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A Mapping of Various Geothermal Education in Indonesia to Ease Geothermal Personnel Gain Comprehensive Knowledge

Rizki Ratna Ayuningtyas[1], Dorman Purba[1], Daniel Adityatama[2], Nadya Erichatama[1,2], Muhammad Rizqi A[1]

[1]ENERKA Bhumi Pratama, Cibis Nine Tower 11th floor, TB Simatupang, Jakarta Selatan, Indonesia

[2]Geoenergi Solusi Indonesia (GEOENERGIS), Cibis Nine 11th Floor, Jakarta, Indonesia

dorman.purba@enerklaz.com; dorman.drilling@gmail.com

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ABSTRACT

Indonesia has been known as one of the largest geothermal energy potentials which are currently in the effort to accelerating geothermal development to meet with target of renewable energy in the Indonesia energy mix, to boost this program, exploration project would become main program of Government of Indonesia to achieve the targets. Geothermal project has unique system than others renewable energy, the energy source obtained from subsurface such as the oil and gas system, however the environment is different, so it needs more personnel who has good knowledge regarding geothermal energy and project. The education of geothermal energy & project knowledge which taken by each personnel who involved on the project is critical to the project success. Now, the formal education about geothermal engineering in Indonesia especially for Strata-1 (S1) still classified in the general energy study program (not specific) such as geological engineering, geophysical engineering, petroleum engineering, mechanical engineering, etc. However, this formal education when associated with the geothermal project, currently it takes 1-2 years to take more comprehensive knowledge and education.

The current conditions, majority of geothermal project personnel in Indonesia have non-geothermal education background and indicates there are no institutions that provide regular training or short courses on geothermal topics, so for these personnel who want to migrate from other energy to geothermal will face constraint to acquire required personnel competencies. This paper aims to map the various of formal and informal educations about geothermal such as webinars, short courses, training, workshop, and another education event in Indonesia, to ease the company or personnel gain the knowledge about geothermal study. In this study, the literature review and discussion will be the methods used to achieve the objective of this paper.

1. INTRODUCTION

1.1 Geothermal Overview in Indonesia

Indonesia known as one of the largest geothermal energy potentials which are currently in the effort to accelerating geothermal development. As the second-largest geothermal resource in the world, Indonesia already has 23,356 MW of potential electricity generated by geothermal energy (ESDM, 2022). However, the utilized geothermal energy in Indonesia is still about 2,286 MW or 9,8% of the total resource. It means that there are still many geothermal resources that have not been utilized optimally.

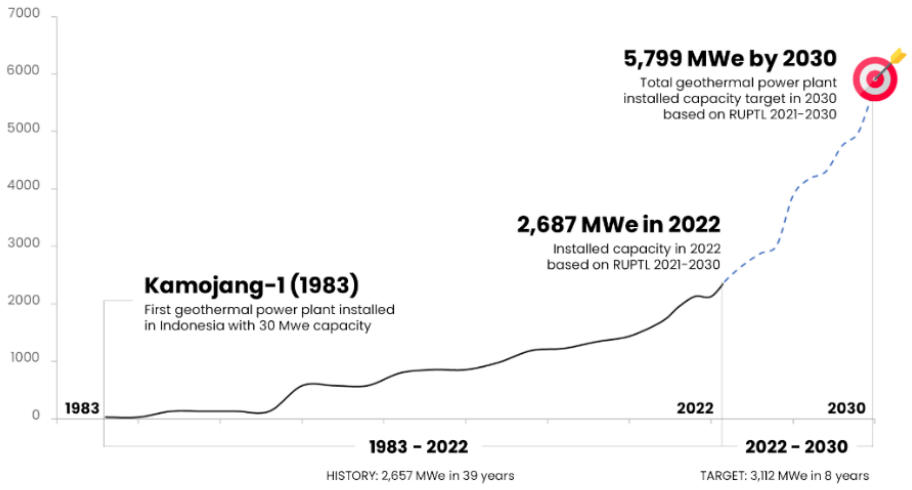

Figure 1. Target of Geothermal Development in Indonesia modified from (Purba, et al., 2020)

With the government's ambitious target of building geothermal installed capacity by 2030 shown in **Figure 1** to achieve 5,799 MWe installed capacity, it means that many personnel will be required to be involved in geothermal projects. However, there are still limited number of human resources with specific competences in geothermal. Most of the personnel in geothermal today are engineers who are shifting from petroleum engineering or other related industries. Whereas geothermal fields have quite different characteristics

from oil and gas fields. In fact, the characteristics and challenges of each geothermal field can also be different. Thus, it becomes important to have personnel with a basic knowledge of geothermal energy. One of the important things in geothermal project is competencies of the personnel. The education of geothermal energy & project knowledge which taken by each personnel who involved on the project is critical to the project success. Now, the formal education about geothermal engineering in Indonesia especially for Strata-1 (S1) still classified in the general energy study program (not specific) such as geological engineering, geophysical engineering, petroleum engineering, mechanical engineering, etc. However, this formal education when associated with the geothermal project, currently it takes 1-2 years to take more comprehensive knowledge and education.

This paper will summarize the various formal and informal educations in geothermal. Informal educations that will be discussed are covering webinars, short courses, training, workshop, and another education event in Indonesia. This educational resource mapping is expected to help the prospective geothermal personnel in obtaining geothermal education through the mapped educational programs.

2. CURRENT STATUS OF GEOTHERMAL EDUCATION IN INDONESIA

2.1 Challenges of Geothermal Education in Indonesia

Geothermal development in Indonesia has several challenges that have an impact on the installed capacity value of 2,286 MW out of 23,357 MW of geothermal resources in Indonesia. Based on (Purba, et al., 2021) and Author's finding, four challenges in developing geothermal energy in Indonesia with assumption has corelated with human resources and education is limited people with specific capabilities in geothermal energy, multitudes work types with any educational background, lack of knowledge transfer to local communities and supported by technology literacy issue in gaining of knowledge or educational information about geothermal energy projects (Ismail, 2021).

1. Limited number of human resources with specific competences in geothermal
   Human resources who involved in geothermal project commonly required a specific competence. For example, personnel with educational background in geoscience should know the calculation from drilling engineer, social sciences, environmental aspect, and obviously it requires a lot of knowledge and good learning ability. Currently, majority of geothermal project personnel have non-geothermal educational background, this is because of the oil and gas industry is considered older than the geothermal industry, especially in Indonesia. This leaves many geothermal developers looking for professionals from the oil and gas industry to integrate directly into the geothermal industry to cover the staffing shortage. Unfortunately, many geothermal companies have yet to realize that, while they look similar, there are significant differences between geothermal developments and oil and gas projects. As such, all certified and experienced personnel in the oil and gas industry can work directly on geothermal projects without realizing that there are certain differences between the two industries that can threaten safety, labor, and the environment. (Purba, et al., 2021). This becomes very important because personnel are the key to the success of geothermal projects.

2. Multitudes work types with any educational background
   Geothermal energy project starting from preliminary survey until operation and maintenances requires multidisciplinary knowledge. This challenge arises because the personnel who involved in the project should know the integration of knowledge between each other to supports the success of geothermal projects. Summarized from (ESMAP, 2012) & (Purba, et al., 2021), **Table 1** mentioned the multidisciplinary that required in each phase of geothermal project align with the activities.

Table 1. Mapping of Multidisciplinary Background of Geothermal Personnel

	Preliminary Survey	**Exploration Survey**	**Exploration/test drilling**	**Project review and feasibility**	**Field development**	**Power plant construction & commissioning**	**Operation**
Activities required	Power market analysis, infrastructure, regulation, political, financial, environmental, permitting, and social analysis. Remote sensing, geoscientific data, preliminary data	Detail 3G survey (geology, geochemistry, & geophysics study), geotechnical & environmental study. Conceptual model, resource estimation, and pre-feasibility study	Exploration infrastructure construction, well drilling, well logging, well testing, refining conceptual model, determination of well productivity, design development well	Design of location, pad, and other civil works, development drilling target and well design, forecast reservoir performance, power plant design, project budget and revenue projection, environmental social assessment, PPA agreement	Infrastructure construction, development drilling, production, and reinjection, well logging, well testing, update conceptual model, update reservoir model	Engineering, Procurement, construction, and commissioning	Operation and maintenance, well intervention, make up well drilling, annual inspection, major overhaul
Personnel background	Geological, geophysicist, geochemist, reservoir engineer, law, legal environmental engineer, management, finance, business	Geological, geophysicist, geochemist, reservoir engineer, drilling engineer, environmental engineer, mechanical engineer, law, communication & public relation, civil engineer	Geological, geophysicist, geochemist, reservoir engineer, drilling engineer, environmental engineer, production engineer, mechanical engineer, law, communication & public relation, civil engineer,	Geological, geophysicist, geochemist, reservoir engineer, drilling engineer, environmental engineer, production engineer mechanical engineer, law, communication & public	Geological, geophysicist, geochemist, reservoir engineer, drilling engineer, environmental engineer, production engineer mechanical engineer, law, communication & public	Geological, geochemist, reservoir engineer, drilling engineer, environmental engineer, production engineer mechanical engineer, law, communication & public relation, civil engineer,	Geological, geophysicist, geochemist, reservoir engineer, drilling engineer, environmental engineer, production engineer mechanical engineer, law, communication

			health & safety environment,	relation, civil engineer	relation, civil engineer, health & safety environment,	health & safety environment,	& public relation, civil engineer, health & safety environment,

From table above shows that geothermal projects do not only contain technical personnel such as engineers, geosciences, mechanical, etc., but also non-technical aspects such as law, legal, finance, management, public relations, journalistic, etc.

3. Technology literacy issue in gaining of knowledge or educational information about geothermal energy projects. Technology has a big portion to help the massive information or knowledge, especially in geothermal information. By today, the Government of Indonesia, geothermal developers, and other stakeholders have used this technology during the pandemic as an example of providing free webinar to inform the updated progress or information of geothermal project in Indonesia, free webinar to show the opportunity, challenges, and target of geothermal development in Indonesia to all participants, and others education and information about technical or non-technical issue of geothermal to raise the understanding of entire communities and the everyone who involved in geothermal project. However, education through this technology should be able to implement specifically to community of around the geothermal project, because if the community lack of understanding of geothermal project technically or non-technically, it often would be leading a community rejection and causes delays in geothermal project.

2.2 Current Status of Geothermal Education

Education a has a big portion of increasing the competences human resources that involved in Indonesia geothermal energy projects. Discussing of education, the terms commonly known in Indonesia and the world are formal and informal education. Formal education refers to the established, officially listed, and structured academic institutions whose purpose is to provide education and nurture students, such as primary, middle, and high schools as well as higher education institutions (Cameron & Harrison, 2012). Informal education is educative processes endowed with flexible curriculum and methodology, capable of adapting to the needs and interests of students, for which time is not a pre-established factor but is contingent upon the student's work pace. The characteristic of informal education are does not require student attendance, decreasing the contacts between teacher and student and most activities take place outside the institution – as for instance, home reading and paperwork ((Dib, 1988). Informal education can be categorized as webinar, talk show, training, workshops, online course, and others.

Currently, formal education about geothermal engineering in Indonesia especially for Strata-1 (S1) or bachelor's degree still classified in the general energy study program (not specific) such as geological engineering, geophysical engineering, petroleum engineering, mechanical engineering, etc. However, this formal education when associated with the geothermal project, currently it takes 1-2 years to take more comprehensive knowledge with title of master's degree (S2) in geothermal energy. Based on (Umam, et al., 2021) Potential workers with a formal education cannot work immediately and require additional skills. In addition to experience, abilities and competences can also be acquired through training. The knowledge and skills gained from this experience and training can be demonstrated at least by certification in the field of geothermal energy. To ease personnel gain information about geothermal education or geothermal knowledge, in the next section will show and explain the mapping of various geothermal education in Indonesia both of formal and informal education.

3. MAPPING OF VARIOUS GEOTHERMAL EDUCATION IN INDONESIA

As per discussed on previous sub chapter, geothermal education in Indonesia currently has 2 types of education such as formal and informal education. In this chapter, Author would be mapping of educational type of geothermal in every university and educational energy provider in Indonesia.

3.1 Formal Education Related to Geothermal

Table 2 represents any courses related to geothermal energy in any level degree in Indonesia universities. It consists of course name information, level of degree, credit course, and remarks of the courses. All information references in the table below based on official website of each program study and university. Credit course in the table give information of the time it takes for students to be able to have the 'ability' that is formulated in a course (Endrotomo, 2014). 1 SKS consist of 50 minutes of direct learning in class, 50 structured activities, 60 minutes self-study activities.

The aim of mapping formal education that related to geothermal basic knowledge is for to show that there are only a few study programs that focus on geothermal education, and all of them are at level master's degrees. Most of the geothermal education at the bachelor's degree level is under other study programs such as petroleum engineering, geological engineering, geophysical engineering. So, it requires support from informal education to improve the competence of personnel in geothermal projects.

Table 2. Geothermal Formal Education Mapping in Indonesia

Course	Degree	Course credits (SKS)	Remarks
Institut Teknologi Bandung			
Geothermal Engineering	Master-Degree	37	Under Geothermal Engineering program study
Geothermal Engineering	Bachelor-Degree	3	Under Petroleum Engineering program study

Course	Degree	Course credits (SKS)	Remarks
Geothermal Field Development	Bachelor-Degree	3	Under Petroleum Engineering program study
Vulcanology and Geothermal	Bachelor-Degree	2	Under Geological Engineering Program Study
Geothermal Geology	Bachelor-Degree	2	Under Geological Engineering Program Study
Geothermal Geochemist	Master-Degree	2	Under Geological Engineering Program Study
Vulcanology and Geothermal	Bachelor-Degree	3	Under Geophysical Engineering Program Study
Geothermal Exploration	Master-Degree	2	Under Geophysical Engineering Program Study
UPN "Veteran" Yogyakarta			
Introduction to Petroleum & Geothermal Engineering	Bachelor-Degree	3	Under Petroleum Engineering program study
Geology of Oil, Gas, and Geothermal System	Bachelor-Degree	2	Under Petroleum Engineering program study
Lab Work. of Geothermal Reservoir Simulation	Bachelor-Degree	1	Under Petroleum Engineering program study
Geothermal Reservoir Engineering	Bachelor-Degree	2	Under Petroleum Engineering program study
Geothermal Production Engineering	Bachelor-Degree	2	Under Petroleum Engineering program study
Geothermal Drilling	Bachelor-Degree	2	Under Petroleum Engineering program study
Oil, Gas, and Geothermal Field Trip	Bachelor-Degree	2	Under Petroleum Engineering program study
Geological Concept and Model of Geothermal Field	Master-Degree	3	Under Petroleum Engineering program study
Geothermal Drilling Management	Master-Degree	3	Under Petroleum Engineering program study
Geothermal Reservoir Management	Master-Degree	3	Under Petroleum Engineering program study
Geothermal Production Management	Master-Degree	3	Under Petroleum Engineering program study
Geothermal Law, AMDAL, Environmental, and HSE aspects	Master-Degree	3	Under Petroleum Engineering program study
Geothermal Reservoir Simulation	Master-Degree	3	Under Petroleum Engineering program study
Geothermal Drilling Problem Prevention and Mitigation	Master-Degree	3	Under Petroleum Engineering program study
Geothermal Drilling Optimization	Master-Degree	3	Under Petroleum Engineering program study
Geothermal Technology	Master-Degree	3	Under Petroleum Engineering program study
Petrophysical and Geothermal Reservoir Characterization	Master-Degree	3	Under Petroleum Engineering program study
Introduction of Geothermal Exploitation	Master-Degree	3	Under Petroleum Engineering program study
Exploration Geology of Oil, Gas, and Geothermal	Master-Degree	3	Under Petroleum Engineering program study
Universitas Indonesia			

Course	**Degree**	**Course credits (SKS)**	**Remarks**
Geothermal Exploration	Master-Degree	40	Under physical sciences department
Geothermal Geology	Bachelor-Degree	3	Under geology program study
Geothermal Exploration	Bachelor-Degree	2	Under geophysics program study
Universitas Gadjah Mada			
Geothermal Technology (mandatory course)	Master-Degree	12	Under geological engineering program study
Geothermal Technology (elective course)	Master-Degree	17	Under geological engineering program study
Geothermal geology & practicum	Bachelor-Degree	3	Under geological engineering program study
Geothermal Exploration & practicum	Bachelor-Degree	3	Under geophysical engineering program study
Universitas Andalas			
Geothermal Physics	Bachelor-Degree	2	Under physics program study
Universitas Diponegoro			
Geothermal	Bachelor-Degree	3	Under geology program study
Geothermal geochemistry	Bachelor-Degree	2	Under geology program study
Geothermal geophysics	Bachelor-Degree	2	Under geology program study
Universitas Pertamina			
Geothermal specialization	Bachelor-Degree	11	Under geological engineering program study
Geothermal engineering	Bachelor-Degree	3	Under petroleum engineering
Geothermal science and technology	Bachelor-Degree	3	Under geophysical engineering
Geophysics method in geothermal development	Bachelor-Degree	2	Under geophysical engineering
Universitas Padjadjaran			
Geothermal & Vulcanology	Bachelor-Degree	2	Under geophysics program study
Geothermal Hydrochemistry	Bachelor-Degree	2	Under geology program study
Geothermal Geological Exploration	Bachelor-Degree	2	Under geology program study
Geothermal Geochemist Exploration	Bachelor-Degree	2	Under geology program study
Institut Teknologi Sepuluh Nopember			
Geothermal Exploration	Bachelor-Degree	3	Under geophysical program study
Geothermal Engineering	Bachelor-Degree	3	Under geophysical program study
Universitas Jember			
Geothermal Field Development	Bachelor-Degree	3	Under petroleum program study
Capita Selecta Geothermal and Non-Conventional	Bachelor-Degree	3	Under petroleum program study

3.2 Geothermal Informal Education

Table 3 shows of informal education in Indonesia. There are lots of trainings or webinar sessions from governments, institutions, and the university such as center research, and capacity building from international collaboration with Indonesia's programs.

Table 3. Geothermal Informal Education Mapping in Indonesia

Institution/Provider	Programs	Topics	Learning Method	Time of Education
PT Enerka Bhumi Pratama (ENERKA)	Free Webinar	Drilling, reservoir, production, geoscience, surface facilities, social, finance	E-Learning	1-2 hours
	Training	Drilling, reservoir, production, geoscience, surface facilities, social, finance, procurement	Online Training & Hybrid	8-12 hours
	Online Courses	Drilling, geosciences	E-Learning	10 hours
PT Anugerah Indonesia Lima (AILIMA)	Free Webinar	Drilling, Production, Reservoir	E-Learning	1-2 hours
	Online Courses	Drilling, geosciences, production, reservoir, finance	E-Learning	3 hours
Gemilang Training	Training	Introduction of Geothermal	Offline Training	2 days
PT Vyntech Multi Solutions	Training	Introduction of Geothermal	Offline & Online Training	2 days
Institute Technology Bandung	Training	Geothermal Exploration & Development	Online	Tentative

4. DISCUSION

Education is the important thing of geothermal project. Concept and foundation of geothermal both of technically and non-technically must be measurable for all personnel who involved in the project. Concern of personnel is important because this is the key to project success, increasing the personnel capacity and competencies is a necessity increase the productivity of work and the results. As discussed on the previous chapter, there is an indication of any another background industry directly involved in geothermal project with basic concept and the knowledge slightly different with geothermal, so the personnel who involved in the project necessarily needs a platform or institutions that provides the education or knowledge related to geothermal.

A mapping of formal and informal education shows that there is any institution or providers which provide the platform for learning and getting knowledge of geothermal concept, and it also provides the platform for sharing the experience of any professional personnel in Indonesia or worldwide. Formal education still taking a role as an important basic for the concept knowledge, but from previous mapping shows for geothermal courses only from several institution or university that provide a comprehensive education of geothermal by the number of credits earn and this is generally obtained at the master's level with a 1-2 year education and have a high commitment to complete the study, other geothermal course is a still as a specialized programs or elective course in bachelor's level. Another type of education is informal education, this is still needed to support the knowledge and skills of the personnel to strengthen the competences and experiences of geothermal personnel.

Informal education such as webinar, trainings, courses both of online and offline already massive implemented in Indonesia. Government in Indonesia, geothermal developers, and other stakeholders is also participating in any informal geothermal education for all communities or geothermal project personnel. Based on mapping, there are any informal education platform or institution which can be followed by the flexibility of time, materials, and learning methods. Informal education is quite needed in terms of flexibility and educational methods to boost the personnel competencies in a brief period. Currently, the informal education has a good assessment method so that the success of the learning can be measured by the assessment.

Formal and informal education can not eliminate each other, but it can support each other to improve the competencies of geothermal project personnel in terms of support the Government of Indonesia's to achieve the geothermal capacity target in 2030. So, with this mapping study of formal and informal education can ease and inform the geothermal project personnel to learn the basic concepts of geothermal which has a slightly different concept with any industry especially of oil and gas industry.

5. SUMMARY AND PATH FORWARD

The target of Government in Indonesia in 2030 to achieve the 5,799 MWe geothermal capacity are the responsibilities of all stakeholders in Indonesia, geothermal developers, geothermal consultants, government, communities. The competencies of personnel who involved in the geothermal projects is one of the keys to support this target. Formal and informal education in Indonesia can support this factor to boost the competencies of personnel. The personnel from any educational background can learn comprehensively of geothermal concepts with the time or methodology concern which has the same output by choosing the formal and informal educational methods.

By this study is aimed to ease the personnel of geothermal project gain the information of educational methods in geothermal and this should be conducting more research about the details of activities or syllabus in formal and informal education to give the overview of learnings and mapping the study assessment of formal and informal education to show the comparison of learning assessment.

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