ABSTRACT

Building the Resilience of Renewable Energy Human Capital Towards Sustainable Development: A Case of Tunda Island, The Enchanting Island

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Abstract. Tunda Island, is a small island located in the Java Sea, included in the Serang Regency, Banten. In order to fullfill the electrical energy needs of the people of Tunda Island, they use hybrid electrical energy sources, Solar Power Generation off grid 25 kWp and diesel oil generators. Tunda Island has the potential to become a leading island based on green energy, eco tourism, a low-carbon island and a center for marine products and other SMEs based on the other local natural resources. The problem that the community faces is the shortage of electrical energy due to a decrease in the capacity of Solar Power Generation off-grid and this time that people use more fossil energy sources to generate the electricity. This condition is certainly very unfortunate, so a solution is needed to sove

the problem. How Solar Power Generation off grid can operate optimally as a source of green energy and become a driving force for eco tourism and efforts to increase community productivity through marine-based food production and other eco-tourism. Based on the the investigation and observation observation, we found that problems related to Solar Power Generation off grid, e.g. there are only two operators to serve the community with competencies that really need to be improved, the number of operators that need to be increased, as well as how to operate and maintain the off grid Solar Power Generation professionally and efficiently. through organizations such as BuMDes so it can be integrated with other economic activities. Building human capital of Solar Power Generation or other renewable energy sources for operation and maintenance is the key so that renewable power generation can operate sustainably. Furthermore it will make Tunda Island as an enchanting, low-carbon and prosperous island for Tunda Island's community.

Keywords: *human capital, Tunda Island, resilience, solar power generation, off grid, renewable energy, green energy, competency*

INTRODUCTION

Tunda Island is one of the islands that relies on solar power generation (PLTS) as an energy source to support their electricity need for daily activities. PLTS is managed by the community. This study aims to investigate how the management of PLTS on Tunda Island, the competence of PLTS electrical technical personnel, find out the obstacles during operation and maintenance and find solution to solve of PLTS management especially the steps needed in order to support PLTS Island of Tunda operate safely and manage effectively. Related to human resources or human capital in technical and administration, this study would like to convey the existing human resources who responsible for PLTS, include technical personnel and administration personnel for day to day operation of electricity on Tunda Island such competency and resiliency to adapt the future electricity demand especially electricity based on renewable source or green energy.

This study was conducted based on methode field observations, interviews with stakeholders e,g, Head of Wargasara Village, technical personnel, administration personnel, Chairman of Mercubuana BumDes and some of community representatives. Based on observation and interviews results it will be conduct the analysis based on qualitative descriptive. The goal of this study to find the solution how PLTS can be run sustainability and operate by human capital from Island of Tunda community which competence, resilience to achieve the optimal results.

1. Tunda Island Overview

Tunda Island is an encahnted island located in Banten Province with an area of 260 hectares and is inhabited by about 1500 people with a total of 460 households. Almost 90% of Island of Tunda's residents are fishermen. The journey to Tunda Island start from Serang to Karangantu port by using a fishing boat which takes time about two hours if the waves are calm and the weather is sunny. The journey can be longer if the waves and the weather are not friendly.

Tunda Island has big potential of natural resources such as marine ecotourism, religi tourism, home industries from marine fisheries and other marine natural resources, agriculture and farm such as chicken, goat and cattle. Energy is a major need in developing the economy, productivity and welfare of the community.

For this purpose the adequaty, safety, reliability and environmental friendy is key for the energy supply especially electricity. Another big potential of Tunda Island that its island is very possible to be developed as a Low Carbon Model Island whose the electricity source from renewable energy or green energy which have been running since middle of year 2013.

Fig. 1.The Enchanting Island of Tunda

2. Solar Power Generation of Tunda Island (PLTS) 25 kWp

One of the renewable energy sources used to support community and economic activities on Tunda Island is a solar power plant (PLTS). PLTS on Tunda Island has a capacity of 25 kWp, which was built in 2013.

Fig. 2. PLTS 25 KWp Off Grid on Tunda Island

2.1. Existing Condition PLTS Tunda Island 25 kWp Off Grid

In general the the scheme or component PLTS Tunda Island 25 kWp off grid can be described as in Figure 3.

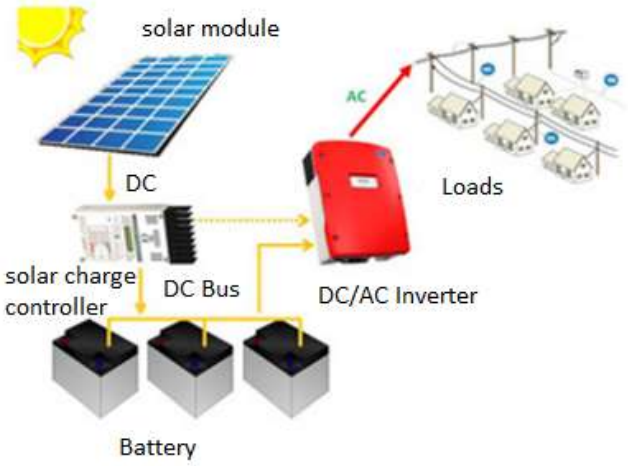

Fig. 3. Scheme or Components PLTS 25 kWp Off Grid on Tunda Island

The field observation of PLTS 25 kWp OffG on Tunda Island was conducted in April 2022 and the condition of PLTS components is as follow in Table 1.

Table 1. Existing Condition of Component PLTS 25 kWp Off Grid of Tunda Island

No.	Component	Condition	Remark
1.	Solar modules	good	
2.	Solar Charge Controllers	good	
3.	Inverters	good	
4.	Batteries	not good	48 batteries from 120 batteries malfunction

Fig. 4. Field Observation of PLTS 25 kWp Off Grid of Tunda Island

2.2. Existing Human Capital of PLTS 25 kWp Off Grid of Tunda Island

Technical personnel and administration personnel related to the electricity management on Tunda Islands as follow in the Table 2.

Table 2. Availability Human Capital for The Management Electricity System on Tunda Island

No.	Personnel	Number of Personnel	Remark
1.	Operator & Maintenance	2	1 personnel fulltime and 1 personnel part time
2.	Administration	1	

LITERATURE REVIEW

Based on observations of the PLTS 25 kWp Off Grid on Tunda Island, we can feel the extraordinary dedication of the human capital who work and manage for electricity, which only consists of 1 administration staff, and 2 technical personnels (1 personnel work fulltime and 1 personnel work part time) that it can be assume only 1 technical personnel which is reponsible to run the electricity system day to day operation and maintenance who work extraordinary. Based on interviews which has been conducted it showed that initially in middle of year 2013 there were 6 technical personnels on Tunda Island electricity system for day to day operation. As time goes by, 4 personnel switch professions with jobs that have more promising income. The question is how to ensure the sustainability of the electricity system on Tunda Island, which is managed based on the Tunda Island community, can continue to be handled by human capital which is competent and resilience? How many human capital are needed? What competencies are needed? What solutions can be given to answer the challenges of the electricity system, especially renewable energy-based power generation on Tunda Island.

1. Human Resources Empowerment

Human resource empowerment is defined as a concept that refers to efforts to foster a desire in someone to actualize themselves, carry out upward mobility and provide psychological experiences that make a person empowered (Makmur, 2006). Empowerment requires expanding roles, authority and power and increasing flexibility in how these roles are performed (Stewart, 1998). Empowerment is a way of enabling employees to be more capable of making decisions (Bowen and Lawler, 1992) and as a personal phenomenon in which each person is responsible for his or her own actions (Pastor, 1996).

The first definition relates to how management facilitates and implements a culture of empowerment, while the second definition emphasizes the importance of individuals to succeed in empowering. To improve the ability of human resources, it is done through training and development or also called human resource development. Meanwhile, creating a culture of empowerment is creating a conducive environment for empowerment efforts (Erstad, 1997).

2. Human Capital

According Schultz (1993), the term “human capital” has been defined as a key element in improving a firm assets and employees in order to increase productive as well as sustain competitive advantage. To sustain competitiveness in the organization human capital becomes an instrument used to increase productivity. Human capitals refer to processes that relate to training, education and other professional initiatives in order to increase the levels of knowledge, skills, abilities, values, and social assets of an employee which will lead to the employee’s satisfaction and performance, and eventually on a firm performance. Kate (2005) stated that human capital is an important input for organizations especially for employees’ continuous improvement mainly on knowledge, skills, and abilities.

Thus, the definition of human capital is referred to as “the knowledge, skills, competencies, and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being” (Brand & Jax, 2007).

3. Human Capital Resilience

Resilience is one of the most important research topics with respect to sustainability (Kates et al., 2005; Foley et al., 2005; Brand & Jax, 2007). However, resilience has been frequently redefined and expanded using different dimensions at various levels (Holling, 2001; Pickett et al.,

2004; Zhou et al., 2009). A group of researchers (Pelling, 2003; Cardona, 2005; Zhou et al., 2009; Buckle et al., 2001) point out that resilience is the ability of an actor to cope with or adapt to the stress of a disaster. Other scholars (Folke et al., 2006; Pelling, 2003; Cardona, 2005) stress three characteristics of capacity: the capacity to absorb disturbances, the capacity to self-organize, and the capacity to learn.

The literature on resilience reveals two views of measuring resilience. The first is that resilience is the sum of various types of household or community capitals (human, social, natural, physical, and financial) (Mayunga, 2007; Kulig et al., 2013; Thulstrup, 2015). The second is that resilience is a set of particular components, such as age, language competency, learning, housing, income, savings, access to healthcare, sanitation, etc. (Akter, 2013).

METHOD, DATA, AND ANALYSIS

1. Method

In this study, the method used for investigation is direct observation in the field which includes reviewing the existing condition of PLTS 25 kWp, interviews with personnel who handle PLTS from generation, operation, distribution and power line to residents' homes, administrarive staff, Head of Wargasara Village-Tunda Island and related parties such as Chairman of BumDes and some electricity users. Observations and interviews were also conducted to find out the obstacles in the field related to PLTS 25 kWp Off Grid and electricity system on Tunda Island, How to get solution and How to improve human capital related in technical aspect, management aspect and administration aspect in order to maintain the sustainability of the electricity system based on renewable energy on Tunda Island.

2. Data

The data used in this study are primary data consisting of qualitative and quantitative data based on conditions in the field 0f power generation on Tunda Island.

3. Analysis

The analysis carried out in this study is descriptive analysis based on the results of field observations related to power generation, PLTS 25 kWp Off Grid and technical personnel and administration personnel who handle power generation, PLTS 25 kWp Off Grid.

RESULT AND DISCUSSION

1. Results and Discussion of PLTS 25 kWp Off Grid Current Condition Based On Field Observation

Current condition of PLTS 25 kWp can be seen that PLTS 25 kWp Off Grid on Tunda Island which was built since 2013 is still in good condition for modules, solar charge controllers and inverters. The non-functioning of 48 batteries resulted in reduced electricity supply to meet the electricity needs of the community.

One of the causes of the lack of power supply is the decreased ability of the battery to store electricity. Decreasing power supply from PLTS 25 kWp Off Grid make fossil fuel oil consumption for diesel power generation increased. The increasing consumption of fossil fuels for diesel power generation to meet the electricity needs of the people on Tunda Island of course is not in line with the low-carbon development program.

2. Results and Discussion of PLTS 25 kWp Off Grid Supply

The supply of PLTS 25 kWp Off Grid is not sufficient for the electricity needs of the people on Tunda Island. Electricity sourced from PLTS is only for an average of two hours a day. For electricity needs, especially at night, people rely on fossil fuel power generation. The projection increasing electricity demand for future needs by considering population growth, economic growth and residential growth have not been mapped yet.

It is also necessary to consider how to increase the capacity of electricity based on solar and other renewable energy source. The use of fossil fuel for power generation have to be minimized or eliminated so that Tunda Island can be based on renewable energy as in middle 2013. This shortage of electricity supply is not only caused by a decrease in power generation capacity but also due to population growth, in this case the number of houses being built which was not anticipated at the time of PLTS 25 kWp Off Grid in 2013.

3. Results of Observations and Discussions related to Human Capital Who Handle Electricity on Tunda Island.

Human capital who handle PLTS 25 kWp at the beginning of PLTS operation is 4 (four) technical personnel who have been certified competence. As time goes by, 3 (three) of 4 (four) technical personnels have switched their professions that are more financially promising. This condition of course reduces the reliability of the PLTS 25 kWp Off Grid, both in terms of operation, maintenance ,distributionand power line services to the community homes.

The scope of work human capital especially technical personnel among others: PLTS 25 kWp off grid operation and maintenance, diesel power generation operation and maintenance, operation and maintenance distribution line, electricity line connection to the houses on Tunda Island residents' and maintenance of houses power line.

The electricity utilization power line for residents' homes is a cluster system with a limiter is installed each house.

Fig. 6. Cluster and Limiter Systems for Connecting Electricity to Residents' Houses

The current condition is that there is only one technical personnel who handle of the generation of both PLTS and generators, operation, maintenance and trouble related to electricity in each resident's house. So that one technical personnel must be ready at any time to be called by residents if there is a power outage at residents' houses, mcb step down or outage at residents' houses if residents use electricity exceeds from the predetermined limiter. One other technical personnel only occasionally helps because he has other permanent jobs or profession. Besides technical personnel there is also 1 (one) administration staff related to the administration, whose job is collecting and recording of payment residents' electricity usage. Electricity payment are made and collected every 7 (seven) days. The duties and job description of technical personnel who handle the electricity on Tunda Island day to day operation as follow in Table 3.

Table 3. Duties and Job Description Technical Personnel

No.	Task	Job Desription
1.	Generation PLTS 25 kWp OFF GRID	Daily checking per componen Start Electric Load Sharing Stop Reporting
2.	Generation Genset – fossil fuel	Daily checking (BBM, oil, filter, etc) Start Electric load sharing Stop Reporting
3.	Operation	Operational monitoring and handle the trouble during operation Reporting
4.	Distribution	Electricity networt from generation to cluster and cluster to homes Reporting
5.	Home Installation	Electricity connection from cluster to homes
6.	Maintenance	PLTS 25 kWp Off Grid: Checking component PLTS, maintenance area of solar module (from grass, shrubs), tidy up the solar module cable DC Panel AC Panel Reporting

		Genset- fossil fuel: Checking component of Genset Reporting
		Panel Distribution Distribution Cable, cluster and limiter
7.	Home services	On called by residents because there is an electrical problem at their home

The job descriptions of administration staff are as follows in Table 4.

Table 4. Job Description Administration Staff

No.	Job Description
1.	Make electricity bill
2.	Make a record of residents' electricity fees
3.	Keeping book about electricity bills and fees
4.	Keeping records of income and expenses
5.	Reporting

Fig. 7. Technical Personnel on Tunda Island

Based on the duties and responsibilities of the technical personnel that handles electricity on Tunda Island, and compare with the availability technical personnel where there is only one technical personnel who work full-time and one person who work part-time, it will be difficult for technical personnel to carry out its duties and responsibilities which cover all on Tunda Island. Based on the analysis of technical personnel competency which refer to National Standard of Electricity or SKTTK (Standar Kerja Kompetensi Tenaga Teknik Ketenagalistrikan) we try to map the needs of technical personnels who handle electricity on Tunda Island and also the needs of administration personnel based on observation as follows in Table 5.

Table 5. Technical Personnel and Administraion Needs on Tunda Island

No.	Job and Responsibilites	Human Capital Needs	Eksisting	Gap
1.	Operator & Maintenance PLTS	4 person	1 person fulltime & 1 person part time	3 person
2.	Operator & Maintenance Diesel Power Generation	4 person		4 person
3.	Operator & Maintenance Distribution and Houses Power Line	4 person		4 person
4.	Administration	2 person	1 person	1 person

Technical personnel and administration personnel who handle electricity on Tunda Island are human capital that needs to be managed, developed and empowered to become competence, motivated, resilience and prosperous (good income from their job or profession) in the context of managing of electricity on Tunda Island based on community. so the sustainability of the electricity system on Tunda Island, especially electricity based on renewable energy can be achieved. In order to build human capital which have competency and resilience as well as dedication to their job and profession, the solutions that concern for human capital improvement for electricity management on Tunda Island can be provided as follows:

a. Recruitment of human resource needs for engineering personnel by empowering the community, especially the younger generation to become technical personnel;
b. Conducting of training to improve knowledge, skills and work attitude of technicl personnel related in the field of electricity among others generation, operation and maintenance, distribution and power line also installation who always consider the electricity safety;
c. Mentoring or Coaching of Technical Personnel who will handle electricity on Tunda Island;
d. Competency Assesment or certification for Technical Personnel who handle electricity on Tunda Island;
e. Regular motivation by Kades or Head of Village or civil service so the Technical Personnels and Administration Personnel are always dedicated and work diligently and responsibly;
f. Giving salary proportionally to Technical Personnel and Administration Personnel.

In addition to developing human capital in order to realize a competent, reliable and resilient human capital in handling electricity on Tunda Island and providing services to the community optimally regarding electricity, there are many things that need to be built in order to create synergy and collaboration to meet energy-based electricity needs on Tunda Island as follows:

a. Replacing the malfunctioning battery in PLTS 25 kWp Off Grid, around 48 batteries based on observation and field survey;
b. Increasing the power capacity of renewable energy-based power generation according to the potential of Tunda Island, for example solar power generation. With the availability of sufficient power generation, it will increase community productivity and grow small medium enterprises (SMEs) or home industries based on marine products and local agricultural products;
c. Management of electricity by the people of Island of Tunda through institutions such as

BumDes on Tunda Island, BumDes Mercubuana has been established since 2019;

d. Improving the economy of the Tunda Island community, for example by increasing local products, marine tourism, religious tourism and home stays which is managed and marketed and promoted through BumDes which is integrated with electricity management. Thus, the income of technical personnel and administration personnel who handle the electricity on Tunda Island can be increased;
e. Another effort that needs to be conducted is to build an energy-saving culture among the people on Tunda Island;
f. Efforts to reduce the use motorcycle which consume fossil fuel only for activities entire island, because the distance is affordable by bicycle or on foot;
g. Utilizing solar water pump or Pompa Air Tenaga Surya (PATS) for distribution of clean and freshwater on Tunda Island.

CONCLUSION

Based on observations and survey which has been carried out on Tunda Island, in order to increase the resilience of human capital for electricity management especially Technical Personnels and Administration Personnel on Tunda Island, it can be conducted by fulfilling the need of Technical Personnels and Administration Personnels related in electricity management on Tunda Island. According to the analysis refers to SKTTK the needs of Technical Personnels that are 4 (four) Technical Personnels of Operator and Maintenance PLTS 25 kWP Off Grid, 4 (four) Technical Personnels of Operator and Maintenance of PLTD, 4 (four) Technical Personnels of Operator and Maintenance of Distribution and Power Line and 2 (two) Administration Personnels. The development of human capital resilience of Technical Personnels and Administration Personnels is carried out by providing competency-based training for Technical Personnels, Certification, providing motivation and proportional income so that they can contribute and dedicate in managing the sustainability of electricity based on renewable energy sources on Tunda Island. This is in line with national goals towards Low Carbon Development. Meanwhile, for Administration Personnels, it can be done by increasing competence in the field of administration in the context of administrative management.

The synergy and collaboration of various programs in the context of increasing productivity and the community's economy as well as electricity management will have a positive impact on human capital resilience. It also will support the sustainability of electricity based on renewable energy source or green energy on Tunda Island.

IMPLICATION/LIMITATION

This study will contribute to the empowerment of the Tunda Island community, especially how to build a resilience human capital in managing electricity on Tunda Island based on renewable energy and improve renewable energy development and utilization to meet the need of energy or electricity of Tunda Island in the future. The Technical Personnels which have competency it can achieve the electricity running safely, reliable and environmental friendly. The management of power generation can be handle by Bumdes in order to guarantte optimal and effective management and sustainability of electricity Based on field observations, Tunda Island has tremendous potential to be developed into a Low Carbon Model Island with communities that can be developed as entrepreneurs in the field of local marine and agricultural products, marine tourism, religious tourism and home stays that are organized and managed by BumDes.

This study has limitations related to the duration of observation only around 7 (seven) days. In addition, there are also limitations related to the information or data of average income of the residents onTunda Island, projected population growth, housing growth and the growth of community of Tunda Island on electricity demand.

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