Analysis Of Solar Power Plant Utilization For Public Street Lighting In Probolinggo, Jawa Timur, Indonesia

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Abstract.

Fossil fuels namely coal, petroleum, and natural gas have long been chosen as the main energy sources in meeting global energy needs. However, fossil fuels have the main problem in that their amount is limited and causes global warming. To overcome these problems, renewable energy such as solar energy can be used. Solar energy can be converted into electrical energy by using solar panels. The installation of a solar power plant certainly requires a large budget, to check its feasibility and can be simulated using PVSyst and RETScreen. In particular, PVSyst is used to search for the amount of material needed, the power capacity produced, and energy losses (there is energy lost). Then, RETScreen is used to calculate photovoltaic installation costs, operational and maintenance costs after photovoltaic installation, and emissions. Probolinggo has enormous potential to use solar power plants with Photovoltaic modules. This study simulates the installation of photovoltaic modules in Probolinggo which still has shortcomings in terms of public street lighting. From the simulations carried out, it can be concluded that Probolinggo is feasible for the installation of the solar power plant. With PVSyst, the total number of photovoltaic modules installed is 15,112 pieces. The total power generated is 10,145 MWh. Then, by using RETScreen, a photovoltaic installation fee of Rp142,978,410,000 was obtained. and annual maintenance costs of Rp1,281,870,000.

Keywords: *Renewable energy, solar power plant, PVSyst, and RETScreen.*

I. INTRODUCTION

The rapid development of industry in the era of globalization, increasing the world's electrical energy needs. To meet existing electricity needs, fossil materials are used as the main energy source, it is estimated that 80% of the total energy used globally comes from fossil fuels. Fossil fuels namely coal, petroleum, and natural gas were chosen because they are energy-rich and relatively cheap to process. However, fossil fuels have a major problem: they are limited in quantity and they release carbon dioxide into the atmosphere in the combustion process. The increase in carbon dioxide in the air is the main cause of global warming because carbon dioxide traps heat in the atmosphere [1]. To overcome these problems, renewable energy such as hydropower, geothermal, solar power, wind power, and biogas can be used instead of fossil fuels [2] [3].Since the 1970s, the use of solar energy as an alternative energy source to overcome the energy crisis has gained attention from many countries in the world. Solar energy is renewable energy because its amount is unlimited and in its use does not cause pollution that can damage the environment. Solar energy can be converted into electrical energy by using solar panels. Solar panels consist of smaller photovoltaic cells. Each cell consists of two layers of silicon, phosphorus which gives a negative charge, and boron which provides a positive charge. Solar panels or solar panels work by letting photons pass so that they can hit atoms to free electrons so that electricity can move.

In order for this cell to maintain an electric field, it is necessary to separate it using opposite charges, namely the positive and negative poles. When photons arrive, the panel absorbs and this generates an electric current that causes electrons from the silicon part to break free into the electric field, which will be drawn based on the direction of the current. In this way, electricity can flow. This whole phenomenon is called the photovoltaic effect [4].Indonesia has a huge potential for solar energy or solar energy, which is around 4.8 kWh/m^2 or equivalent to 112,000 GWp, but the energy that has been utilized is only about 10 MWp. Currently, the government has issued a solar energy utilization plan that targets an installed solar capacity of 0.87 GW or around 50 MWp/year until 2025. This number shows Indonesia's great potential in the development of solar energy in the future [5]. This is in line with Indonesia to achieve the New Renewable Energy (EBT) mix target of 23% by 2025 [6]. The installation of PLTS certainly requires a large budget, to check its feasibility can be simulated using PVSyst and RETScreen. PVsyst is software for designing comprehensive and standard solar systems for large solar systems and utilities [7]. PVSyst includes simulations of grid-connected systems, stand-alone systems, pumping systems, and direct current networks for public transportation (DC-grid). PVSyst also includes an extensive and diverse database of sources of meteorological information and data on photovoltaic components.

RETScreen is software used to simulate clean energy planning, implementation, monitoring, and reporting. RETScreen Expert which is an advanced version of the software is available in Viewer mode which is completely free [8]. RETScreen helps professionals and decision makers to be able to identify, assess and optimize the technical and financial feasibility of potential clean energy projects. The software also helps measure and verify the performance of existing facilities and helps find energy savings or additional production opportunities. The tool is provided by the Government of Canada with data derived from NASA's Prediction of Worldwide Energy Resource (POWER) project [9]. By using PVSyst and RETScreen, decision-making is easier because it can estimate the number of materials needed, the budget, power capacity, and profit.One form of solar panel utilization is a street lighting lamp. Street lighting is important to illuminate the road at night so as to reduce the possibility of accidents and reduce crime. However, street lighting requires electrical energy to be lit. Meanwhile, electrical energy is getting thinner and thinner. So, it's time to use new energy such as solar energy to be used as electrical energy. Solar panels are a tool to convert solar energy as energy so that it can be used as street lighting.

II. METHODS

This research uses 2 main applications, namely PVSyst and RETScreen. PVSyst is used to find the number of solar panels, inverters, and cables needed, the power capacity scaled, and energy losses due to energy loss. Then, RETScreen is used to calculate the initial costs required in photovoltaic installation, operational and maintenance costs after photovoltaic installation, and emissions. In PVSyst and RETScreen simulations the same type of solar modules and the same number of solar modules are used. From the results of the PVSyst simulation, the number of solar modules needed will be obtained. The number of solar modules is entered into RETScreen to find out the initial costs required in photovoltaic installation, as well as operational and maintenance costs after photovoltaic installation. Next, the results of PVSyst and RETScreen simulations were analyzed and compared to produce conclusions.

The software needed to simulate PVSyst is Google Earth Pro which is used to determine and draw the field to be built by the solar power plant at the latitude and longitude of the planned location. In PVSyst, all you have to do is determine the regional database, analyze the optimum tilt and azimuth that have been obtained in the Global Solar Atlas, adjust the pre-sizing, select the PV module and its capacity, choose the inverter and number of modules and string, then the simulation results will be obtained.While the workflow in RETScreen, of course, must determine the destination location first. After that, it is necessary to select the type of facility, power needed, initial costs, and O&M costs. After that, the results of cost, emissions, finance, risk, and electricity production analysis will appear every week, month, and even year.

III. RESULT AND DISCUSSION

In this section, the results of the simulation carried out are included and at the same time, a comprehensive explanation is given. There are four things that will be discussed in this section, namely solar panels, location, PVSyst, and RETScreen.

Solar Panel

The solar panel used in this simulation is a SunPower solar panel with the mono-si-SPR-E20-435-COM model both for PVSyst and RETScreen as in Fig. 1 and Fig. 2. This solar panel uses a monocrystalline type because it has a wide spectral absorption range resulting in higher efficiency and longer life span, and can work in low lighting [10]. Sunpower solar panels were chosen because they are one of the best efficiency solar panels with efficiencies between 20.7%-22.8%. This solar panel has a capacity of 435 W and with an efficiency of 20.7%, the power produced is much greater than using solar panels with low efficiency [11].

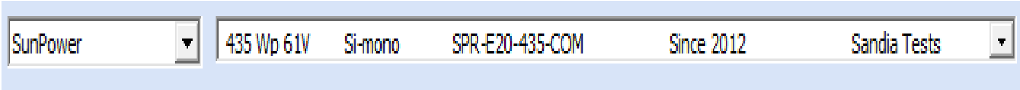

Fig 1. Solar Panel in PVSys

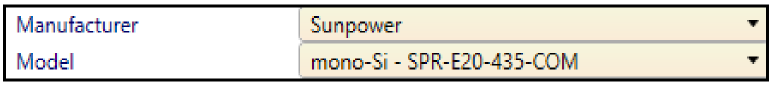

Fig 2. Solar Panel in RETScreen

FTIR and Raman's spectroscopies were used to identify binding media, SEM-EDS was used to identify inorganic pigments and fillers, and Py-GC/MS was used to identify minor binders and plasticizers. Results are presented in Table 1.

Location

The location chosen for the study was Probolinggo, East Java. That's because this area still has shortcomings in the public street lighting section [12]. After being viewed through the Global Solar Atlas page such as in Fig. 3, Probolinggo has a fairly high Global Horizontal Irradiation value, which is 5,741 $\frac{kwh}{m^2}$ per day.

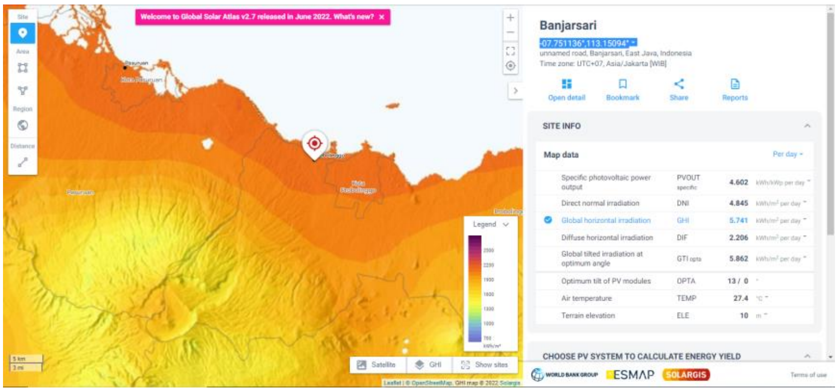

Fig 3. Global Horizontal Irradiation in the Global Solar Atlas

This shows that Probolinggo has enormous potential to use solar power plants with Photovoltaic modules. The use of Photovoltaic will certainly have a positive impact on Probolinggo, especially in reducing carbon gas emissions.

PVSyst

The orientation consists of Tilt and Azimuth obtained from the Global Solar Atlas website. Tilt describes the vertical angle of the solar panel and azimuth describes the angle of rotation from west to east to find north and south. North is characterized by azimuth 0°, east with azimuth 90°, south with azimuth 180°, west with azimuth 270°, northeast with azimuth 45°, southeast with azimuth 135°, southwest with azimuth 215° and northwest with 315° [13]. From the Global Solar Atlas website, the optimum tilt is 13°, which means the vertical angle of the solar panel is 13°. Then, we get the optimum azimuth is 0° which means the solar panel faces north which is shown in Fig. 4.

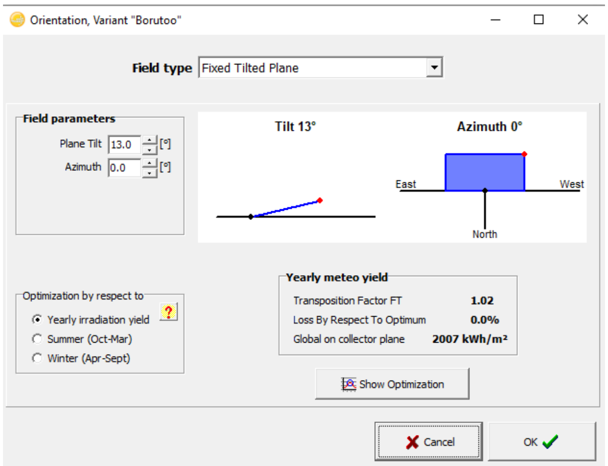

Fig 4. The orientation of solar panel in the location

There are three main parts contained in the system section. The first is the type of Photovoltaic module used, where in this simulation using Sunpower modules which have the highest level of efficiency among other Photovoltaic modules. The second is the inverter type. The inverter itself functions to convert DC electricity into AC. In this simulation, the type of inverter used is generic because of the limited cost to use a better type of inverter. If you have more costs, Schneider Conext can be a good inverter choice. The third is the number and design of simulated modules. The total number of Photovoltaic modules used is 15,112 pieces. The area needed to install photovoltaic modules is 32678 m^2 which is still within the wide range of available areas of 32,678.68 m^2 which is obtained from Google Earth Pro.

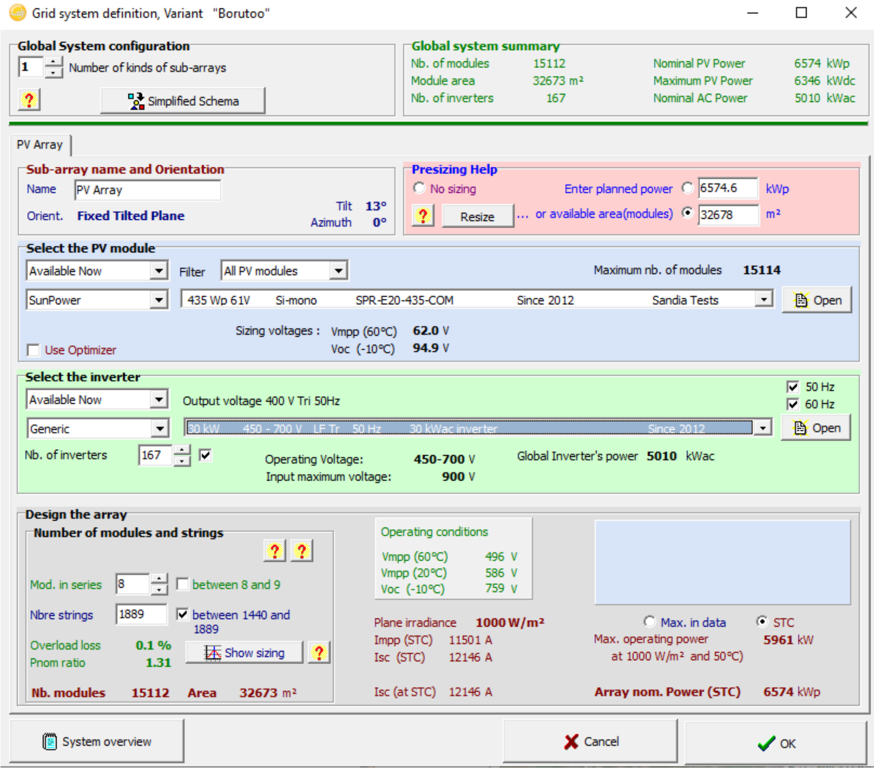

Fig 5. Global Horizontal Irradiation in the Global Solar Atlas

Fig. 6 is the result of PVSyst. From the simulation results, system production, specific production, performance ratio, normalized production, array losses, and system losses were obtained. System production shows the total energy production for a year used to evaluate the results and benefits of the PV system created. In this system, a production system of 10,145 MWh/yr is obtained. This shows that the total energy production in a year is 10,145 MWh. Specific production is an indicator of production based on available irradiation (location and orientation). In this system, a specific production of 1543 kWh/kWp/yr was obtained. The performance ratio describes the quality of the system itself. In this system, a performance ratio of 0.771 or 71% is obtained. Normalized production shows the energy lost to cool PV, which is used to assess the performance of PV systems.

In this system, normalized production of 4.23 kWh/kWp/day is obtained. Array losses are defined as all events that cause the output energy of the array to be less than the nominal output power on a PV module under STC conditions. In this system, an array of losses of 0.94 kWh/kWp/day is obtained, which shows a considerable energy loss, this can occur because solar panel modules are used very much. System Losses are caused by inverters in grid-connected systems, or battery inefficiencies in a stand-alone state. In this system, system losses of 031 kWh/kWp/day are obtained. So, from the simulation results, system production of 10145 MWh/yr, specific production of 1,543 kWh/kWp/yr, performance ratio of 0.771 or 77.1%, normalized production of 4.23 kWh/kWp/day, array losses of 0.94 kWh/kWp/day, and system losses of 0.31 kWh/kWp/day.

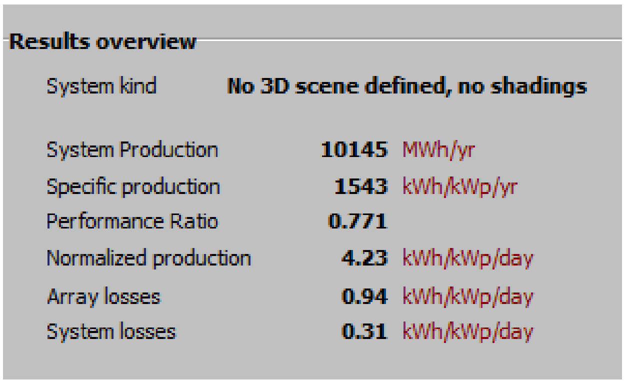

Fig 6. PVSyst result

RETScreen

RETScreen is used to determine installation costs and future predictions from the economic side and reduce greenhouse gas emissions.

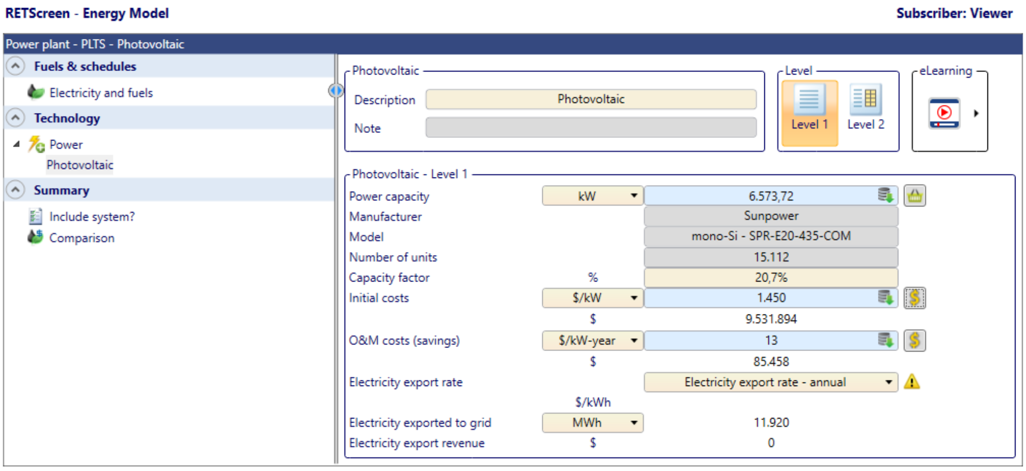

Fig 7. Photovoltaic installation cost data

The initial cost used for the installation of photovoltaics in this simulation is 9,531,894 USD or around Rp142,978,410,000-. The maintenance cost incurred for photovoltaic is Rp1,281,870,000. Although the installation cost can be said to be high, in fact, there are savings when photovoltaic starts to operate.

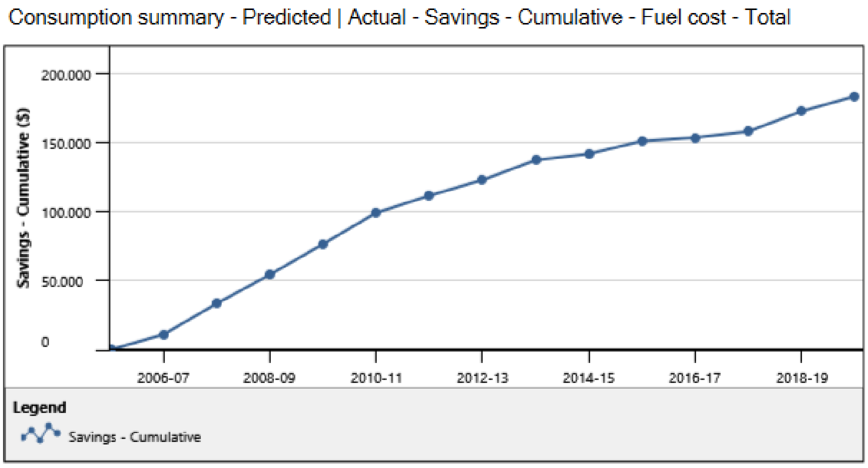

Fig 8. Data savings after photovoltaic installation

Based on the Fig. 8, in the first year, there were no savings because photovoltaic had not been installed in Probolinggo. As time goes by, we can see the savings graph is always increasing. In 2008-2009, the total savings made were more than 50,000 USD. In 2019, the savings made were 180,000 USD. The graph is increasing because people are starting to wake up to the existence of Solar Power Plants and starting to leave Steam Power Plants from coal.

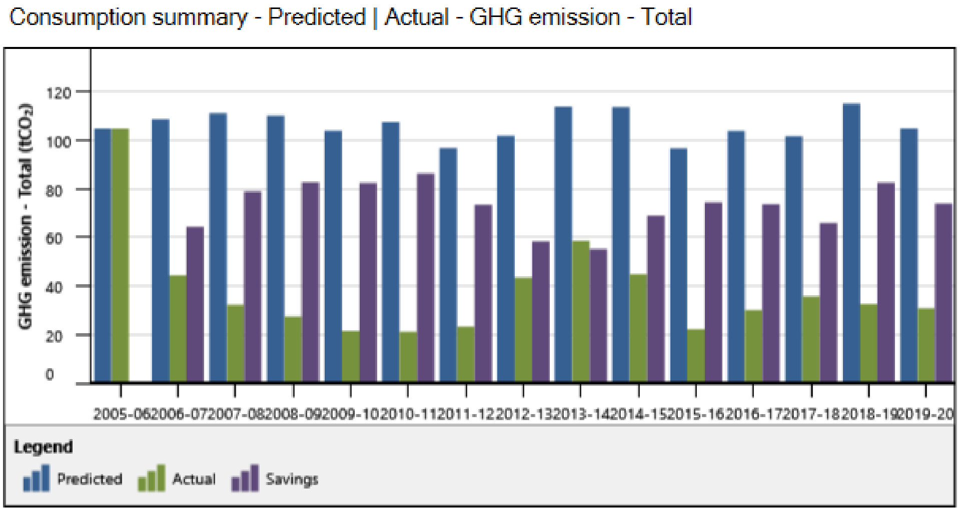

Fig 9. Gas emission forecast graph

Fig. 9 explains the reduction in gas emissions due to photovoltaic installation. Seen in 2005-2006, there was no decrease in gas emissions. In the following year (after the installation of photovoltaic), gas emissions dropped from 107 to 42. The following year also had a similar decline and it proved that the installation of photovoltaic modules had a positive impact on the environment in Probolinggo.

IV. CONCLUSION

Solar Power Plants that use photovoltaic modules are one way to reduce greenhouse gas emissions. This study aims to simulate the installation of photovoltaic modules in Probolinggo which still has shortcomings in terms of public street lighting. Using the Global Solar Atlas page, it is shown that Probolinggo is a place that has excellent potential, with a Global Horizontal Irradiation of 5,741 kWh/m^2. By using RETScreen, a photovoltaic installation fee of Rp142,978,410,000 was obtained and maintenance costs per year of Rp1,281,870,000. Although the cost of installing and maintaining photovoltaics is high, in fact, there are savings that always increase every year. In addition, photovoltaic installations also help Probolinggo in reducing greenhouse gas emissions. It can be concluded that Probolinggo is feasible for the installation of the solar power plant.

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