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# Training on the Utilization of On-Grid and Off-Grid Solar Panels

**[1]Sarah Najla Hanifati, [2]Readysal Monantun, [3]Mochammad Djaohar, [4]Muksin, [5]Abdul Malik**
[1,2,3,4,5]State University of Jakarta, Indonesia

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**Abstract**
*The community engagement activity in the form of training on the utilization of on-grid and off-grid solar panel systems at SMK Madinatul Ilmi, Muara Gembong, intended to enhance the community's understanding and technical skills in utilizing solar energy. The training was conducted using a participatory approach and hands-on practice. Evaluation was conducted through pre-tests and post-tests to measure the impact of the training. The post-test results showed a significant increase in participants' knowledge, with the average score rising from 40.67 to 84.67. The N-Gain score indicated an effective improvement, with a value of 77.6. Participants were able to identify the main components and demonstrated the ability to install and maintain solar panel systems. This training also successfully raised community awareness of renewable energy and encouraged initiatives to implement this technology in daily life. The program involved university students as part of the implementation of the Merdeka Belajar Kampus Merdeka (MBKM) program, providing them with practical field experience. This empowerment model can be replicated in other coastal areas with similar characteristics.*



***Corresponding Author:***
**Sarah Najla Hanifati**
State University of Jakarta, Indonesia
sarah.najla@unj.ac.id

## 1. INTRODUCTION

Coastal areas often face challenges in providing reliable and sustainable energy. Pantai Mekar Village, located in the Muara Gembong Subdistrict, Bekasi Regency, is one example of a region with limited electricity supply due to its remote location far from energy distribution centers. This significantly impacts the quality of life of the residents, as well as educational and economic activities in the area. Yayasan Madinatul Ilmi, as an educational institution in this region, also experiences difficulties due to its dependence on the unstable conventional electricity supply from the national electric company as know as PLN (Perusahaan Listrik Negara).

In this context, the abundant year-round solar energy potential presents an alternative solution that needs to be utilized optimally. The use of new and renewable energy, particularly solar panel technology, has become a key focus in efforts to improve energy resilience and reduce carbon emissions in various developing countries. Solar panel technology offers two main systems, there are on-grid and off-grid, each with its own advantages and challenges. The on-grid system allows direct integration with the national electricity grid, while the off-grid system provides an independent solution without relying on the main network.

Several previous studies have highlighted the importance of strengthening community capacity in renewable energy management as part of sustainable development strategies. Handayani et al. (2019) emphasized that the energy transition in developing countries requires institutional support and public education to ensure widespread adoption of technology. Furthermore, Munir and Syamsudin (2021) stated that empowering coastal communities through renewable energy technologies significantly contributes to reducing production costs and improving welfare. These studies reinforce the urgency of community-based training programs that directly target local groups in remote areas. In Indonesia, the development of this technology

still faces obstacles in terms of public understanding as well as limited access to technology and technical training.

The residents of Pantai Mekar Village generally work in the agriculture and fisheries sectors, which are highly dependent on stable energy supplies for their production activities. High energy costs are one of the main burdens in daily operations, while solar energy has not been fully utilized due to a lack of technical knowledge. This condition is worsened by the limited access to information and renewable energy technologies. Therefore, an initiative is needed to address the need for improving the community's capacity to understand and apply solar panel technology.

The community engagement activity conducted by the Faculty of Engineering at State University of Jakarta aims to resolve this issue through training on the use of both on-grid and off-grid solar panel systems. This program is designed to empower the community around Yayasan Madinatul Ilmi and Muara Gembong so that they can manage and operate solar energy systems independently. The training not only provides conceptual understanding but also practical skills in installation, maintenance, and optimization of solar panel technology based on local needs.

## 2. RESEARCH METHODS

This research is a quantitative study employing a pre-experimental design with a one-group pretest-posttest model. The program is intended to evaluate the effectiveness of a training program on solar panel technology both on-grid and off-grid systems conducted for the local community around SMK Madinatul Ilmi in Pantai Mekar Village, Muara Gembong Subdistrict, Bekasi Regency. The participants, totaling 15 people, were selected purposively based on their interest and involvement in energy-related activities, which are highly dependent on a stable energy supply.

To collect data, the research used an instrument conceptual test on solar energy given before and after the training. The training consisted of both theoretical sessions and practical workshops on the installation, maintenance, and optimization of solar panel systems.

The data collected from the prestest and posttest were analyzed using the normalized gai (N-gain) formula to determine the level of improvement in participant's knowledge.

$$Gain = \frac{Posttest - Pretest}{Maximum\ Score - Pretest}$$

The N-Gain is calculated by comparing the difference between the posttest and pretest scores to the maximum possible improvement. Based on Hake's criteria, the N-Gain scores are categorized as high ($0.70 \leq g$), medium ($0.30 \leq g < 0.70$) or low ($g < 0.30$).

Table 1. Criteria for the N-gain Value Scale

| Value Scale | Interpretation |
|---|---|
| $0.70 \leq g \leq 100$ | High |
| $0.30 \leq g < 0.70$ | Medium |
| $0.00 < g < 0.30$ | Low |

This analysis serves to assess the effectiveness of training program in enhancing both the theoretical understanding and practical capabilities of the participants in applying solar energy technologies relevant to their local context.

In addition to the research design and data analysis, this community engagement program was implemented through a systematic method designed to approach the specific needs and challenges faced by the residents of Pantai Mekar Village. The core focus was to enhance the community's understanding and ability to independently and sustainably operate solar panel systems. The implementation method involved five main stages: socialization,

technical training, technology implementation, mentoring and evaluation, and sustainability planning.

1. Socialization

The initial phase was developed to raise awareness about the importance of renewable energy and introduce basic concepts of solar panel technology to the community and the stakeholders at SMK Madinatul Ilmi. This was conducted through direct meetings, educational videos, and informative leaflets to build a foundational understanding of solar energy as a clean and sustainable energy source.

Image 1. Documentation of training team and participants

2. Technical Training

The second phase focused on hands-on technical training in two key areas: (a) the installation and maintenance of on-grid and off-grid solar panel systems, and (b) the practical use of solar technology for household. The training followed a participatory, "learning by doing" approach and included participants from various backgrounds, such as teachers, fishermen, and farmers. The content covered component introduction, system operation, installation techniques, and maintenance procedures, delivered by university lecturers and renewable energy practitioners.

Image 2. Documentation of technical training by the instructor

3. Technology Implementation

Following the training, participants applied their knowledge by installing solar panel systems at selected sites, including school facilities and partner households. The program team supervised the installation process to ensure optimal system function. This stage provided direct, real-world experience in applying the skills gained during the training.

4. Mentoring and Evaluation

Regular mentoring sessions were conducted to ensure that participants were able to independently operate and maintain the solar panel system. The evaluation was conducted through field observations and by measuring the effectiveness of the training using pre-test and post-test methods. The results of the evaluation indicated a significant improvement in participants' understanding and skills. The average pre-test score was 40.67, while the post-test score increased to 84.67, demonstrating the effectiveness of the training methods used.

5. Sustainability Planning

To ensure long-term impact, a local working group was formed from training participants to serve as a community-based hub for continued learning and technical support. Additionally, the school was encouraged to integrate this training content into its vocational curriculum (specifically in the electrical engineering practical courses) to support continuous knowledge transfer and future capacity building.

The community engagement team consisted of lecturers, students, and technical experts from the Electrical Engineering Education Program, Faculty of Engineering, State University of Jakarta. Lecturers were responsible for designing materials and delivering training, students provided field assistance and documentation, while technical experts supported system installation and evaluation.


Image 3. Documentation of the training team, foundation leaders, participants and students.

## 3. RESULTS AND DISCUSSION

### 1. Research Results

The research results show that the training program on solar panel technology had a significant effect on improving the participants' understanding and skills. Based on the pretest and posttest scores from 15 respondents, the average pretest score was 40.67, while the average posttest score increased to 84.67. This demonstrates a substantial improvement in participants' knowledge after the training.

Table 2. N-gain Result Analysis

| Respondent | Pre test | Post test | Gain Score | Normalized Gain | % N-Gain | Interpretation |
|---|---|---|---|---|---|---|
| 1 | 20 | 70 | 50 | 0.625 | 62.5 | Medium |
| 2 | 50 | 100 | 50 | 1.000 | 100 | High |
| 3 | 40 | 90 | 50 | 0.833 | 83.3 | High |
| 4 | 80 | 100 | 20 | 1.000 | 100 | High |
| 5 | 50 | 80 | 30 | 0.600 | 60.0 | Medium |
| 6 | 50 | 90 | 40 | 0.800 | 80.0 | High |
| 7 | 50 | 90 | 40 | 0.800 | 80.0 | High |
| 8 | 10 | 60 | 50 | 0.556 | 55.6 | Medium |
| 9 | 50 | 90 | 40 | 0.800 | 80.0 | High |
| 10 | 80 | 100 | 20 | 1.000 | 100 | High |
| 11 | 40 | 80 | 40 | 0.667 | 66.7 | Medium |
| 12 | 30 | 80 | 50 | 0.714 | 71.4 | High |
| 13 | 20 | 70 | 50 | 0.625 | 62.5 | Medium |
| 14 | 20 | 90 | 70 | 0.875 | 87.5 | High |
| 15 | 20 | 80 | 60 | 0.750 | 75.0 | High |
| **Average** | **40.67** | **84.67** | | **0.776** | **77.6** | **High** |

The N-Gain analysis was used to measure the effectiveness of the training. The average normalized gain (N-Gain) was 0.776, or 77.6%, which according to Hake's classification, increase into the "high" category of effectiveness. This indicates that the training was successful in significantly increasing participants' conceptual understanding of on-grid and off-grid solar panel systems. This suggests that the training was generally effective for most participants, with a small variance depending on initial knowledge and other individual factors.

## 2. Discussion

The discussion of this research focuses on the interpretation of the findings and how they relate to theory, literature, or previous research. The research results are critically analyzed to understand the patterns, relationships, or differences found. In the discussion, it explains how the findings support or challenge existing theories as well as factors that may have influenced the results. In addition, the discussion includes the practical and theoretical implications of the research, including how these results can be applied or further developed. Limitations of the study are also identified to provide greater context, followed by suggestions for future research to deepen or extend the findings. The discussion of this research focuses on interpreting the above findings within the context of community-based energy education, particularly in rural or underserved coastal areas. The high average N-Gain score (0.776) confirms that the training program was effective in enhancing the knowledge and practical competencies of the participants regarding solar energy technologies. This supports existing literature that states structured training programs combined with hands-on practice can significantly improve understanding and adoption of renewable energy technologies in local communities.

The results are aligned with findings from similar studies, which show that practical engagement and contextual learning lead to better knowledge retention and skill acquisition, particularly in vocational or technical subjects. In this case, the mix of theoretical sessions and real-life installation practice likely contributed to the strong learning outcomes observed.

Empowering local communities with knowledge of solar energy not only supports energy independence but also opens opportunities for local economic development.

Theoretically, this study contributes to the field of community empowerment and renewable energy education by demonstrating that even a short-term training program can yield significant improvements when delivered in an interactive and locally relevant manner.

However, the study has certain limitations. The sample size was relatively small (15 participants), and the duration of the training was limited to one day. These factors may limit the generalizability of the results.

For future research, it is recommended to include a larger sample size, extend the duration of the training, and conduct post-training evaluations after several months to measure long-term impact. Comparative studies involving different training models or demographic groups could also provide deeper insights into the most effective methods for community-based renewable energy education.

## 4. CONCLUSIONS

Provide a statement that what is expected, as stated in the "Introduction" chapter, can ultimately result in the "Results and Discussion" chapter, so that there is a match. In addition, prospects for the development of research results and prospects for the application of further research (based on the results and discussion) can also be added.

The results of this study confirm that the training on solar panel technology covering both on-grid and off-grid systems effectively improved the knowledge and practical skills of the participants from the coastal community of Pantai Mekar Village. As expected and stated in the Introduction, this initiative successfully delivered the need for building local capacity in understanding and utilizing renewable energy solutions, particularly in areas with limited and unstable access to conventional electricity sources.

The N-Gain result showed a high average gain of 0.776 (77.6%), indicating that the training program had a significant positive impact on the participants' learning outcomes. This outcome aligns with the study's objective to empower the local community through technical education, and further supports the importance of renewable energy education in remote or underdeveloped regions.

Looking ahead, the findings of this research open promising prospects for the development of similar community-based training programs in other areas facing energy access challenges. The successful implementation in this case can serve as a model for broader applications, particularly in Indonesia's rural and coastal regions. Future research can expand this study by involving a larger number of participants, incorporating long-term impact assessments, and exploring other forms of renewable energy training. Furthermore, integrating this type of training into formal or informal educational curricula could help sustain the knowledge transfer and support wider adoption of clean energy technologies at the grassroots level.

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