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Empowering Gili Ketapang Island: Dissemination of Environmentally Friendly Photovoltaic Technology to the Young Generation

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Abstract Solar Cell Research Group, which is under Advanced Materials Research Group, Department of Physics, Faculty of Science and Data Analytics, ITS Surabaya, with its competency and research, tries to be actively involved in contributing and providing alternative solutions to problems in society, especially regarding the problem of global warming and energy crisis. One of the concrete actions is through community education activities to increase understanding and awareness of the use of environmentally friendly photovoltaic technology on Gili Ketapang Island, Probolinggo. This island is one of the most populous small islands in Indonesia with the problem of 'high-cost electricity from the state electricity company. The training materials provided for this activity include the Qur'an and Science, global warming, energy crisis, and renewable energy, and the use of photovoltaic energy technology. Thus, the understanding, awareness, and independence of the community of Gili Ketapang Island in the electricity sector can be improved by utilizing renewable energy sources, especially photovoltaic technology. In the long term, the role of various renewable energies in the future is expected to be more significant on this island by utilizing this abundant solar energy.

1. INTRODUCTION

Today, the world relies heavily on non-renewable energy sources, which account for nearly 80% of total world consumption. If this continues, there will be a tremendous energy crisis shortly. This will happen because the supply of fossil fuels such as oil and natural gas is very limited, coupled with the increasing world population so that the demand will increase for these energy sources. Uncontrolled use of fossil fuels also causes 'Global Warming' by the greenhouse effect due to the increase of carbon dioxide (CO_2) in the atmosphere. Figure 1 shows the world's consumption of energy from a variety of different energy sources.

The same thing happened in Indonesia. Renewable energy sources have not been used optimally. As much as 98% of energy in Indonesia

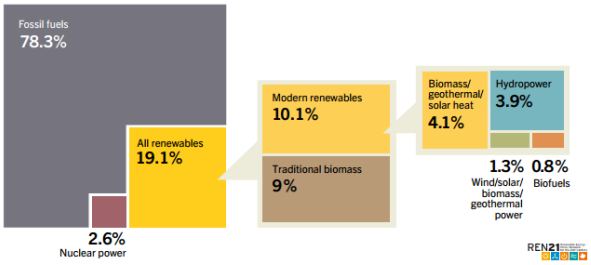

Figure 1. World energy consumption from different energy sources (REN 21, 2015)

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still uses fossil-based energy (coal, petroleum, and natural gas), and the rest, approximately 2%, uses renewable energy sources (Jawa Pos, 2018). It is inversely proportional, considering that Indonesia has a high potential for renewable energy sources. Of the various available renewable energy sources, only water energy is widely used. The number of power plants sourced from geothermal, wind, and solar energy can still be counted on the fingers, and even if there is, it is still with a very small energy capacity. Moreover, the energy source that comes from the sea provides abundant potentials while none of them have been successfully developed.

Gili Ketapang Island is a coral island located in the north of Probolinggo Regency at the coordinates of 113°15'21" East Longitude and 7°40'48" South Latitude, with typical coastal conditions and the inhabitants of the Madurese Tribe. Figure 2 shows the island of Gili Ketapang with a length of 2.1 km, a width of 0.6 km, and an area of approximately 0.61 km^2. The population on the island of Gili Ketapang based on the statistical data of Probolinggo Regency in 2009 was 7,988 people consisting of 3,924 men and 4,064 women, with a population growth rate of more than 1%. Based on these data, Gili Ketapang Island can be categorized as a small island, even a very small island with the densest population in East Java (population density reaches 13,095 people).

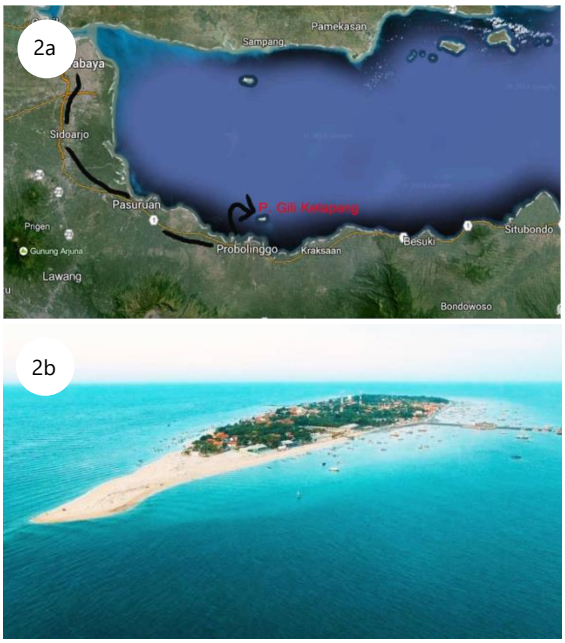

Figure 2. Gili Ketapang Island, Probolinggo Regency a) map; b) view

The geographical conditions of this island indicate that the island of Gili Ketapang holds the potential for diverse and very abundant renewable energy, especially sunlight, to produce electrical energy. This is one of the abundant renewable energy potentials that should be utilized to overcome the problem of electrical energy in this region. This renewable energy will be very useful for people who live on the island of Gili Ketapang, who have so far not been touched by electricity from the Indonesian electrical company (PLN). Of course, there will be a high cost to connect the power cable to the island of Gili Ketapang. Moreover, the island's geographical location, which every year moves to the east for an average of 1 meter, makes it difficult for PLN to distribute electricity to the island. Therefore, an independent power plant is needed to meet the people's need for electricity.

As the oil price continues to skyrocket and its availability will become increasingly scarce, especially with increasing awareness about the dangers of rising pollution, alternative solutions must be sought, developed, and continuously informed to the public. Solar energy is a very promising source of energy because it is very large in quantity and is more sustainable. The total solar energy that reaches the Earth's surface is 2.6×10^{24} Joules every year (Nicolas, 2012). The amount of solar energy available is 104 times the world's energy needs, which has reached 2.6×10^{20} Joules/year.

The Solar Cell Research Group under the auspices of the 'Advanced Materials Research Group', Department of Physics, Faculty of Science and Data Analytics (FSAD), Institut Teknologi Sepuluh Nopember (ITS) Surabaya, with the competence and "tri dharma" has been done (Cahyono et al., 2018; Cahyono et al., 2017) in partnerships with other stakeholders to try to get involved and take an active role in providing alternative solutions to problems in the society. This includes the energy crisis and global warming, which is one of the electricity problems on the island of Gili Ketapang, Probolinggo district. This community service activity is a concrete form of activities carried out through community education activities to increase understanding and awareness of the use of environmentally friendly photovoltaic energy technology in one of the most densely populated small islands in Indonesia with all the high-cost problems of electrical energy in it. Hence, the understanding, awareness, and independence of the people of Gili Ketapang in the field of electrical energy can be improved, by utilizing renewable energy sources, particularly photovoltaic technology. In the long term, the role of various renewable energies in the future, especially photovoltaic technology, is expected to become more significant on this island with abundant solar energy. Thus, the potential of the community and natural resources on the island of Gili Ketapang can be empowered to increase the energy independence of the local community. This is also an integral part of the efforts and contributions to overcome the world energy crisis and reduce global warming.

2. METHODS

This community service activity focused on the use of renewable energy sources in the island of Gili Ketapang, Probolinggo Regency. This location was selected because 'energy scarcity', 'isolation', and 'high cost' of PLN electricity were the problems there even though the natural character and potential of renewable energy sources are abundantly available on the island. In the last few years, marine tourism in the form of snorkeling on the island of Gili Ketapang has developed and increased rapidly as shown in Figure 3. The tourism area, which is inhabited and organized by the youth of the Gili Ketapang people, has indeed succeeded in attracting tourists. Now the people who are involved directly or indirectly have significantly improved their economy. The rapid increase in the flow of tourism in the future will require a very large source of "cheap" energy to support all the activities of their programs. Thus, this community service activity is very suitable to support the government program in energy fulfillment and conservation and contributes to the prevention of global warming.

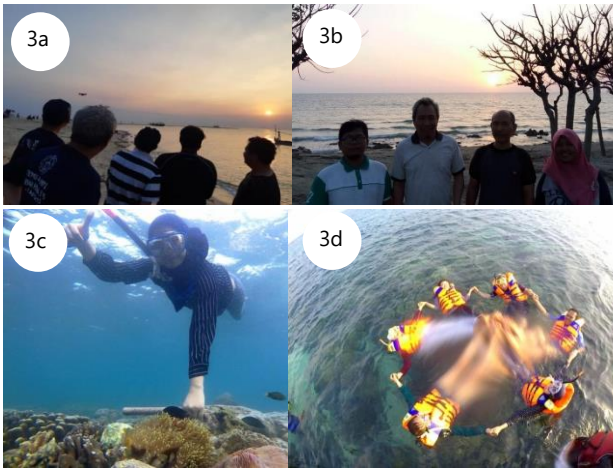

Figure 3. Destination a) sunset; b) sunrise; c) snorkling; and d) Gili Ketapang island sea tours

The problems that will be resolved from this community service program are:

1) The perspective of the Gili Ketapang island community on global warming, the greenhouse effect, the energy crisis, and the importance of using renewable energy such as solar energy using photovoltaic technology.
2) The dependence of the people on the island of Gili Ketapang on PLN electricity, even though there are other alternative power plants that they can independently use so that they can still get electricity.

From the interviews that were conducted some time ago, it turned out that the people of the Gili Ketapang island people who were interviewed did not know well what renewable energy sources were. Therefore, it was necessary to inform and explain in real terms what renewable energy was, its use, advantages and disadvantages, costs, and how to use it to the target community. It was necessary to explain to the target community about the use of this renewable energy for individuals and groups because not all people can afford the required costs.

The strategy carried out in solving problems in this program was knowledge sharing (workshops) and learning about the use of renewable energy through lectures and practice of designing, manufacturing, and installing environmentally friendly solar cell power generation systems. The nature of Gili Ketapang Island is not very supportive of using conventional power plants (PLN), which require high investment costs. Moreover, this strategy was in line with the government's program to save energy, reduce the use of fossil energy, and contribute to preventing and reducing global warming.

The people who are considered strategic to be the target of this community service activity were the younger generation because they were in their productive age and had a promising future ahead of them. Because of this, the youth, youth groups, and young mothers on the island of Gili Ketapang were selected. Mothers have a central role in the use and saving of electrical energy in the household. This community service activity was carried out in the form of workshops, giving lectures through practical methods. There were four lecture materials: *Al Quran and Science, global warming and the energy crisis, renewable energy, and photovoltaic energy*.

As a first step, it was necessary to study the renewable energy literature related to the position of the Gili Ketapang Island's region, its natural potential, technology, and economic studies. The next step was studying the literature in the field of solar cell work systems, their design, efficiency, and economic value, comparing it to other sources of electrical energy. The manufacture and assembly of solar cell power plant installations were carried out at the ITS campus, Surabaya, at the Advanced Materials Laboratory, Department of Physics, Faculty of Science and Data Analytics, ITS Surabaya. The schematic flow of the complete implementation of community service activities, solar cells, and their supporting components, measuring instruments for weather parameters, and other solar cell demo tools are shown in Figure 4.

Figure 4. a) Schematic flow of community service activities on the island of Gili Ketapang; b) solar cell demo; c) solar cell; d) environmental meter; and e) 1 set of solar cell modules.

3. RESULT

3.1. Preliminary activities in Gili Ketapang Island

The initial visit, which was from 17 to 18 July 2018, was intended to arrange permits for activities at the local village office and coordinate with the target community, youth organizations, and several community leaders in Gili Ketapang. It was agreed that the target community groups were youth organizations and young mothers because they were very young, with insights into environmental knowledge that could still be formed. The long and bright future lies ahead of them, and the future the island of Gili Ketapang relies on the shoulders of these young people. Figure 5 shows the activities of these preliminary activities. This initial visit was also used to measure real data or primary weather data at the location of the activity, including wind speed, temperature, humidity, and the intensity of solar radiation. This data was needed to be used as reference data to find out how far the performance of solar cells was when used in the real weather environment of Gili Ketapang Island.

Figure 5. a) Preliminary discussion with a young leader of the Gili Ketapang island community (H. Nur) and b) collecting primary data on weather parameters at the location

3.2. Solar cell power generation system design

The design and trial of the solar cell power plant system were carried out at the Advanced Materials Laboratory, Department of Physics, FSAD, ITS Surabaya. The components and instruments used, shown in Figure 6, consisted of the solar cell module, battery, controller, inverter, and cables. Solar cells convert photon energy from the sun into electrical energy. Electricity generated by solar energy will be stored in the battery via a charger controller. The charger controller is used to regulate the voltage and current entering the battery. Loads are electronic devices that require an AC power supply, so an inverter is needed to convert the DC voltage from the battery to an AC voltage.

3.3. Disseminating environmentally friendly science and technology for solar cell power plants

The people of Gili Ketapang island since 2018 have enjoyed non-stop electricity for 24 hours since the inauguration of a 3×500 kW Diesel Power Plant (PLTD) on Thursday 22 February 2018 (Supriyatno, 2018). The people of Gili Ketapang Island had long been expecting to be provided with electricity for 24 hours, which could support the utilization of the island's potentials (its beautiful beach and coral reefs) for tourism. However, in the long term, energy-saving must be carried out continuously by training the locals on how to use alternative energies that are environmentally friendly and sustainable. This is because fossil energy sources are about to run out and other things are of similar importance, namely reducing the price of subsidized electricity and the occurrence of global warming or the greenhouse effect. The natural

potential of the island is very supportive of the use of alternative energies, especially photovoltaic energy or solar cells. Therefore, this dissemination activity can provide alternative solutions to people in the Gili Ketapang Island region in an attempt to participate in overcoming the problem of the world's energy scarcity or crisis and in preventing global warming. This activity had also received positive responses from the target community, especially from the village head and other local community leaders.

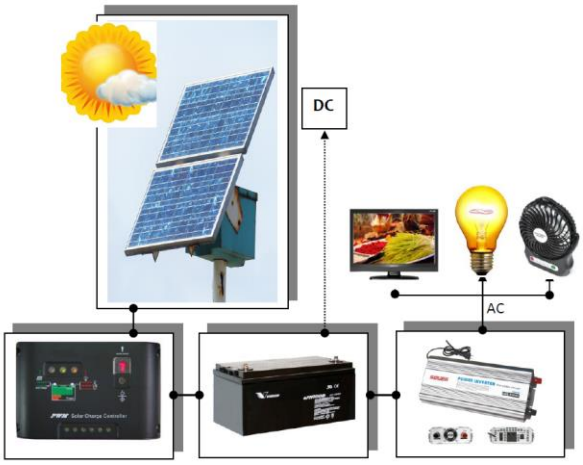

Figure 6. Schematic of designing a solar cell or photovoltaic power plant

The knowledge sharing and dissemination activities were attended by 44 participants on the first day and 48 other participants on the second day. Considering the culture of the Madurese community, which is generally very religious, the first talk in the workshop series presented the subject 'Al Qur'an and Science', given by Prof. Agus Purwanto, D.Sc. A form of a psychological approach that involved religious teaching seemed to be able to encourage the participants to manage and conserve nature through the mastery and application of science and technology. The second talk was carried out by a member of the community service team, Dr. Zaenal Arifin, M.Si., with the subject of "Energy crisis, global warming, and renewable energy". The next talk was given by the head of the Gili Ketapang Community Service Team, Dr. Yoyok Cahyono, M.Si., with the title of "Utilization of electrical energy using photovoltaic or solar cell technology".

The talks on the utilization of solar cells covered the following aspects.

1) How to design a PV system or PV mini-grid for households

The design steps include finding the total usage load per day, determining the size of the solar module capacity according to the usage load, and determining the capacity of the battery. The design and testing of the solar cell system are shown in Figure 7.

2) Installation

The installation location must be in an open field that is not obstructed by giant trees or tall buildings. The installation position is expected to be tilted facing north because Indonesia is situated in the southern part of the Earth. The location of the battery should be placed in a humid place and out of reach of children. Meanwhile, other solar panel accessories that are located outdoors must be resistant to sunlight. The position of the regulator should be easily accessible for easy checking and maintenance.

3) Maintenance

The treatment includes replacing solar cell modules, lamps, batteries/accumulators, and other things related to how this electrical system of the solar cell can live and be used as long as possible.

Figure 7. a) Design activities and b) testing of electrical systems from solar cells

After that, the event was continued with a question-and-answer session and suggestions written on a piece of paper. There were a lot of interesting questions and suggestions from the participants of this meeting related to the use of renewable energy, especially those related to solar cells. From the questions given to participants about the energy crisis, renewable energy, global warming, and environmentally friendly energy such as photovoltaic energy, it was found that almost all participants did not know and did not understand these issues. Actually, on the island of Gili Ketapang, several units of solar energy owned by the government (PLN) have been installed. It was also found that the participants had often seen this photovoltaic technology because it has been widely used there, especially for street lighting. However, the participants did not understand the use of this technology so far, so they did not use it to meet their household energy needs, at least for lighting needs. The main problem faced in the application of this photovoltaic technology is the cost that is its large initial investment, which economically made most participants not interested in using it.

4) Monitoring, evaluation, and sustainability

After the information session on the use of solar cell technology as a source of electrical energy from solar energy, the next activity was monitoring and evaluation aimed at seeing how much interest the participants had in using solar cell technology. In this activity, a 'casual chat' approach was carried out to find out the participants' interest and enthusiasm for using this technology. Overall, the participants felt very fortunate to receive the training in solar cell technology although they do not want to apply it shortly soon. At the end of the knowledge-sharing session, the participants knew very well that this solar cell technology did not require additional costs to operate, is pollution-free, and does not cost much money for maintenance.

In addition to the huge funding problems required initially, the dissemination of photovoltaic knowledge and technology for application to the target community needs to be taken seriously. Keeping in mind that this technology was new to the target community, it was very necessary to provide continuous technical assistance. Community empowerment initiative is not a program that can be done only once and let the target community continue the work. Organizing such a program can be analogous to a person planting flowers. Every day these flowers must be watered and cared for so that one day they will beautifully bloom and their beauty and fragrance will be enjoyed by people around them.

By seeing the geographical location and topography of Gili Ketapang Island, it is clear that there are no hills or mountains, and this island is alone in the middle of the sea. It leads to the intriguing question, "Is it possible that solar cells or solar power plants (PLTS) can be utilized optimally there?". Local (ambient) temperature and humidity are natural factors that are difficult to control and may negatively affect the output performance of the solar cells. It is estimated that Gending wind, which is a type of Fohn wind blowing past the island, will significantly affect the performance of solar cells to generate electricity with maximum efficiency. More in-depth research and analysis (currently ongoing) are needed to determine the effects of the ambient conditions on the Gili Ketapang Island's microclimate on the performance of the solar cells. These endeavors are part of an effort to maximize the potential of solar cell applications on the island of Gili Ketapang. Furthermore, technical guidance for the community must be continuously provided.

4. CONCLUSIONS

In general, the dissemination of environmentally friendly technology for solar cells can be said to be successful although the community service team came across insignificant obstacles. The response from the target community was also quite positive. They were very enthusiastic about understanding how important science and technology were to be applied in everyday life, such as photovoltaic electrical energy. There was great enthusiasm from the people of Gili Ketapang Island, especially the young people, to learn new things that included the use of solar energy as an electrical energy source.

For most Gili Ketapang Island people, the use of solar cell technology was not a novelty because some of them had seen this technology to power street lighting. However, for various reasons and considerations, the problem was that they had not used it to meet their household energy needs. Changing the culture of a society is not easy. It is certainly not as easy as turning your palms up or down.

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