marapi. A study can established there in order to measure the level of disaster preparedness.

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**Figure 1.** KS ORKA Project Locations in Indonesia

## 2. COMPANY PREPAREDNESS LEVEL

Preparedness level of company is an image of how good the company is able to cope with the threats from disaster, which based on three components of company management, officers of the company, and site employee of the company. The preparedness level based on the five parameters i.e. Knowledge and Attitude (KA), Policy (PS), Emergency Planning (EP), Warning System (WS), and Resource Mobilization Capacity (RMC) in the company. The result of the study shows that preparedness level of Sorik Marapi Geothermal Power in Mandailing Natal is in nearly prepared category, with the index value of 62.41. This result affected by the good value PS and EP index. On the other hand, Sorik Marapi Geothermal Power in Mandailing Natal has low value of KA, RMC and WS index.

### 2.1 Construction of Sorik Marapi, the Fastest Geothermal Power Plant

The Steam field Diagram Options (SAGS) conceptual design based on wellpad separation concept with the separated fluids running the Well Head Units (WHU) installed within the production wellpad. This SAGS concept is a decentralized system with shorter pipelines per plant. The SAGS concept has the advantage of a faster time to see its development compared to the traditional concept. The implementation schedule based on adopting a single EPC contract for the construction of multiple wellhead units and its Balance of Plant.

ISSN 2541-223X
Volume 4 2022

**Table 1.** Comparison of Well Head Units and Centralized Units

| Subject | Well Head Units | Centralized Units |
|---|---|---|
| **Resource Utilization** | • WHUs can be spread over the concession area, making it easier to utilize the entire geothermal resource<br>• WHUs can be designed to utilize varying inlet pressures | • Centralized units need extensive steam gathering system ; use of entire resources not practical<br>• Centralized units can only utilize narrow pressure range |
| **Technical Flexibility** | • WHUs can be customized to accommodate differing well characteristic (temp, pressure, chemistry)<br>• WHUs can be easily modified or potentially relocated to accommodate changes in resources over time | • Centralized Unit can only accommodate specific range of characteristics; cannot handle complex resource with carrying pressure and chemistry<br>• Centralized Unit rely on steam mixing and make-up drilling |
| **Construction Time** | • Modular construction with limited installation at site<br>• Short lead times due to modular manufacturing<br>• Portable or permanent options<br>• Very limited steam gathering system | • Complicated on-site construction<br>• Long-lead times<br>• Inflexible, permanent construction<br>• Extensive, expensive steam gathering system required |
| **Land Use** | • WHUs have small footprint; can install on well-pad or small adjacent site | • Centralized unit and steam gathering system requires extensive land acquisition |
| **Speed to Generation** | • WHUs can be developed incrementally as steam-field is still being developed, allowing for early power generation | • Centralized Units can only be built once the steam-field has been substantially |
| **Financing** | • The incremental development model allows incremental financing | • Centralized Units can only be built once the steam-field has been substantially |

## 2.2 Measure Company Disaster Preparedness Level

LIPI-UNESCO/ISDR stated there are five preparedness critical factors that used to anticipate disaster i.e.: (a) knowledge and attitude (b) policy statement (c) emergency planning (d) warning system (e) resource mobilization capacity. These five critical factors conducted, as a parameter in a framework assessment. Knowledge and attitude (KA) comprise knowledge about disaster and emergency; knowledge about environmental vulnerability; knowledge about physical buildings, vulnerability and significant facilities for disaster emergencies and attitude towards risk. Policy statement (PS) consist of types of preparedness to anticipate disaster and emergency; relevant regulations; and relevant guidelines. Emergency Planning (EP) consist of disaster management organizations; evacuation equipment; important facilities for emergencies; and exercise and evacuation simulation. Resource Mobilizations Capacity (RMC) consist of institutional arrangement and command system; human resources; technical assistance and provision of material for disaster preparedness; financial mobilizations; coordination and communication among stakeholders; monitoring and evaluation of disaster preparedness activities. Warning system (WS) consist of traditional warning system; technologically based warning system; exercise and simulation.

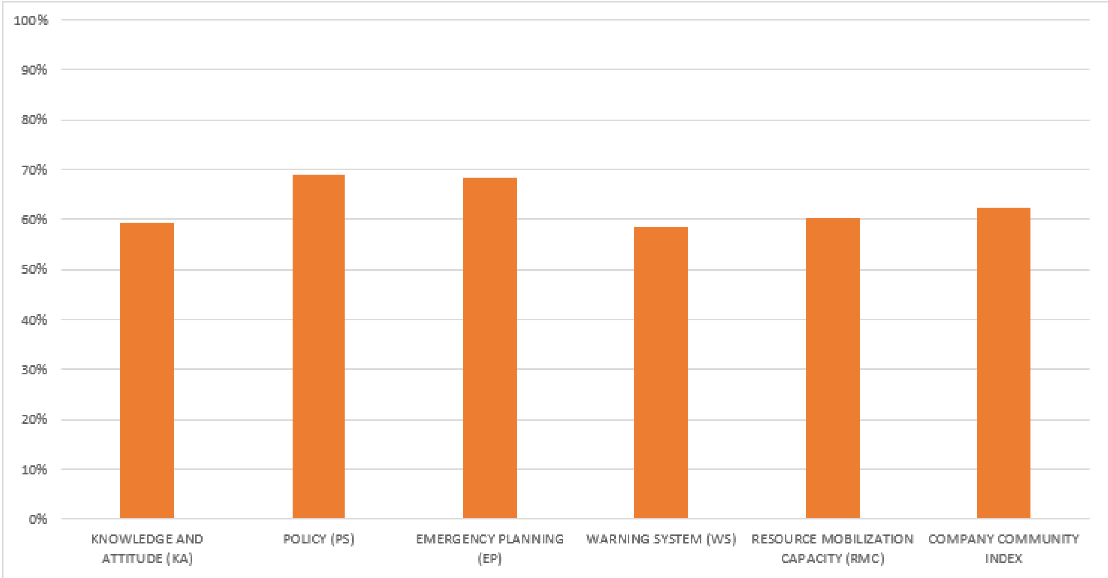


**Figure 2.** SMGP Company Preparedness Level

Study result shows that preparedness level of company community is variated according to the company components. Even though the score for PS Index is high, the KA, RMC and WS index scores are low. This might be due to unimplemented policy or regulation in terms of disaster preparedness in the company.
This research will use a Company Community parameter index of Company (C1), Office employees (C2) and Refinery Employees (C3) and Refinery Employees (C3) which will be mathematically presented into equation (2), (3), and (4), using composite index number without any calculation. Every question in this parameter will have assumption of equal score. Calculation of Index values uses an equation as follow:

$$Index = \frac{Total\ Score\ of\ Real\ Parameter}{Maximum\ Score\ of\ Parameter}\ x\ 100\% \qquad (1)$$

Maximum score of parameter is obtained from several questions in the index parameter (each question has one point). If there is a question that has sub question (e.g. a, b, c and d), every sub question will be scored 1/total sub question. Total score of the real parameter index obtained by summarizing real score of every question related parameter. The index value is in 0-100 scale, which mean the higher index value will be the higher preparedness level as well. The index value of the whole sample can be determined after calculating the parameter index of one respondent of Management, Officer and Site employees. If the total sample is n, the total sample index calculated by summarizing index of every sample, which divided by total sample (n).
Composite index from several parameters counted using measure composite index, where each parameter has different points. The composite index in this research covers the Management level, Officer and Power Plant employees. (LIPI-UNESCO/ISDR).

Management Index (C1)
(10/340*PS + (14/34)*EP + (4/34)* WS + (6/34)* RMC (2)
=0.29 PS1 Index + 0,41 EP1 Index + 0,12 WS1 Index + 0,18 RMC1 Index
Officers Index (C2)

0,71 KA2 + 0,17 EP2 +0,07 RMC2 + 0,05 WS2 (3)

Worker Index (C3)

0,83 KA3 + 0,08 EP3 + 0,04 RMC3 +0,04 WS3 (4)

As the company who developing Geothermal Power Plant, SMGP shall have preparedness to resilience with the hazard that may occur during the construction and operation. The Company and Employee required sufficient knowledge, policy and resource to become resilience with the risk.

In particular comprehensive detailed surface studies, numerical simulations and interference tests are very useful to inform the possibility of occurrence of various forms of resource risk. This allows the resource risk formulation of the management strategy. Incremental development and hazard monitoring are strongly recommended to ensure resource sustainability. A deliberate and targeted basic engineering study, involvement of host stakeholders and a diligent environmental management program are essential to reduce project disruption from natural hazards such as Earthquakes and Landslides.

**Table 2.** Recapitulation of Disaster Management Evaluation of SMGP

| No. | Observation | Standard | Evaluation | Recommendation |
|---|---|---|---|---|
| 1. | Company | | | |
| | a. Unit Regulation of Disaster Preparedness | Exist | Not Exist | a. Release the regulation in related disaster preparedness especially nature hazard like Earthquake and Landslide |
| | b. Global Regulation of Disaster Preparedness | Exist | Exist | b. Do the regular evaluation and sustainable program |
| 2. | Officers | | | |
| | a. Skills | Skillful | Moderate | a. Make workshop as a mandatory and regular program complete with Key Performance Index for each employee. |
| | b. Knowledge to disasters | Well Knowledge | Moderate | b. Make trainings as a mandatory program |
| | c. Disaster Respond Team | Active | Inactive | c. SMGP shall prepare dedicated team related Emergency Respond Team which certified and well trained |
| 3. | Site Employee | | | |
| | a. Skills | Skillful | Moderate | a. Make workshop as a mandatory program |
| | b. Knowledge to disasters | Well Knowledge | Moderate | b. Make trainings as a mandatory program |
| | c. Disaster Respond Team | Active | Inactive | c. Give rewards to those who are active involve in the ERT |

## 3. Evaluation of Undamaged Building use inaRISK, FEMA P-154 and ASCE 41-17 Tier 1 and 2

In this study, the hazard level is define from inaRISK Personal application that issued by BNPB. This application contain information on the level of danger of an area and is equipped with recommendation for action to anticipate it in a participatory manner. Rapid Visual Screening is a method of collecting building data visually that implemented relatively quickly and cheaply to identify building that are potentially earthquake hazard. The data collection method is by observing the physical building only take around 15-30 minutes (ATC, 2002).

The procedures of the steps related RVS survey have detail like below:

- Planning and Estimated Costs
  To Implement RVS with large number of building samples will require a lot of energy, cost and time. The large number of building samples will require a lot of energy, cost and time. However, in this study, the only building that evaluated was the Control building at Power Plant area. By doing the arrangement, the RVS not require significant resources.
- Pre-Field Planning
  Pre-field planning and identification of areas to screen with data search is useful to facilitate the implementation in the field. If some data has obtained during pre-field planning then the remaining data will complete during site survey.
- Selection and Review Forms
  There are three (3) categories of RVS forms in FEMA 154, which categorized based in three seismic regions like Low (L), Medium (M) and High (H). Each form contain a section for recording building identification information, drawing a building sketch (plan and elevation display), attaching a photo of the hazard, final structural score (S).

Following the cutting score from FEMA P-154 is less than 2.0, the building evaluation is continue to ASCE 41-17 Tier 1 and 2. ASCE 41-17 allows the engineer to define any level of seismic hazard of interest. However, ASCE 41 defines four specific seismic hazard levels that are usually considered.

- BSE-1E : Basic Safety Earthquake-1 for use with the Basic Performance Objective for Existing Buildings, taken as a seismic hazard with a 20% probability of exceedance in 50 years, but not greater than the BSE-1N, at a site.
- BSE-2E : Basic Safety Earthquake – 2 for use with the Basic Performance Objective for Existing Buildings, taken as a seismic hazards with 5% probability of exceedance in 50 years, but not greater than the BSE-2N at a site
- BSE-1N : Basic Safety Earthquake-1 for use with the Basic Performance Objective Equivalent to New Building Standards taken as two-thirds of the BSE-2N at a site,
- BSE-2N : Basic Safety Earthquke-2 for use with the basic Performance Objective Equivalent to New Building Standards, taken as the ground shaking based on the Risk- Targeted Minimum Considered Earthquake (MCEr) per ASCE 7at a site

Buildings identified by this procedure as potentially hazardous should be analyzed in more detail by an experienced seismic design expert. The RVS method identifies building attributes that may contribute to poor seismic performance, and conservative assumptions are made in developing the methodology. However, due to rapid visual screening designed to be carried out from the pavement, with interior inspection not always possible, hazardous details will not always be visible and seismically hazardous buildings

are not identified as such. On the other hand, a building initially identified as potentially hazardous by the RVS may prove adequate. The methodology presented here can serve as an efficient measure of risk assessment as part of a broader seismic risk management program. The cost is 15 to 75 minutes of inspection time for each building of interest, plus travel time between buildings, possibly several days of preparation time, and possibly a few people days to gather results into decision making.
The Seismic evaluation methods with respect to the time cost and the qualification method to perform the evaluation is showing in the table 3.2 below:

**Table 3.** Comparison of Prominent Seismic Evaluation Methods in United States

| **Undamaged Building** | **FEMA P-154** | **ASCE/SEI Tier 1** | **ASCE/SEI Tier 2** | **ASCE/SEI Tier 3 FEMA P-807 FEMA P-58 HAZUS** |
|---|---|---|---|---|
| Time required | Minutes | Hours | Days | Weeks |
| Relative Cost | $ | $$ | $$$ | $$$$ |
| Qualifications | Properly Trained Building Professionals (See Section 2.2 FEMA P-154) | Structural engineers experienced in seismic evaluations and design | | |

## 4. Disaster Risk Analysis

Disaster risk analysis in SMGP includes the hazard index and vulnerability index. According to IRBI (Indeks Rawan Bencana Indonesia) in 2019 which is published by BNPB, Mandailing Natal has hazard index 214.80 (seventh rank in the national scale) which in high Hazard. This index data consist of Hazard, Vulnerability and Capacity. Therefore, the formula that used to calculate the score of disaster risk is shown as follow:

$$R = H\ x\ V\ x\ E/C$$

Where,
$R$ = Risk, $H$ = Hazard; $V$ = Vulnerability; $E$ = Exposure; $C$= Capacity

ISSN 2541-223X
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**Table 4.** Scoring Risk Classification based on IRBI 2019.

| Total Scoring | Risk Classification | Color (in the Map) |
|---|---|---|
| $S_{min} - (S_{min} + X)$ | Low Risk | Green |
| $(S_{min} + X) - (S_{min} + 2X)$ | Middle Risk | Yellow |
| $(S_{min} + 2X) - S_{max}$ | High Risk | Red |

Where:
Low Risk score = 1, Medium Score = 2, High Risk Score = 3
N = Number of district in the particular province

$$S_{min} = Nx1$$

$$S_{max} = Nx3$$

$$X = \frac{(S_{max} - S_{min})}{3}$$

Determination of the score for each parameter done by multiplying between classes (1, 2 and 3) with a predetermined weight. The scores for each parameter added up as a whole to obtain a total disaster score in the district. The following table describes in detail the parameters, classes, weights and scores used in this method.

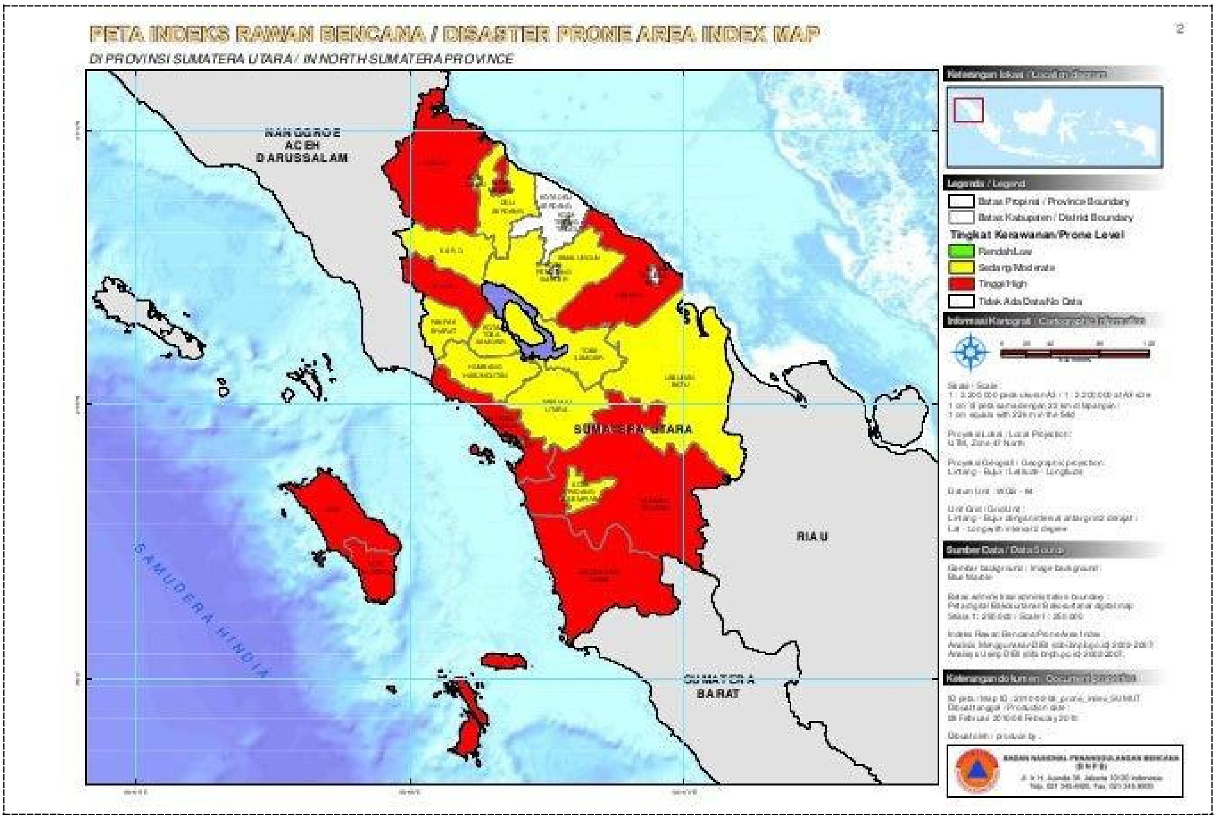

**Figure 2.** Disaster Risk Index North Sumatra 2019

The risk score of Mandailing Natal is 214.80 has a High Risk category in 4 years consecutive years (2015-2019).. Eventually, due to North Sumatra province has 4 (four) fault segments that are the source of the earthquake, namely the Renun fault, The Toru fault, The Angkola fault and the Barumun fault. In addition, in the North Sumatra region there are several active volcanoes. One of them is Mount Sinabung, which has erupted since 2013 and caused people to evacuate to the safe place.

## 5. Conclusion

Build and operate geothermal power plant in North Sumatra, especially in Mandailing Natal is quite challenging. Beside the nature of North Sumatra have high risk like earthquake, landslide and volcano, Like all other Industrial projects, land is a required for the geothermal project to establish the wells, road infrastructure, the power plant and the power evacuation system. Therefore, geothermal development competes with other land uses. Land access and leaves is one of the most sensitive aspects of a geothermal project mainly because it causes the project to result in the resettlement of people out of the project area. Construction of geothermal power plant make the risk higher since most of location of Geothermal Power Plant near Volcano Mountain. The high terrain condition combine with dense rainfall intensity make landslide potentially higher.

Force majeure is an event that occurs without the action or inaction of either party or agent preventing any or all of the parties from fulfilling their obligations under the contract. These events include wars, strikes, crimes, hurricanes, flooding, earthquakes, and volcanic eruptions. In order for such events to be declared as a force majeure condition, the cause must not be due to the failure of the party who reported it, nor must it be predictable or preventable.

However, there is design limitation related design of power plant to make power plant reliable for design years (e.g. SMGP have Power Purchase Agreement for 30 years with PLN).

Disaster preparedness of the SMGP is Moderate Capacity Category with the index value of 62.41. The level of preparedness based on the five parameters:

- Policy (PS) with the index value of 59.39 (Nearly Prepared category);
- Knowledge and attitude (KA) with the index value of 69.05 (Prepared category);
- Emergency Planning (EP) with the index value of 68.20 (Prepared category);
- Warning System (WS) with the index value of 58.41 (Nearly Prepared category);
- Resource Mobilization Capacity (RMC) with the index value of 60.34 (Nearly Prepared category).

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**Acknowledgments**
Authors wishing to acknowledge assistance or encouragement from colleagues, thanks to Sorik Marapi Geothermal Power Team that have taken part to commit and contribute to this study and questionnaire, and all individuals who have contributed by providing insights and corrections