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Developing Geothermal Drilling Training in Indonesia: an Effort to Implement the National Competence Standard

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ABSTRACT

The Indonesian geothermal industry, with an installed capacity of around 1948 MW is currently the country with the second-largest installed geothermal capacity in the world. However, the target of the Indonesian Government in 2025 is still far from the current installed capacity, which is more than 7000 MW. It will require a lot of effort to achieve this ambitious target, one of which is to provide a lot of competent human resources. In addition to formal schooling or higher education, vocational education institutions are expected to contribute to meeting these needs, especially training centers spread throughout Indonesia.

The Indonesian National Work Competency Standards (SKKNI) cover aspects of knowledge, skills, and work attitudes that are relevant to the implementation of tasks and the terms of the positions given. Likewise, there has been a standard of competence for geothermal drilling even though it is still grouped with oil and gas drilling. The grouping of these two into one standard is proof that the Government still considers that both are similar. However, previous research has identified that geothermal drilling and oil and gas drilling are different.

This paper will discuss the application of onshore drilling standards that applied in Indonesia to produce a geothermal drilling training program curriculum. An overview of current geothermal energy status in Indonesia, relating to the development of human resources will be presented. Furthermore, this study will analyze the competency standards used in Indonesia. The results of the discussion of this paper are in the form of materials proposed to be included in the geothermal drilling training curriculum in Indonesia. The implementation of a curriculum specifically for geothermal drilling is intended to reduce the risks in drilling significantly so that geothermal projects become more affordable to reach the Government's target in 2025.

1. INTRODUCTION

The Government of Indonesia plans to achieve approximately 7,241.5 MW of installed geothermal power capacity by 2025 from an estimated geothermal resource of 29,544 MW (RUEN, 2017). However, the current development was only 1,948.5 MW until the end of 2018 (MEMR, 2019). The future government targets and their relationship to the development of geothermal human resources are stated in the National Energy Policy and the National Energy General Plan. The Government has made several efforts for the development of geothermal human resources. They also assisted by related stakeholders such as geothermal companies, universities, and support from international institutions. According to Gehringer & Loksha (2012) and Hervey et al. (2014), the development of a geothermal project is divided into eight phases, namely preliminary survey, exploration, test drilling, project review and planning, field development, power plant construction, commissioning, and operation and monitoring. One form of government effort is the implementation of geothermal drilling training and certification. Drilling has become critical since the overall requirement of drilling engineers in geothermal development is one fifth drilling engineers (21%) which is second highest after reservoir engineers (Campen et al., 2015).

1.1 National Energy Target

The National Energy Policy (KEN) is described in Government Regulation No. 79 of 2014 on national energy policy. The Government targets energy independence and national energy security in the future. This can be achieved by realizing the development of technological capabilities, energy industry, and domestic energy services to be independent and increase the capacity of human resources to create jobs.

One of the national energy policy targets for the fulfillment of energy supply and energy use is the achievement of the optimal primary energy mix in 2025. This policy states that the role of new energy and renewable energy of at least 23%, the part of petroleum is less than 25%, the part of coal is at least 30% natural gas at least 22%. By 2050, the role of new energy and renewable energy is projected at least 31% as long as its economy is met. While the role of petroleum is less than 20%, the part of coal is at least 25%, and the part of natural gas is at least 24%.

Further, the Indonesia national energy policy is described in the Presidential Regulation of the Republic of Indonesia Number 22 the Year 2017 About the General Plan of National Energy (RUEN). The National Energy Board (DEN) as the drafter of RUEN performs a series of modeling as a reference in energy development in Indonesia until 2050. The result of the modeling of primary energy supply shows that geothermal contribution to new Renewable Energy (EBT) supply is 21.8 MTOE or 23.6% in 2025 and 58.8 MTOE or 18.6% by 2050. While the modeling results of the development of EBT power plants show geothermal generating 7,241.5 MW in 2025 and 17,546 MW in 2050 or 59% of the geothermal potential of 29.5 GW.

However, this RUEN does not specify as much about the development of human resources as a step to achieve the target of geothermal power plant development (PLTP).

1.2 Geothermal potential and development status

The latest figure from RUEN (2017) asserted that the potential geothermal energy in Indonesia is 29.544 MW, which consists of 11.998 MW resource and 17.546 MW reserve. However, the current installed capacity is 1.948,5 MW.

Table 1: The potential and installed geothermal energy in Indonesia 2017 (MW) (RUEN, 2017; MEMR, 2019).

No	Location	Resource	Reserve	Total	Installed	
1	West Java	2,159	3,765	5,924	1,224	
2	North Sumatera	434	2,316	2,750	228	
3	Lampung	1,243	1,339	2,582	220	
4	South Sumatera	918	964	1,882	55	
5	Central Java	517	1,344	1,861	60	
6	West Sumatera	801	1,035	1,836	0	
7	East Nusa Tenggara	629	763	1,392	17.5	
8	East Java	362	1,012	1,374	0	
9	Others	4,935	5,008	9,943	144	
Total	Total	11,998	17,546	29,544	1,848.5	

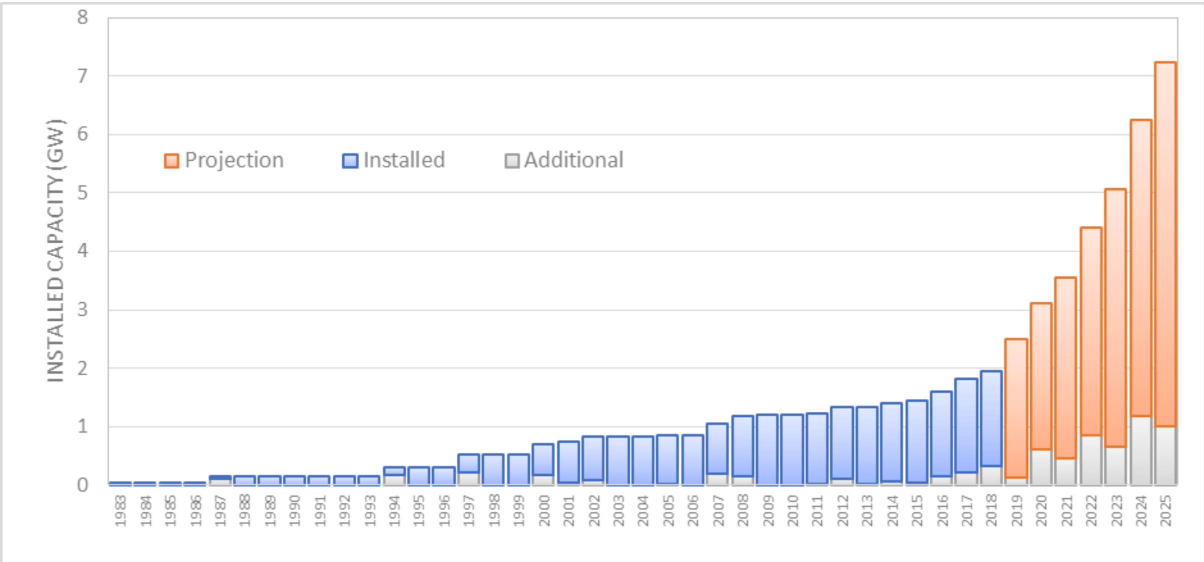

Figure 1: Installed capacity, additions (planned) and projected capacity of Indonesia's geothermal power plants from 1983 to 2025 (Adapted from Darma et al., 2010; Darma et al., 2015; RUEN, 2017; MEMR, 2019).

1.3 The drilling training and certification by PPSDM Migas

The center of human resources development for oil and gas (PPSDM Migas) is a unit in the Ministry of Energi and Mineral Resource that specialized in human resource development for the oil and gas sector. It has been in operation for more than half a century under a different name. Currently, PPSDM employs approximately 280 employees, including 59 professional trainers and 70 laboratory staff.

For drilling training, the center delivers around 30 training and drilling certification per year for floorman, derrickmen, drillers, and toolpushers. The training generally covers upstream oil and gas activities, well control techniques, BOP equipment, engineering and drill tools, and safety of drilling.

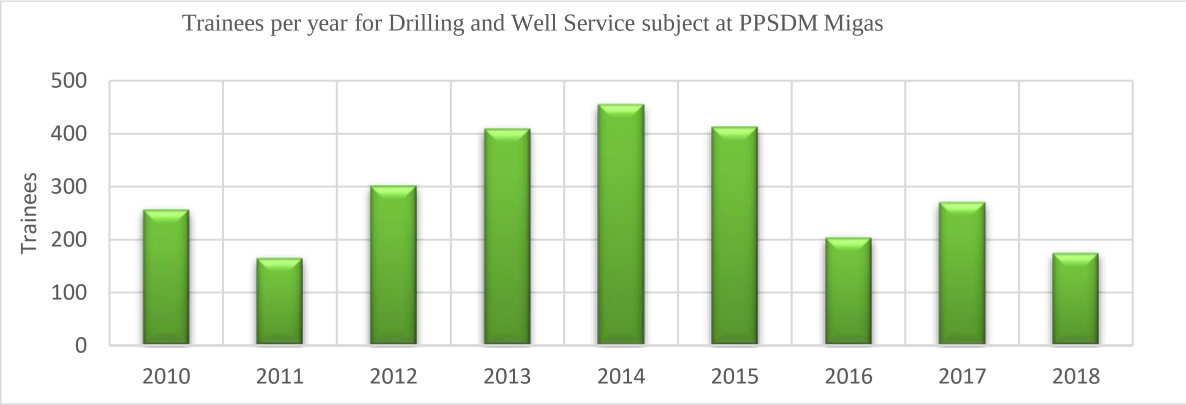

Figure 2: Number of trainees in PPSDM Migas since 2010 (PPSDM Migas, 2018)

PPSDM Migas is accredited by the International Association of Drilling Contractors (IADC) the USA and a member of the IWCF UK. The center is also certified by the National Accreditation Committee (KAN), which is a member of the International Accreditation Forum (IAF).

The center has undertaken training for a managerial level, which included drilling engineers and supervisors of Geothermal Well Drilling in 2017. The training was a pilot course funded through the New Zealand Aid Programme by the Ministry of Foreign Affairs and Trade (MFAT) in cooperation with HRD Agency of MEMR (BPSDM). The training aimed to support Indonesia's geothermal sector by increasing the number of geothermal well drilling specialists as well as upgrading their competency.

The center also has its own professional certification body, namely LSP PPT Migas. The LSP began certifying from 1999 with accreditation from the National Accreditation Committee (KAN-BSP) and the National Personal Accreditation Committee (BNSP).

The scope of the certification in PPSDM Migas includes HSE, seismicity, drilling, production, and aviation. Most workers in the oil and gas industry in Indonesia indeed have been certified in PPSDM Migas. The certificate commonly has a valid period of three years and should be renewed by taking a new assessment.

The competency standards for drilling in Indonesia can be implemented for both geothermal, oil, and gas industry (Umam et al., 2018). For drilling, certification is available for a floorman (level 2), a derrickman (level 3), a driller (level 4), and supervisor (level 5) which includes a toolpusher, rig superintendent, company man, and rig manager. The requirements for following (level 2-4) certification are a secondary education certificate and two years' experience at a lower level. To be able to take a driller certification, for example, a derrickman requires at least two years' experience as evidenced by a warrant from the company.

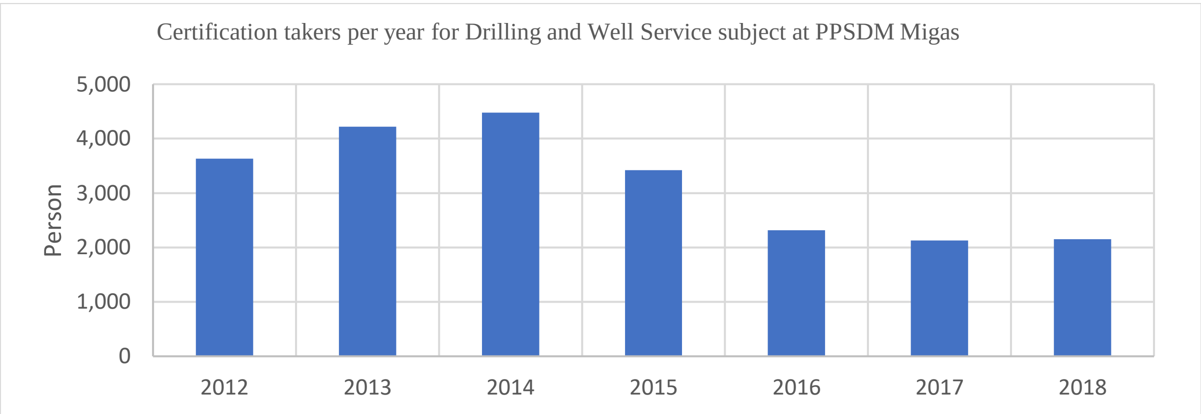

Figure 3: Certification takers at PPSDM Migas from 2012 to 2018 (PPSDM Migas, 2018)

2. DRILLING COMPETENCIES ON QUALIFICATION FRAMEWORK

2.1 Drilling competency standards in Indonesia

The drilling competency standards have been applied in Indonesia since 2007. Even though the application is still limited to oil and gas drilling, this covered both geothermal and hydrocarbons. Competencies mapping that was established by the Minister of Manpower (MoM) (2015) mentions that there are fifty core competencies in onshore drilling. However, this competency mapping does not mention the level and qualifications of personnel. In the previous decree of the Minister of Manpower and Transmigration (MoMT) (2008), five qualifications could be gained, as shown in Table 2.

Table 2: Qualification and competencies of onshore drilling in Indonesia (MoMT, 2008)

Level	Qualification	Unit Competencies*
6	Rig Superintendent, Drilling Supervisor**	-
5	Tool Pusher	7 GC, 17 CC, 2 SC
4	Driller	6 GC, 19 CC, 3 SC
3	Derrickman	4 GC, 9 CC, 2 SC
2	Floorman	4 GC, 7 CC, 1 SC

* GC = General competencies, CC = Core competencies, SC = Special competencies
**This qualification is currently merged with the Tool Pusher qualification (level 5)

The 2015 competency standard is composed by referring to the Regional of Model Competency Standard (RMCS) based on job competencies analysis. The standard is signed by the Minister of Manpower based on the results of the onshore drilling national convention of IQF. The ILO (2006) illustrates that RMCS has three primary components, namely industry descriptor and coverage, primary functions, and units, as shown in Figure 4.

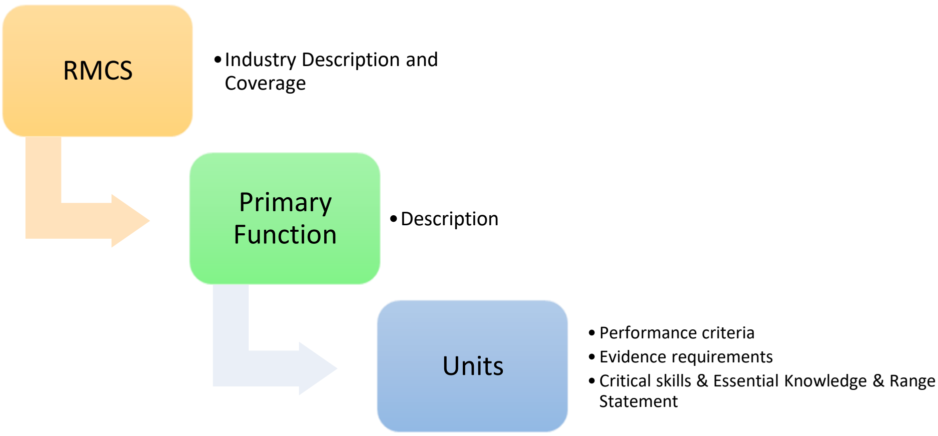

Figure 4: The primary functions and the detailed units in the RMCS (ILO, 2006)

This model has been applied to the new competencies mapping in Indonesia. The new onshore drilling competencies mapping can be seen in Figure 5.
This competency standard can be used for both drilling sectors, namely oil and gas drilling and geothermal drilling. The share of competencies for both areas can facilitate the transfer of labor from one industry to another. However, oil and gas staff might interpret problems such as a stuck pipe and loss of circulation mechanisms inappropriately without proper training on geothermal drilling. Thus, this could lead to lengthy drilling time or drilling failure in severe cases.

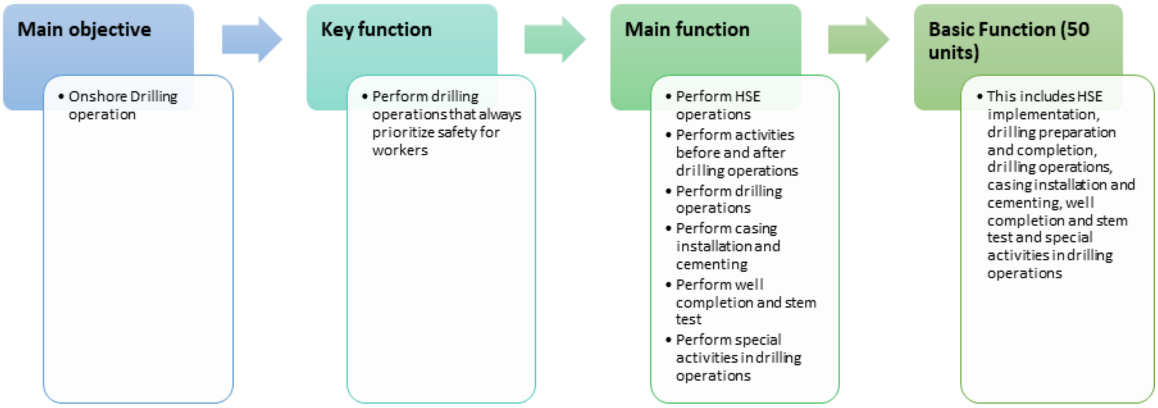

Figure 5: Qualification and competencies of onshore drilling based on the Ministry of Manpower (2015).

Another advantage of using one of these standards is centralized training and certification for workers. This reflects that there are only a few official training institutions for drilling. There are also only two professional certification bodies that can issue drilling competency certificates. However, such a system could limit the proliferation of labor needs in a short time. Hence, this needs to be improved by the enhancement of a competencies-based capacity building system in the future.

2.2 The recognition of different qualifications

In terms of the competency standard, there are differences in responding to emergencies between the hydrocarbon and geothermal drilling. Moreover, due to the differences in drilling methods, some competencies needed to be reassessed include:

- Appropriate drilling methods, systems, and processes for specific drilling environments.
- Drilling Systems and processes operation and monitoring, hole condition monitoring, and responding to downhole problems in a drilling environment.
- Moving drill rig and associated equipment to meet workplace requirements safely.
- However, other competencies considered similar between both domains include:
- Apply risk assessment procedures and workplace HSE procedures.
- Interpret and apply client/contract specifications to safely meet operational targets.
- Provide mentoring and on-the-job training to drill crew.
- Communicate with clients, internal staff, and the general public as required to meet relevant workplace policies and procedures.
- Lead reporting on drilling operations.

For standard competencies required in Indonesia, existing oil and gas drilling certification can be directly used in the geothermal sector. This acceptability is because, in general, the oil and gas industry is considered to have a higher risk and more complicated challenges than the geothermal sector.

2.3 Applying the SKKNI on geothermal drilling

Although using the same standards, the geothermal industry determines one competency is more important than other competencies. The application of each skills between oil and gas drilling and geothermal drilling is discussed below:

- Obeying legislation is the first and main competency in both geothermal drilling and oil and gas drilling. The regulation covers occupational health safety requirements such as fire prevention and suppression, first aid on accidents and implementation of emergency conditions. Furthermore, the policies of environmental protection such as environmental pollution prevention in the workplace of drilling and regulations on the oil and gas mine and geothermal should also be obeyed.

- Competencies about casing and cementing comprise the ability to develop casing program, design casing and cementing program, and perform casing installation and cementing. This competency is the most critical capability in geothermal, which ensures successful drilling of geothermal wells and its utilization for the long term. The selection of materials for the casing can be very crucial regarding the well conditions such as temperature cycle and corrosive fluids. In addition to metals damage due to acidic properties, geothermal fluid can also cause scaling due to its mineral content. On the other hand, the cementing job is usually done just after the installation of the casing. This cementing will require a husked additive that is resistant to the hot well conditions. Cement placement techniques also require high skills because the number of loss zones that might fail to return to the surface if the cementing job is not appropriate. Hence, casing and cementing are the most essential assets in geothermal production. If these fail due to misplaced or design error, this will result in cessation of production that will be difficult to fix.

- Drilling operations in geothermal are ranked third because the geothermal drilling is aimed at massive loss circulation zone due to fault or fracture. This is the main distinction between oil and gas drilling, which tends to avoid loss circulation. Another factor which makes this competency more critical than others is because of the higher chance of stuck pipe in the geothermal drilling. This is mainly due to the drilled formation that formed of hard rock is abrasive and easy to crumble. Thus, the ability to analyze the situation and make the right and quick decisions are critical at this stage.

- On the other hand, well control is the primary competency required in oil and gas drilling. This is coupled with the skill to design the mud program. Mud is an important part to control the pressure inside the well so that both get a high rank. Hydrocarbon wells typically have very high pressures and can be very dangerous. They are flammable and could cause an explosion when it is failed to be controlled. Conversely, the pressure in the geothermal well is commonly not very high, and the steam kick tends to be easier to control with just cold water. The formation pressure of geothermal well is generally equal or even smaller than the hydrostatic pressure of the drilling mud. Thus, well control in geothermal drilling is not significant.

- Further, evaluation of the program is useful for fix the problems when they are observed so that they can be anticipated in subsequent drilling. The ability of log interpretation of drilling data and problem handling during drilling operations in geothermal drilling is essential. Oil and gas drilling, on the other hand, more prioritize well completion because this is important with the success of oil and gas production through tubing. While in geothermal, the well completion process is more straightforward because the geothermal fluid is sufficiently produced through the casing.

- Lastly, specialized competencies, including fishing jobs and the prevention of toxic gases are added value in geothermal and oil and gas drilling. Therefore, this competency gets the lowest rank in both industries. From the description above, although the units of competency are the same, the priority of each competency unit is different between oil and gas and geothermal.

3. DRILLING TRAINING PROGRAM

3.1 Competency needed for drilling

Drilling is a significant step to confirm the existence, precise location, and reservoir potential by involving more engineers than scientists. Predictions about the productivity of the well are rarely accurate before drilling commences. Gehringer & Loksha (2012) and Hervey et al. (2014) estimate that about 10 to 30 percent of drilled production wells are producing remarkably low power or are very weak to harness. Figure 6 describes the companies and experts involved in the drilling operation of an oil well. Nonetheless, until recently this scheme is still being applied in geothermal drilling. Ford (2004) describes the roles and functions of those who manage drilling operations as follows:

1. The operating company or operator is the main company that manages drilling and production operations. Operators are tasked to prepare designs, work programs, transportation services, consumable goods, and support for drilling operations. Operators typically employ drilling contractors and service companies to drill a well.

2. Drilling contractors are tasked to provide drilling rigs and personnel to drill wells. They are also responsible for maintaining drill rigs and training personnel required to operate the rigs.

3. The service company provides specific specialized skills or equipment such as logging and surveying during drilling. It is also tasked to develop and maintain the equipment and hire staff as operators.

Furthermore, some of the key personnel involved in a drilling operation are as follows:

1. The company man is a representative of the operators. He ensure the drilling operations run as planned (schedule and budget), make decisions affecting well progress, and manage the availability of drilling equipment and materials (Ford, 2004).
2. The drilling engineer is responsible for designing wells and casing along with the cementing program, drilling rig selection and other drilling support equipment.
3. Geologists are responsible for assisting and supervising drilling, geological logging, analyzing and interpreting drill cuttings and cores. They also helping to determine the productivity of wells, determining drilling and different depth, and estimating corrosion risk.
4. The rig manager is the highest representative of the rig contracting company. His job is to ensure the rigs are provided according to the operator's requirements (as per the contract).
5. The toolpusher is responsible for overseeing the daily activities of all rig crews on the rig site, including equipment maintenance.
6. The driller is tasked to prepare drill series such as Bottom Hole Assembly (BHA) and BOP and communicate directly with crews.
7. Drilling crews are working under the direction of the driller and are tasked with performing manual activities related to well drilling which generally comprise of:
   - Derrickman oversees helping driller running in hole or pull out BHA of the hole (trimming).
   - Floorman or roughneck unplug the drill pipe circuit, install the sheath, install rig tong, operate spinner, and so forth.
   - Supporting crews such as mechanics, electricians, tow carriers, roustabouts, and others.
8. The mud engineer is tasked to prepare drilling mud by the drilling program that has been approved.
9. The directional driller is the person responsible for directional drilling by the direction/target set in the drilling program.
10. Heavy transport and construction personnel are assigned for the transportation and construction of drilling rigs.
11. Reservoir engineers and modelers at this stage will update the models that have been made at the exploration stage using data from the geoscientist obtained from drilling.

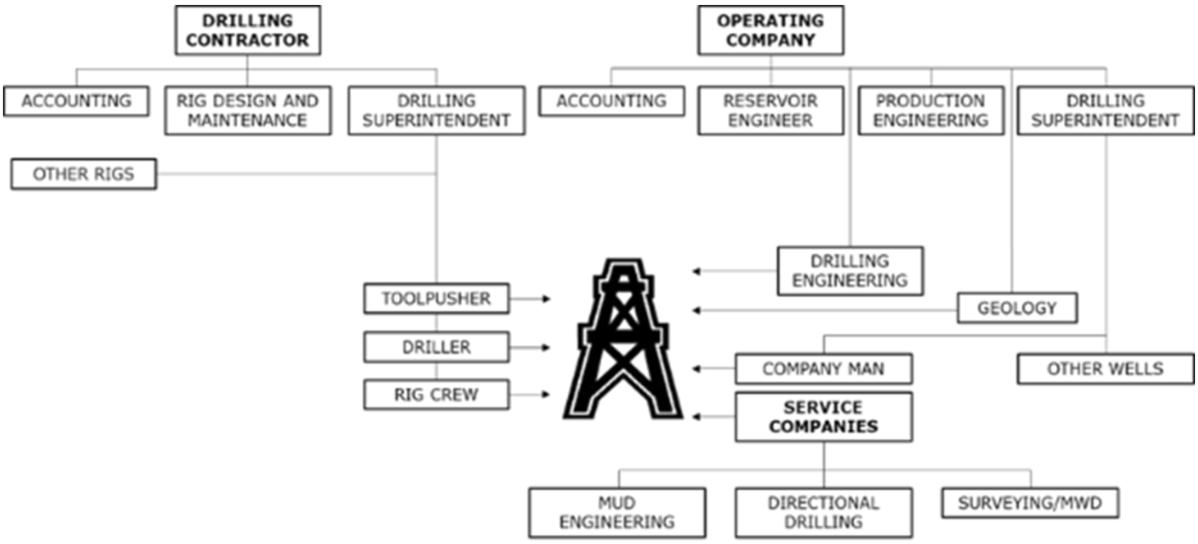

Figure 6: Personnel involved in drilling an oil well (adapted from Ford, 2004)

3.2 The difference between oil and gas drilling and geothermal drilling

Visser et al. (2014) conducted a comparative analysis of 21 geothermal wells and 21 petroleum wells, and interviews with geothermal and oil and gas drilling experts. They found that the main challenges of geothermal drilling were loss of circulation, selection of the right rig and equipment, technical drilling programs, proper cementing practices, and time management evaluation. The study also shows the opportunity to apply the method of drilling petroleum fields to the geothermal industry and vice versa.

Drilling is one of the most essential and expensive phases in the development of petroleum and geothermal fields. Anderson et al. (2011) estimate that drilling for exploration and production accounts for more than 42% of the total cost of developing geothermal. Petroleum drilling technology was established more than 150 years ago, while the first geothermal well was drilled in the early 20th century. Therefore, geothermal drilling adopts many technologies from petroleum drilling. The ability of drilling engineers to identify various challenges in drilling is a crucial factor in the success of this operation.

However, drilling for petroleum and geothermal is not the same in all respects. Indeed, Tilley et al. (2015) found that geothermal drilling usually takes longer and spends more money on the same depth due to harder rocks and larger holes. The main difference between the two is the location and type of resource. The geothermal fluid is often occurs in fractures and cracked volcanic formations, while petroleum is in the pore space of the sediment formation (Capuano, 2016). To date, most geothermal drilling equipment is used and experienced workforce from oil and gas drilling. Some significant differences between drilling conditions in the oil and gas industry and geothermal are described below.

Table 3: The differences between oil and gas and geothermal drilling (Umam, 2018)

Parameters	Petroleum	Geothermal
Rock formation	Mostly sandstone/ mudstone, sedimentation layer	Igneous & hard metamorphic rock (e.g., rhyolite, andesite, diorite, etc.)
Reservoir pressure	High (might reach 90 MPa).	Relatively low, might be lower than hydrostatic pressure.
Reservoir temperature	Up to 200°C, relatively low	High temperatures (160°C to above 300°C)
Drilling fluid	Bentonite blends	Aerated mud or water with air or nitrogen mixture
Drilling bits	Typically, Polycrystalline Cutter (PDC)	Roller cone or drag bits, impregnated diamond bits
Drilling orientation	Vertical, deviated, horizontal	Typically, vertical or J-shaped, horizontal drilling is unlikely
Casing	perforated production casing	Slotted liner, large diameter casing
Cementing	protecting the casing from hydrocarbon corrosion	Limit casing transformation/deformation due to high temperature, prevent thermal fatigue
Completion	perforating and swabbing with NaCl saltwater	Slotted liner installation and swabbing with brine

3.3 Important competencies for geothermal drilling

From the discussion above, it is known that the application of SKKNI on land drilling in geothermal drilling will be slightly different from the implementation of oil and gas drilling. Hence, the necessary knowledge or skills to be included in geothermal drilling curriculum are as follows:

1. Basic regulations and management. This material contains understanding Health, Safety, and Environment (HSE) protection requirements, cooperation, prevention and control of fires, first aid in accidents, emergency conditions, pollution prevention, and the application of oil and gas and geothermal mining laws.
2. Casing and Cementing Design. This subject includes loading factors, and sheathing capability must meet minimum safety factor requirements. This subject will also highlight differences in casing design in geothermal drilling, design cementing programs, and implement lowering and cementing casings.
3. Planning and managing the drilling program. This include plans, stages, procedures, and reporting techniques in drilling activities, and reservoir management in geothermal fields. This subject also covers conducting drilling operations such as selecting drilling bits, pipe trimming, drilling optimization, core drilling, directional/horizontal drilling, rod test operations, hydraulic drilling, solid/gas separator controls, drilling rigs instrumentation, tilt controls, wells direction and hydraulics programs
4. Maintaining well control on pressure and explosion prevention devices includes assembling and operating the parameters used in drilling such as Penetration Rate (ROP), Per Minute Rotation (RPM), how to focus on safety while controlling parameters.
5. Creating a mud program. This subject includes designing a mud program, calculating the mud weight to maintain well control, and selecting the acceptable mud. The trainees also expected to be able for determining the nature of the mud and assisting in handling mud, and operating the mud pump. It also includes basic knowledge of drilling fluids, drilling fluid systems, materials, and chemicals used in drilling fluids, mud tests, and drilling mud conditions.
6. Prepare drilling equipment. This subject covers equipment selection, transfer of drilling rig, rig-up/rig-down, selecting the primary drive system, lift system, rotary system, and circulation system. This material also includes drilling machine components and working principles, the type of mud, and the fuel used during drilling activities, work safety facilities, waste disposal facilities.
7. Establish evaluation programs. This subject includes the development of evaluation programs, evaluation of drilling problems, maintenance of rotational equipment, daily inspection, daily rig equipment maintenance. The evaluation subject also covers the logging system such as PTS Logging (Pressure, Temperature, Spinner), logging types, well testing, drilling well simulation, design and operation of the drill stem test, and completing the well.
8. Basic knowledge of drilling technology. This subject includes an overview of geothermal drilling technology and a geological perspective, the prevention of hazardous/toxic gases with a simple analysis of various possibilities for toxic gas problems in geothermal drilling operations. It also includes case studies of drilling activities such as explosions, lost circulation, traffic pipes, and fishing work.

4. SUMMARY AND RECOMMENDATION

Currently, Indonesia does not have standards for geothermal drilling (non-hydrocarbon drilling). In terms of standard competencies in Indonesia, oil and gas and geothermal drilling in Indonesia only use one standard. Four qualifications can be achieved in hydrocarbon drilling: Floorman (level 2), Derrickman (level 3), Driller (level 4), and Toolpusher (level 5).

This paper suggests that geothermal drilling learning programs are needed with different durations and materials for each level. The primary purpose of this program is to understand geothermal characteristics and challenges such as steam kick, waste management, and geohazards.

This study also believes that several training institutions can be utilized to commence geothermal drilling training. Thus, the geothermal drilling HRD needs of Indonesia can be met effectively and efficiently. The geothermal drilling curriculum needs to be designed and established as the implementation of SKKNI in onshore drilling competency standards. Further, the MoM and MEMR is advised to re-map the Indonesian competencies to add competency standard for geothermal drilling.

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