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Impacts of Different Funding Sources on Long-lead Items Procurement in Indonesia Geothermal Drilling Projects

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ABSTRACT

Following the Paris Agreement on climate change, Indonesia has committed to reduce its greenhouse gas emissions by 29-41% against the business as usual scenario by 2030. In addition, Indonesia also has been encouraged to boost its national energy security and independence. To accomplish these targets, the Government of Indonesia has embarked on various attempts as emphasized in the National Energy Plan by increasing the use of renewable energy, especially from geothermal energy sources. However, the significant capital costs and risks have caused geothermal projects less attractive and more challenging. The cost of drilling dominates the proportion of the overall project investment cost, including long-lead items such as casing pipes.

In the Indonesian geothermal industry, the developers have been encouraged to source the components from local manufacturers to increase the competitiveness between the domestic manufacturing industry and to minimize transportation costs. In contrast, some geothermal developers, which are financed by international funding institutions, are required to do international bidding as required in the procurement guidelines in order to give a wide choice of selection. Therefore, the international bidding requirements necessitate importing finished casing pipes into Indonesia. Inaccurate decisions during procurement processes, especially for casing pipes, could lead to major operational issues and costs in the future.

This research aims at getting a deep understanding of how different funding sources can give impacts to long-lead items procurement, especially casing pipes, in geothermal development projects in Indonesia. The paper also investigates the challenges and opportunities that come with the use of local content. The research of local content for long-lead items on Indonesia geothermal drilling procurement has been limited. Thus, the presence of this paper intends to fill the gaps in the field.

1. INTRODUCTION

Indonesia's population is projected to reach 270 million people in 2025, an increase of 51 million compared to 2005 (BAPPENAS, BPS, & UNFPA, 2008). It means that this will have an impact on the national energy consumption in the future, which currently is still dominated by fossil fuels, especially oil-based energy. The declining fossil energy sources production and the increase of the country's dependence on oil and gas imports have encouraged the Government of Indonesia to put renewable energy as the main priority to achieve national energy security and independence. In addition, Indonesia has committed to reduce 29% of its greenhouse gas emissions against the business as usual scenario by 2030 under the Paris Agreement on climate change (Kamia, Yoram, & Tatiana, 2017). The target should be increased to 41%, given the availability of international financial support.

Indonesia has commenced various attempts to achieve these targets by incresing the renewable energy usage, as stated in the Indonesian National Energy Plan (RUEN), shown in the figures below. Figure 1 shows that the renewable energy source should account for 23% or 45 gigawatt (GW) of the total national energy consumption by 2025, including 7.2 GW from geothermal energy, as shown in Figure 2 (Presidential Regulation, 2017).

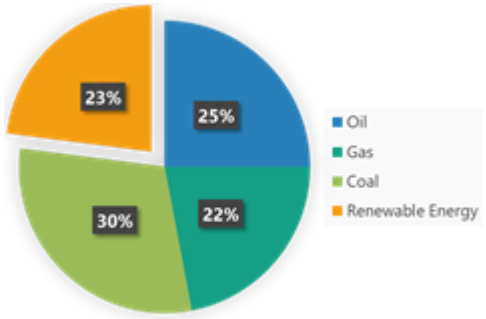

***Figure 1*. Indonesian energy mix target in 2025 (modified from Presidential Regulation, 2017)**

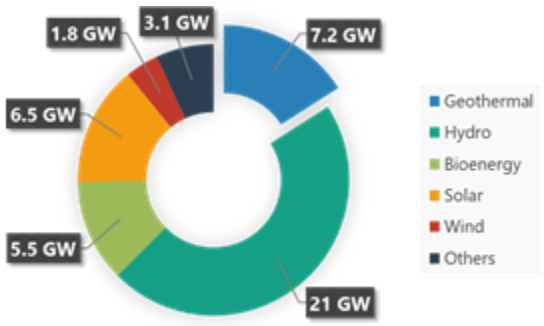

***Figure 2*. Target installed capacity from renewable energy in 2025 (modified from Presidential Regulation, 2017)**

Located on the Pacific Ring of Fire with 127 active volcanoes, Indonesia possesses excellent geothermal resource availability that can help meet the country's rising energy and electricity demand. The geothermal potential in Indonesia is estimated at 25 GW, which is composed of 10 GW resources and 15 GW reserves scatterd on 331 locations across several islands. However, the current installed capacity of geothermal power plants (PLTP) is only 1.9 GW (Badan Geologi, 2018; ThinkGeoEnergy, 2020).

No	Island	No. of Locations	Potential Energy (MW)					Total	Installed Capacity (MW)
			Speculative	Hypothetic	Reserves				
					Possible	Probable	Proven		
1	Sumatera	103	2,776	1,689	3,889	1,083	1,028	10,465	561
2	Jawa	73	1,190	1,460	3,708	516	1,820	8,694	1,257
3	Bali	6	70	22	122	110	30	354	0
4	Nusa Tenggara	28	225	210	829	121	12.5	1,397	13
5	Kalimantan	14	151	18	12	0	0	181	0
6	Sulawesi	89	1,360	362	1,041	180	120	3,063	121
7	Maluku	33	560	91	497	6	2	1,156	0
8	Papua	3	75	0	0	0	0	75	0
	Total	**349**	**6,407**	**3,852**	**10,098**	**2,016**	**3,012**	**25,385**	**1,951**
			10,259		**15,126**				
			25,385						

Table 1: Potential Geothermal Energy in Indonesia (Modified from Badan Geologi, 2018, and ThinkGeoEnergy, 2020)

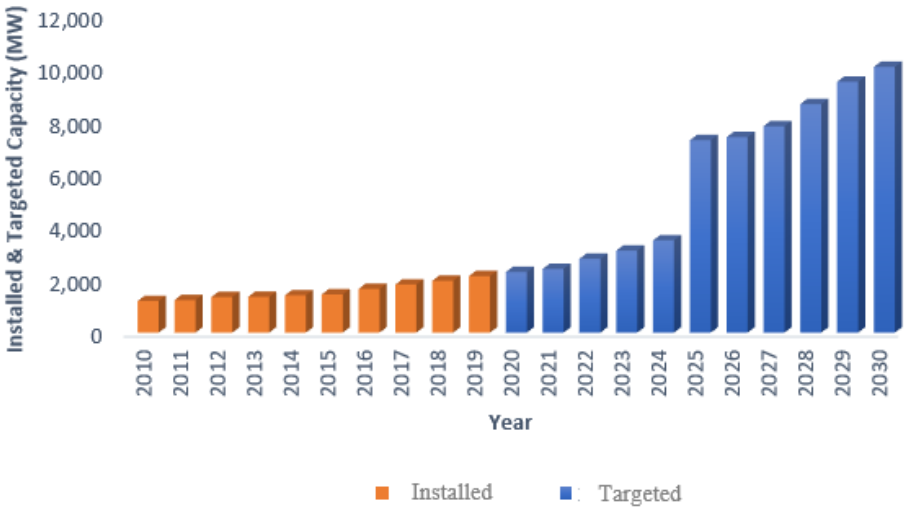

***Figure 3*. Geothermal installed and targeted capacity development in Indonesia (modified from ESDM, 2019)**

As we can see from Figure 3, the installed capacity development has been not very significant for the past ten years. The current installed capacity is still 5.3 GW away from the 2025 target. It shows slow development history but a very ambitious target. The slow progress in geothermal energy development and utilization in Indonesia has been caused by several problems: high exploration risk, low drilling success ratio, and high manufacturing components import, especially exploration and production facilities components (Presidential Regulation, 2017).

According to Rayhanna (2017), the gradual progress in the geothermal sector in Indonesia is also caused by the limited progress in some assigned geothermal prospect areas through public tender. Most of the fields remain underdeveloped due to various issues, such as complexity of the process, lack of financial resources, political landscape, and bureaucracy in the country.

Moreover, Purba et al (2019) stated that there are several identified geothermal development challenges in Indonesia, such as insufficient geological, geophysical, and geochemical data in the area, high resource risk in the upstream sector, high upfront investment cost with an uncompetitive energy price, limited equity funds, lack of sufficient incentive mechanisms, limited number of human resources with specific competences, social issues, and lack of infrastructure.

Thus, the most common barrier to advancing geothermal development around the world, including in Indonesia, is the highly resource risk associated with the exploration phase of geothermal development and significant capital cost. The geothermal energy is stored around two kilometers beneath the surface, which makes it difficult to be assessed and accessed. In the exploration phase, the uncertainty is high. In that case, the investors must make decisions to invest in a high-cost drilling campaign, which may cause the private sector and other funding institutions to be discouraged from supporting geothermal energy projects.

Figure 4 shows an overview of the various stages in geothermal development and the associate changes in the level of risk and capital investments (ESMAP, 2012). In newly tendered (green field) projects, the highest risks are faced during the early stages of surface reconnaissance and exploration drilling. During these early phases, the uncertainty regarding the temperature, permeability, or other relevant parameters is high. The uncertainty is considerably decreased after the resource availability has been confirmed through exploration drilling. If successful, these may be followed by calculation of reserves and well productivity, and then by development drilling, which in turn allows the financial feasibility of proceeding to subsequent development stages to be calculated.

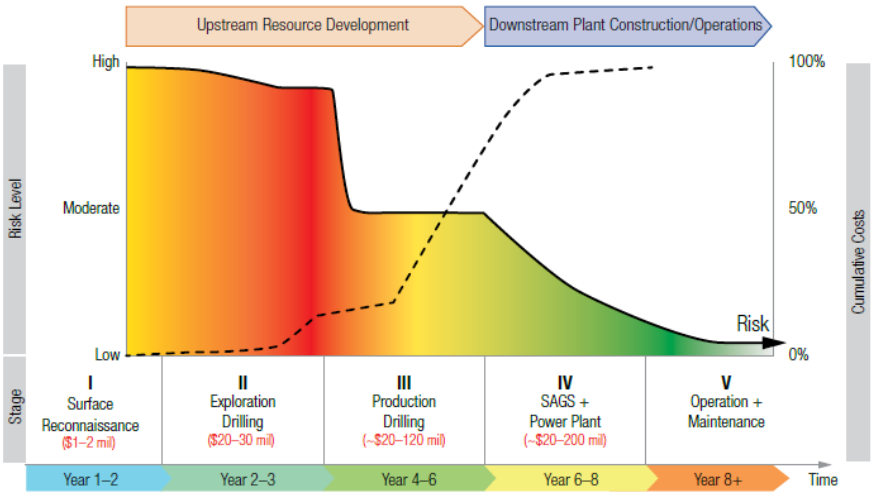

***Figure 4*. Project cost and risk profile at various stages of geothermal development (ESMAP, 2012)**

It can be seen as well from Figure 4 that exploration campaigns and initial test drilling programs of three to five geothermal wells cost from US$ 20 – 30 million (Sanyal et al., 2016). According to Thorhallsson and Sveinbjornsson (2012), the cost of geothermal wells and field development may reach up to 40% of the total investment cost for new high-temperature geothermal plants. The cost will be varied depending on the depth of the geothermal resource and rock formation. These parameters may affect the initial and final diameter, the rate of penetration and drilling speed, the total time required to complete the well and the number of casing strings required. Although the casing cost is approximately 10%, the usage of casing in the geothermal wells is very important. Failure to provide the required casing size and type needed may affect the project in the future.

In Indonesia, it is very common to have local content requirement in the procurement process. The reason behind this regulation is to increase the competitiveness between local contractors and to minimize the transportation cost. However, some international funding institutions require international bidding as a requirement. Despite the higher transportation and import tax costs, it is considered to give a wide choice of selection.

In terms of long-lead items, generally, casing pipe manufacturers import the green pipes and conduct the heat and thread process on the casing pipe in Indonesia. Thus, they never import the finished casing pipes into Indonesia. In the case of geothermal developers, who are funded by international funding institutions, they will face a difficulty to import casing pipes needed, if the casing supplier does not have heat treatment or threading facilities in Indonesia. As a result, they will import the finished product into Indonesia, and it will be very difficult to get the permit to import the casing pipe into Indonesia.

2. RESEARCH OBJECTIVE AND METHOD

2.1 Research Objective

This paper aims at figuring out how different funding sources can impact long-lead items procurement of geothermal project in Indonesia. It also aims to increase stakeholders' awareness (government, developers, funding institutions, and academic community) about the importance of local content in order to achieve the capacity target in 2025. The answer to the main queries will be constructed based on the findings to the following set of proposed research questions:

1. How important is the role of long-lead items, especially casing pipes, in the whole geothermal drilling project?
2. What are the barriers, primarily on long-lead items, in geothermal drilling operation in Indonesia?
3. What are the geothermal financing mechanisms in Indonesia? How do they impact to the long-lead items procurement in Indonesia?

2.2 Research Method

The research is conducted by doing a comprehensive literature review. The review of the literature focuses on the information presented in the Indonesian government regulation, peer-reviewed journals, and conference papers, which cover geothermal development, long-lead items, procurement, international bidding, and also the geothermal financing mechanisms in Indonesia. The data sources that will be used are varied, including data from the World Bank, the Indonesian Ministry of Energy and Mineral Resources (ESDM), the Indonesian Ministry of Industrial, and other confidential reports.

3. RESULT AND DISCUSSION

3.1 Geothermal Drilling Project Cost

On average, drilling costs comprise 35 - 40% of the total capital cost of a geothermal project, which will be varied depending on the size, location, and geothermal resource power capacity (International Finance Corporation, 2013). Similar illustrations have been shown by data from Iceland in Figure 5 (ESMAP, 2012). Well costs are the major factor of the total cost of any geothermal project. Thus, it becomes key to determine the economic life of a geothermal field (Kipsang, 2015). There are several parameters that affect the well cost. According to Sanyal et al. (2011), depth is the main determinant of the drilling cost of a geothermal well. The drilling of deep exploratory holes in Indonesia is in the range from 1.5 to 3 km, which is also typical in most countries (GeothermEx, 2010).

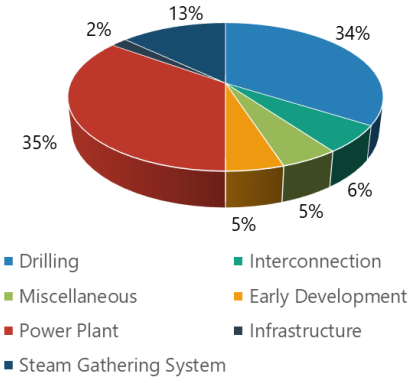

***Figure 5*. Investment cost breakdown of geothermal power development in Iceland (modified from ESMAP, 2012)**

Generally, drilling costs consist of preparation of drilling location, tubular equipment, line hangers, wellhead, drilling rig, mud service, drilling bits, directional drilling or performance drilling services, cementing, logging, and company labor and supervision (Gul & Aslanoglu, 2018). Table 2 shows list of services commonly utilized in a geothermal drilling project in Indonesia based on actual field data.

List of services commonly utilized in a geothermal drilling project in Indonesia	
Rig Services	Drill Bit
Top Drive	Conventional Coring
H2S Service	Fuel Supply
Heavy Equipment	Fishing Tool
Mud Logging Unit	Aerated Drilling
Directional Drilling and MWD (Personnel and Equipment)	Wireline Logging (Truck and Tool)
Cementing and Casing Accessories (Personnel, Equipment and Material)	Drilling Fluids (Personnel and Material)
Liner / Casing Tieback	Drilling Water Supply
Rig Inspection	Tubular Inspection
Project Implementation Team	Casing Drilling Level 1 (Personnel and Material)
Casing and Liner (OCTG, long-lead)	Wellhead and Master Valve (long-lead)
Drilling Waste Management	Casing Running Services
VSAT (Internet and Telecommunication)	General Services

Table 2: List of Services in a Geothermal Drilling Project in Indonesia (Modified from Actual Data Field)

Figure 6 shows an illustration of drilling cost allocation taken from actual data. It can be seen that rig, cementing, directional drilling, and casing dominate the overall drilling cost.

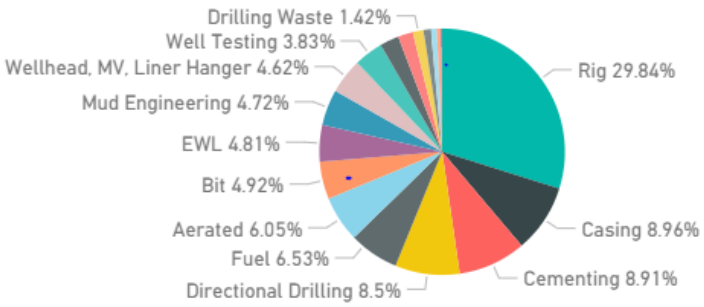

***Figure 6*. Illustration of drilling cost allocation (from actual field data)**

In geothermal wells, casing is used to prevent contamination of fresh well zones, to prevent unstable upper formations, to isolate different zones, to contain well fluids and pressures, etc. (Kivure, 2016). Moreover, the casing is required to flow the steam from the reservoir to the power plant. In exploration drilling, casing pipes are used 1.5 – 3 km beneath the surface, which makes it difficult to be seen. Thus, the appropriate casing design is highly recommended. Hole (2008) stated that the most critical aspects to design drilling programs is the selection of casings, casing specification, casing shoe depths, and how the well is completed. Figure 7 illustrates the typical casing design (big hole) in one of the geothermal fields in Indonesia.

Many essential items for geothermal drilling projects have a very long lead time. Providing wellhead and its equipment can take up to 12 months, while casing pipes typically have 9 months lead time. Therefore, failure to provide required casing on time may influence the overall project since the well is expected to have enough integrity to perform for as long as possible.

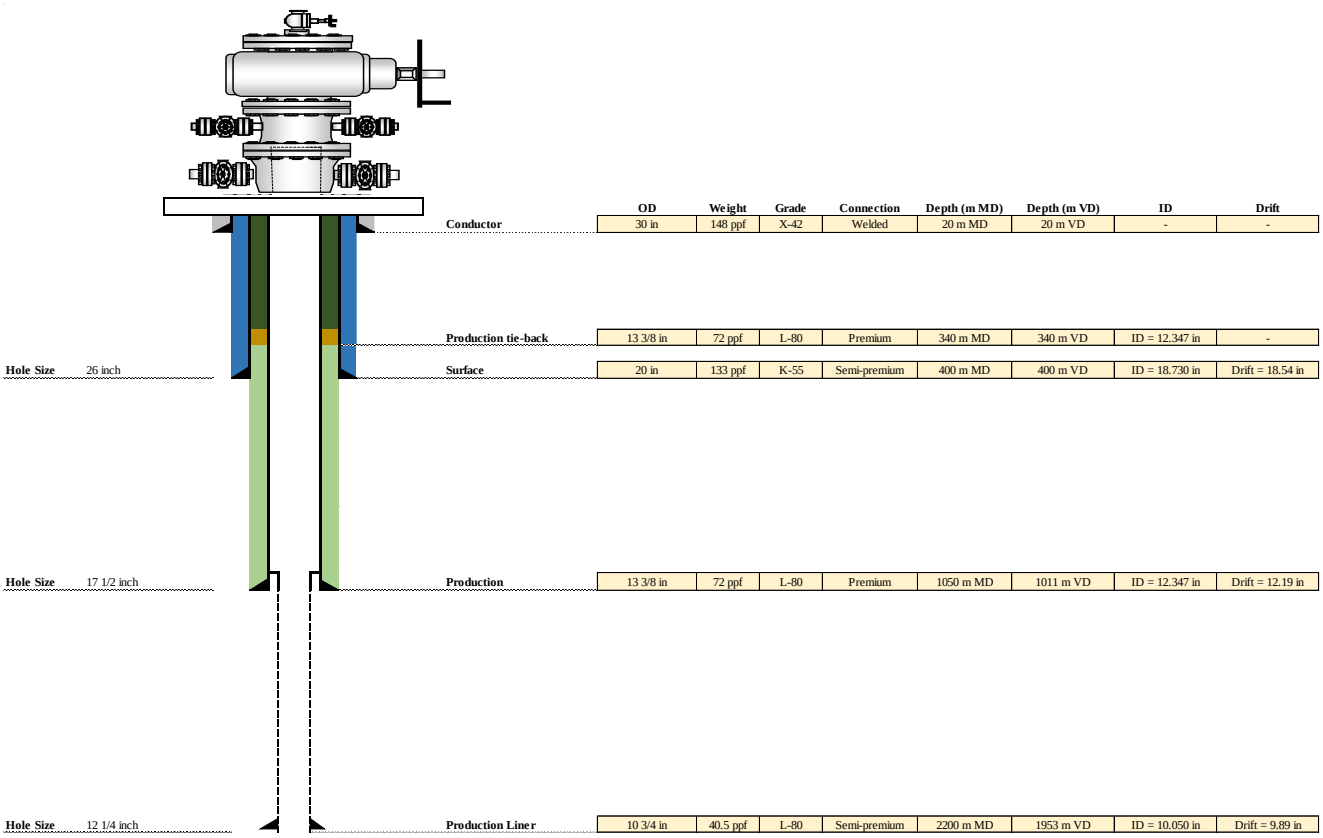

Figure 7. **Typical casing design (big hole) in a geothermal field in Indonesia (from actual field data)**

3.2 Local Content Regulation in Indonesia

According to Dewanti (2012), local content requirements necessitates that companies use a certain amount of components that are produced in the host country. In the early forms, local content tended to be simply defined as "local" or "nationally owned" companies. Nowadays, the definition becomes broader as "total value added in-country", which is usually expressed in monetary terms (Anderson, 2019).

There are many barriers to local suppliers, such as lack of experience, insufficient knowledge, limited skills, and lack of equipment, work-space, and access to finance. However, the local content policy is believed to give some advantages for developing countries, such as to increase the competitiveness between local contractors (national protection), to minimize the transportation cost, to expand employement opportunities, and to transfer the technology and knowledge. Due to these reasons, the Government of Indonesia has implemented the local content (TDKN) policy for goods, services, and combination of goods and services in various sectors. The government has required contractors of energy service projects to source a proportion of their components from local manufacturers.

According to the Ministry of Industrial Republic of Indonesia (2011), component considered as local content on goods includes the use of raw materials, construction and manufacturing, fabrication, assembling and final finishing on works originated from and conducted within the territory.The calculation on local content on goods is made based on comparison between the local cost of product against its total value. The costs include direct material cost, direct labor cost, and indirect factory overhead cost. The calculation is using the method in which the total cost costs (direct material cost, direct labor cost, and indirect factory overhead cost) minus the foreign component costs on each aspect divided by the total costs, resulting in the percentage of local content on goods (Legisperitus, 2015).

There has been no comprehensive standard practice to regulate local content on geothermal exploration projects so far. Other opportunities to enter the market include manufacturing components for the renewable energy sector, an area of huge potential in Indonesia that remains untapped. Generally, the geothermal developers follow Ministry of Energy and Mineral Resources (ESDM) regulation, which is shown in Table 3.

In the oil and gas sector, the ESDM has introduced a regulation detailing varied rates of mandatory local content for different activities that fall within the category of energy projects that are shown in the table below:

No	Comodities	Target Local Content (%)		
		Short-term (2013-2016)	Mid-term (2017-2020)	Long-term (2021-2025)
1	Drilling Pipe (OCTG)			
	a. High Grade	25	40	55
	b. Low Grade	15	25	40
2	Line Pipe			
	a. Spiral/SAW	50	65	80
	b. ERW	50	65	80
	c. Seamless Pipe	10	30	50
3	Drilling Fluid, Cement and Chemical	40	55	70
4	Electrical Submersible Pump	15	25	35
5	Pumping Unit	40	55	70
6	Machinery & Equipment	20	30	40
7	Wellhead and X-mas Tree			
	a. Land	40	55	70
	b. Sea	15	30	40
8	Fuel	60	75	95
9	Lubricant	50	60	70
10	Barang lain-lain	15	25	40

Table 3. Targeted Local Content on Oil and Gas (ESDM, 2013)

In the geothermal downstream industry, the Ministry of Industry has implemented the use of domestic products in the construction of electric power infrastructure. Table 4 shows the minimum local content is made on the basis of power plant capacity and type of energy use.

Power Source	Capacity (MW)	Local Content % (Goods & Services)
Steam	<15	70.79
	15-25	49.09
	25-100	44.14
	100-600	40
	>600	38.21
Hydro	<15	70.76
	15-50	51.6
	50-150	49
	>150	47.6
Geothermal	<5	42
	5-10	40.45
	10-60	33.24
	60-110	29.21
	>110	28.95
Gas	<100 per block	48.96
Combined Gas & Steam	<50 per block	47.88
	50-100 per block	40
	100-300 per block	34.76
	>300 per block	30.22
Solar	Scattered	45.9
	Centralized	43.72
	Centralized Connected	40.68

Table 4. Minimum Local Content Requirement for Electric Power Infrastructure Projects (KEMENPERIN, 2012, 2017)

Commonly, casing pipe manufacturers import the green pipes and add local content value by using their heating and threading facilities in Indonesia. Therefore, they never import the finished pipes into Indonesia. Hypothetically, importing the green pipes from outside Indonesia is cheaper than producing the green pipes in Indonesia. International companies, who do not have heat treatment and threading facilities here, could not comply with the local content requirement, as they will import the finished product into Indonesia.

3.3 Geothermal Funding Sources

Geothermal energy production requires large upfront capital investments in debt and equity. Therefore, finding financial sources to accelerate geothermal exploration projects is challenging. There are several financing mechanisms in Indonesia.

3.3.1 International funding institution

The first geothermal financing mechanism is solely funded by international financing institution, such as the International Bank for Reconstruction and Development (IBRD), the Asian Development Bank (ADB), Japan Bank for International Cooperation (JBIC), World Bank (WB) and Japan International Cooperation Agency (JICA) (World Bank & ADB, 2015). These financing institutions have set their own guidelines and standards. Generally, they require international bidding for the purpose of the procurement process. As a result, the borrowers may face a difficulty when importing required casing pipes needed from the casing suppliers who do not have heat treatment or threading facilities in Indonesia. It is very difficult to get the permit to import the casing pipe into Indonesia. Thus, it may lead to prolonged delays and incur high costs.

3.3.2 National funding

Hypothetically, the developers may get a loan from local commercial debt suppliers (banks). However, they may require a higher credit risk premium to account for the higher risk due to the relatively large amount of debt caused by the high capital requirements. Moreover, they might not be interested in geothermal exploration phase because of its uncertainty.

As the Government of Indonesia's designated fund manager for the Infrastructure Financing for Geothermal (PISP), PT Sarana Multi Infrastruktur (PT SMI) have launched various financing products and cooperate with the multilateral institutions and private entities to mitigate geothermal exploration resource risk, including the Indonesia Geothermal Energy Upstream Development Program (GEUDP) and Geothermal Resource Risk Mitigation Project (GREM) as a collaboration with the World Bank and Climate Funds.

In the GEUDP, PT SMI will take over some new and unassigned concessions and drill (green field) to prove geothermal potential within each area. Once the prospect areas are successfully explored and proven, they will be returned to the ESDM. The ESDM will tender the area's data to private developers and state-owned enterprises for further development. The long-lead items procurement by the developers might not be impacted by this program.

The GREM will make it soft financing for both public and private sector developers. For the public sector, support will be provided to public entities, such as State-owned Enterprises (SOEs), SOE subsidiaries, or public service agencies. In the case of unsuccessful exploration, the geothermal developers may get up to 50% forgiveness whereas they have to fully repay the loan to PT SMI if the exploration is successful. For the private sector, the developers will be required to contribute their own equity equivalent to 25% of the total cost. In the case of unsuccessful or successful exploration, the developers have to repay up to 50% of the 75% loan. The remaining 50% will be treated as financial instrument or convertible debt instrument that can be repaid under fair market value if it is successful. The program is in the process of implementation and will be a loan signing between the Ministry of Finance (MoF) and the World Bank this year.

The GREM is a very interesting mechanism because of its forgiveness scheme. However, the geothermal developers must still consider that the long-lead items procurement process might be complicated. It might not comply with Indonesia's local content regulation as it must follow the World Bank's guidelines or principles.

3.3.3 Equity from Parent Company

Third, the geothermal developers use their own equity or strong incentive from parent companies to develop the project, as proven in the Sarulla project (Rakhmadi & Sutiyono, 2015). In this financing mechanism, the procurement process may be flexible and follow the Indonesian local content regulation.

4. CONCLUSION

Geothermal projects provide relatively clean and constant production profiles compared to other renewable energy technologies. However, the electricity production from geothermal energy in Indonesia is still a long way from the ambitious 2025 target. One of the crucial factors of the slow progress in the geothermal sector in Indonesia is caused by high resource risk and high upfront investment costs which are faced in the newly tendered or green field projects. The uncertainty is decreased after the resource availability has been confirmed during the drilling phase. Thus, the cost of drilling is very significant on the overall investment costs, including long-lead items, such as casing pipes. The local content policy has an important role in the geothermal business process. The Government of Indonesia has applied the local content requirement for goods, services, and combination of goods and services in the energy sector as a national protection for local manufacturers. Geothermal developers who are required to do international bidding, will face importing permit issues in the future. If their suppliers are the international companies who do not have heat treatment and threading facilities in Indonesia, they cannot comply with the local content policy, as they will import the finished casing pipes into Indonesia. On the other hand, for the geothermal developers who are financed by their own equity, the procurement process may be flexible and will follow Indonesia's local content regulation. Therefore, the geothermal developers need to increase their awareness about these issues and wisely choose the financial source as it may affect the requirement process, especially for long-lead items on geothermal drilling projects. Failure to provide casing pipes on time may lead to prolonged delay, higher cost, and reduced discounted value of the project's revenues.

5. RECOMMENDATION

The research presented in this paper has led to useful results and conclusions on deepening the understanding of the impacts of different funding sources on the procurement of long-lead items in geothermal drilling projects in Indonesia. Furthermore, it has uncovered many areas that need to improve. Thus, some recommendations have been provided to identify and discuss the need for better geothermal practices in the future:

1. The authors suggest that for long-lead items procurement process, especially casing, the developers may utilize their own equity. The other services in the geothermal drilling project (rig, cementing, directional drilling, etc.) may be borne through other available sources, such as from government support or international loan facilities for geothermal project.

2. International funding institutions should consider local or national regulation in their procurement guideline. Otherwise, if there are contradictory rules or regulations, it will have the potential to delay the project.

3. The Indonesian Ministry of Mineral and Energy Resources, the Ministry of Industry, the Ministry of Finance, and other stakeholders need to coordinate and provide consistent local content policies to accelerate geothermal development in Indonesia.

4. A collaborative approach between the geothermal developers, academic community, international funding institutions, and government is highly encouraged. Collaboration and knowledge sharing can help offset potential misalignment between government expectations and what is actually deliverable, especially regarding local content in both upstream and downstream geothermal projects.

5. The government has worked to broaden the opportunities available to support infrastructure and crucial equipment to energy sector projects and to open the door to foreign companies seeking to enter the market via joint ventures. Foreign casing suppliers could use the opportunity to take advantage of the upcoming geothermal projects through joint ventures and technology transfer with local partners that have market access in Indonesia.

6. REFERENCES

Anderson, G. (2019). Can local content thrive in a lower-cost upstream industry? *Africa Oil Week 2019*.

Badan Geologi. (2018). *Potensi panas bumi di Indonesia.* Jakarta: Badan Geologi, Kementrian Energi dan Sumber Daya Mineral.

BAPPENAS, BPS & UNFPA. (2008). *Proyeksi penduduk Indonesia [Indonesia population projection] 2005 - 2025.* Jakarta: Badan Perencanaan Nasional, Badan Pusat Statistik & United Nations Population Fund.

Dewanti, E. H. (2012). Persyaratan kandungan lokal (local content requirements) di Indonesia dan kaitannya dengan perjanjian internasional di bidang investasi. 203.

EBTKE. (2017). *Potensi panas bumi Indonesia [Indonesia geothermal potential]*. Jakarta: Direktorat Jenderal Energy Baru, Terbarukan, dan Konversi Energi, Kementrian Energi dan Sumber Daya Mineral.

ESDM. (2013). *Peraturan Menteri Energi dan Sumber Daya Mineral Republik Indonesia tentang penggunaan produk dalam negeri pada kegiatan usaha hulu minyak dan gas bumi No. 15/2013*. Kementerian Energi dan Sumber Daya Mineral [Ministry of Energy and Mineral Resources].

ESDM. (2019). Geothermal as a clean and renewable energy source in the energy mix. *The 7th Indonesia International Geothermal Convention & Exhibition*. Jakarta: Kementrian Energi dan Sumber Daya Mineral.

ESMAP. (2012). *Geothermal Handbook: Planning and financing power generation 002/12.* The International Bank for Reconstruction And Development, World Bank.

ESMAP. (2012). *Handbook on planning and financing geothermal power generation: Main findings and recommendations.* Washington DC: The World Bank.

GBG Indonesia. (2014, May 5). *Going local: Understanding Indonesia's local content requirements*. Retrieved from gbgindonesia.com: http://www.gbgindonesia.com/en/main/business_updates/2014/upd_going_local_understanding_indonesia_s_local_content_requirements.php

GeothermEx. (2010). *An assessment of geothermal resource risks in Indonesia.* Richmond, California: GeothermEx, Inc.

Gul, S., & Aslanoglu, V. (2018). Drilling and well completion cost analysis of geothermal wells in Turkey. *43rd Workshop on Geothermal Reservoir Engineering.* Stanford, California: Stanford University.

Handayani, K., Krozer, Y., & Filatova, T. (2017). Trade-offs between electrification and climate change mitigation: An analysis of the Java-Bali power system in Indonesia. *Applied Energy 208*, 1020-1037.

Hole, H. (2008). Geothermal well design - casing and wellhead. *Petroleum Engineering Summer School.* Dubrovnik, Croatia.

International Finance Corporation. (2013). *Success of geothermal wells: A global study*. Washington, DC: International Finance Corporation, World Bank Group.

KEMENKEU. (2017). *Peraturan Menteri Keuangan Republik Indonesia tentang pengelolaan dana pembiayaan infrastruktur sektor panas bumi pada perusahaan persero (PERSERO) PT Sarana Multi Infrastruktur No 62/PMK.08/2017*. Kementrian Keuangan [Ministry of Finance].

KEMENPERIN. (2012). *Pedoman penggunaan produk dalam negeri untuk pembangunan infrastruktur ketenagalistrikan No. 54/M-IND/PER/3/2012.* Kementrian Perindustrian [Ministry of Industry].

KEMENPERIN. (2017). *Pedoman penggunaan produk dalam negeri untuk pembangunan infrastruktur ketenagalistrikan No. 05/M-IND/PER/2/2017.* Kementrian Perindustrian [Ministry of Industry].

Kipsang, C. (2015). Cost model for geothermal wells. *World Geothermal Congress.* Melbourne.

Kivure, W. (2016). Geothermal well drilling costing - a case study of Menengai geothermal field. *SDG Short Course I on Exploration and Development of Geothermal Resources.* Lake Bogoria and Lake Naivasha, Kenya: UNU-GTP, GDC & KenGen.

Legisperitus. (2015, February 06). *Local content requirement in Indonesian oil and gas industry*. Retrieved from Legisperitus.co.id: https://legisperitus.co.id/blog-news/local-content-requirement-indonesian-oil-and-gas-industry

Nurrohim, A. (2015). *Effect of local content on electricity generation cost of small scale geothermal power generation.* Pusat Teknologi Konversi dan Konservasi Energi (PTKKE) Badan Pengkajian dan Penerapan Teknologi (BPPT).

Pambudi, N. A. (2018). Geothermal power generation in Indonesia, a country within the Ring of Fire: Current status, future development and policy. *Renewable and Sustainable Energy Reviews 81*, 2893 - 2901.

Presidential Regulation. (2017). *Rencana Umum Energi Nasional [National Energi Plan] No. 22/2017.*

PT Sarana Multi Infrastruktur. (2019). *Indonesia geothermal resource risk mitigation project (GREM)* . PT Sarana Multi Infrastruktur.

Purba, D. P., Adityatama, D. W., Umam, M. F., & Muhammad, F. (2019). Key considerations in developing strategy for geothermal exploration drilling project in Indonesia. *44th Workshop on Geothermal Reservoir Engineering*. Stanford: Stanford University.

Rakhmadi, R., & Sutiyono, G. (2015). *Using private finance to accelerate geothermal deployment: Sarulla geothermal power plant, Indonesia.* Climate Investment Funds (CIF).

Rayhanna, N. (2017). *Institutional analysis of geothermal energy investment in Indonesia: Operationalization of the IAD framework.* Delft: Delft University of Technology.

Sanyal, S. K., Morrow, J. W., Jayawardena, M. S., Berrah, N., Li, S. F., & Suryadama. (2011). Geothermal resource risk in Indonesia - A statistical study. *Thirty-Sixth Workshop on Geothermal Reservoir Engineering.* Stanford, California: Stanford University.

Sanyal, S. K., Robertson-Tait, A., Jayawardena, M. S., Huttrer, G., & Berman, L. (2016). *Comparative analysis of approaches to geothermal resource risk mitigation: A global survey.* Energy Sector Management Asisstance Program (ESMAP).

ThinkGeoEnergy. (2020). Retrieved from ThinkGeoEnergy.com: http://www.thinkgeoenergy.com/map/

Thorhallsson, S., & Sveinbjornsson, B. M. (2012). Geothermal drilling cost and drilling effectiveness. *Short Course on Geothermal Development and Geothermal Wells.* Santa Tecla, El Salvador: UNU-GTP and LaGeo.

World Bank & ADB. (2015). *Unlocking Indonesia's geothermal potential.* Asian Development Bank and The World Bank.