Tarigan, Elieser

Article

Rooftop PV system policy and implementation study for a household in Indonesia

International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Tarigan, Elieser (2020). Rooftop PV system policy and implementation study for a household in Indonesia. In: International Journal of Energy Economics and Policy 10 (5), S. 110 - 115.
https://www.econjournals.com/index.php/ijeep/article/download/9539/5264.
doi:10.32479/ijeep.9539.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(5), 110-115.

Rooftop PV System Policy and Implementation Study for a Household in Indonesia

Elieser Tarigan*

Department of Electrical Engineering, and Center for Environmental and Renewable Energy Studies, University of Surabaya (UBAYA), Indonesia. Email: elieser@staff.ubaya.ac.id

Received: 05 March 2020 **Accepted:** 13 June 2020 **DOI:** https://doi.org/10.32479/ijeep.9539

ABSTRACT

This paper discusses the recent solar rooftop photovoltaic (PV) system policies in Indonesia, particularly for the implementation of the residential sector. The aim of this study is to demonstrate the rooftop PV system for a household based on the current related policies. The study is conducted by literature reviews and computer simulation for a typical rooftop PV system for residential in Surabaya, Indonesia. The most recent solar energy policy in Indonesia is the Ministry of Energy and Mineral Resources Regulation No. 49, the year 2018, which establishes net metering for the residential, commercial and industrial National Grid (PLN) customers that have excess power from solar rooftop installations. The simulation shows the average values global solar irradiation on a horizontal surface in Surabaya vary between 6.81 kWh/m^2 and 4.82 kWh/m^2 with an average of 5.54 kWh/m^2/day. Energy output by 3 kWp rooftop PV system in Surabaya is found about 4,200 kWh/year, with an average of 11.67 kWh/day. Economically, under present conditions, rooftop on-grid PV system investment would give about 9-10 years of the payback period.

Keywords: Rooftop, PV System, Solar Energy, Residential, Indonesia
JEL Classifications: C58, G18, H41,H50 & Z18

1. INTRODUCTION

Solar energy is one of the most promising of renewable energies in attempting to reduce fossil-based fuel consumption due to its limited reserved and the greenhouses gas (GHG) emissions from the combustion process. Indonesia is located around the equator line, which fortunate to have relatively high and stable daily solar energy throughout most of the year. Statistically, the daily solar irradiation in Indonesia would provide more than 500 GW of potential solar sources (Dang, 2017; UNEP DTU Partnership, 2016). However, the solar photovoltaic (PV) sector has not been well tracked in Indonesia. By the time of writing this paper, based on various sources (Hamdi, 2019; Tarigan, 2018; Tarigan et al., 2015), it is estimated that there are approximately 14.7 MW of solar PV system running on-grid, 48 MW under construction, and an estimated 326 MW in the pipeline. This capacity is relatively small in comparing to the neighboring South East Asian countries such as Thailand (2.6 GW) and the Philippines (868 MW) (Hamdi, 2019).

The success of the implementation of the rooftop PV system in a country might be affected by many factors such as technical and policy or regulation. It is important for electricity consumers to consider the factors to ensure the beneficial use of the PV system. A number of studies for different countries were found in the literature regarding the policies that regulate the rooftop PV systems in particular countries. Goel (2016) studied and reported the policies, challenges, and outlook of solar rooftop in India. It is reported that with a strong commitment to increasing the renewable sources based energy capacity to 175 GW by 2022, India has a target to install 100 GW of solar energy capacity. Of this 40 GW would be the share of grid-connected solar PV rooftop (Goel, 2016). Xin-Gang and Yi-Min (2019) studied the economic performance of industrial and commercial rooftop PV in China.

It was reported that for a small rooftop PV investment payback period is short and the risk is low. The levelized cost of electricity is reported at about 0.2727 - 0.5573 CNY/kWh. The techno-economic impact of the rooftop PV system for schools in Palestine is reported by Ibrik and Hashaika (2019) by taking three different schools as the study cases. It is reported that the application of the rooftop PV systems was experiencing a significant increase and expanding vastly as an alternative source of energy provider for different buildings.

The Government of Indonesian under the Ministry of Energy and Mineral Resources (MEMR) has set a target of 23% of renewable energy of total national energy needs by 2025 (ESDM, 2016). In this connection, the PV rooftop system regulation has recently been introduced (Government of Indonesia, 2018), i.e Permen ESDM or MEMR RegulationNo 49/2018. The regulation allows and encourages users, including residents, public, and commercial buildings to generate electricity by using PV system installed on the building roofs. The produced energy can be exported or fed into the utility grid.

The present paper discusses the current solar rooftop PV system policies in Indonesia, particularly for implementation for the residential sector. The available previous related policies on solar energy are compared, and the electricity Feed-in Tariffs (Fit) per are identified. In addition, simulation for a 3 kWp rooftop PV system for residential is done using solar PVSpot (SolarGis, 2017). The objective of this study is to demonstrate the rooftop PV system for households based on the current related policies and to figure out the opportunity benefits from the user's perspective. The information and the results from this work are expected to be useful for the development of solar rooftop PV system applications for a larger scale in Indonesia, particularly for residential sectors.

2. METHOD

The study in this present work is carried out by literature reviews and computer simulation. The related solar PV policies documents and literature were retrieved through the internet, and then they were reviewed and discussed. Implementation of solar rooftop PV system for a typical household is simulated by taking Surabaya as object location.

In terms of capacity by the National Electricity Grid (Perusahaan Listrik Negara, PLN), there are several types and sizes of installation capacity for residentials, however, the installation with 1300 kVA and 2200 kVA (BPS Kota Surabaya, 2019) are dominating the houses in urban area such as Surabaya. The amount of energy consumption with these capacities varies between 3 and 15 kWh/day. Hence, the analysis and simulation in this study are conducted for a 3 kWp capacity of the on-grid rooftop PV system, which assumes that it would be able to supply the daily energy demand. Simulation is done using PVspot online software by SolarGIS (SolarGis, 2017). In addition, economic and environmental analysis is carried out using RETScreen (Natural Resources Canada, 2017) simulation software. The geographical position of the simulated location is $-7^{o}19$'S and; $112^{o}46$' E; altitude: 3m. The other parameters for the simulation are shown in Figure 1.

3. RESULTS

3.1. Solar Energy Policies in Indonesia

Since 2013, the government of Indonesia, through the Directorate General of New and Renewable Energy and Energy Conservation (DGNREEC) of the MEMR has started to regulate solar energy sectors in Indonesia. The first policy was introduced with MEMR Regulation Number 17/2013. In the early years, solar technology was still perceived as expensive and unreliable relative to conventional technologies. This has made the lack of a market for solar energy. In the course of time, there have been the regulation changes in Indonesia as shown in the road map solar energy policies in Figure 2.

Table 1 presents the comparison of solar regulations ever issued in Indonesia. The important issues of regulations are mainly concerning: requirement of local content, feed-in tariffs, procurement method, residential application, the build own operate transfer (boot) rules, and deemed dispatch in case of force majeure. It can be seen that none of the regulations specifically regulate the rooftop PV system until the latest MEMR Regulation Number 49/2018 was introduced.

3.2. Rooftop PV System Policy

The most recent solar energy policy is in Indonesia is MEMR Regulation No. 49 the year 2018 which establishes a net metering

Figure 1: Simulation parameters for studied rooftop PV system

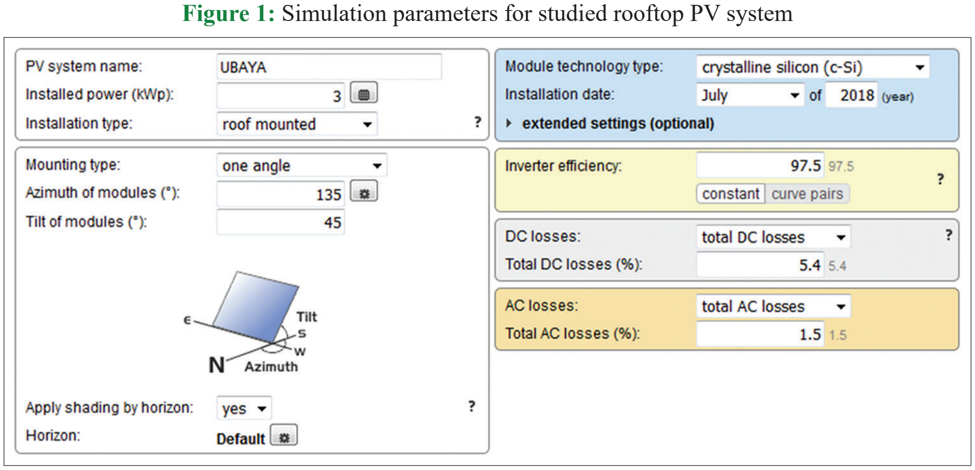
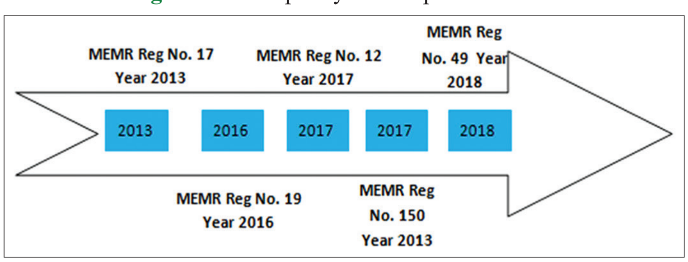


Table 1: Solar energy policies in Indonesia

Regulation items	MEMR Regulation No. 12/2017 Updated by No. 50/2017	MEMR Regulation No. 49/2018 – (Solar Rooftop)	Regulation No. 17 the Year 2013	Regulation No. 19 the Year 2016	Regulation No. 12 the Year 2017, Updated by Regulation No. 50 the Year 2017	Regulation No. 49 the Year 2018 – (Solar Rooftop)
The requirement of local content			Yes	Yes	Yes	Yes
Feed-in tarrifs			US$ 0.30/kWh (using modules with >40% local content) US$ 0.25/kWh (using modules with <40% local content)	The range between US$ 0.145 – 0.25/ kWh depending on the project location	The tariff should be lower than the National supply cost of electricity (National BPP) or no more than 85% of local electricity supply cost (regional BPP) which ranges from US$ 0.048 – 0.144/kWh depending on the location	Net metering scheme Exported electricity will be offset with imported electricity from PLN Exported electricity is valued at 65% for compensation If the export is higher, the balance can be accumulated for up to 3 months before it expires 7
Procurement method			Auction based on quota per annum Direct appointment allowed if only 1 company bids	Auction based on quota for certain pre-determined regions Project size per developer is subject to a limit based on the available quota in the region	Direct selection based on quota capacity	Self-procurement
Residential application			Not regulated	Not regulated	Not regulated	Regulated
BOOT			No	No	Yes	No
Deemed Dispatch in case of force majeure			Not regulated	Not regulated	In 2017, MEMR released several regulations concerning deemed dispatch. The latest issue was No 10/2018, wherein the case of force majeure (from a natural disaster), PLN is not obligated to pay deemed dispatch to IPPs	Yes Industry/commercial rooftop users are charged with parallel operation charges which include an emergency charge

Figure 2: Solar policy roadmap in Indonesia



scheme for the customers of PLN, including the residential, commercial and industrial customers that have excess power from solar rooftop installations. Under the regulation, the installation and construction of a rooftop PV system require prior approval and verification from PLN. The process of approval and verification involves application submission to office of relevant PLN distribution unit, along with the required technical information and administrative matters, such as the PLN customer identification number, the capacity of the rooftop PV system planned to install, one-line diagram of the planned PV system, and the specifications of the equipment to be installed.

Upon customer application, PLN will make the evaluation on the application and notify the decision within 15 business days. The decision can be either approved or rejected. The installation work for the PV system can only be started after a customer gets formal approval.

With the rooftop PV system, the electricity bill for PLN customers will be calculated monthly using the export-import energy meter. The calculation is based on the energy used (kWh import) value minus energy produced by the rooftop PV system (kWh export) value. Under MEMR Regulation No 49 the year 2018, the price of electricity by rooftop PV customers that exported to the grid will be valued at 65% of the applicable PLN tariff. To illustrate, if a rooftop PV system customer exported 1000 kWh to the grid (daily accumulated for a certain month), and the customer imported 1200 kWh from PLN, the export value will be calculated as 650 kWh. In this case, the customer would be billed for 550 kWh (i.e. 650 subtracted from imported of 1200 kWh). Some key points of MEMR Regulation 49 the year 2018 are:

- The allowed capacity of the rooftop PV system is limited at a maximum of 100% of the PLN customer's installed capacity.

exemption of emergency energy charge and capacity charge for rooftop PV systems;
- The industrial users can install rooftop PV systems either off-grid on an on-grid installation. For the off-grid installations, capacity charge and emergency energy charge are exempted, while for on-grid installation will be subject to both charges.

There have been some questions raised related to the latest MEMR Regulation 49/2018, including how the electricity that exported from rooftop PV systems valued by the government, and what is the additional requirements to obtain approval prior to system installation. The multiplier of 65% applied to exported energy is considered unfavorable to rooftop PV users (Hamdi, 2019).

3.3. Implementation Study for Household

The conversion process of solar energy into electricity is affected by many factors, including materials properties and operating environment conditions. The material properties have been fixed during the manufacturing process of solar cells, while environmental operating conditions factors can be simulated to find out optimum conditions. The Solar GIS PV planner simulation results showed the potential of the site solar irradiation presented in the form daily sum of global irradiation.

The result from the simulation shows that the average values global solar irradiation on a horizontal surface in Surabaya vary between 6.81 kWh/m^2 and 4.82 kWh/m^2 with an average of 5.54 kWh/m^2/day. The global solar irradiation consists of direct, diffuse, and reflected components. The diffuse component of radiation is quite significant especially during March – October, while reflected radiation relatively small throughout the year. The monthly global from simulation results is shown in Figure 3. The global radiation in the past time was usually higher during month April – October than the other months due to dry season, meanwhile low radiation during December – March due to rainy season. However, in the present time, the season period is likely unpredictable, and further investigation should be done. Daily air tem perature showed that the ambient temperature in Surabaya varies about 26-30°C.

The results of the simulation on energy output by 3 kWp PV system presented in Figure 4. Total annual energy production from the system is found at about 4200 kWh. The lowest energy production was in December and January which is about 190 kWh. Further specific studies are recommended to investigate the main factors such as dust, shading, weather, etc to optimize the energy output.

3.4. Economic Analysis

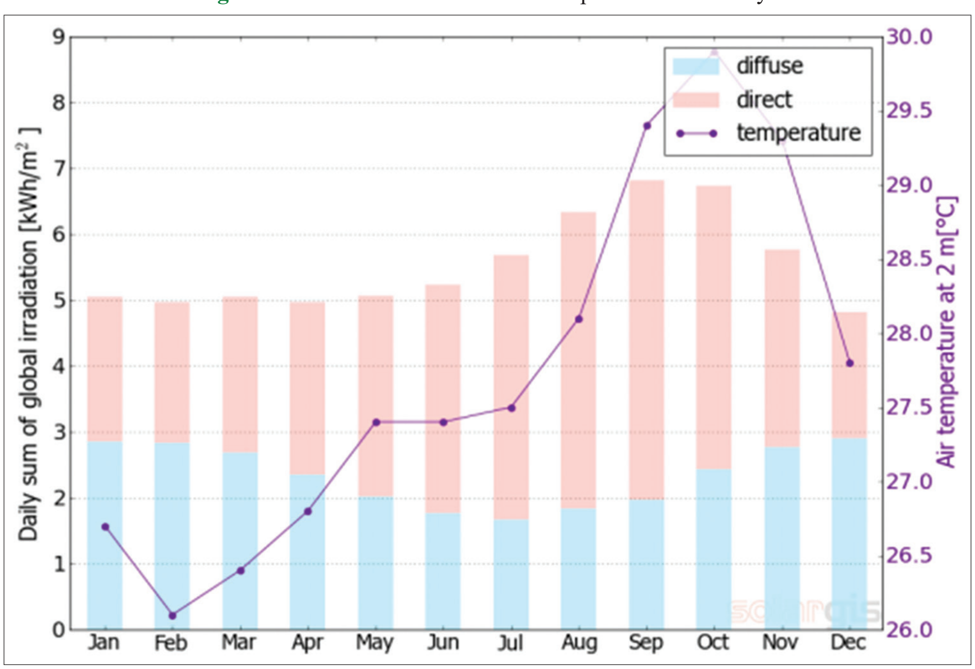
A quick market survey on the retail price of PV system components in Surabaya was conducted using the internets. There was a variation of the price for each of the components by different brands, types and vendors or suppliers. The average prizes among all surveyed data are used for economic analysis. The retail price of components and cost for installing 3kWP rooftop on-grid PV is presented in Table 2.

A financial simulation was carried out with RETScreen software with financial parameters as presented in Table 3. Assuming that the price of one kWh of exported electricity from rooftop PV

Table 2: Cost component for 3 kWp PV system

Components	Retail price or cost (USD)
3 kWp PV modules	2400
Inverters 3000 W	350
Cabling	100
Construction cost	250
Total	3100

Figure 3: Global irradiation and air temperature in Surabaya



system to the grid is 0.09 (USD/kWh), then during 1 year, based current situation above, the system will be generated earning: 4.200 (kWh/year) ×0.09 (USD/kWh) ×1 (year) =378 (USD/year). Lifetime for PV panels is considered about 20 years, while for inverters are 6-7 years.

Table 3: Simulation parameters for financial simulation

Parameters	Value
Debt ratio	50%
Debt interest rate	6%
Inflation rate	5%
Project life	20 year
Electricity export rate	1.2 USD/kWh
GHG emission factor	0.709 tCO_2/MWh
debt term	10 year
Capacity factor	14%

The annual cumulative cash flows are presented in Figure 5. The cumulative cash flow in the figure is from the accumulation of money value of electricity produced by the PV system in comparison to system incremental of installation cost. It can be seen that under present conditions, rooftop on-grid PV system investment would give about 9-10 years of the payback period.

3.5. Environmental Analysis

Replacing fossil fuel with renewable ones for power generation would give a positive impact on the environment. It has been known that the combustion process of fossil fuels in power plants would realize GHG such as Sulphur dioxide (SO_2), nitrogen oxide (NOx), and Carbon dioxide (CO_2) to the atmosphere. Besides, it also produces a large amount of ash that needs particular handling. Mathematically, reducing GHG emissions from using 3 kWp solar panels in Surabaya (due to replace the burning of fossil fuel

Figure 4: Energy output by 3 kWp PV system in Surabaya

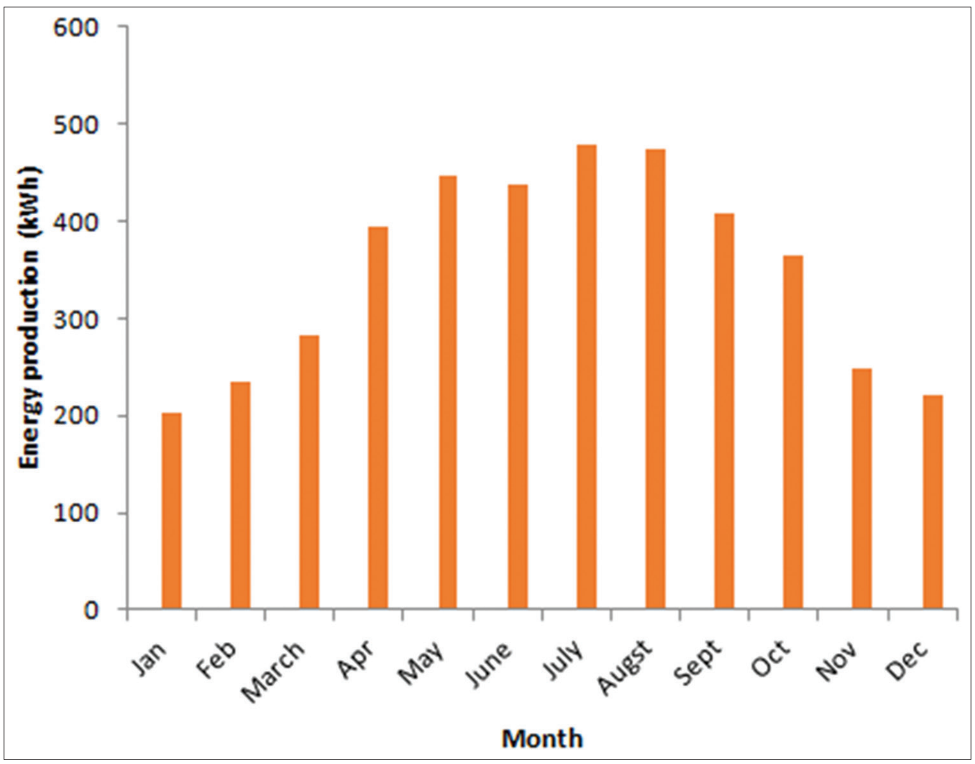


Figure 5: Cash flows cumulative of rooftop PV system investment

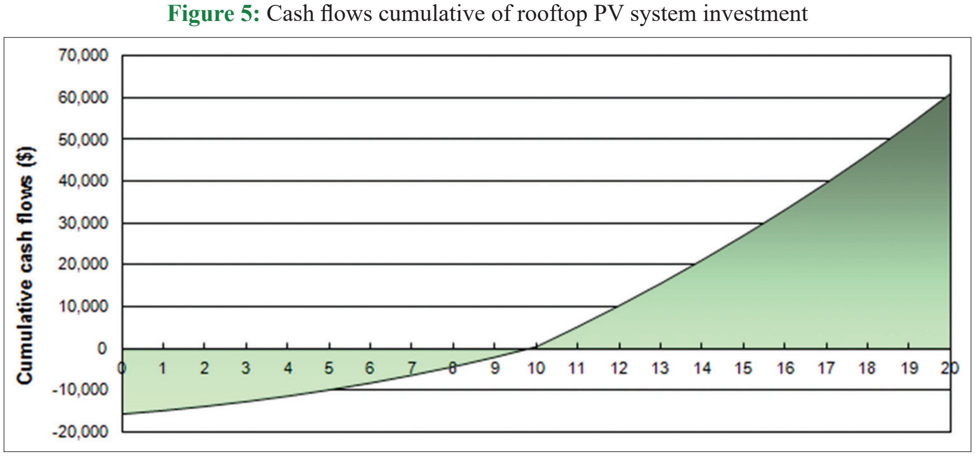


Table 4: Greenhouse gasses reduction by 3 kWp PV system

Greenhouse gasses from the coal power plant	Per kWh (g)	For annual energy production of E=4200 kWh (kg)
SO_2	1.24	5.21
NOx	2.59	10.88
CO_2	970	4075.00
Ash	68	285.6

with the equivalent of produced energy) (RETScreen, 2019) is presented in Table 4.

GHG reduction as shown in Table 4 is just representing by applying the PV system by a household. If the number of the house installing PV increases then the amount of reduction GHG should be multiplied by the number of houses with PV systems.

4. CONCLUSIONS

The regulation on solar energy application in Indonesia has been reviewed, and the simulation of the rooftop PV system a typical household in Surabaya Indonesia has been conducted. The most recent solar energy policy in Indonesia is MEMR Regulation No. 49 the year 2018 which establishes a net metering scheme for the customers of PLN, including the residential, commercial and industrial customers that have excess power from solar rooftop installations. Under the current regulation, the electricity bill for PLN customers will be calculated monthly using the export-import energy meter. The calculation is based on the energy used (kWh import) value minus energy produced by the rooftop PV system (kWh export) value.

The price of electricity by rooftop PV customers that exported to the grid will be valued at 65% of the applicable PLN tariff. The simulation shows the average values global solar irradiation on a horizontal surface in Surabaya vary between 6.81 kWh/m^2 and 4.82 kWh/m^2 with an average of 5.54 kWh/m^2/day. Energy output by 3 kWp rooftop PV system in Surabaya is found about 4200 kWh/year, with an average of 11.67 kWh/day. Economically, under present conditions, rooftop on-grid PV system investment would give about 9-10 years of the payback period. Enviontally, a 3 kWp rooftop PV system would reduce CO_2 emission about 4, 7-ton kg/year.

REFERENCES

BPS Kota Surabaya. (2019), Kota Surabaya Dalam Angka 2019. Available from: https://www.surabayakota.bps.go.id/publication.html?publikasi%5btahunjudul%5d=2019 and publikasi%5bkatakunci%5d=surabaya+dalam+angka and yt0=tampilkan.

Dang, M.Q. (2017), Solar Energy Potential in Indonesia. 19th International Conference of Young Scientist. p199.

ESDM. (2016), Rencana Umum Energi Nasional (RUEN). Available from: https://www.esdm.go.id/id/publikasi/ruen.

Goel, M. (2016), sciencedirect solar rooftop in India : Policies, challenges and outlook. Green Energy and Environment, 1(2), 129-137.

Government of Indonesia. (2018), Peraturan Menteri ESDM No. 49 Tahun 2018 Tentang Penggunaan Sistem Pembangkit Listrik Tenaga Surya (PLTS) Atap. Indonesia: Government of Indonesia.

Hamdi, E. (2019), Indonesia's Solar Policies: Designed to Fail? Available from: http://www.ieefa.org.

Ibrik, I., Hashaika, F. (2019), Techno-economic impact of grid-connected rooftop solar photovoltaic system for schools in Palestine: A case study of three schools. International Journal of Energy Economics and Policy, 9(3), 291-300.

Natural Resources Canada. (2017), RETScreen. Available from: http://www.nrcan.gc.ca/energy/software-tools/7465. [Last accessed on 2017 Sep 14].

RETScreen. (2019), Clean Energy Management Software. Available from: https://www.nrcan.gc.ca/energy/retscreen/7465.

SolarGis. (2017), Solargis PvPlanner. Available from: http://www.solargis.info/pvplanner. [Last accessed on 2017 Mar 01].

Tarigan, E. (2018), Simulation and feasibility studies of rooftop PV system for university campus buildings in Surabaya, Indonesia. International Journal of Renewable Energy Research, 8(2), 895-908.

Tarigan, E., Djuwari, Kartikasari, F.D. (2015), Techno-economic simulation of a grid-connected PV system design as specifically applied to residential in Surabaya, Indonesia. Energy Procedia, 65, 90-99.

UNEP DTU Partnership. (2016), Indonesian Solar PV Rooftop Program. Karnataka: ISPRP.

Xin-Gang, Z., Yi-Min, X. (2019), The economic performance of industrial and commercial rooftop photovoltaic in China. Energy, 187, 115961.