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Reducing the Threat of Electrical Hazards through the Application of Solar Energy: Realizing Child-Friendly Electricity in Elementary Schools.

[1)] ***Sutoyo Sutoyo, [2)] Ferriawan Yudhanto***
[(1,2)] Automotive Engineering Technology, Universitas Muhammadiyah Yogyakarta, Bantul, Yogyakarta
**Email: sutoyo@umy.ac.id*
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ABSTRACT

The advancement of information technology provides ease of learning. However, learning media in schools usually depends on average electrical settings and electronic devices to support information technology (IT). The learning media in Indonesia generally depends on the utilization of PLN's electrical energy. It is undeniable that electricity is a basic need in teaching and learning activities today, even though the existence of electrical installations in the midst of children saves dangers that need to be anticipated. The solution is to provide socialization and education on child-friendly technology. In this case, the school community will be introduced to utilizing and building safe electrical installations for children. In principle, some electrical components available on the market will have their own level of safety, and safe and child-friendly components must be chosen. Furthermore, electrical installations will be built with solar energy sources because the technology has many advantages, including renewable energy, without high-voltage cable networks, and providing efficiency in school operational costs. It is more important that solar electricity can work at low voltages to be safe in children's environments. The result at the activity location installed electricity from Solar Power Plant with a 300 Watt inverter to provide electricity for school computer devices. In addition, 10 outdoor lighting points are installed that are set to turn on and off automatically. The main goal to provide efficient and safe electrical facilities for children has been well realized.

Keywords: *child-friendly, electrical, solar, energy, safe*

ABSTRAK

Kemajuan teknologi informasi memberikan kemudahan belajar. Namun, media pembelajaran di sekolah biasanya bergantung pada rata-rata pengaturan listrik dan perangkat elektronik untuk mendukung teknologi informasi (TI). Media pembelajaran di Indonesia umumnya bergantung pada pemanfaatan energi listrik PLN. Tidak dapat dipungkiri bahwa listrik merupakan kebutuhan dasar dalam kegiatan belajar mengajar saat ini, meskipun keberadaan instalasi listrik di tengah-tengah anak-anak menyimpan bahaya yang perlu diantisipasi. Solusinya adalah dengan memberikan sosialisasi dan edukasi teknologi ramah anak. Dalam hal ini, komunitas sekolah akan diperkenalkan untuk memanfaatkan dan membangun instalasi listrik yang aman untuk anak-anak. Pada prinsipnya, beberapa komponen listrik yang tersedia di pasaran akan memiliki tingkat keamanannya sendiri, oleh karena itu komponen yang aman dan ramah anak harus dipilih. Selanjutnya, instalasi listrik akan dibangun dengan sumber energi surya karena teknologi tersebut memiliki banyak keunggulan, antara lain energi terbarukan, tanpa jaringan kabel tegangan tinggi, serta memberikan efisiensi biaya operasional sekolah. Lebih penting bahwa listrik tenaga surya dapat bekerja pada tegangan rendah agar aman di lingkungan anak-anak. Hasilnya di lokasi kegiatan terpasang listrik dari PLTS dengan inverter 300 Watt untuk menyediakan listrik bagi perangkat komputer sekolah. Selain itu, 10 titik lampu penerangan luar ruangan dipasang yang diatur untuk hidup dan mati secara otomatis. Tujuan utama untuk menyediakan fasilitas listrik yang efisien dan aman bagi anak-anak telah terwujud dengan baik.

Kata Kunci: ramah anak, kelistrikan, surya, energi, aman

I. Introduction

This activity is located at the Muhammadiyah Beji Elementary School, one of the Muhammadiyah Business Charities in the "Pengurus Ranting Muhammadiyah" of Gading, Gunungkidul Regency. Considering some of the problems, one way considered appropriate and wise is to build a community mainset that SD Muhammadiyah Beji is a quality school with the best educational services. Thus, it is hoped that it will attract the interest of the surrounding community to make the elementary school a priority study destination for their children. One of the important things to consider in choosing a school in addition to the quality of education, is the guarantee of security, safety, and comfort. As a place for children to learn, it is necessary to have quality and child-friendly facilities and infrastructure services [Eiser*,* *et all*, 1983] at [Novrikasari, *et all*, 2018]. Generally, children are vulnerable to danger because they have cognitive limitations. Some actions children consider safe to do are not safe from an adult's point of view.

In the current era, technological advances provide ease of learning. However, learning media in schools usually depends on average electrical settings and electronic devices to support information technology (IT). The use of information technology has a positive and negative impact depending on the ability of users to use it, including children [Saputra, *et all*. 2017]. Electrical media is generally limited to the utilization of PLN's electrical energy. It is undeniable that the existence of electricity is a basic need in teaching and learning activities today. Actually, the existence of the electrical installation in the midst of children saves dangers that need to be anticipated, considering that they do not have the ability to respond to these dangers. Moreover, outside school hours, some open contact points (sockets) of PLN electricity outside the room, including cable networks, are in an unsupervised situation, which is dangerous for children. The issue of personal safety in children is an important issue that needs the attention of parents and schools [Agnes, *et all*, 2005].

The right thought in addressing the dangers of PLN's high-voltage electricity is to choose several options, including using learning media with a DC electric current source so that a low-voltage battery power source can be chosen. In installing lighting systems, lamps with solar panels can be applied. The advantages of solar technology are installations without high-voltage cable networks, the power source in the battery can be used directly (DC current electricity) or changed using a DC to AC inverter.

Fig 1. SD Muhammadiyah Beji as a children's playground

Current technological developments in renewable energy have offered many solutions for society to replace fossil fuel consumption. This is because fossil fuels which are non-renewable energy, are used by conventional power plants for a long time and drain non-renewable energy sources so that the reserves are getting less [Anggara, *et all*, 2014]. For example, solar energy absorbed through solar cells, which are available abundantly in the universe, can potentially solve the problem of electricity availability in the community. The government has officially passed regulations related to the provision of electricity to people in border areas, disadvantaged areas, isolated areas, and outer islands. This regulation was issued in the form of a Presidential Regulation on the Provision of Energy-Saving Solar Lights (LTSHE) for People Who Do Not Have Access to Electricity [*Presidential Regulation (Perpres) Number 47 of 2017*]. The working principle of LTSHE is that energy from the sun is captured by solar panels, converted into electrical energy, and then stored in batteries.

The electrical energy inside this battery is then used to power the lights [*http://ditjenppi.menlhk.go.id/kcpi/index.php/aksi/mitigasi/implementasi/319-lampu-tenaga-surya-hemat-energi-ltshe, 2020*].

The advantages of solar energy when compared to fossil energy are that solar energy is easy to obtain because it comes from the sun itself, environmentally friendly, in accordance with various geographical conditions, installation and operation, and maintenance are not difficult, and electrical energy obtained from solar energy can be stored in batteries [Rinna, *et all,* 2019]. In this case, SD Muhammadiyah Beji deserves to be the target of service activities for the application of solar energy, considering that outside school hours, the location is always crowded as a playground for surrounding children (Figure.1). Thus can be achieved application of electrical technology that is child-friendly, and reduces concerns about the danger of electric shock in children's play areas.

II. Methodology

As previously explained, SD Muhammadiyah Beji is located less strategically than other public and private elementary schools. The distance of this school is further to reach several ABA kindergartens in the Gading region. As a result, some children of Muhammadiyah residents are forced to enter non-Muslim schools. This may be due to many factors, such as economic ability and lack of vehicle ownership, causing children to access closer schools. Therefore, to make SD Muhammadiyah Beji the first choice school, several concrete efforts are needed to ensure that the school becomes a school with the best service. However, several problems need to be addressed. Some of the problems of SD Muhammadiyah Beji as a partner are presented in Table 1.

Table 1. Partner Issues

Problems	Impact
The number of students has not met the target. Currently, the overall number of students is around 67 children.	School operational costs are very limited, and the quality and quantity of educational services are not optimal.
Limited school operational funds.	The school does not yet have good and child-friendly school facilities and infrastructure.
PLN's electrical installation network is poorly maintained due to limited school budgets.	Installation damage, voltage drops, cable insulation leaks, the emergence of electric shock, and short circuit hazards.
Lack of understanding of the school community regarding the dangers arising from electricity.	Lack of attention and efforts related to mitigating hazards arising from electricity.

Solar cells or solar panel is tools to convert solar energy into electrical energy [Zainal, *et all*, 2010]. *Photovoltaic* or PV is a technology that serves to convert or convert solar radiation into electrical energy directly. Research advances in materials science are gradually increasing the efficiency of photovoltaic systems [Jayme, *et all*, 2014]. PV is usually packaged in a unit called a module. A solar module consists of many solar cells that can be arranged in series or parallel. Solar cells have an output power constraint that is not large enough, and one method of optimizing solar cells is to use sunlight-reflecting mirrors [Rismanto, *et all*, 2014]. In its application, light intensity is one of the factors affecting solar cells' efficiency in monocrystalline silicon solar cells [Rifany, *et all*, 2022].

Applying solar power systems requires several calculations to adjust the electrical load and the selection of solar panel capacity to obtain optimal system work. Solar powerplant design is carried out to determine the size of photovoltaic cells, batteries, and Solar Charge Controller (SCC) for the solar power system. The design steps are as follows [Priska, *et all*, 2022] :

1. Determining the need for electrical power

By calculating how many watts of power are needed by each piece of equipment to be supplied by the PV system and how many hours per day of use, the result of this calculation produces power in units of watt-hours per day. However, the electrical energy produced by PLTS is not 100% usable because during the transmission period from solar panels to the end of the load (electronic devices), up to 40% of electrical energy is lost. Therefore, adding 40% of the total power is necessary (Equation 1).

Total power = (number of load x load power) x load usage time (time): (100%-40%) (1)

2. Solar panel (PV) capacity

To determine the number of solar panels needed, it is important to know what Peak Wattage (WP) is. So, Watt Peak is the magnitude or optimal nominal highest power that can be generated from a solar panel. For most homes in Indonesia, that solar panel requires about 4 hours of sunlight a day. Calculating the necessary number of solar panels is through the following Equation 2.

Solar panels=total power:optimal time (2)

3. Calculating the Number of Battery

The battery in the PLTS system is used as a component to store electrical energy generated by solar panels during the day, then drain the electricity load without PLN's electricity network at night or in cloudy weather. The electrical energy in the battery is not 100% usable. Because when in the inverter, the potential energy loss can be as much as 5%, and it is necessary to have a reserve of 5% that must be added. So the formula used is (Equation 3).

Power reserve = total power : (100%-5%) (3)

Next, choose the right battery specifications as needed. And calculate the number of batteries used by Equation 4.

Number of batteries = electric power : battery capacity (4)

4. Determining the Inverter

Inverter is a useful tool that converts DC current (direct) into AC current (alternating current). It can be assumed that all the tools are powered on simultaneously to determine the inverter. Thus, choosing an inverter with an output greater than the required power is important.

5. Determining the capacity of the Solar Charge Controller (SCC)

Before determining the SCC (Sollar Charge Controler), first look at the solar panel. Usually, on solar panels written, the following code: Pm = 100 WP, Vm = 18 VDC, Imp = 5.8 A, Isc = 6 A. Then, the Isc (short circuit current) is multiplied by the number of solar panels. The formula is (Equation 5) to determine the capacity of SCC.

Power SCC = Isc x Number of Solar Panels (5)

Based on the identification of partner problems in Table 1, two problems are selected to be addressed. In general, the solution to the problem at hand lies in the transformation to solar energy applications. The solar energy that can be used for all of Indonesia's land with an area of 2 million km2 is 4.8 kWh/m2 daily, equivalent to 112,000 GWp distributed [Hamzah, *et all*, 2020]. This service activity will be carried out with stages of socialization and education, application of solar power systems (on lighting facilities), and monitoring and evaluation of activities. Socialization will be carried out for all school residents at SD Muhammadiyah Beji. The goal is to understand solar-powered electricity technology and hazard mitigation measures from the electrical system. Build solar-powered lighting installations in classrooms, courtyards, teachers' rooms, and toilets/bathrooms. Furthermore, the construction of an electrical network with child-friendly components to ensure safety from the danger of electric shock is necessary.

III. Result and Discussion

PLN's electrical installation network is poorly maintained due to limited school budgets, causing installation destruction, voltage drops, cable insulation leaks, the danger of electric shock, and short circuits. This needs to be given the right solution related to the emergence of electrical hazards. Electrical hazards are divided into two, namely primary hazards and secondary hazards. Primary hazards are hazards caused by direct electricity, such as electric shock hazards and fire or explosion hazards. In comparison, secondary hazards are caused by electricity indirectly. But that does not mean that the consequences caused are lighter than the primary [Prih, *et all*, 2008]. Examples of secondary hazards include body/body parts burned either directly or indirectly, falling from a height, and others.

Lack of understanding of the school community regarding the dangers arising from electricity. Have an impact on the lack of attention and efforts related to mitigating hazards arising from electricity. The use of technology in everyday life and in the learning process needs wise use so that the existing benefits can be maximized and in accordance with needs [Luthfatun, *et all*, 2020].

Therefore, everyone who accesses technology, including electricity, must understand the basic procedures and mitigations needed to avoid the dangers that arise. Given that the school community within the scope of elementary schools has limitations in understanding the development of science and technology, it is necessary to socialize activities and introduce electrical technology that is developing today, namely the concept of renewable energy. Some solution steps related to the introduction and education of electrical technology that will be carried out in this community service are:

- Socialization of child-friendly technology in electrical applications.

- Counseling related to solar-powered electricity technology targeting all Muhammadiyah Beji Elementary School communities.
- Counseling on electrical hazard mitigation in schools for teachers and employees of SD Muhammadiyah Beji.

Table 2. Implementation of activities.

Main Activities
Application of solar-powered electricity installations to reduce PLN's electricity usage.
Replacement of old sockets with closed sockets that ensure safety for children.
Repair PLN electrical cable installation networks that are indicated to be damaged in wet and damp areas such as toilets and bathrooms.
Replacing outdoor installations such as street and yard lighting using solar-powered lights.
Remove all lighting cable networks prone to damage and leakage, including those crossing the trees in the school area.
Education of child-friendly technology in electrical applications.
Counseling related to solar-powered electricity technology targeting all school communities of SD Muhammadiyah Beji.
Counseling on electrical hazard mitigation in schools for teachers and employees of SD Muhammadiyah Beji.

1 Implementation of Main Activities

In accordance with the solutions offered to partners, there are 8 main activities in this devotion, as shown in Table 2.

1.1 Calculation of Solar Power Plant load and power

Total load

The main load is 1 EPSON L310 printer (10 watts), 1 Laptop (20 watts), and 10 lamps with 10 watts (100 watts) power. Then the total load that needs to be supported by Solar Power Plant is 130 Watts. In this case, the load requires an electrical voltage of 220 Vac is a laptop and printer of 30 Watts, while a 100 Watt lamp requires a 12 v dc power supply (through a mini inverter on each lamp).

Battery Power

Available electrical power is reviewed based on battery capacity (Ah). Then the power is calculated based on the following Equation 1;

$$P = V.\ I \quad (1)$$

P = Power in 1 hour (watt hour), Wh, or (VAh).
V= Battery voltage (V)
I = Battery current (Ah)

Thus it is known that the available power is

P = 12 V x 45 Ah = 540 Wh (this power is in the form of a DC voltage of 12 V). In its application, the battery capacity can only be taken in the range of 80% so that the actual power is estimated at 432 Wh (meaning that if a load is used, for example, a 12 V DC lamp of 432 Watts, the battery will be empty in 1 hour).

Effect of inverter and output power

If a Solar Power Plant battery is used in a 12 V DC to 220 V AC inverter, then a calculation must be made that the inverter only works at a minimum DC input voltage in the range of 10 Volts. If the battery's starting voltage is 12.6 V, then the voltage that the inverter can convert is (12.6 – 10 = 2.6) Volt. If using Equation 1, then the output of the inverter in the form of a voltage of 220 V AC is;

P = 2.6 V x 45 Ah = 117 Wh

P (80%) = 182 x 0.8 = 93.6 Wh (this power is in the form of 220 V AC mains).

The conclusion is that inverter electricity is still able to supply a total load of printers and laptops of 30 Watts for 3.12 hours. In practice, not every day the backup electricity of this Solar Power Plant will be used, but only when there is a PLN power outage.

Battery Charging by solar panel

Solar Power Plant is installed in this activity using an MPPT-type controller to achieve maximum current from solar panels. As per the specifications on the panel, it is known that:

Magnitude of current (Imp) = 5.69 A.

Max voltage (Vmp) = 17.6 Vdc.

Panel power = 100,144 WP.

The voltage (Vmp) is lowered by the MPPT controller to a range of 13.8 Vdc for battery charging. This actually increases the charging current by:

100.144 W/ 13.8Vdc = 7.25 A.

Thus charging the battery to be full can be calculated by Equation 2 ;

$$\text{CHG Time} = \left(\frac{Battere\ capacity}{Charging\ current}\right) + \left(\frac{20\%\ of\ battere\ capacity}{Charging\ current}\right) \quad (2)$$

Waktu = (45/7,25) + (3,89) = 7,44 Jam

If it is assumed that in a day of 8 hours of maximum charging, then it takes 1 day for the battery to be full.

IV. Conclusion

The prioritized solution is to provide socialization and education on child-friendly technology. In this way, the school community will understand how to utilize and build safe electrical installations for children. In principle, some electrical components available on the market will have their own level of safety. Thus, safe and child-friendly components must be chosen.

The result at the activity location installed electricity from Solar Power Plant with a 300 Watt inverter to provide electricity for school computer devices. In addition, 10 outdoor lighting points are installed that are set to turn on and off automatically. After all, the systems are assembled, then testing is carried out to turn on the computer, printer, and fan stand load, and the results function well as planned. Automatic lights can function to turn on and off automatically according to the settings on the controller. The main goal to provide efficient and safe electrical facilities for children has been well realized.

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