JESE 4 (2) (2024)

Journal of Environmental and Science Education

http://journal.unnes.ac.id/sju/index.php/usej

Solar Power Plant Implementation as Renewable Energy in Learning at Wisuda Karya

Farah Shoufika Hilyana[1]*, Margareta Rahayuningsih[2], Aditya Marianti[3]

[1)] Primary Teacher Education, Faculty of Teacher Training and Education, Universitas Muria Kudus, Indonesia
[2)]Biology Department, Faculty of Mathematics and Natural Sciences,Universitas Negeri Semarang, Indonesia
[3)]Doctoal Program of Science Education, Faculty of Mathematics and Natural Sciences,Universitas Negeri Semarang, Indonesia

DOI: 10.15294/jese.v4i2.6059

Article Info

Received 27 February 2024
Accepted 15 September 2023
Published 30 September 2024

Keywords:
Solar Power Plant, Renewable Energy, Learning, Vocational High School

*Corresponding author:
Farah Shoufika Hilyana
Universitas Negeri Semarang
E-mail: hilyanafs@students.unnes.ac.id
Farah.hilyana@umk.ac.id

Abstract

This article examines the implementation of Solar Power Plants (Id. Pembangkit Listrik Tenaga Surya - PLTS) as renewable energy sources in the learning process at Wisuda Karya Vocational High School, Kudus. The utilization of renewable energy, particularly solar power, has gained significant attention due to its sustainability and environmental benefits. The study aims to analyze the effectiveness and challenges of integrating PLTS into the curriculum at the vocational high school level. Through qualitative research methods, including interviews and observations, data were collected to assess the impact of PLTS implementation on students' learning experiences and environmental awareness. The findings indicate positive outcomes in terms of student engagement, practical knowledge acquisition, and environmental consciousness. However, several challenges were identified, such as initial investment costs, technical maintenance, and curriculum integration. Recommendations for addressing these challenges and optimizing PLTS implementation in vocational high school education are provided. This article contributes to the discourse on renewable energy education and offers insights for educators and policymakers interested in promoting sustainable practices in vocational learning environments.

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ISSN 2775-2518

INTRODUCTION

Solar Power Plants (in Indonesian, Pembangkit Listrik Tenaga Surya - PLTS) have become an attractive alternative in overcoming energy and environmental challenges. A photovoltaic (PV) cell, commonly called a solar cell, is a nonmechanical device that converts sunlight directly into electricity. In the educational environment, solar PV has great potential to provide economic, environmental, and educational benefits. The utilization of renewable energy has become the main focus in efforts to overcome global energy challenges and reduce the environmental impact caused by conventional

energy sources (Ahn et al., 2019). One technology that stands out in this regard is Solar Power Plants, which offer sustainable benefits in terms of energy sustainability. PLTS uses solar energy as the main energy source to produce electricity, which has great potential to reduce carbon emissions and reduce dependence on fossil fuels (Fathurrahman & Ramadani, 2020).

The implementation of PLTS in Vocational High Schools (in Indonesian, SMK) still faces various challenges that need to be overcome. Implementing PLTS can significantly reduce electricity costs by utilizing a freely available energy source, namely sunlight (Perdana et al., 2020). However, despite its great potential, the implementation of PLTS still faces various challenges in the educational context, especially in Vocational High Schools. During the increasing need for energy and the increasingly real challenges of climate change, it is important to understand in depth how PLTS can be adopted and integrated with educational environments to support sustainable learning and energy efficiency (Ministry of Education and Culture, 2018). PLTS provides an opportunity for students to learn directly about renewable energy and related technologies, broadening their understanding of sustainable solutions to energy needs (Satria & Susilo, 2019).

Technical education in vocational schools has an important role in preparing the younger generation to face increasingly complex technological and environmental challenges. However, most vocational schools still depend on conventional energy sources such as electricity from the public network, which is not only expensive but also has a negative impact on the environment. In this context, the implementation of PLTS in vocational schools is a promising innovation to increase energy efficiency, reduce operational costs, and provide practical education about renewable energy to students. One of the main challenges in implementing PLTS is the high initial costs for procurement and installation of the PLTS system (Surya & Dewi, 2017). By reducing dependence on conventional energy sources, the implementation of PLTS can help reduce carbon emissions and negative impacts on the environment (Wibowo & Firmansyah, 2018). Another challenge is the lack of awareness and understanding of the benefits of PLTS as well as the lack of technical knowledge about its installation and maintenance among students, teachers, and school staff (Pratama et al., 2021). Implementing PLTS requires appropriate space and infrastructure, such as a roof that is large and strong enough to support solar panels and an appropriate energy storage system (Setiawan & Kusumawardani, 2019).

Some vocational schools in Kudus City (SMK Ma'arif and SMK Wisuda Karya) have adopted PLTS technology as part of efforts to integrate renewable energy sources in their school operations. However, there are variations in adoption rates depending on the availability of funding and the ability of schools to install PLTS systems (Anwar & Harjanto, 2018). Even though several vocational schools have successfully installed PLTS systems, there are still challenges related to system capacity and performance. Some installations may not reach their full potential due to technical constraints or inadequate maintenance (Susanto & Prabowo, 2019). The implementation of PLTS at Wisuda Karya Vocational School has provided significant benefits in terms of saving electricity costs and educating students about renewable energy. However, challenges such as high initial costs, lack of understanding of technology, and availability of suitable infrastructure still need to be overcome (Firmansyah & Indarto, 2020).

PLTS is a promising technology to reduce dependence on conventional energy sources and reduce environmental impacts. However, despite its great potential, there are still many challenges in implementing PLTS, especially in educational environments. Most of the school community, including students, teachers, and administrative staff, tend to accept and feel satisfied with the use of solar energy in educational environments. They consider it a positive step in supporting environmental sustainability and a valuable source of learning about renewable energy (Rahayu & Hidayat, 2019). The use of solar energy can also increase environmental awareness among the school community, helping them understand the importance of using clean and environmentally friendly energy sources (Priambodo & Utomo, 2020).

The majority of people tend to support and are enthusiastic about the use of solar energy in educational environments. They see it as a progressive step in reducing negative environmental impacts and improving the quality of education (Wardani & Santoso, 2018). This research aims to investigate the implementation of Solar Power Plants in the Wisuda Karya Vocational High School environment in learning, analyze the benefits of implementing PLTS in the Vocational School environment, and find out responses to implementing PLTS in schools.

METHOD

This research was conducted using a case study approach to PLTS which has been implemented in vocational schools. Data will be collected through direct observation, interviews with teachers and students, as well as analysis of related documentation. Data analysis is obtained from data collected and analyzed. With a deep understanding of the implementation of PLTS in vocational schools, this research aims to contribute to the development of more effective strategies for adopting renewable energy technology in educational environments. The

results of this research can be a valuable source of information for relevant stakeholders, including schools, local governments, and the community, to support the expansion and improvement of PLTS implementation in vocational schools and increase awareness of the importance of renewable energy in technical education.

RESULT AND DISCUSSION

Implementing Solar Power Plants in school learning can provide significant benefits in increasing students' understanding of renewable energy and green technology. When PLTS is integrated into school curricula, it can be a powerful tool for practically demonstrating physics, engineering, and sustainability concepts. In the context of direct practical learning with PLTS at school, students can be involved in observing and understanding the process of converting solar energy into electricity directly. This not only enhances their conceptual understanding but also provides valuable practical experience. Research has shown that hands-on experience with renewable energy technologies such as solar PV can increase students' understanding and interest in science and technology (Fernandez & Breidenbach, 2018). Direct practice with renewable energy technology, such as direct observation of PLTS installations at schools, allows students to concretely understand the concept of converting solar energy into electricity. This experience not only enhances students' conceptual understanding but also provides opportunities to apply knowledge in real-world contexts.

In this context, a study conducted by Chang (2019) also supports the importance of direct experience with renewable energy technology in learning. The research shows that the integration of solar energy in physics teaching can improve students' understanding of concepts. Through direct observation of solar power plants, students have the opportunity to directly experience the conversion of solar energy into electricity, which can deepen their understanding of the physical principles involved. Thus, direct experience with PLTS at school can make a significant contribution in increasing students' understanding of renewable energy and its conversion process.

Implementation of a Solar Power Plant in the Wisuda Karya Vocational School environment in learning

Contribution to developing more effective strategies in adopting renewable energy technology in the educational environment, such as PLTS at the Wisuda Karya Vocational School, contributes to the development of the curriculum that includes aspects of renewable energy, including PLTS. The curriculum is designed to incorporate knowledge of renewable energy into a variety of subjects, from science and engineering to environmental studies and economics. The subjects taken by students in the Electrical Engineering department are special subjects added to the curriculum.

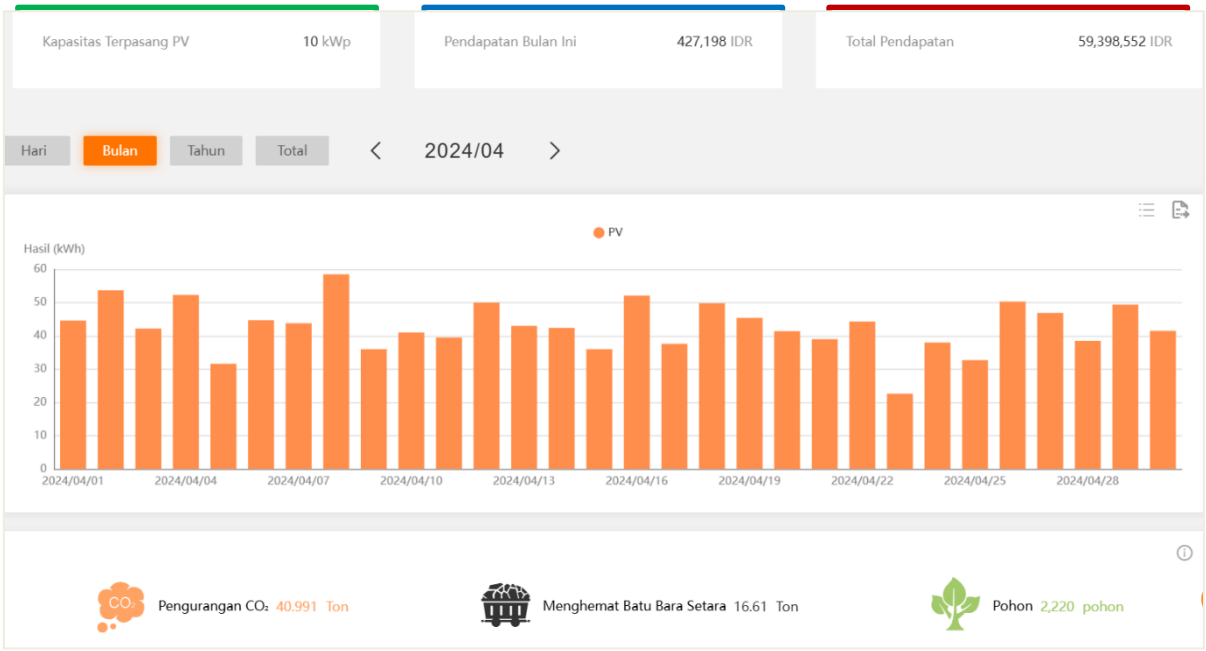
Teachers also integrate PLTS and renewable energy topics into this teaching, including an understanding of renewable energy concepts, PLTS technology, and effective teaching methods to discuss these topics with students. Interesting and relevant learning resources about renewable energy and PLTS are used by teachers and students. These learning resources are in the form of learning modules, presentations, simulations, or other teaching materials that can increase students' understanding of the concept of renewable energy in PLTS. The PLTS used in learning is the result of collaboration with external parties (SUN from the Djarum Foundation) to support the implementation of PLTS in schools. This includes providing resources, project financing, or technical support for the installation and maintenance of PLTS at the Wisuda Karya Vocational School. Through contributions in this area, we can develop more effective strategies in adopting renewable energy technologies such as PLTS in educational environments, thereby promoting awareness about renewable energy and providing a positive impact on the environment and society as a whole.

Figure 1. Learning activities by implementing PLTS at Wisuda Karya Vocational School, Kudus

Benefits of implementing PLTS in vocational school environments

The implementation of Solar Power Plants in Vocational High Schools has many significant benefits, including that PLTS provides an opportunity for students to learn practically about renewable energy. They can understand the concept of converting solar energy into electricity directly through observation and interaction with the PLTS system installed in the school environment. In research conducted by Fernandez and Breidenbach (2018), it was found that direct experience with renewable energy technology such as PLTS provides

opportunities for students to learn practically about electricity. This has the potential to reduce the



renewable energy. They can understand the concept of converting solar energy into electricity directly through observation and interaction with the PLTS system installed in the school environment. This research highlights the importance of a practical approach to learning renewable energy to increase students' understanding and interest in science and technology.

Figure 3. Display of PLTS monitoring results produced in April 2024

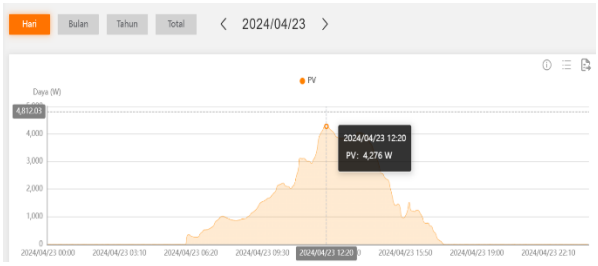
Implementing PLTS can reduce school operational costs in the long term by reducing dependence on electricity from the public network. The energy produced by PLTS can be used to meet some of the school's electricity needs, reducing monthly electricity bills, including reducing monthly electricity bills and saving maintenance costs. PLTS produces electricity from renewable energy sources, namely sunlight, which is free. In this way, schools can reduce or even eliminate dependence on electricity from the public network and produce their monthly electricity bills that schools have to pay. Reductions in monthly electricity bills have been documented in various studies and projects implementing PLTS in schools. One example is a study conducted by Huang et al. (2018) which shows that schools that adopt PLTS can reduce their monthly electricity bills significantly.

PLTS requires little periodic maintenance and has a long service life. In addition, solar energy as a source does not require additional fuel costs. This reduces the long-term operational costs of schools, as they do not have to spend on maintenance and additional fuel as with conventional power plants. Savings in maintenance costs and additional fuel have been documented in the literature related to renewable energy and solar PV. The study by Khan et al. (2016) that is show that PLTS has lower maintenance costs and longer service life compared to conventional power plants.

Using solar PV as a clean energy source helps reduce the school's carbon footprint and supports sustainable environmental education. Students become more aware of the importance of using environmentally friendly energy sources to protect the environment. The carbon footprint of implementing PLTS at Wisuda Karya Vocational School, until April 2024 reduces carbon emissions by up to 40,991 tonnes, is equivalent to planting 2220 trees, and saves coal equivalent to 16.61 tonnes (Figure 3).

The power value resulting from the implementation of PLTS at Wisuda Karya Vocational School, for one month produces different power values every day, the highest result was obtained on April 8 2024, amounting to 10,204 W, and the lowest result on April 23 amounting to 4,276 W (Figure 4).

(a) Highest yield (8 April: 10.204 W)



(b) Lowest yield (23 April: 4.276 W)

Figure 4. Value of power produced by PLTS in April 2024

In developing work skills carried out by Wisuda Karya Vocational School students, by carrying out PLTS installation, maintenance, and monitoring projects, students have the opportunity to develop technical and professional skills that are relevant to the renewable energy industry, especially in PLTS energy sources, so that they can prepare students to careers in the renewable energy sector in the future.

Responses to implementing PLTS in schools

The class XI elective subject about PLTS activity has been done in one semester including PLTS learning that consists of 6 elements; renewable energy, K3 occupational safety and health, basic PLTS systems, PLTS components, PLTS design, operation and maintenance, explanation of PLTS, theory, and explanation of material, practice. The learning at Wisudha Karya Vocational School is very interesting for students to learn about renewable energy, they can directly see the solar power system that has been installed in their school, so students don't just get the theory, but students get the opportunity to directly install PLTS in turn, even on a scale. small, but students can feel the sensation of how to install and maintain the PLTS system.

The main benefits of using PLTS in learning at vocational schools include broadening knowledge about renewable energy, increasing technical skills related to PLTS installation and maintenance, encouraging creativity and innovation in learning, and increasing awareness about sustainability and the environment.

Table 1. Results of responses to student statements regarding the implementation of PLTS in learning at Wisuda Karya Vocational School

No	Statement	Respons
1	PLTS can clearly illustrate the working principles of converting renewable energy sources into electrical energy.	agree
2	PLTS learning attracts students' attention to learning	very much agree
3	PLTS learning helps students more easily understand renewable energy material.	agree
4	PLTS learning is material from the Electricity Department and is by curriculum standards	agree
5	PLTS learning helps teachers explain renewable energy.	agree
6	PLTS learning is very useful in the teaching and learning process.	very much agree
7	PLTS learning is practical and easy to use in the teaching and learning process.	agree
8	PLTS Learning Props, are creative and innovative teaching aids	agree
9	PLTS learning can explain the use and application of renewable energy	agree
10	PLTS learning helps explain the application of this energy in everyday life.	very much agree
11	There is a guidebook that helps with PLTS learning	agree
12	PLTS Learning Motivates students to learn	very much agree
13	PLTS Learning Connects with other learning programs	agree
14	PLTS Learning Improves the student learning process	agree
15	I am familiar with the concept and how PLTS works	agree
16	I already know PLTS	agree
17	The application of PLTS as a learning medium in vocational schools is very effective	agree
18	PLTS learning is very fun and useful	agree
19	Learning with PLTS helps in understanding the concept of renewable energy technology	agree
20	Do students experience difficulties in participating in learning using PLTS?	not agree

Responses to the implementation of PLTS in learning at school (Table 1), especially in class very useful in the teaching and learning process, helps explain the application of energy in everyday life, and motivates students to learn. And they stated that they agree that PLTS can clearly illustrate the working principles of converting renewable energy sources into electrical energy, helps students more easily understand renewable energy material, it is material from the Electricity Department and is by curriculum standards, helps teachers explain renewable energy, practical and easy to use in the teaching and learning process, creative and innovative teaching aids, can explain the use and application of renewable energy, there is a guidebook that helps with PLTS learning, connects with other learning programs, and improves the student learning process. They are already familiar with the concept and how PLTS works, and already know PLTS, so the application of PLTS as a learning medium in vocational schools is very effective, which is very fun and useful, and learning with PLTS helps in understanding the concept of renewable energy technology. There is disagreement if students do experience difficulties in participating in learning using PLTS, so they consider it easy to follow during these learning activities.

CONCLUSION

The implementation of Solar Power Plants (Pembangkit Listrik Tenaga Surya-PLTS in Indonesian) in learning at schools, especially at Wisuda Karya Vocational High School, provides a number of significant benefits. The use of PLTS in the school curriculum helps students understand the concepts

of renewable energy and green technology practically. Through direct experience with PLTS, students can deepen their understanding of the conversion of solar energy into electricity. Teachers integrate PLTS into teaching by using relevant and interesting learning resources, as well as utilizing collaboration with external parties for installation and maintenance of PLTS. The implementation of PLTS at Wisuda Karya Vocational School also produces long-term benefits, such as reducing school operational costs, developing students' technical skills, and increasing environmental awareness. Students' responses to learning with PLTS are very positive, they assess that PLTS helps them understand the concept of renewable energy better, attracts their attention to learning, and motivates them to learn. Apart from that, students consider learning with PLTS not difficult and very effective in improving their learning process.

ACKNOWLEDGMENT

We would like to thank SMK Wisuda Karya Kudus, Mr. Irfa' Chasan, S.Pd. Head of Electrical Engineering Expertise Program, all students in the Electrical Engineering Expertise Program for their participation in the research survey, and staff Mr. Ahmad Aris Nugroho, S.T for all their assistance.

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