Enabling electricity access to rural areas in Indonesia: Challenges and opportunities

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Abstract. Energy is at the core of important issues such as economy, environment, and world development. A developing country like Indonesia needs energy access in order to increase its prosperity. Indonesia successfully surpassed the electrification ratio target at the end of 2018. However, electrifying the remaining 1.7% will be more difficult and costly. This paper provides a better understanding of the challenges of rural electrification program and opportunities to achieve universal electricity access. In this research, a literature review method was used to collect and review relevant studies regarding rural electrification program. Based on this literature review, the characteristics of rural areas such as low population density, low income and low electricity demand were found to be the main challenges. According to these studies, committed governance, supportive regulations and policies, and well-prepared financing can overcome said barriers.

1. Introduction

Energy is at the core of important issues such as economy, environment, and world development. It is not a usual commodity; instead, it is a strategic, important commodity for all life sectors such as health, education, economy, and social life [1,2]. As a developing country, Indonesia needs energy access in order to reduce poverty and increase people's prosperity, as well as increasing productivity and supporting its economic growth [3,4].

Indonesia is the biggest archipelagic country with more than 17,000 islands and a population of more than 260 million lives from Sabang to Merauke. Its economic growth over the past 20 years has not only contributed to poverty reduction but also raised the status of the Republic of Indonesia into the 10th largest economy in the world [5]. Small islands in Indonesia have a lot of potentials for tourism, fisheries, ports, and other important economic functions. Nonetheless, unfulfilled energy resources will limit their economic and social development [6]. For example, Papua is rich of natural resources, but this province has a high level of poverty because without energy access, these resources are not fully utilized [7].

Despite the ongoing positive socio-economic developments, Indonesia faces enormous challenges in the supply and distribution of electricity. According to Electricity Power Supply Business Plan 2019-2028, Indonesia’s average electricity growth is at 6.42%. Indonesia successfully surpassed its electrification ratio target at the end of the year 2018 [8]. However, there are still 2,510 villages across Indonesia that are not yet electrified [9]. These villages are included in the government’s rural electricity...
development program called *Listrik Pedesaan* (LisDes). It started in 2016 with a funding from Government Capital and PLN [9], with the objective to achieve a 100% electrification ratio in 2020 [8].

Rural electrification can also increase renewable energy mix diffusion. Renewable energy is a resource that is sustainable, limitless, and harmless to the environment [10]. It usually plays a major role in rural electrification and have been used in several countries in Asia Pacific [11]. The promotion of renewable energy mix will also support Indonesia’s commitment to Paris Agreement.

Despite the ongoing LisDes program, to the best of our knowledge no study has been performed to figure out its future challenges. In this paper, we examine the issues and hope to provide better insights for stakeholders, policy makers, related institutions and practitioners about the main issues that may interfere with rural electrification program and the opportunities to overcome them by learning the lessons from the past experiences of other countries.

2. Methods

Literature review was used to have a better understanding of rural electrification. The academic literature in this review was found through Science Direct, SCOPUS, Google Scholar, and IEEE. The literature was obtained from the database based on certain keywords and various combination of words such as ‘rural electrification’, ‘micro-grid’, ‘mini-grid’, ‘off-grid’, ‘on-site generation’, ‘decentralized’, ‘distributed’, ‘energy’, ‘challenges’, ‘opportunities’, ‘lesson learned’, and ‘Indonesia’. Manual search on Google was also used because there are other sources of energy literature besides academic journals. We also drew electricity and energy reports from the energy ministry and other relevant organizations’ official websites. The scope of paper retrieval was scaled down to the past 15 years by taking the relevancy of the topic into account.

3. Results and discussion

3.1. Current electrification condition in Indonesia

Data in Figure 1 showed that until October 2018, Indonesia’s produced 231,149 TWh of electricity from own generator, lease, and excess power/IPP/purchase. In this period, the generation mix was still dominated by coal (59.6%), followed by natural gas which constituted about 22.5%. Renewable energy slightly increased to 12.2% and PLN successfully reduced the usage of fossil fuel from 23.7% in 2011 to only 5.8% in October 2018.

![Figure 1. The electricity production in Indonesia (TWh) [8].](image-url)

Indonesia successfully improved the electrification ratio to approximately 98.3% in 2018, a number which even surpassed PLN’s target. This was claimed as the result of Indonesia’s LisDes and the distribution of 172,996 Solar Energy-Saving Lamp units for pitch-black villages [12]. In general, eastern Indonesia has the lowest electrification ratio with NTT having the lowest ratio of all because only 61.9% of its households have access to electricity. In contrast, most provinces in Sumatera, Java, and Bali have 99.99% electrification ratios. However, even though the eastern region of Indonesia has the lowest
electrification ratio, the number of unelectrified households in East Java province is greater than that of the whole Papua Island. East Java province has 238,687 unelectrified households while Papua and West Papua together have 10,805 [13]. Illustration of the unelectrified households in Indonesia and the electrification ratio for each province is shown in Figure 2.

![Figure 2. Electrification ratio [8].](image)

According to the Asian Development Bank analysis [14], the regional disparity is not caused by the poor condition of the eastern region in Indonesia. It is a matter of policy rather than wealth, and the efforts to achieve universal electricity access should be nationwide, even if the challenge of electrification is most critical in the eastern region of Indonesia [3].

LisDes program is an Indonesian rural electrification program. This program is a realization of Law No 30 Year 2009 article 4 on Electricity, which states that the government ought to provide funds to deliver electricity for impecunious people, construct electricity infrastructure in underdeveloped regions, construct electricity generation in remote and border areas, and electrify rural areas. The Directorate General of Electricity and PLN, in collaboration with the government, set a 100% electrification ratio as their 2020 target. The development planning of rural electricity has been constructed in a plan called Roadmap Listrik Desa PLN.

3.2. Rural electrification challenges and opportunities

There are options for electrifying the remaining unelectrified households. Unfortunately, electrifying the remaining 1.7% of the Indonesian households is not an easy task. Indonesia is an archipelagic country, meaning that providing electricity especially to an underdeveloped region will need more rigors and higher cost [14,15]. Due to the challenging geographical situations, decentralized electrification is more suitable than extending the central grid especially for remote and rural areas [16,17]. This geographical situation also worsens with poor infrastructure access, making the area hard to reach. That region most likely has lower population density and often lower income while the costs for supplying electricity tend to be high. This situation presents a challenge of payment and affordability [18,19]. Moreover, the low-density population with low income and low demand for electricity result in a lack of enthusiasm among private sectors to invest in electrification in rural areas [20]. Investing in the outermost and remote islands in Indonesia is not attractive to private investor because high economy activity is mostly located in Java [21], despite remote islands needing investment on energy so that they can stimulate their economic development. Other than that, the electricity demand in rural areas usually matures slowly but this progression is unpredictable, making uncertainty of the returns of investment on
electricity in rural areas [22]. Institutional weaknesses and the limited financing are also affecting rural electrification programs in developing countries [20]. This statement is similar to the Asian Development Bank [14] which states that to reach universal access by 2020, Indonesia needs to increase the current funding and revise the funding mechanisms to be more efficient and right on target.

There are several fundamental requirements that need to be implemented in order to cope with the rural electrification challenges. The lessons learned from other countries that have successfully achieved universal electricity access were summarized in several studies. Committed governance and supportive regulations and policies are one of the most often stated in these literature sources e.g. [2,14,20,23]. Policymakers and related institutions need to create an enabling environment so that the future will be clearly defined [2,24]. Moreover, a collaboration of appropriate policies and government will increase private sector’s participation in the rural electrification program [23]. The government can also formulate policies to regulate subsidies and/or affordability of electricity services [20,23]. Developing innovative, sustainable, and sufficient financing can also contribute to enhancing the program’s success [14,23-25].

4. Conclusion
The rural electrification program has been adopted in many countries to achieve universal access to electricity. There are some typical issues in providing electricity to rural areas around the world that are also relevant to the condition in Indonesia. This paper studied the future challenges of rural electrification programs in Indonesia and presented lessons learned from other countries that have successfully overcome such barriers.

Indonesia has successfully surpassed the electrification ratio target at the end of 2018. However, electrifying the remaining households in Indonesia will be harder since they are mostly located in underdeveloped areas, or the inhabitants are too poor to afford electricity. The rural electrification program is one of government’s efforts to achieve a 100% electrification ratio. In its implementation, there are several issues that need to be addressed. Low population density and low income is a problematic characteristic of underdeveloped regions [18,19]. In contrast, providing electricity to such area will tend to be costly and that becomes the main issue that influences the payment and affordability aspect [14,15,18,19]. In addition, high economy activity is mostly located in Java [21]. This condition results in a lack of private sector interest to invest [20]. Institutional flaws and finite financing also affect rural electrification program [20].

The findings disclose that government’s actions and appropriate financing scheme are the most important things to do in order to support rural electrification program [2,14,20,23]. It is highlighted that committed governance and supportive regulations and policies are the fundamental requirements to implement in order to cope with the rural electrification challenges. Policy makers and related institutions need to create an environment that supports the electrification diffusion in rural communities so that the future will be guaranteed [2,24]. To enhance the program's success, it needs innovative financing that is sustainable and sufficient [14,23,24,26].

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