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Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Hybridization of Islands, Thailand

SITE VISIT REPORT
KOH BULON DON

01/05/2017

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1 INTRODUCTION

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is assessing a project for the hybridization of two Thai islands in the Andaman Sea. The target of the study is to select two out of three islands for the design and development of a technical and financial feasible hybrid system using a combination of photovoltaics (PV), batteries and diesel generators to supply large parts of the islands with one power generation system (the Project).

Koh Bulon Don is one of three islands for the Project. The island is located in the Andaman Sea in Satun province. The current power generation relies on diesel generators, which supply either small grids with up to 10 households or single households.

A site visit for Koh Bulon Don was conducted on 1st March 2017 to analyse the load of the islands, the condition of the existing grids, to identify suitable areas for the installation of PV, batteries and a powerhouse, to determine possible long-term impacts and changes of the future energy demand and to investigate the socio-economic situation of the island.

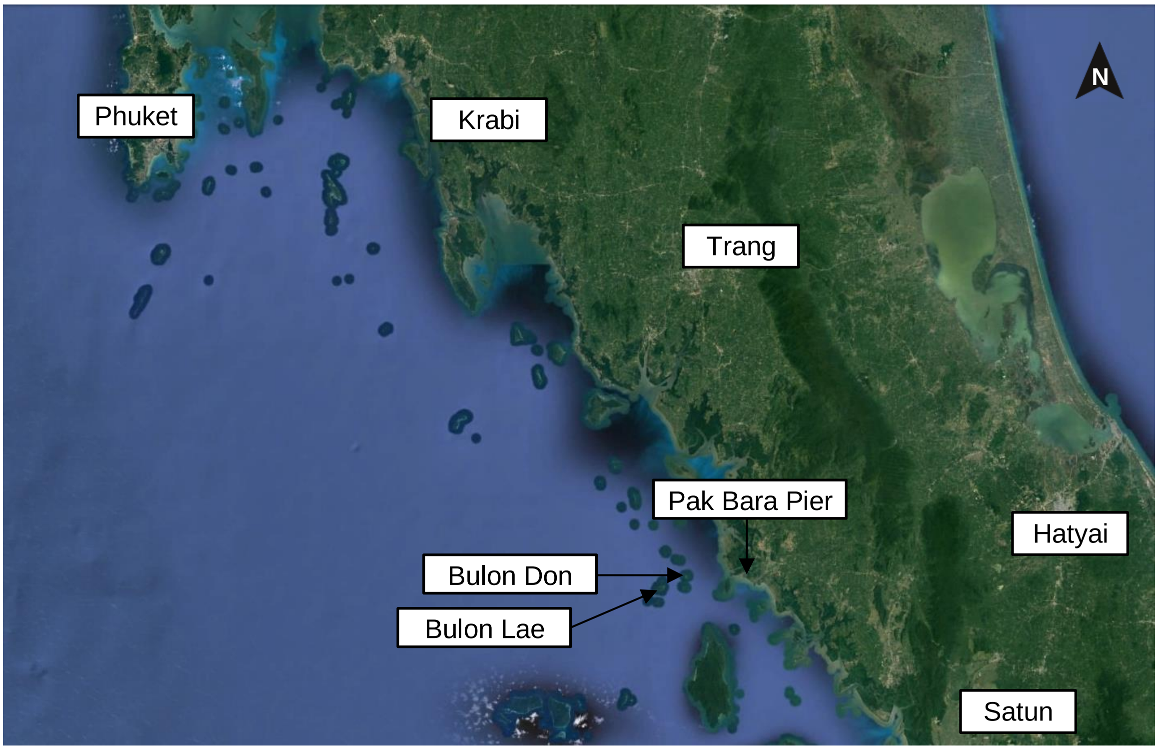

Figure 1: Project location

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2 ISLAND GENERAL OVERVIEW

The island of Bulon Don is located approx. 22 km West of Pak Bara pier. The current power generation relies mainly on small diesel generators.

Approximately 300 locals are living on Koh Bulon Don in a total of 81 households. The main business is fishery and farming (chicken and goat). All of the households are clustered towards the South-East of the island, within the dotted area in Figure 2. There are three public buildings, namely the health centre, a school and the mosque. Koh Bulon Don is part of Mu Koh Phetra National Park.

Depending on the season, dry, hot weather and strong rainfalls are impacting the island, a tsunami occurred in the past. Strong soil and waste pollution caused by diesel leakage and a lacking waste collection system was observed during the site visit.

There is no Base Transceiver Station (BTS), the mobile signal and internet data are however good for DTAC and AIS.

Figure 2: Koh Bulon Don overview (Source: Google Earth taken in 2005)

To gain a better understanding of the island, a flight with a drone showing the residential area in the South-East of the island has been conducted as shown in Figure 3.

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1) Lake for retaining of raining water
2) 4 water storage concrete tanks
3) PV system (see Chapter 5.2)
4) Island deputy’s house (Mr. Mhard)
5) Mosque
6) School
7) PV system (see Chapter 5.3)
8) Football field
9) Abandoned PV system (see Chapter 5.5)
10) Graveyard
11) Public health centre with PV system (see Chapter 5.4)

Figure 3: Drone picture of the island village

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3 SOCIO-ECONOMIC SITUATION

3.1 Demography

According to Chaipattana Development report, the number of households in 2012 was 79. The number of population and households in 2016 were 300 and 81 respectively. The number of households increased by only two within the last 4 years, therefore, the household number can be considered stable. There are no resorts, bungalows or other touristic infrastructures available on the island, which means tourism is rare. People of all ages are living on the island, with a slightly lower percentage of teenagers who might leave the island for higher education. The gender distribution seems to be balanced.

3.2 Education

There is a combined elementary (1st to 6th grade) and secondary (7th to 9th grade) school on Bulon Don Island currently educating 72 students. After elementary school the students are either going to the mainland for higher education (30%, mostly children with relatives on the mainland), visiting the island's secondary school (40%) or stop institutional education joining the family fishery or gastronomy business (30%).

9 teachers are currently working and living on the island. Next to the school is a building to host them, but it is lacking sufficient capacity (planned to host 5 teachers). The remaining 4 teachers are staying at the library building. Therefore, the community is currently constructing a second teacher's building next to the mosque.

3.3 Occupation, Local Business and Economic Situation

The main income source is fishery. Some residents are running a small restaurant or shop. The average income of the population is widely spread ranging from approx. 4,500 to 45,000 THB/month, averaging around 8,000 THB/month (mode average). As a fisher island, the generated income always depends on the day-to-day and seasonal condition of the sea as people stated in the survey.

3.4 Typical Appliances

The survey showed that a typical household on the islands has 2-4 light bulbs, 1-2 mobile phones, 1-2 fans and mostly a TV. Some households also own a washing machine and a CD player. The three public buildings (school, health centre, and mosque) have more electric appliances installed (additional light bulbs, fans, TVs as well as speakers, fridge etc.); details can be found in the survey evaluation table in Appendix 4.

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3.5 Community Spirit

The overall impression of the community spirit on Bulon Don was positive. People were organized, well informed and very keen on providing all necessary data and information. The site assessment was scheduled for the 28th of February and people gathered on the island instead of leaving for fishery to welcome the team and contribute to the community meeting. Due to bad sea conditions, the team was not able to visit the island as scheduled and had to postpone for one day. The willingness to conduct telephone interviews on 28th of February proved their commitment.

The idea to reactivate the centralized community grid and include high shares of renewable energy was received very positive and was supported.

However, one villager stated that a centralized system would only work sustainably if it is operated and maintained by an external party. From her experience, previous projects weren’t successful because the villagers did not care about maintenance for long term operation as they were lacking knowledge on long term effects. Special training courses and other capacity building measures might help to improve the situation and are part of the Project.

3.6 Local Resources

The water storage and supply situation is explained in detail in Chapter 12. It has to be mentioned that the island is frequently facing slight fresh water shortages so that the villagers are saving water as much as possible.

The availability of local building materials is limited due to the national park restrictions.

Currently a lot of villagers are operating and maintaining their own diesel generators, which means they have a certain technical know-how the Project can build upon. Most houses are also constructed by themselves which may promise support in construction work for the Project.

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4 DIESEL GENERATORS

A community diesel generator was installed around 3 years ago and operated on Koh Bulon Don. The generator was provided by the local government (SAO). All households were connected to the generator via a central grid transmission line on the island. Approximately 1 year ago, the generator failed after just 2 years of operation and has not been replaced so far. Therefore, residents are sharing diesel generators to have basic power supply.

During the site visit, 15 generators were observed on the island as shown together with the connected households in Figure 4. They are in use and supplying 2-10 households, shops and restaurants with power via separate micro-grids.

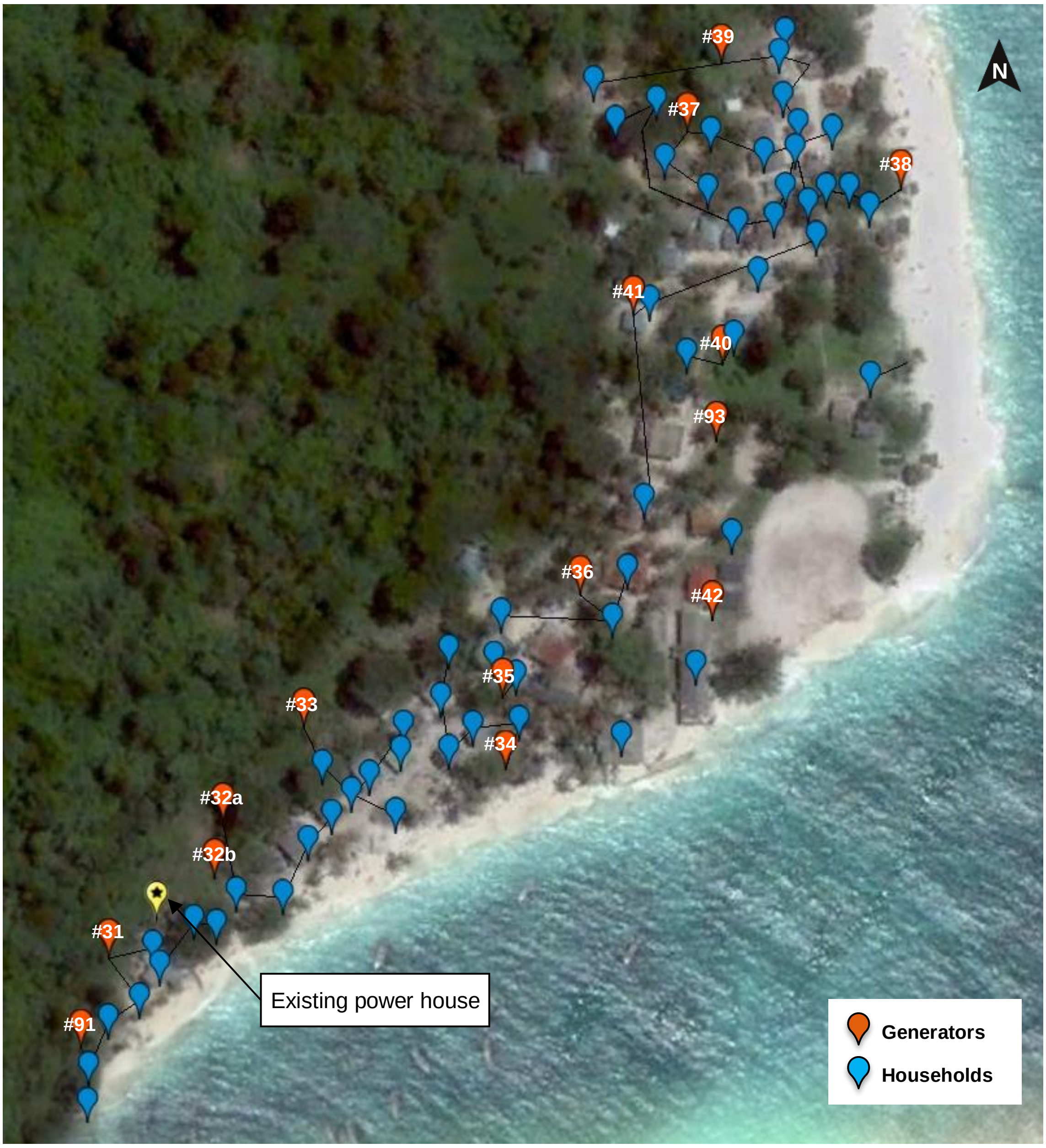

Figure 4: Overview of generator and household locations observed on the island

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Table 1 summarizes the owner and the number of connected households of each generator observed on the island. Some generators are for specific purposes such as boat repair, washing machines, etc. Some of them are connecting 8-10 households, e.g., Generator #31, Generator #37 and Generator #38. Due to the time constraint during the site visit, not all of the generators could be technically evaluated. Only generators connected to several households were assessed. The selection was made to cover most of the island's current power supply units and ensure that a representative amount of generator was analysed.

Table 1: Description of each generator according to Figure 4

No.	Generator Ref.	Owner and Operator	Number of connected households
1	Generator #91	Mr. Sumet	For boat repair only
2	Generator #31	Ms. Anchulee	8 households
3	Generator #32b	Mr. Pun	For washing machine only
4	Generator #32a	Mr. Pun	4 households
5	Generator #33	Ower: Mr. Alidan Operator: Mr.LamLi	4 households, plus rest area
6	Generator #34	Mr. Hat	6 households
7	Generator #35	Mr. Nud	2 households
8	Generator #36	Mr. Nirun	3 households
9	Generator #42	School	For backup in case the electricity from PV is not enough, e.g., rainy season
10	Generator #93	Mr. Tawan	N/A
11	Generator #40	Unknown	1 household, 1 restaurant
12	Generator #41	Mr. Sa-Eden	3 households
13	Generator #38	Unknown	10 households
14	Generator #37	Mr. Jaesen	9 households, incl. 2 shops
15	Generator #39	Mr. San	5 households

It has to be noted that this chapter only describes the generators, the grids shall then be described in Chapter 6. The following generators were assessed during the site visit. The detailed specifications of each generator are listed in Appendix 2.

4.1 Community Generator

The generator, KIPOR KDE30SS3 26 kVA provided by the local government (SAO), together with the central grid transmission line were installed around 3 years ago and supplied the electricity for all of the households on the island. However, approx. 1 year ago, the generator failed after just 2 years of operation and shall be replaced by a new 50 kW generator (SAO applied for it) within the next months. The generator is housed in

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an open powerhouse under a medium size corrugated sheet roof based on concrete poles as shown in Figure 5.

The generator used to be operated by a community team and was connected to the central grid transmission line with proper steel poles on the island. The generator was taken care of by Mr.Pun who was selected as operator during a community meeting.

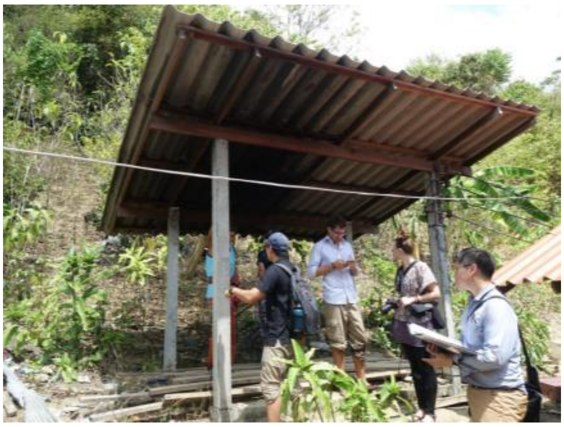

Figure 5: Community generator on June 2014 (left) and on 1st March 2017 (right)

4.2 Generator #31 (owned by Ms. Anchulee)

The generator is located at the far Southern side of the island. The generator type is YANMAR TF115–HM which has a maximum power of 8.5 kW. This generator is connected to 8 households. Diesel consumption is around 2.5 litres per night. The connected households are taking turns to buy the diesel every two nights.

Figure 6: Generator #31

4.3 Generator #32a (owned by Mr. Pun)

The generator is YANMAR TF115-HM which has maximum power of 8.5 kW. There is no powerhouse and the generator is located under a tree. Diesel consumption is around 2

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litres per night, powering 4 houses. It is operated by Mr. Pun who also set up the connection cables by himself.

Figure 7: Generator #32a under a tree

4.4 Generator #33 (owned by Mr. Alidan)

The generator is Valvolin, Kurota Diesel, 5D30 B. The nameplate of the generator was completely corroded, but the estimated power is 8 kW as informed by Mr. Lamli, who is the operator of this generator. There is no powerhouse. Therefore, the generator is placed under a small roof of welded brass. Diesel consumption is around 2.5 litres per night, powering 4 houses and a rest area.

Figure 8: Generator #33 under a small roof of welded brass

4.5 Generator #37 (owned by Mr. Jaesen)

This generator is located at the Northern part of the island. The engine brand is Yanmar TF 115-HM and the electric generator brand is SHIBA A.C. It is a synchronous generator with a power generation of 5 kW. Diesel consumption is around 7 litres per night. There is no powerhouse, the generator is placed under a canvas. It is operated by Mr. Jaesen and connected to a grid of 9 households and 2 shops. The grid was set up more than five years ago.

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It shall be noted, that the load measurement device has been installed and measured the load of this generator as described in Chapter 7.1.

Figure 9: Generator #37 under a canvas

4.6 Generator #38 (Unknown owner)

This generator is located in the East of the island. The engine brand is Yanmar and the electric generator brand is FOLK Alternators Co. of England. The power generation is 3 kW. There is no powerhouse; therefore, the generator is placed under a canvas with a small roof sheet. It is connected to a grid of 10 households. The local grid has been set up and operated even before the community generator was in operation.

Figure 10: Generator #38

4.7 Generator #40 (Unknown owner)

This generator is located next to the graveyard. The generator is Urogen 3.0HP which has power of 2.2 kW. There is no powerhouse. Instead, the generator is placed in a small shop/restaurant under a metal sheet roof. It supplies power to 1 household and 1 restaurant as needed.

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Figure 11: Generator #40 in a small shop/restaurant under metal sheet roofs

5 EXISTING PHOTOVOLTAICS SYSTEMS

An overview of existing PV system locations on the island is provided in Figure 3. The detailed specifications of each system are listed in Appendix 3.

5.1 Solar Home Systems

Around 20 Solar Home Systems (SHS) have been observed during the site visit. Some examples are shown in Figure 12. The PV modules are typically 130 W_p, made by Northern Sunshine. Different setups in each household such as various inclinations, various azimuths, installation types (rooftop or ground-mounted) were observed. Some households have SHS with batteries as shown in Figure 13.

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Figure 12: Solar Home Systems observed on the island

Figure 13: Households with Solar Home System and Battery

5.2 PV system at water storage

Figure 14 shows the PV system which was built in 2011 and used to supply the electricity for street lights. The system is located on a hill around 100 m west of the inhabited area. The system is currently not working. According to the information of the community representatives, the system broke down due to an overvoltage caused by a lightning strike. The Consultant cannot confirm, since no obvious signs of lightning strike have

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been observed. However, the Consultant did not observe any installed lightning protection.

The system´s azimuth is facing South West with 210° and an inclination angle of 20°. It comprises of 60 modules (three tables, 20 modules/table) of Bangkok Solar (BSC) 50 W_p thin film modules, totalling 3 kW_p. The size of the installation is approximately 6.5 m × 10 m. There is no additional space for new modules available as the area is titled as National Park, therefore, trees and vegetation shall not be cut. The replacement of the existing system could be an option. The modules are shaded caused by the surrounding trees in the Eastern and Southern direction. Far shading may also occur caused by the mountain toward the West.

Figure 14: 3 kW_p PV system located next to water storage

The modules look broken as shown in Figure 15. Glass breakage of thin-film solar modules will cause short-circuit of the cells, resulting in a complete blackout of the entire module.

Rusty metal of a mounting structure has also been observed as shown in Figure 16.

Figure 15: Damaged PV modules

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Figure 16: Rusty metal [left] and disconnected cable [right]

5.3 PV-battery systems at school area

Figure 17 shows the overview of the PV system located within the school area. There are two PV systems supplying the electricity to the school:

1) The system using Uni-Solar solar modules is in total 5.12 kW_p, consisting of 80 modules connected via charge controller to 24 batteries of Union model 8 OPZS 800 (specification of battery: nominal voltage 2 V, capacity 800 Ah). The system is connected via an inverter as shown in the left photo of Figure 18. However, the system is not working anymore, due to low maintenance and low quality installation.
2) The system using Schutten solar modules is in total 3.0 kW_p, consisting of 12 modules connected via charge controller to 8 batteries of Globatt INVA150 (specification of battery: nominal voltage 12 V, 150 Ah). It is connected via an inverter as shown in the right photo of Figure 18. It is currently working and supplies electricity to the school and charges a battery inside the mosque.

Both systems are facing towards South and slighty to east (150°) with an inclination of 20° (Uni-Solar system) and 15° (Schutten system).

The building close to the PV system causes some shading of the modules. The distance between the PV table (No.3a) and the school building is approximately 1 m and the school building's lowest height is around 3 m.

Figure 17 also shows the tsunami warning system with two PV modules to supply electricity.

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1) Tsunami warning system
2) Powerhouse for Uni-Solar modules
3) 5.12 kW_p Uni-Solar built in 2003
4) 3.0 kW_p Schutten modules

Figure 17: Overview of PV system located within school area

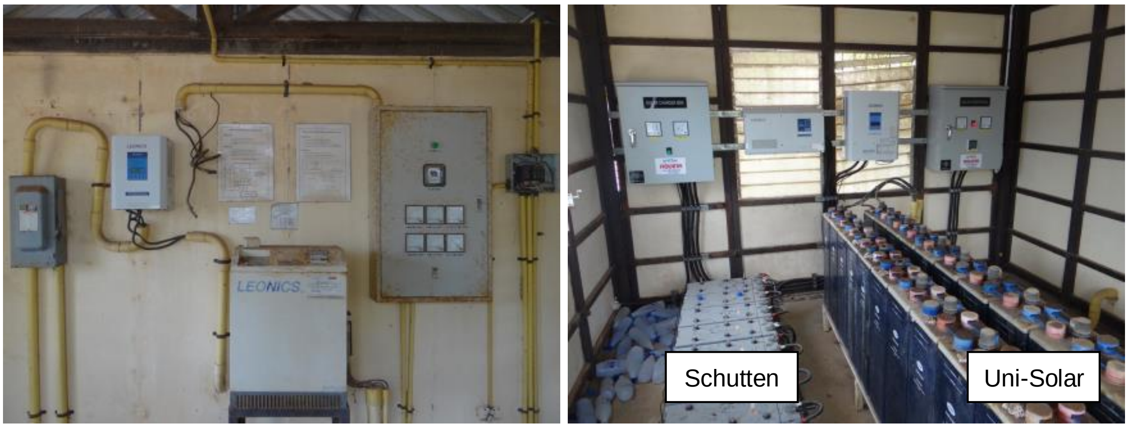

Figure 18: Inverter and batteries system inside powerhouse

Figure 19 shows a severe rusty combiner box. It can be presumed that the material is not corrosion resistant and suitable for the application.

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Figure 19: Rusty combiner box

Garbage, such as battery packaging and distilled water bottles for battery refilling, is not well-organized in the powerhouse as shown in Figure 20.

Figure 20: Unorganized garbage in the powerhouse

5.4 PV-battery system located at health centre

Figure 21 shows two PV modules of Sharp 220 W_p (not in-use) and six PV modules of Suntech 285 W_p totalling 1.71 kW_p (in-use). The Suntech system was built in 2014 supplying the electricity for the public health centre only. The system is facing South (180°) with an inclination of 15°. The PV modules are connected via charge controller to 4 batteries of Globatt model 190H52R (specification of battery: nominal voltage 12V, capacity 200 Ah) as shown in Figure 23.

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Figure 21: Two PV modules not in use [left], 1.71 kW_p PV system for health centre [right]

Figure 22: Inverter and charge controller [left], four Globatt batteries [right]

Figure 23 shows the installation of the Suntech system. Loose clamps and a missing clamp can be observed. As shown in Figure 24, the combiner box is not properly organized and the mounting structure is damaged.

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Figure 23: loose clamp [left], missing clamp of PV module [right]

Figure 24: Untidy combiner box [left], damaged mounting structure [right]

Rusty screws are observed and the grounding cable is disconnected as shown in Figure 25.

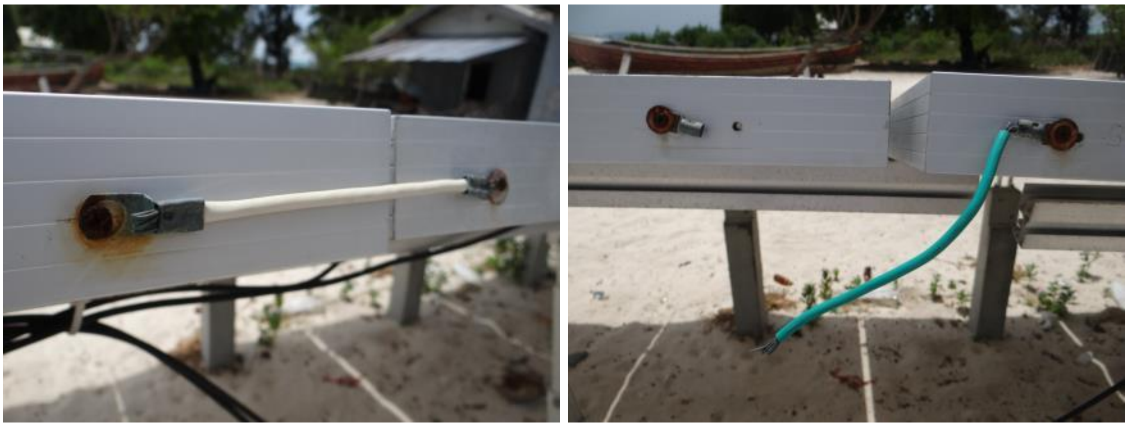

Figure 25: Rusty screws [left], disconnected grounding cable [right]

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5.5 Abandoned PV system

Figure 26 shows an abandoned/broken PV system with unknown specification. The system was installed to supply a charging station, where villagers could charge their private batteries.

Figure 26: Abandoned PV

6 GRIDS

There is an existing central grid transmission line which was used to connect all households. The grid was fed by a community generator as described in Chapter 4.1. Since the generator broke down, the grid is not in use and the private mini-grids have been re-activated or newly implemented. There is currently no interconnection between the generators and the central grid transmission line.

Due to the time constraint during the site visit, not all mini-grids could be technically evaluated. Therefore, only grids, covering the majority of the consumers and the main parts of the island have been investigated in detail.

The cable specifications as observed on the island are compiled in the following table:

Table 2: Cable types

Cross-section	Spec.	Thai Standard year	Manufacturer	Connected to Generator
2 x 1.5 mm^2	VAF	2531	Bangkok cable	#32a, #33, #40, #37 and #38
50 mm^2	THW – A	2541	Nation TCI	Existing central grid transmission line

As seen from Table 2, it can be presumed that the most cables besides the existing central grid transmission line are 2x1.5 mm^2 VAF.

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Existing central grid transmission line (currently not in use)

This grid was installed around three years ago by the Sub-District Administrative Organization (SAO) as shown in Figure 27. Individuals had to purchase and provide the tapping equipment and cable to connect to the main grid. The grid is currently not in-use because of the broken community generator. This grid uses the 50 mm^2 THW–A cables (3 phase, 4 wires) as shown in Figure 28. The insulation of the cables is in a good condition.

Figure 27: Existing central grid transmission route

Figure 28: THW 50 mm^2 cable (Existing central grid transmission line)

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It has to be noted that the central grid might be used for the hybrid system. However, extension of this grid shall be considered, to cover the whole island.

Private generator's grids (currently in use)

Most of the private generator's grids, which were installed by the locals (between one to five years ago), are very similar. The grids consist mainly of 2x1.5 mm^2 VAF cables as shown in Figure 29 to Figure 32. The insulation of the cables has been fixed several times, but the repair has not been carried out on a professional basis using regular electrical tape. Exposure to sunlight will dry out the tape which will become brittle or delaminate as a result.

According to Thai Standard, this type of cable should not be exposed to sunlight directly, in other words, this cable should be used for indoor or inside use only.

Figure 29: Grid of Generator #32a

Figure 30: Grid of Generator #33

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Figure 31: Grid of Generator #37

Figure 32: Grid of Generator #38

6.1 Anchor Methods

Solid steel poles were installed for the central grid transmission line as shown in Figure 33. However, the cables are connected to the poles in a height between 2 m – 2.5 m above the ground. This may result in cables hanging down between poles in a height that people can touch them by accident, therefore, the steel poles shall be higher, at least 2.5 m according to Thai standards. Other types of poles have also been observed during the site visit as shown in Figure 34.

Table 3: Pole types

Type	Frequency
Wooden sticks	Some area
Trees	Common
Ground lying	Seldom (some small generators)
Steel poles	For main grid connection route

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Figure 33: Steel pole of main grid

Figure 34: Wooden pole and tree connection of private connections

6.2 Switchgear

All grids having manual switches installed to disconnect the generators from the load. These switches have the purpose to protect the load from the starting current of the generator. Several of the switches are in a bad condition (e.g. open metal parts), which may result in very dangerous electric shocks, if touched during operation.

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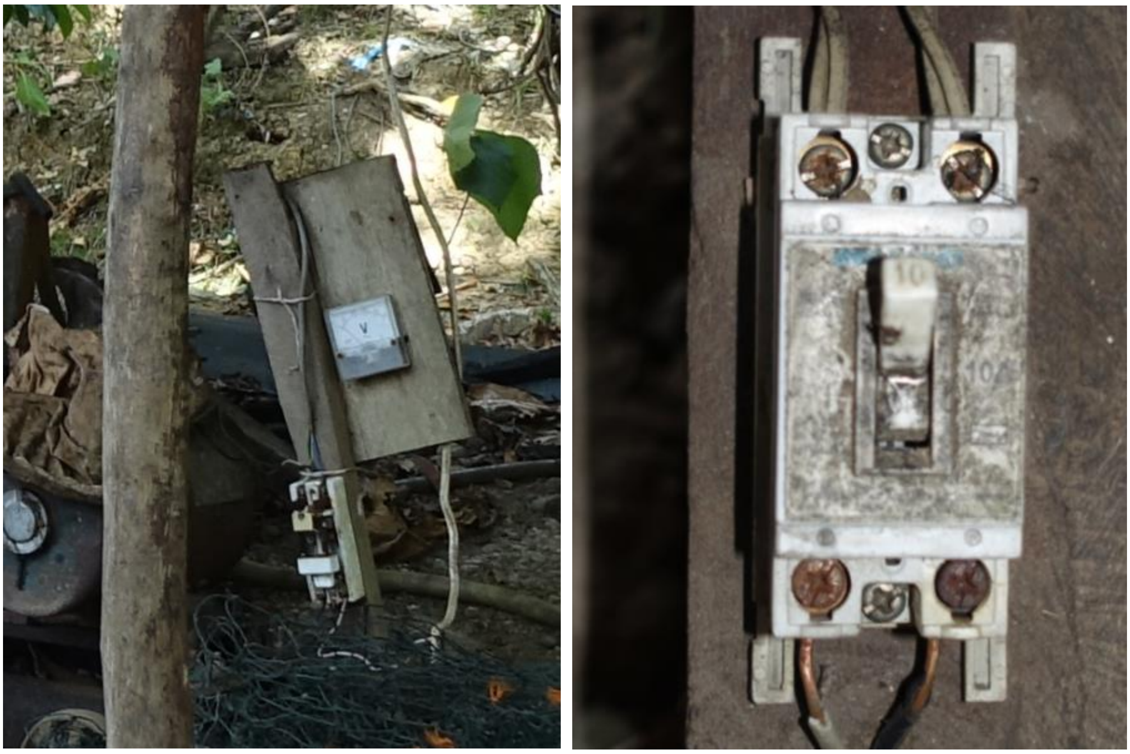

Figure 35: Disconnect Switch and Circuit Breaker for Generators

6.3 Grid Recommendations

When implementing the Project, the existing community grid should either be upgraded and expanded or a new grid route should be considered. It appears that an upgrade and expansion of the existing grid is the better option. During the upgrade, all households shall be connected to the grid to ensure the tapings are conducted professionally.

Figure 36 shows an overview of the island with the proposed transmission line route including the extension. The location of the powerhouse needs to be reconsidered as the current location for the community generator is close to some of the households (in the backyard of three houses). The new location is yet to be confirmed and is so far unknown. The existing transmission grid shall be upgraded with new poles with a minimum height of 2.5 m. Cables, fusses and fixtures seem to be in good condition and do not need a replacement. The existing grid shall be extended to cover all households with the length of approx. 300 m as indicated by the red line. The extended line shall be investigated to be either single phase or three phase at a later stage of the Project.

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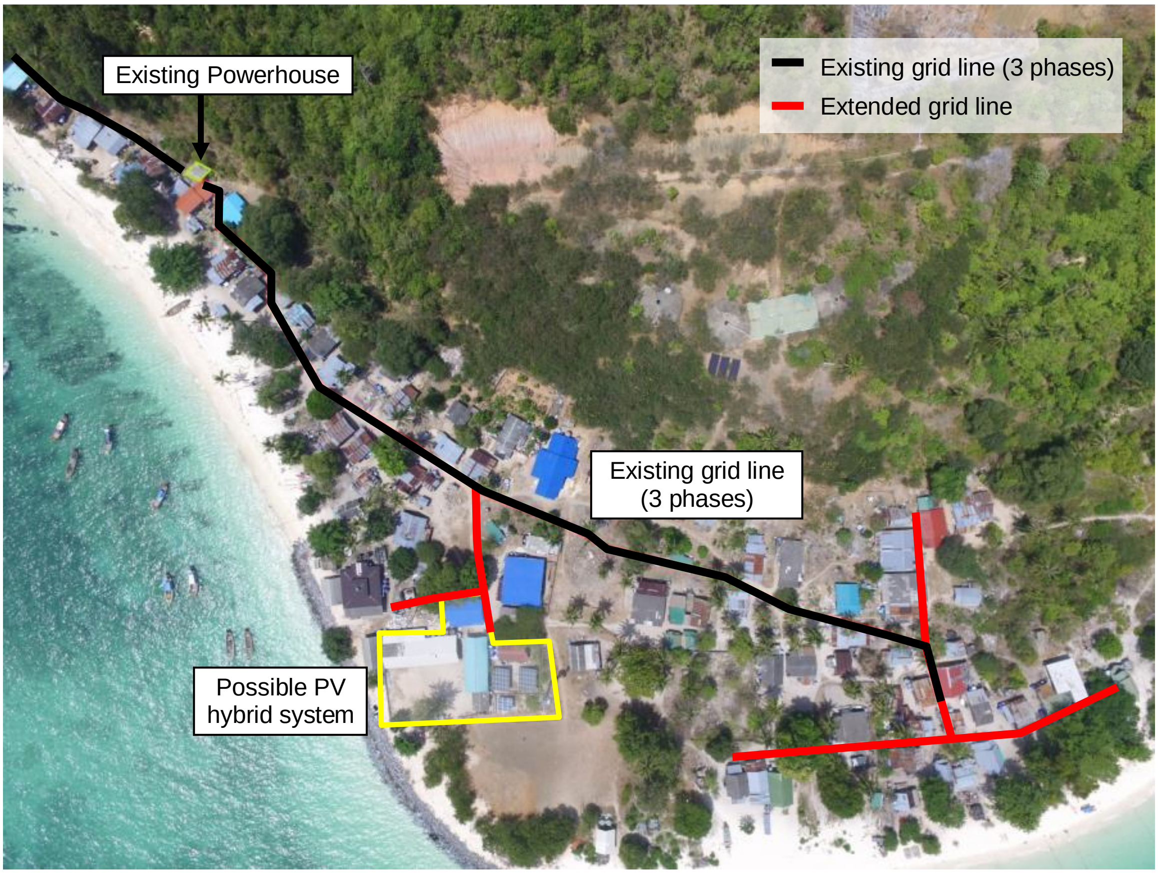

Figure 36: Proposed transmission line on Koh Bulon Don

The following table provides approximate quantities of a new installed grid to power the island with electricity:

Table 4: Proposed setup of the new grid

Parameter	Value
Cables	
Total additional grid extension [m] (red colour)	Approx. 150 m
Cable cross section [mm^2]	To be specified and calculated
Insulation type	XLPE Insulated and PVC Sheathed Power Cable
Cable type	Weather proof conductor
Number of households connected to the hybrid system	To be specified
Poles	
Type	Wooden, concrete or steel poles
Number of poles	To be specified
Height of poles [m]	At least 2.5 m (according to Thai standards)

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Parameter	Value
Others	Pole installation shall be at least in accordance with PEA standard

7 LOAD PROFILE AND ENERGY CONSUMPTION

There are no data loggers at any of the generators on the island. The load profile and energy consumption shall be analysed with the load measurements conducted by the Consultant.

7.1 Load Measurement

The Consultant installed one load measurement device on Koh Bulon Don on 1st March 2017 to measure the energy consumption of the connected generator loads till 1st April 2017. The devices shall measure relevant grid parameters like voltage, current, active and reactive power and frequency for each phase separately. The measurement device was installed in the following grid:

Table 5: Load measurement

Device	Connected to Generator	No. of phases	Number and type of connected houses
Koh Bulon Don	Generator #37	1	- 9 residential households - Incl. 2 shop

8 ELECTRICITY PRICE STRUCTURE

8.1 Previous situation: Community Generator

A central electricity tariff structure was implemented on the island when the community generator was in operation. The cost-allocation was done by a flat rate per month for operation hours between 18:00 and 22:00 daily at approx. 300 THB/household/month. It was agreed that only light bulbs, TVs, and fans can be used. Since there were no meters installed, the electricity was freely used during the operation hours of the generators. Monitoring of actual consumption and the operation and maintenance costs were not recorded. Therefore, the actual generation costs can hardly be assessed. The price agreement was a decision of a community meeting. A new price agreement may be necessary in case the community generator will be replaced.

It can be estimated that the total income for the community diesel generator was approx. 24,000 THB per month with 79 connected households. If the generator consumed diesel fuel of around 900 litre per month at a price of approximately 25 THB/l, total costs for

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diesel fuel would have been 22,500 THB per month. Diesel transport costs approx. 300 THB per roundtrip.

Since a community diesel generator has been installed for only three years, no major maintenance or other costs during this timeframe have occurred. Operational costs for water, lubricant oil and others are unknown.

8.2 Current situation

Currently the residents are using diesel generators in micro-grids supplying 2 - 10 households as outlined above (Chapter 4). The tariff system is agreed upon by the different households sharing one generator ranging from 435 – 2,160 THB per month. Every generator has different operating hours depending on the needs of the people connected to it, therefore the diesel consumption and pricing differs a lot. Most diesel generators run in the evening hours between 18:00-22:00. The diesel and transportation costs are usually equally divided by the households connected. In few cases where one household has much more electronic appliances than others or one household has a lower ability to pay, the electricity tariff per household connected to the same generator differs.

The payment is usually done by a rotation of the connected households being responsible for diesel purchasing and transport. Every 2-4 days one of the households connected is driving to the main land to buy new diesel supply at a price between 25 – 30 THB/litre.

9 FUTURE ENERGY CONSUMPTION

During the socio-economic survey, the future possible appliances were assessed. Most villagers mentioned fridges, washing machines, rice cookers and TVs. Air conditioning is not desired by the people. The survey showed that Bulon Don’s population did not state an immense growth of electricity consumption, the wish for additional appliances is quite modest.

10 POSSIBLE AREA FOR POWERHOUSE

During the site visit, an existing small powerhouse for the former community diesel generator as described in Chapter 4.1 has been observed. According to latest information there is a plan to build a new powerhouse as the current location is too close to some households. Nevertheless, the location has not been officially decided yet. The deputy of the island shall confirm the location.

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11 POSSIBLE AREAS FOR PV INSTALLATION

Areas to install and implement a PV system have been identified and investigated. The results are provided in the following chapters. The final required area shall be determined after system design and the most suitable sites can be selected.

Figure 37 shows the overview of 9 possible PV installation areas. It has to be noted that Koh Bulon Don is currently under Mu Koh Phetra National Park, it is therefore not permitted to use any additional spaces on the island.

1) Area 1: Lake
2) Area 2: Roof of the building
3) Area 3: Existing PV system
4) Area 4: Roof of island deputy's house
5) Area 5: Blue roof of school building
6) Area 6: roof of school building
7) Area 7: roof of school building
8) Area 8: Existing PV system at school
9) Area 9: Abandoned PV system

Figure 37: Overview of 9 possible PV installation areas

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Table 6: Data summary of pre-selected and reviewed PV areas

Item	Area 1	Area 2	Area 3	Area 4	Area 5
GPS coordinates of site	6°51'20.75"N 99°35'37.36"E	6°51'20.70"N 99°35'38.64"E	6°52'28.97"N 99°37'52.27"E	6°51'20.75"N 99°35'37.36"E	6°51'17.80"N 99°35'41.45"E
Land owner	Community	Community	Community	Deputy's island (Mr.Mhard)	School
Area borders	It was not possible to clarify the exact area boundary, no land titles / documentation available at this stage.	Not necessary because of the building (not an open-field area)	It was not possible to clarify the exact area boundary, no land titles / documentation available at this stage.	Not necessary because of the building (not an open-field area)	Not necessary because of the building (not an open-field area)
Size of area	~700 m^2	~350 m^2	~65 m^2	~220 m^2	~80 m^2
Distance to next grid connection	~150 m (from existing main grid line)	~100 m (from existing main grid line)	~100 m (from existing main grid line)	~5 m (from existing main grid line)	~15 m (from existing main grid line)
GPS coordinates for grid connection	It cannot be clarified surely the grid connection point since the possible power house / generation location of a hybrid systems needs to be determined				
Size of grid connection point	Based on the Hybrid System Design				
Distance to power house	To be determined since the new powerhouse location has not been official announced yet.				
Slope	~0°	Unknown	~0°	~0°	~20°
Necessity to clear the site	Yes	Yes, replacement of the roof	Yes	No	No
Visible soil conditions	Sandy to clay	Rooftop	Clay	Rooftop	Rooftop
Temporary flooding risks	Not observed	Not observed	Not observed	Not observed	Not observed
Preferred areas by ILF	Not selected area. A floating PV system shall be considered, however, during dry season there is no water in the lake.	Optional area since the roof structure may require reinforcement and shading may be caused by trees and the mountain in West direction.	Optional area since shading of surround trees and mountain in West direction may cause low performance.	To be discussed with the Deputy of the island	Preferred area

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Item	Area 6	Area 7	Area 8	Area 9
GPS coordinates of site	6°51'17.33"N 99°35'41.83"E	6°51'17.87"N 99°35'41.98"E	6°51'18.24"N 99°35'42.15"E	6°51'19.48"N 99°35'43.73"E
Land owner	School			Unknown
Area borders	Not necessary because of the building (not an open-field area)	Not necessary because of the building (not an open-field area)	It was not possible to clarify the exact area boundary, no land titles / documentation available at this stage.	
Size of area	~250 m^2	~200 m^2	~30 m^2	~30 m^2
Distance to next grid connection	~25 m (from existing main grid line)	~25 m (from existing main grid line)	~25 m (from existing main grid line)	~60 m (from existing main grid line)
GPS coordinates for grid connection	It cannot be surely clarified the grid connection point since the possible power house / generation location of a hybrid systems needs to be determined			
Size of grid connection point	Based on the Hybrid System Design			
Distance to power house	To be determined since the new powerhouse location has not been official announced yet.			
Slope	~30°	~20°	~0°	~0°
Necessity to clear the site	No	No	Yes	Yes
Visible soil conditions	Rooftop	Rooftop	Sandy to clay	Sandy
Temporary flooding risks	Not observed	Not observed	Low	Low
Preferred areas by ILF	Preferred area	Preferred area	Preferred area	Not selected area due to distance from the grid distribution system

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11.1 Area 1-3: Water concrete storage tank area

For Area 1-3, it has to be noted that there is a dirt road access to the area, but the road is very steep as shown in Figure 38.

Figure 38: Steep road access to the Area 1-3

Area 1: Lake

PV modules could be installed on the lake, but shading from the mountain in the Western direction shall be thoroughly considered. It has to be noted that there was no water in the lake during the site visit.

Area 2: Roof of the building next to the water storage

The structure of the roof seems to be too weak for a PV rooftop installation as shown in Figure 39. The roof is facing East-West direction. The structure shall be reinforced and the roof sheet shall be replaced with more durable material. There might be far shading from the mountain in the Western direction.

Figure 39: Structure of the roof of the building next to water storage

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Area 3: Replacement of existing PV system next to the water storage

Since the system is currently defect, the modules can be replaced. However, this area is almost completely shaded, not only by surrounding trees but also by a mountain in the Western direction. Mu Koh Phetra National Park needs to permit cutting of trees in this area.

11.2 Area 4: Roof of the island deputy's house

The roof structure seems strong enough to install a PV rooftop system. The roof is facing into North-South direction and has an inclination of 20°. However, the utilization of the roof needs to be discussed with the island deputy. There is possible far shading from the mountain in the Western direction.

Figure 40: Island deputy's house

11.3 Area 5-8: school area

Area 5: Blue roof of school building

The roof structure seems to be strong enough for a PV rooftop installation. The roof is facing to East-West direction and has an inclination of 20° as shown in Figure 41. Two eight-meter big trees next to the blue roof building have to be considered for shading which affects all roofs (blue, grey and green roof).

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Figure 41: Roof overview and roof sheet shape

Area 6: Grey Roof of school building

The roof structure looks sufficiently strong to install a PV rooftop system. The roof is facing in North-South direction and has an inclination of 30° as shown in Figure 42. The size of the roof is approximately 25 m × 10 m.

Figure 42: Roof overview and roof structure

Area 7: Green roof of school building

The roof structure looks strong enough to install a PV rooftop system. The roof is facing East-West direction and has an inclination of 20° as shown in Figure 43. The size of the roof is approximately 20 m × 10 m.

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Figure 43: Roof overview

<u>Area 8: Replacement of existing PV system at the school</u>

Figure 44 shows the existing PV installation area. The size of the area is approximately 20 m × 20 m. The existing Uni-Solar modules can be replaced with new modules. Shading from the shool building shall be considered if the system is being renewed or replaced.

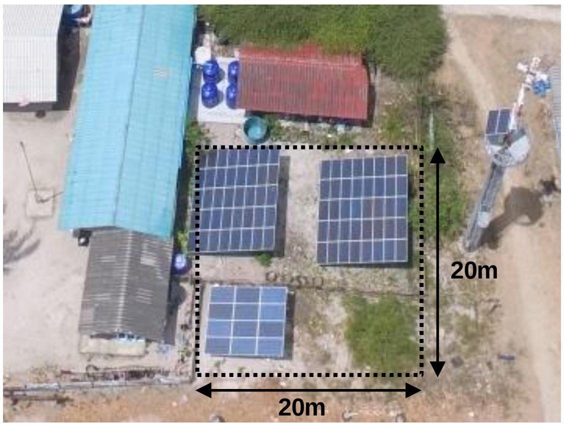

Figure 44: Existing PV area at school

11.4 Area 9: Abandoned PV system

The size of the area is approximately 10 m × 10 m. This area is not only quite far away from the grid distribution system but there are also surrounding trees which might provoke complete shading.

12 WATER STORAGE SYSTEM

Figure 45 shows the water storage system which was built in 2005 by Satun Royal Irrigation Department, consisting of the lake (retaining of raining water) and four water

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storage concrete tanks of 1,000 m^3 capacity each. The size of the lake is approximately 50 m × 15 m × 2.5 m. Most of the households also have individual storage tanks.

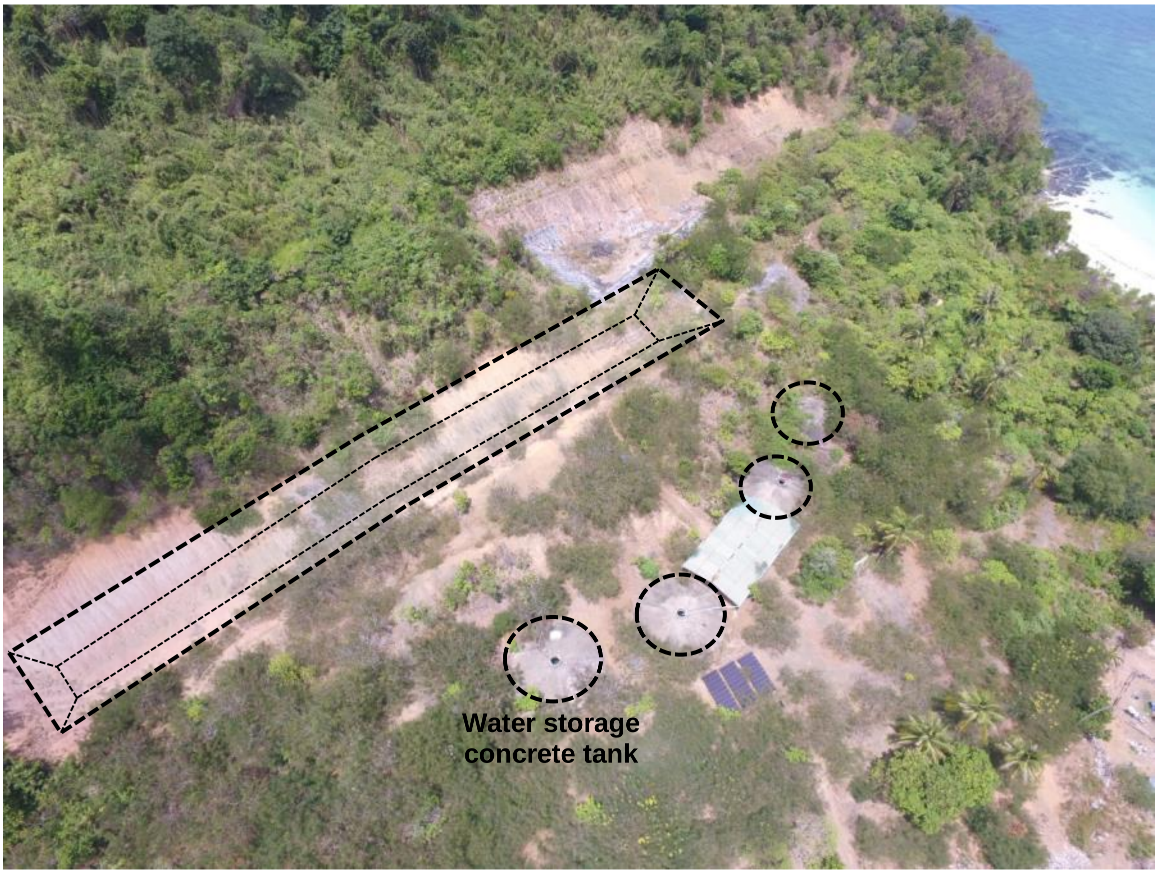

Figure 45: Overview of water system and storage

Figure 46: 1,000 m^3 water storage concrete tank

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Figure 47: Lake for collection of raining water

13 LOGISTICS

13.1 Transport on the island

The people live densely within a radius of 200 m. All transportation is conveniently done by foot.

13.2 Availability of excavation vehicles and manpower skills

There were no excavation vehicles observed.

During the site visit, the construction site of the new school building was observed, for which the labourers are coming from the mainland. Building material, such as wood and sand, is mostly shipped from the mainland.

There is a trained PV operator living on the island (training conducted by Chiang Mai University).

13.3 Possible laydown area and accommodation facilities during execution

Possible laydown area is within the school and the community area. Accommodation for workers shall be provided from the local people (homestay).

13.4 Road

There is no concrete road available on the island, only dirt road.

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Figure 48: Dirt road

13.5 Pier

Mainland Pier

The closest pier to Koh Bulon Don is Pak Bara Pier, approx. one hour driving distance with the local long tail boat. The pier should be sufficient for the shipment of the gear and larger equipment.

Island Pier

There is currently no pier on the island and only small boats, e.g. long tail boats can approach the island in the East side.

13.6 Fuel transport to the island

The fuel is transported by long tail boats from Pak Bara Pier.

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14 APPENDICES

Appendix 1: List of the generators observed during the site visit with GPS location

No.	Reference No.	GPS
1	#91	6.85384, 99.59331
2	#31	6.85408, 99.59338
3	#32b	6.85429, 99.59367
4	#32a	6.85444, 99.59369
5	#33	6.85469, 99.59391
6	#34	6.85458, 99.59444
7	#35	6.85477, 99.59444
8	#36	6.85504, 99.59464
9	#42	6.85498, 99.595
10	#93	6.85545, 99.59501
11	#40	6.85565, 99.59502
12	#41	6.85579, 99.59479
13	#38	6.85612, 99.5955
14	#37	6.85627, 99.59493
15	#39	6.85645, 99.59502

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Appendix 2: Generator information gathered during the site visit

Reference No.	#31	#32a	#33	#37	#38	#40
Generator						
Owner/Operator	Ms. Anchulee	Mr. Pun	Mr. Alidan / Mr.Lamli	Mr. Jaesen	Unknown	Unknown
Continuous Power [kW]	7.2	Unknown	7.2	5	3	Unknown
Power Factor	Unknown	Unknown	Unknown	1.0	0.8	Unknown
Number of phases	1	1	1	1	1	1
Frequency [Hz]	Unknown	Unknown	50	50	50	50
Fuel	Diesel	Diesel	Diesel	Diesel	Diesel	Benzene
Operating hours	6 pm – 10 pm	6 pm – 10 pm	6 pm – 10 pm	6 pm – 10 pm	6:30 pm – 10:30 pm	6 pm – 10 pm
Age	Unknown	Unknown	Unknown	>5 years	>5 years	Unknown
Grid						
Number of connected households	8 households	4 households	4 households, rest area	8 households, incl. 1 shop	10 households	1 household, 1 restaurant
Cables	2x1.5 mm2, VAF, 2531 Thai standard year	2x1.5 mm2, VAF, 2531 Thai standard year	2x1.5 mm2, VAF, 2531 Thai standard year	2x1.5 mm2, VAF, 2531 Thai standard year	2x1.5 mm2, VAF, 2531 Thai standard year	2x1.5 mm^2, VAF, 2531 Thai standard year
Poles	Either cable lies directly on the ground or trees are used as poles	Either cable lies directly on the ground or trees are used as poles	Either cable lies directly on the ground or trees are used as poles	Either cable lies directly on the ground or trees are used as poles	Either cable lies directly on the ground or trees are used as poles	Cable is either attached to palm trees, concrete pillars or lying on the ground
Condition of the cables	Frequently fixed, should be replaced in case of a renovation	Frequently fixed, should be replaced in case of a renovation	Frequently fixed, should be replaced in case of a renovation	Frequently fixed, should be replaced in case of a renovation	Frequently fixed, should be replaced in case of a renovation	Frequently fixed, should be replaced in case of a renovation
Age	Unknown	Unknown	Unknown	>5 years	>5 years	Unknown

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Appendix 3: Summary of PV systems

	SHS	Water storage	School		Health
PV Module					
Brand	NS (Northern Sunshine Co., Ltd.)	BSC (Bangkok Solar Co., Ltd.)	Uni-Solar	Schutten	Suntech
Model	NS 130 C	CS-50	US-64	STP6-250/60	STP285-24/Vd
Max power	130 W	50 W (+/-5%)	64 W	250 W 0/+5 W	285 W 0/+5%
Voltage max power	17.6 V	70.9 V	16.5 V	30.2 V	35.8 V
Current max power	7.38 A	0.71 A	3.88 A	8.3 A	7.95 A
Open Circuit Voltage	22 V	93.4 V	23.8 V	37.75 V	44.8 V
Short Circuit Current	7.93 A	0.86 A	4.8 A	8.98 A	8.37 A
Facing (Azimuth)	Various	210°	150°	150°	180°
Inclination	Various	20°	20°	15°	10°
Battery					
Brand	N/A	None	Union	Globatt	Globatt
Model	N/A	None	8 OPzS 800	INVA 150	190H52R
Voltage	N/A	None	2 V	12 V	12 V
AH	N/A	None	800 Ah	150 Ah	200 Ah
Notes	N/A	PV system is broken due to lightning strike	Not working	Supplying electricity for school	Batteries are connected with two series, two parallel

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Appendix 4: Site Survey Overview

See separate document: “2_Bulon Don_Survey Evaluation_final”

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