A technical and economic analysis of solar PV with local tariff policy in Indonesia

K B Adam*, M Ramdhani and E Suhartono
School of electrical engineering, Telkom University, Bandung, Indonesia

* kharismaadam@telkomuniversity.ac.id

Abstract. Indonesia is still struggling to attract investors in developing the solar photovoltaic (PV) project. The government issued the first regulation on solar PV, announced in 2016. A revision on the local tariff regulation is conducted to reduce the rapid development of the solar PV investment. The major revision is made to change the contract scheme from a build-operate-own (BOO) to a build-operate-own-transfer (BOOT) scheme. This paper investigates how the new local tariff will drive investors and developers to invest in solar PV. This analysis is conducted to know the effectiveness of the policy and the risk of PV investment in Indonesia. Local tariff policy regulation targets PV developers to invest in the solar PV system areas. In the local tariff policy, each area has its PV energy tariff determined by the government. This research proposes a method for deciding demand by considering population data in selected regions to calculate the maximum PV demand of each area. The Levelized Cost of Energy LCOE is used to calculate the economic viability of the PV projects in selected areas in Indonesia. The results show that more than half of the selected areas are profitable for the PV project. The average profit of the projects of the selected areas is 3.21 cent USD per kWh. Most of the areas that have high PV demand have lower local tariffs. Therefore, these areas may not be profitable for developers. The new regulation also cuts the revenue significantly due to the new scheme contract.

1. Introduction

The Indonesia has achieved its electrification ratio target in 2017. The 2017 ratio is 95.35% exceeding the electricity ratio target 92.75%. However, 2 out of 34 provinces have very low electrification with below 70% value. The two provinces that have low electrification value is struggling to develop the electricity facility due to their geographical condition. Alongside the electrification condition, Indonesia also struggling to increase the portion of renewable energy on the system. In 2017, the infestation in total in cost 9.09 billion USD out of the 19.4 billion USD infestation target [1,2].

Four PV regulations in total have been established to attract the investor during 2016 until 2018 period. There are two regulations that applicable feed in tariff policy for residential consumer, and local tariff regulation for PV developer. Rapid changes of regulation indicate that the regulator wants to control the growth rate of solar PV development. The regulator changes show the interest of regulator in solar PV. However, the regulation changes in the local tariff policy also indicates that regulator want the development of solar PV smoothly growthy [3–6].

Indonesia is located around the equator that gets sunshine all year long. however, in the rainy season, irradiation that can be exploited by solar power decreases due to the weather condition. The Indonesian average sun peak hour varies from 4.5 to 6.5 kWh per square meter. The Indonesian government claims...
there is 207.9 GW of solar power potential in Indonesia. However, only 78.5 MW of the existing solar system is installed [7].

Several efforts have been made by the government of Indonesia for promoting renewable energy, especially solar power, but had not given a satisfactory result. Some regulation changes also applied by the government to stimulate investment in renewable energy; however, the regulation still not give a good stimulation to the energy developer [4,5]. There are several works related to solar power regulation in Indonesia. A.J Veldhuis et al. proposed an analysis of PV potential for grid-tied systems in Indonesia. The total PV potential is about 27 GWp that calculated by the provincial level by considering the resident density. The PV energy price in the eastern part of Indonesia is relatively lower than in other areas [8,9].

Because the demand value of PV was only considered from the population density, the accuracy is probably not good because of the possibility of different patterns of the load.

Technical analysis and economic of PV also have for feed-in tariff that has been conducted by Fathoni et al by using the Retscreen software using the payback period analysis. The result has shown that the payback period is varying from 11 to 17.6 years [10]. However, this research did not concern about the sizing of each customer. The sizing method of each customer is important due to the limitation of size and revenue in new feed-in tariff regulation.

Sean F. Kennedy explained that there is rapid changing on PV power regulation in Indonesia. There are 4 regulations regarding PV in the last 2 years. Kennedy conducts the general analysis of the market response to the changing of the regulation using document and media analysis. The analysis that was conducted not including the detailed analysis of the economic and technical side [4,11].

There are two regulations that apply to PV powered power plants, namely the local tariff policy (MEMR Reg. 50/2017) and the new feed-in tariff policy. To make a brief analysis of the current regulation, this research is focusing on the viability of the local tariff regulation by technical and economic analysis.

The analysis predicts how the new regulation can lead the developer having interest or not on PV system. This paper is contributing to the existing regulation transition and help the stakeholder and the regulator to make decision in the PV investment in a technical aspect and the economic consideration.

2. Regulation and suitable area

2.1. Local tariff policy

The new feed-in tariff policy is a policy that can cost the customer to install the PV to their system connected to the PLN grid. This regulation applies alongside the existing local tariff policy. In conclusion there are two schemes for injecting PV power grids, the local tariff policy that targets a developer to inject large-scale PV systems and the New feed-in tariff policy that is able to cost the customer such as a residential costumer to contribute installing the PV system on their home. In the local tariff scheme, the price obtained by the developer is the determined local tariff. Unlike the price of the local tariff scheme, the price of the feed-in tariff scheme depends on the electricity price.

The first local tariff policy established in MEMR Reg. 12/2017. This regulation started the PV selling price regulation which was previously determined by the business to business agreement in MEMR Reg. 19/2016. The government renewed the regulations that were originally built operate to be built operate and transfer. This change is an important consideration for developers because their revenue will certainly be reduced. The technical analysis and economic analysis are needed to find out whether the new rules are still profitable or not.

2.2. Suitable area

Figure 1 shows the local tariff rates and the amount of sun peak hour in Indonesia. It appears that eastern Indonesia has a greater irradiance potential than other regions. These conditions make the area of eastern Indonesia have more appeal for developers. In this article several areas were selected from all regions in Indonesia. The selection of this area is based on the mapping of local tariff prices set by the government.
2.3. Technical analysis

Using the energy and energy calculation considering the irradiance and the wind data. The energy of PV has several loses before injecting it to the grid. In this paper the loses are divided into three, PV array losses, the wiring losses and the inverter losses as illustrated in Figure xxx. Since there is no PV temperature data, the PV temperature is derived from the irradiance and ambient temperature and wind velocity.

PV has fluctuating characters, meaning that the power generated by PV is very dependent on irradiation and temperature so we cannot predict it. For that in determining the PV demand we need to know the flexibility of the system. Flexibility is the ability of the system to overcome short term uncertainty. Flexibility is closely related to the ability of the generator to respond to changing loads.

Total flexibility in this study for one province was estimated by equation (1). \( P_{\text{imax}} \) depends on the minimum generation value of each \( a_i \) generator. The \( a_i \) value is influenced by the type of generator, and the character of each generator.

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P_f = \sum_i (1 - a_i) P_{\text{imax}}
\]  

(1)
Figure 3. Demand of selected areas.

Figure 2 is an illustration of the flexibility of the grid. Demand flexibility is the summing of all flexibility possessed by the generator. Where: $P_f$ is Grid flexibility, $a_i$ is minimum generation ratio of power plant $I$, $P_{\text{max}}$ is maximum operating capacity of power plant $I$, $P_{\text{PV}}$ is PV demand. $P_{\text{Dres}}$ is reserve demand, $P_l$ is Load demand, $P_r$ is reserve power.

$P_{\text{Dres}}$ is reserve demand that is smaller or equal to $P_f$. $P_{\text{PV}}$ is PV demand that is less than the power demand. In this simulation we assume that $P_{\text{PV}}$ is 50% of $P_{\text{Dres}}$ and $P_f$ is equal to 20% of $P_l$.

$$0 \leq P_{\text{Dres}} \leq P_f$$  \hspace{1cm} (2)

$$0 \leq P_{\text{PV}} \leq P_{\text{Dres}}$$  \hspace{1cm} (3)

To calculate the demand for a city, population data is the reference. The PV demand value for city C is calculated proportionally by comparing the total population in that city compared to the total population in one province contained in equation (4), where $P_{\text{PV,c}}$ is local PV demand of city $C$, $P_{\text{PV,p}}$ is PV demand at provincial level, $R_c$ is the total residence in the city and $R_p$ is the total residence in the province. This city demand PV value is the reference for the PV project value limit in the area.

$$P_{\text{PV,c}} = P_{\text{PV,p}} \frac{R_c}{R_p}$$  \hspace{1cm} (4)

The LCOE is used to analyze the adequacy of regulations for developers. With LCOE we can also compare how much generation costs are in each region. To find out whether the project is profitable, the value of LCOE in each region with Local tariff compared to one region to another.

Local tariff policy made by the government to regulate each tariff for different areas. This tariff aims to interact with renewable energy developers. However, we must know whether it is profitable for the developer. LCOE is used to calculate the profitability of selected areas to analyze the viability of new regulation.

A comparison is made between the profits obtained from the old rules and the new rules. In addition, a large analysis of the estimated profit that will be obtained by the developer. With that we can estimate whether the new regulations are still attractive or not for investors.
Figure 4. Profitability of selected areas.

Figure 3 shows the demand value of the selected area. The installed PV energy is focused to meet the energy needed by the local area. For this reason, Demand is counted within the scope of one city. We can see in Figure electricity demand is varying, some city has a demand of more than 10 MW while some have very small demand of less than 1 MW. Large demand will certainly affect the investment price per Watt peak PV installed. The greater the value of the PV capacity to be installed, the smaller the price per watt obtained.

Figure 4 is the Price-LCOE curve towards the selected area. We can compare that with the new rules, the estimated profit value is reduced. This will certainly reduce the interest of developers in building PV power systems.

The value of the difference between price and LCOE varies from high to low. Areas with high local prices have margins on PV systems made with the same size of 10 MWp project size. Conversely areas with low local tariffs have low profit margins too. But in the calculation by considering PV demand, the amount of demand also affects the estimated value of the profits obtained. Regions that have high local tariffs do not necessarily have high profits because the small value of project power results in high investment cost per watt peak prices. This will certainly be a consideration for developers. The developer must not only consider the value of the local tariff but must also consider how many project sizes might be implemented.

3. Conclusion
Local tariff policy is profitable only for certain areas. The developer must be careful to determine the profitability of the PV project in Indonesia. The local tariff price is the component that most influences the profitability of the project. In addition, the size of the project also affects the profitability of the PV system. The greater the local tariff the better the potential profit from the project, besides, because the price of installation per watt of PV is also influenced by the size of the project, the greater the value of the project capacity, the greater the potential profit. From the simulation results, more than half of the selected area has the potential to generate profits. Therefore, these areas may not be profitable for
developers. The average profit of the projects of the selected areas is 3.21 cent USD per kWh. Some areas have limited demand for PV systems but are still profitable. The new regulation also cuts the revenue significantly due to the new scheme contract.

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