Social and technical barriers that affect the growth of small-scale hydropower independent power producers in Indonesia

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Abstract. Indonesia has a strong commitment on increasing renewable energy resource utilization to produce electricity. One of the potential renewable energy resources is hydropower. In Indonesia, the hydropower is divided into small scale hydropower (less than or equal to 10 MW) and hydropower (more than 10 MW). In order to enhance the utilization of small scale hydropower several financial and regulation supports have been released. In this study the growth of small scale independent power producer has been investigated. The study focused in Sumatera Utara province which is known as the province with big potency of small scale hydropower and the electricity infrastructure is quite developed. The results reveal that there are 115 locations of small scale hydropower projects had been developing in the province. The total capacity is 930.3 MW. However, only seven of the projects (6%) have been in operation stage and produce electricity to the grid. Almost all of the projects have experienced over design budget and time. There are several technical and social barriers that affect the growth. Technical barriers include low quality of pre and full feasibility studies, low quality of detailed engineering design (DED), limited access to relevant expertise, tend to underestimate the technical complexity of developing a small-scale hydropower. Social barriers include the environmental issue, land acquisition, and electricity needs of local people.

1. Introduction

Greenhouse gas (GHG) emissions to the atmosphere cause global warming and climate change to the globe. In order to avoid the globe from the catastrophe, GHG emission must be decreased. Many countries have released the targets on GHG emission reductions. For instance, Indonesia has released the target to reduce its emission 29% from level business-as-usual by 2030 using own budget, and it can be up to 41% using international aids [1,2]. One of the potential solutions is to enhance renewable energy utilities. There is a strong commitment worldwide to reduce fossil fuel utilization with renewable energy sources. Several renewable energy sources can be used to replace the fossil fuel such as solar energy [3, 4], bioenergy [5, 6], wind energy, and hydropower.

At the present, hydropower is one of the most significant renewable energy sources. According to World Energy Council [7], in the year 2016, about 23% of worldwide electricity generation is produced by renewable energy sources. Hydropower is the leading sources, it supplies 71% of all renewable electricity. There has been a major upsurge of hydropower
development in the world in recent years. The total installed capacity is 1,064 GW. In the last
ten years, the average growth rate of hydropower is about 4% per year. In other words, the
total installed capacity has grown up to 39% during 2005 to 2015. Significant new
development of hydropower is concentrated in China, Latin America, and Africa. Asia has the
largest employed potential, estimated at 7,195 TWh/year. This makes Asia is the leading
market for future development. China accounted for 26% of the global installed capacity in
2015, followed by USA (8.4%), Brazil (7.6%) and Canada (6.5%).

Those facts have been motivating researchers to focus on hydropower development.
According to the installed capacity, hydropower plants can be classified into small, large and
super hydropower plants. This study focuses on the small-scale hydropower plant. Many
researchers have reported the study on hydropower development. Pang et al. [8] investigated
small hydropower development in Tibet by focusing the survey in Nagqu Prefecture. The
objectives include appraising existing problems that challenge the sustainable development of
small hydropower in Tibet and to provide policy recommendations. Some recommendations
are appropriate management, retention incentives, training of local personnel and provision of
sufficient construction funds and smart design for new small hydropower plants. Supriyasilp
et al. [9] explored the challenge of incentive for small hydropower commercial investment in
Thailand. In order to improve the renewable energy development, Thailand implemented a
premium-price Feed-in Tariff (FIT) in 2006. However, this system has failed to motivate the
investors. Later, Thailand government replace the program into a fixed-price FIT program
since 2014. Thus the, the effectiveness of the latest FIT was investigated. The study
recommended a supporting program to the FIT such as promoting social cost and social
benefits. Yah et al. [10] reported a review on small-scale hydropower in Malaysia. The
objectives are to present the potential of small hydropower in Malaysia, the current status, and
the challenges facing by the small renewable power plant in Malaysia. It was shown that
despite hydropower technologies are preferable choices for energy generation in Malaysia,
they have not been fully exploited yet due to some technical, economical, and institutional
challenges.

Those reviewed studies show that development of a small hydropower relates to
multidisciplinary study includes social and technical aspects. Recently, there has been a surge
in research on social acceptance of renewable energy power generation. During 2003 to 2015,
data from the Scopus indicated almost 350 articles with the keyword “social acceptance” has
been published in energy and environmental science journals [11]. The increasing policy
focus on the deployment of renewable energies has contributed to the interest in this topic.
Hydropower energy technology is a mature one. This fact shows that the challenges are now
shifting towards obtaining a social acceptance.

Indonesia is known as a country with the fourth largest potency of hydropower in Asia.
The potency includes large and small scales hydropower. However, the installed capacity is
very low. In Indonesia, Sumatera Utara province has a significant potency of small
hydropower with a better electricity infrastructure. This province is expected to be a role
model in small-scale hydropower development. In this paper the growth of small hydropower
Independent Power Producers (IPP) in Sumatera Utara Province of Indonesia is investigated.
The focus will be on social and technical barriers. The investigation includes review on
electricity needs in Indonesia and Sumatera Utara province. The results are expected to supply
the necessary information to meet Indonesian target on reducing GHG emission.
2. Methods
The methodology of this study consists of literature and document review, interview, focus group discussion and site visit. Three steps of research have been carried out in this study. The first step is literature and document reviews. Here all of documents include statistic and reports related to hydropower development in Indonesia in particular in Sumatera Utara province are reviewed. In addition, the policy and regional and national development plans document are also considered. The objective is to collect sufficient information on the growth of small hydropower development in Indonesia. Based on the results of the first step, in the second method several interviews and focus group discussions with related stake holders are carried out. The stakeholders include government officers, state electricity company (PLN), local head of regencies, project owner, academicians, consultants, Financial institutions, and social leader and local people close to the power plant projects. Several site visits to the power plant projects are also carried out. The study was performed during 2012 to 2017.

3. Results and Discussions
3.1. Indonesian electricity
Indonesia is known as a developing country. The electricity need is growing very fast. The electricity seller in Indonesia is monopolized by PLN (State Electricity Company). Before 2009, PLN is the only company in Indonesia has the right to produce and sell the electricity. Since 2009, private power company known as Independent Power Producer (IPP) can produce electricity and sell it to PLN. This is supported by Law of Republic Indonesia No. 30 of 2009 concerning on Electricity. However, IPP can only produce but can’t sell the electricity directly to the market. Indonesia consists of more than 17,000 islands and the population is about 261 million people in the year 2016. Not all of these islands and population use electricity. The national electrification ratio is 92.8%. However, in several provinces electrification ratio is less than 50%.

![Figure 1. Electricity consumption in Indonesia](image_url)
Fig. 1 shows the history of electricity consumption and the projection until 2026. In the figure, the history of electricity consumption during the last 7 years (2010–2016) and projection until 2026 are shown. The projection is made based on several assumptions as follows. The population growth decreases from 1.23% in the year 2017 to 0.88% in the year 2026 and growth domestic product increases from 5.1% in year 2017 to 6.4% in the year 2026 [12]. The projection reveals that the electricity need will increase up to 483 TWh in the year 2026. The average growth is 8.3% yearly. The highest consumption is shown by household sector which consumes 39% of the total consumption and followed by industrial and commercial sectors, respectively. The yearly electricity consumption per capita in Indonesia will also increase significantly in the next 10 years. In the year 2017 is 896 kWh/year/capita and will grow up to 1,681 kWh/year/capita. This fact reveals that Indonesia electricity needs will grow significantly in the next 10 years.

Fig. 2 shows the projection of electricity production based on energy sources. It can be seen that the main fuels for electricity production in Indonesia are coal and gas. Only small portion of the electricity produce by oil fuel. Renewable energy resources are expected play an important role in the electricity production. It will grow from 11.2% in year 2017 to 22.4% in year 2026. Indonesia has abundant renewable energy resources that can be used to meet the target. The most suitable resources are hydropower and geothermal energy.

3.2. Electricity in Sumatera Utara Province

Indonesia consists of 33 provinces include Sumatera Utara which is known as a province with abundant of renewable energy resources from hydropower, geothermal and agricultural waste. However, this province undergoes many blackouts due to deficit of electricity. This situation affects the industrial development in the province. The projection of electricity consumption and number of costumer are shown in Fig. 3. The figure shows that the electricity consumption grows 11.5% yearly in the next 10 years. This is because the costumer will increase from 3.3 million in year 2017 to 3.9 million in the year 2026.
The growth of the electricity consumption must be filled with development of power plants. Since the province has a big potency in Renewable Energy resources, it is expected to explored to meet the electricity need. Fig. 4 shows the projection of energy mix in Sumatera Utara province in the year 2026. The total target from renewable energy is 39.3% which consists of hydropower and geothermal of 17% and 21.1%, respectively. At the present, the energy share from Hydro and Geothermal are 14% and 5.6%, respectively. This fact suggests that there is a strong commitment from the government of Indonesia to increase the utilization of hydropower to produce electricity.

3.3. Present status in Sumatera Utara Province
As mentioned in the previous section there is a strong commitment on development of hydropower in Sumatera Utara province due to big potency and the growth of electricity consumption. The review of regulation shows that since 2009, the private sector can produce electricity and sell it to PLN. The first regulation of the electricity price was released in 2002. However, after 9 years, in the year 2011 the first IPP produce electricity and sell it into the grid. The survey has been carried out and the present status of the IPP is shown in Fig 5. The figure shows that there is a total of 115 locations of small hydropower that has been identified in Sumatera Utara province. The total capacity of those sites is 930.3 MW. This fact shows that the potency of small scale hydropower can fill the target of energy share.
Figure 5 Present status of IPP Hydro in Sumatera Utara Province

The total potencies of the IPP small scale hydropower can be divided into 5 stages. Seven IPPs with a total capacity of 49.5 MW are in operation stages. This is only 6% of the total locations. There 10 locations (8.7%) are in construction stages and those are expected to be operated soon. Furthermore, 15 locations (13%) have signed Power Purchase Agreement (PPA) and 19 locations (16.5%) are processing the PPA. Most of the locations (55.65%) are still in the preparing proposal and field survey. This fact shows that even though there is a strong commitment to develop IPP small scale hydropower, however, only 6% of those potency have been explored.

3.4. Technical barriers
Based on the experience of the success IPP there have been many barriers found in the fields. Almost all of the IPPs have experienced on over design budget and time. The barriers can be divided into four sections. They are technical, social, financial, and regulations. In this work, only technical and social barriers are discussed. In the technical barriers, several problems are found.

The main problem in the technical barrier is lack of accuracy of data. There is no sufficient data can be found in the field. Thus, the IPP frequently over estimates the capacity of the projects resulting in lower financial rates of return than anticipated. The quality of pre and full feasibility studies of the projects are very low. Detail Engineering Design (DED) need to be improved. Access to relevant expertise is very limited. Thus, IPPs hire local consultants with low capability. They tend to underestimate the technical complexity of developing a small-scale hydropower. There is a tendency to skip some of serious design parameter which leads to problems and undermines performance.

In many cases the mistakes are quite fundamental and could be easily eliminated. To compound this situation there is a clear lack of awareness of the importance of putting in place proper technical due diligence measures (external consultant) to assess and scrutinize designs at planning stage. The reason for neglecting the step of technical due diligence is more due to lack of awareness rather than economic considerations (the cost of a consultant to carry out this work is largely irrelevant in the context of overall project cost). Typical technical failures that found in the field are shown in figure 6 and figure 7.
Several recommendations to solve technical problems should be considered by the Government of Indonesia. The provision of an informal and semi-informal support facility comprising the necessary technical knowhow to which IPPs could draw on. This would facilitate a relatively easy due diligence process for IPPs. This could comprise a network or pool of experts who could be commissioned for specific value engineering tasks upon request paid for by the individual IPPs. Their presence could also be complimented with the preparation of media that could be disseminated among the IPP community highlighting the common mistakes [13].

3.5. Social Barriers
IPPs also have to overcome the social barriers. Several social barriers that found in the fields are as follows. Typically, the projects are located in the remote areas and far from sufficient access. In addition, sometimes those sites fall in the location with very sensitive issues such as virgin forest, related to local belief etc. In the preparation stage, social problems typically occur in the Site Acquisition & Litigation. It was recommended to recruit local well-known people. In the construction stage, the environmental issue initiates the social problem such as construction waste to the river and on the flow areas. Here, continuous explanation to the local people is a must. After the project in operation stage and connect the power into the grid, the local people near the project typically asked the electricity for their needs. This is very
difficult to be realized because according to Indonesian regulation, only PLN can sell the electricity to the costumers. In other words, the IPP can’t sell the electricity directly to the costumers.

Those social barriers have strongly affect to the growth of the small scale IPP hydropower in Indonesia. Typically, those problems will delay the projects significantly. However, every location has different specific social barrier. It is recommended the government plays important role to solve the social problems.

4. Conclusions
Indonesia has strong commitment in developing the potency of small scale hydropower to produce electricity. In this work, the growth of electricity in Indonesia has been reviewed. One of the potential solutions to meet the target is to develop small scale hydropower IPP. The financial and regulation have been released by the government. However, the growth is still very low. Based on the study carried out in Sumatera Utara province, the conclusions are as follows. There are a total of 115 locations of small hydropower that has been identified in Sumatera Utara province. The total capacity of those sites is 930.3 MW. However, only seven IPPs with a total capacity of 49.5 MW are in operation stages. This is only 6% of the total locations. There 10 locations (8.7%) are in construction stages and those are expected to be operated soon. Furthermore, 15 locations (13%) have signed Power Purchase Agreement (PPA) and 19 locations (16.5%) are processing the PPA. Most of the locations (55.65%) are still in the preparing proposal and field survey. This fact shows that even though there is a strong commitment to develop IPP small scale hydropower, however, only 6% of those potency have been explored. Several technical and social barriers are there is no sufficient data can be found in the field. Thus, the IPP frequently over estimates the capacity of the projects resulting in lower financial rates of return than anticipated. The quality of pre and full feasibility studies of the projects are very low. Detail Engineering Design (DED) need to be improved. Access to relevant expertise is very limited. Thus, IPPs hire local consultants with low capability. They tend to underestimate the technical complexity of developing a small-scale hydropower. There is a tendency to skip some of serious design parameter which leads to problems and undermines performance. Social barriers include the environmental issue, land acquisition, and electricity needs of local people.

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