Kumawula, Vol.8, No.2, Agustus 2025, 540 – 549
DOI: https://doi.org/10.24198/kumawula.v8i2.58399
ISSN 2620-844X (online)
ISSN 2809-8498 (cetak)
Tersedia *online* di http://jurnal.unpad.ac.id/kumawula/index

SUSTAINABLE ENERGY EDUCATION THROUGH IOT-BASED PLTS KIT TRAINING AND MENTORING AT SMAN 3 SINGKAWANG

Abqori Aula[1*], Syaifurrahman Syaifurrahman[1], Dedy Suryadi[1], Neilcy Tjahjamooniarsih[1], Fitriah Fitriah[1]

[1]Department of Electrical Engineering, University of Tanjungpura
Jl. Prof. Dr. Hadari Nawawi, Pontianak, Indonesia

[*]Correspondence : abqoriaula@ee.untan.ac.id

ABSTRACT

The integration of Internet of Things (IoT) technology into training and mentoring programs for Photovoltaic Power System (PLTS) kits can significantly enhance the education of renewable energy, particularly in West Kalimantan, Indonesia. The partner in this community service program is State High School 3 of Singkawang City, West Kalimantan. The purpose of this community service is both to educate on the use of IoT for monitoring PLTS kits and to educate high school students about renewable energy. This approach involves classical teaching and hands-on learning, which enables real-time monitoring and data analysis, making it more effective and engaging for students. The method used in this service consists of the preparation stage, the implementation stage, and the evaluation stage. Within the preparation stage, PLTS kits were designed and constructed with an embedded IoT module. The implementation stage involved socialization about new and renewable energy as well as the trend in IoT, followed by hands-on training for participating students using the PLTS kits. There were about 20 students and a couple of accompanying teachers. The results of the evaluation stage show that the student participants were happily thrilled with the hands-on training, and the teachers were satisfied with the mentoring program.

Keywords: *Community Service; Internet of Things; Renewable Energy; Solar Power*

RIWAYAT ARTIKEL
Diserahkan : 11/10/2024
Diterima : 18/12/2024
Dipublikasikan : 01/08/2025

ABSTRAK

Integrasi teknologi *Internet of Things* (IoT) ke dalam program pelatihan dan pendampingan untuk kit Sistem Tenaga Fotovoltaik (PLTS) dapat secara signifikan meningkatkan pendidikan energi terbarukan, khususnya di Kalimantan Barat, Indonesia. Mitra dalam program pengabdian masyarakat ini adalah SMA Negeri 3 Kota Singkawang, Kalimantan Barat. Tujuan dari pengabdian masyarakat ini adalah untuk mendidik penggunaan IoT untuk memantau kit PLTS dan juga untuk mendidik siswa sekolah menengah tentang energi terbarukan. Pendekatan ini melibatkan pengajaran klasikal dan pembelajaran langsung yang memungkinkan pemantauan waktu nyata, dan analisis data, sehingga lebih efektif dan menarik bagi siswa. Metode yang digunakan dalam layanan ini terdiri dari tahap persiapan, tahap implementasi, dan tahap evaluasi. Dalam tahap persiapan, kit PLTS dirancang dan dibangun dengan modul IoT yang tertanam. Tahap implementasi melibatkan sosialisasi

tentang energi baru dan terbarukan serta tren di IoT, diikuti oleh pelatihan langsung bagi siswa yang berpartisipasi menggunakan kit PLTS. Ada sekitar 20 siswa dan beberapa guru pendamping. Hasil tahap evaluasi menunjukkan bahwa para peserta siswa merasa gembira dan gembira dengan pelatihan praktik, sedangkan para guru merasa puas dengan program bimbingan.

Kata Kunci: Pengabdian masyarakat; *internet of things*; energi terbarukan; energi solar

INTRODUCTION

The urgency of incorporating renewable energy education, such as IoT-based PLTS, is indeed significant. This is due to renewable energy sources, like solar power, are crucial for sustainable future (Strielkowski, Civín, Tarkhanova, Tvaronavičienė, & Petrenko, 2021). As the world grapples with climate change and the finite nature of fossil fuels, it's essential to educate students about renewable energy. This knowledge can empower them to contribute to a more sustainable world.

Incorporating IoT-based PLTS into education can provide practical, hands-on experience. It can help students understand the workings of renewable energy systems, promote innovation, and foster skills in STEM (Science, Technology, Engineering, and Mathematics) fields (Nguyen, Nguyen, & Tran, 2020). The urgency lies in preparing the next generation to face the challenges of climate change and energy scarcity. In the context of the Indonesian curriculum, the importance of renewable energy education, including IoT-based PLTS, is recognized and integrated into various subjects (Mudhoffar & Magriasti, 2024).

The Indonesian Ministry of Education and Culture has been promoting the integration of environmental education into the curriculum (Khulaemi, 2021). This includes teaching about renewable energy sources and their importance in sustainable development (Nugroho & Angela, 2024).

For instance, according to Fitri & Susilana (2021), students as early as in Junior High School, in science and technology subjects, can learn about the principles of solar energy and how IoT-based PLTS work. In mathematics, they can calculate energy production and efficiency. In engineering, they can design and build small-scale solar power systems (Fuada, et al., 2022).

Moreover, the curriculum also encourages character building and life skills development (Vioreza, Hilyati, & Lasminigsih, 2023). Learning about renewable energy can foster a sense of responsibility towards the environment and develop skills in problem-solving, critical thinking, and innovation (Savana, Handayani, & Lesmana, 2023) (Wiyono, et al., 2024).

However, the specific implementation can vary depending on the school and the region (Marianti, et al., 2023) (Rianto, Utari, Jenawi, & Sujarwani, 2020) (Junihartomo, Thamrin, & Boedoyo, 2022). Education about solar panels and the Internet of Things (IoT) in West Kalimantan, Indonesia, is still in its infancy (Langer, Quist, & Blok, 2021). However, the government and several educational institutions have restored focus on environmental education and advanced technology (Bati & Angela, 2024).

An IoT-based PLTS is a solar power system that uses Internet of Things technology to optimize energy production and distribution (Budihartono, Maulana, Rakhman, & Basit, 2022) (Basit, Bakti, & Afriliana, 2024). It typically includes solar panels, an inverter, a battery system for energy storage, and a monitoring system (Mungkin, Satria, & Indrawati, 2024). The monitoring system, which is the IoT component, allows for real-time data collection and analysis, enabling users to track energy production, identify issues, and make necessary adjustments (Kurniawan, 2022). This technology can increase the efficiency and sustainability of solar power systems (Syaifurrahman,

Tjahjamooniarsih, Elbani, Saleh, & Suryadi, 2022).

Based on these premises, a team of lecturers from the Department of Electrical Engineering, University of Tanjungpura conducted a training and mentoring on the application of IoT-based PLTS for high school students as part of its community service program (PKM). The school partner for this activity is State High School 3 of Singkawang City (SMAN 3 Singkawang).

The purpose of this community service program is (i) to educate high school students about the integration of Internet of Things and solar-based power generation, as well as (ii) to stimulate students' awareness of the importance of renewable energy and (iii) the trend of internet-based monitoring system.

METHOD

The hands-on training and mentoring method was chosen rather than the teacher-centered learning process, because it can expand the interest of participating students and provide direct experience to the topics taught (Saleh, Darwis, & Arhas, 2021) (Pradnyana, Sntyadiputra, & Darmawiguna, 2020). In this community service activity, the PKM FT UNTAN Team tried to create a learning kit in the field of renewable energy (PLTS), which is intended for school students, so that teaching and learning activities become more lively and interactive.

The targeted participants for this activity are the top 3 rank students representing each class from grades 10, 11, and 12. This selection is part of the PKM team's effort to promote and encourage the best students to enroll in the Faculty of Engineering. Twenty-five students are participating in this activity. Current activity will involve five lecturers, one PLP, and two university students, who will go directly to the intended and targeted school partner.

Before the PKM activity is accrued out, several stages are involved. The stages of the proposed activity are (a) preparation, (b) kit manufacturing, (c) internal team coordination, and (d) coordination with school partner.

a. Preparation Stage

The first stage is literature study or browsing for sources related to the development of PLTS (Zulmiftahul, Khairudin, Lukmanul, & Zebua, 2020) and IoT (Yaddarabullah, Khrisnasari, & Pranoto, 2022). Literature studies are also carried out on the training materials that will be taught to the students.

b. Manufacturing Stage

The PLTS kit is intended to provide convenience for students in understanding various PLTS devices or components as well as its installation. The manufactured PLTS kit consists of several components will be equipped with electrical loads that are packaged in one compact container for portability, so that it will be easy to carry anywhere.

The electronic and electrical components required for developing the proposed PLTS kit include:

1. Solar panel module. This module contains a group of inter-connected solar cells which converts light to electricity.
2. Solar charger controller. This module supervises and manages the power that goes inside the battery from solar panel (Azzahra, et al., 2020). In the PLTS kit developed for current PKM activity, a battery charging module was also appended into the package. This module acts as an alternative for power charging if the intensity of sunlight is insufficient.
3. Battery to store electric charges. In this PKM program, the kit uses Lithium Ion battery type 803450 with 1500 mAh capacity.
4. IoT devices. This device consists of a communication radio for sending and receiving data wirelessly (Huda, Latif, Rifaldi, Wisely, & Fajri, 2024) (Sari, Heryadi, & Alexandri, 2019). Some devices work in 2.4 GHz frequency, others

include WiFi and Bluetooth communication within its package, such as NodeMCU ESP8266 (Bustami, 2024) (Efendi, Astari, Sinlae, Zulfikar, & Sholikhak, 2023). This IoT board is common for IoT application development.
5. An LCD (Liquid Crystal Display) for displaying letters, numbers or other symbols. LCD type 1602 is used for this community service program.
6. Light sensor. The BH1750 light sensor device is used to measure the intensity of light within the range of 1 to ±65535 lux (Pebriyanto, Monita, Kurniawati, Dirgantara, & Lasiani, 2023).
7. Power sensor. The INA219 power sensor device is chosen for current project. It can measure voltage, current and power within an electronic circuit (Pebriyanto, Monita, Kurniawati, Dirgantara, & Lasiani, 2023).
8. Arduino IDE and Blynk. These software and web platforms are used to create an interface for receiving and monitoring data obtained from the sensors connected by IoT system (Wijaya, 2023).

c. Coordination within PKM Team

After confirming the required materials and components to develop the proposed IoT-based PLTS kit and teaching material, the team then coordinates the role of each team member before performing the service at the aimed school. In current PKM activity, the roles are planned as follows:

1. Welcoming speech by the Head of the PKM Team, Mr. Abqori Aula, as well as the screening of the video profile of the Faculty of Engineering and the Department of Electrical Engineering UNTAN
2. Profile of the Basic Electrotechnical Laboratory (Lab. Eldas) was presented by Mr. Syaifurrahman, as the Head of the Laboratory.
3. The introduction of PLTS technology was delivered by Mrs. Fitriah.
4. The introduction of LoRa technology was delivered by Mrs. Neilcy Tjahjamooniarsih.
5. The introduction to PLTS Module was delivered by Mr. Dedy Suryadi.
6. The introduction to Blynk and Arduino programming was delivered by university students.
7. The training on the use of the built PLTS kit, including hands-on practice and mentoring, was guided and assisted by all team members.

The teaching materials presentation by lecturers, was limited to a maximum of 15 minutes each, and kit training and mentoring guided by two university students.

d. Field Orientation and Coordination with Aimed School Partner

This stage is aimed to synchronize the schedule of each member of the current PKM team and the targeted school, the duration of the activity, the tools and/or equipment prepared by the partner as well as the number of participating students. This is essential to ensure the smooth running of the activity.

e. Activity Evaluation

The proposed evaluation on the activity is composed of two part, i.e. (i) direct evaluation in the form of direct observation during active session using quiz and questioner leaflet, and (ii) indirect evaluation by observing the extent of the participant's interest and the quality of graduate to enter admission to the Department of Electrical Engineering, Faculty of Engineering, University of Tanjungpura.

RESULT AND DISCUSSION

a. PLTS Kit

The PLTS learning kit was made in the form of a compact prototype encased by 2 mm aluminum sheet. Figure 1 shows the manufactured PLTS kit from the proposition in the preparation stage. The kit incorporates two 1Wp solar panels, one solar charge controller and battery charging module, one light sensor, one power sensor, one LCD, one lithium ion battery, and a couple of LEDs as loads.

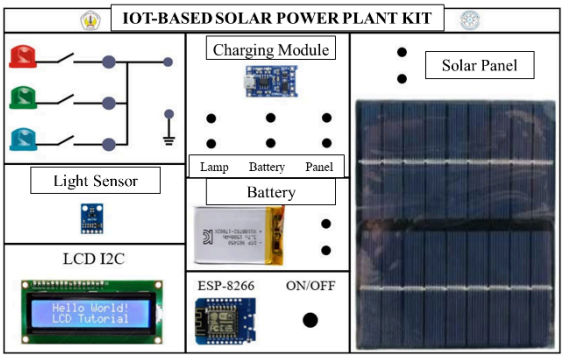

Figure 1. The Layout of the Developed PLTS Kit
(Source: Personal Docs, 2024)

Each of the solar panel modules has a specification of 6 V and 1 Wp, and a dimension of 12 cm by 6 cm. In addition, to ease the installation of the PLTS, the kit was equipped with jacks or sockets as terminals for connecting cables from one component to other. Such that the participating students do not have to perform a complete PLTS installation.

b. PKM Activity

The school partner of current PKM activity was SMAN 3 Singkawang. The high school is located approximately 150 km away from the Faculty of Engineering, UNTAN, at Jl. Pahlawan, Kel. Roban, Kec. Singkawang Tengah, Kota Singkawang. Figure 2 indicates this distance.

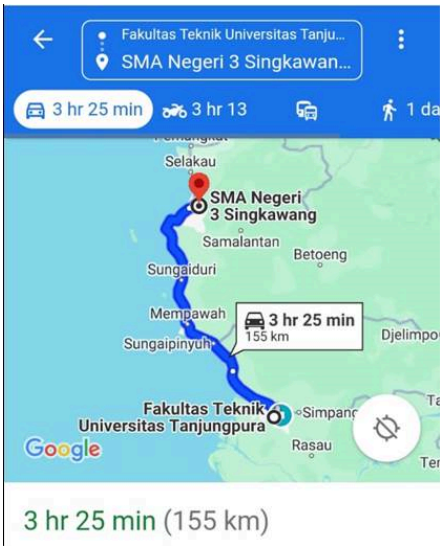

Figure 2. Approximate Distance to Targeted School Location
(Source: Google Maps, 2024)

The team (as showcased in Figure 3) which consist of five lecturers, one PLP (educational laboratory administrator), and two university students traveled to Singkawang on August 5th 2024. The PKM team's arrival on August 6th 2024 was warmly welcomed by the school's headmaster Mr. Mus'an, S.Pd., vice headmaster Mrs. Rini Susilowati, S.Sos., M.Pd. and other staffs.

Figure 3. Welcoming Discussion with School Headmaster and Staffs
(Source: Personal Docs, 2024)

The PKM activity was held for half a day, tentatively starting from 08:00 in the morning until just before noon. The activity began with an opening remarks, followed by welcoming speech from the school's vice headmaster Mrs. Rini Susilowati, S.Sos., M.Pd. and the team's leader Mr. Abqori Aula. The introduction on the profile of the Department of Electrical Engineering and Faculty of Engineering was video-showcased by the head of Eldas Laboratory Mr. Syaifurrahman. The activity was then continued with presentations introducing the IoT and PLTS systems by other team members, which ended by training and mentoring session on the usage of the IoT-based PLTS kit.

During the PLTS kit training session, the participants were divided into groups of five. Each group was then required to download and install Blynk application on one Android-based smartphone only. The PKM team then explained about how to create a monitoring interface utilizing the Blynk application to

connect and monitor the built PLTS kit. Using the connected smartphone, participating students then could monitor physical quantities of the PLTS kit, such as current, voltage, light intensity and battery capacity. The participants were also directed to bring their kits outdoor for the demonstration on how a small scale PLTS works. The excitement of participants is clearly seen in Figure 4.

To spice up the activity and to assess the result of the training and mentoring session, before closing the activity, a quiz session was held. The participants with the correct answer were given a souvenir as appreciation for their attention during the activity. During this session, participating students and their accompanying teacher were handed a questioner sheet, as part of a written evaluation of the activity. The quiz session was moderated by Mr. Syafurrahman as shown by Figure 5.

Figure 4. A Very Enthusiastic Training and Mentoring Session
(Source: Personal Docs, 2024)

Figure 5. Quiz Session
(Source: Personal Docs, 2024)

At the end of this activity, three PLTS learning kits were handed over to the school. The kit was handed over by Mr. Abqori Aula and received by the school's representative, Mrs. Rini Susilowati as shown in Figure 6. The tentative event outline is presented in Table 1.

Figure 6. Handing Kit Over to the School
(Source: Personal Docs, 2024)

Table 1. Tentative Event Outline

Time	Event	Handler
08:00	Opening: - National anthem - Pray	School
08:00-08:15	Welcoming speech 1	School
08:15-08:30	Welcoming speech 2	PKM team
08:30-08:45	Profile of Institution	PKM Team
08:45-09:00	Introduction on IoT and PLTS	PKM Team
09:00-09:30	Introduction on Arduino IDE and Blynk	PKM Team
09:30-11:30	Training and Mentoring	PKM Team
11:30-11:45	Quiz & gift	PKM Team and the School
11:45-12:00	Kit handover & closing remark	PKM Team and the School

(Source: Author, 2024)

c. Evaluation

The evaluation process of this community service activity was carried out jointly by the PKM team and the accompanying teachers. The questioner for participating students

consists of three parts, i.e. to address the participants' knowledge before and after, as well as their responses during the training and mentoring session. The scale was rated by numerical 1 to 5, which indicates "very low" to "very high" agreement. Meanwhile, the questioner for accompanying teachers only consists of some questions regarding the participant's behavior during training and mentoring session. The inputs from both participants and observing teachers are then evaluated and analysed.

There are four same statements that were embedded into the "Before" and "After Part" of the questioner. Each statement was only rephrased to trick the participants. The statements are:

1. Whether the participant thinks the topic is interesting or not,
2. Whether the participant has any knowledge about the topic,
3. Whether the participant has previously mastered the topic, and
4. Whether the participant will pay attention to the topic.

On the first statement, when asked whether the topic brought was interesting or not, before the teaching, training and mentoring (TTM) session, all participants answered interesting (rate 4) and very interesting (rate 5). This remark stands until after the TTM session.

Regarding the second statement, before the PKM activity, 11 out of 26 had not quite the knowledge about the topic presented (rate 2), while the rest of the participants partially knew about the topic. After the TTM session, only 4 left out of 26 participants with enough knowledge (rate 4) about the topic, while the majority of them fully understood the topic.

The result on the third statement concludes that none of the participants have fully mastered the topic before the PKM activity, while after the TTM session, most participants have fully mastered the topic (rate 4 and 5).

Lastly, the topic of the PKM activity was considered interesting to all participants, and they were eager to listen and pay attention to it throughout the session, based on the non-changing rating of the fourth statement.

The questions for "during the TTM session" includes whether: (i) the concept / illustration / demonstration of the topic is clear, (ii) there was discussion / enrichment, (iii) at least one mentor was present during group practice session, (iv) there was interaction with mentor during group practice session, and (v) the group practice was fun and enjoyable.

The participants' responses on the "during TTM session" questions indicate that the TTM session was delivered successfully, with only 6 participants who thought that the discussion session was only enough (rate 3). All participants "very agreed" that the group practice session was fun and enjoyable and at least one mentor was always present during this session.

CONCLUSION

A group of lecturers from the Department of Electrical Engineering, Faculty of Engineering, University of Tanjungpura conducted a community service program at State Highschool 3 of Singkawang. The topic of the program was to bring awareness about renewable energy and current trend in industry 4.0, which is Internet of Things. This topic was delivered in the means of training and mentoring of IoT-based PLTS kit to the students.

Direct observation by means of quiz session and questioner imply that the activity was a great success. The observed participants showed high enthusiasm during the teaching, training, and mentoring session. A plus point was added after the participants showed very high interest in the Department of Electrical Engineering in particular, and the Faculty of Engineering University of Tanjungpura in general.

ACKNOWLEDGEMENT

The authors thank the headmaster and vice headmaster of SMAN 3 Singkawang and everyone who contributed to this community

service program. This community service program was supported and funded by the Faculty of Engineering, University of Tanjungpura, fiscal year 2024.

REFERENCES

Azzahra, S., Samsurizal, Christiono, Fikri, M., Luthfiansyah, M., & Malik, A. (2020, Desember). Pemasangan Lampu Jalan dan Pembangunan Pembangkit Listrik Berbasis Solar Cell Sebagai Prototype Pembelajaran Nergi Terbarukan di MA Al-Khairiyah Rancaranji. *Terang: Jurnal Pengabdian Pada Masyarakat Menerangi Negeri, 3*(1), 100-105. doi:10.33322/terang.v3i1.1010

Basit, A., Bakti, V. K., & Afriliana, I. (2024, April). Peningkatan Kompetensi Siswa Dalam Implementasi Internet Of Things Dengan Interface Cloud. *Jurnal Masyarakat Mandiri, 8*(2), 2383-2392. doi:10.31764/jmm.v8i2.22068

Bati, N., & Angela, D. (2024). Strategi NGO Lingkungan Greenpeace Indonesia Dalam Mendorong Transisi Energi Baru dan Terbarukan (EBT) di Tengah Kontroversi Realisasi Net Zero emission (NZE) 2060 di DKI Jakarta. *Gayana: Jurnal Ilmu Sosial dan Humaniora, 7*(3), 164-181. doi:10.37329/ganaya.v7i3.3365

Budihartono, E., Maulana, A., Rakhman, A., & Basit, A. (2022, Juni). Peningkatan Pemahaman Siswa Tentang Teknologi Iot Melalui Workshop Teknologi IoT. *Jurnal Masyarakat Mandiri, 6*(3), 1595-1602. doi:10.31764/jmm.v6i3.7519

Bustami, B. (2024, Juni). Pengenalan Internet of Things (IoT) Pemanfaatan dalam Kehidupan Sehari-Hari Bagi Siswa dan Siswi SMK. *Jurnal Solusi Masyarakat Dikara, 4*(2), 82-85.

Efendi, Y., Astari, T., Sinlae, A. A., Zulfikar, A. A., & Sholikhak, M. (2023, Juni). Penerapan Teknologi Internet of Things Pada SMK Negeri 1 Perhentian Raja Kampar Riau. *Masyarakat Berdaya dan Inovasi, 4*(1), 51-57. doi:10.33292/mayadani.v4i1.113

Fitri, A., & Susilana, R. (2021). Desain kurikulum mikro sustainable development goals di sekolah menengah pertama. *EDUCATIO: Jurnal Pendidikan Indonesia, 7*(1), 38-45. doi:10.29210/120212936

Fuada, S., Hendriyana, H., Majid, N. W., Sari, N. T., Isnawan, O. A., Zahra, Z. N., . . . Andriyani, D. D. (2022, Oktober 20). Transfer Knowledge Robot Sederhana untuk Mengenalkan Teknologi Robot bagi Anak-Anak di Dusun Galingan, Boreng, Lumajang, Jawa Timur. *J-ABDIPAMAS (Jurnal Pengabdian Kepada Masyarakat), 6*(2), 111-130.

Huda, M. K., Latif, M. A., Rifaldi, M. R., Wisely, S. C., & Fajri, H. K. (2024, Pebruari). Pengaplikasian Internet Of Things (IoT) dalam Mata Kuliah Sistem Operasi di Prodi Teknik Informatika Universitas Negeri Semarang. *Jurnal Angka, 1*(1), 135-143.

Junihartomo, M. T., Thamrin, S., & Boedoyo, M. S. (2022, April). Potential analysis and regulations of solar power plant development in Indonesia. *International Journal of Innovative Science and Research Technology, 7*(4), 518-522.

Khulaemi, A. (2021, Oktober). Kesiapan Perguruan Tinggi dalam Mencetak Sumber Daya Manusia di Sektor Energi Baru Terbarukan (Renewable Energy). *Risenologi, 6*(1b), 97-105. doi:10.47028/j.risenologi.2021.61b.255

Kurniawan, I. (2022). Implementasi Internet Of Things (Iot) Dalam Pembelajaran Di UNISNU Jepara. *Jurnal Portal Data, 2*(4), 1-9.

Langer, J., Quist, J., & Blok, K. (2021). Review of Renewable Energy Potentials in Indonesia and Their Contribution to a 100% Renewable Electricity System. *Energies, 14*(21), 7033. doi:10.3390/en1421703

Marianti, M. M., Permatasari, P., Manurung, E. M., Wardhana, I. W., Alim, T. E., & Wahyuputri, F. W. (2023). Village Fund for Renewable Energy Development: A Case Study. *International Journal of Energy Economics and Policy, 13*(4), 225-236. doi:10.32479/ijeep.14541

Mudhoffar, K., & Magriasti, L. (2024). Ekonomi Politik Energi Terbarukan: Peluang dan Tantangan di Indonesia. *Multiverse: Open Multidisciplinary Journal, 3*(1), 47-52. doi:10.57251/multiverse.v3i1.1382

Mungkin, M., Satria, H., & Indrawati, A. (2024, Februari). Implementasi PLTS Sistem Off Grid Sebagai Wujud Media Pembelajaran Efektif Pada Siswa SMK Citra Harapan Kecamatan Percut Sei Tuan. *Jurnal Masyarakat Mandiri, 8*(1), 1527-1538. doi:10.31764/jmm.v8i1.20994

Nguyen, T. P., Nguyen, T. H., & Tran, T. K. (2020). STEM Education in Secondary Schools: Teachers' Perspective towards Sustainable Development. *Sustainability, 12*(21), 8865. doi:10.3390/su12218865

Nugroho, B., & Angela, D. (2024, Juni). Strategi NGO Lingkungan Greenpeace Indonesia Dalam Mendorong Transisi Energi Baru dan Terbaharukan (EBT) di Tengah Kontroversi Realisasi Net Zero Emission (NZE) 2060 di DKI Jakarta. *Ganaya : Jurnal Ilmu Sosial Dan Humaniora, 7*(3), 164–181. doi:10.37329/ganaya.v7i3.3365

Pebriyanto, Y., Monita, D., Kurniawati, N., Dirgantara, M., & Lasiani, L. (2023, Januari). Demonstrasi Perakitan Alat Sistem Panel Surya Di Smps Golden Christian School Sebagai Upaya Memunculkan Minat Siswa Dalam Pemanfaatan Energi Terbarukan. *J-ABDI: Jurnal Pengabdian kepada Masyarakat, 2*(8), 5733–5740. doi:10.53625/jabdi.v2i8.4487

Pradnyana, I. M., Sntyadiputra, G. S., & Darmawiguna, I. G. (2020, Januari). Pelatihan Penggunaan Edmodo Bagi Siswa Di SMP Negeri 2 Nusa Penida. *Jurnal Widya Laksana, 9*(1), 30-38. doi:10.23887/jwl.v9i1.21890

Rianto, F., Utari, D. S., Jenawi, B., & Sujarwani, R. (2020). Renewable Energy on Islands: Lessons for Indonesia to Apply. *Jurnal Rekayasa Bahan Alam Dan Energi Berkelanjutan, 4*(1), 19-26. doi:10.21776/ub.rbaet.2020.004.01.04

Saleh, S., Darwis, M., & Arhas, H. (2021, Januari). Pelatihan Pembuatan Dan Penggunaan Media Pembelajaran Berbasis Elektronik Dan Non-Elektronik. *Jurnal Masyarakat Mandiri, 5*(1), 73-80. doi:10.31764/jmm.v5i1.3259

Sari, D. S., Heryadi, D., & Alexandri, M. B. (2019). Sosialisasi Pengenalan Revolusi Industri 4.0 dan Internet of Things (IoT) bagi Siswa SMAN 1 Cicalengka, Jawa Barat, Indonesia. *Kumawula: Jurnal Pengabdian kepada Masyarakat, 2*(2), 163-174. doi:10.24198/kumawula.v2i2.24391

Savana, B. A., Handayani, R. D., & Lesmana, A. D. (2023). The Application of Problem-Based Learning with STEM Approach to Practice Students' Self-Regulated Learning on Renewable Energy Topic. *Prosiding Seminar Nasional Fisika (SNF) UNESA 2023* , *7*, pp. 140-144.

Strielkowski, W., Civín, L., Tarkhanova, E., Tvaronavičienė, M., & Petrenko, Y. (2021). Renewable energy in the sustainable development of electrical power sector: A review. *Energies, 14*(24), 8240.

Syaifurrahman, Tjahjamooniarsih, N., Elbani, A., Saleh, M., & Suryadi, D. (2022). Pengenalan dan Pelatihan Internet Of Thinks Bagi siswa/i Sekolah Menengah Atas Negeri 1 Singkawang. *Jurnal Buletin Al-Ribaath, 19*(1), 29-35. doi:10.29406/br.v19i1.3585

Vioreza, N., Hilyati, W., & Lasminigsih, M. (2023, Juli 31). Education for Sustainable Development: Bagaimana Urgensi dan Peluang Penerapannya pada Kurikulum Merdeka? *PUSAKA: Jurnal Educational Review, 1*(1), 34-48. doi:10.56773/pjer.v1i1.11

Wijaya, M. C. (2023, Desember). Edukasi Dan Pendampingan Pembuatan Aplikasi Mobile Untuk Siswa SMAK Bpk Penabur Singgasana Bandung. *Kumawula: Jurnal Pengabdian Kepada Masyarakat, 6*(3), 644-651. doi:10.24198/kumawula.v6i3.46611

Wiyono, K., Zulkardi, Madang, K., Suhery, T., Yusup, M., Effendi, . . . Shahrill, M. (2024). The preliminary prototype of learning material based on STEM framework in renewable energy topic. *The 5th Sriwijaya University Learning And Education (SULE) International Conference 2022, 3052*. Palembang. doi:10.1063/5.0201402

Yaddarabullah, Khrisnasari, E. D., & Pranoto, G. T. (2022, Mei). Pelatihan Dasar Kompetensi Internet of Things Untuk Siswa SMK Pembangunan Jaya. *Jurnal Industri Kreatif dan Informatika Series*

(JIKIS), 2(1), 30-33. Retrieved from http://jikis.org/index.php/main/article/view/36

Zulmiftahul, H., Khairudin, K., Lukmanul, H., & Zebua, O. (2020). Pelatihan Instalasi Sistem Plts Bagi Siswa-Siswi Di SMK 2 Mei Bandar Lampung. *Prosiding Senapati Seminar Nasional Pengabdian Kepada Masyarakat Teknologi Dan Inovasi*, *2*, pp. 285-288. bandar Lampung. Retrieved from http://repository.lppm.unila.ac.id/id/eprint/34004