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Stakeholders' Recount on the Dynamics of Indonesia's Renewable Energy Sector

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Abstract: The study described in this paper uses direct evidence from processes applied for the developing economy of Indonesia, as it defines the trajectory for its future energy policy and energy research agenda. The paper addresses the research gap to make explicit the process undertaken by key stakeholders in assessing and determining the suitability, feasibility, and dynamics of the renewable energy sector. Barriers and enablers that are key in selecting the most suitable renewable energy sources for developing economies for the renewable energy development have been identified from extensive analyses of research documents alongside qualitative data from the Focus Group Discussions (FGD). The selected FGD participants encompass the collective views that cut across the political, economic, social, technological, legal, and environmental aspects of renewable energy development in Indonesia. The information gained from the FGD gives insights into the outlook and challenges that are central to energy transition within the country, alongside the perceptions of renewable energy development from the influential stakeholders contributing to the process. It is notable that the biggest barriers to transition are centred on planning and implementation aspects, as it is also evident that many in the community do not adhere to the same vision.

Keywords: focus group discussion; sustainability; renewable energy development; Indonesia; geothermal

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1. Introduction

The development of alternative renewable energy sources in Indonesia is of paramount importance not only to fulfil the ever-increasing energy demand in the country but also to contribute to reducing the carbon emission, as well as combating the devastating effects of climate change. During the Conference of Parties (COP) 21 in 2015, known as Paris Agreement, countries around the world committed to reducing carbon emissions by ratifying the agreement. All the countries who participated set the targets in regard to carbon reduction, according to their respective capabilities, known as Nationally Determined Contributions (NDCs).

As one of the countries who participated in COP, Indonesia plans to reduce carbon emission by 29% with its own effort or 41% with international aid by 2030 [1]. Renewable energy sector plays an important role to reduce the carbon emissions, and Indonesia is currently aiming to increase the share of renewable energy to become 23% by 2025 within the National Energy Mix [1]. Due to its unique geographical contour features, Indonesia hosts an enormous potential for renewable energy from various sources, such as geothermal, hydropower, solar energy, bioenergy, wind energy, and ocean energy. The country is undergoing a journey to seek the most suitable renewable energy sources to be developed.

By 2020, Indonesia has only reached halfway towards the 2025 renewable energy target. The development of renewable energy in Indonesia is currently suffering from many obstacles ranging from technical to policy aspects that have significantly hindered its progress. Exploiting renewable energy sources requires a careful appraisal of the potential key predicaments and enablers of its development. Identifying and focusing on a specific type of renewable energy source is therefore deemed essential to mitigate the risks of failure. Analysing the progress of existing development of renewable energy can be done using various ways, for example, by pulling together insights from all relevant stakeholders, which in the case of Indonesia, broadly encompass both state and market players.

In order to acquire a more comprehensive and dynamic outlook, it is necessary to move from the preliminary stakeholder analyses onto probing some crucial information directly from the sources, i.e., the stakeholders. This paper therefore aims to obtain the stakeholder's recount on the assessment and of the suitability, feasibility, and dynamics of the renewable energy sector in Indonesia, that will ultimately pave a trajectory of our future agenda of research. To ascertain a transparent, repeatable, and credible research execution, the following research questions have subsequently been set.

- RQ1 According to the stakeholders' recount and outlook, what are the main key challenges, barriers or problems associated with renewable energy development in Indonesia?
- RQ2 What are the stakeholders' views on the potential key enablers for the renewable energy development in Indonesia?
- RQ3 What is the most suitable renewable energy type to be developed in Indonesia?
- RQ4 Depending on the type of the renewable energy selected, what can be proposed to support the development of that particular renewable energy in Indonesia?

Such information gathering can be done via interviews, surveys or focus group discussions involving key stakeholders of the renewable energy in Indonesia, with an ultimate goal to collate the previously disparate information, experience and decision-making processes.

This structure of this paper is as follows. Section 2 set out the foundation of this work by elaborating the various work not only pertinent but also relevant to this paper. In this way, gaps in the existing literature that this work will address can be clearly identified. Section 3 details how the research will be conducted, including the data collection method and analysis. Sections 4 and 5 discuss the findings and their implications to the body of knowledge. Section 6 concludes the paper by showing the process of how a set of proposals are defined that lay down a pathway for the development of renewable energy in Indonesia, a research gap and process that had not previously been evident.

2. Related Work

A successful transition of energy sources from fossil fuel to renewables requires careful evaluation in terms of the planning system and renewable energy selection [1]. Evaluating the renewable energy system can be a complicated process. Such an evaluation process requires appropriate tools that support the data analysis of the availability of the renewable energy sources, selection criteria and methods used in the selection process [2].

2.1. Renewable Energy Selection and Decision Making

Many researchers have carried out the evaluation and selection of the most suitable renewable energy in many countries and different scenarios. There are many decision-making methods that can be applied for renewable energy selection. In this section, we will have a look at some of the previous research on renewable energy selection in different countries, using different research approaches.

One of the many popular methods that can be used for assessing the most suitable renewable energy to develop is a mathematical modelling method. Gonçalves da Silva (2010) [3] used a conceptual framework and a set of mathematical models to evaluate the energy balance of energy conversion technologies for renewable energy development in Brazil. The result showed that wind energy was the most favourable renewable energy source to develop in Brazil, while solar power was the least suitable for development. Another method that can be applied for evaluating and selecting renewable energy is Multi-Criteria Decision Making (MCDM) method. Emir (2014) [4] performed the selection of renewable energy for small islands using the MCDM method, applicable for Malta, Cyprus, Cuba, Jamaica, Dominican Republic, and Singapore. They considered cost analysis, technical issues, social issues, locations, and environmental issues as the criteria for evaluation. Solar energy was deemed the most suitable renewable energy to invest and develop in small islands.

Analytical Hierarchy Process remains the most popular method to use for selecting the most suitable renewable energy in many different countries. The research conducted with this type of method typically employed a variety of criteria, such as technical performance and efficiency, ecological integrity, economic expedience, sustainable development, socially responsible operation, and technological innovativeness. Based on these criteria, different countries have different results in regard to the most suitable renewable energy [5–8].

2.2. Renewable Energy Selection in Indonesia

Indonesia is one of the countries with abundant potential for many different types of renewable energy development; therefore, selecting the most suitable type of renewable energy to develop is very vital for the energy transition. Despite having quite a few choices for renewable energy with abundant potential, research that is specific to the selection of the most suitable renewable energy in Indonesia is still lacking.

Rumbayan and Nagasaka (2012) [9] used the Analytical Hierarchy Process (AHP) method to identify and rank the most suitable renewable energy in Indonesia, using the level of availability of renewable energies as the primary consideration. Three types of renewable energy were analysed for this study, including solar energy, wind energy, and geothermal energy. The result shows from this study that geothermal is the best criteria, followed by solar and wind alternatives. Tasri and Susilawati (2014) [10] used the Fuzzy Analytical Hierarchy Process (F-AHP) to determine the most appropriate type of renewable energy to develop in Indonesia. This research used several selection criteria, such as sustainability, economic, social, and technological point of view. They evaluated renewable energies for this research include solar energy, hydropower, geothermal energy, wind energy and biomass energy.

Based on the previous research, it is evident that the quantitative approach, especially the Analytical Hierarchy Process (AHP), remains the most popular method to use for renewable energy selection. While the quantitative approach can provide tangible information by generating numerical data, which is beneficial for statistics, it also has certain limitations. A quantitative approach may not be able to provide a deep understanding and insights that explain the underlying reasons behind those numbers. Quantitative approaches are most suitable for countries with a more mature system of renewable energy development, the abundance of data, and clear parameters. However, this method does not provide an explanation that gives insights suitable for countries developing with limited resources. Use of a qualitative approach here provides an extended explanation and reasoning behind each dataset. Collating a deep understanding and explanation of the decision-making process from qualitative analysis is thus important. In the case of renewable energy selection, this information can be used not only as an input for evaluating and selecting the best renewable energy for an area, but it can also provide the thoughts, opinions, and essential information that can be useful for potential follow-up research, for example, research on policy development, which involves many parties and stakeholders. In addition to that, policymaking is often performed through a qualitative approach or science diplomacy. Therefore, for this research, the qualitative approach is preferable over the quantitative approach, and it is chosen to evaluate and to select the most appropriate renewable energy technology in Indonesia. The research could be a reference for performing renewable energy selection in other countries with limited resources in terms of data abundance, parameters, a less mature system of renewable energy development. Moreover, Indonesia is dealing with the power balance issue, where the stakeholders are mostly taken into account in terms of regulatory aspects. Because of that, stakeholders' recount plays an important role in the early stage of policymaking. This paper can be applied to the countries or locations that have similar characteristics to Indonesia.

3. Methodology

In terms of renewable energy evaluation and selection, the quantitative approach appears to be the most popular method used [2–10] as it offers a number of benefits, notably providing a more tangible data analysis thus preventing perceived biases [11]. The qualitative approach, on the other hand, takes the benefits of the flexibility of qualitative data and the level of feedback that is capable of explaining phenomena that are difficult to be quantified [11]. In the context of renewable energy selection, many unquantifiable parameters need to be considered, for instance, appropriate technology, political impacts, capacity building, stakeholder engagement, community acceptance, etc. [12]. Obtaining a deeper understanding of these unquantifiable parameters in renewable energy development can be done by incorporating the roles of stakeholders within this industry. Yudha and Tjahjono (2019) [13] performed a stakeholder analysis to map out the actors in the renewable and sustainable energy sector in Indonesia using PESTLE (Political, Economic, Social, Technological, Legal and Environmental) analysis. Each stakeholder encompasses specific areas, for example, the Ministry of Energy and Mineral Resources covers the political and economic aspect, while the public covers the social aspect. According to this study, there are numerous stakeholders in the renewable energy sectors that can provide thoughts and opinion in regard to renewable energy development in Indonesia [13]. However, incorporating all this input using a quantitative approach would be less effective than using a qualitative approach.

This research employed a qualitative approach based on a Focus Group Discussion (FGD) as a primary research method, complemented by the document analysis (Figure 1).

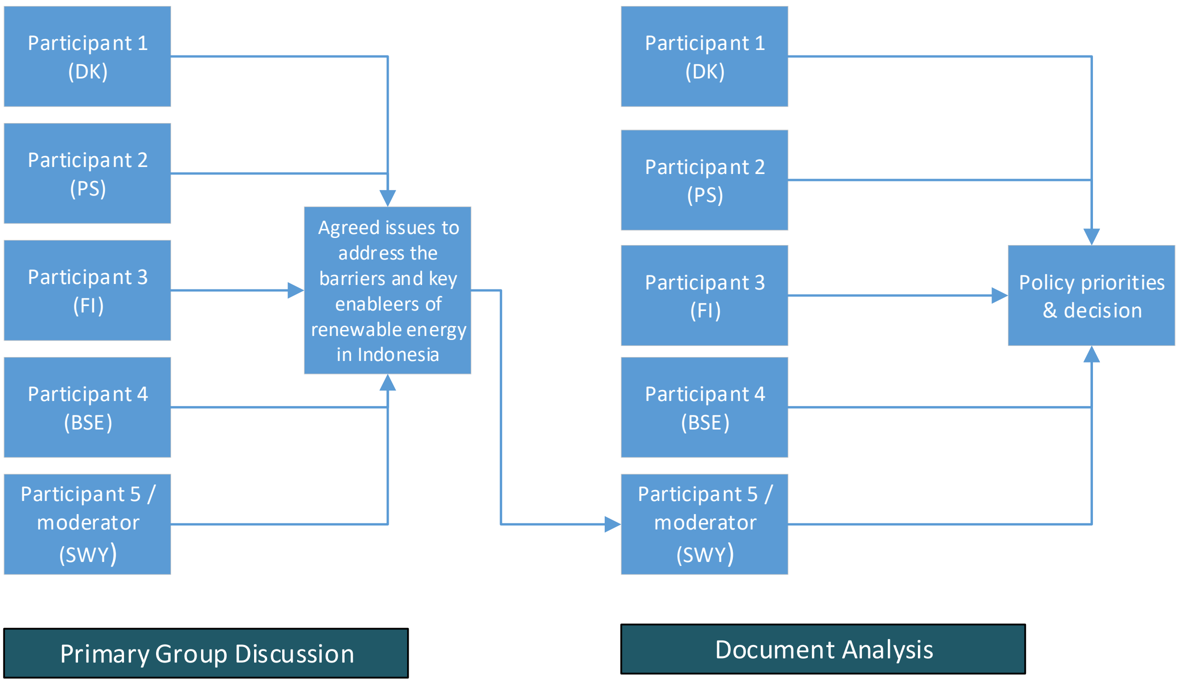

Figure 1. Flowchart of primary group discussion and document analysis.

This method is selected since it allows the researcher/interviewer to question several individuals systematically and simultaneously [14] or in this case, the stakeholders in sustainable and renewable energy. FGD, or also known as the group interviewing method can be based on structured, semi-structured, or unstructured interviews [15,16] and can generate data [17–19] which can be both descriptive and explanatory [20]. This method is frequently used as a qualitative approach to gain an in-depth understanding of complex issues [21]. Krueger (1994) [11] warned that there are advantages and disadvantages to conducting an FGD. The clear advantage of FGD is that it can capture real-life data within a social environment, and it has high flexibility, high face validity, and a speedy result, in addition to its low cost. However, when conducting FGDs, care must be taken when moderating it, as it can potentially be a problem when there are differences within the group, in which case it could lead to a great deal of difficulty in analysing the outcomes. Following the primary group discussion, document analysis was performed to corroborate the points raised during the FGD and to formulate the policy priorities on Indonesia's renewable energy. The process of policy development and confirmation in this FGD is shown in Figure 2.

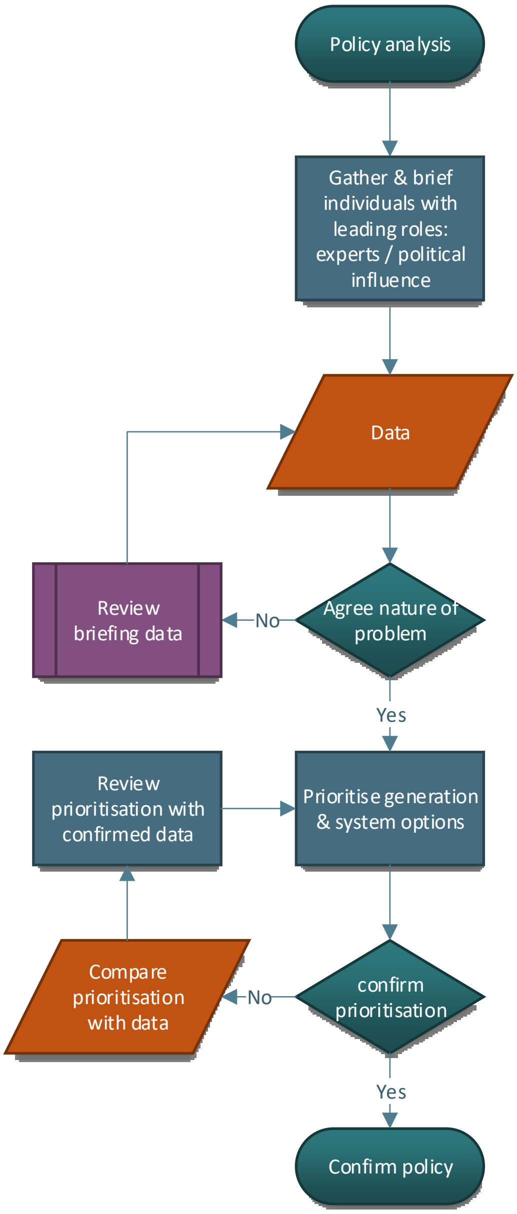

Figure 2. FGD process of policy development and confirmation.

The group size can range from as few as four to as many as 12 people within a conducive environment to engage in a guided discussion of a certain topic or issue [19], in this case, prospects and challenges in Indonesia's renewable energy development. The participating subjects are selected on the basis of relevance to the topic under study. In addition to this, special consideration is given to the role of the researcher/interviewer, as the moderator in the focus group process. As Babbie (2010) [22] comments: "*In a focus group* *interview, much more than in any other type of interview, the interviewer has to develop the skills of a moderator*", thus there is a need to control the dynamics within the group.

The FGD was conducted on 15 January 2020, incorporating four participants as the sample population, plus one of the researchers, who acted as the moderator. The participants were chosen due to their expertise and experience in renewable energy development in Indonesia. Their representation encompasses the collective view of stakeholders identified by Yudha and Tjahjono [13], cutting across the political, economic, social, technological, legal, and environmental (PESTLE) aspects of the renewable energy development in Indonesia (Table 1). The participants represent the government of the Republic of Indonesia, comprised of the Ministry of Energy and Mineral Resources (executory) and the Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas; regulatory); industry actors, comprised of the renewable energy division of the Indonesian House of Commerce, as well as a business actor and observer (member of public).

Table 1. Summary of FGD participants and their representation in the renewable energy sector in Indonesia (modified from Yudha and Tjahjono (2019) [13]).

Participant	Representing	Political	Economic	Social	Technology	Legal	Environment
DK	Ministry of Energy and Mineral Resources	√	√				
PS	Special Task Force for Upstream Oil and Gas Business Activities		√		√		√
FI	Indonesian House of Commerce	√	√			√	
BSE	Member of public			√			
SWY	House of Representative, the Republic of Indonesia	√	√				√

Without necessarily reducing the essence of the perspective of PESTLE analysis, the numbers of the participants were purposely kept to a small number to keep the forum conducive. This purposive sampling of participants was ensured to cater for the range of expertise at hand, to enable the document analysis that was also used as a basis of the analysis during the FGD.

The unit of analysis chosen, consistent to the previously applied PESTLE method of analysis, is the stakeholders' outlooks and responses with regards to renewable energy development in Indonesia. In this research, the FGD also served other purposes, such as developing specific insight and practical knowledge, as well as obtaining the feedbacks and propositions for renewable energy development, based on each stakeholder's perspectives.

In addition, the FGD was also open to members of the press, including the House of Representative's official press, covering the political, environment and legal aspect, to inquire and provide input to the participants during the questions and answer session.

4. Findings

The FGD began with an introductory opening by the moderator, who introduced the participants and laid out the overall theme of the discussion. Each of the participants was then given the time and the opportunity to share their recounts and outlooks on the renewable energy in Indonesia, including the challenges associated with renewable energy development in Indonesia, and the propositions for moving forwards and overcoming these challenges.

Following the discussion, all the participants proceeded to analyse each type of renewable energy in Indonesia, specifically wind, solar, ocean, biomass, hydropower, and geothermal. Using multiple secondary information and research documents as a basis of the analysis, the group then appraise these energy sources in terms of their potentials, current development, limitations, and opportunities for development. The main objective was to map out the progress of each type of renewable energy development. Unlike the previous session, in this session, every participant was encouraged to voluntarily give their opinion and constructively rebut each other in an open discussion. The outcome of both sessions will be used to pave the way forward to deciding the most suitable and feasible renewable energy type for further development in Indonesia.

4.1. A Snapshot of Renewable Energy Development in Indonesia

Following the introduction, the moderator described the precarious situation of Indonesia's inevitably declining fossil energy supply and the urgent need for a transition from fossil to renewable energy. Using this opening statement, the moderator then invited the FGD participants to voice out their views.

First to speak was DK, Secretary to the Director-General of New and Renewable Energy of the Ministry of Energy and Mineral Resources, representing the Director-General of New and Renewable Energy, RM. In general, DK outlined the Indonesian government's readiness in developing Indonesia's renewable energy sector, as well as provided the government perspectives as to the current situation and challenges of the industry. For example, DK highlighted the imperative of developing renewable energy in Indonesia, not only from the aspect of promoting environmental consciousness but also as a crucial element in the realisation of Indonesia's sorely needed and ambitious national electrification goal.

> *"Renewable energy is driven by its environmental aspect, given its environmentally friendly and clean nature. For us, aside from the environmental aspect (there is a presidential regulation already in effect concerning emissions), renewable energy contributes to reducing greenhouse gases".* (DK)

According to DK, what was deemed important from the point of view of energy and mineral resources was the ultimate goal of developing renewable energy is to help accelerate energy access for the large population of the nation who live in far-flung areas from the capital.

> *"In Java, Madura, or Bali, electricity is sufficiently supplied by PLN [State Electricity Company], but if we travel to the eastern regions and islands, there are still many of our brothers and sisters who have not yet benefited from electricity."* (DK)

Recent data indicated there are 12,500 villages in the eastern Indonesia regions have been electrified, but this figure is far from ideal as there are at least 2500 villages are still without any access to electricity. Responding to the queries from the audience, he further stated:

> *"We will carry out our village electrification program until 2019. The Director-General of New and Renewable Energy has been tasked by the Minister of Energy and Mineral Resources to assist in the provision of access to electricity sources".* (DK)

Furthermore, he mentioned that it has been promulgated in Government Regulation No. 79/2014, also known as the National Energy Policy, that renewable energy is targeted to comprise 23% of the primary energy mix by 2025. However, Indonesia currently has only 7% of renewable energy in its energy mix. To make up for the relatively significant difference in renewable energy composition within the energy mix, DK highlighted key renewable energy potentials as well as several ongoing government strategies for renewable energy development. These include, among others, Indonesia's 11,000 hectares of oil palm plantation which can be used for biodiesel.

The second speaker was PS, Deputy of Finance and Monetisation at the Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas). PS made several key observations, firstly concerning present obstacles in Indonesia's oil and gas industry stemming from the global decline of oil prices. As a representative of the government regulatory body for oil and gas, PS also interestingly noted that

> *"... [the oil and gas] business has become over-regulated. Our oil and gas management practices are currently under scrutiny. Are our current regulations capable of providing incentives to bring results to our oil and gas resources?"* (PS)

Concerning renewables, PS posed important statements from his observation:

> *" . . . considering the fact that major corporate players in fossil-fuel energy have been uniformly and consistently diversifying their portfolios into the renewable energy sector, is our capability in managing the fossil energy business transferrable to the renewable energy business?"* (PS)

This was subsequently responded by other participants proposing differing views. Nonetheless, they in the end reached a collective view, acknowledging that although the technicalities differ, long-time corporate players have arguably brought along their managerial and economic know-how of the fossil energy industry to leverage their business activities in renewables, particularly geothermal. It can therefore be concluded that learning from Indonesia's experience in managing fossil fuel, the country is hopeful to use its wealth of experience and know-how to manage the renewable energy sector. Exactly how these are going to be managed indeed needs further elaboration and thoughts.

Following PS, the third speaker was FI from the Renewable Energy Division of the Indonesian Chamber of Commerce (Kamar Dagang Indonesia or Kadin). FI expressed his disappointment with the present state of Indonesia's renewable energy sector. He then proceeded to identify the primary barrier of uptake from the private sector:

> *"Kadin is pushing forward in the renewable energy sector, but what is the obstacle? Regulation!"* (FI)

Referring to tenurial disputes over several renewable energy projects, particularly geothermal, FI also mentioned that the development of renewable energy in Indonesia is often "*... hampered by NGOs, indigenous communities, and others.*"

FI also hit on the barriers to renewable energy development that cause the slow uptake by investors, mentioning that

> *" . . . feed-in-tariffs must also be fairer and involve stakeholders, not suddenly prescribed. This is indeed a problem in the renewable energy sector; as initial technologies are exorbitant, investors choose to wait and see."* (FI)

Lastly, FI sees the need for a strong local manufacturing and supply chain, so that components for renewable energy would be cheaper to produce domestically rather than that of an import.

The final speaker was BSE, an observer of the renewable energy industry. BSE opened by hypothesising that energy sustainability is linearly correlated with welfare and the wealth of a nation. BSE proceeded to outline his solutions:

> *"The question that follows is how to satisfy the large amount of energy needed by low-cost, clean energy sources? We cannot do business as usual. We must push for breakthroughs."* (BSE)

He asserted that electrification consists of three large components: power generation, transmission, and distribution. Therefore, it would be sensible to clearly split the responsibilities between those components. BSE argued that this was necessary to stimulate a healthy competition and to foster the core competence.

> *"PLN [State Electricity Company] should only focus on transmission and distribution of electricity, giving an opportunity for other parties, including private sectors to 'play' in the renewable energy generation arena, especially clean, large-scale power generation. There are only three options: hydro, geothermal, and nuclear."* (BSE)

The moderator concluded this first session with a summary of key findings and lessons learnt.

Finding 1: There remain problems in both planning and implementation stages of renewable energy, mainly due to the [lack of] regulations, but this does not necessarily mean that both stages do not adhere to the same vision.

Finding 2: Lessons learnt from the oil and gas sector should later be transferred over for the future development of renewable energy, so as not to fall into the same pitfalls that impede and create inefficiency in the oil and gas sector.

4.2. Renewable Energy Types in Indonesia

The second session of the FGD analysed in detail several documents, mainly government policy analyses of various renewable energy sources. The moderator led the discussion (following the method illustrated in Figure 1) and asked the participants of FGD to comment on the suitability of the six sources of renewable energy and come up with a collective decision on the most suitable renewable energy source that Indonesia should develop going forward.

In order to hit 23% of renewables in the primary energy mix by 2025 and 31% by 2050, Indonesia has been attempting to achieve the targets [23]. Renewables accounted for just 15.7% of the country's primary energy mix by 2019, while fossil fuels accounted for 87.6% by 2019 [23,24]. Indonesia is a host to a variety of renewable energy sources, namely, wind energy, solar energy, ocean energy, biomass energy, hydropower, and lastly geothermal energy [25]. The development of each type of energy sources varied, and the FGD looked at each type of renewable energy, how they have been developed in Indonesia, and the challenges that each energy type encounters, with an expectation that the group came up with a collective view on the preferred renewable energy type.

4.2.1. Wind Energy

Wind energy is the type of energy that uses the conversion of wind speed into a useful source of power, and it can be used for multiple purposes, such as electricity generation, mechanical power wind turbines, water-driven wind turbines, or ship propellers [26]. Wind energy is one of the renewable energy innovations, as it does not contribute to air pollution or greenhouse gases and has a slight impact on the climate.

The use of wind power as an energy source in Indonesia has great potential for further growth, especially in coastal areas where the wind is quite abundant. According to the previous research, Indonesia has an estimated total potential for onshore wind energy of 9.3 GW. With the range of wind speeds between 2 and 6 m per second, Indonesia is suitable for installing small-scale (10 kW) and medium-scale (10–100 kW) wind-driven generators [27]. Indonesia has installed five units of windmill generators across the country each with a capacity of 80 kW and seven other units with the same capacity have been established in four places, North Sulawesi, the Pacific Islands, Selayar Island, and Nusa Penida in Bali [28]. Several wind-based power plants, namely, Sidrap, Tanah Laut, and Jenepoto, have currently been under construction, while the ones in Sukabumi, Banten, and Bantul are currently being considered to be placed under construction planning [28].

Price is one of the biggest obstacles that Indonesia faces in installing wind energy. The initial cost of developing wind energy is very high, particularly with the use of offshore wind turbines. IRENA suggests that it costs about US$3–US$4 million per megawatt (MW) to install offshore wind turbines compared to geothermal power plants that cost about US$2–US$3 million [29].

However, wind energy has some issues associated with the geographical locations the jeopardises the consistency of supply, as pointed out by a participant,

> *" … indeed, we know that it [wind] is a promising form of energy in our country [Indonesia]. But its intermittent nature, makes it hard to provide electricity 24/7. It generates unstable and fluctuating electricity, and good source of wind power is only available in certain parts of our country [Indonesia]".* (FI)

Another difficulty is caused by the availability of other renewable energy sources available in Indonesia, such as geothermal, hydropower, biomass, and solar, which makes the cost analysis method challenging to carry out [29].

4.2.2. Solar Energy

Solar energy is a source of renewable energy that uses the power of the sun to produce electricity. Globally, solar energy has the fastest and highest growth compared to the rest of renewable energy types. It is currently considered as one of the most promising sources of clean, renewable energy and has greater potential than any other energy source to solve the world's energy problems.

As Indonesia is a tropical country situated on the equator line, the country has an abundant capacity for solar energy. Many areas of Indonesia have very strong solar radiation with average daily radiation of approximately 4 kWh/m^2 [27]. According to the report from Directorate of New and Renewable Energy (Ditjen EBTKE) in 2018, Indonesia has the potential to harness solar energy of up to 207.8 gigawatts peak (GWp) [30]. However, as of 2019, Indonesia has only installed 25.19 megawatts (MW), which is mainly used to meet energy demand in rural areas, including lighting for public service areas and places of worship [28]. The Institute for Energy Economics and Financial Analysis (IEEFA), an energy research institute, has reported that about 48 MW of solar power is currently under construction and about 326 MW is under construction planning [31].

Indonesia is still far behind other ASEAN countries in solar power utilisation. Thailand has 2.6 GW of installed solar capacity and the Philippines 868 MW of installed solar capacity [32]. Vietnam is also working on an expansion of more than 3000 MW in solar and wind power capacity by 2019 and 2020, and Malaysia is targeting an additional 3000 MW in 2020 [33].

There are many obstacles to the implementation of solar energy in Indonesia. One of them being the high prices of the solar cell, including the solar panels, inverters, batteries, wiring, installation, and battery storage [33]. This situation not only impacts financial institutions to provide resources to implement this program but also limits local communities' confidence and interests in using this system due to its exorbitant costs. Because of that, the implementation of this program is highly dependent on government funding. Despite its huge potential, a solar panel is very dependent on sunlight to effectively capture solar energy. Even though it can capture the energy during cloudy and rainy days, it can also give measurable technical effects on the energy system. Due to its intermittent nature, solar energy might be more suitable for a household scale, but it might not be the best option for a larger scale energy system. This is emphasised by one of the participants:

> *"It's fortunate that being in the equator, we [Indonesia] are blessed with warm climate all year round. We have the potential to develop solar energy. However, much like wind, it is intermittent and it [solar] will require storage systems to generate electricity after daylight".* (DK)

4.2.3. Ocean Energy

Ocean energy, or sometimes referred to as marine energy, is a type of energy that is carried by ocean's elements, such as ocean's tide, wave, salinity, and temperature. Each one of these elements can be exploited as different types of energy, namely, tidal energy, wave energy, salinity gradient energy, and ocean thermal energy conversion (OTEC). Wave energy converts the ocean waves to produce electricity, while tidal energy harvests the power that was produced during high and low tides [34]. Salinity gradient energy can generate electricity due to the difference in salt concentration between freshwater and seawater [35]. OTEC converts the temperature difference between cold seawater and warm surface seawater, typically at around 800 to 1000 m of depth, to produce electricity [36].

Indonesia is the world's largest archipelago with 70% of its area is covered by ocean, thus it has the largest potential of ocean energy. According to the research from the Indonesian Ocean Energy Association (INOCEAN), the potential of ocean energy resource that can be exploited is around 92.2 GW. The majority of its potential is coming from OTEC, with 43 GW of resource potential, followed by tidal and wave energy with 4.8 and 1.2 GW of resource potential, respectively. Despite its considerable amount of potential for harnessing ocean energy, the installed capacity for ocean energy is only 0.3 MW or 0.002% of the total energy use [24]. As of 2020, ocean energy is still under the stage of Research and Development, and this type of renewable energy has yet to be commercially developed in Indonesia [28].

> *" . . . unlike solar and wind, ocean energy can provide electricity throughout the entire day since it does not require the sun or the wind to harness electricity. Nevertheless, ocean energy is still rather far from the full commercialisation in Indonesia".* (DK)

4.2.4. Biomass

Biomass energy is one of the types of natural renewable energy that are generated from organisms, and it mostly comes from farm crops and residues, forest waste, farm foods, and animal waste [37]. Biomass is the only renewable energy that can be used to generate three types of fuels: liquid, solid, and gas. A proper biomass energy development could also reduce not only energy issues but also waste management issues.

As an agricultural country, the potential of biomass resources in Indonesia is relatively abundant. According to the report from Directorate of New and Renewable Energy in 2018, Indonesia has a potential of harnessing 32.6 GW of biomass energy [24]. However, only 167.54 MW of biomass energy in Indonesia has now been properly exploited. Currently, Indonesia's estimated total biomass production is around 146.7 million tons, which is equivalent to 470 gigajoules per year (GJ/y) [38]. Most of the biomass energy source comes from the rice residue and rubberwood, which contributes to 150 GJ/y and 120 GJ/y, respectively [38]. These are followed by sugar residues (78 GJ/y), palm oil residues (67 GJ/y), and other types of residues (20 GJ/y) [38]. Such biomass sources can help supply both heat and electricity to rural households and sometimes small-scale industries.

Bioenergy, in general, has faced similar problems as other renewable energy sources. One of the primary issues is the high investment cost for bioenergy installations, as claimed by one participant:

> *" . . . while Indonesia has an abundant amount of biomass energy that can be utilised to generate liquid, solid, and gas, it is still expensive to invest in and the lack of support from financial institutions has hindered its growth".* (DK)

Part of the reason is that bioenergy deployment feasibility studies are mostly not attractive for bank loans [39]. From the perspective of technology, the reliability and efficiency of the existing technology for biomass energy is still lower than those of fossil fuels [39], hence hindering bioenergy development.

4.2.5. Hydropower

Hydropower energy is a type of renewable energy source that extracts energy from flowing water, to produce electricity. As a potential future source of energy, hydropower has become an increasingly attractive choice for small capacity of the renewable energy. This type of energy, as well as other renewable energy sources, are the clean energy sources as they emit a negligible amount of greenhouse gas.

Hydropower is one of Indonesia's large-scale, commercially viable, renewable energy sources. According to the report from the Nippon Koei, the hydropower capacity in Indonesia is projected at around 26,321 MW [40]. Currently, the installed capacity of hydropower is 4938.64 MW from various hydropower plants all across the nation; the large-scale plants are operated by the state-owned electricity company (PLN), and many small-scale plants are owned by small enterprises. According to 2019–2028 Electricity Supply Business Plan issued by PLN, it has been reported that 5956 MW of hydropower capacity is currently under construction scattered in many places, while the new 16,027 MW of potential capacity has just been built as of 2018 and is considered for being placed under construction planning [24].

To date, the hydropower energy in Indonesia is still the most established and the most utilised small-scale renewable energy source, particularly for the rural areas. Hydropower systems provide unique operational versatility in that they can adapt to sudden fluctuating demand for electricity, which means that it can be tailored to satisfy market demand [41]. Hydropower is also able to provide the supports for the development of other renewable energy sources, for example, its storage capacity and flexibility can be the most cost-effective and efficient to support the utilisation of intermittent renewable energy sources such as solar and wind energy. Hydropower can generate vast quantities of energy, and the price is relatively stable, as it is less affected by market price fluctuations such as oil and gas, although the price advantage is proportional to the capacity of the plant, i.e., relatively small capacity. There is, however, a major drawback of hydropower development as it is heavily dependent on the geographical features (i.e., large rivers) to generate electricity. Therefore, large-scale utilisation of hydropower is only limited to certain places with specific geographical features, making micro-hydropower-with a lower price advantage-a more viable option, as asserted by FI:

> *" ... no, the majority of them [sources] are only suitable for small-scale power plants. Only certain areas of Indonesia have the full capability to generate large scale electricity".* (FI)

4.2.6. Geothermal

Geothermal energy is the type of renewable energy that uses heat derived from the sub-surface of the Earth, which can be transmitted in the form of hot steam, hot water, or a mixture between both forms. Nowadays, it has been one of the most important alternatives for energy sources with significant growth potential. It not only provides alternative energy but also helps to reduce the effects of global warming and the risks to public health due to the use of conventional energy sources, as well as our dependence on fossil fuels. Geothermal energy may be used for district heating purposes or harnessed to produce renewable electricity, depending on its characteristics. Lower enthalpy type of geothermal is mostly suitable for direct use (e.g., room heater, tourism, agriculture/agro-industry, and fisheries), while medium to high enthalpy type of geothermal can be used for generating electricity, which is typical for the regions with active tectonics [42]. Indonesia has varying types of geothermal energy that can be utilised for both direct heating and generating electricity [43].

Indonesia is one of the countries in the world that falls on the "ring of fire", which traversed around the edges of the Pacific Ocean and is responsible for most active volcanoes and earthquakes. Due to its tectonic setting, Indonesia is a host to most of these active volcanoes, which accounted for 117 active volcanoes in total [44,45]. These active volcanoes are distributed in Sumatra, Java, Nusa Tenggara, Sulawesi, and Maluku. Consequently, Indonesia has a considerable amount of high heat flow, which makes it one of the countries with a large potential for geothermal energy.

According to studies, Indonesia has the world's largest geothermal energy potential, accounting for about 40% of the world's potential or approximately at 28,617 MW [42]. Most of these potential energy resources and reserve are distributed in several regions in Indonesia. Sumatra and Java have currently the highest total potential energy, which accounts for 12,760 and 9717 MW, respectively [42]. The rest of the potential are distributed in many other regions, namely Bali, Nusa Tenggara, Sulawesi, Maluku, Kalimantan, and Papua [42,43].

According to FI, geothermal, when compared to other sources of renewable energy except nuclear, can guarantee the provision of electricity at a stable rate throughout the entire year without being affected by weather patterns and conditions. He further added:

> *"The cost of geothermal technology in the future will be increasingly competitive and is expected to continue to fall. Thus, the optimisation of geothermal energy in Indonesia is*

vital in helping the government achieve its renewable energy target and reduce greenhouse gas emissions". (FI)

Despite having a considerable amount of potential, geothermal energy utilisation in Indonesia, especially for the electricity generation, is not quite optimal. Currently, the geothermal energy in Indonesia that has been utilised for generating electricity is 2130.6 MW [46], making it the second-largest country with installed geothermal capacity, putting Philippines in third place with 1868 MW of installed capacity and following United States with 3639 MW of installed capacity [47]. Most of the installed geothermal capacity in Indonesia comes from the geothermal power plant in Java, which accounts for a total of 1253.8 MW of installed capacity, followed by Sumatra with 744.3 MW, Sulawesi with 120 MW, and lastly, Nusa Tenggara with 12.5 MW of installed capacity [46,48]. The development of geothermal energy is still yet to be done in many other regions in Indonesia.

Up until 2019, the utilisation of geothermal in Indonesia was only 2130.6 MW out of 56,509.53 MW, or around 3.77% of the total energy utilisation [24]. This number is still very small compared to the Philippines that have already 44.5% of its energy use from geothermal energy [28]. There are a few factors that have been the reason for Indonesia's lagging development of geothermal energy utilisation. Exploration and resource commercialisation of geothermal utilisation is a costly process, in addition to a small market for the resource. Limited investment financing schemes for geothermal development has also contributed to the stagnation in this industry.

According to PS, Deputy of Finance and Monetisation at the Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas),

" ... geothermal development has a very unique characteristic, since it includes the upstream phase, similar to that of oil and gas sector". (PS)

He further underlined the transferability of management know-how from the fossil fuel economy to the geothermal business. In essence, the pitfalls of Indonesia's oil and gas industry retrospectively provide lessons learnt for the management of geothermal. Although these two sectors quite different in terms of the nature of the commodities involved, PS believes that the technical management know-how from the oil and gas industry should be transferred and refined.

There is a difference between the outcome of the renewable energy selection provided by several authors in their previous works and the renewable energy selection as a result of the discussion between the stakeholders. For example, Tasri and Susilawati (2014) [10] evaluated that hydropower is more suitable than geothermal energy. On the other hand, earlier research on renewable energy, Rumbayan and Nagasaka (2012) [9], evaluated that geothermal, solar, and wind energy are the most suitable renewable energy. In this research, having considered many factors from the stakeholders' point of views, such as its availability; technology; and operational, financial, and market situation, geothermal energy is the most suitable renewable energy in Indonesia. Therefore, future research focusing on the geothermal energy development would certainly enhance the renewable energy development Indonesia. However, since the stakeholders contended that the lagging development of geothermal energy sources is mainly caused by the hefty initial cost, government intervention is needed, e.g., in the form of financing schemes.

Finding 3: Geothermal stood out during the FGD as the most promising renewable energy source that Indonesia should develop.

Finding 4: Exploration of geothermal utilisation needs an intervention from the government in the form of financing schemes, so as to alleviate the burden of upfront investment.

5. Discussion

Indonesia has a few choices when it comes to developing renewable energy sources. Having the capability to develop all types of renewable energy to a point where it cannot only fulfil the whole country's energy demand but also fully liberate the country out of fossil fuel dependency would be an ideal case. Although achieving this would require long years of huge effort and costly processes, having this ideal scenario would lead us to significantly contributing to reducing carbon emission and increasing the economic growth of the country. Reflecting on the participants' feedbacks reported during the FGD, we can glean from this dialogue that different stakeholders have alluded differing inherent interests and point of views based on their respective institutions. The differences are mainly related to the key enablers and barriers of renewable energy development in general leading to selection of the most suitable renewable energy to focus on future development.

5.1. Barriers and Key Enablers

Indonesia has tremendous renewable energy capacity which is still underutilised by the Indonesian power sector. The long dependency on fossil fuels, particularly coal, has proved difficult to break as the image of coal as cheap energy while renewable sources remain as expensive technologies. Although some steps to enhance renewable energy have been placed since many years ago, the Indonesian renewables sector has yet to take off.

The development of renewable energy sources in Indonesia has not been without any barriers, as it has encountered quite a few challenges from the operational, financial regulatory challenges. The operational challenge is mostly related to the nature of each type of renewable energy sources, which includes the availability and reliability issues. Financial challenge is mostly related to the exorbitant initial cost of installation, and it has been one of the major hurdles for the development of renewable energy, regardless of the type of renewable. Lastly, the regulatory challenge is viewed as the primary obstacle in the energy transition and renewable development, especially for the private sector, which hampers the development process, i.e., the regulation that define the conservation area makes it impossible for the exploration of renewable energy in the area with high potentials. Having analysed the barriers, the obstacles are quite evident in both the planning and implementation stage of renewable energy development. However, this does not necessarily mean that both stages of development do not adhere to the same vision. Therefore, regulation and policy refinement are indeed necessary, thus becoming the most important key enablers, as they allow us to tackle multiple present barriers effectively.

According to the stakeholders' points of view, some of the important key enablers are classified as follows, so identifying these enablers is of paramount importance for the transition to renewable and sustainable energy technologies.

1. The availability of an institutional framework of national targets and development plans that transcend organisational leadership is one of the most important initial key enablers, as it reflects the government's commitment to renewable energy endeavour. The imperative development of renewable energy in Indonesia needs to be viewed not only from the aspect of promoting environmental consciousness but also as a crucial element in the realisation of Indonesia's sorely needed and ambitious national electrification goal, as well as the national primary energy mix as a tangible target for now, which is achieving 23% of renewables in the primary energy mix by 2025 and 31% by 2050.
2. Focusing on the forward-thinking scheme of supply chain management for the manufacturing of renewable energy is viewed as another significant key enabler. Such a scheme needs to consider how local industries can effectively source the materials and technology needed for Indonesian-made renewable energy supply and market. Especially in the presently liberalised global economy, Indonesia needs to strengthen its local leverage in terms of competitiveness of goods and trade. The ultimate and obvious aim of this endeavour is to make local renewable energy supplies and technology cheaper to produce domestically than to import.
3. Refining the regulation and policy is one of the most vital key enablers for the energy transition. The courage of institutions and organisations is essential to break down

outdated and inadequate regulations, as well as to design new regulations and policy that can accommodate the interests of all relevant stakeholders. Therefore, having higher regulations covering the renewable energy sector, such as Renewable Energy Bill, Presidential Regulation, and Governmental Regulation, would have stronger impacts on renewable energy development.
4. Focusing on the clean, large scale types of renewable energy for power generation, for instance, hydropower and geothermal energy. Nuclear power as another new energy source has also been considered and is still categorised as a viable option, considering all the relevant safety and technical concerns being put in place.

5.2. Selection of Renewable Energy Type for Development

Focusing on developing the most suitable type of renewable energy would be an important first step towards better utilisation of renewable energy. Here, we will have a look at each type of renewable energy and use a comparative analysis to decide the most suitable renewable energy to focus on developing in Indonesia, considering the limitation and opportunity that each type of renewable energy has to offer, according to the expertise' inputs during the FGD.

Ocean energy is the least developed renewable energy in Indonesia. Despite having a huge potential for developing ocean energy, no commercial-scale ocean power plants now exist as it is now still under the research and development stage. According to 2019–2028 Electricity Supply Business Plan issued by PLN, there has been no technology manufacturer for ocean energy that has proven its reliability to operate commercially for at least 5 years. The development will be reconsidered once the technology is mature enough to generate electricity on a commercial scale.

Wind and solar energy can provide not only alternative sources for renewable energy but they can also give us a number of environmental benefits, as they produce a negligible amount of carbon footprints. However, the development of these renewable energy sources has major drawbacks. The initial deployment process of wind or solar energy can be quite costly, and it hinders the investment due to its exorbitant costs. Even though both solar and wind energy should be seen as low-risk investments with potentially major returns, they are hefty investments nonetheless. Moreover, both wind and solar energy are intermittent by nature, as they are heavily dependent on the weather. Therefore, the electricity generated by these renewables is most likely to be fluctuating, and it can potentially become a problem. Fluctuating supply of electricity is not a reliable power supply, as it is not best-suited for providing base-load. Furthermore, fluctuating electricity, particularly in the solar panel system, may have measurable effects on the power instrument. Therefore, relying solely only on solar and wind energy may not be the best option for now, especially for a massive commercial scale, but they may be suitable for smaller-scale development.

Biomass energy development is currently in a better state than previous sources of renewable energy now that the Minister of Energy and Mineral Resources Regulation (*Permen ESDM*) Number 50 of 2017 has been issued. Not only does it contribute to meeting the energy demands, but proper biomass energy development also allows us to cope with better waste management. However, the expensive upfront cost to get the power plants up and running has been the most common issue in developing the renewables, which also applies to biomass energy. In addition to the exorbitant upfront cost, biomass development would require additional costs associated with the extraction, transport, and storage of biomass prior to the generation of electricity. Biomass energy plants also require quite a bit of space with constant supply for biomass resources, which might not be suitable for big cities. Therefore, the development of biomass energy may be more suitable for underdeveloped, isolated region in the country.

Hydropower is by far the most established and the most utilised renewable source of energy. Hydropower has been operating as a commercial-viable, massive scale. Due to its operational flexibility, hydropower can adapt to sudden fluctuating demand, and it can be tailored to satisfy market demand, thus making it a very reliable source of energy.

Its development has been very steadily growing every year, with numerous ongoing projects. However, being heavily dependent on the geographical features (i.e., large rivers) to generate electricity has been a major drawback of hydropower development. Large-scale utilisation of hydropower is only limited to certain places with specific geographical features. Therefore, focusing more on a different type of renewable with huge potential for growth and suitability that needs further development might be the best option and more necessary in order to meet the 2025 national energy mix target.

Indonesia's abundant geothermal potential is not questionable. Despite having a considerable amount of potential, its utilisation, especially for the electricity generation, is not quite optimal. By 2020, only 2130.6 MW out of 28,617 MW had been properly utilised. Unlike wind and solar energy, geothermal energy is not an intermittent source of energy, and it has very high-capacity factors; thus, it can be a reliable source of energy.

Geothermal energy utilisation has very unique attributes, which can be viewed as a promising opportunity when it comes to massive development. In contrast to other renewable energy projects, geothermal power projects must include upstream activities to verify the resource and to determine the most favourable location for development. This upstream phase is very similar to the upstream process of an oil and gas field or that of a coal mine. Such a unique attribute may allow us to have a transferability of management know-how from the fossil fuel sector to the geothermal energy business. The knowledge transfer may be able to help us to reduce the hefty risk that can come during geothermal development, for instance, with the lesson from the oil and gas sector, the declining phase of production might be recognised earlier, giving us the time to work on the operational and managerial solution to avoid the pitfall. The nature of the geothermal operation and the availability of knowledge transfer can reflect on the managerial maturity that the geothermal sector can offer, compared to the rest of the renewable energy sources, thus becoming its greatest opportunity. It is also implied that geothermal energy, far from being a simple market competitor, is internalised within the oil and gas industry as the inevitable way forward, hence the emphasis on transferability of knowledge.

The geothermal energy sector has a fair share of obstacles when it comes to its development. Similar to the other renewables, the hefty cost has been one of the biggest obstacles that Indonesia has faced in the development of geothermal energy. The exploration and resource commercialisations are both costly processes, which makes it very reliance on heavy investments. Regulations have also become one of the major challenges for the geothermal sector, for instance, the land dispute caused by wavering regulations are most likely to hinder its development. There might have been many more underlying issues with regard to geothermal energy development; therefore, a further investigation on the geothermal supply chain trajectory is necessary to address the potential barriers in its development. Furthermore, developing a set of policies also can be done to bridge these potential barriers and to ultimately enhance the pace and magnitude of geothermal energy development [49]. Despite the obstacles, just as much as the other types of renewable energy, the high potential, reliability, and opportunity that geothermal energy can offer make it the most suitable renewable energy source to develop.

6. Conclusions

The FGD has provided unique inputs to this research via a combination of subjective and institutional leanings and experiences, particularly in identifying key enablers and barriers of renewable energy development. Throughout the course of FGD, the barriers were actually expected as there is an evident contradiction between policy and business, particularly in the planning and implementation stages. However, this does not necessarily mean that both stages do not adhere to the same vision. In particular, the private sector highlighted the lack of representative regulations truly needed to boost private participation in renewable energy development. The key enablers include constructing the national target as a framework and renewable development plans, building a forward-thinking scheme of supply chain management of renewable development, and regulation and policy refinement.

Regarding the renewable energy selection, geothermal energy has been considered as the most suitable and feasible renewable energy source to focus on further development in Indonesia. Not only does it have a considerable amount of potential for generating electricity, but it also has the most unique characteristics out of all the other options of renewable energy. The FGD has identified that the geothermal energy projects must include a set of supply chain trajectories, which include the upstream, midstream, and downstream. The upstream phase in this supply chain trajectory is in fact similar to that of the oil and gas sector. This allows us to perform the transferability of management know-how from the fossil fuel sector. The lessons learnt from the oil and gas sector should later be transferred over for the future development of geothermal energy, so as not to fall into the same pitfalls that impede and create inefficiency in the oil and gas sector. This implies a growing sense of corporate and institutional responsibility within the oil and gas sector, one that is visionary and should be capitalised on. Despite the tensions and disagreements between stakeholders, all parties agreed that the development of renewable energy, particularly in geothermal energy, should continue to be supported for the good of the public as well as the market. In order to do this, further investigation on geothermal supply chain trajectories needs to be done to identify the potential barriers and to design a set of policies that can bridge these barriers, thus enhancing the pace and magnitude of renewable energy development, or more specifically, geothermal energy.

Aside from directly absorbing the bold aspirations from each stakeholder, 'reading between the spoken lines' has provided plenty of room for abstraction and further inquiry. Most importantly, the FGD has succeeded in answering the four research questions posed at the beginning of this paper, meaning that we have acquired both (1) stakeholders' recount and outlook of institutional and market challenges associated with renewable energy development in Indonesia, as well as their (2) responses for overcoming the challenges, (3) their collective views on the most feasible renewable energy to develop in the near future, and, lastly, (4) the propositions to support the development of that particular renewable energy, i.e., geothermal, in Indonesia.

We recognise that, despite the benefits of FGDs, they have certain limitations, i.e., that it is possible that the participants may be hesitant to openly express their opinions when it is a sensitive topic or alternatively be dominant within the group about the topic being debated. Another limitation is that it may not be a true representation of the target group. Conscious of these limitations, we were diligent in selecting the participants plus followed specific sensitive questions individually.

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