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Solar energy technology: Knowledge, awareness, and acceptance of solar energy in Ngada, East Nusa Tenggara, Indonesia

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ABSTRACT

One of the Indonesian Government's efforts to meet the target of 23% fulfillment of new and renewable energy by 2030 is to provide solar electricity through government assistance. The priority of solar energy projects by the government, one of which is East Nusa Tenggara. The area is area that has a pretty good potential for solar energy. In addition, the site has a low level of access to electricity in Indonesia. In 2007, solar energy projects through a microgrid system were started and continued with a home system. However, the receiving group is a group that lacks knowledge of new renewable energy and is also economically vulnerable. This research was conducted to identify the level of understanding, awareness, and acceptance of solar energy users, which generally demands good knowledge and economic strength. Questionnaires containing demographic, attention, and approval information to utilize solar PV technology were distributed to 20 selected respondents from Maghilewa, Jere, Watu, and Belaraghi in Ngada, East Nusa Tenggara. The study revealed that although 90% of respondents had no basic knowledge of science, their level of awareness of solar energy technology and its use was at an average score. However, respondents showed a high level of technology acceptance because of the hope for social and economic improvement. In addition, the study also found that respondents in 4 kampongs were deeply involved in the changes that new technology products brought to society. The respondent gives total commitment to using and maintaining solar power.

Contribution/Originality: Some studies have shown that user knowledge and awareness drive the motivation to adopt new renewable energy. This research claims that this is not the only motivation to accept the technology but rather a positive perception of its users on social and economic impact towards their life.

1. INTRODUCTION

The depletion of fossil energy reserves due to increasing consumption and global warming is driving changes in energy use. Technologies over renewable energy are increasingly needed to help humans provide alternative energy, avoid global warming, and minimize economic capital over energy. Research on renewable technologies lets humans know about alternative energy, such as water, wind, solar, geothermal, biomass, ethanol, and ocean waves. Such alternative energy is a rational choice for the state to provide energy facilities, especially in rural areas where it is difficult to access electrical energy (Min et al., 2018).

The character of fossil energy which tends to be non-renewable and continues to decline, indicates the vulnerability of energy security. In Indonesia, the same situation is found where there is a high demand for energy

and increasing dependence on fossil fuel use. This need is projected to continue to grow with energy demand for all scenarios (BaU/Business as Usual scenario, SD/Sustainable Development scenario, and LC/Low Carbon scenario) still dominated by the transportation sector, which is around 35% and in 2050 dominated by the industrial sector between 37-42%. Meanwhile, electricity demand until 2050 in all scenarios is still dominated by the household sector, then the industrial and commercial sectors (Secretariat General of National Energy, 2019).

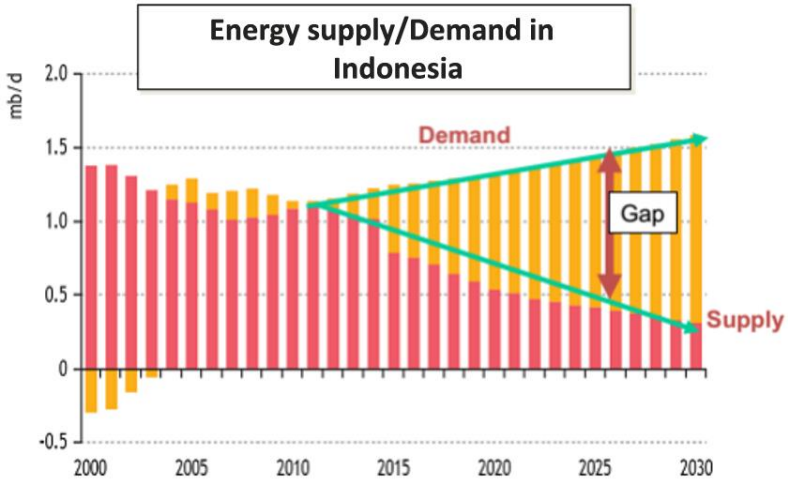

Figure 1. Gap between energy demand and availability in Indonesia.
Source: Pusat Perancangan Undang-Undang Badan Keahlian DPR-RI 2018.

Unfortunately, the energy availability did not support the energy demand, so the gap between need and availability is even more significant, as shown in Figure 1. The supply decline is mainly due to decreased domestic oil production. In 2011 the reserves continued to decline to only 3.7 billion barrels, and in 2019 there were only around 2.5 billion barrels (Umah, 2021). This situation creates energy security vulnerabilities due to the growing dependence on imports.

An effort to increase the contribution of renewable energy must be carried out to support national energy availability to prevent future energy crises and strengthen energy sustainability. Renewable energy is a rational choice given its huge potential, but it has not yet been exploited enough. Former Deputy Minister of Energy and Mineral Resources (MEMR) Rudi Rubiandini said the most significant energy reserves came from New Renewable Energy/NRE. Hydro, for example, reserves reached 45,379 megawatts (MW), while the installed capacity of the new plant was 8,671 MW or 19.1 percent. Then geothermal or geothermal resources amounted to 29,544 MW, but the installed ones were only 2,600 MW or 8.8 percent. Even though Indonesia has the most immense geothermal potential globally, the sources have not yet been explored. Meanwhile, mini-micro hydro reserves amounted to 19,385 MW, but the installed ones were only 1,438 MW or 7.4 percent. Meanwhile, other green energy potentials, such as biomass, solar energy, wind energy, ocean waves, and so on, have not been used much to diversify the energy (Mainly, 2020).

To increase the production and contribution of NRE, the Indonesian Government gives priority to the development of NRE. Through the Government Regulation of the Republic of Indonesia Number 79 of 2014 concerning the National Energy Policy (NEP), the Indonesian Government has determined the role of NRE to reach at least 23% of the national energy mix by 2025. Indirectly, the policy of implementing the function of NRE has also been strengthened politically in Law Number 30 of 2007 concerning Energy.

Efforts to encourage the use of renewable energy are certainly not easy. Until 2020, the contribution of NRE has only sought 11.51%, from the target of 13.4% (Directorate General of EBTKE, 2022). This sluggish growth makes reaching 23% of NRE in 2025 difficult to meet. There are some challenges faced in the development of alternative energy. At least three things are the main obstacles to developing alternative energy. First of all, most Indonesians

still have a high dependence on fossil energy. Second, the cost of generating NRE is relatively expensive. Third, NRE culture has not yet grown. People are not used to managing plants and using NRE. As a result, opposition to using new and renewable energy often occurs.

The challenges in using NRE prevent some people from depending on fossil energy. Knowing people's motivations and perceptions is essential for the government to make policies regarding NRE. The research will be directed to find two things. (1) the perception of renewable energy. Perceptions concern what they recognize about renewable energy, impressions, views, and opinions of community members due to contact with the use and benefits of renewable energy. (2) after exploring perception, the research will explore the motivation of the community in maintaining the sustainability of renewable energy generation and its use.

2. RESEARCH METHODS

The conceptual framework used to support this research was adapted from the Technology Acceptance Model (TAM) developed by Davis and Davis (1989). Acceptance has been seen as a function of user participation in the developmental system. Figure 2 describes the TAM model, which consists of two main constructions: *Perceived usefulness* (PU) and *Perceived ease of use* (PEU). PU and PEU are two cognitive beliefs in TAM. Davis defines PU as the stage where a person trusts a particular technology that will improve their ability to perform work. External variables affect PU, PEU, and attitudes toward using new technologies. The user's perspective determines the intended behavior of the use of technology. This model states that when users are introduced to new technology, several factors influence their decision to use it. In other words, the use of new technologies is directly or indirectly affected by the technology's behavioral intentions, attitudes, PU, and PEU.

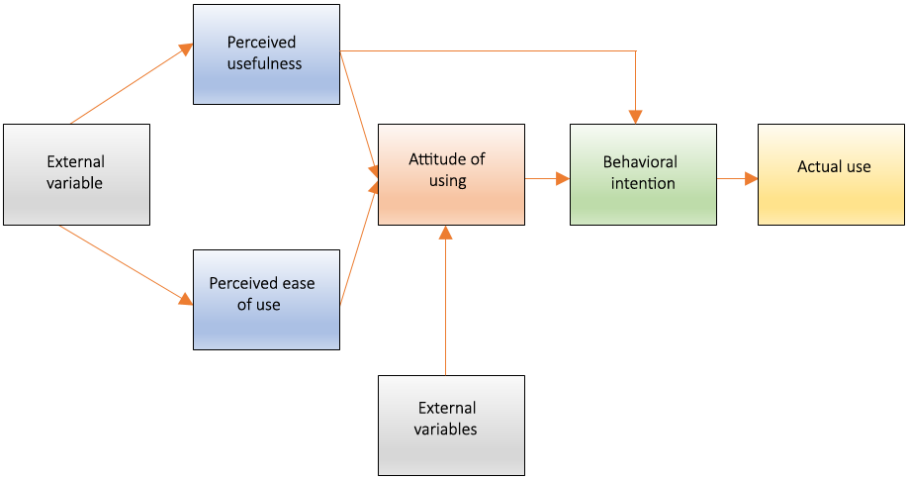

Figure 2. Technology acceptance model (TAM).
Source: Malik and Ayop (2020).

This research used a sample of 20 people (25% of the total population living in four indigenous kampongs). Kampong is an area that is smaller than a hamlet. The research locations were four traditional kampongs in Ngada Regency, East Nusa Tenggara. Those are Maghilewa, Watu, Jere, and Belaraghi kampongs, located in the Inerie District, which contains 54 traditional houses with a total population of 80 people. Ngada Regency was chosen because this area has traditional villages that do not have access to the State Electricity Company (SEC). Therefore, in 2002, the Government introduced solar panel power generation technology. There are two types of solar power plants that are built, namely those in the form of microgrids and home system models. The type of renewable energy that is the object is the use of the solar power plant.

The research used a mixed method research method, namely by distributing a closed questionnaire to 20 respondents as a sample to find out their knowledge and awareness of solar energy. Meanwhile, the interview method is used to complete and inter-achieve the data.

3. LITERATURE REVIEW

Changes in the behavior of community groups in energy use are one of the factors for the success of NRE implementation. Fossil energy consumption can be significantly reduced by targeting consumer behavior to achieve sustainable energy savings and promoting consumption patterns in NRE. Several studies have been conducted to determine how attitudes/behaviors can support the success of NRE implementation. Research on people's attitudes/behaviors or motivations can be the basis for making practical guidelines for implementing new renewable energy projects in Indonesia. It can also help the government realize the 23% alternative energy target by 2025.

Most academic research on behavior toward implementing NRE shows a positive correlation to their basic knowledge and level of awareness about technology with a high level of acceptance of government policies in using NRE. Research by Assali, Khatib, and Najjar (2019) in Tanjung Malim Regency, Malaysia, shows that the increased education and knowledge of citizens, awareness of the positive impacts of solar energy as well as economic motivation encourage them to establish a positive response to government policies in addition to promoting, and educating their families in solar energy technology. Likewise, research by Guven and Sulun (2017) shows that the level of education is exceptionally influential on a person's awareness (wanting to learn, having knowledge of a specific subject, being aware of problems, and making efforts to improve skills to solve problems) to change their energy consumption behavior can be deliberately built through the curriculum in schools. The same idea is also found in Pietrapertosa et al. (2021) which found that the construction of awareness of alternative energy can be done through the *living laboratory*, which targets student participation through the School4energi school project. The *School4energi* project consists of *School Race*, *Art4energy*, and gamification, which bases itself on monitoring energy consumption to shape students' mentality. Koirala et al. (2018) mentioned that the level of education is not the only factor for positive behavior toward NRE. Concern, the acceptance of renewable energy, energy independence, community trust, community resistance, education, energy-related education, and awareness of local energy initiatives are the most critical factors in determining the willingness of citizens to participate in NRE.

Alawin et al. (2016) agreed that awareness of NRE was not found in a survey conducted at several public and private universities in Jordan. A closed survey was given to 600 randomly selected participants from Ibadan, Akobo, and Asi, Nigeria, conducted by Wojuola and Busisiwe (2019). The survey results show the public can obtain that information about NRE from formal education, mass media, and government socialization of NRE. In contrast to the previous research, Alawin et al. (2016) and Wojuola and Busisiwe (2019) show no relationship between the level of education and knowledge about NRE and awareness of the use of NRE. Thus, public acceptance of renewable energy may not be driven by their formal education, which does not provide sufficient knowledge about renewable energy.

If Wojuola and Busisiwe (2019) allude to the role of the Government in raising awareness of the use of NRE in Nigeria, the same was also discovered by Assali et al. (2019); Oluoch, Lal, Susaeta, and Vedwan (2020) and Al-Marri, Al-Habaibeh, and Watkins (2018). Both found that a policy not supportive of the initiation of NRE would not give a positive result to the willingness to use NRE. Assali et al. (2019) in 46 communities in six districts of Xiamen city, China, show that residents are willing to use NRE, but there is no support from the Government. Assali et al. (2019) did not find a renewable energy mix in government programs. In practice, there is no energy conservation and renewable energy awareness program initiated by the government. Respondents are very willing to save energy and pay for renewable energy sources. Likewise, Al-Marri et al. (2018) found that government policies tend not to be supportive by continuing to provide subsidies to fossil energy so that citizens, with their rational choices, ignore the use of NRE based on economic considerations. The Kenyan Government uses economic reasons to voice to people the importance of NRE, encouraging them to accept NRE (Oluoch et al., 2020). In general, people in both villages and cities (the level of education thus has no significant influence) are willing to take advantage of NRE (except biomass) mainly because of the reduced costs incurred for electricity. More than just the need for policy support from the Government, Komendantova (2021) shows that changes in behavior or willingness to receive NRE are also contributed by opportunities for them to participate in policy-making related to NRE in the region. The behavior

change concerns public concerns about the economic burden caused by NRE, socioeconomic, and environmental impacts.

The research that has been carried out on changes in behavior on the willingness/acceptance of NRE mentioned above shows many supporting factors, including education, knowledge of NRE, government support, and access to policies at the local level. Those research can guide this research, although there are differences in the level of education demographically. Those research will also be necessary for this research so that the study can provide significant findings on the public's willingness to use NRE.

4. RESULTS AND DISCUSSION

4.1. Demographic

The respondents' background in 4 traditional villages in Ngada households generally shows that the residents living in the four areas are people with limited economic conditions and low education, as shown in Table 1. The number of males and females is not much different, and only it is dominated by an age that is no longer young. The entire population works as farmers who manage their fields and produce communally. The low education of the ordinary people who did not finish high school or even did not go to school was high enough; 75% caused them to have no other job alternatives besides farming. The average income earned is relatively low and uncertain because it is based only on the sale of garden products. Geographical conditions not supported by good road access prevent intermediaries from regularly coming to these villages.

Table 1. The demographic situation of residents of 4 traditional villages.

Variable	Sum	Percentage
Man	48	60
Woman	32	40
Age under 30 years old	10	12.5
Age 30-40 th	27	33.75
Age over 40 yrs	43	53.75
Finished high school	25	31.25
Farmer	80	100
Official	0	0
Private workers	0	0
Revenue above 50 $	0	0
Revenue 30 -50$ /mo	70	87.5
Revenue under 10-30$ /mo	5	6.25

4.2. Basic Science Knowledge

Research on basic knowledge of solar energy is needed to determine the essential knowledge possessed by respondents. This basic knowledge helps assess the initial motivation of adopters to receive solar electricity. Tables 2 and 3 show the study's results, where more than 100% of respondents did not know the technology until solar panels entered their villages about 3 or 5 years ago or around 2007 and 2009. Respondents also had no basic knowledge of the sun and earth and did not know that sunlight could be converted into electric power and support the lights in their homes at night.

Interestingly, although some respondents said they were worried about solar-powered electricity, they did not show any rejection of solar energy. References regarding facilities provided by coal-fired electricity became a reference for citizens to adopt solar-powered electricity.

Table 2. Knowledge of solar energy

Solar energy	Answer	Sum	Percentage
Since when to use solar electricity?	3 Years	14	0.7 %
	5 Years	6	0.3 %
What is the impression that you feel when you first use solar panel electrical energy	It's nice	17	0.85 %
	Worried	3	0/15 %
Where do you know about solar energy as a source of electricity?	Know	0	0 %
	Do not know	20	100 %

Table 3. Respondent's basic knowledge.

Basic knowledge	Right	Wrong	Not sure	No answer
The earth circles the sun	5	5		10
Sun is always above the equator	5		5	10
Geographically, Indonesia is at the equator	10		5	5
Sunlight can be converted into electrical energy				20

4.3. Solar Energy Awareness

The third part of the research is focused on the level of awareness of solar energy and related technologies. Data is obtained in Table 4. Shows that 100% of respondents have no knowledge or information regarding solar electricity. Respondents did not know about new renewable energy, including solar energy. So is how it works and maintains. In addition to low education, it turns out that installing solar-powered electricity does not involve socialization and training to support solar panels and the safe use of electricity. In many interviews with residents in the four villages, none claimed to know about solar lamps and their maintenance. No one claimed to be asked or invited to discuss the installation of solar lights. They tend to be afraid if exposed to electricity (Roma, 2022). They also do not understand how to replace solar lamps and where to get new ones if the solar light installed in the house is damaged. The contractor working on the project came to install the installation and briefly explained how to turn on the light and remove and reinstall the light. The contractor did not present enough about the intermittent electricity of solar panels, relying heavily on the strength and stability of sunlight.

This condition is different from the rules that the Guidelines have set for the Environmental Management of Solar Power Plants issued by the Directorate of Various New and Renewable Energy, Directorate General of New Renewable Energy, and Energy Conservation of the Ministry of Mineral Resources. The guidelines explain, among others, that before the solar power plant is built, a construction permit and an environmental impact analysis must be applied. The solar power plant construction stages must also go through the pre-construction stage, which includes site readiness surveys, land acquisition and allotments, socialization, and public consultation. The construction phase provides for the workforce recruitment, manufacture, and operation of basecamp, mobilization of equipment/materials, preparation/maturation of land, and so on. The Operation Stage includes labor recruitment, plant operation, battery maintenance, plant maintenance, sanitation system management, and waste management. These stages are carried out by involving residents as potential users. Prospective users must understand how it works, environmental risks, and machine maintenance to adequately maintain solar power plant components.

The impact of this ignorance is the use of lamps that are continuous and shorten the life of the lamp. Some residents always left the lights on, thinking that the sun would still shine throughout the day. They don't have to pay for the sunlight and electricity it generates. In the case of microgrids in Maghilewa, using lamps during the day reduces the electrical capacity stored in the battery, which should extend the usage time at night. While in a separate solar power plant installation at home, the lamps left on throughout the moment shorten the life of the solar light. The damage that occurs seems to be caused by the wrong use habits. Its root is ignorance of the principle of electrical work of solar panels. Socialization about the power that can be generated and utilized by solar energy has never been conveyed (Lukas, 2022).

Nevertheless, Table 4 also shows the under-awareness of electricity's effect on some users' economic conditions. Photovoltaic electricity has allowed citizens to work at night. Kobus said that when there was no electricity, he had to peel and slice betel nuts during the day because he used a sharp knife. The small size of the betel nut slice requires precision; therefore, electric light is needed in the activity (Yakobus, 2022). Mama Sia said that betel nut that has been sliced and dried has a better price compared to raw betel nut. One kilogram of dried betel nut can be sold at Rp. 10,000 (Lusia, 2022). Another productive activity is to separate the clove flowers from the twigs and *rebe puka (*slicing the banana stem). Banana stalks are pigs' leading food, livestock of very high economic value.

In recent years, Belaraghi, located in Aimere and Maghilewa districts in the Inerie districts, has begun to attract tourists. The existence of electric lights is one of the factors that make it easier for locals to serve tourists. Belaraghi is a village located in the Inerie district with relatively better highways than the other Three villages, Watu, Jere, and Maghilewa. In addition to electricity providing them with the opportunity to carry out the broader economic activity at night, the electricity obtained from solar power allows them to communicate better through mobile phones. This communication is used to coordinate related to cultural banquets provided by residents if many tourists are visiting (Bene, 2022).

Several studies on the implementation of solar power plants showed positive results on social and economic conditions. Huang et al. (2021) research in China, Buragohain (2012) in India, and also Bulavskaya and Reynès (2018) research (2018) in the Netherlands suggest that there is an increase in economic figures and also an increase in welfare levels. The increase in financial statistics is due to solar power plants providing wider opportunities for users to carry out productive activities at night and during the day. Residents can still do study work at night, weaving, breaking nutmeg, etc. Meanwhile, during the day, various electrical energy jobs grow many household business units that become new sources of income. Meanwhile, the level of social welfare has also increased because the literacy rate is getting higher with the study time becoming longer. Likewise, the increase in evening meetings supports a better level of social welfare and access to information through television, radio, and the Internet.

Table 4. Level of awareness.

Level of awareness	Answer	Sum	Percentage
What do you know about new renewable energy?	Know	0	0
	Do not know	20	100
What do you know about solar/Solar energy?	Know	0	0
	Do not know	20	100
Do you know how to work and maintain solar panels?	Know	0	0
	Do not know	20	100
What do you know about global warming?	Know	0	0
	Do not know	20	100
Do you know how solar panels can generate electricity	Know	0	0
	Do not know	20	100
What do you think about your region's potential to produce solar energy?	Know	0	0
	Do not know	20	100
What do you think that electricity from solar power can add income?	Know	15	75
	Do not know	5	15
What do you think about the impact of solar panels on health?	Know	0	0
	Do not know	20	100

4.4. Acceptance to Use Solar Energy

The fourth part of the study was set to determine the level of acceptance of respondents in using solar energy to improve social and economic conditions. Table 5 shows that the overall acceptance is high. All items surveyed were highly rated unless the question 'Agree to reduce greenhouse impact' obtained a low score related to respondents' knowledge of non-proprietary greenhouses. The impression shows that respondents fully support government programs to improve solar energy technology's social and economic conditions. The study also showed that

respondents were highly committed to caring about the maintenance of solar panels in 4 villages through their willingness to contribute monthly contributions to the cost of maintaining solar panels.

They realized this willingness through a willingness to provide land for the construction of powerhouses that require large enough land. Similarly, when a microgrid system switches to a home system, they are willing to install solar panels on the roofs of houses. Residents are also willing to contribute to Rp. 15,000 - every month, which they entrust to the village head. The money is provided to maintain existing facilities and be on guard if there is damage to the components. Unfortunately, such centralized solar power plants can no longer function correctly. However, the change of centralized solar power plants to be scattered did not prevent residents from stopping building commitments to maintain solar power plant facilities. In addition to the willingness to maintain and replace solar lamps, the desire to support can also be suspected through the awareness that arises along with increasing knowledge. The increasing caution can see this awareness of residents in using solar lights. By looking at the indicator of energy willingness in solar lamps, residents can estimate how much energy is left in the solar lamps. Then, they will not force their use for purposes that the remaining power cannot provide.

Table 5. Solar energy acceptance rate.

Acceptance rate of solar energy use	Answer	Sum	Percentage
Believe that solar energy can have a better economic impact every month.	Disagree	0	0 %
	Do not know	5	0.25 %
	Agree	15	0.75 %
Supports the use of solar energy in their environment	Disagree	0	0 %
	Do not know	5	0.25 %
	Agree	15	0.75 %
Agree to provide an area for solar panels.	Disagree	0	0 %
	Do not know	0	0 %
	Agree	20	100 %
Willing to provide a roof for solar panels.	Disagree	0	0 %
	Do not know	0	0 %
	Agree	20	100 %
Encourage families and neighbors to use solar energy.	Disagree	0	0 %
	Do not know	0	0 %
	Agree	20	100 %
Agree to reduce the impact of the greenhouse	Disagree	0	0 %
	Do not know	20	100 %
	Agree	0	0 %
Willing to transmit knowledge and educate children about environmentally friendly technology.	Disagree	0	0 %
	Do not know	5	0.25 %
	Agree	15	0.75 %
Support the government to build solar energy as a substitute for coal-fired electricity.	Disagree	0	0 %
	Do not know	5	0.25 %
	Agree	15	0.75 %

Residents also show acceptance of solar energy to maintain hope for the sustainability of solar energy facilities. They hope solar electricity will continue to exist for their lives and the future of children who need lighting at night. The destruction of many solar lamps and the difficulty of removing the components of the lights prompted them to seek help from the government. Although it did not work because of bureaucracy, the change of authority, and responsibility to the local Government, the hope was there. Interviews with the resident of four kampongs found that some still hoped that the Government would assist so that solar electricity would continue to be on.

5. CONCLUSION

This study was motivated by solar power assistance projects in some Ngada, East Nusa Tenggara villages. The purpose of the program is that in addition to providing electricity assistance so that residents' social and economic conditions increase, solar energy efforts aim to encourage the reduction of fossil energy use.

The research on four villages in Ngada, namely Maghilewa, Jere, Watu, and Belaraghi, shows exciting findings. Although residents have minimal knowledge of new renewable energy, including solar energy, and have low education, this does not affect their high acceptance of solar energy.

The absence of socialization and training on solar lamp maintenance does not set back their expectations for the sustainability of solar lamps. The improvement in socioeconomic conditions they felt after the existence of solar lamps strengthened their willingness to continue to maintain and maintain solar lamps. In addition, residents also showed their commitment to providing their land and roofs for solar light projects and making dues.

This finding is much different from research on the willingness to adopt solar lamps, which is always preceded by high education and sufficient knowledge of solar energy. However, the destruction of several solar lights without government repairs could threaten residents' hopes. Further studies are recommended to focus on the policy and implementation of solar energy policies. However, a mature plan from a single aspect is very much needed considering that solar energy technology is still an expensive technology. Similarly, access to its components, such as electricity with coal energy, is unavailable.

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