Vol. 13 No. 1 (2022) 12-19

Jurnal Riset
Teknologi Pencegahan Pencemaran Industri

Journal homepage : http://www.jrtppi.id

Kementerian Perindustrian
REPUBLIK INDONESIA

Soaking Up The Sun: Designing Small Scale Photovoltaic (PV) Rooftop for Micro, Small, and Medium Enterprises (MSME): Study Case at Rattan Crafts Center in Trangsan Village, Sukoharjo, Central Java

Sujarwanto Dwiatmoko[1], Archibald Nagel [1,2]*, Jaka Windarta [2,3]

[1]Energy And Mineral Resources Services of Central Java

[2] Postgraduate School, Master of Energy, Diponegoro University

[3]Departement of Electrical Engineering, Diponegoro University

ARTICLE INFO

Article history:

Received 29 March 2022

Received in revised form 17 May 2022

Accepted 22 May 2022

Available online 27 June 2022

Keywords :

Solar Energy

PV Rooftop

MSME

Helioscope

ABSTRACT

The National Energy General Plan has set a target of achieving a Renewable Energy (RE) mix of 23% by 2030, to achieve this the transition of non-renewable energy to RE must be done immediately. Solar energy is one of the renewable energy that is very abundant in Indonesia. Along with the issuance of the Minister of Energy and Mineral Resources Regulation number 49 of 2018 regarding the Use of Rooftop Solar Power System by Consumers of PT Perusahaan Listrik Negara (Persero) which provides opportunities for the utilization of PV Rooftop for household and commercial sector. Given this, the Central Java Government plans to install Rooftop Power Plant in the Micro, Small, and Medium Enterprises (MSME) Sector to develop the utilization of RE in the productive sector while improving the economic recovery from the Covid-19 pandemic. This study analyzes the potential development of PV Rooftop in Rattan MSME Center in the village of Trangsan, Sukoharjo Regency. The use of renewable energy (EBT) is expected to save electricity costs in MSMEs. The results of planning using Helioscope software showed that the three MSMEs with different PLTS capacities, namely 1 Kwp, 2.04 KWp, and 4 KWp can produce annual energy production of 1,191 MWh, 2,433 MWh, and 5,352 MWh respectively. After the installation of the PLTS, it was proven that in the first two months after installation, energy consumption can decrease to minimum usage.

1. INTRODUCTION

Indonesia has known to be blessed with abundant solar energy potency. Located on the equator, nearly all areas in Indonesia have the potential to develop solar energy plants with an average output reaching about 4 kWh/m2 according to the National Handbook of Energy 2020. As stated in National Energy Policy (Government Regulations No. 79, 2014), the government targeted a minimum share of 23% usage of renewable energy in the 2025 national energy mix. As the current achievement of renewable energy shares in the national energy mix reaches about 9,15% in 2019 there is a 12 % gap that needs to be filled in six years. In line with central government policy, Central Java recently declared itself to be the first solar energy province in Indonesia (IESR 2020). Based on the province's abundance of solar energy potency, the Local Government has planned and worked out things such as installing numerous Photovoltaic (PV) rooftops in government buildings, schools, and pesantrens, as well as the emergence of solar energy usages in industries and other economic sectors such as MSME to boost the Renewable Energy, particularly solar energy portion in provincial's energy mix.

*Correspondence author.

E-mail : archibaldnagel@students.undip.ac.id (Archibald Nagel)

doi : https://10.21771/jrtppi.2022.v13.no.1.p12-19

2503-5010/2087-0965

Accreditation number : (Ristekdikti) 158/E/KPT/2021

Based on the data, Central Java has solar energy potential more than Indonesia's average, with the approximate solar energy potential in Central Java is 4.05 kWh/kWp per day, while the average solar energy potential in Indonesia is 3.75 kWh/kWp per day (Gandabhaskara Saputra, 2020) the Local Government has proclaimed themselves to be the first solar energy province in 2019 (Directorate General of New Renewable Energy and Energy Conservation, 2020). Since then, through multiple resources and funding, Central Java has successfully built 127 PV Installation units with a total capacity of no less than 5.199 kWp (by October 2020) (Directorate General of New Renewable Energy and Energy Conservation, 2020) Nevertheless, when the COVID-19 pandemic broke out in early 2020, solar energy development through private sector funding was somewhat stalled. Economic growth in the first quarter of 2020 was a mere 2.60 percent, down from 5.34 percent in 2019 (Central Bureau of Statistics, 2020) Pandemic conditions are precisely seen at the right time for the leap of energy transition to renewable energy (RE) by the Central Java Provincial Government, with one of its activities is to develop rooftop solar panels for productive sectors that are among the most affected by the pandemic, namely MSME (Simanjutak, 2021). The transition of conventional energy to RE could be one of the Government's options in restoring the economy because for the first time during the pandemic conventional fuel sources such as oil have fallen in price to negative for the first time in history (Sumarno, Bachtiar, & Jati, 2020). Development of renewable energy, including PV Rooftop, can also reduce unemployment growth as a result of the COVID-19 pandemic, and improve energy independence and reliability (Sumarno, Bachtiar, & Jati, 2020).

The issuance of regulation of the Minister of Energy and Mineral Resources Regulation number 49 the year of 2018 concerning the Use of Rooftop Solar Power System by Consumers of PT Perusahaan Listrik Negara (State Owned Electricity Corporation) and its changes have provided opportunities for the public to utilize solar energy through the plots system on grid widely (Setyawati, 2020). The growing number of PV rooftops installed in Indonesia indicates that most PV rooftops are installed in residential areas, but the substantial load comes from the industrial category (Tambunan et al, 2020). The MSME sector, which is one of the economic supporters in Indonesia, has not used much PV Rooftop. In general, the regulation has not made a specific difference in the MSME sector, although it has been given a grouping of users between the industrial and commercial sectors who are obliged to bear additional operating costs such as emergency charges (Tarigan, 2020). The development of regulations for the use of solar energy from an on-grid system can be reviewed in Regulations of the Minister of Energy and Mineral Resources No. 49 The year 2018 were stated that only 65% of the electricity exported from PV Rooftop can be "compensated" (Modjo, 2020). Based on those regulations, designing the PV rooftop precisely will help determine the best output from the PV rooftop. Unlike the PV rooftop design in major industries which usually provides greater area and complicated roof segmentation due to the building's uneven roof construction (Rega, Sinaga, & Windarta, 2021), the roof at Trangsan Rattan Centre is commonly narrow and the construction is identical. Different from the studies conducted in MSMEs that are mobile and only use electricity for production purposes only that ideally use off-grid systems (Windarta, Handoko, et al, 2021), MSMEs in the Trangsan Rattan center have the characteristics of production and residence into one and have become electricity customers of PT. PLN so that the design will use the base of the on-grid system.

Some barriers might emerge from developing PV rooftops in MSME. Lesson learned from a similar study conducted in India, five barriers that currently halt the usage of PV Rooftops for the MSME sector, which are breakdown as operational, technical, financial, commercial, and awareness barriers (Deloitte, 2019). Those technical barriers among others are some MSMEs have inadequate roof space, MSMEs are mainly located in a highly popullated industrial areas so the shadow will affect the proper roof area and their roof are often being replaced at routine intervals.

This study is conducted to see whether is the technical barriers in India and Indonesia with the study case of Rattan MSME in Trangsan Village, Sukoharjo is quite identical, based on three sample buildings with a various electricity meter and PV rooftop.

Based on those issues mentioned above, the designing and the planning of PV rooftop installation in MSME will be very important to maximize the output and provide renewable energy introduction to the sector.

2. METHODS

This research aims to calculate the potential generation capability of the PV Rooftop Power Plant system in the MSME sector in Central Java, by taking place in the Rattan Handicraft Center, Trangsan Village, Gatak District, Sukoharjo Regency. The Rattan Crafts Center commonly uses one single electrictiy source, which is electricity powered by the state-owned electricity firm (PT. PLN). The average installed capacity is around 1.300 VA to 4.400 VA. This study will use a method to calculate the potential output PV power based on the width of the rooftop area in three MSMEs with different electricity installed capacities using Helioscope. Helioscope is a web-based PV plant designing software that is developed by Folsom Labs.

Data collection is conducted based on field observation for measurement of roof area, roof tilt, shading potential, and daily power load for three sample buildings. The Helioscope version that will be used is the non-beta version that was released in 2019.

Helioscope analysis is based on many aspects, one of them is geographical location and the surrounding potential shading. It is also consider choosing the proper type of panels and inverters, the complete layout of the plant is automatically generated with all the relevant data like power output, system loss, energy to the grid, number of modules and inverters, grouping of panels and other parameters (Md.Shahin Ali, Nazmun Nahar Rima, 2018).

The yield result of annual energy production from the design will be compared with the real energy load based on one year load before the PV is installed. The comparison will be analyzed with Microsoft Excel Office 2019 to determine whether the PV rooftop system will be able to provide energy for the MSME load needs significantly.

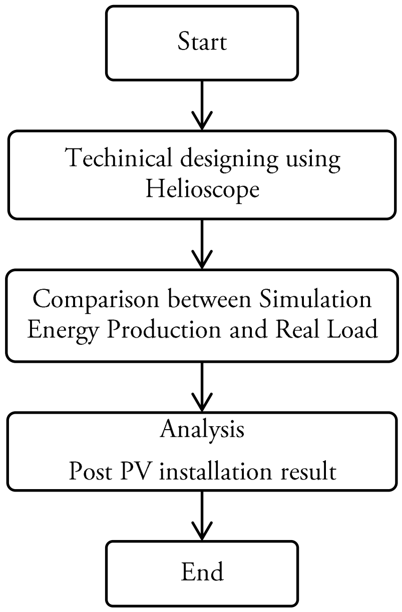


Figure 1. The Flowchart of The Study

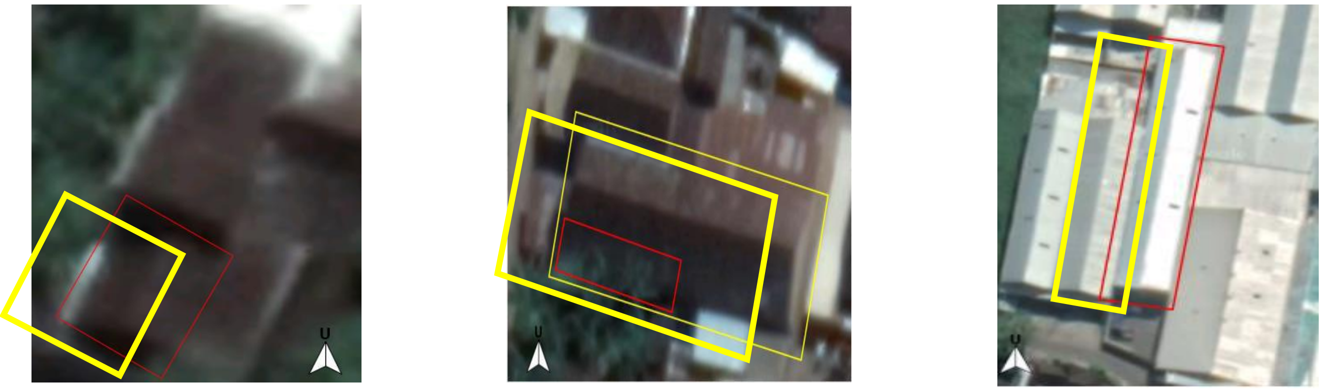
Based on observations in the field, data related to three MSME buildings, covering the width, length, and slope of the roof as well as general load data use. The calculation of the available area in the MSME which is used as samples is using the image provided by Helioscope. The calculation of the available area is shown in figure 2 below.

The image of the roof area shows that there are different characteristics of each MSME, such as coordinates, tilt, material, azimuth, and the surrounding buildings as shown in Table 1. These features were used to determine which area is proper for installing the PV panel.

The data shown in table 1 is used to create a simulation 3D design to analyze which part of the roof that proper to put the PV panel as shown in figure 3 below.

The calculation of the area of the roof to be installed PV Rooftop needs to address the area of the roof that is not affected by shadows, and the strength of the roof is assumed to be able to receive the load of solar panels. As a parameter of the area of PV modules, will be used PV module with a capacity of 340 Wp which is a maximum area of 2 m2, Thus, based on the parameters mentioned above the results could be used as boundary to of the analysis made through Helioscope that shown by Figure 4. Based on the calculations and according to the Regulation of the Minister of Energy and Mineral Resources No. 49 of 2018

Article 5 mentioned that "The capacity of PV rooftop is limited to at least 100% of the connected power of consumers of PT PLN (Persero)". Therefore, the maximum PV Rooftop capacity that can be installed in Asri Rotan is limited to 1.3 Kwp, Putra Jaya is 2.2 Kwp and Surya Rotan is 4.4 Kwp.

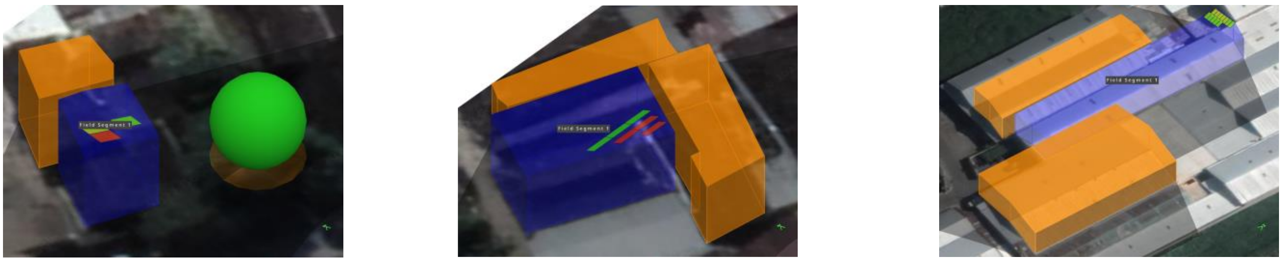


(a) (b) (c)

Figure 2. The available roof area of (a) Asri Rotan, (b) Putra Jaya Rotan and (c) Surya Rotan

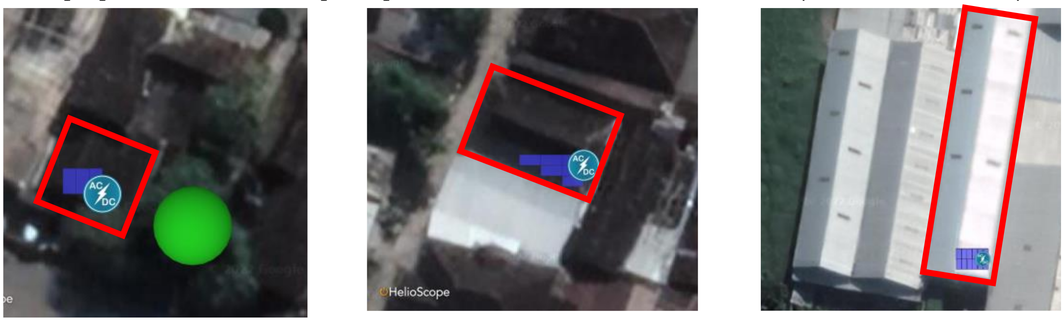
Table 1. MSME Data Samples

No	MSME	Roof Structure Material	Coordinates		Width (m)	Length (m)	Tilt (degree)	Azimuth (degree)	Surrounding Object(s)
			x	y					
1.	Asri Rotan	Wood Block	472.372	9.161.527	6	15	27	90	Buildings
2.	Putra Jaya	Wood Block	471.616	9.161.761	8	24.2	32	0	Trees & Buildings
3.	Surya Rotan	Canal C Steel	471.662	9.161.825	12.2	57	18	180	Buildings



(a) (b) (c)

Figure 3. The proper roof area and PV panel placement of (a) Asri Rotan, (b) Putra Jaya Rotan and (c) Surya Rotan



(a) (b) (c)

Figure 4. The PV placement from Helioscope for PV rooftop installation of (a) Asri Rotan, (b) Putra Jaya Rotan and (c) Surya Rotan

The other parameters that were used in terms to complete the design are the PV rooftop components. The components were divided into two main components which are the PV panel and the inverter. Based on the different PV rooftop capacities, the component is also distinguished for each MSME as shown in table 2 below.

Table 2. MSME Component Data

No	MSME	PV Panel	Inverter
1.	Asri Rotan	AE Solar 340MM6-72	Solis Mini 4G - 1000
2.	Putra Jaya	AE Solar 340MM6-72	Solis Mini 4G - 2000
3.	Surya Rotan	AE Solar 340MM6-72	Solis Mini 4G - 4000

The result of the simulation shows that there is a peak performance between July to October before declining acts in November and December.

3. RESULT AND DISCUSSION

The analysis result from Helioscope shows that the PV rooftop's peak energy production at Asri Rotan is obtained in October with 114.6 KWp, meanwhile at Putra Jaya is obtained in August with 246.3 KWp and Surya Rotan's in September with 524.7 KWp. PV rooftop's lowest energy production at all three MSMEs is obtained in February, with the energy production at Asri Rotan, Putra Jaya and Surya Rotan is 82.8 KWp, 157.5 KWp and 372.4 KWp respectively. The PV rooftop simulation energy yield from Helioscope is also compared to the actual annual load used by the three MSMEs in 2021 to give the depiction how the PV rooftop energy will affect the energy consumption of the MSME. The comparison is shown in table 3.

Based on calculations and analysis, data from the three MSMEs showed different results. Asri Rotan which has a Rooftop PV capacity of 1 KWp able to make savings of about 40 % annually, while Putra Jaya Rotan where the energy load is lower yet has a larger rooftop PV capacity of 2 KWp shows that the energy generated from rooftop PV has been able to supply overall energy needs. The results shown by rooftop PV in Surya Rotan show that with a capacity of 4 KWp and a greater load than the previous two MSMEs, it is still able to reduce energy loads above 50% annually.

Meanwhile, after the PV rooftop installation is completed at the end of January 2022, the measurements of the energy produced by the system are conducted through the display on the inverter screen and the data collected from the calculation of energy exports in the PLN Mobile application. It was found that in February 2022 when rooftop PV had been working for a full month, rooftop PV energy production in Asri Rotan, Putra Jaya, and Surya Rotan had exported 68 kWh, 109 KWh, and 226 KWh of energy respectively. The data on electricity cost also show that all three MSMEs is having a significant decrease in electricity bill.

The data collected from the PLN mobile application also shows that Asri Rotan's electricity bills have dropped from an average of Rp.366.667 to Rp.198.415 in February and continuing dropping to Rp.176.369, while Putra Jaya's bill dropped from the average Rp.308.645 to Rp.138.576 in February and March, whereas Surya Rotan's bill dropped from average Rp.988.376 to Rp.416.053 in February but significantly rising into Rp.863.280 in March as shown in table 5.

The comparison shown in table 5, ndicates that the PV rooftop installation is working properly and reducing the energy cost of all three MSMEs, where there is an interesting result is in Putra Jaya because the rooftop PV system has been able to supply almost all the energy needed. The results also showed that even though it has been able to supply all energy needs, Putra Jaya still has to pay the minimum payment bill per the January-March 2022 tariff adjustment on the letter issued by PT. PLN that based on the Minister of Energy and Mineral Resources Regulation Number 28 of 2016 where the provision for R1 customers is the subscription capacity multiplied by 40 hours of usage multiplied by electricity tariffs. The amount of electricity tariff for the R1 customer type is Rp.1,444.70 per Kwh so the bill value of Rp.138,576 obtained by Putra Jaya in February 2022 is the minimum bill obtained from the equation (1) below plus the street lighting tax.

The imposition of this minimum payment does not apply to prepaid customers, but with the provision that rooftop PV users must migrate to post-payment, the imposition of this minimum bill can cause new cost factors that halt MSME players' interest in participating in using rooftop PV.

$$\boldsymbol{Minimum\ payment} = (\boldsymbol{40\ hours} \times \boldsymbol{electricty\ capacity\ meter} \times \boldsymbol{tariff})\ (1)$$

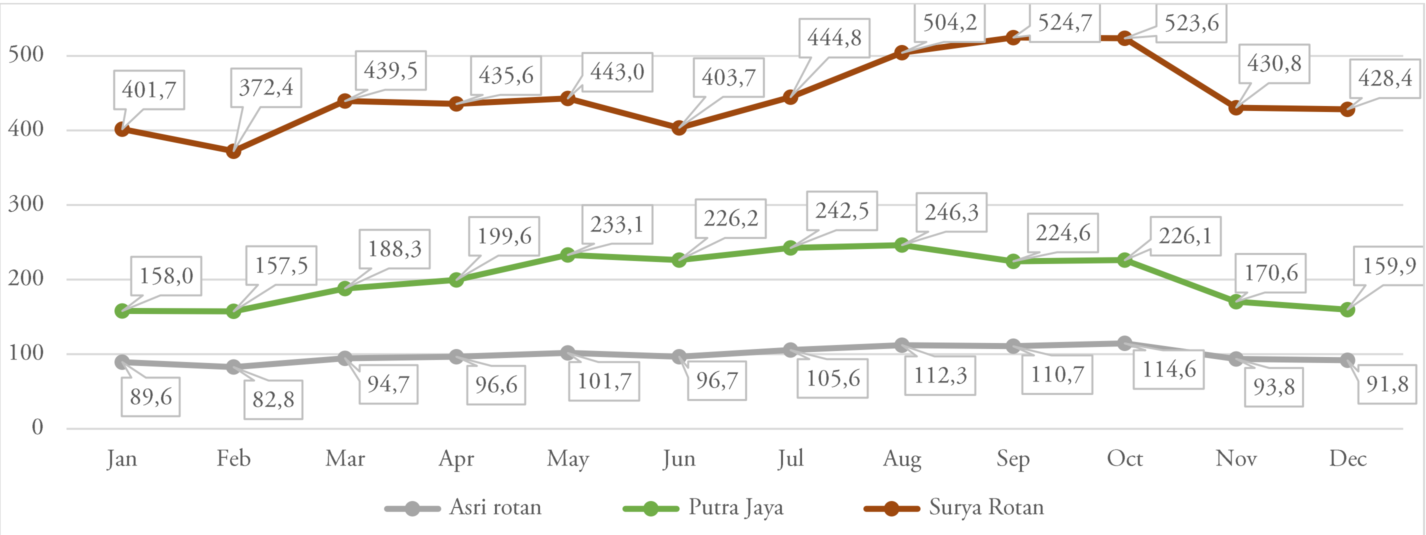


Figure 5. The monthly energy production result from Helioscope for PV rooftop installation of Asri Rotan, Putra Jaya Rotan, and Surya Rotan

Table 3. Comparison between annual energy production and the annual load

No.	MSME	Annual Energy Used* (KWh)	Annual PV Rooftop Energy Yield** (KWh)	Annual Energy Gap (KWh)	Monthly Energy Gap*** (KWh/Month)
1.	Asri rotan	2,796	1,191	1.605	133,75
2.	Putra Jaya	2,292	2,433	-141	-11,75
3.	Surya Rotan	9,338	5,352	3.986	332,17

* = The annual load is based on the actual energy used from January to December 2021 for Surya Rotan and Putra Jaya. The annual load for Asri Rotan is based on average prepaid credit for the last three months in 2021

** = The annual energy yield from PV rooftop is based on Helioscope simulation

*** = The monthly energy gap is calculated from the difference between the annual load and the annual energy divided by 12 months

Table 4. The Pre and Post PV Rooftop Instalation Energy Load Comparison

NO	MSME	Subscription TYPE	Pre PV (Kwh)			Post PV Import (Kwh)		Post PV Export (KWh)	
			Oct	Nov	Dec	Jan	Feb	Jan	Feb
1.	Asri rotan	R1	233,2	233,2	233,2	51	170	23	68
2.	Putra Jaya	R1	180	226	256	212	149	25	109
3.	Surya Rotan	B1	767	910	796	765	494	69	226

Table 5. The Pre and Post PV Rooftop Instalation Energy Cost Comparison

NO	MSME	Electricity Meter (VA)	Pre PV (Rp)				Post PV (Rp)		
			Oct	Nov	Dec	Average	Jan**	Feb	Mar
1.	Asri rotan*	1300	366.667	366.667	366.667	366.667	56.690	198.415	176.369
2.	Putra Jaya	2200	283.450	355.887	403.129	347.489	308.645	138.576	138.576
3.	Surya Rotan	4400	919.633	1.091.090	954.404	988.376	863.280	416.053	863.280

* = Asri Rotan Pre PV subscription type was prepaid so the average bills were counted on the total token bought around October to December 2021

** = The PV Installation was completed at the end of January so the migration system is not considered done by the date the January bill issued

4. CONCLUSION

According to the results of the analysis and simulation, several conclusions can be drawn, such as the results of the analysis show that the research site is potential for the development PV Rooftop among MSMEs especially small-scale PV rooftops. While the study in India shows that there are technical barriers such as inadequate rooftop space and most MSME is located in congested industrial areas where a useable roof area is greatly reduced because of shadows and congested of nearby objects were not found in Trangsan, there might be the same operational barriers such as some of the MSME is using a tin shed roof that might have to replaced regularly. Meanwhile, there is another barrier caused by monthly minimum payment regulation. Even if PV rooftop able fully supply the energy load in the MSME, the new regulation of minimum payment make the MSME still have to pay some amount of money.

There must be clear regulations to categorize whether the MSME sector belongs to the commercial sector or not. This is because there will be differences in economic costs if this sector bears other mandatory costs such as monthly minimum payment. As a follow-up step, the Government needs to prepare a financing scenario that is not necessarily through grants, but can be through a credit scheme with competitive interest for the MSME sector to develop PV Rooftop. As the basis of the previous point, it is necessary to analyze the technology related to the utilization of Rooftop Power Plant for the MSME sector including, installation price, maintenance costs to the willingness to pay from the MSME sector.

ACKNOWLEDGMENT

The author would like to thank Energy and Mineral Resources Services of Central Java and Colleagues in the Section of Renewable Energy for the support that has been provided during the writing. The author also expressed his gratitude for the willingness of the Trangsan Rattan Industry Forum Cluster in providing data and information related to the study.

REFERENCE

Central Bureau of Statistics. (2020). Jawa Tengah Province in Figures. Badan Pusat Statistik, 1–604.

Deloitte. (2019). Scaling up of rooftop solar in the SME sector in India Main report, (April).

Directorate General of New Renewable Energy and Energy Conservation. (2020). Direktorat Jenderal EBTKE - Kementerian ESDM. Siaran Pers. Retrieved from https://ebtke.esdm.go.id/post/2021/06/02/2871/indonesia.berkomitmen.capai.net.zero.emission

Gandabhaskara Saputra, U. S. (2020). Inaugurates the Largest Solar Roof Power Plant in Central Java_ Energy Transition is Inevitable - IESR. Retrieved from https://iesr.or.id/en/inaugurates-the-largest-solar-roof-power-plant-in-central-java-energy-transition-is-inevitable#:~:text=Central Java Province itself has,(3.75 kWh %2F kWp).&text=With the inauguration in Klaten,PLTS in its four factories.

Md.Shahin Ali, Nazmun Nahar Rima, M. I. H. S. and M. F. K. (2018). Helioscope Based Design Of A MWP Solar PV Plant On A Marshy Land Of Bangladesh

And Prediction Of Plant Performance With The Variation Of Tilt Angle. GUB JOURNAL OF SCIENCE AND ENGINEERING, 05(01), 1–5.

Modjo, S. (2020). PLN vs Energi Terbarukan: Peraturan Menteri ESDM Terkait Penggunaan Sistem Pembangkit Listrik Tenaga Surya Atap. Jurnal Hukum Lingkungan Indonesia, 6(1), 19–40. https://doi.org/10.38011/jhli.v6i1.89

Rega, M. S. N., Sinaga, N., & Windarta, J. (2021). Perencanaan PLTS Rooftop untuk Kawasan Pabrik Teh PT Pagilaran Batang. ELKOMIKA: Jurnal Teknik Energi Elektrik, Teknik Telekomunikasi, & Teknik Elektronika, 9(4), 888. https://doi.org/10.26760/elkomika.v9i4.888

Setyawati, D. (2020). Analysis of perceptions towards the rooftop photovoltaic solar system policy in Indonesia. Energy Policy, 144(August 2019), 111569. https://doi.org/10.1016/j.enpol.2020.111569

Simanjutak, U. (2021). The User of Solar rooftop Increasing, Central Java Government Optimistic to Achieve the Renewable Energy Mix Target of 21.

Sumarno, T. B., Bachtiar, A., & Jati, A. N. (2020). Accelerating the Economic Recovery in Indonesia Post Covid-19: Justice in the Energy Transition. Global Energy Law and Sustainability, 1(2), 140–148. https://doi.org/10.3366/gels.2020.0018

Tambunan, Handrea Bernando, Dzikri Firmansyah Hakam, Iswan Prahastono, Anita Pharmatrisanti, Andreas Putro Purnomoadi, Siti Aisyah, Y. W., & Sandy, and I. G. R. (2020). The Challenges and Opportunities of Renewable. Energies, 13, 1–22.

Tarigan, E. (2020). Rooftop PV system policy and implementation study for a household in Indonesia. International Journal of Energy Economics and Policy, 10(5), 110–115. https://doi.org/10.32479/ijeep.9539

Windarta, J., Handoko, S., Irfani, K. N., Masfuha, S. M., & Itsnareno, C. H. (2021). Analisis Teknis dan Ekonomis Pembangkit Listrik Tenaga Surya Off-grid Menggunakan Software PVSyst untuk Usaha Mikro Kecil dan Menengah (UMKM) Coffeeshop Remote Area. Teknik, 42(1), 290–298. https://doi.org/10.14710/teknik.v42i3.40242