Study of Rooftop Solar PV Policies that Have an Impact on Techno-Economic, and Socio-Environment in a Leading Heavy Equipment Company in Indonesia

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Abstract*—The government continues to encourage efforts to increase renewable energy, one of which is by issuing a ministerial regulation of energy and mineral resources (MEMR) 49/2018 with amendments no. 13/2019 and 16/2019. The key points of this policy are reducing the constant in charge capacity for industry, simplifying the licensing process and the existence of operating permits and certificates of operation feasibility, as well as compensation for export credit of 65% which is still deemed unfavorable. As of October 2020, 2,566 solar PV rooftop customers have registered, with a total capacity of 18.19 MWp. This research aims to not only analyze the gap policy, but also to make a case study in a Leading Heavy Equipment Company in Indonesia building on the existing PV rootop policy. By using a web-based simulation that is Helio Scope and the calculation of investment feasibility, the results are not economically profitable. This is due to the high investment value, interest rate value, and other parameters.

***Keywords*—rooftop solar PV, energy policy, gap analysis, helio scope, Indonesia.**

1. INTRODUCTION

Electric energy consumption is a key variable with economic activity and development. Electrical energy plays a role important in economic development and become an important factor that sustains people's welfare. In Indonesia every year there is an increase in the level of electricity consumption, this shows the ease of getting electricity in each region.

But the majority energy that used for electricity was source from fossil energy that has impact global warming. Indonesia has very kind of renewable energy potential, and the biggest one come from solar PV energy which is the potential value is 207.8 GW, but only 0.02% has recently been utilized.

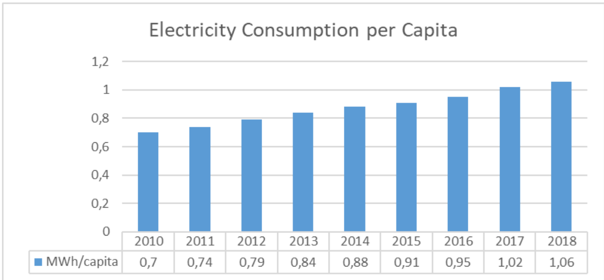

Fig. 1. Indonesia electricity consumption per capita 2010 - 2018 (BPS 2019)

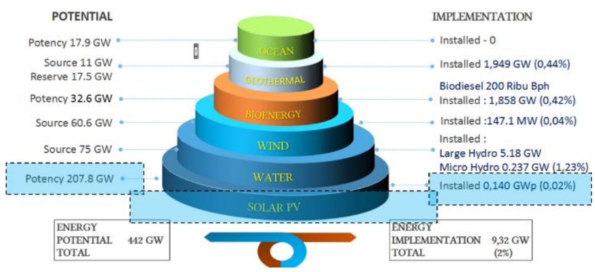

Fig. 2. Renewable energy development (MEMR 2019)

The Government has set up the energy mix for renewable energy by 23% at 2025 that has declare from National Energy Plan (RUEN), that shown in Fig 3.

Fig. 3. Energy mix target by 2025

Rooftop solar PV is an effort to increase the energy mix for RE. Rooftop solar PV user in Indonesia is too far from the target too, until 2020 only 18.19 MWp was achieved, with a total of 2346 users, even though the target was 1 GWp.

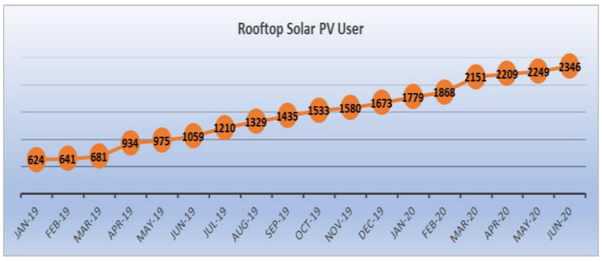

Fig. 4. Rooftop solar PV user in Indonesia by 2020

Based on the data and figures above, the achievement of the solar PV rooftop installation target is still far from the target. The policy is considered to be a barrier to achieving the target, and need more efforts so the people can be interested in installing rooftop solar PV.

This research uses a case study on a leading heavy equipment company in Indonesia. The Company has many buildings which is roofs are not utilized and potential in head office and branch office. That building will be object research plan if company will expand the rooftop solar PV depend on latest regulation.

The Objectives of this work are

- To assist in making decision easly if Company will install and expand rooftop solar PV in another buildings.
- Analysis policies about rooftop solar PV in Indonesia.
- Provide suggestions regarding the lack of solar PV policy in Indonesia.

II. LITERATURE REVIEW and RESEARCH METHODOLOGY

A. *Literature Review*

The latest literature review has explained various kinds of thoughts from previous researchers. This helps researchers to make more recent studies. In the previous study, it was related to the regulation of rooftop solar PV in residential buildings, so that the latest regulations regarding rooftop solar PV in industrial or business buildings have not been reviewed. Then the previous research explained about the financial aspects to get an investment feasibility study. In this research, the investment study starts with a simulation using a web-based application, namely Helioscope. And after that, economic calculations are carried out to determine the financial aspects and investment feasibility.

The definition of policy refers to three things, namely points of view, series of actions, and regulations. These three things become guidelines for decision makers to running a policy. Public policy is an action taken by government in regulating and controlling government both central and regional. Public policy and enforcement law has an important and strategic importance in every development. Therefore, public policy comes with specific goals to foster life together in use achieve the goals (mission and vision) that have been agreed upon. Public policy is a way to achieve goals together.

According to the Energy Law number 30 2007, a national energy policy is an energy management policy based on the principle of justice, sustainable, and insightful environment in order to create independence and national energy security.

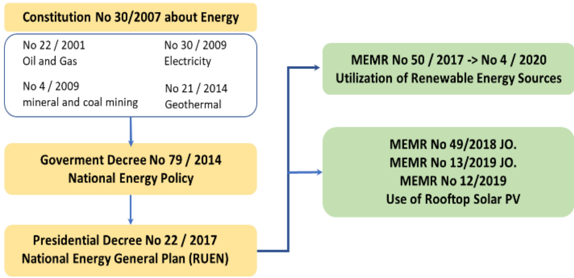

Fig. 5. Regulation about energy and rooftop solar PV

Then the energy policy developed into Government Decree no 79/2014 concerning about National Energy Policy and Presidential Regulation no 22/2017 concerning about National Energy General Plan. After that the Government through the Ministry of Energy and Mineral Resources issued regulations no 50/2017 and 4/2020 concerning about the use of renewable energy. Then in 2018 it began to develop regarding rooftop solar PV, and the Ministry of Energy and Mineral Resources issued a policy on no. 49/2018, 12/2019, and 13/2019 which is discussed details about the use of rooftop solar PV in Indonesia.

B. *Research Methodology*

This study was conducted beginning with collecting policies that related to rooftop solar PV, looking for literature, making gap analysis between current policy and ideal condition policy, implementing simulation and calculation rooftop solar PV based on current policy in head office building and branch company for retrieving the data that will be used for technical analysis, and economical analysis.

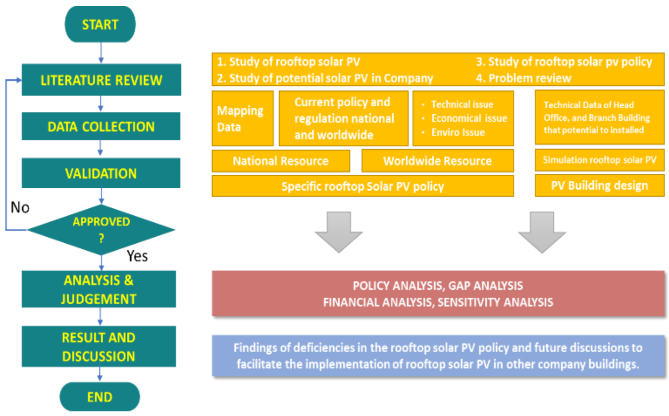

Fig. 6. Research design flow chart

Data collection techniques are the most strategic steps in research, because the main purpose of research is to get data about latest policy rooftop solar PV, that impact to the industry. There are several data collection techniques used in a study. The data collection techniques used in this study include: (1) Literature research, Conducted to obtain primary research data, by conducting a review of theories that related to the research topic which is get from library research sources. Sources of literature research can be obtained from: books, journals, seminars, previously published research results (thesis and dissertation), and other sources (internet, etc.) that are in accordance with the research topic. (2) Field research, Conducted to obtain secondary data needed in research by direct observation related to policy studies and technical and economic analysis of rooftop solar PV. Field research was carried out in the following way, like observation by doing technical analysis on the building which is used as a case study for placing rooftop solar PV and doing various kinds of measurements, for example measuring the area of an empty building roof, measure the investment feasibility of planning a rooftop solar PV. And the other way to filed research is interview by asking questions to related parties with the aim of obtaining data or information related to the problem that study.

III. RESULT

Since its establishment in 2009, the Directorate General of New and Renewable Energy and Energy Conservation (DGNREEC) of the Ministry of Energy and Mineral Resources (MEMR) has attempted to design domestic policies for the development of the solar energy sector. Unfortunately, the efforts made by the Ministry of Energy and Mineral Resources (MEMR) have not received sufficient response from from business actors and the public due to lack of information and the price of solar modules, which were relatively expensive at that time. Based on information from IRENA (2016), the price of solar modules in Europe continues to decline every year, the price of solar modules until 2016 is around below 1 USD/Watt.

The government's commitment to clean energy can also be seen by passing law No. 16/2016 concerning the ratification of the Paris Aggreement to the United Nation Framework Convention Climate Change (UNFCCC). Where the aim of the Paris Agreement is to limit global temperature rise to below 2 °C from pre-industrialization levels and to undertake efforts to limit this to below 1.5 °C. As we know the fossil energy in big capacity can make the global warming.

This policy has prompted the government to issue regulations for the installation of rooftop solar PV in Indonesia. This policy was issued by the energy policy maker in Indonesia, namely the Ministry of Energy and Mineral Resources, and in collaboration with state-owned enterprises as the operator of electricity supply in Indonesia, namely PLN.

In addition, On September 13, 2017, the Declaration of the One Million Rooftop Solar PV National Movement was launch. there is considered to provide many benefits. One of them is the electricity subsidy burden will be reduced by Rp. 800 billion to Rp. 1.3 trillion at the current rate.

The policy on the use of the Rooftop Solar Power Plant system in Indonesia is regulated by the Regulation of the Minister of Energy and Mineral Resources (MEMR) of the Republic of Indonesia number 49/2018, junto number 13/2019 and number 16/2019 which states that the customer for rooftop solar energy comes from PT Perusahaan Listrik Negara (PLN) for their purposes.

TABLE I
REGULATION ABOUT ROOFTOP SOLAR PV IN INDONESIA

MEMR NO. 49/2018	MEMR NO. 12/2019	MEMR NO. 16/2019
Must have a certificate of operation acceptance (SLO). Capacity > 200 kVA must have an operating license (IO)	An operating license (IO) and is certificate of operational acceptance (SLO) required for rooftop solar PV plants with a capacity > 500 kVA	-
Rooftop Solar PV capacity is limited to 100% from the connected power	-	-
The rooftop solar PV system consists of a solar module, inverter, electrical connection, safety connection, and EXIM kwh	-	-
If there is an overproduction of PV, the reduction in the electricity bill is only 65%. The rest becomes a deposit in the next month, and is valid for only 3 months	-	-
Must submit an application for installation with the applicable terms and conditions	-	-
For industry, there is a capacity charge and an emergency energy charge for 40 hours of operation	-	Capacity charge is reduced from 40 hours to only 5 hours per month and the emergency charge is no longer applied

Based on the comparison Table1, regarding rooftop solar PV in Indonesia, it can be seen that there is a change in policy in terms of operating license and certificate of operational acceptance, making it easier to install small-scale solar PV rooftops without complicated bureaucracy and of course costs are reduced because permits do not need anymore. Another change in this regulation is by reducing the capacity charge value for industry. from 40 hours to just 5 hours. This change is certainly very helpful for the industrial sector in installing rooftop solar PV, so that the efficiency value of PV is greater and the payback period can be shorter.

After the enactment of the Minister of Energy and Mineral Resources Regulation Number 49 of 2018, the development of Rooftop Solar Power Plant is getting better, and can immediately add as many as 600 rooftop solar PV users. Even though previously not many people were interested in this technology and still chose conventional energy. This is due to amendments and regulatory changes that are increasingly profitable for investors or potential new rooftop solar PV users in the industrial class.

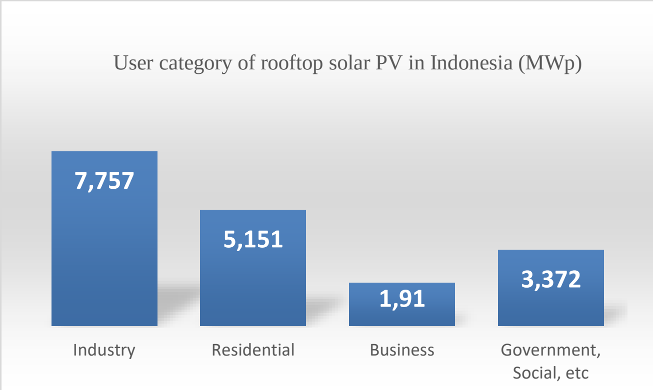

Fig. 7. Number of users category of rooftop solar PV in Indonesia 2020

Researchers also tried to compare policies regarding rooftop solar PV in other countries, such as in the USA, Germany, India, China, and Japan. In other countries, they are very serious in advancing rooftop solar PV in their country. This can be seen from the policies that have been made to continue to strive to be a priority for the government and its citizens. For example, there is an incentive policy if citizens install solar PV rooftops in their homes or office buildings. These incentives can be in the form of fiscal or non-fiscal, such as tax cuts, awarding, providing capital, loans with low interest rates, and etc. Comparative foreign policy research regarding rooftop solar PV is summarized in the Table 2.

After doing the policy mapping, the researchers then simulated using a helioscope on the building that was planned for the installation of the solar PV rooftop. Here are the results:

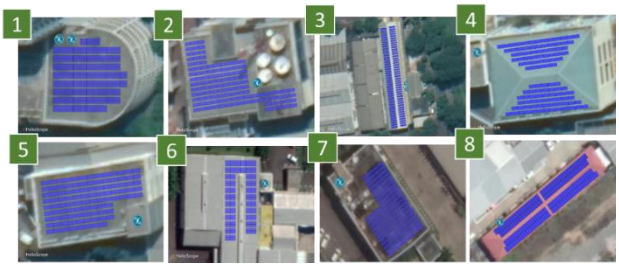

Fig. 8. solar PV rooftop installation simulation

Simulation using a web-based application with regardless of shading analysis. After placement and drawing the PV installation plan on the roof of building, we will get the number of PV modules used, the number of inverters, the value of solar radiation, and the amount of energy production from PV.

After that, the data from Table 3 is used to calculate the investment feasibility value of several buildings to be studied. By entering the formula Net Present Value (NPV), Profitability index (PI), Internal rate of returns (IRR), and Discounted payback period (DPP).

TABLE II
COMPARATION ROOFTOP SOLAR PV POLICY IN OTHER COUNTRY

Parameter	USA	Germany	India	China	Japan
Permitting and Licensing Requirements	• On-Line permitting practise • Single-window clearance	• Streamlined permittinç process • No permit fee for small residential PV system	• Single-window clearance • Technical standards are pre-defined	• No Data available	• On-Line permitting system • Requires both a pre and final inspection
Fit vs Net-Metering	• Net Metering	• Market-based net metering	• Net-Metering is mostly used	• Net-Metering (self-consumption) and FiT	• FiT policy has been implemented
Self Consumption	• Net Metering and self consumption are populai	• Self consumption is legally permitted unde the renewable energy act	• 25 of 29 states have prepared policies on net metering and self consumption	• self consumption is allowed	• Fit is the main option
Incentives	• Green building incentive soft loans, guaranteed loan, property tax exemption, capital subsidy, tax credits, up-front rebate on rooftop solar PV system cost	• Guaranteed grid interconnection for all RSPV plants and low-interest loans	• Capital subsidy, training and capacity development programs	• Renewable Energy Func with tax benefits, renewable purchase obligation (RPO) for utilities, capital subsidies as high as 30 – 50% for distributed generation	• Residential incentive of $0.20/W for systems priced below $4.10/W. RPO, tax incentives of 30% against standard purchase prices or 7% tax deduction (for small & medium enterprises)
Energy storage for rooftop solar	• Self Generation Incentive Program, and regulate the sector utility for energy storage	• Provides a grant of 30% for investment for rooftop solar PV and energy storage.Low interest loan	• Cross subsidies or investment capital are provided for systems that use energy storage	• Energy storage is in the research and development stage.	• regulations that discuss for approval big electricity storage system more than 80,000kWh

TABLE III
SIMULATION RESULT

No	Building	Power Consumption (kWh/year)	Tariff group	Qty of PV	Investment Cost (Rp/year)	PV Production (kWh/year)	PV Capacity (kWp)
1	Carpark	3.254.007	B3	166	Rp857.525.000	82.188	66,4
2	ITC	1.802.020	I3	125	Rp755.755.000	63.814	48
3	Motorpark	760.728	I3	180	Rp888.855.000	91.212	72
4	Corporate U	462.771	B3	108	Rp699.615.000	54.006	43,2
5	KMSI Office	696.410	I3	101	Rp697.675.000	54.260	40
6	Medan Offic	259.978	I3	112	Rp709.295.000	47.939	40
7	Balikpapan	869.744	I3	109	Rp702.035.000	46.351	43,6
8	Banjarmasin	388.671	I3	168	Rp844.815.000	88.743	67,2

TABLE IV
INVESTMENT FEASIBILITY STUDY

List of Buildings	Methods	Value	Explanation
Carpark building	NPV	-Rp244.068.966	Not feasible
	PI	0,72	Not feasible
	IRR	7,7%	Not feasible
	DPP	28	Not feasible
ITC building	NPV	-Rp288.805.017	Not feasible
	PI	0,62	Not feasible
	IRR	5,9%	Not feasible
	DPP	30	Not feasible
Motorbike park building	NPV	-Rp199.303.753	Not feasible
	PI	0,78	Not feasible
	IRR	8,6%	Not feasible
	DPP	27	Not feasible
Corpu building	NPV	-Rp287.336.356	Not feasible
	PI	0,59	Not feasible
	IRR	8,2%	Not feasible
	DPP	32	Not feasible
KMSI building	NPV	-Rp285.256.842	Not feasible
	PI	0,59	Not feasible
	IRR	8,3%	Not feasible
	DPP	32	Not feasible
Office Medan building	NPV	-Rp371.705.542	Not feasible
	PI	0,48	Not feasible
	IRR	7,1%	Not feasible
	DPP	34	Not feasible
Office Balikpapan building	NPV	-Rp377.689.308	Not feasible
	PI	0,46	Not feasible
	IRR	6,9%	Not feasible
	DPP	35	Not feasible
Office Banjarmasin building	NPV	-Rp173.096.662	Not feasible
	PI	0,80	Not feasible
	IRR	10,1%	Not feasible
	DPP	27	Not feasible

The calculation of the investment value is based on an interest rate of 11%, the life cycle cost includes operation and maintenance costs with a value of 1% of the investment value, and a life cycle time of 25 years based on the warranty of the PV product used.

Based on the calculations in Table 3 and Table 4, the NPV, PI, IRR, and DPP values are minus and below the interest rate, so the rooftop solar PV installation project in this study is not feasible. Then the researcher uses sensitivity analysis, by changing the investment value to be lower than before and changing the interest rate. So, we get the following results:

TABLE V
SENSITIVITY ANALYSIS BY CHANGING INVESTMENT COST

List of Buildings	Methods	Value	Explanation
Carpark building	NPV	Rp109.738.293	Feasible
	PI	1,21	Feasible
	IRR	12,4%	Feasible
	DPP	15	Feasible
ITC building	NPV	Rp114.258.240	Feasible
	PI	1,30	Feasible
	IRR	12,9%	Feasible
	DPP	12	Feasible
Motorbike park building	NPV	Rp139.899.096	Feasible
	PI	1,24	Feasible
	IRR	12,6%	Feasible
	DPP	14	Feasible
Corpu building	NPV	Rp75.553.058	Feasible
	PI	1,22	Feasible
	IRR	12,5%	Feasible
	DPP	14	Feasible
KMSI building	NPV	Rp102.055.660	Feasible
	PI	1,32	Feasible
	IRR	13,0%	Feasible
	DPP	12	Feasible
Office Medan building	NPV	Rp8.740.939	Feasible
	PI	1,02	Feasible
	IRR	11,2%	Feasible
	DPP	23	Feasible
Office Balikpapan building	NPV	Rp5.294.242	Feasible
	PI	1,02	Feasible
	IRR	11,1%	Feasible
	DPP	24	Feasible
Office Banjarmasin building	NPV	Rp159.991.200	Feasible
	PI	1,30	Feasible
	IRR	12,9%	Feasible
	DPP	12	Feasible

TABLE VI
SENSITIVITY ANALYSIS BY CHANGING INTEREST RATE

List of Buildings	Methods	Value	Explanation
Carpark building	NPV	Rp280.417.266	Feasible
	PI	1,33	Feasible
	IRR	8,6%	Feasible
	DPP	17	Feasible
ITC building	NPV	Rp110.423.002	Feasible
	PI	1,15	Feasible
	IRR	6,4%	Feasible
	DPP	21	Feasible
Motorbike park building	NPV	Rp390.241.569	Feasible
	PI	1,44	Feasible
	IRR	9,7%	Feasible
	DPP	15	Feasible
Corpu building	NPV	Rp26.306.593	Feasible
	PI	1,04	Feasible
	IRR	4,7%	Feasible
	DPP	24	Feasible
KMSI building	NPV	Rp32.660.518	Feasible
	PI	1,05	Feasible
	IRR	4,8%	Feasible
	DPP	24	Feasible
Office Medan building	NPV	-Rp83.076.833	Not feasible
	PI	0,88	Not feasible
	IRR	2,9%	Not feasible
	DPP	27	Not feasible
Office Balikpapan building	NPV	-Rp100.383.616	Not feasible
	PI	0,86	Not feasible
	IRR	2,7%	Not feasible
	DPP	28	Not feasible
Office Banjarmasin building	NPV	Rp401.202.065	Feasible
	PI	1,47	Feasible
	IRR	10,0%	Feasible
	DPP	15	Feasible

From Tables 5 and 6, it can be said that the investment value is the main parameter on the solar PV rooftop installation project, with a reference of Rp. 8,000,000/kWp, which is lower than the current best practice value that issued by Minister of Energy and Mineral Resources. Interest rates are also taken effect in the investment feasibility study, however by reducing the interest rate to 4%, this is something that is impossible in Indonesia.

As we know that by installing a solar PV rooftop, the electricity bill from the residence or building we live in should be reduced in use, because electricity can be produced from the PV produced by the sun. Researchers try to calculate the reduction in cost and power generated by the rooftop solar PV simulation of each of the buildings studied in this thesis. The table below will explain.

TABLE VII
ELECTRICAL CONSUMPTION YEARLY

No	Building	Power Consumption / year	
		kWh/year	Rp/year
1	Carpark	3.254.007	3.722.312.841
2	ITC	1.802.020	2.061.360.712
3	Motorpark	760.728	870.209.438
4	Corporate University	462.771	529.371.460
5	KMSI Office	696.410	796.635.006
6	Medan Office	259.978	297.393.167
7	Balikpapan Office	869.744	994.914.657
8	Banjarmasin Office	388.671	444.607.235
	Total Billing	8.494.329	9.716.804.515

Basse on Table 7 and Table 8, with install rooftop solar PV, the Company will get saving for 6,2% from kWh, and 5,6% from amount of money. These savings are based on annual calculations

TABLE VIII
PV PRODUCTION MEAN ELECTRICITY SAVING

No	Building	PV Production / year		Percentage Saving
		kWh/year	Rp/year	
1	Carpark	82.188	85.146.768	2,3%
2	ITC	63.814	66.111.304	3,2%
3	Motorpark	91.212	94.495.632	10,9%
4	Corporate University	54.006	55.950.216	10,6%
5	KMSI Office	54.260	56.213.360	7,1%
6	Medan Office	47.939	49.664.804	16,7%
7	Balikpapan Office	46.351	48.019.636	4,8%
8	Banjarmasin Office	88.743	91.937.748	20,7%
	Total Saving	528.513	547.539.468	

In this rooftop solar PV research, it was made with a self-use scheme, with a planned PV module capacity of less than 100 kWp. Due to the large investment value of the rooftop solar PV system, and the limited area of the roof of the building. With this self-use scheme, it is expected that all production from solar PV will be used to reduce the building's own electricity bill without having to export.

IV. CONCLUSIONS AND SUGGESTIONS

Conclusions

- In the case studies that have been carried out in several company-owned buildings, The installation of a solar PV rooftop doesn't feasible and not profitable, because the value of PV production too small if compare with electricity billing. In this study, the investment value, interest rate, and the amount of PV capacity greatly affect the economic feasibility value.
- With the current rooftop solar PV policy and supported by various initiatives, rooftop solar PV users have increased to 2,566, with a total of 18.19 MWp. Where the largest contributor from the industrial sector amounting to 7,757 MWp. This figure is still far from the General Plan for National Energy and the plan for the National Movement of One Million Solar Roofs in the range of 1 GW.
- The current strategy and government policies related to rooftop solar PV will not be able to significantly increase rooftop solar PV investment at the national level. Because there is a policy gap that is still burdensome, such as the capacity charge for the industrial sector, which should receive incentives because they have installed renewable energy.
- The investment cost which is still high, which is around Rp. 11,000,000 - 15,000,000/kWp is still a consideration for some people. Meanwhile for this research using self-use scheme, not for export – import scheme.

Suggestions

- A massive promotion is needed to market this solar PV rooftop. Of course, this will be accompanied by information about credible applicators in installation, benefits to the environment because it can reduce CO_2 carbon emissions, etc
- When referring to other countries, Indonesia can imitate it by providing fiscal and non-fiscal incentives. Such as up-front rebate or capital subsidy. Then other incentives such as reducing land and building taxes, and fixed installments with low interest can be options.
- The local government through the Ministry of Energy and Mineral Resources and State-Owned Enterprises PLN should consider give insentive to people that want to install rooftop solar PV, like giving reduction of investment costs, or long term loans at low rates.

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