Development of a Solar Power Plant in the Production Unit of SMK Muhammadiyah 2 Turi as a Green School Embodiment

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ABSTRACT

Implementing new and renewable energy (EBT) in Vocational High Schools can support the green school program. EBT is clean energy and clean technology that can be applied in the context of realizing a green school. Vocational High Schools whose curriculum is more inclined towards a practice that provides a more significant portion of skills to students, so skills are needed in technology, especially those related to EBT. Solar Power Plant (PLTS) is one of the EBTs that is easy to apply in green school-based vocational schools. Vocational High School 2 Turi is a Vocational High School that has implemented a green school-based school that needs to be given knowledge and skills about EBT and PLTS. Implementing this service consists of EBT counseling and PV mini-grid training. The EBT extension program and PLTS installation training participants were 20 students and ten teachers. EBT counseling increased students' knowledge by 70%, from 15% to 80% after counseling. Meanwhile, for teacher participants, there was an increase of 75% from 25% to 100%. The results of the PLTS installation training increased by 75% for all participants, student participants from 0% to 75%, and teachers from 5% to 80%. At the same time, the rest can improve their skills by practicing themselves in assembling PLTS components that have been granted.

KEYWORDS
New and Renewable Energy;
Solat Power Plant;
Extension and Training;
SMK2 Muhammadiyah Turi;
Green School

1. Introduction

Renewable Energy is a growing trend nowadays [1]–[4]. Renewable energy is clean energy obtained from natural energy sources that are renewable and sustainable [5]–[8]. Energy that is free of pollution (clean energy) and sustainable (sustainable) is very good for the survival of living things on earth [9]–[12]. This energy is expected by the government to fulfill the entire energy mix in the future. A lot of community empowerment has been carried out to develop renewable energy potential and implemented in the community to support the development carried out by the government in order to achieve a comprehensive renewable energy mix so that it is expected to reduce the use of fossil energy which still produces air pollution. One form of embodiment of the implementation of renewable energy that is easiest and can be implemented in society is PLTS (Solar Power Plant) [13]–[16].

With these problems, research on Renewable Energy Photovoltaic is used as a reference in this community service. Environmental Energy Harvesting Techniques to Support Independent IoT-Equipped Sensors and Their Application in 5G Communications was researched by Singh [17]. Applying Renewable Energy Technology in Integrated Optimization Methods for Residential Building Design was researched by Aparicio-Ruiz [18]. An overview of the latest photovoltaic module cooling methods: advancing PVT systems was researched by Shahirah Binti Rukman [19]. An indicator based sustainability assessment method for indigenous peoples: a case study from Mexico researched by Molina [20]. On delivery of minigrids with large penetration rates of various renewable energies was studied by Dweekat [21]. The design of a single-phase inverter for photovoltaic applications controlled by sinusoidal pulse width modulation was investigated by Alhamrouni [22]. Adaptation of building forms to the consumption of renewable energy was studied by Gorgiladze [23]. A new Pythagorean

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fuzzy-SWARA-TOPSIS framework for evaluating EU progress towards sustainable energy development was investigated by Kamali Saraji [24].

The selection of circular suppliers using intuitionistic fuzzy sets with interval values was studied by Perçin [25]. Topology Review of Small Power Rating PV Inverters and Smart PV Inverters researched by Vairavasundaram [26]. Reactive Power Injection to Reduce Frequency Transients Using Grid-Connected PV Systems was investigated by Huo [27]. The Impact of Photovoltaic Agriculture on the Environment in the Romanian Plain was investigated by Vrînceanu [28]. Expansion of Renewable Energy in Federal Settings: Austria, Belgium, and Germany in Comparison investigated by Wurster [29]. Optimization and life cycle cost analysis of renewable energy supply options for academic buildings - Case study investigated by Paragond [30]. Metallurgical infrastructure and technological criticality: the relationship between photovoltaic, sustainability, and the metal industry was investigated by [31]. The "My Electricity" Program as a Way to Reduce CO2 Emissions in Poland was researched by Olczak [32]. Predictive Control by Current-Based Maximum Power Point Tracking for On-Grid Photovoltaic Applications was investigated by Muñoz [33]. Sustainability of motivation for renewable energy investment during feed-in-tariff transition: evidence from a laboratory experiment investigated by Maekawa [34]. The Optimal Energy Optimization Strategy for Integrated Smart Grid with Renewable Energy Sources and Demand Response Program was researched by Ullah [35]. Forecasting solar power plants using an ensemble approach based on deep learning and statistical methods researched by AlKandari [36].

A new optimization algorithm for the selection of solar panels to self-powered EV parking lots and their impact on the distribution system was investigated by El-Bayeh [37]. Prospective assessment of energy technology: a comprehensive approach to sustainability assessment researched by Haase [38]. Detailed Study of Solar Energy Conversion System using Boost Converter—A New MPPT Technique was investigated by Balasubrahmanyam [39]. Tracking the maximum power point in a photovoltaic system under different operational conditions using the ZA-INC algorithm was investigated by Rajabi [40]. The Life Cycle of Carbon Emissions and the Energy Implications of High Penetration of Photovoltaics and Electric Vehicles in California was investigated by Raugei [41]. Green energy research: forecasting wind power for a cleaner environment using a robust hybrid metaheuristic model investigated by Kerem [42]. Environmental Energy Sustainability in Universities was researched by Montoya [43]. Real Time Energy Management and Microgrid Control based on Renewable Energy on the Grid was researched by Worku [44].

Renewable energy development can also be implemented in educational institutions. This can educate the academic community in increasing caring attitudes towards the environment. An attitude of caring for the environment can also be implemented by managing waste (waste management), greening schools, and understanding the importance of protecting/conserving the environment. However, to achieve a green school is more massive if it is done by utilizing technology such as empowerment which has been carried out in various schools. Therefore the use of one of the renewable energy technologies is very suitable to be implemented in schools in order to realize the green school program which is one of the school's visions and missions, for example by utilizing PLTS, a renewable energy that is easy to apply, as well as being able to educate students, teachers and the staff at the school.

Muhammadiyah 2 Turi Vocational High School (SMK Muhammadiyah 2 Turi) is located on Jl. Turi-Temple Km. 3.5 Ngablak, Bangunkerto, Kapanewon Turi, Sleman (Figure 1). SMK Muhammadiyah 2 Turi consists of two expertise programs, namely: 1) Audio Visual Engineering and 2) Nursing. Muh 2 Turi Vocational School has a vision of "realizing graduates who are ready to work, independent, have a work ethic, are cultured and are devoted to Allah SWT in facing global challenges". Mission of Muhammadiyah 2 Turi Vocational School 1) Familiarize school members to live an Islamic life; 2) Train students to have life skills; 3) Develop competitive human resources based on science and technology; 4) Familiarize schools to live clean, healthy and preserve an environmentally friendly culture; 5) Empowering all school resources to shape the personality of Muhammadiyah.

Fig. 1. SMK Muhammadiyah 2 Turi

SMK Muhammadiyah 2 Turi is determined to become a green school, which means developing and implementing programs and activities to internalize environmental values. Green School is the embodiment of one of its missions, which is to familiarize schools with a clean, healthy life and to preserve an environmentally friendly culture. Learning through the environment is a strategy that encourages students to learn not only depending on what is in the book, but also in real life. This learning concept departs from conceptual learning which puts forward the principle that what students need to learn first is what is in their environment. Empowerment has been carried out related to environmental and greening insights at this SMK. However, empowerment has never been carried out regarding the importance of implementing renewable energy in realizing a green school. In fact, with the application of green energy, the vision will be more complete to achieve green school-based schools.

Increasing the competence of students in Vocational High Schools is very important to support their scientific fields as provisions after graduation. Vocational schools are the first to produce skilled workers who are ready to work and can also continue their studies at the tertiary level. SMK Muhammadiyah 2 Turi has several excellent programs in the field of science and technology (Science and Technology) to support student competence, one of which is PLTS (Solar Power Plant). Based on the school's mission, which is to develop competitive human resources based on science and technology, as well as to accelerate the realization of a green school, it is deemed necessary to develop PLTS as a source of renewable electrical energy. Green school or green school is a strategy or effort to create a healthy and environmentally friendly school environment. PLTS development can be developed and commercialized through production units in schools. PLTS has been widely applied to public facilities by utilizing solar energy which can be a business opportunity for school production units in commercializing science and technology and new renewable energy.

Fig. 2. The Solar Module Owned by SMK Muhammadiyah 2 Turi

SMK Muhammadiyah 2 Turi has received assistance from the Directorate of Vocational High Schools, Directorate General of Vocational Education, Ministry of Education and Culture in 2020 in the form of school equipment facility funds, one of which is to realize Green Technology and Green Energy through PLTS equipment at SMK Muhammadiyah 2 Turi. However, the HR (Human

Resources) at this SMK is lacking in terms of assembling PLTS. It is feared that SMKs only ask for help from parties outside the school and do not work on it with existing human resources. Therefore it is necessary to strengthen competence for Teachers and Students at SMK Muhammadiyah 2 Turi in the knowledge and skills of assembling PLTS. Until now Muhammadiyah 2 Turi Vocational School has only one 100 Wp Monocrystaline Solar Module unit, shown in Figure 2 above, with a set of electronics and one 100 Ah battery unit as a source of electric current charging shown in Figure 3 below. In terms of assembling PLTS obtained from this assistance, the Head of SMK Muhammadiyah 2 Turi, Purwati, S.Pd., M.Sc. as the Head of Muhammadiyah 2 Turi Vocational School asked for help from the Head of the Community Service Team in this proposal so that the PLTS could be assembled and the school could use it in teaching and other activities. According to him, it is necessary to add PLTS devices and increase competence for teachers and SMK students in installing and maintaining PLTS so that the school's vision of becoming a green school is achieved.

Fig. 3. There is only 1 unit of electronic device and battery as a PLTS charging source

The service program with a contribution to developing PLTS in school production units in understanding PLTS is expected to be able to realize green schools through green energy and green technology. Second, this community service program is able to improve the competence of human resources, namely teachers and students of the audio video expertise program in understanding and applying PLTS installation and maintenance skills. Third, SMK Muhammadiyah 2 Turi is able to create reliable and competitive PLTS products nationally.

2. Method

This section describes the methods used in implementing this community service program. Through the PKM Scheme Community Service Program (Community Partnership Program) Muhammadiyah University of Yogyakarta (UMY) this solution is provided to solve the problems that have been described. The targets in this community service are teachers and students of the Audio Video and Nursing Expertise Program. Problems and solutions as well as outcomes obtained after the solutions are given are summarized in Table 1.

Table 1. Partner Problems and Solutions Provided.

No	Problem	Solution	Output and Outcome
1	An understanding of new and renewable energy (EBT) is needed to support the school's vision of becoming a Green School	Counseling on the introduction and explanation of various types of new and renewable energy (EBT)	Teachers and students of SMK Muhammadiyah 2 Turi understand new and renewable energy (EBT)
2	Need an understanding of PLTS	Counseling on the operation and maintenance of PLTS in the school environment	Teachers and students of SMK Muhammadiyah 2 Turi understand the operation and maintenance of PLTS in the school environment
3	The absence of the application of	Provide training and develop PLTS	Students can develop PLTS into products that are ready

No	Problem	Solution	Output and Outcome
	science and technology in accelerating the realization of the Green School	in school production units so that PLTS products can operate properly	to be used at least in the SMK Muhammadiya 2 Turi environment
4	All sources of electricity still rely on supplies from PLN	PLTS installation in the school environment	The existence of a power source from PLTS can at least be used to charge cellphones and laptops in the school environment

The flowchart of the implementation of community service to SMK Muhammadiyah 2 Turi partners is shown in Figure 4.

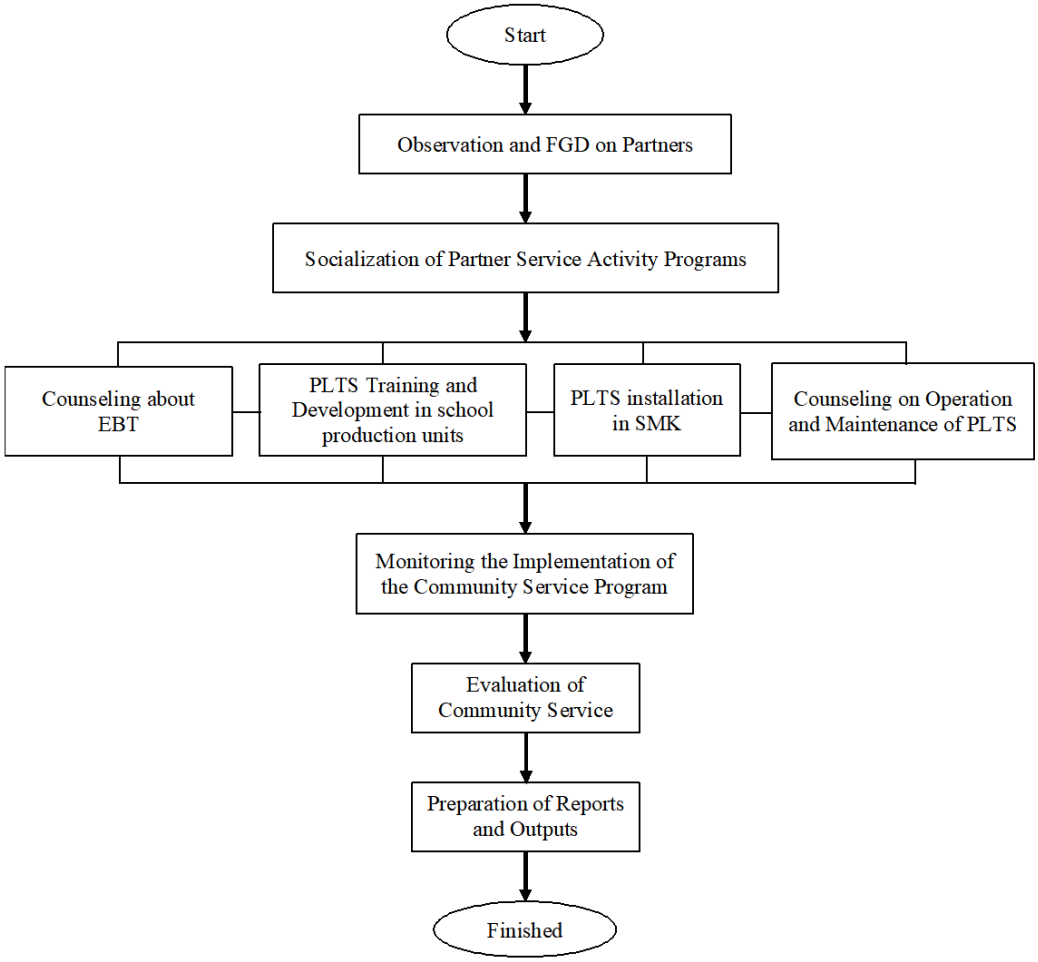

Fig. 4. Community Service Flowchart

The method for implementing the 2022 PKM Scheme Community Service is with the following stages:

2.1. Observations on Partners and FGD (Focus Group Discussion) with the Principal, Head of the Audi Video Technical Expertise Program, and Teachers of SMK Muhammadiyah 2 Turi

Observations and FGDs are carried out by visiting partner locations to collect all data, both qualitative and quantitative data, supported by visual data with photo and video documentation to find problems and potential for partners which can be used as a reference for designing service programs so that they can solve problems for partners effectively. accurate.

Vol. 2, No. 6, 2022
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2.2. Dissemination of Partner Service Activity Programs

Dissemination of all programs that will be carried out at partners is carried out so that partners know the flow of implementing this community service activity.

2.3. Extension of New and Renewable Energy (EBT)

This counseling was given to all teachers and students of SMK Muhammadiyah 2 Turi so that they have an understanding of EBT which can support the school's vision, namely a green school. The resource person in this training activity is a Vocational Engineering Technology Lecturer who has competency expertise in the field of Energy Conversion and Renewable Energy, namely the Chief Executive of this Community Service.

2.4. PLTS Training and Development in School Production Units

The application of science and technology in school production units is an effort to accelerate the realization of green schools by developing PLTS and a means of increasing competence for students of the Audio Video Engineering expertise program. The resource persons in this training activity were Lecturers in Automotive Engineering Technology, Vocational Studies, UMY who have competency expertise in the field of Energy Conversion and Renewable Energy (Chairman of Community Service) and Lecturer in Electro-medical Engineering with expertise in Electronics (Member of Service from Yogyakarta Muhammadiyah University). This activity, of course, begins with the provision of counseling to provide knowledge about PLTS in advance to participants such as the method of implementing community service that has been carried out previously which is also related to PLTS, namely providing counseling about PLTS installation.

2.5. Installing PLTS in Schools

The PLTS installation was carried out by students of Mechanical Technology and Electrical Engineering Institute of Science & Technology AKPRIND Yogyakarta who were accompanied by a Lecturer in Electro-medical Engineering as an electrical installation electronics expert and an Automotive Engineering Technology Lecturer as a renewable energy expert with two circuit packages with maximum power for each circuit, namely 100 Watts. The PLTS installation is expected to be able to reduce the cost of using PLN's electricity and accelerate the realization of green school at SMK Muh 2 Turi.

2.6. Counseling on Operation and Maintenance of PLTS

Counseling on the operation and maintenance of PLTS was carried out with speakers from the Mechanical Engineering Institute of the AKPRIND Yogyakarta Institute of Science & Technology with manufacturing and material expertise competencies, namely members of the lecturers in community service who also designed the PLTS assisted by Mechanical Technology students.

2.7. Monitoring and Evaluation of the Service Program Implementation

Monitoring and mentoring is carried out in each of the above programs after the counseling is carried out. This stage is the main process of community empowerment in a whole series of community service activities. Because in this activity partners are directly involved in practicing what has been conveyed during counseling and training. Each sub-program ends with an evaluation carried out for each of the above sub-programs. After all service programs have been completed, a final stage of evaluation is carried out.

3. Results and Discussion

This section describes the results obtained during the implementation of the community service program. Community Service Activities for the PKM scheme are carried out at SMK Muhammadiyah 2 Turi from February 2022 to April 2022. The sequence of stages for implementing community service is described in sequence based on the established method of implementation.

1. Extension of New and Renewable Energy (EBT)

This counseling activity was attended by 20 students and 10 teachers of SMK Muhammadiyah 2 Turi. This counseling aims to provide knowledge of New and Renewable Energy (EBT) so that it can support the school's vision towards a green school through green energy or renewable energy (clean,

Vol. 2, No. 6, 2022
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environmentally friendly energy or renewable energy). Seen in Figure 5, the head of the community service executor from UMY (Automotive Engineering Technology lecturer) gave counseling about New and Renewable Energy (EBT), all participants were very enthusiastic in participating in the activity.

Fig. 5. Extension of New and Renewable Energy

At the beginning of the activity and at the end of the counseling the participants were given pre-test and post-test questions to measure their knowledge of New and Renewable Energy (EBT) before and after the training was carried out. Seen in Figure 6 the service team distributes post-test questions to extension participants at the end of the extension activity.

Fig. 6. Participants Working on Post-test Questions After the Counseling is Complete

Based on the data obtained (Table 2), of the 20 students prior to participating in the EBT counseling, only 10% already knew and understood EBT, while the remaining 85% did not know and understand EBT. While the results of the pre-test for teacher participants, out of 10 teachers who attended this counseling, 25% understood EBT. There are 75% of teachers who do not know and understand EBT. After the Counseling was completed, the result was an increase in the knowledge and understanding of the participants. There were 80% of students who already knew and understood EBT, while for the teacher participants, all teachers (100%) who attended this counseling knew and understood EBT well. So it can be concluded that there was an increase in the knowledge of student participants by 70% and teachers by 75% after the completion of this counseling.

Table 2. Results of Increasing Participants' Knowledge of EBT

No	Counseling Participants	Pre-Test	Post-Test
1	Student	10%	80%
2	Teacher	25%	100%

Increasing the knowledge of students and teachers who participated in this counseling was said to be successful. The participants had experienced an increase of at least 70% from the data before the counseling was carried out and the final result was that 80% of students and all teachers mastered knowledge about EBT.

2. PLTS Training and Development in School Production Units

This training activity was also attended by the same participants, namely students and teachers, each of which totaled 20 students and 10 teachers of SMK Muhammadiyah 2 Turi. The resource persons in this training activity were lecturers in Automotive Engineering Technology, Vocational Studies, UMY who have competency expertise in the field of Energy Conversion and Renewable Energy (Chairman of Community Services) and lecturers in Electro-medical Engineering with expertise in Electronics (Members of Community Service from Yogyakarta Muhammadiyah University). The two sources were assisted by a team of community service collaborators from Akprind. Seen in Figure 7 the collaborative service team from providing training on assembling PLTS components that will be installed at this SMK.

Fig. 7. PV mini-grid training

All participants were very enthusiastic in participating in this training. During the question and answer session, not only did the students ask questions, the teacher participants were not shy about asking what they wanted to know about the PLTS installation, as shown in Figure 8.

Fig. 8. Enthusiastic Teacher Participants Ask in PLTS Training

At the end of the training activity, all participants and the service team took a group photo for documentation for both the service team and SMK Muhammadiyah 2 Turi, shown in Figure 9. This photo document is used as a memento and proof of the implementation of this useful activity when there is a visitation from the education office as well as LPM (Public Service Institute) Muhammadiyah University of Yogyakarta. With this activity, it will be mutually beneficial for both parties, UMY and partners, in this case SMK Muhammadiyah 2 Turi.

Fig. 9. Group Photo Session After the PLTS Training

Prior to the training, there was only one teacher (5%) who understood about PLTS installation because he was a productive teacher with audio video competence. Based on the data in Table 3, the results of this training can improve the skills of students and teachers in assembling PLTS components by 75%, while there are 25% of students who are not yet skilled, they only need time to become skilled in this matter and 20% of teachers are also unskilled can practice on their own in assembling PLTS components that have been granted by the service team to this SMK.

Table 3. Results of Increasing Participant Skills in PLTS Training

No	Counseling Participants	Pre-Test	Post-Test
1	Student	0%	75%
2	Teacher	5%	80%

The increase in skills resulting from this training was successful because it had increased 75% of the total participants who attended. However, in the future it is hoped that all teachers and students of SMK Muhammadiyah Turi will have skills in installing PLTS components to support green school-based schools.

3. PLTS installation at SMK Muhammadiyah 2 Turi

The PLTS installation at SMK Muhammadiyah 2 Turi involves students and teachers as a form of successful indicator of community empowerment. The Community Service Team was assisted by students and teachers in installing solar panels (2 units of 100 Wp each), shown in Figure 10.

Fig. 10. Installation of Solar Panels on the School Roof

The PLTS electrical panels are assembled and installed in the library and hall rooms, shown in Figures 11(a) and 11(b). These two points were chosen because in these two spaces there are often activities that require a source of electricity. The library is not only used as a reading facility but is used as a place for discussion and doing assignments for students, while the hall room is used for meetings or meetings for teachers as well as in events attended by guests from outside the SMK. So that these two rooms are right for placing the electrical output from PLTS or a socket that can be used for charging laptops and cellphones (HP).

(a) (b)

Fig. 11. Electrical Panel Installation (a) in the SMK Hall and (b) Library Room

4. Counseling on Operation and Maintenance of PLTS

Counseling on the operation and maintenance of the PLTS installation that has been installed and can be directly used by all the academic community at SMK Muhammadiyah 2 Turi was attended again by all student and teacher participants who had previously attended EBT counseling and PLTS training. In this activity a tutorial or demonstration of the operation of the PLTS maintenance pan is given in the hope that the entire academic community will be able to properly operate and maintain the PLTS installation that has been granted. As seen in Figure 12, one of the teachers advised students to be able to take care of the PLTS that had been donated by the team from UMY.

Fig. 12. Counseling on Operation and Maintenance of PLTS

The entire academic community of SMK Muhammadiyah 2 Turi has been able to operate and maintain the PLTS units that have been donated. The grant for 2 PLTS installation units provided by the service team is expected to be useful in supporting green schools and providing benefits in all activities that require charging, especially laptops and cellphones.

5. Monitoring and Evaluation of the Service Program Implementation

SMK Muhammadiyah 2 Turi has been given a grant of 2 PLTS units that have been installed and are ready to be used. The 2022 PKM scheme service program has been successfully implemented, all stages of the service program have gone through well, the results are very satisfying, and useful for SMK Muhammadiyah 2 Turi. Plt. The head of SMK Muhammadiyah 2 Turi thanked the UMY LPM

(Community Service Institute) and the Community Service Team and hoped that this community service program could continue with other subsequent programs so that fellow AUM (Muhammadiyah Charity) could move forward together.

Fig. 13. One of the Teachers Interviewed When the Service Team Conducted Monitoring and Evaluation

One of the teachers (productive teacher of audio video technical expertise) who was interviewed by the service team during monitoring and evaluation at SMK Muhammadiyah 2 Turi gave a positive impression and response to this service program, seen in Figure 13 above. According to him, this program really supports the Green School SMK Muhammadiyah 2 Turi program.

4. Conclusion

The PKM service scheme for the 2022 implementation year was successfully implemented. There are 80% of the student participants at SMK Muhammadiyah 2 Turi who already know and understand New and Renewable Energy (EBT). Meanwhile, all teacher participants already know and understand New and Renewable Energy (EBT). So it can be concluded that there is an increase in the knowledge of student participants by 70% and teachers by 75%. The PLTS training that has been carried out can increase the skills of students and teachers in assembling PLTS components by 75%, while the rest can improve their skills by practicing themselves in assembling PLTS components that have been granted by the service team to this SMK. Grants for 2 PLTS units for charging cellphones and laptops were given by the UMY service team to SMK Muhammadiyah 2 Turi. According to Plt. Principal of SMK Muhammadiyah 2 Turi this service activity is very useful for teachers and students in supporting the school's vision towards a green school. He hopes that this community service program can be continued with other subsequent programs so that fellow AUM (Muhammadiyah Charity) can develop together..

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Author Contribution

The activity plan for the implementation of this community service consists of EBT counseling and PLTS training. Participants in the EBT counseling program and PLTS installation training were 20 students and 10 teachers.

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Conflict of Interest

The authors declare no conflict of interest.

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