

The Role of Renewable Energy in A Pacific Island: Experiences from Makalehi Island, Indonesia

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ABSTRACT

The role of solar energy utilization in the Pacific island communities are need to be explored. Makalehi island is one of the small and remote island which situated in the North of Celebes, Indonesia located in the Pacific regions. It experiences the implementation of solar photovoltaic power for electricity generation in island communities. This paper describes the role of solar PV power, the current status as well as the potential resources, challenges and barriers to the implementation of renewable energy in the island communities of Indonesia, case study of Makalehi island. Makalehi island's experience with solar power plant indicates that solar energy potential is reliable as the option for energy sources to serve energy demand for small and remote island communities. However there are many challenges such as management, maintenance, technical assistance, spare part matter, operation skill level need to be solved and improved for the role of renewable energy utilisation in remote and small island.

Keywords: Renewable Energy, solar energy, remote island, Pacific Island, Makalehi, Indonesia

1. INTRODUCTION

Makalehi Island is Indonesia's outermost island that located in the border between North part Indonesia and South part of Philippines. Makalehi Island is part of the territory of the government of Kepulauan Siau Tagulandang District Biaro, North Sulawesi province, Indonesia. It has population about 1325 (2015) and it has a land area of approximately 420 ha. The location of Makalehi island that situated in the West part of Siau Island is shown in Fig. 1.

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Fig. 1. The Location of Makalehi island that situated in the West of Siau Island
 (Sumber: <https://sitara.files.wordpress.com/2009/02/peta.jpg> & <https://sitara.wordpress.com/2009/02/21/kondisi-geografis-kabupaten-kepulauan-siau-tagulandang-obiaro>)

To reach Makalehi island from Manado port takes 3-4 hours by ship to Ulu Siau Port that located in Siau island. Then the trip continue from Siau island to Makalehi by boat takes 1-2 hour to the west of Sulawesi Sea. Makalehi island is one of the remote and small island, that situated on the Sulawesi Sea at latitude 2°44'15" North and longitude 125°9'28" East. Figure 2 shows the Makalehi island and the lake that located in the island.



Fig.2 The Makalehi Island and the Lake that Located in the Island
(Sumber:<https://sitara.files.wordpress.com/2009/02/peta.jpg>&imgrefurl=<https://sitara.wordpress.com/2009/02/21/kondisi-geografis-kabupaten-kepulauan-siau-tagulandang-biaro>)

Remote and small islands rely on expensive imports of fossil fuels for electricity generation. In other hand, on small islands have renewable resources which are abundantly available as local energy source. Island communities rely on fossil fuel to supply a large portion of domestic energy needs which are increasing time by time. Consequently, energy supply to such communities is of considerable concern.

This paper is primarily a desk study based on available information, includes description of implemented centralized solar power system and current status and barrier of solar energy implementation in Makalehi island as case study about the role of renewable energy for the small islands.

2. The Review of the Role of Renewable Energy in the Small Islands

This section is a review about best practices of the role of renewable energy in the small island over the world as the example to be implemented. A small island is defined as a land mass smaller than a continent that is surrounded by water with the size smaller than 10,000 km². The issue about high cost of imported fossil fuel and environmental consideration of fossil fuel utilisation make the role of renewable energy should be considered.

Electricity supply is an important issue in islands, and the most island power systems mainly rely on the imported fossil fuels. However, the oil price in islands is 3–4 times higher than that in the mainland. (Yong etc, 2015). Most small islands around the world today are dependent on imported fossil fuels for their energy needs, especially for transport and electricity production. Because of the small size and isolated location of many islands, infrastructure costs such as energy are up till three to four times higher than on the mainland. The high price for fossil fuels combined with the limited demand increases the unit cost of production for conventional power production. This creates a

competitive situation for renewable energy technologies on islands. Furthermore, most of the islands are endowed with good renewable resources, primarily sun and the wind.

Due to offshore isolation condition, islands incur more difficult and expensive energy supplies; however, offshore islands are usually granted with a variety of Renewable Energy Sources (RES). Each island needs to choose the optimal hybrid energy system technically and economically. Many RES, such as wind, solar, hydro, biodiesel and biomass, have been popularly utilized in offshore islands. Table 1 listed several famous offshore islands that develop renewable energy. This article will introduce the renewable energy development in those islands in detail. (Jhih etc, 2016).

Thomas Lynge Jensen (2000) in *Renewable Energy on Small Islands* stated that around the world a few islands already have taken the decision to become a Renewable Energy Island (REI) in the short or medium term. Samsøe (Denmark), Pellworm (Germany), Aeroe (Denmark), Gotland (Sweden), El Hierro (Spain), Dominica and St. Lucia have an explicit target of becoming 100% selfsufficient from renewable energy sources. Around the world a few islands already have some of the characteristics of a Renewable Energy Island (REI) La Desirade (France), Fiji, Samsøe (Denmark), Pellworm (Germany) and Reunion (France) are currently producing more than 50% of their electricity from renewable energy sources 21% of the islands in the overview that are utilising renewables for electricity generation are producing between 25-50% of their electricity from renewable energy sources. Nearly 70% of the islands in the overview that are utilising renewables for electricity generation are producing between 0.7-25% of their electricity from renewable energy sources.

Just around 12-14% of the islands in the overview that have utilised renewables is situated in the North Pacific Ocean, South Pacific Ocean and Caribbean Sea respectively compare to 40% of the islands in the overview that have utilised renewables are situated in the North Atlantic Ocean. The potential for renewable energy use on small islands is vast. Many small islands in every region in the world use or propose to use renewable energy: the Azores and Canary islands in the North Atlantic, Gotland and Samsøe in the Baltic, Sardinia and Sicily in the Mediterranean, Mauritius and Reunion in the Indian Ocean, Fiji and the Hawaiian islands in the Pacific, as well as Dominica and the Guadeloupe islands in the Caribbean. Many small islands have achieved their goal of transitioning to renewable energy (Jensen, 2000).

3. The Renewable Energy Potential in Makalehi Island, Indonesia

This section describes the renewable energy potential in Makalehi island based on the literature study and secondary data.

Renewable energy is an abundant energy resource in the Makalehi island which is situated in North Sulawesi province, Indonesia. The potential of renewable energy resources in term of monthly average daily solar radiation, clearness index, sunshine duration and wind speed are summarized in Table.1.

Table.1 The potential of renewable energy resources in Makalehi island

Month	Average Daily Radiation *(kWh/m ² /day)	Clearness Index*	Sunshine Duration *(%)	Windspeed (m/s)**
January	4.216	0.432	72	2.5
February	4.68	0.459	71	2.5
March	5.127	0.490	77	2.5
April	5.273	0.511	94	2.5
May	4.868	0.492	87	2.5
June	4.377	0.456	54	3
July	4.436	0.458	89	3.5
August	4.941	0.490	86	4
September	5.380	0.520	86	3
October	5.020	0.492	84	3
November	4.376	0.446	74	2
December	4.297	0.448	58	2.5

*Source : NASA database, 2017(<http://eosweb.larc.nasa.gov/>)

**Source : Agency of Meteorology, Climatology and Geophysics, 2017

Based on the data and literature study, the renewable energy sources potential for Makalehi island are summarized in Table 2.

Table 2. The potential of renewable energy resources in Makalehi island

Source Potential	Remarks
Solar	Excellent Resource
Wind	Good Resource as the average wind speed as 3 m/s in this island
Biomass	Has Potency from coconut husk for cooking purpose
Hydro	Definite potential but extent unknown as the island has lake
Geothermal	Not yet explored
Wave	Definite potential but extent unknown

4. The Experiences of the Role of Renewable Energy in Makalehi Island, Indonesia

As the energy resources and community characteristics are unique to each island, then the case study of each island is needed to be explored. This section describes about the experiences of the role of renewable energy in particularly solar energy on Makalehi island, North Sulawesi, Indonesia.

The existing of two 250 kW diesel generators operate in parallel with centralized solar power system 260 kW. The electricity supply in Makalehi island has a prime power diesel plant that serve the island's load. The installed Electricity Capacity for the Makalehi island by Source in 2015 are listed in the Table 3.

Table 3. The installed electricity capacity for Makalehi island by source

No	Source	Capacity	Percentage
1	Diesel Power Plant	500 KW	70%
2	Solar Power Plant	260 KWp	30%

The existing of centralized solar power system with installed capacity as 260 kWp has shown in Fig. 3



Fig. 3 The Solar Power System Installed in Makalehi island of Indonesia

Source : (Lumempouw etc, 2015)

Based on the data collection from interview and site visit, it is found that the performance of solar power sytem in the Makalehi island for the first year can be operate for 24 hours, then the performance in the second year experience to be reduce for 20 hours of operation. Due to the technical problem and lack of the availability of spare part of power system, the performance of solar power system becomes reduce by the time.

Based on the observation, it is found that the most significant barriers for developing renewable energy sources in this island are the limited spare parted and the limited operation skill level. The solar power system are facing not properly maintained due to the limitation of spare part and the limitation of technician's operation skill. The instaled of power system should be provided with a guarantee of sustainable technical operation during lifetime and availability of spare part of the power sytem must be provided. The transfer of skill for the technician for operation and maintenance must be provided in order to solve the problem of the limation of the operation skill.

In addition, the main obstacle for the development of renewable energy resources for electricity production in the Makalehi island is the lack of policy and strategy of implementation. Regulatory frameworks of the renewable energy utilisation for small island is important to be developed in the national level as well as local level. The barrier of the high initial costs for implementation of renewbale energy for small islands is need to further analysis for develop the strategy to empower the economy of island communities by incentives or subsidies option.

5. CONCLUSIONS

The role of renewable energy systems is a crucial issue in a small-island. The potential of renewable energy resouces in Makalehi island are needed to be explored more technically and economically. The experience of the solar energy power plant for small and remote island such as Makalehi could be a lesson learned for some barriers and challenges to be solved.

In order to increase the role of renewable energy system in island communities, several significant strategies should be planned. They include the improvement of the technician's operational skill of renewable energy system technology, the provision of incentives and subsidy for renewable energy utilisation for island communities. The islands can become visible laboratories for renewable energy technology implementation and financing. Experiences gathered on islands can be used, not only on islands, but in mainland local communities as well.

Some barriers for the under-exploitation of renewable energy role are lack of awareness to enhance the utilisation of renewable energy resources on islands and lack of knowledge on the skill operation of renewable energy technologies. The organisational models for planning, implementation, ownership, financing strategy for improving the role of renewable energy in island communities are needed to be analysed further.

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