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Solar Panel Education as a Renewable Energy System for Students of SMAN 20 Surabaya

Reza Sarwo Widagdo[1(*)], Puji Slamet[2], Balok Hariadi[3], Ratna Hartayu[4], Izzah Aula Wardah[5]
[1,2,3,4,5]Department of Electrical Engineering, Universitas 17 Agustus 1945 Surabaya, Indonesia

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ABSTRACT

Introduction of Solar Panels as a Renewable Energy System for high school students in Surabaya City. In particular, the city of Surabaya can be an effort to support the realization of the Sustainable Development Goals (SDGs) program. The team has held online discussions with partners, namely SMAN 20 Surabaya to carry out the introduction of solar panels as a renewable energy system to students at SMAN 20 Surabaya. The purpose of community service is to socialize the use of solar power plants through learning activities (education) and solar power plants training for school students and teachers. The method used in this activity is divided into three stages. In the first stage, field observations were carried out to find problems related to the availability of electrical energy in schools. In the second stage, the implementation of community service includes the delivery of solar panel material with lectures, demonstrations, and the design of solar power plants systems at schools. In the third stage, it is an evaluation or feedback stage by giving questionnaires to participants. The results of this community service activity provide information on understanding solar panels and batteries in the good category. Practical activities need to be taught to student, so solar power plants teaching aids are needed at the school. The team made an educational activity for students, namely a demo of converting solar energy into electrical energy. The implementation of this community service has been carried out well.

(*) Corresponding Author: rezaswidagdo@untag-sby.ac.id

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INTRODUCTION

Sources of reserves of fossil energy sources or petroleum have decreased every year. In addition, the production of fossil energy has also decreased, while the consumption of fossil energy (petroleum) has increased by 6% annually. This is because the amount of demand for fossil energy sources is not comparable to the available energy sources. As a result, Indonesia imports petroleum from other countries to meet energy consumption in society (Priyohadi, K., et al. 2020). The dependence of power plants in Indonesia on the use of non-renewable energy sources to produce electricity as fuel for power plants is still quite large. Indonesia is a country located on the equator, with abundant sources of solar energy. This source of solar energy can be obtained every day and the use of this source to generate electricity does not cause environmental pollution (Handoko & Jaka, 2021). In addition to solar energy, the potential for wind energy to be integrated into microgrid systems has also begun to be developed in Indonesia (Adhi Kusmantoro et al., 2021). The dependence of power plants in Indonesia on the use of non-renewable energy sources to produce electricity as fuel for power plants is still quite large (Defi et al., 2020). Indonesia is a country located on the equator, with abundant sources of solar energy. This source of solar energy can be obtained every day and the use of this source to generate electricity does not cause environmental pollution (Kristiawan et al., 2019). To

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increase the use of solar panels, an analysis of the output power is carried out. The output power of solar panels that have been obtained is influenced by the intensity of solar radiation or weather when data is collected (Ta'lim Nurhidayat, 2021). Solar panels can not only be used for residential homes, but also for a source of electricity on agricultural land. When the weather is not good, it is necessary to consider the use of batteries, so that the need for electrical energy can be met (Oya Imam Sanjaya et al., 2019). Photovoltaics are devices that can convert sunlight directly into electricity.

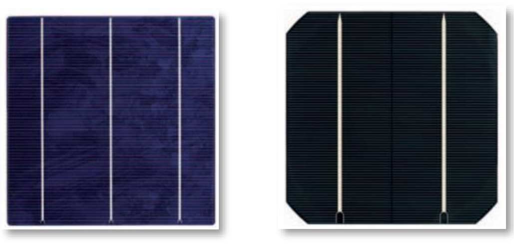
The word photovoltaic is usually abbreviated as PV. Semiconductor materials such as silicon, gallium arsenide, and cadmium telluride or copper indium deselenide are usually used as raw materials. Crystalline solar cells are usually widely used to make solar cells. The types of crystal solar cells (PV cells) that are widely available on the market are:

1. Monocrystalline solar panels: use pure silicon produced by a fairly complicated crystal-growth process with a thickness of around 0.2 – 0.4 mm. The efficiency is quite high, ranging from 13 – 19% (Andriawan, 2017).
2. Polycrystalline solar panels: sometimes called multi-crystalline, solar panels are made from polycrystalline cells which are cheaper and their efficiency is still below mono-crystalline, around 11 – 15% (Meliala, 2021).
3. Amorphous solar panels: this type is not a real crystal, but is a thin layer of silicon deposited on a base material such as metal or glass with a free surface shape. The efficiency is smaller, namely around 5 – 8%. More complete types of solar (PV) cells are listed in Table 1, where the cell area required to produce 1 kWp of power is also listed (Sukmajati, 2015).

Table 1. Solar Cell Materials and Their Efficiency

Cell Material	Modul Efficiency	Surface Area Need for 1 kWP
Monocrystalline Sillicon	13 – 19 %	5 – 8 m^2 (3 pcs modules)
Polycrystalline Sillicon	11 – 15 %	7 – 9 m^2 (4 pcs modules)
Micromorphous Tandem Cell (a-Si / µc-Si)	8 – 10 %	10 – 11 m^2 (6 pcs modules)
Thin Film Copper Indium/Gallium Sulfur/Diselenide (CI/GS/Se)	10 – 12 %	8 – 10 m^2 (4pcs modules)
Thin Film Cadmium Telluride (CdTe)	9 – 11 %	9 - 11 m^2 (5 pcs modules)
Amorphous Sillicone	5 – 8 %	13 – 20 m^2 (8 pcs modules)

A solar cell in producing electrical energy does not depend on the size of the silicon field area, and will constantly produce energy ranging from ± 0.5 V - max 600 mV at 2 A, with a solar radiation power of 1000 W/m^2 = "1 Sun" will produce an electric current (I) of around 30 mA/cm^2 per solar cell. The common colors of solar cell materials sold on the market are shown in Table 1, there are two types of shapes, namely Poly Crystalline and Mono Crystalline which are shown in Figure 1 (Saga, 2010).



(a) (b)

Figure 1. Rooftop Solar Panel Silicone Material (a) Polycristalline (b) Monocristalline

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Therefore, the purpose of community service activities at SMAN 20 Surabaya is to socialize the utilization of solar power plant through solar power plant learning (education) activities and training for students and school teachers. Activities are carried out with counseling, demonstrations or practice using solar power plants components, and solar power plants planning at SMAN 20 Surabaya (Figure 2).

Figure 2. The Location of SMAN 20 has the Potential for Installing a Solar Power Plant.

METHODS

In accordance with the objectives of community service activities, the method used is divided into three stages, namely observation/survey, implementation, evaluation. In the early stages a field survey was carried out, namely at the SMAN 20 Surabaya by holding discussions with the school principal and teachers regarding teaching materials about solar panels. In the survey, the Community Service Team is also looking for information on the amount and capacity of the electricity load in schools. In addition, observations were made of the intensity of solar radiation at the school location. In this early stage it can be seen the level of students' and teachers' understanding of solar power plants, the need for electricity in schools, and the potential for solar energy in school locations. The second stage is the implementation of community service through the delivery of solar power plants theory and its components. In this stage lectures are carried out in the classroom with teacher and school student participants, conducting solar power plants demonstration outside the classroom, and asking questions during the activity. In this implementation stage, the community service team also designed a solar power plant with an off-grid system for electricity needs in schools. The third stage is the feedback stage from community service participants. In this stage a questionnaire is given to determine the level of understanding and interest in solar power plants. These three stages can be shown in Figure 3.

Stage 1	**Stage 2**	**Stage 3**
In the early stages, field observations were carried out to find problems related to the availability of electrical energy in schools	In the second stage, the implementation of community service includes the delivery of solar panel material with lectures, demonstrations, and solar power plant system.	In the third stage, it is an evaluation or feedback stage by giving a questionnaire to the participants.

Figure 3. Activity Steps

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The location of the school has a large radiation potential, so using solar panels in the solar power plant system as a source of electrical energy can reduce dependence on PLN electricity. The service participants are 10 teachers and grade 10 and 11 students at SMAN 20 Surabaya, totaling 60 students. After the completion of the activity or after the third stage, monitoring is also carried out every month for one year to find out the benefits of the community service activities that have been carried out.

RESULT AND ANALYSIS

Result

At the implementation stage, lectures were held in the classroom which were attended by all teachers and students of SMAN 20 Surabaya. In this stage an understanding of the conversion process from solar radiation to DC electricity using solar panels is given. In addition, an explanation of other components used in solar power plant is given. Explanation of the material in class is shown in Figure 4.

Figure 4. Submission of Material in Classroom

Presentation of material related to renewable energy, especially solar panels as a complex system to become a Solar Power Plant (Ulinuha et al., 2022). Solar panels absorb sunlight and convert it into electricity. The electricity generated from the solar panels enters the solar charge controller (SCC) device which is used to regulate the outgoing electric current. Electricity from the SCC can be utilized directly connected to direct current (DC) electronic components such as DC lamps or stored in batteries/accumulators. The electricity stored in the battery can be used directly to DC electronic components or converted into alternating current (AC) electricity using a DC to AC power inverter.

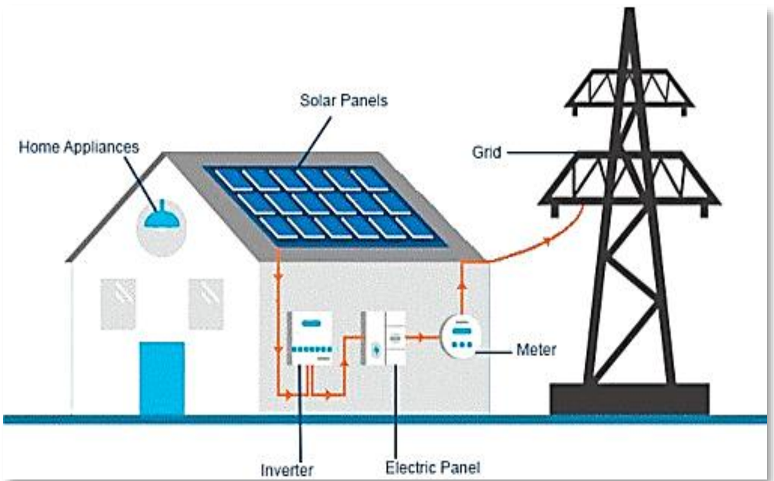

Figure 5. Solar Power Plant Scheme (Helman, 2014)

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The electricity converted by the inverter has been turned into alternating current electricity which can later be used to power electronic devices such as AC lights, water pumps, etc. The use of batteries / accumulators as a storage of electrical energy can run even in the afternoon, at night, or during rainy conditions. The solar power plants work scheme with its electronic components is shown in Figure 5. To show solar power plants works, practice is carried out directly outside the classroom. In this demonstration activity, a 50 WP solar panel, a 30 Ah battery, a 1 kW inverter, a 10 A solar charge control, and a 20 W lamp load were used. This hands-on practical activity with students is shown in Figure 6.

Figure 6. Practice Activities with Students

The solar panel used in this test is a 50 WP. The test was carried out using an incandescent light load. This is done to determine the characteristics of the output voltage and current of the solar panel. Test time is 09.00 to 14.00 with sunny weather conditions. Basically, this test aims to find out characteristics of the solar panel. Which is where the solar panel has a peak. Solar panel testing data can be seen in Table 2.

Table 2. Solar Panel Test Data

Time	Voltage (Volt)	Current (Ampere)
09.00	16,42	0,0017
10.00	16,54	0,0017
11.00	16,52	0,0016
12.00	18,87	0,0016
13.00	18,57	0,0016
14.00	18,41	0,0015

The output power generated by the solar cell module is obtained from the times between the voltage and current obtained from the solar cell module (Rusmaryadi et al., 2018). Calculation of output power using the following formula:

$$P = V \times I \tag{1}$$

where,
P = Output Power (Watt)
V = Voltage (V)
I = Ampere (A)

From these data it can be seen that the maximum power output of the solar panel is 0,031 Watt, namely the data obtained at 12.00 with a voltage value of 18,87 Volts and a current of 0,0016 Ampere (Table 3). It is known that the efficiency value of a solar cell module is very low (Tira et al., 2020). The PV efficiency value reaches 15% (Nadandi et al., 2021). The efficiency of a solar cell module is determined by the number of photons of absorbed sunlight (Saputra &

Gusa, 2022). The efficiency value (η) of a solar cell module is obtained from the quotient of the output power (Pout) with the input power (Pin) and is expressed in units of percent (%).

Table 3. Output Power Calculation Results

Time	Power Output (Watt)
09.00	0,028
10.00	0,028
11.00	0,027
12.00	0,031
13.00	0,030
14.00	0,029

The resulting efficiency value indicates the level of reliability of photovoltaic (Utomo et al., 2017). Previously the electrical engineering community service team succeeded in saving energy by installing a solar power plant to supply renewable energy to farms in Sajen village (Widagdo et al., 2023). In terms of economic value, we can calculate if the field trials use solar cells with a capacity of 440 WP. The following is a calculation for the savings value by using a solar cell with a capacity of 440 WP:

1. Example: Solar panel installed @440 Wp x 6 sheets = 2.640 Wp = 2,64 kWp
2. Energy that can be absorbed by solar panels:
   00.00 until 06.00 = 0 Wh
   06.00 until 18.00 = 3000 Wh
   18.00 until 24.00 = 0 Wh
   Total Energy = 3000 Wh/day
   Total Energy (Per Months) = 3000 × 30 = 90 kWh/month
3. Energy obtained for one month:
   2,64 kWp × 90 kWh = 237.6 kWh
4. Electricity savings that can be done for one month:
   237.6 kWh × Rp. 1.444,70 = Rp. 343.260, 72/month


Figure 7. Questionnaire Filling by Participants

Installing solar panels in Indonesia is very profitable because Indonesia is located on the equator with the sun shining all year round and has an average daily radiation of 4.85 kWh/m^2 (Overen & Meyer, 2022). After this activity, monitoring is carried out every month to follow up on the use of solar power plants in schools. The success of the activities that have been carried out can be seen from the evaluation results and the amount of student interest in learning about solar power plants and schools to start using solar energy as a source of electricity. This is very beneficial for students as the younger generation to develop renewable energy as a source of electricity in Indonesia. In the evaluation stage, questionnaires were given to service participants to find out their interest and level of understanding of solar power plant. At this final stage students were asked to fill out a questionnaire regarding their understanding of Solar Panels, Batteries and Inverters in practice. Figure 7 is the condition when the participants filled out a questionnaire prepared by the electrical engineering community service team.

Education about solar panels helps increase public awareness of the potential and benefits of solar energy. People are becoming more aware that solar energy is a clean, environmentally friendly and renewable energy source. Additionally, Education about solar panels allows individuals and communities to understand how to generate their own energy. By installing solar panels in their homes or buildings, people can reduce their dependence on conventional power grids and even generate a surplus of energy that can be sold back to the grid. Thus, education about solar panels and solar energy has a broad impact on society, the economy, and the environment. With a better understanding of the potential of this renewable energy, society can contribute to the shift towards cleaner and more sustainable energy. The feedback provided becomes information data for the Service Team to evaluate the activities that have been carried out as presented in Table 4.

Table 4. Evaluation of Activity Results

Category	Percentage (%)
Understanding of Solar Panels	85
Understanding of Battery	79
Understanding of Inverters	65
Solar Power Plants Practice	48

Analysis

The benefits of installing a solar power plant are starting to be felt by various parties. Starting from the household segment that installs solar power plants on school roofs, to the industrial segment, government buildings and the agricultural sector. Various parties are starting to switch and decide to build solar power plant installations because they are aware of the various benefits of solar power plant installations. Ease of managing a solar power plant is one of the many benefits of installing a solar power plant that can be enjoyed directly. What's more, the solar power plant can work immediately after installation is complete and the free electricity produced can be used immediately. There are also many other benefits of installing a solar power plant and have a bigger impact. From the aspects of cost, investment, natural environment and lifestyle, the presence of a solar power plant will be significantly influenced. Surabaya is one of the cities that has the potential for high solar radiation in Indonesia. The average solar radiation received by the city of Surabaya is 5.29 kWh/m2 every year. This potential can be utilized for daily needs such as using solar panels. Recommendations for installing solar power plants can be adjusted according to the design in Figure 8 by installing them on school roofs (Rumokoy, 2020).

The benefit of installing solar power plant built in schools is as a direct learning medium for students, especially for students. Solar power plant can be an example of direct application of what they learn. Having solar power plant at school can give students the opportunity to learn it more clearly through direct observation or practice. Then, schools are institutions that are the hope for producing superior generations in the future. It is fitting that schools should also be pioneers for good breakthroughs, including in terms of the transition to Renewable Energy which is expected to be a solution to current energy problems. Building solar PV installations in the school environment can be a concrete manifestation of school action to contribute as a pioneer in the energy transition and provide positive inspiration for students and teachers.

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Another benefit of installing a solar power plant is that it helps reduce air pollution due to the burning of fossil fuels in the electricity generation process. Currently, fossil fuels are still the main energy source for generating electricity in Indonesia. By building a solar power plant installation, the school directly plays a role in reducing electricity production from fossil fuels. Reduced carbon emissions can reduce air pollution and global warming indirectly.

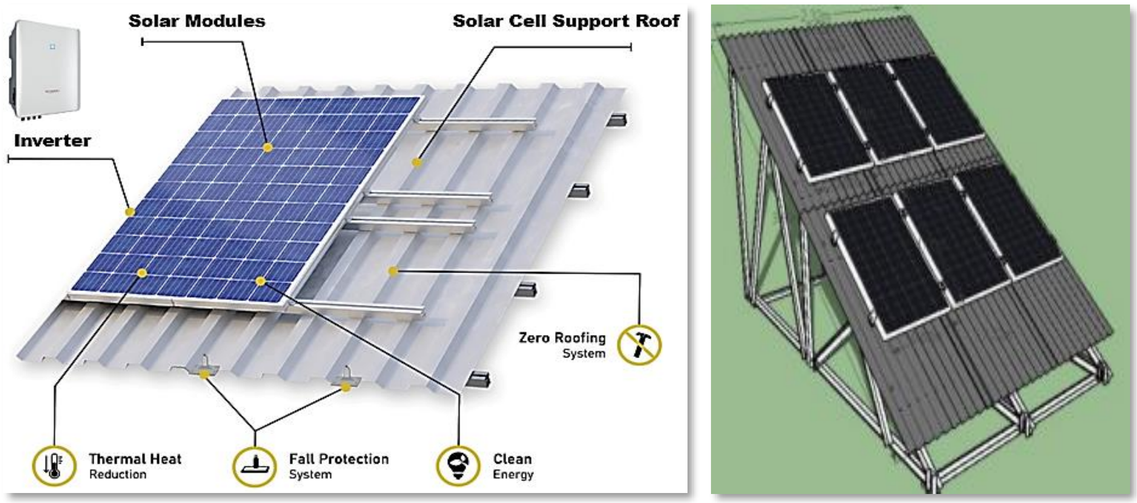

Figure 8. Application of Rooftop Solar Power Plant Design

CONCLUSION AND RECOMMENDATION

Conclusion

Based on the results of the implementation of community activities, information on understanding solar panels and batteries is in the good category. Practical activities need to be improved for grades 10 and 11 students, so solar power plants teaching aids are needed in these schools. It can be concluded that the interest of schools, especially to find out more about solar power plants with great interest for students as the younger generation, is very important for developing renewable energy as a source of electricity in Indonesia. Solar power plant installation can increase the value of school building assets. Currently, properties that have solar panels are valued higher than buildings that do not have a solar power plant. Therefore, school buildings that are equipped with solar power plants tend to become more expensive and are predicted to continue to increase in value in the future.

Recommendation

Installing a Solar Power Plant on the roof of a school can be a good step to reduce energy consumption and support environmental sustainability. Plan your solar PV installation by considering safety and maintenance. Ensure that access to the PLTS system can be done safely for routine care and maintenance. Involve students in the installation process and explain the benefits of renewable energy. This can create environmental and sustainability awareness among students. Installing rooftop solar PV at schools requires careful planning and collaboration with various related parties. With a good approach, schools can achieve long-term benefits from using renewable energy.

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