KEMENTERIAN AGAMA
UNIVERSITAS ISLAM NEGERI SULTAN SYARIF KASIM RIAU
FAKULTAS SAINS DAN TEKNOLOGI
كلية العلوم و التكنولوجيا
FACULTY OF SCIENCES AND TECHNOLOGY
Jl. H.R. Soebrantas KM. 18 No. 155 Simpang Baru Panam - Pekanbaru 28129 PO. Box. 1004 Telp. (0761) 589026-589027
Fax (0761) 589025, Web Site: www.uin-suska.ac.id, E-mail: faste@uin-suska.ac.id

PENGESAHAN

No.: Un.04/F.V/PP.00.9/6787-a /2015

Dekan Fakultas Sains dan Teknologi UIN Sultan Syarif Kasim Riau dengan ini menyatakan penelitian berikut:

Judul	: Sosio-Economic Assesment of Air Sena Village for the Preparation of Hybrid Power Generation System.
Peneliti	: Kunaifi, ST., PgDipEnSt., MSc.
NIP	: 197607242007101003
Bidang Ilmu	: Teknik Elektro
Fakultas/Unit	: Sains dan Teknologi
Jenis Penelitian	: Terapan
Bentuk Penelitian	: Individu
Lokasi	: Desa Air Sena, Kecamatan Siantan Tengah, Kab. Kepulauan Anambas, Prov. Kepualuan Riau

telah dinyatakan sah sebagai laporan resmi penelitian dosen pada semester genap TA. 2014/2015.

Pekanbaru, 1 Juli 2015
Dekan

Dr. Hartono, M.Pd.
NIP. 19640301 199203 1 003

RESEARCH REPORT

Sosio-Economic Assesment of Air Sena Village for the Preparation of Hybrid Power Generation System

Oleh:
Kunaifi, ST., PgDipEnSt., MSc.
NIP. 19760724 200710 1 003

DEPARTMENT OF ELECTRICAL ENGINEERING
FACULTY OF SCIENCE AND TECHNOLOGY
UNIVERSITAS ISLAM NEGERI SULTAN SYARIF KASIM RIAU
2014

CONTENTS

CHAPTER 1. INTRODUCTION

1.1. Background and Objectives

Indonesia is by far the largest economy in Southeast Asia. With 13.466 islands (Timnas PNR Report 2010; in GIZ PDP Indonesia 2014) and around 237.64 million population (Statistics Indonesia 2020; in GIZ PDP Indonesia 2014), achieving 100% electrification rate remains one of the biggest challenges faced by the country.

Electricity production for the national grid is predominantly generated through the use of fossil fuels (i.e. coal, natural gas and oil), whilst the remote islands and outer regions are mostly powered through diesel-fired power plants.

As Indonesia provides substantial subsidies for transport and power generation sectors, the high cost of oil has placed a heavy burden on Indonesia's economy. To lessen this burden, the Indonesian Government is looking towards renewable energy (RE) as a complementary energy source for these sectors.

Unfortunately at this stage, developing RE in emerging countries such as Indonesia is not without its own challenges. Business and development policy need to have a common interest in structuring political, economic, legal and social framework conditions which promote RE development. Under the Public-Private-Partnership (PPP) concept, it is hoped that companies and development cooperation organisation can work hand in hand. The target-oriented combination of the different strengths of the two partners creates new possibilities for positive development impulses in the partner countries.

Against this background, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is implementing the Project Development Programme in Indonesia (PDP-Indonesia). Funded by the German Federal Ministry of Economics and Energy, the programme's main objective is to help initiate development of RE pilot projects through bridging business partnerships between Indonesian and German companies.

One of the pilot projects pursued is the mini-grid hybrid (solar-wind-diesel) application in the fishing villages, located in one of the islands of Riau Archipelago Province. Air Sena Village has a population of 202 households and the majority of the households are currently served by diesel generator (genset) and grids sufficient for six (6) hours of electricity per day.

Typically, the village is using two 140 kVA gensets working alternately, to power 148 households and 5 public facilities. However, smaller gensets are also used by some households to provide additional power, in which the costs are shared among 5-8 households.

This research was conducted for the Technical Data Survey and Energy Audit for Air Sena-Fishing Village Hybrid-PV Project in Sumatra Remote Islands to provide information for the preparation of implementing a pilot project that will serve as a model to showcase possible RE solutions to help improve the livelihoods of the villagers and encourage replication of mini-grid hybrid power plant projects across Indonesia.

The **objective** of this is to analyse the socio-economic situation and requirements needed for a mini grid-hybrid project.

1.2. Location

This project took place at Air Sena Village - Central Siantan District - Anambas Archipelago Regency of the Riau Island Province. The map location of the Village is shown in Figure I-1. The centre of the Village lies on 3^0 24' 7" N and 106^0 28' 0" E. Air Sena Village is located on the Southern part of Matak Island, amid the South China Sea, between Malaysia and Kalimantan-Indonesia. The closest mainland cities to Matak Island are Kuantan-Malaysia (around 177 nautical miles distance), Pontianak-Indonesia (around 273 nautical miles distance), and Singapore, Batam-Indonsia, Tanjung Pinang-Indonesia (around 180 nautical miles distance).

Due to its remote location, currently the Air Sena Village can only be reached by using three different types of transportation modes. The first, which is the more secure option in terms of regularity of transportation, is by ferries from Tanjung Pinang to Tarempa Town in Siantan Island (approximately 9 hours), then is continued by small boats from Tarempa to Air Senathat usually take around 30 minutes. However, during December to February, when the sea wave is at its highest condition, the ferries are normally not in operation. The second option is by airplanes from Batam or Tanjung Pinang to Matak Airport in Matak Island, then continued by land transport from Matak Airport to Matak Port (approximately 30 minutes), and by boats from Matak Port to Air Sena (Approximately 35 minutes). Unfortunately, the flights to and from Matak are not always available. The flight reschedules or even cancellations are often occurring. At the moment this report is being prepared, all flights to and from Matak are unavailable. The third option isusing the Conoco company's private aircrafts (Matak – Jakarta Halim Perdanakusuma Airport route) that sometime can be shared for non-Conoco staff for free. However, it is considerably difficult to get a seat on the Conoco's flights because priority is given for the Conoco's staff, local NAVY's staff, and local Government staff.

1.3. General Methodology

The primary objectives for the socio-economic assessment are to ensure the provision of economically viable, socially acceptable and well-managed hybrid power generation systems to be proposed in the village. The assessment of socio-economic condition in the village used both secondary and primary data. The secondary data was purchased from the local Statistics Office, while the primary data was obtained from the surveys and interviews.

The assessment looked into for the following information:

- household profile,
- size of family,
- sex,
- ethnics and religions,
- gender aspects on energy uses,
- age groups,
- income and expenditure,
- percentage of expenditure for energy (e.g. electricity, firewoods, gas, kerosene, etc.),
- education level,
- occupation,
- household attitudes on the current energy consumption, generation, and costs,
- household expectation about the number of hours of electricity supply per day,
- level of acceptance to the proposed hybrid system,
- household attitudes on proposed hybrid power system,
- Affordability and willingness to pay for hybrid energy systems,

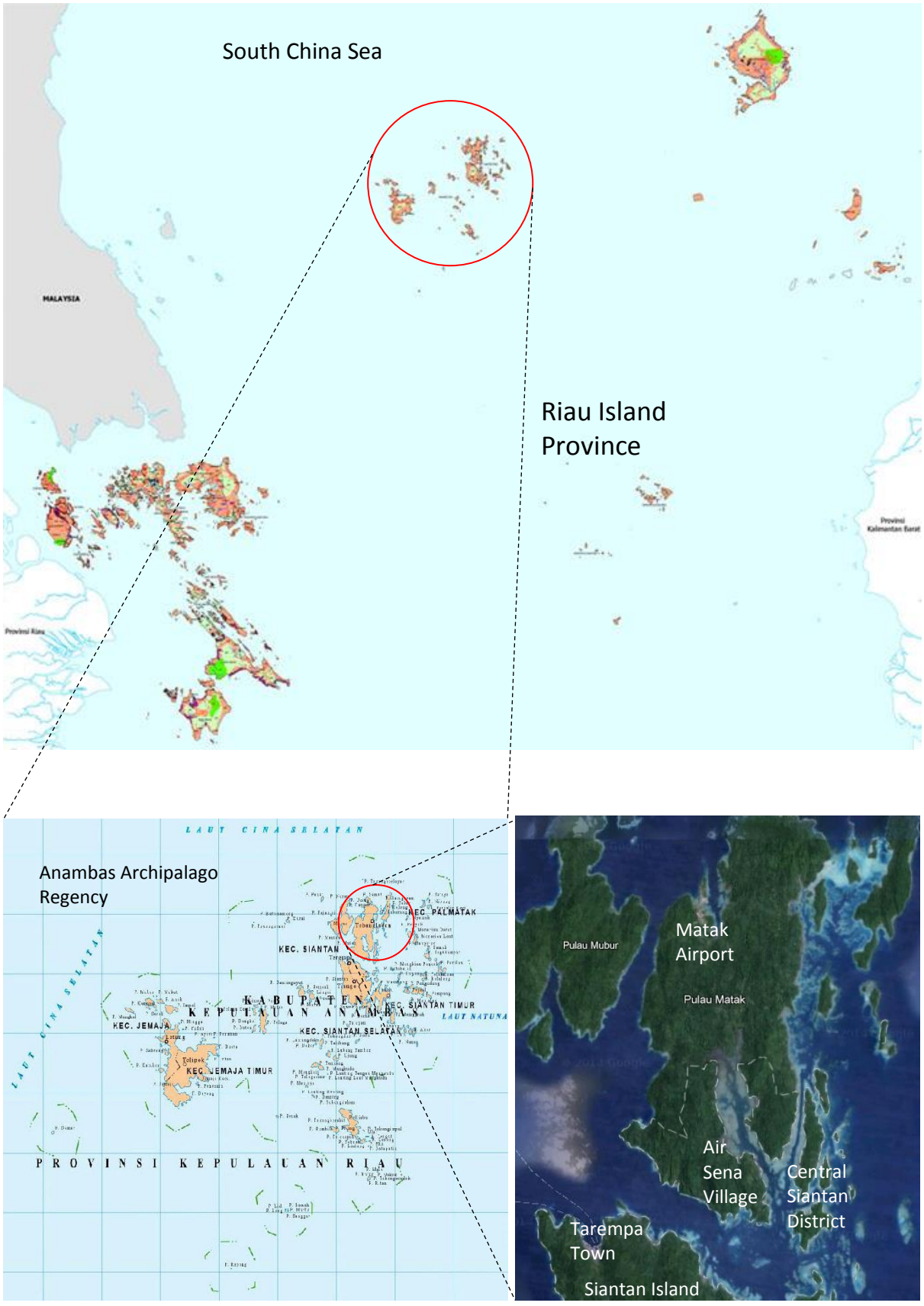

Figure I-1. Location of Air Sena Village

- preference in the methods of paying electricity bill generated from the hybrid system,
- desired uses of electricity (for income generating and non-income generating activities),
- local organization(s) or community group(s) available in the village,
- energy requirement for block-ice production for preservation of fishes,
- ownership and management of the current and proposed hybrid system,
- willingness to have renewable power system (e.g. solar home system) installed in houses.

The assessment also looked at the management aspects of the current and proposed power generating system such as the owner of the current system, the operational practices of the current system, etc., as well the respondent preference about the ownership and the operational practices of the proposed system. There was also an observation about the availability of the land to install the hybrid system if the study recommends a centralized system, the owner of the proposed site/land, or how the site could be provided by the villagers. Site visit were undertaken to the potential site location(s) of the proposed hybrid system(s).

1.4. Introduction to Anambas Archipelago Regency

1.4.1. Geography

Based on Statistics of Kepulauan Anambas Regency (2013), Anambas Archipelago Regency is a small archipelago of 255 islands located 180 nautical miles north east of Batam Island in the South China Sea between the Malaysian mainland to the West and the island of Borneo (Kalimantan) to the East. Anambas Archipelago Regency consists of big and small island clusters and is positioned in both the northern and eastern hemispheres. It is geographically spread between 2^0 10' 0" N and 3^0 40' 0" N; and between 105^0 15' 0" E and 106^0 45' 0" E.

1.4.2. Climate

Based on the Badan Meteorologi, Klimatologi dan Geofisika, BMKG, the local meteorological office (in Statistics of Kepulauan Anambas Regency (2013), the temperature in the region in 2012 ranged between 20.20^0C and 35.00^0 C. The Atmospheric pressure in the region in 2012 was between 1,008.3 mb and 1,009.5 mb, while the atmospheric humidity ranged between 49% and 100%. The highest rainfall in 2012 occurred in May i.e. 349.3 mm, while December was the month with the largest number of rain days of 21 rain days. Figure I-2 shows an example of actual measurement on the relative humidity and temperature at Air Sena.

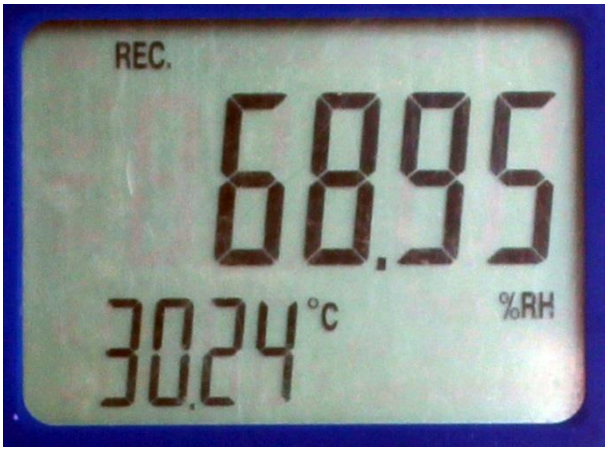

Figure I-2. Location of Air Sena Village

Anambas Archipelago area is surrounded by open seas i.e. South China Sea and Natuna Sea and therefore some extreme wind speeds usually occur during December, January, and February. This situation affects the socio-economic life of the people, including the sea and air transportations.

1.4.3. Administration

Anambas Archipelago Regency was officially established on 24 June 2008 through the Law No. 33/2008. It consists of seven districts include Siantan, East Siantan, South Siantan, Central Siantan, Palmatak, Jemaja, and East Jemaja Districts. There are 54 villages across Anambas Archipelago Regency, where two villages are urban areas while the rest 52 villages are classified as rural areas (Statistics of Kepulauan Anambas Regency 2013).

The Dinas Energi dan Sumberdaya Mineral/ESDM (The Office of Energy and Mineral Resources) is the leading Government institution that possesses the authority to formulate development policies of the energy sector in Anambas. The ESDM also provides administrative services related to the energy sector. The process of activities and budget planning in energy sector is initially proposed by the ESDM to the Development Planning Office (Bappeda). Furthermore Bappeda will analyse whether the proposal are in accordance with the development priority referring to the Middle Term Development Plan of Anambas Regency (Rencana Pembangunan Jangka menengah/RPJM). Once the Bappeda approve the proposals, then they will be preceded to the House of Representative of Anambas Regency (Dewan Perwakilan Daerah /DPRD). The DPRD then discuss all proposals and further, along with the Regent of Anambas (Bupati), a local legislation will be issued in which all activities and their budgets included.

The development of the electricity sector however, is not only the responsibility of the ESDM, but also the duty of the State Utility Company (PT. Perusahaan Listrik Negara/PLN). The PLN is responsible for developing and operating its power systems, while the ESDM develops power systems in areas not covered by the PLN's grids. The operational of the power systems developed by the ESDM may be managed by the community organisations or by the PLN. In this instance, the ESDM and PLN always develop close relationship.

Related to the investment permits in energy sector, there are no specific regulations governing the licensing process and requirements in Anambas. According to the Head of ESDM, any potential investors are expected to coordinate with the ESDM office prior to the project implementation.

CHAPTER 2. PROFILE OF AIR SENA VILLAGE

2.1. Area, Geography and Topography

The total area of Air Sena Village is about 10 km^2. It has a peak elevation of 200 m above sea level and the lowest elevation is the sea level. Figure II-1 shows the situation of Air Sena Village. The map of Air Sena Village is shown in Figure II-2 showing entire area of Air Sena that consists of both land and water areas. This map also shows the Village's electrical load which is mainly concentrated on the land area. However, some load premises also exist on the water area. Although the number of households is 202, but some households possess also settlements off-shore (camps). There are seven clusters of camps off-shore where each cluster usually consists of some houses. Therefore, In terms of power connection, we consider the number of premises is 211 instead of 202.

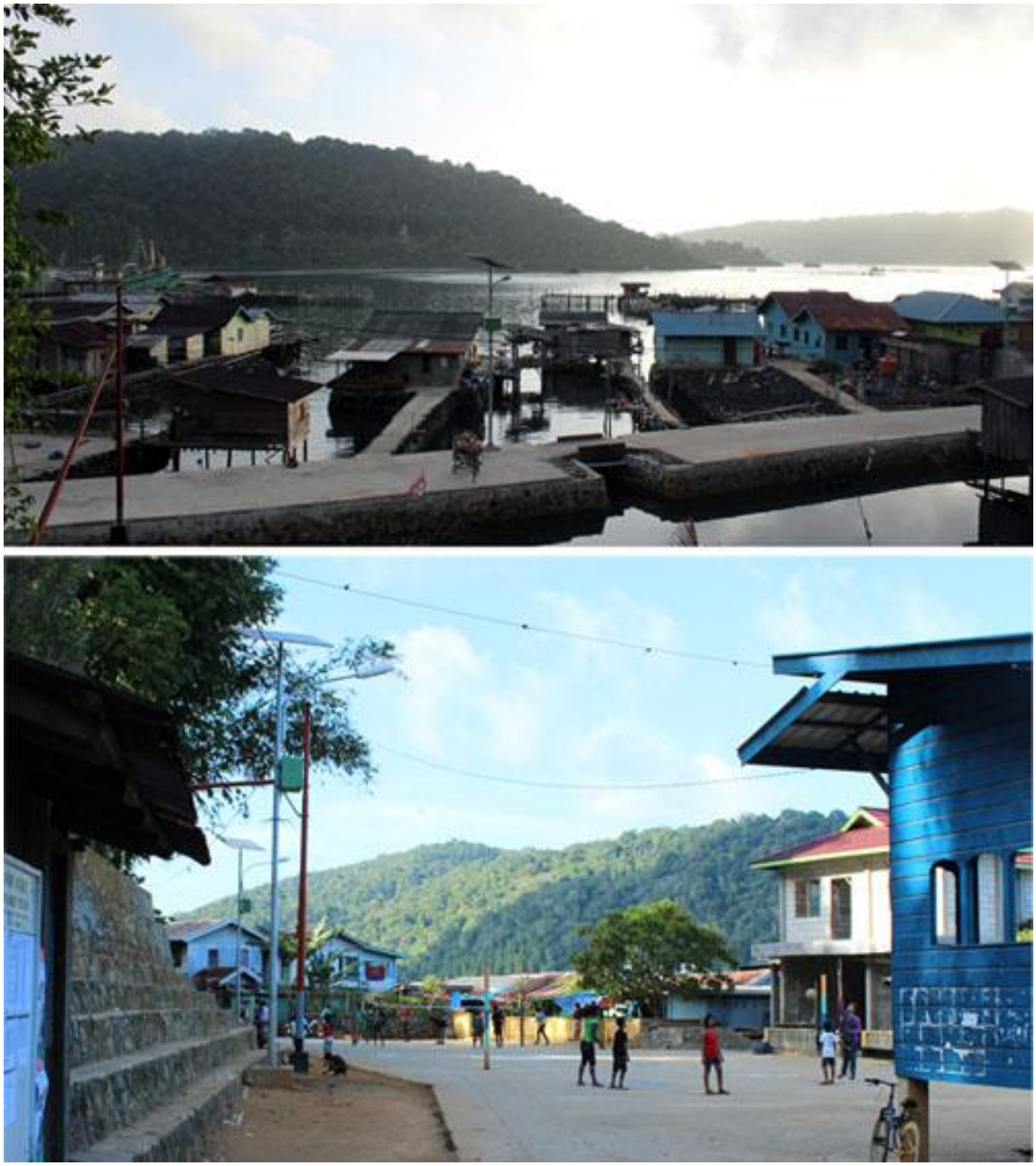

Figure II-1. Situation at the Air Sena Village

Air Sena Village consists of 5 Community Association (RW) and 8 Neighbourhood (RT). In the North, Air Sena is bordered with Air Nangak Village and Teluk Sunting Village, in the South it is bordered with Batu Belah Village and the South China Sea, while in the West it is bordered with Jeruan Village and Tarempa, and in the East it is bordered with Air Asuk Village.

The concentration of residential centre of the villager in Air Sena was located along the coastline, this due to the majority of the villager livelihoods associated with coastal and marine areas. The resident of the villager was concentrated in the northern of Air Sena which bordered to Air Nangak Village. The type of house of Air Sena villager is mostly constructed from wood (70%), some houses can be moved out from one place into another. The detail about the house distribution of the villager of Air Sena can be seen on Figure II-2.

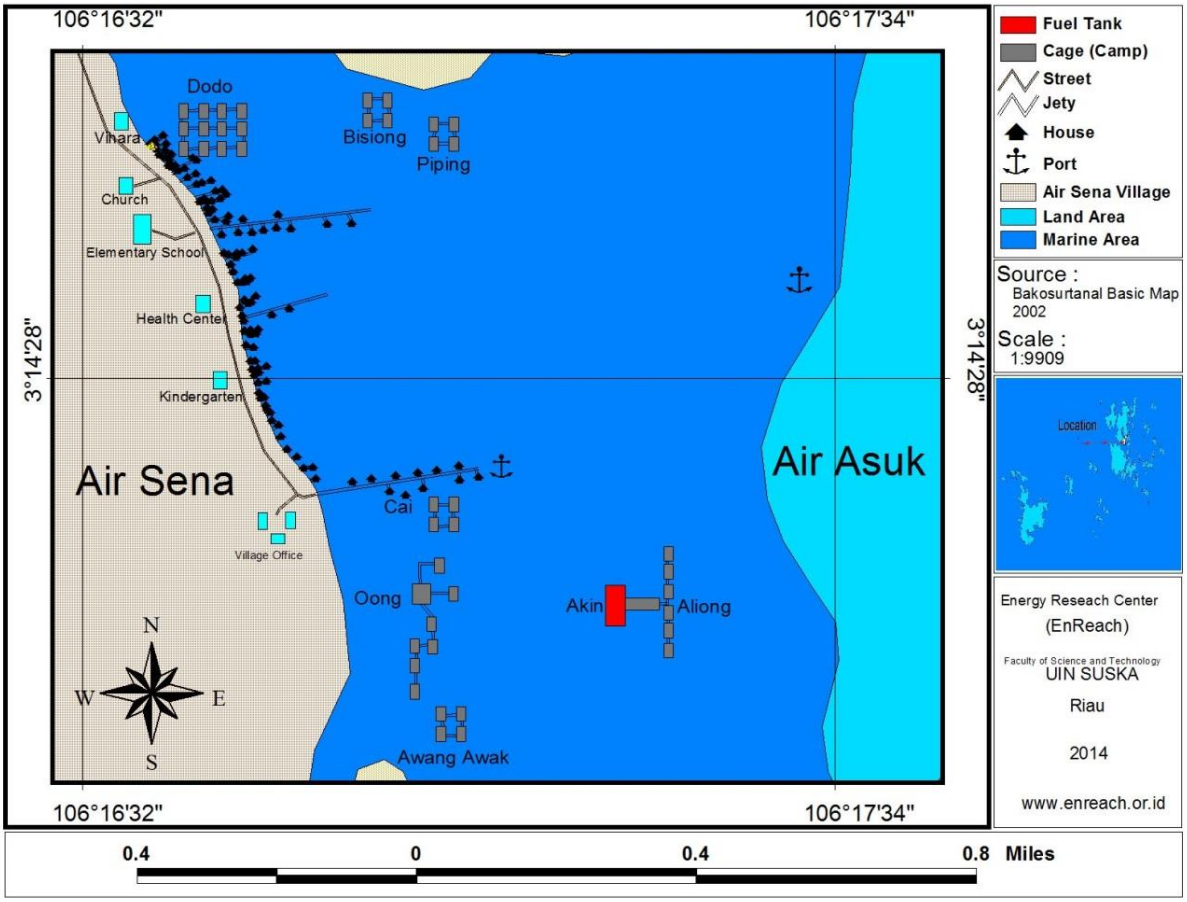

Figure II-2. House Distribution of Air Sena Village

Air Sena Village is a coastal area with hilly topography with the maximum altitudes is 200 meters above sea level. While the concentration of the residential of the population was located along the coastline, this is due to the livelihoods of the majority of the villagers of Air Sena Village associated with coastal and marine areas. The topography of Air Sena can be seen in Figure II-3.

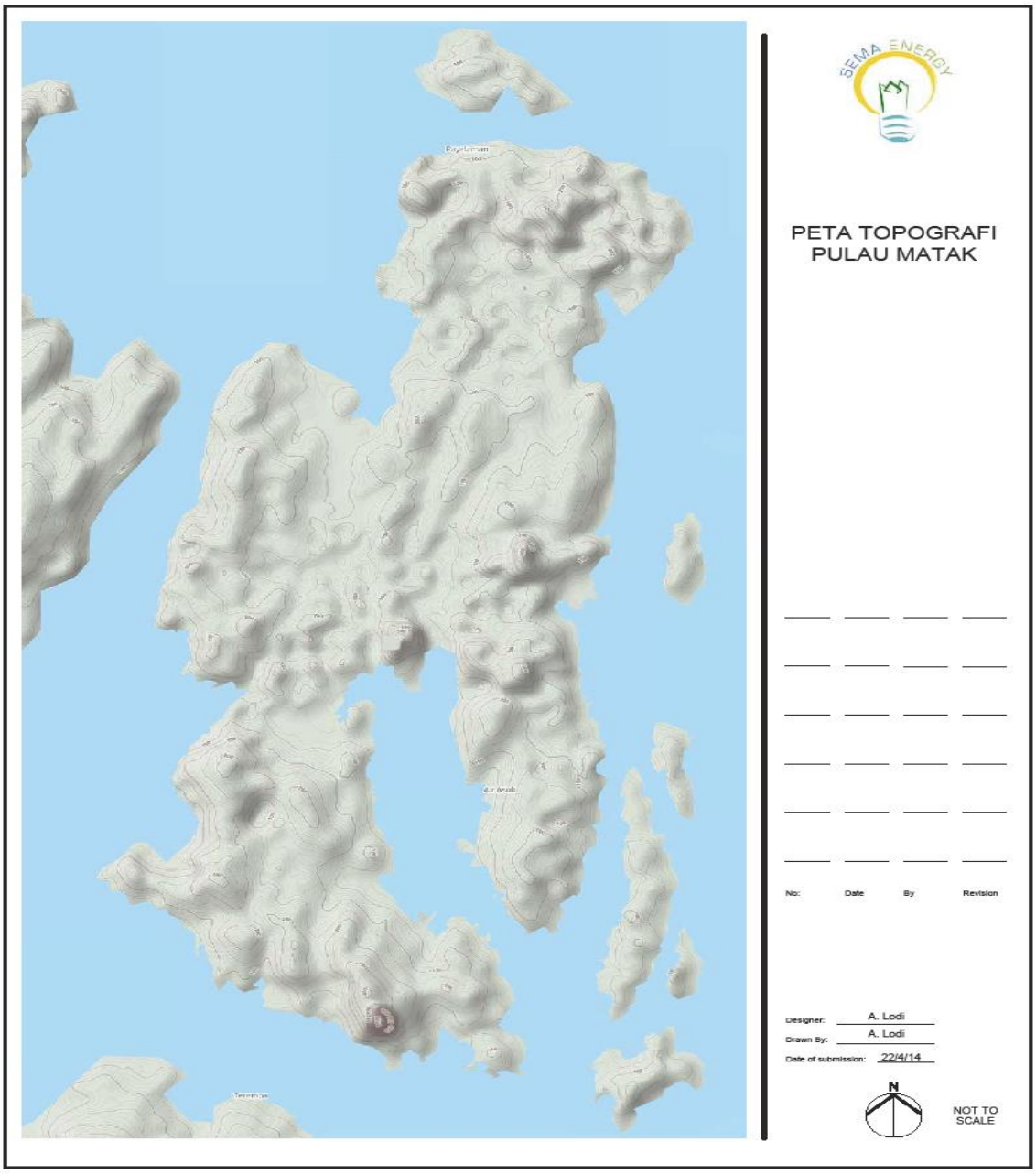

Figure II-3. Topography Maps of Matak Island (Image: PT. Suar Intermuda 2014)

Fisheries sector is main commodity in Air Sena Village, it is proven by the majority of the villager occupation is as a fisherman (84%). For fisheries aquaculture Air Sena has become one of the central in of the fisheries aquaculture sector in Anambas Archipelago Regency. The main commodities of fisheries aquaculture in Air Sena are Napoleon (Cheilinus sp), Kerapu (Epinephelus sp), and Kakap (Lutjanus sp). While the main commodity for the wild fisheries in Air Sena is stare Tongkol (Euthynnus sp), Tenggiri (Scomberromo sp), Selar (Caranx Sp), Teri (Stolephtorus sp), Kembung (Rastrelliger sp).

Figure II-4. One of the Fish Breeding sites at Air Sena Village

Based on information of Fisheries and Marine Department of Anambas Archipelago Regency, there is no specific information about total production of wild and aquaculture fisheries in Air Sena Village. The available information is only about wild fisheries production for Anambas Archipelago with total commodity of 4454.01 Ton per Year. The biggest commodity is Tongkol (Euthynnus sp) with 894.40 ton or up to 20.08% of total production per year. The detail information about wild fishery commodity can be seen in Table II-1 below. Tongkol and Tenggiri are the most common fish commodities available in Anambas Archipelago.

Table II-1. Wild Fishery Main Commodity in Anambas Archipelago

No	Local Name	Latin Name	Total Production (T/Y)	Percentage (%)
1	Tongkol	*Euthynnus* sp	894.40	20.08
2	Tenggiri	*Scomberromo* sp	864.30	19.40
3	Selar	*Caranx* Sp	484.40	10.88
4	Teri	*Stolephtorus* sp	286.00	6.42
5	Kembung	*Rastrelliger* sp	264.00	5.93
6	Other	*Other*	1660.91	37.29
	Total		**4454.01**	**100.00**

Source: DKP Provinsi Kepulauan Riau (2014)

Beside fisheries sector, there is also commodity in plantation sectors. The main commodities in plantation sector are coconut, clove, rubber, and palm oil. There is no specific information available about the area of plantation but clove, Air Sena village has 49 ha of clove plantation. In the agriculture sector, there are no routine activities that may due to: land availability, because the majority of land area in Air Sena Village are owned by residents of other villages; the habit of the community, based on ethnic background the villager of Air Sena is accustomed to be a fisherman not to be a farmer and they do not have experience in farming activity; and soil fertility, based on a survey activity stated that the land of Air Sena is not support to agriculture activity. Figure II-5 shows one of the plantation products at Air Sena Village.

Figure II-5. Rubber is one of the plantation products at Air Sena Village

Total population of Air Sena is 714 persons consist of 202 head of family (KK) or households. In general, the differentiation of male and female population is not significant, where 371 (52%) of the population are male and 343 female (48%). The population distribution based on the age showed that the highest percentage is at the age of 0 - 4 years old with a number of 89 persons (12.46%), while the lowest percentage is on the age level 70 - 74 and 75> year old, each of the age group is 4 persons (0.56%). The detail information regarding population distribution based on age and gender can be figured out from Table II-2.

Table II-2. Population distribution Based on Age and Gender

No	Age (Year)	Male (Person)	Female (Person)	Total (Person)	Percentage (%)
1	0 - 4	43	46	89	12.46
2	5 - 9	32	38	70	9.80
3	10 - 14	36	24	60	8.40
4	15 - 19	34	29	63	8.82
5	20 - 24	44	31	75	10.50
6	25 - 29	30	36	66	9.24
7	30 - 34	29	26	55	7.70
8	35 - 39	35	47	82	11.48
9	40 - 44	21	16	37	5.18
10	45 - 49	22	17	39	5.46
11	50 - 54	17	7	24	3.36
12	55 - 59	5	9	14	1.96
13	60 - 64	14	12	26	3.64
14	65 - 69	5	1	6	0.84

15	70 - 74	1	3	4	0.56
16	75>	3	1	4	0.56
	Total	**371**	**344**	**714**	**100.00**

Source: Air Sena Village Government (2014)

2.2. Demography

2.2.1. Population Distribution Based on Level of Education

Reviewed from the level of education of Air Sena Village population, the percentage of the population does not/not yet in school is the highest percentage which reached 256 people (38.85%), while the lowest percentage is undergraduate degree which only 1 person (0.14%). The detail information regarding the population distribution based on level of education can be figured out from Table II-3.

Table II-3. Population Distribution Based on Level of Education

No	Education Level	Total (Person)	Percentage (%)
1	Not/Not yet in School	256	35.85
2	Not Graduated from Elementary School	228	31.93
3	Graduated from Elementary School	151	21.15
4	Graduated from Junior High School	40	5.60
5	Graduated from Senior High School	27	3.78
6	Graduated from Diploma (I/II/III)	11	1.54
7	Under Graduate Degree (S1)	1	0.14
Total		**714**	**100.00**

Data Source: Air Sena Village Government (2014)

Families of Air Sena do not consider education beyond elementary school to be important since residents have historically been able to obtain income as fishermen from a young age. Additionally, the two largest income earners of the village (47% of total village income) do not have education beyond elementary school, as described in Section 2.5.4. The decline of the fishing industry may affect this mindset, as described in Section 5.2.

2.2.2. Population distribution based religion

The majority of Air Sena residents are Catholic and Buddhist faiths. Catholic has the highest number as many as 339 people (47.48%), while the number of adherents of Protestant Christianity was the lowest as many as 6 people (0.84%). The detail about Population distribution based religion adherent can be seen in Table II-4 below.

Table II-4. Population distribution based religion adherent

No	Religion	Total	Percentage (%)
1	Islam	38	5.32
2	Protestant	6	0.84
3	Catholic	339	47.48
4	Hindu	-	0.00
5	Buddha	331	46.36
6	Others	-	0.00
Total		**714**	**100.00**

Data Source: Air Sena Village Government (2014)

It is likely that there is no a significant correlation between religion and economic conditions of Air Sena residents. Religion has no rule in defining the economic or income activities. The people in Air Sena live side by side in peace and tolerance.

2.2.3. Population Distribution based on Occupation

Based on the data of Air Sena Village Government In 2014, the majority of the population of Air Sena are fishermen, it is up 84.10% or 201 persons from the total of 239 persons employee of Air Sena Village. The detail about Air Sena Village population distribution based on occupation can be figured out from Table II-5 below.

Table II-5. Population Distribution Based on Occupation

No	Type of Work	Total	Percentage (%)
1	Farmer	4	1.67
2	Fisherman	201	84.10
3	Civil Servant	6	2.51
4	Private Employee	7	2.93
5	Honorary Worker	4	1.67
6	Labour	6	2.51
7	Entrepreneur	11	4.60
Total		**239**	**100.00**

Source: Air Sena Village Government (2014)

2.3. Human Resources

Of 714 population, 67% is categorized to productive age and 33% others are categorized to non-productive age. The calculation of the ratio based on the government legislation No. 13 in 2003 which stated that the productive age is between 15 – 64 years old. The detail about the ratio between productive and non-productive age in Air Sena Village can be seen in Table II-6 and Figure II-6 below.

Table II-6. Productive and Non Productive Age Ratio of Air Sena Villagers Population

No	Category	Total	Percentage (%)
1	Productive Age	481	67
2	Non Productive Age	233	33
	Total	**714**	**100**

Source: Air Sena Village Government (2014)

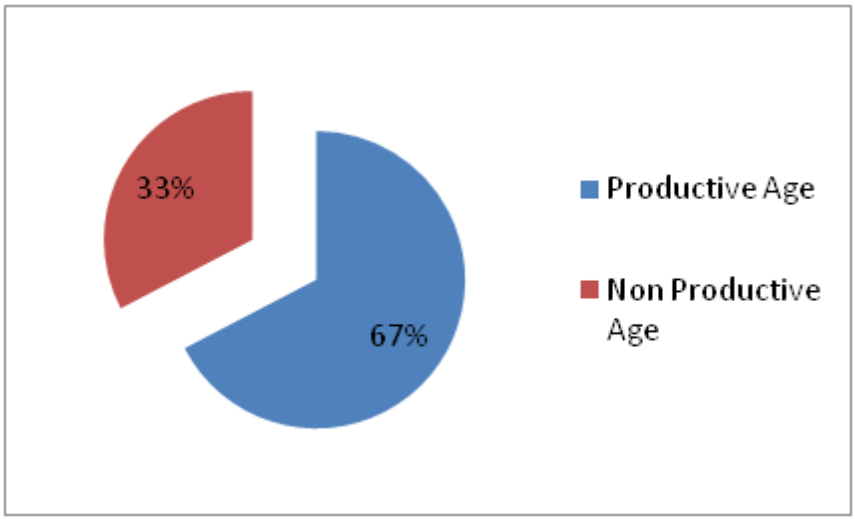

Figure II-6. Productive and Non Productive Ratio in Air Sena Village

From total of 481 productive age in Air Sena Village, only 239 person of them are under employment (49.69%), while 242 others are still unemployment (50.31%). The detail regarding the ratio of employment of the productive age population in Air Sena Village can be seen in Table II-7 below.

Table II-7. Ratio of Employment and Unemployment

No	Category	Total (Persons)	Percentage (%)
1	Employment	239	49.69
2	Un Employment	242	50.31
	Total	**481**	**100.00**

Source: Air Sena Village Government (2014)

2.4. Public Facilities

2.4.1. Electricity Service

The primary electricity supplies in Air Sena Village is supplied by a diesel power plant (PLTD), purchased in 2012 by the ESDM. The plant consists of two identical 140 kVA generators, with regular daily service from 17:30 to 23:30 of local time (WIB) each day. During Sunday, the generator is operated from 07:00 to 12:00. Currently, PLTD supplies electrical energy to 152 consumers (148 households 4 public facilities). Since the PLTD operates only 6 hours a day, some villagers have their own diesel generators with the rated power between 1 to 5 kVA.

The decision regarding the duration of PLTD to operate was based on collective agreement of Air Sena Villagers and the Village' Government, considering the sustainability of the diesel generator and the cost to be paid by the consumers. Only households that have to pay for the electricity bill while the public service premises do not.

Regarding satisfaction of Air Sena Villagers on the electricity service, some 47% of the villagers are not satisfied with the electricity service due to the short duration of electricity supplies; 31% are slightly satisfied, and only 22 % are satisfied with the currently condition. The detail overview regarding the level of satisfaction of the villagers on the electricity service in Air Sena Village is shown in Figure II-7.

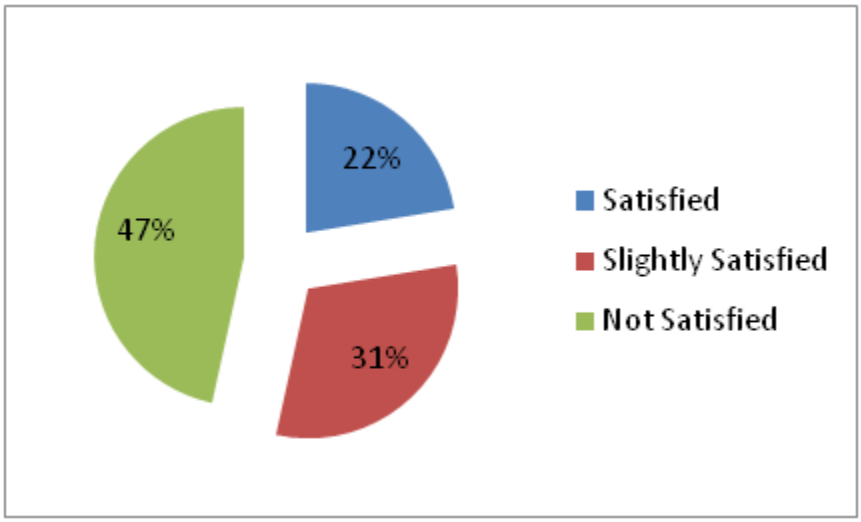

Figure II-7. Level of Satisfaction of Air Sena Villagers on the Existing Electricity Service

2.4.2. Access to Clean Water

Similar to some other areas in Anambas, access to clean water is one of the major issues in Air Sena Village. To provide clean water supplies for the villagers, the government through the PNPM Mandiri Pedesaan built public clean water supplies in 2012. The water source comes from Air Nangak Village about 1 km in the North of Air Sena. The public clean water supplies 109 households; operated from 14:00 to 17:00 every day. To maintain the sustainability of the clean water supplies, the village government mandated the management of the public clean water supplies to the LPMD. The tariff for the public clean water supplies is IDR 20,000 per month per household.

In addition to the public clean water supplies, in Air Sena have also other private clean water supplies with the tariff range from IDR. 30,000 – 50,000 per month. There are five private clean water supplies in Air Sena Village that take water from the hill behind the village to the West and from the another side of the island trough underwater piping network. Based on the interview regarding the level of satisfaction of the villager on the access to clean water, 40% of household are satisfied, 33% other are not satisfied, while 27% other are slightly satisfied. The detail about the level of satisfaction can be seen on Figure II-8.

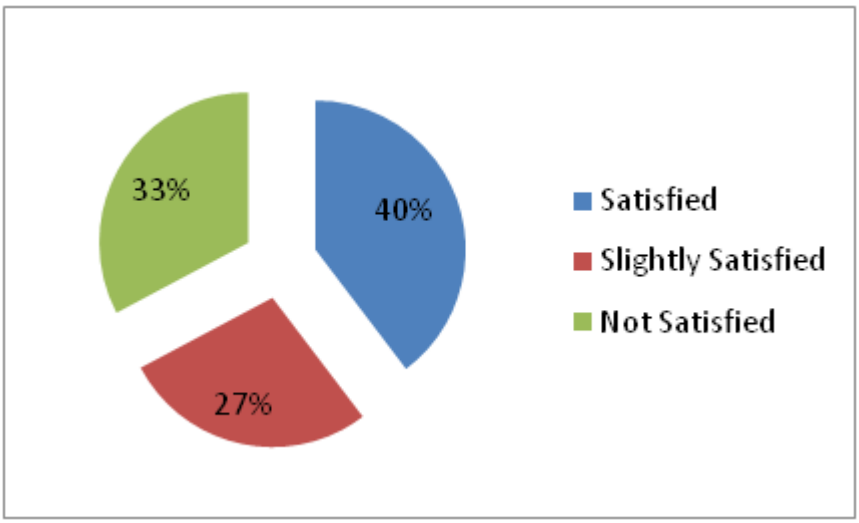

Figure II-8. Level of Satisfaction of Air Sena Villagers on the Access to Clean Water

2.4.3. Access to Education

There are two schools in Air Sena Village i.e. an elementary school and a kindergarten. The elementary school was built in 1982. It has 7 teachers and 86 students. The school is located at the population central of the Village on the hill. The closest junior high school is at Air Asuk Village around 2 km from Air Sena, and it can be reached by Speed Boat about 5 – 10 minutes or by Traditional Motorboat (Pompong) about 15 – 20 minutes. The nearest senior high school is at Tarempa about 5 km from Air Sena, and it can be reached by Speed Boat about 15 - 20 minutes or by Traditional Motorboat (Pompong) about 45 – 60 minutes. For student transportation, the Government of Kepulauan Anambas provides free transportation by traditional motorboat (pompong) from Air Sena to Air Asuk and Tarempa.

Some 47% of the households are satisfied with the access to education, while 43% is slightly satisfied, and 10% is not satisfied. The detail about the level of the villager satisfaction regarding the access to education can be seen from Figure II-9.

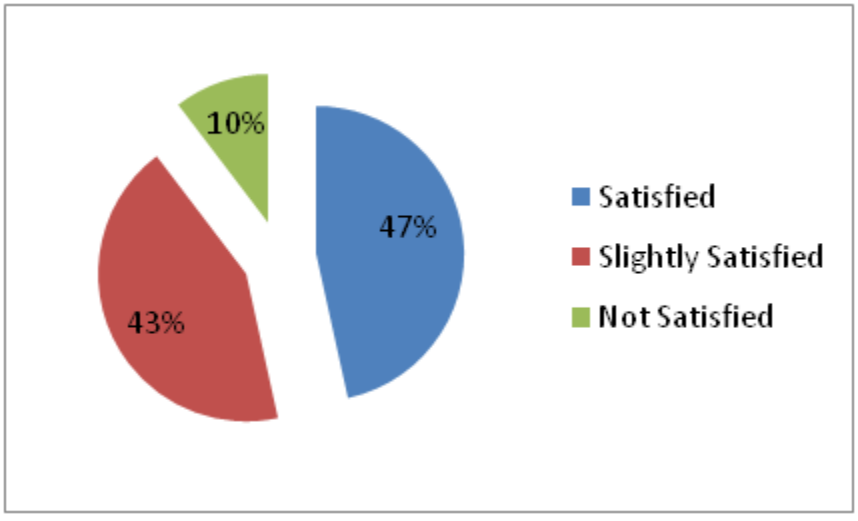

Figure II-9. Level of Satisfaction of Air Sena Villagers on the Access to Education

2.4.4. Worship Centre

There are only two worship centres in Air Sena Village; a Church and a Vihara. Based on the observation regarding general overview of public opinion on the level of satisfaction on the worship facilities mostly are satisfied (72 %), slightly satisfied (24%) and not satisfied (4%). The detail overview regarding the villager satisfaction on the worship centre access can be seen in Figure II-10.

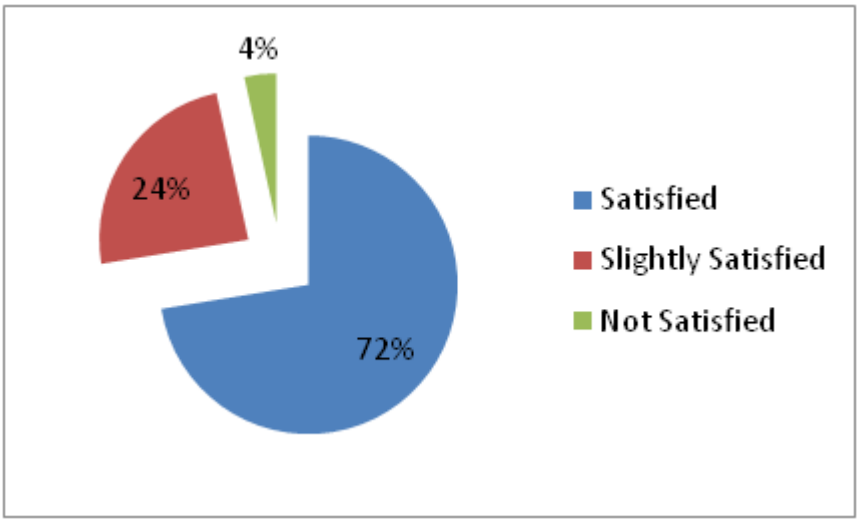

Figure II-10. Level of Satisfaction of Air Sena Villagers on the Access to Worship Centre

2.4.5. Health Care Service

Air Sena Village has a small health clinic a small maternal care centre with a nurse and one midwife on service. They are opened during working time, Monday – Saturday. There is no doctor work in the Village, and therefore the villagers must go to Air Asuk or Tarempa to see a doctor. General overview regarding the level of satisfaction of the villagers on public health service is: 33% are not satisfied, 41% are satisfied, and only 26% are satisfied. The detail description regarding the level of satisfaction of the villagers toward the health care service can be figured out from Figure II-11.

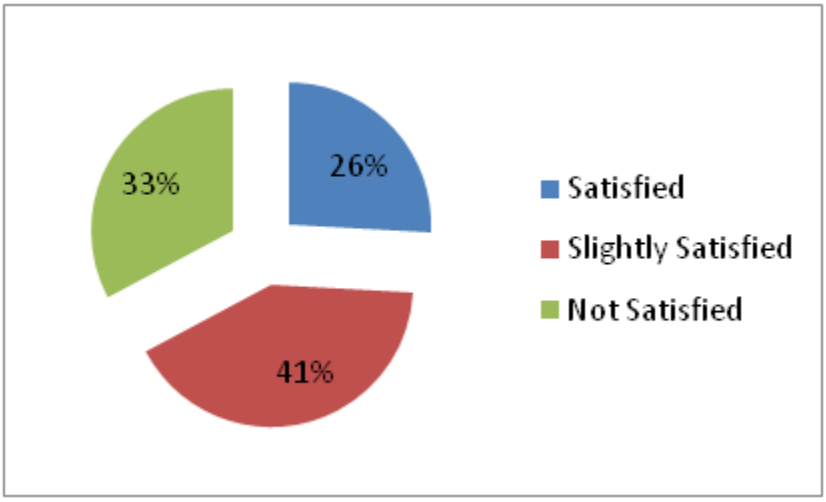

Figure II-11. Level of Satisfaction of Air Sena Villagers on Health Care Service

2.4.6. Transportation and Accessibility

The primary access to Air Sena Village is through sea route from Tarempa, the capital city of Kepulauan Anambas Regency. Air Sena Village can be accessed by speed boat about 15 - 20 minutes, or by traditional motorboat (pompong) about 45 – 60 minutes. The secondary access is through the land route from Matak Airport, it only able to be accessed on foot or motorcycle about 1.5 hours due to the bad condition of infrastructure of the land route itself. Transportation infrastructure in Air Sena Village itself from the total of 8.25 km, 6.65 km already paved and the other 1,7 km still unpaved. The means of transportation has been used in Air Sena Village are motorcycle, bicycle, canoe, and motorboat (speed boat and pompong).

Table II-8. Means of Transportation in Air Sena Village

No	Type of Means Transportation	Total Unit	Percentage (%)
1	Motorcycle	64	15.92
2	Bicycle	88	21.89
3	Canoe	138	34.33
4	Motorboat	112	27.86
Total		**402**	**100.00**

Data Source: Air Sena Village Government (2014)

Level of satisfaction of the villagers toward public transportation service in Air Sena Village, only 10% of them were satisfied with the public transportation service, 43% were not satisfied, and 47% others were slightly satisfied. The detail review regarding the level of satisfaction of the villagers toward public transportation service can be seen in Figure II-12.

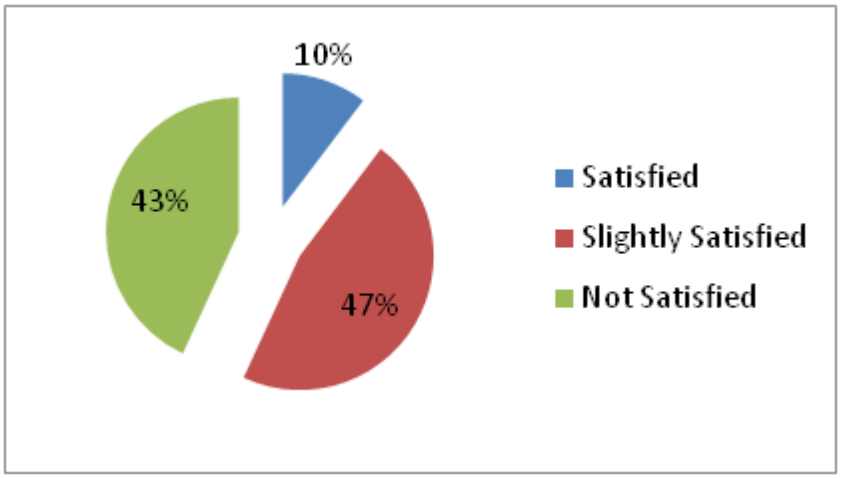

Figure II-12. Level of Satisfaction of Air Sena Villagers toward Public Transportation Service

2.4.7. Communication Service

Air Sena Village is covered by mobile network and GSM the internet network. The network is available in the 2G technology provided by Telkomsel and Indosat. The internet access only available on the mobile network and it is still facing the stability issue. Regarding the level of satisfaction of the villagers toward public communication service, most of them are slightly satisfied (60%), while 29% others are not satisfied; only 11% of them are satisfied. The detail about the percentage can be seen in Figure II-13.

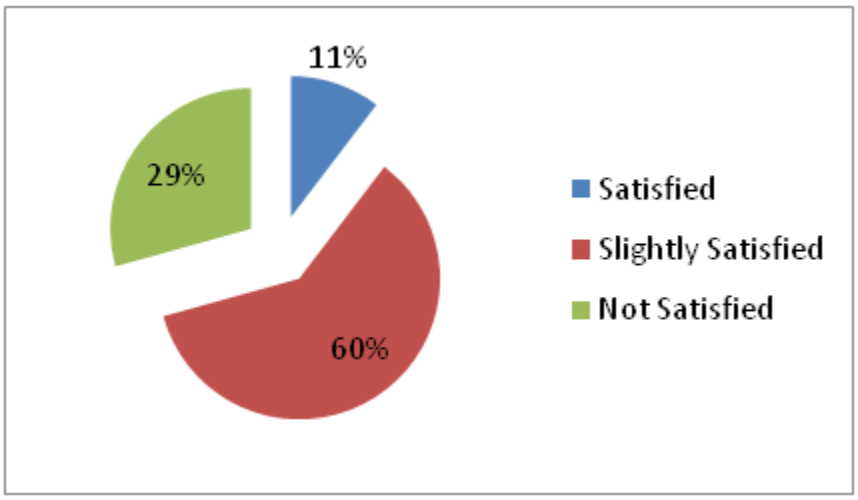

Figure II-13. Level of Satisfaction of Air Sena Villagers on the Communication Service

As overall table II-14 below described as detailed regarding the level of satisfaction of Air Sena Villages toward public facilities.

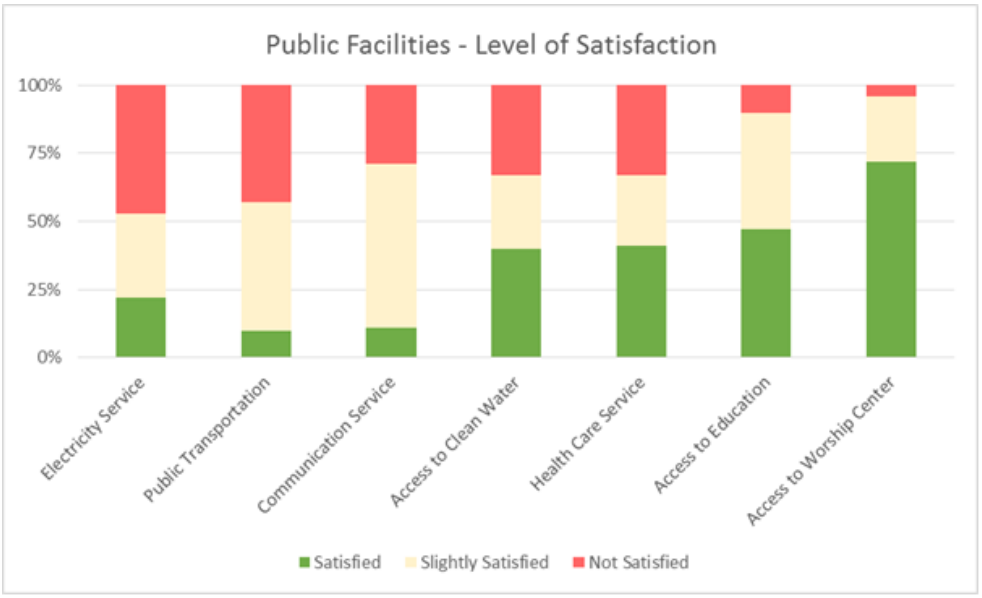

Figure II-14. Levels of Satisfaction of Public Facilities in Air Sena

Public facilities that the community is least satisfied with are electricity, public transportation and communication services. Based on the survey, the majority of Air Sena residents do not have standard of expectation on public facilities although many of them expect for better services.

2.5. Socio-economic Condition

2.5.1. Villager Occupations

The majority of Air Sena Villagers are fisherman (fishing and aquaculture). From total of 239 employed villagers, 201 (84%) of them work as fisherman as primary occupation, while the other 16% are farmers, civil servants, private employees, honorary workers, labourers and entrepreneurs. Generally, the rest 16% choose fishing as their secondary occupation. There are two type of

fisherman in Air Sena: Fishing and aquaculture, but most of them combine both. The detail about Air Sena villager occupation can be seen in the Figure II-14 below.

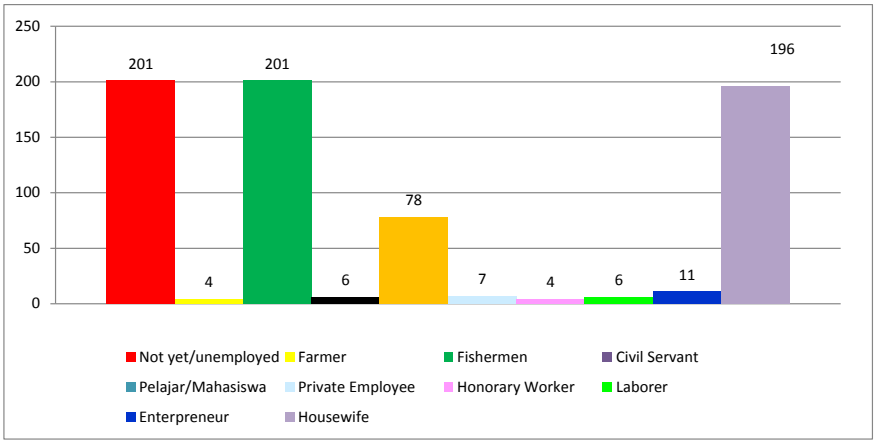

Figure II-14. Distribution of Type Occupation of Air Sena Villagers

2.5.2. Social Institution and Activity

A Kinship among the villager of Air Sena was quite strong and most of them have family ties. Social structures in Air Sena Village was homogeneous, they stick to the leaders, and also have a good awareness. One of program has been initiated by the government to enhance the local social institution and the villager participation is through PNPM Mandiri Pedesaan implementation in Air Sena. PNPM Mandiri Pedesaan has been facilitated several program initiated by the village government such as construction of public clean water supplies, building kindergarten building and facilities and increase men and woman participation in generating household income. In 2011 PNPM Mandiri Pedesaan formed three women's group in Savings and Loans system activities. The program was intended to enhance women participation in household economic management. The program was implemented successfully in Air Sena with the ratio of payback more than 78%.

Beside PNPM Mandiri Pedesaan Program, the local government through it program also enhance the local social institution trough the villager participation in the development program. Some of the local government programs in Air Sena Village are road construction, diesel generator aid (PLTD), and street lights with solar system, which most of the aid is manage and maintain by the local institution. Through the department of fisheries and marine of Anambas Archipelago Regency, the local government also enhance the local institution through fisheries group (Nelayan Teri Group). The fisheries group was formed in 2011, with the total member 0f 10 people, the group is inter village group within Central Siantan District with focus on enhance fisheries activity in Air Sena and Central Siantan District.

Figure II-15. One of the PNPM project at Air Sena, fresh water supply system

Beside of intervention of local government and other institution to enhance the local social institution, the role of Church and the Vihara as the biggest religion based community also play a big role in enhancing the local institution in Air Sena. Each of these group of community also have own program which contribute to the development of Air Sena Village. In Air Sena village, men become the backbone of the family, earning a living for the family meet the needs (food, education, health, etc.). The women usually stay at home, doing domestic activities, such as taking care of the home, child care, preparing meals, washing, etc.). At the Air Sena village, there are two fairly large religious group, characterized by two buildings, namely the Catholic Church and the Buddhist Vihara, which becomes facilities of worship villagers.

2.5.3. Formal and Informal Leader

Historically, local inhabitants of Air Sena came from Taiwan and were families each other. So far, both formal and informal leaders are usually local inhabitants. However a few numbers of local leaders come from outside Air Sena since they work at Air Sena as civil servants (PNS) such as the Principal of the Elementary School.

In the daily life of the community, in the village of Air Sena, there are activities of village government headed by a village chief with his staff (village secretary, village heads, and the heads of the RW and RT). In addition, this village there are institutions Consultative Body (BPD) and the Institute of Rural Community Empowerment (LPMD), are the institutions that comprise elements villagers In addition to the formal figures above, there are also other informal village leaders are the villagers themselves, through religious social activities that interact with the community, recognized and become role model for society. These figures are the heads of the group or organization (fishermen, youth leaders, sports, savings and loans, Posyandu, the monastery and churches, etc.).

Figure II-16. Formal and informal leaders of Air Sena: Head of Village, Mr. Sensen (left), Mr. Acen (right)

2.5.4. Household Income and Outcome

Household Income

Based on data interpolation of the report of Regional Technical Implementation unit (UPTD) of Fisheries and Marine Department of Anambas Archipelago Regency, total Air Sena Village income is IDR. 22,622,825,581. From the total income of Air Sena Village, fisheries and marine sectors contributed about 19,263,000,000 per year (85.15 %). While the rest 14.85% come from entrepreneur, civil servant, farmer, private employee, labour, and honorary worker. Compared to other villages in Anambas Archipelago Regency, Air Sena Village is known as the highest household income.

Based on the observation, this fact is due to the high income of two business household in Air Sena Village (Aken and Dodo). Both households contribute high economic income to Air Sena Village. Aken household is a Pertamina Distributor in Anambas Archipelago in the sector of Fuel Distribution in Anambas Archipelago Regency and also have a business in the sector of fisheries aquaculture. While Dodo is a primer businessman in fisheries aquaculture sector in Anambas Archipelago Regency. The detail about the contribution of Aken and Dodo household income in generating Air Sena Village average income can be seen from Table II-9 and Figure II-15 below (UPTD Perikanan, 2014). It can be seen that the income of these two businessmen is higher than income of all other residents combined. This information is useful when considering the future electricity demand of the Village if these two businessmen are included in the proposed hybrid system.

Table II-9. Comparison of total (Aken and Dodo) household income to others Household Income

#	Household Income	Total per Month (IDR)	Percentage (%)
1	Aken and Dodo Household Income	650,000,000	47
2	Other Household Income (Excluding Aken and Dodo))	726,000,000	53
	Total	**1,376,000,000**	**100**

Maximum income of Air Sena Villagers including the Aken and Dodo income is IDR. 425,000,000 per month, the minimum income is IDR. 1,250,000 per month, the average income is IDR. 9,333,849 per month. While the maximum income of Air Sena Villagers excluding Aken and Dodo is IDR. 95,000,000 per month, the minimum is IDR. 1,250,000 per month , and the average is IDR. 5,619,118 per month. The detail can be seen in Table II-10.

Table II-10. Summary Income of Air Sena Villager including and Excluding (Aken and Dodo)

#	Household Income	Amount Include (IDR)	Amount Exclude (IDR)
1	Maximum Income	425,000,000	95,000,000
2	Minimum Income	1,250,000	1,250,000
3	Average Income per household	9,332,849	5,619,118

Villager Expenditures

Maximum expenditures of Air Sena Villagers is IDR. 7,070,000 per month, the minimum is IDR. 110,000 per month, while the average outcome of Air Sena Villagers is IDR. 1,759,216 per month. The highest average outcome is come from Food about 1,948,148 per month and the lowest average outcome is from for clean water as much as 28,909 per month. While the outcome from Aken and dodo cannot be calculated, because they cannot calculate the amount of the outcome. The detail about the outcome of Air Sena Villagers can be seen from Table II-11 below. It can be seen that the share of electricity supply is 12 % in average of the household outcome.

Table II-11. Summary Outcome of Air SenaHousehold excluding Aken and Dodo

Category	Household Expenditures (IDR)						
	Food	**Education**	**Electricity**	**Energy**	**Clean Water**	**Others**	**Total**
Maximum	3,500,000	2,000,000	1,000,000	3,000,000	100,000	3,800,000	13,400,000
Minimum	300,000	350,000	80,000	28,000	20,000	75,000	853,000
Average	1,900,000	1,175,000	540,000	1,514,000	60,000	1,937,500	7,126,500

Note: - Energy includes kerosene, LPG, and firewoods.
- * The Total above is an overall value of household expenditures without split into food, education, etc

The medium to high income households appear to spend less than half of their income for essential services. Low income households spend mostly for food and education.

2.6. Energy Stakeholders and Local Capacity

There are 2 x 140 kVA diesel generators (PLTD) in the village of Air Sena, the diesel generator operating for 6 hours each day (17:30 to 23:30) for 30 days per month, and also every Sunday between 7:00 a.m. to 12:00 a.m. The consumers of the PLTD are household and public facilities and infrastructures (government office, worship center, schools, health centre, etc.). The village street lighting uses electricity from solar PV systems developed by the ESDM with installed capacity of 40 x

40 Wp. There are only few business activity which associated with the household being consumer of the PLTD supplies, and there no consumer from industrial group. The detail about the consumer group of PLTD Air Sena can be seen in Table 12 below.

2.7. Energy Overview in Air Sena

2.7.1. Existing Energy situation

Sea transportation and power generation dominate energy use in the Air Sena Village. Business is mostly limited to small private shops owned by some households and fuel distribution facility owned by one of the villagers. Industry on the other hand, is mostly limited to a large scale fish breeding and fish processing facilities on the Village which rely directly on electricity. Traditional biomass use for cooking – although rapidly declining at the moment in favour of kerosene and later LPG – still accounts for the significant share of overall energy use in the Village. With the exception of some contributions from the PV street lighting system, energy use in the Air Sena Village is dominated by fossil fuels; diesel fuel and kerosene in particular. Despite that Anambas Archipelago Regency possesses one of the important national oil exploration fields operated by the Conoco Phillips, the absence of local oil refining facility in Anambas area means that the crude oil is exported for refining and then the refined oil products must be re-imported over great distances at high and volatile costs.

Electricity production in the Air Sena Village uses diesel fuel to operate the Village's generators and smaller diesel generators owned by some household or groups of several households.

From the monthly electricity bill data prepared by the LPMD, in February 2014, there are 148 households and 4 public facilities connected to the PLTD grid. In terms of the installed power capacity on the consumer premises, they are divided into five groups. There are 127 premises with 4 Ampere electrical system that consume 66.37% of the power produced that make this group as the largest consumer group.

The average of electricity bill in Air Sena Village is IDR. 231.000. Reviewed from the amount of average income of the villager of Air Sena as much as IDR. 5,619,118. The percentage of electricity bill from the average income is 4.11%.

Table II-12. Existing Electricity situation

#	Ampere	Total	Consumption (kWh/month)		Payment (IDR/month)		Electricity Cost
	(A)	Consumers	Average	Total	Average	Total	*(IDR/kWh)*
1	2	2	11	22	62,000	124,000	5,636
2	4	127	44	5588	125,000	15,875,000	2,841
3	6	17	105	1785	269,000	4,573,000	2,562
4	10	5	184	920	468,000	2,340,000	2,543
5	20	1		0	-		
Total		**152**	**86**	**8,315**	**231,000**	**22,912,000**	**3,396**

Source: LPMD (2014)

From the above Table II-12, the 4 A, 6 A, and 10 A consumers have large potential to utilize electricity for income generating activities when the proposed hybrid system implemented, particularly those with 4A connection. The customer/household paid IDR 2,815 per kWh in average for electricity supply.

2.7.2. Energy Challenges and Opportunities for Renewables in the Air Sena Village

Islands present unique challenges and opportunities for the deployment of renewable energy (RE). Air Sena Village and all other islands in Anambas Archipelago Regency are located far from major oil distribution hubs and depend on complex and lengthy fuel supply chains. Fuel delivery logistics are often further complicated by lack of modern port facilities, requiring the use of smaller, specialized boats. The small population sizes of many islands limit the level of fuel demand while the small geographic size constrains fuel storage. Both of these factors reduce the purchasing power of such island communities.

As a result, Air Sena Village faces some of the Indonesia's highest fuel costs and has greater exposure to price volatility and supply disruptions. In 2014 the consumer electricity tariffs produced by the local (non-PLN) diesel generation is averaged at IDR 2,000/kWh with 6 hours power supply per day, which is much higher than those in the cities of between IDR 275 and IDR 495 per kWh for comparable tariff group with mostly 24 hours power supply per day. High energy costs, price volatility and risks to fuel supply are of particular concern because most households in the Air Sena Village have small economies.

Figure II-17. Fuel supply is one of big issua in Air Sena

Figure II-18. The only one fuel station at Anambas Archipelago owned by Mr. Akin

In addition, climate change effects associated with oil consumption in the local diesel generators are major concerns for the Village. Anambas Archipelago Regency in general faces a significant threat from rising ocean levels, with some islands having a maximum elevation of less than 5 meters above sea level. Increased storm activity and weather disruptions associated with climate change threaten the many islands that are in the path of seasonal cyclones and typhoons.

Against this background, the provision of renewable-based power generation could be a good option for Air Sena Village as an effort to improve the electricity supply for the village. The improvement might be through longer electricity supply e.g. 12 hours or even 24 hours per day, cheaper per kWh tariff, more secure supply, and more environmentally friendly power generation system.

CHAPTER 3. EXISTING POWER SYSTEMAND LOADS

3.1. Generation System

3.1.1. Diesel Generators

Diesel generators are the most common generation technology used for power systems in remote areas such as Anambas and often provide isolated communities with their first access to electricity. A number of factors make diesel generators well suited for island power generation. Diesel fuel has a high energy density which greatly reduces fuel storage requirements compared to other fossil fuels such as coal. The generators are relatively compact and available in a wide range of capacities. These are meant for power plants to closely match the community's demand. The majority of power plants in the Anambas use several diesel generators running in parallel. This gives operational flexibility as individual generators can be started up or shut down when demand changes. Multiple small generators also increase efficiency and security of supply versus a single large generator. Diesel generators have relatively quick start times and good flexibility in meeting daily and seasonal variations in demand. They provide fast response times and good power quality and are relatively simple to operate and maintain. The technology is robust and has a long track record of successful deployment.

Since September2012, the Air Sena Village has a Diesel Power Plant (Pembangkit Listrik Tenaga Diesel / PLTD) received from the rural electricity development program by the Government of Riau Islands through the Energy and Mineral Resource Office of the Anambas Archipelago Regency (Dinas Pertambangan dan Energi / ESDM) and is operated by the Lembaga Pemberdayaan Masyarakat Desa (LPMD) of Air Sena Village. The PLTD consists of **two 140 kVA identical diesel gensets**. By 12 March 2014, the operational hours of each genset are 1,990 hours and 2,031 hours during the period of 558 days, or equal to 4,021 hours for the two gensets. Therefore, it can be calculated that the annual average operation hour of each genset is 2,630 hours. It also can be calculated that the daily average operation hour of the genset are 3.57 hours to 3.64 hours.

Some 148 households are currently supplied by two identical 140 kVA diesel generators that typically run alternately on a daily basis from 17:30 pm until 23:30 pm and additional operating hours on Sunday from 07:00 am until 12:00 pm and special national holidays. The power house (7m L x 5m W x 4.5m H) of the PLTD is positioned at the centre of the village on the hill slope facing east toward the bay. Figure III-1 shows the front view of the diesel power plant.

Figure III-1. The front view of the Diesel Power Plant

Each generator includes a 12 Volt battery with 100 Ah capacity and manually-operated electrical starter motor to bring the main engine online. Once the engine is running a small amount of power is used to keep the starter battery charged and to power some lamps in the power house. The generators produce three-phase alternating current (AC) electricity, the same type of power generated by traditional mainland power plants. They are also equipped with active power and frequency control to match the power generation with the demand from customer loads and therefore minimize the sudden spikes and drops when the demand change rapidly. FigureIII-2 shows the diesel generator at Air Sena Village.

Figure III-2. Diesel Power Plant at Air Sena Village

Generators are designed to run at certain speed of rotation (rpm) regardless of their level of power output. A generator's alternator is designed such that this rpm is directly proportional to the frequency of the AC power being produced. The generators have also the active voltage regulators (AVR) that play a key role in maintaining a constant voltage on the grid. Table III-1 shows the specification of both generators.

Table III-1. Specification of diesel generators at Air Sena Village

Producer	**Perkins**
kVA Base Rate	140 kVA
kW Base Rate	112 kW
Frequency	50 Hz
rpm	1500
Output Voltage	380 Volts
Phase	3
Amps Base Rate	212.7 Ampere
Power Factor	0.8

Engine Fuel Type	Diesel
Operational lifetime	10,000 hours

3.1.2. Operational Time

From the energy bill data of the LPMD, the average energy production is 7,500 kWh per month. Based on this information and of the above Table II-12, it can be estimated that only around 35% of the generator capacity is used by the load. Therefore, the average energy produced by the Air Sena Village's PLTD is equal to the 0.35 x kW base rate of the generator times the number of online hours. Table III-2 shows the estimation of the energy production of the Air Sena Village's PLTD. The average daily energy production is 235.2 kWh per day (Sunday and special events are excluded); 1,824 kWh per week (special events are excluded); 7,500 kWh per month; and 100,901 kWh per year (all included) or similar to 100.9 MWh per annum for two gensets. Therefore it can be estimated that the Capacity Factor of each genset is 5.14% only. Such a low Capacity Factor is due to the generators are oversized due to the procurement standard applied by the Dinas ESDM.

TableIII-2. Energy Production of the Air Sena Village's PLTD

#	Day/Event	Diesel Online	Number	Number	Total	Average Energy Production (kWh)		
		(Time of day)	of hours per day	of days / year	online hour / year	Daily	Weekly	Annually
1	Monday - Sunday	17:30 – 23:30	6	365	2190	235.2	1646.4	85,848
2	Sunday	07:00 – 12:00	5	52	260		196	10,192
3	Chinese New Year	06:00 – 17:30 23:30 – 24:00	12	7	84			3,293
4	Vesak	07:00 – 15:00	8	1	8			314
5	Ester	07:00 – 15:00	8	1	8			314
6	Christmas	07:00 – 15:00	8	2	16			627
7	Volley ball competition	07:00 – 15:00	8	1	8			314
	Total				**2574**	**235.2**	**1842.4**	**100,901**

3.1.3. Energy Production/Demand and Efficiency

A series of measurement have been conducted to generate important information from the PLTD. The measurement used the Hioki 3196 Power Quality Analyser (see FigureIII-3) that automatically collected data with the intervals every 10 minutes and 15 minutes. Three measurements of the generator output voltage and frequency were conducted on Friday 14 March 2014 from 18:12:17 PM to 23:27:17 PM; Saturday 15 March 2014 from 17:38:38 PM to 23:38:38 PM; and Sunday 16 March 2014 from 07:41:08 AM to 12:11:08 AM.

Figure III-3. Hioki 3196 Power Quality Analyser

The frequency of the output voltage when no load connected to the generator is 50 Hz. However, as anticipated, the frequency slightly down when the generator start supplying power to the load. As shown by Table III-3 the maximum and minimum frequencies during the tests were 49.87 Hz and 49.16 Hz, respectively. The average frequency was 49.58 Hz. The frequency deviation was 0.42 Hz, which is lower than the maximum allowable frequency deviation for Jawa-Bali power system of 0.5 Hz and outside Jawa-Bali system of 1.5 Hz.

The quality of the output voltage of the Air Sena Village's PLTD is slightly beyond (does not meet) the PLN standard for voltage variation i.e. (+5%) and (–10%). As shown in Table III-4, the maximum voltage was 400.56 Volts which is 5.4% higher than the normal voltage or 0.4% higher than the highest allowable voltage. Similarly, the minimum voltage was 334.14 Volts which 12.07% lower than the normal voltage or 2.07% lower than the allowable minimum voltage. However, in average, the rms values of output voltage are 1.2% - 2.3% lower than the normal voltage.

Table III-3. Electrical measurement result of the Air Sena Village's PLTD

Date of Measurement	Time of Measurement	Measurement Interval (minutes)	Voltage Out (Volts)			Frequency (Hz)		
			Max	Min	rms	Max	Min	Ave
3/14/2014 - Fri	18:12:17 - 23:27:17	15	380.76	368.58	375.38	49.73	49.20	49.45
3/15/2014 - Sat	17:38:38 - 23:38:38	10	400.56	341.11	375.18	49.75	49.16	49.47
3/16/2014 - Sun	07:41:08 - 12:11:08	15	387.06	334.14	371.19	49.87	49.80	49.82
Average								49.58

In order to estimate the efficiency of the diesel generator, some information needed such as - the amount of energy contained in the fuel used to produce a given amount of electrical energy and the

amount of energy produced. The type of diesel fuel in Indonesia's market is Diesel Fuel Number 48 with flash point 52^0 C. This type of fuel has the density of 847.5 kg/m^3 and heating value of 44.23 MJ/kg (Yuliarita 2011). The average fuel consumption, based on information from the genset operator and management, is 2.6 ton per month. By converting both monthly input and output energies into megajoule and divide monthly energy output by monthly energy input, it is estimated the efficiency of the Air Sena Village's PLTD is 23.07% (Table III-4).

Table III-4. Efficiency of the Air Sena Village's PLTD

Energy Input		**Energy Output**		**Efficiency (%)**
Monthly fuel consumption (kg)	Energy input (MJ)	Monthly Electricity Produced (kWh)	Energy Output (MJ)	
2,600	114,998	7,370	26,532	23.07

Diesel generators operate most efficiently at a certain load, generally 65-80% of the maximum rated capacity. Island power plants are generally designed to meet varying demand while keeping generators as close to this load as possible. This delivers higher efficiency and provides spinning reserves to meet demand increases. Operating below this load reduces generator efficiency, limiting the desired fuel savings. Operation below 30- 40% of the rated load can result in engine over-fuelling, which carbonises injection tips and disrupts the fuel spray pattern. The resulting poor combustion leads to soot formation and un-burnt fuel residue which clogs and gums piston rings (Source: Generator Solution). As a result prolonged low load operation has numerous cost impacts. It further decreases generator efficiency, increases maintenance requirements and reduces a generator's lifespan.

3.1.4. Operational Management

In 2014 Air Sena consists of 202 households and 7 camp clusters. However, only 148 households (73%) are currently connected to the PLTD grid and the number of grid-connected households is rising. All of the connected households are located on the land area while none of the camps are connected due to the distance.

The operational and maintenance of the PLTD is managed by the LPMD. There are seven people involved in the PLTD management. Below is the organisation of the PLTD.

- Chairman : Mr. F. X. Celi
- Secretary : Mr. Yulius
- Bill Collector : Mr. Yeremias Hartono
- Operator Coordinator : Mr. Belon
- Operator Team Member : Mr. Sontet, Mr. Gegen, and Mr. Suhar.

All of the PLTD team members are paid by the LPMD using the money collected monthly from the consumers, except Mr. Belon, the Operator Coordinator who get monthly paid from the ESDM. In case the expenditure (O&M) of a certain month is larger than the income of that month, the difference is normally paid by the Village Management using the Village's money. Before 2012 the price of diesel fuel was IDR 4,500/litre, but since 2012 becomes IDR 6,000/litre.

There appears to be an increasing trend in diesel fuel price in the future due to the increasing price of crude oil in international markets and the government plan to reduce oil subsidy. Although the crude oil prices in international markets are often predictable, the national oil subsidy reduction is often a political preference of the government and therefore it is not predictable. Information about the future diesel fuel price is not available either in the 2012-2031 National General Plan on the Electrical Energy or in the draft National General Plan of Energy, or in the BPPT's Indonesian Energy Outlooks, or in the Anambas Archipelago's Electrical Energy General Plan.

Table III-5. O&M cost of the PLTD and responsible institution.

Cost	Frequency	Average Value (IDR)	Responsible Institution
Diesel Fuel	1 x 1 month	15,600,000	LPMD
Lubricant Oil	1 x 180 hours of diesel operation	1.400.000	LPMD
Lubricant Oil Filter	1 x 180 hours of diesel operation	Unknown	ESDM
Diesel Fuel Filter	1 x 6 months	Unknown	ESDM
Operator Coordinator salaries	1 x 1 month	Unknown	ESDM
Operator member salaries	1 x 1 month	3,200,000	LPMD
Electricity Bill Collector Salary	1 x 1 month	1,000,000	LPMD

As the Coordinator of the PLTD operator, Mr. Belon was trained for 12 days in Jakarta and Bandung prior to the PLTD installation to operate and maintain the PLTD. The training was financed by the ESDM. In addition, Mr. Belon then conducted trainings for other two operators who assist Him to operate and maintain the generator.

The current LPMD started to manage the PLTD since January 2014. Before this time, the previous management applied different system. The electricity bill to be paid by the consumers was based on the installed power capacity (VA) and appliances used. For example, for a refrigerator the consumer paid IDR 25,000 per month while for television and lighting the consumers paid IDR 150,000 despite the number of lamps and television in a household.

The current billing system adopts parts of the system applied in areas connected to the PLN grid. Each premise pay for both installed power capacity (VA) and energy consumed. The price of the installed power capacity is flat while the price of energy consumption depends on the amount of kWh used. A 4A, 6 A, and 10 A premise pay for IDR 40,000; IDR 60,000; IDR 100,000; per month. The price of consumed energy is IDR 2,000 per kWh. This cost is applied for household only, while public facilities such as school, health clinic, and worship centre do not pay for the electricity bill.For comparison, the following Table III.6 shows the current elecricity tariff for households connected to the PLN, whic is much cheaper than the current electrical energy price applied in Air Sena.

Table III-6. Electricity tariff for households connected to the PLN.

No	Tariff group	Power Limit (VA)	Regular Connection		Pre-Paid Connection
			Load Cost (IDR/kVA/month)	Consumption Cost (IDR/kWH)	
1	R1-TR	up to 450	11,000	Block I : 0 – 30 kWH: 169 Block II : above 30 kWH – 60 kWh: 360 Block III : above 60 kWh: 495	415
2	R1-TR	900	20,000	Block I : 0 – 20 kWH: 275 Block II : above 20 kWH – 60 kWh: 445 Block III : above 60 kWh: 495	605
3	R1-TR	1,300	*	979	979
4	R1-TR	2,200	*	1,004	1,004
5	R2-TR	3,500 – 5,500	*	1,145	1,145
6	R3-TR	6,500 above	*	1,352	1,352

Note:
* Minimum Account (RM) applied. RM = 40 (number of active hours) x connected power (kVA) x Consumption cost.

Source: ESDM (2014)

The PLTD has a 5 ton fuel tank mounted on the side of the power house. However, the tank is not used to anticipate the unwanted fuel loss due to thief. Instead, the fuel is stored inside the power house in 62 gallons. Figure III-1 above shows the fuel tank next to the power house and Figure III-4 shows the fuel gallons.

Figure III-4. Gallons used for fuel storage at the PLTD Air Sena Village

3.2. Local Grid

The electric power system on Air Sena Village does not have any high voltage transmission lines. It is a small distribution system with nominal voltages of 380 Volts to bring electricity to customers. Electricity grids have three wires. Household loads such as lights and appliances use only one phase. The AC frequency is 50Hz. The transmission line use metal posts with twisted cables. In general, the grid is in a good condition. However, in some locations the cables touch the trees or the metal roof of houses. Figure III-4 shows the grid on Air Sena Village.

Beside the PLTD grid, there is also a solar photovoltaic street lighting system connected at the Air Sena. The system works properly and provides necessary lighting for the village during the nights. Figure III-5 shows some of the solar photovoltaic street lighting systems.

Figure III-4. Grid condition at Air Sena Village

Figure III-5. Solar photovoltaic street lighting system at Air Sena

3.3. Existing Electricity Load Profile

The consumers of the PLTD are households and public facilities (village government office, worship centre, schools, health centre, etc.). The gensets do not serve the street lighting because the village street lighting is supplied by solar energy. There are only few business activities that associated with the household consumers of the PLTD, and there are no industrial consumers in the village. The detail of the consumer group and their averaged monthly power consumption can be seen in Table III-7. Households dominate the power consumption. Nearly all electricity produced by the PLTD (97.74%) goes the households. This indicates that there is an opportunity to change the people's habit from consumptive way of utilizing electricity in to income generating activities. Very small fraction of energy produced is consumed by public facilities because they are normally operated during the day when the gensets are off-line. Although the Kantor Desa is not connected to the PLTD grid, it consumes a very small electricity during the nightime, but some electrical appliances are operated during the work hours using a 5.5 kW genset. Other premises currently not connected to the grid have but not used electrical appliances and are expected to have more appliances when they are connected to the grid in the future.

Table III-7. Electricity Consumption of the PLTD Air Sena Based on Consumer Group

No	Category	Monthly Energy Consumption (kWh)	Percentage (%)	Note
1	Household	7,500	97.74	
2	Government Offices:			
	- Office of Village Govt (Kantor Desa)	99	1.29	
	- Village Activity Centre (Balai Desa)		0	Not connected to the grid
	- Village Representative Office (BPD)		0	Not connected to the grid
3	Schools:			
	- Kindergarten (TK)		0	Not connected to the grid
	- Elementary School (SD No 03)		0	Not connected to the grid
4	Worship Centres:			
	- Church (Gereja Katolik Santa Martha)	50	0.65	
	- Vihara	22	0.28	
5	Health Clinics:			
	Polindes		0	Not connected to the grid
	Puskesmas Pembantu	4	0.05	
Total		**7,674**	**100**	

Figure III-6 shows the households daily load profile of the Air Sena during weekdays (148 households currently connected to the PLTD) based on the energy audit activities. The loads were measured at 0.5 hour interval. It starts at 17:30 PM when the PLTD starts and goes up to the peak power of 62.5 kW at 19:00 in the evening. The load constantly reduces after 19:00 PM until the PLTD shut down at 23:30 PM. The daily energy consumption based on the energy audit is around 265.75 kWh which matches the information generated from the diesel energy production calculation (around 235 kWh/day).

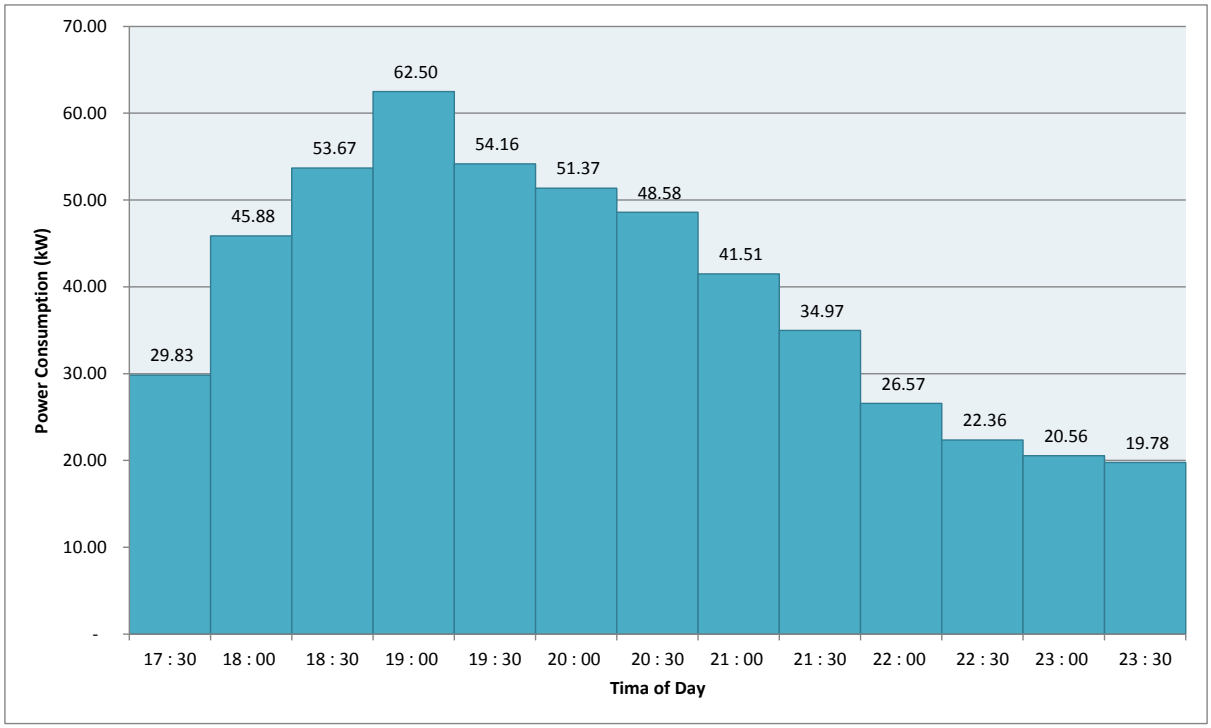

Figure III-6. Households weekday electrical load profile of the Air Sena Village, weekdays

Figure III-7 shows the households daily load profile of the Air Sena on Sunday (148 households currently connected to the PLTD) based on the energy audit. The load starts at 07:00 AM when the PLTD starts and ends at 12:00 PM when the PLTD shut down. The load is relatively constant with small fluctuation where the peak power of around 38.1 kW occurs around 9 AM. The daily energy consumption based on the energy audit is around 207 kWh which matches the information generated from the diesel energy production calculation (around 196 kWh).

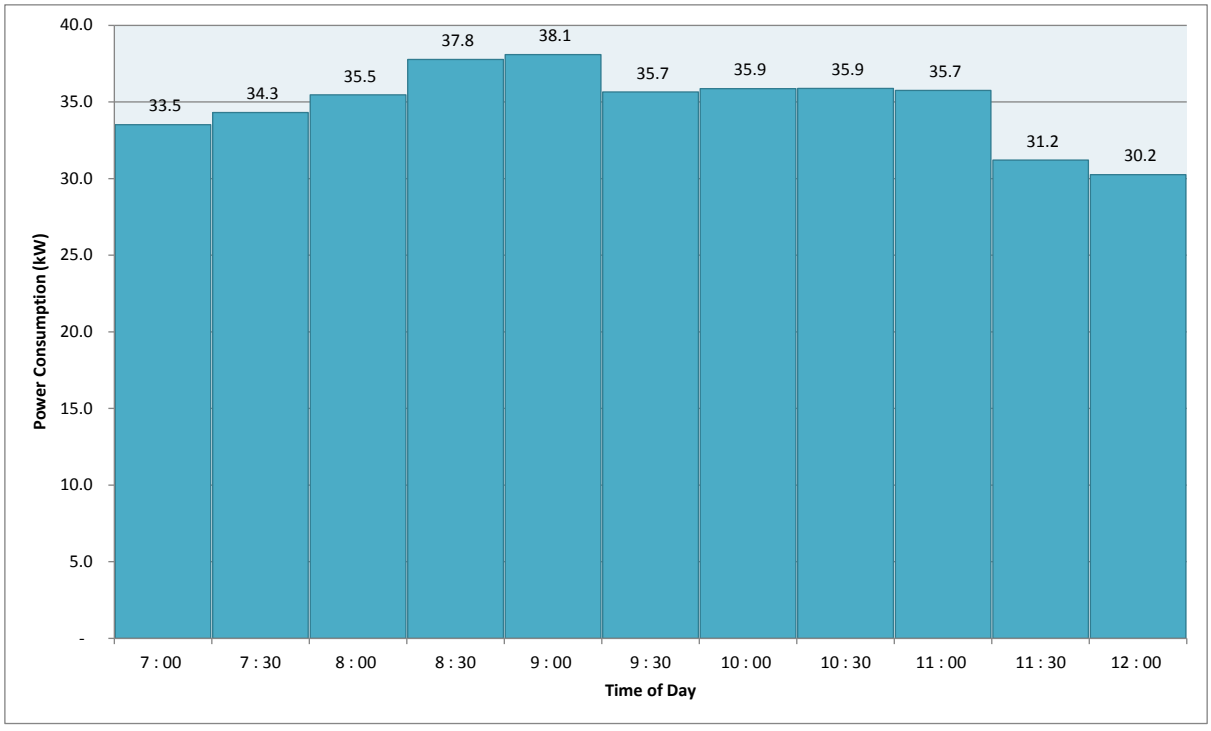

Figure III-7. Households Sunday electrical load profile of the Air Sena Village

Figure III-8 shows the public facilities daily load profile of the Air Sena on weekdays based on the energy audit. The loads consist of Head of Village Office, the Church, the Vihara, and the small health clinic currently connected to the PLTD grid. The load starts at 17:30PM when the PLTD starts and ends at 23:30 PM when the PLTD shut down. The only load comes from the lightings in those premises with the total amount of 0.12 kW. The daily energy consumption based on the energy audit is around 1.56 kWh.

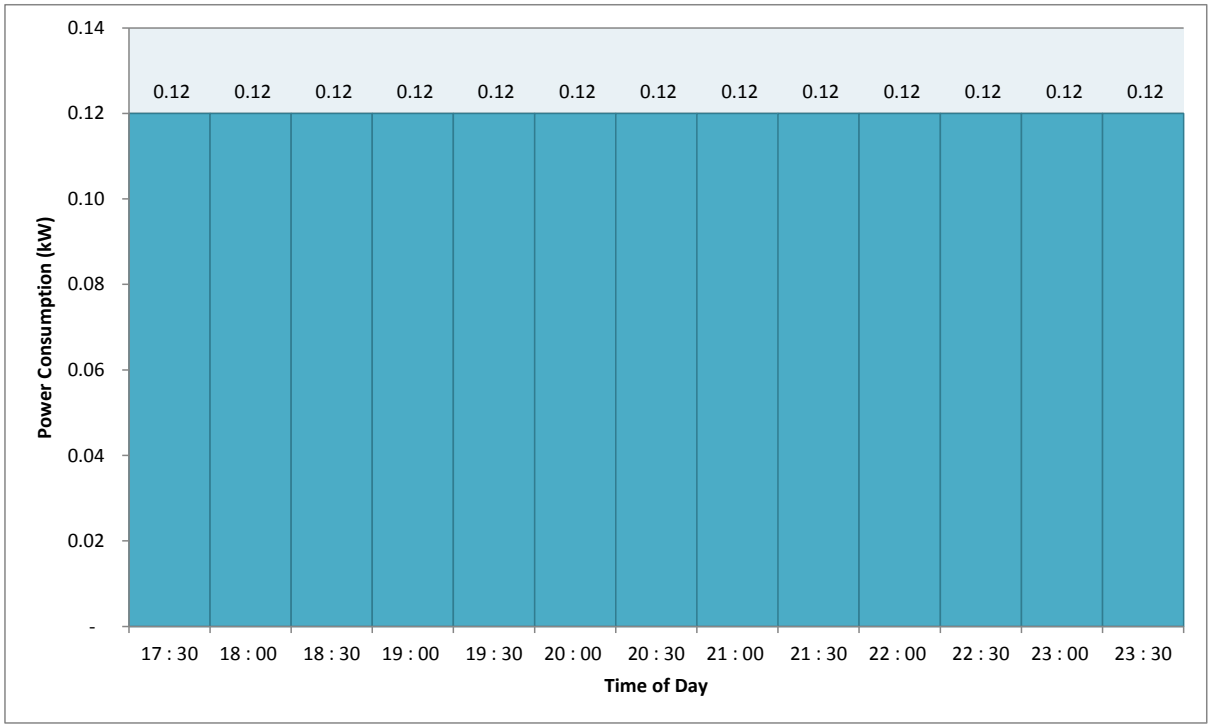

Figure III-8. Public facilities weekdays electrical load profile of the Air Sena Village

Figure III-9 shows the public facilities daily load profile of the Air Sena on Sunday based on the energy audit. The small load starts at 07:00 AM when the PLTD starts and ends at 12:00 PM when the PLTD shut down. The peak power of around 0.3 kW occurs from 9 AM to 12 AM due to Sunday service at the Church.

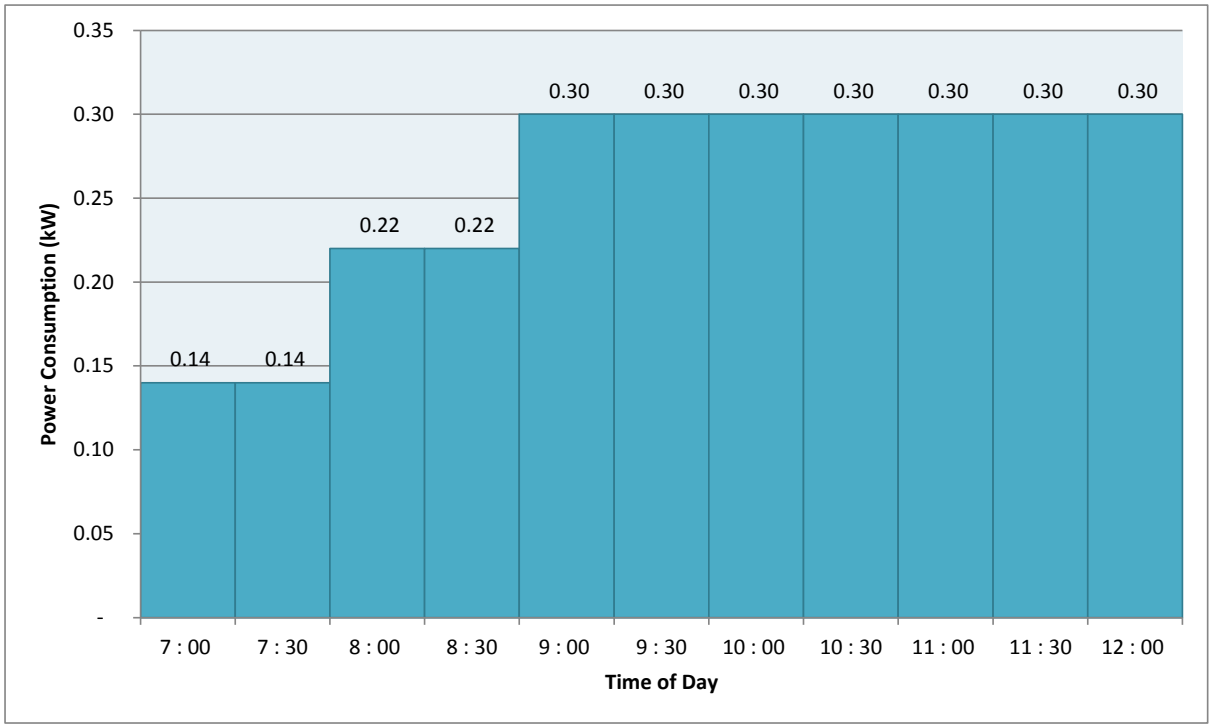

Figure III-9. Public facilities Sunday electrical load profile of the Air Sena Village

3.4. Grid integration of renewable power and its impacts

The primary goal of RE integration in Air Sena power generating system is decreasing power output from diesel generators to fuel consumption and extending the power supply hours to more than 6 hours a day. High level RE integration can cause generator to run at low load and could even allow the generator to be shut down. Low generator loading and frequent stops, however, have important performance and safety implications.

Low load operation is also a concern for power quality. Many RE assets are capable of providing frequency and voltage control. However, their control systems are normally designed to monitor the frequency and voltage produced by the diesel generator and links their output to these “master control” levels. Below 30-40% of rated load most generators cannot support power quality on the grid. Technologies exist that will allow some RE resources to support power quality on the grid.

The deployment of technologies such as centralised inverters will allow RE generation systems to supply the power quality needed to support grid stability. This will allow generators to be shut down permitting the grid to run on 100% RE and greatly increasing fuel savings. However, if RE production suddenly drop, generators would need to quickly be restarted. Frequent stop-start operation reduces efficiency, increases wear and tear and reduces the useful lifespan of the system. Systems will need to be designed to limit start/stop operation.

Low load and start-stop operations are of particular concern for power systems in Islands regions. Many of these generators have already exceeded the OEMs recommend running hours and as such non-standard operation could severely impact efficiency, maintenance costs and increases the risk of generator failures. Older control systems may simply not allow for prolonged low load operation or rapid shutdown and startup. There are low load generators that can operate safely and efficiently below 10% of rated load. In this context it is essential for islands considering high RE penetration to perform a detail inventory of their diesel generator assets and factor possible replacement of current diesel assets into the budgets for RE programs.

The variability of RE output is a challenge but it is not an insurmountable one. Modern generator control systems provide a great deal of operational flexibility and control systems on older generators can be upgraded. Advanced power electronics and supervisory control systems can greatly reduce the impacts of RE variability on diesel grids.

CHAPTER 4. SOCIO-ECONOMIC CHALLENGES OF INTRODUCING OF HYBRID POWER SYSTEM

4.1. Institutional Aspect

4.1.1. Affected stakeholders

From the aspect of formal institution and formal leader, the local governments support is one of the most important issues in the development of renewable energy in Air Sena Village. The local governments are consisted of the government of Anambas Archipelago Regency, the government of Central Siantan Districts, and the government of Air Sena Village. The structural government above will play role primarily in the legislation and administrative support. Furthermore, for the Anambas Archipelago Regency government, the role of the regent of the regency (Bupati) will be very significant in the implementation of renewable energy since the initiative of Indonesian State of Electricity Company (PT. PLN Persero) which give authority to the local government of Anambas to manage own electricity supplies (Various Media, May 2014).

General overview about the respond of the formal leader (Bupati, Head of Energy and Mineral Resources department, head of village, Head of School, head of the Church, the Head Temple, PLTD Management) is very welcome regarding the planning of renewable energy development in Air Sena Village. The formal leader want to increase the electricity service for the community in term of increase the long hour with the lowest tariff, especially for the villages which still not connected to the PLN grid system. The head of Air Sena village believe that with the improvement of electricity service in Air Sena Village will be able to stimulate the local economy growth and also able to escalate the social welfare. Through the improvement service in the electricity sector also will be able to support the education system and social activities in Air Sena Village. As overall they were and will be open and support the development of the renewable energy in Air Sena Village.

While the opinion of the Informal Leader, through the observation which identified individual may play a big role in the social community system in Air Sena Village were consisted of local business leader and the young leaders. The local business leader consisted of Mr. Dodo and Mr. Aken, while for the young leaders were consisted of Mr. Acen, Mr. Esin, Mr. Chaili, etc. As overall, the informal leader of Air Sena Villages showed an enthusiastic to support the development of renewable energy in Air Sena. The informal leader also has a willingness to participate in the process of the implementation of renewable energy development (hybrid power system).

4.1.2. Local capacity building

Local capacity building is one of the major issues in the aspect to maintain the sustainability of a development programs, this due to the local community will be the first parties correspond to the implemented program. In the term of local capacity building program implementation in Air Sena Village, there are already several program implemented by the local and national government to enhance the local capacity of Air Sena Village. By far, the preparation and the development of local capacity by the local and national institution in handling the local and national government aid has a good trade record.

The local government of Anambas Archipelago Regency through Fisheries and Marine Department of Anambas Archipelago Regency already implemented some program to enhance fisherman capacity in the development of fisheries sectors. Since 2011, Fisheries and Marine Department of anamabas initiated to establish fisherman group and fisherman community outreach in Air Sena Village to

enhance the villager capacity to generate income from the fisheries sector. The community outreach addressed to the wild and aquaculture fisheries. Some of the fisherman groups are Nelayan Teri community, Napolion Community, Ikan Libam Community, and Ikan Mayuk Community. To maintain the sustainability of fisheries and marine resources the Fisheries and Marine Department also established fisherman inspector group (Kelompok Masyarakat Pengawas) were also involved the villager of Air Sena Village in its implementation. While through the department of ESDM, the local government also involved the local community participation in the diesel generator management. The local government has been trained the local people for the diesel generator technician and also give authority to the village of Air Sena to manage and determine the electricity tariff.

National government through national program for rural area PNPM Mandiri Pedesaan (PNPM MP) already implemented several program in stimulating the development of Air Sena Village by enhancing the local capacity and local participation. In 2011 PNPM MP formed three women's group in Savings and Loans system activities. The program was intended to enhance women participation in household economic management. The program was implemented successfully in Air Sena with the ratio of payback more than 78%. The other development program which has been implemented by the national government through PNPM MP was the construction of public clean water supplies. Beside the construction of public clean water supplies, to maintain the sustainability aspect of the program, PNPM MP also prepared local capacity to manage the public clean water resources. By far, the management of its implementation of public clean water supplies already success to maintain its sustainability service to the local community of Air Sena Village.

For the management propose to manage the operational of hybrid power system Air Sena Village, it is important to involve the local participation in its management system. The participation of local community not only to empower the local community, but also considered as the aspect to maintain the sustainability of its program. The involvement of local community participation to manage the hybrid system is through the village government of Air Sena. The recommendation is based on previous experience of implemented program in Air Sena Village and also based on observation of local community perspectives. Most of the villagers of Air Sena Village stated that the decision will be based on the government village decision which collectively represented the intention of the villager. The decision is based on collective forum discussion among the villagers, because most of village decision always based on collective discussion among the villagers. Today management is based on government village decision through the collective discussion among Air Sena Villagers. Almost 70% of Air Sena villagers stated that the current management already gives a good performance, and most of them agree to give this management team to manage the hybrid system.

4.2. Economic Challenges

The primary source of Air Sena economy is from the fisheries sector (wild and aquaculture fisheries). Which 84% of the community work as fisherman, while 16% other are a civil servant, private company employee, entrepreneur and others. Some of 16% of non-fisherman, sometime also put the fisherman as their secondary occupation.

Looking at recent preview of Air Sena fisheries sector, there are a vulnerable issues regarding the fisheries sector. The primary issue is about Napoleon commodity, considering Napoleon as the primer commodity in Air Sena and highly contributed to their economy. The issue is in the term of the market of Napoleon commodity and also the decline of the Napoleon population. Based on the interview with Air Sena Village fisherman, in the term of the price rate of Napoleon as the primary commodity in Air Sena have a markdown. Since 2013, there has been a significant decline in the price rates of Napoleon commodities from 180 SGD/kg to 70 – 80 SGD /kg. The significant decline of Napoleon price rate was predicted by a new regulation issued by Democratic Republic of China in Napoleon consumption in the china society. Until today, there is not yet a fix regulation in

determining the Napoleon price between Hongkong with the government of Indonesia. In the other fact, the decline of Napoleon price also followed by the the decline of Napoleon fish stock itself.

Based on the overview of fisheries current condition in Air Sena with the uncertain price rate and the decline of fish stock may put Air Sena Village into vulnerable economy. In this regard, it is recommended that Air Sena village have to found an alternative livelihood beside the Napoleon commodity. The other issue is also about the Napoleon population scarcity in Amambas Island waters. This issues has become international attention, in 2004 IUCN already include the Napoleon into endangered species. It is possible for several year to come this commodity no longer have space in international market due to regulation which may be issued by Indonesian Government, Republic of China Government as consumers, or through International regulation. In this step, will possibly to take Air Sena Village into serious vulnerable economy.

Looking at Air Sena way of life, habit, competence and their perspective on livelihood, it is hard to change their livelihood and occupation from fisheries sector (wild and aquaculture) into another. Furthermore there is still no significant potential in the other sector to be their livelihood. Through this recommendation, Air Sena villager does not necessarily have to find another source of livelihood and occupation. It is only recommended that Air Sena villagers can not only depend on Napoleon commodity without considering the other alternative in the fisheries or non-fisheries sector. The other chance to be sources of economy in Air Sena Village which may be worth to be considered is the chance of seaweed aquaculture development. Based on the observation and interview in Air Sena Village, the water quality of Air Sena Village is support to development of the seaweed aquaculture. The community of Air Sena also has a willingness to develop seaweed aquaculture. But the villagers still don't have a certain market overview. It is need further research and study about the potential of seaweed aquaculture in Air Sena Village.

4.3. Gender Issues

Most of economic activities in the village of Air Senaare carried out by the men (Head of the Family). Generally women do not have a significant roles in the economic, most of them acts only as a housewife, only about 10 – 15 % were act as entrepreneur, civil servant, honourer, etc. Portrait of Gender in Air Sena, the role of productive, domestic, and strategic about the general idea of gender condition, particularly about the role in the family, there is still a simple division of labour that were:

1) Husband or father is the head of the family, and responsibility to fulfil the needs of the family (wife, son, etc.) mostly every day, between 7-24 hours, the husband/father is outside the house. The husband/father activities are outside of the house as a breadwinner in various occupations and mostly of them were going to fish ponds (camp). The husband/father activities at home usually in the late afternoon/evening more the resting activity (watching TV or sleeping).

2) Most of the wife or mother are taking care of home and children, and if any work is to help the main function of the husband. Almost 24 hours a day, the wife/mothers are at home with the domestic routine activities: washing, cleaning, cooking, watched TV and other entertainment activities.

3) The children or other family members.

   The main activity is to go to school, whether the school within the village and outside the village (junior high school is in Air Asuk Village and senior high school is in Tarempa, capital city of Anambas Regency) between the hours of 06:00 to 14:00 (or 8 hours / day). Other routine activities are watching TV, sports, etc.

The detail about the woman roles in the society and the household can be seen through Table V-1 below.

Table V-1. Gender roles in Ar Sena Village

No	Category	Roles
1	Education	Man and woman has the same access to education and they has the same content of classes
2	Profession	The workplace is dominated by man, but man and woman has equal professional opportunity in the workplace
3	Housework	Housekeeping and child care are the primary functions of the woman; participation of the man in these functions is only partially wanted.
4	Decision making	The man is more dominant in final decision making, but in the most cases woman mostly influence in the decision making
5	Child care and education	Even man and woman share these function equally, woman takes care of the largest part of these functions; she educates children and cares for them in every way

In terms of electricity consumption, the role of woman is more dominant than the man, especially in the provision of energy while purchasing fuels (i.e. gasoline, diesel oil and kerosene)are generally done by men because the location of the fuel station is far, even women also sometimes do this tasks. For household electricity bill payments, usually women or other family members do it.

CHAPTER 5. CONCLUSION

- Power generation expansion plan is not only aimed at providing electricity access for all consumer group toward 100% electrification ratio, but also to increase the length of daily power supply up to 24 hours.
- The cost of energy of the proposed hybrid system is high, and therefore the project developer should establish the income generating activities at the village to improve local economic condition - and in turn – to improve the purchasing power of the local people.
- The formal leaders and the community of Air Sena and higher levels of government are highly supportive the development plan of the hybrid system at Air Sena and other islands in the future.
- Among the informal leaders in the Air Sena, Mr. Dodo and Mr. Aken are the most influencing figures that the investor should consult with prior to the project implementation.
- Jobs as fishermen are the only economic activity that generates money made by Air Sena fishermen. They're a lot more outside the home, while the mother and other family members more often at home. In general, there is no or very little economic activity is carried out by family members or Air Sena villagers. Productive economic activity generally only be making ice cubes, seasoning production / kitchen, making cakes and other fast food supply (upon request)
- Most of villagers agree to pay more (30% - 50% higher than current electricity bill) for longer electricity supply.
- Mr. Dodo and Mr. Aken are the large future consumers of the energy produced by the hybrid system. They are enthusiastic to have their business facilities connected to the proposed generating system.

REFERENCES

ESDM. 2014. Regulation of the Minister of Energy and Mineral Reources No. 09/2014 on the Tariffs of Electrical Energy Provided by PT. PLN (Persero).

GIZ PDP Indonesia. 2014. PN 12.9071.7-001.02 TOR Energy Audit & Socio-Economic Assessment of Fishing Villages.

Hau, Erich. 2006. Wind Turbines: Fundamentals, Technologies, Application, Economic, 2nd Edition. Krailling: Springer.

http://www.generatorsolutions.org/#/gen-faqs/4534128446.

OECD. 2013. Economic Outlook - OECD Annual Projections. http://stats.oecd.org/Index.aspx?QueryId=51659#

Raharjo, Irawan and I. Fitriana.n.d. Analisis Potensi Pembangkit Listrik Tenaga Surya di Indonesia. Seminar Strategi Strategi Penyediaan Listrik Nasional Dalam Rangka Mengantisipasi Pemanfaatan PLTU Batubara Skala Kecil, PLTN, Dan Energi Terbarukan.

Statistics of Kepulauan Anambas Regency.2013. Kepulauan Anambas in Fugures 2013.

Yuliarita, Emi. 2011. Pembuatan Bahan Bakar Minyak Solar 48 Bertitik Nyala Minimum 55 ^{0}C dan 52 ^{0}C Melalui Cutting Distillation. Jurnal Lembar Publikasi Lemigas 45(1).