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für Internationale
Zusammenarbeit (GIZ) GmbH

Renewable Energy Hybrid Grid Systems for Thai Islands

Koh Bulon Don – Project Summary

Contents – Koh Bulon Don

- Introduction
- Site Assessment Summary
- Proposed System Design
- Business Models
- Next Steps, Impact and Outlook

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Renewable Energy Hybrid Grid Systems for Thai Islands

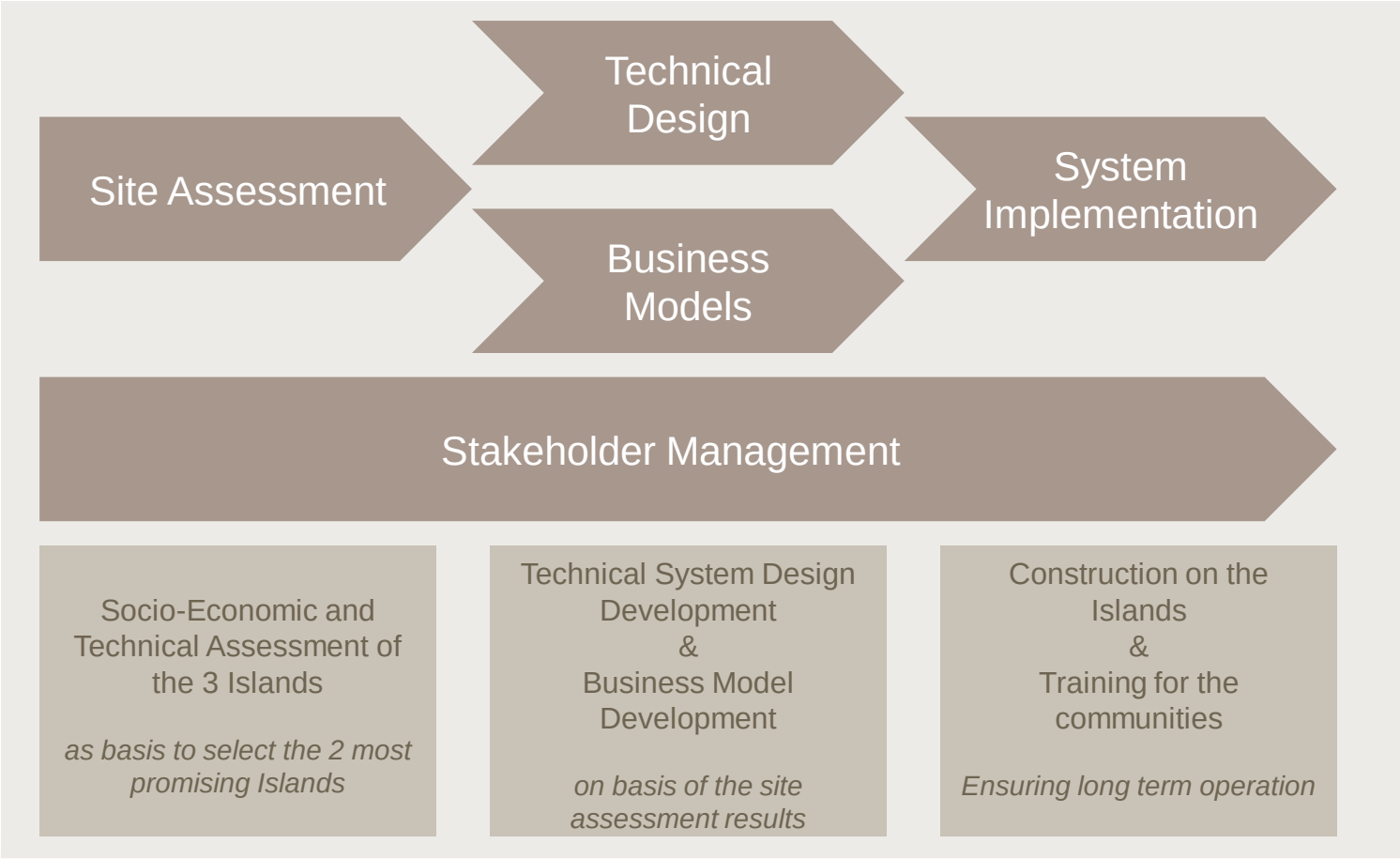
Koh Bulon Don – Introduction

Introduction – Project Milestones

1. Kickoff Event — **5 Islands**
2. Selection of Suitable Islands — **3 Islands**
3. Site Assessment — **3 Islands**
4. Development of Hybrid Grid System Design — **2 Islands**
5. Community-Based Operation & Business Model — **2 Islands**
6. Project Implementation Consortium
7. Project Implementation and Local Capacity Building

Current Status

Introduction – Project Process



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Renewable Energy Hybrid Grid Systems for Thai Islands

Koh Bulon Don – Site Assessment Summary

Site Assessment - Approach

Meeting with community representative & Island walk

Technical inventory (existing grid, installed RE capacities, diesel generators)

Community Meeting

Survey & GPS mapping

Koh Bulon Don – Impressions

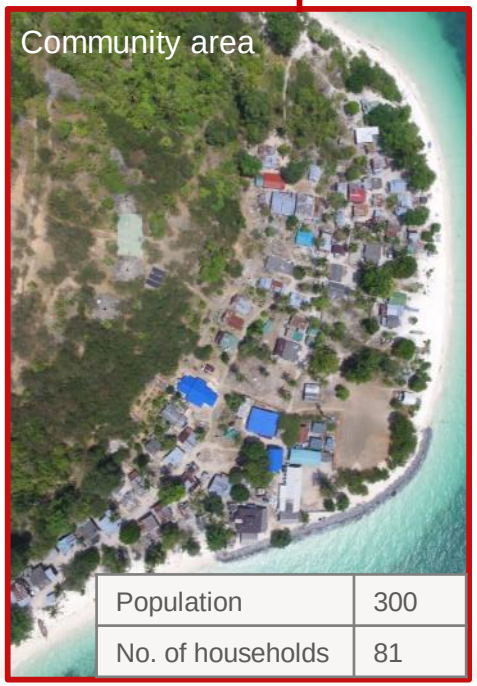







Overview of Koh Bulon Don

Overview of Koh Bulon Don



Population	300
No. of households	81

- **Fishery village** without tourism sector
- population considered as stable
- Income range: 4,500 – 45,000 THB/month (average 8000 THB/month)

- Existing SAO's **grid infrastructure** for centralized diesel powered system (currently not in use, DG broke down)

- **14 stand-alone diesel generators**
- each supplies 5 - 10 households
- operating between 18:00 – 22:00

- **4 existing PV systems** installed by both government and private CSR (only 2 are working)

Lake for retaining of raining water

4 water storage tanks

PV system

Public health centre (with PV system)

Graveyard

Island deputy's house

PV system (abandoned)

Football field

PV system

School

Mosque

General Information

Population	300
No. of households	81

Overview of Koh Bulon Don - Local Habits

Fishery Schedule

- At 06:00 the fishermen are usually leaving the island and return around 09:00
- some fishermen leave the island again around 16:00 for squid fishing and return around 21:00-22:00
- App. 5-6 days a month the island experiences low tides and the fishermen cannot leave according to their regular schedule: they depart later between 08:00 to 09:00 and return at around 12:00

Seasonal Fluctuations

High (Tourist) Season: October- April

- 80 % of people are leaving the island (to work in Koh Lipe) and come back to Don occasionally
- 20 % of the remaining population are students, women with young children/babies & old people

"Transition" Season: After April (depends on each year, May/June):

- 100 % on the island

Monsoon Season: After May (depends on each year):

- If there is enough to fish around the island, they stay on the island
- If there is not, 60 % of the people are leaving for 4-5 days a week to fish in other areas

Power Generation on the Island – Diesel Generators

Previous Situation: 1st Community DG, Centralized Mini-Grid

- **Community DG** supplied electricity to 79 households through community grid (25 kW generator)
- Generator was procured and installed by SAO, incl. transmission grid (3-phase system) to supply all households
- *broke down mid 2016*

Transition Phase: HH DG, Micro-Grids

- **15 Small DG** supplied groups of households (2 – 10 households)
- Mid 2016 – end 2017

Current Situation: 2nd Community DG, Centralized Mini-Grid

- **Community DG** supplies electricity to 79 households through community grid (50 kW generator)
- Generator was procured and installed by SAO using the previous community grid (now reduced to 2-phase system)

Power Generation on the Island – Diesel Generators

Previous situation

- 26 kW community DG supplied electricity through grid
- DG broke down 1 year ago

Transition Phase

- 15 small DGs supplies electricity to group of households

Possible scenario – transition to RE Hybrid System

New 50 kW DG provided by SAO supplies the community until the hybrid system is implemented (generator will be used on the neighboring island afterwards)

Power Generation on the Island – Solar Home Systems

- Around **20 SHS** observed
- 130 Wp panel

Power Generation on the Island – Community PV Systems

PV system
@ water storage
3 kWp (for streetlights)
Not working

PV system @ public health centre
220 Wp (not working) +
1.71 kWp (working)

Abandoned PV system
@ beachfront

PV system @ School
5.12 kWp (not working)
+ 3.0 kWp (working)

Grids – Existing Community Grid (out of order)

- Installed & operated by SAO
- 79 households connected
- 3 L + 1 N (50 mm^2 THW-A)
- Supplied by 25 kW/50 kW community DG
- Supply hours: 18:00 – 22:00 (4 hrs)

- Previous Tariff:
  300 THB/month/HH
  only light bulbs, TV, and fans are allowed

- Current Tariff:
  200 THB/month basic tariff
  Light bulbs only
  300 THB/month plus fan
  450 THB/month plus TV
  600 THB/month plus washing machine

- Tariff structure was determined by the community

Power Demand

Households

Example of household in Koh Bulon Don

Typical appliances

- 2 – 4 light bulbs
- 1 – 2 mobile phones
- 1 – 2 fans
- TV (mostly)
- Washing machine (some)
- CD player (some)

Public Buildings

(1) School, (2) health centre, and (3) mosque

Health Centre

School

Additional appliances

- Refrigerators (school)
- Internet router (school)
- Computers (school)
- Water pump (school)
- Speaker (mosque)
- 350 W Oxygen concentrators (health centre)

Current Tariffs and Willingness to Pay

Transition Phase (Micro-Grids)

- Residential type I :

  12.78 – 42.30 USD/month

  435 – 1,440 THB/month

- Residential type II :

  12.78 – 63.45 USD/month

  435 – 2,160 THB/month

Current Situation (Community Mini-Grid)

- 6.4 – 19.1 USD/month
- 200 – 600 THB/month

Willingness to Pay (Survey)

- Residential type I :

  14.69 – 29.38 USD/month

  500 - 1,000 THB/month

- Residential type II :

  8.81 – 44.07 USD/month

  300 – 1,500 THB/month

Other Infrastructure - Road

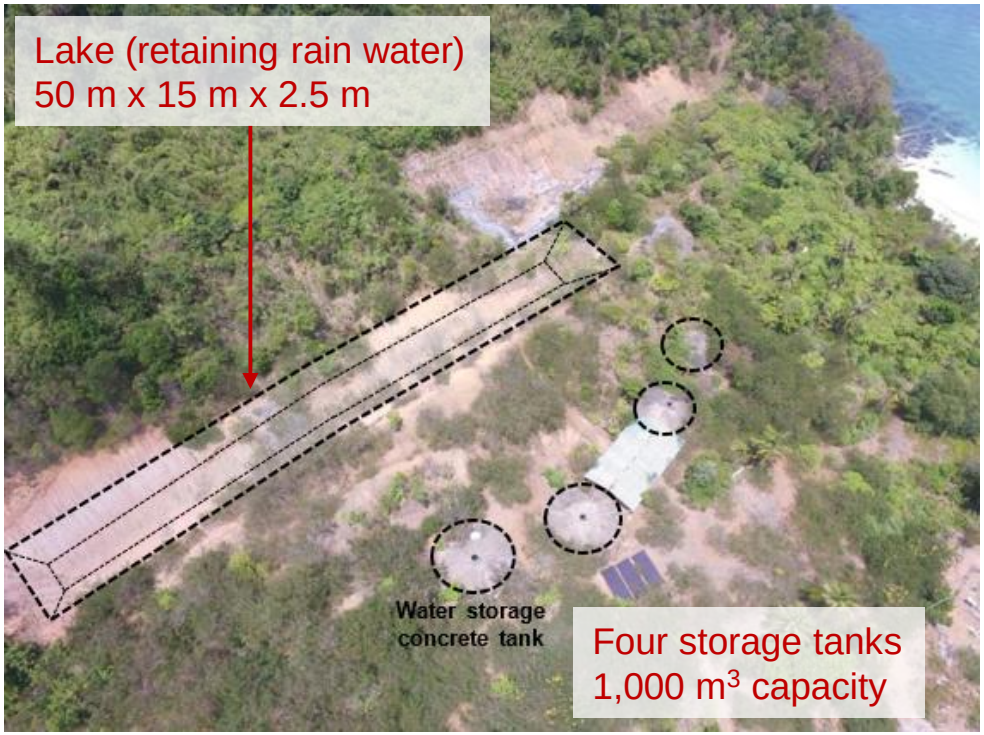
- Only dirt road on the island
- No vehicle in use; walking only
- Community is settled in one small area (within 200 m radius)

Other Infrastructure - Pier

- Concrete pier suitable to ship equipment at Pak Bara

- No pier on Bulon Don Island
- Boats can approach the island on the East coast
- Can be accessed during high tide only
- As the island is far off-shore, weather conditions may affect the accessibility (wind direction etc.)

Other Infrastructure – Water Storage System

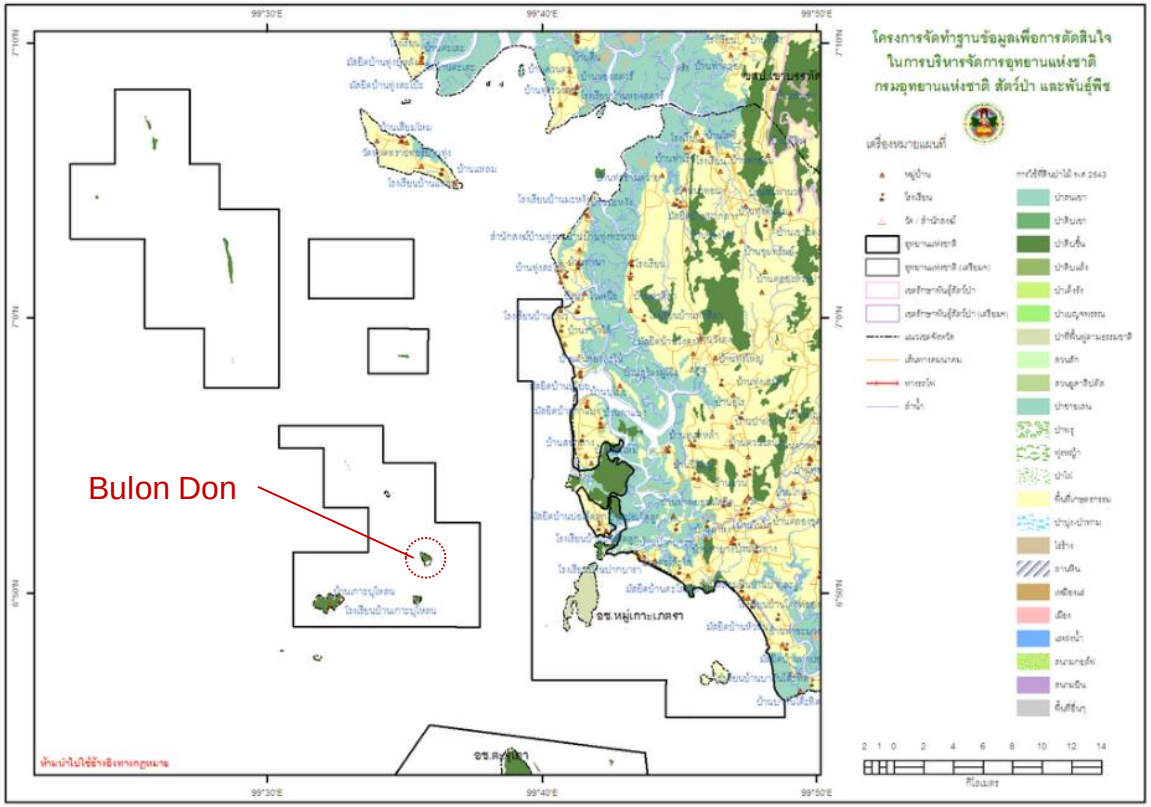


- Primary source of water: rain water collected by each HH
  right picture
- Backup: rain water storage tanks on the hill installed by Satun Royal Irrigation Dept.; built in 2005
  left picture

- Note: SAO is planning to bring a water purification unit to the island (no technical specifications yet, more detailed information will follow)

- Note: water storage area is one option for powerhouse and PV installation; e.g grey roof area between the storage tanks

Other Issues – Land Use Rights



- Bulon Don Island is part of Mu Koh Petra National Park
- The project needs to be proposed to the local and central National Park Office (encouraging the community benefits, containerized “non-permanent” solutions might be beneficial)
- If the central National Park Office agrees, the system can be built

Source: Department of National Parks, Wildlife, and Plant Conservation

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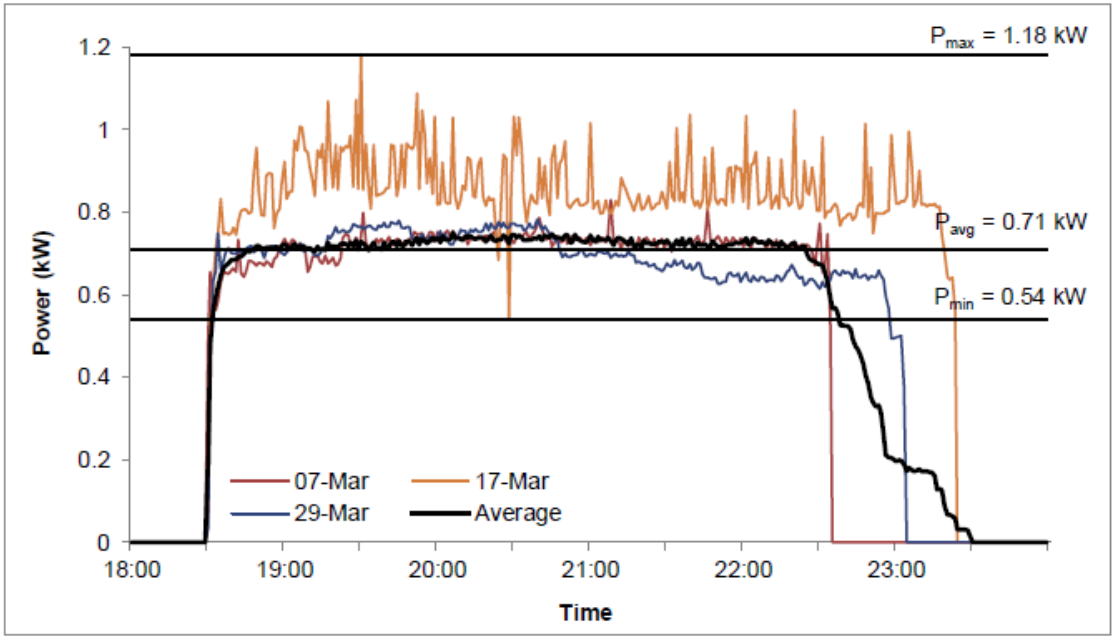
Renewable Energy Hybrid Grid Systems for Thai Islands

Koh Bulon Don – Proposed System Design

Load Profile – Measurement

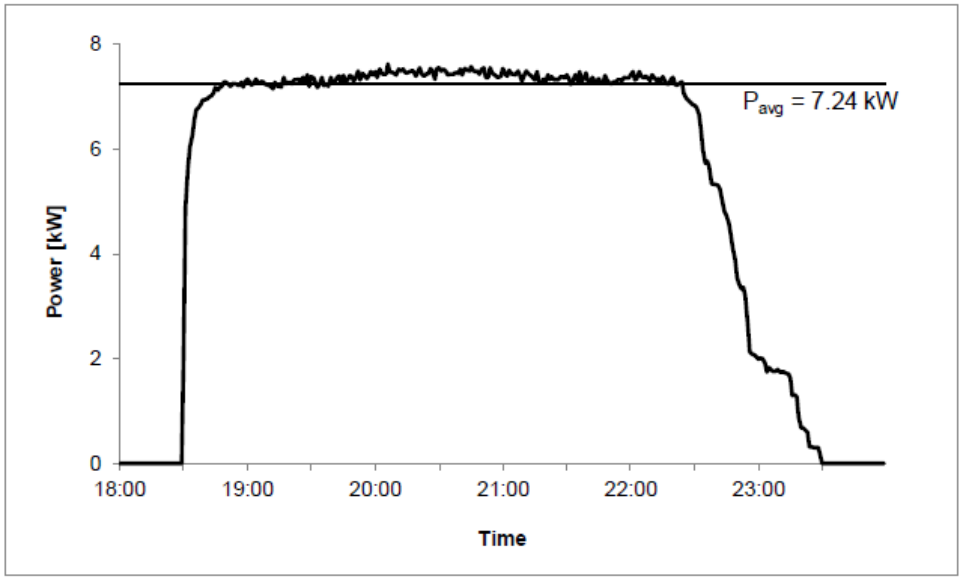
One Grid



Information	Value
Duration of measurement	1 month
Residential Type I (no TV) Residential Type II (with TV)	4 5
Max. Power	1,183 W
Average Power	711.3 W
Total Average Energy	3.1 kWh/d
Average Operation Hours	4.42 hours

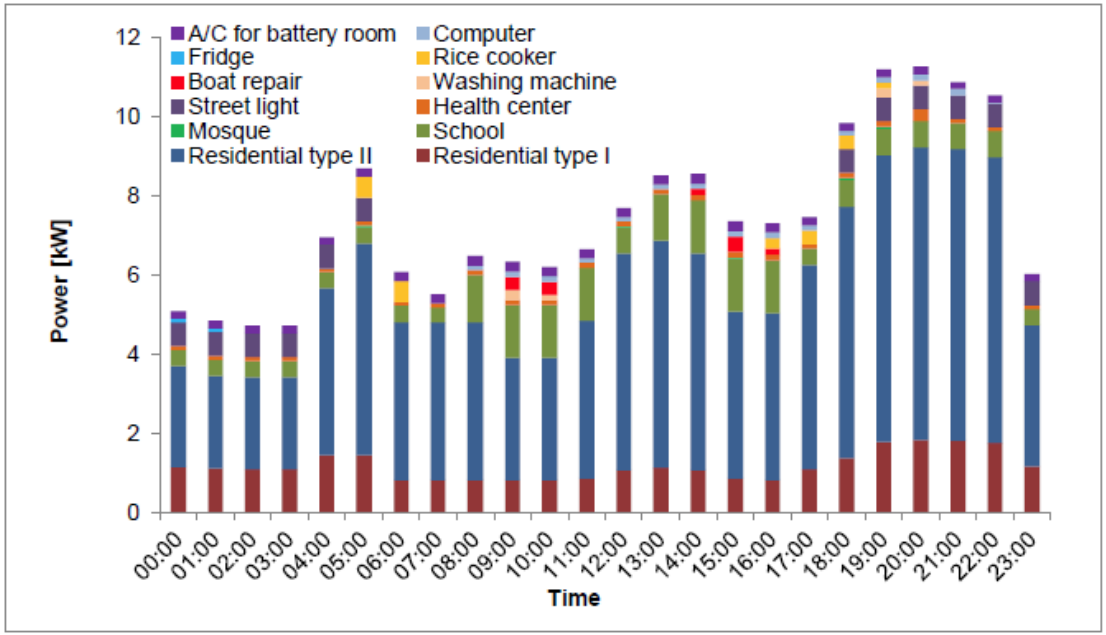
Load Profile – Measurement

Extrapolation for the whole island



Information	Value
Average Power	7.24 kW
Total Average Energy	32.01 kWh/d
Average Operation Hours	4.42 hrs

Load Profile – Forecast



Year	2018	2022	2027
Energy Demand [MWh/a]	65	90	105
Energy Generated [MWh/a]	66	91	106

System Design – Overview

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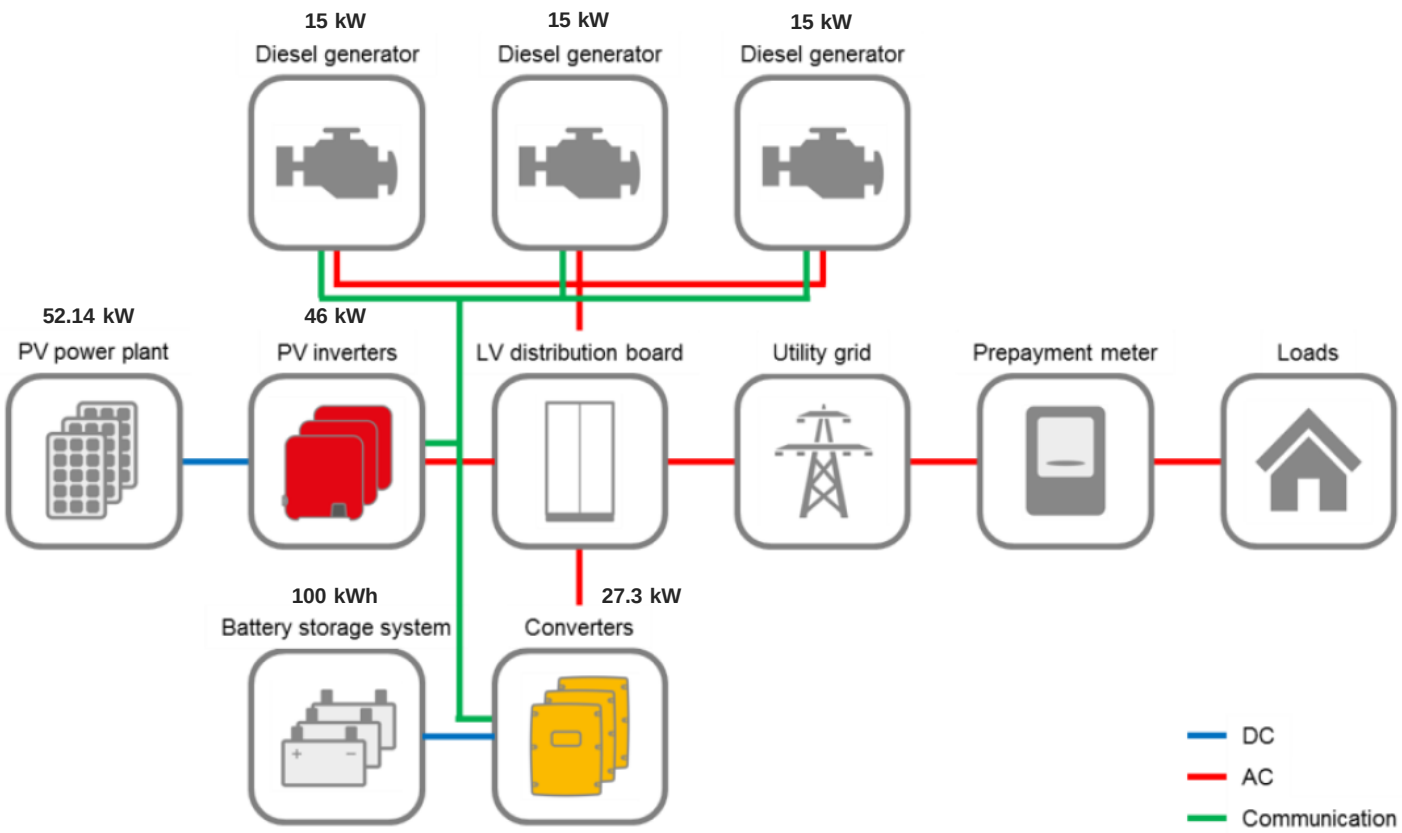
Potential PV System & Powerhouse Locations

Diesel	PV	Battery
3 x 15 kW	52.14 kWp	100 kWh

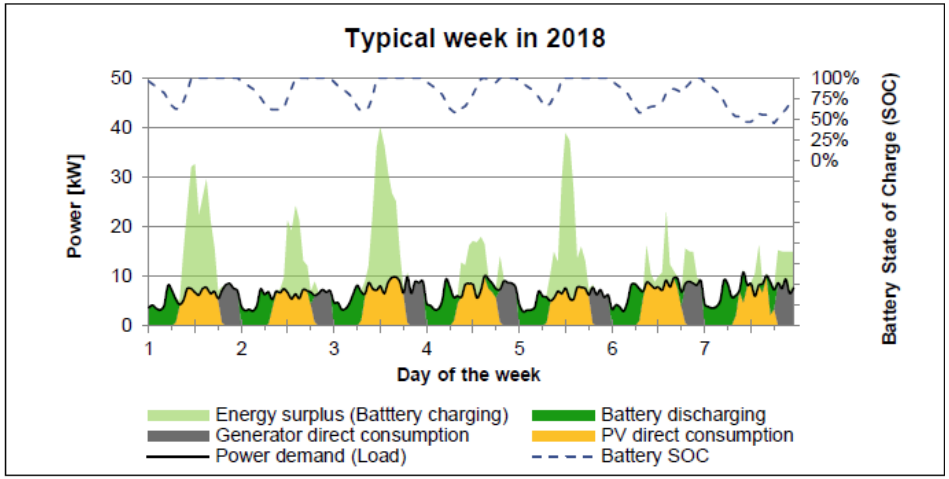
Distribution Grid
220 V
350 m (with 200 m extension)

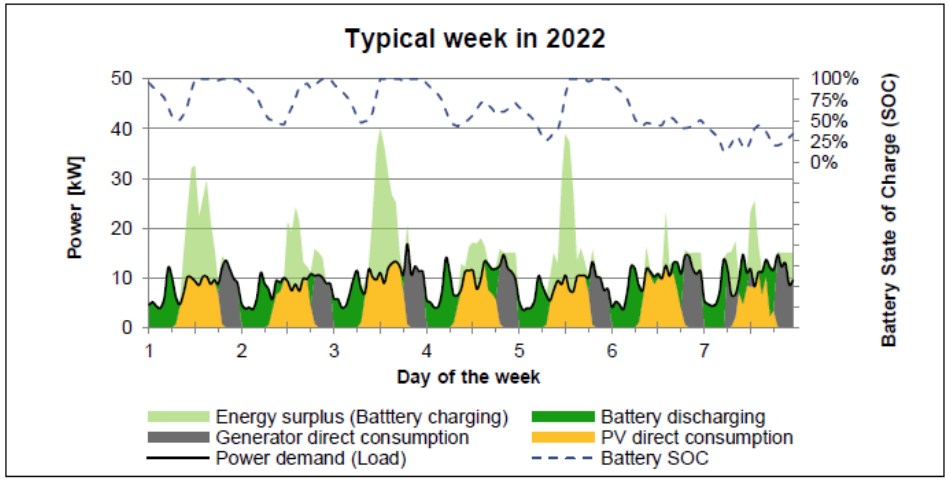
Icons: The Noun Project
Generator by Jon Trillana
Solar panel by Saeful Muslim
Battery by Ben Davis
Electricity Pole by Ben Davis

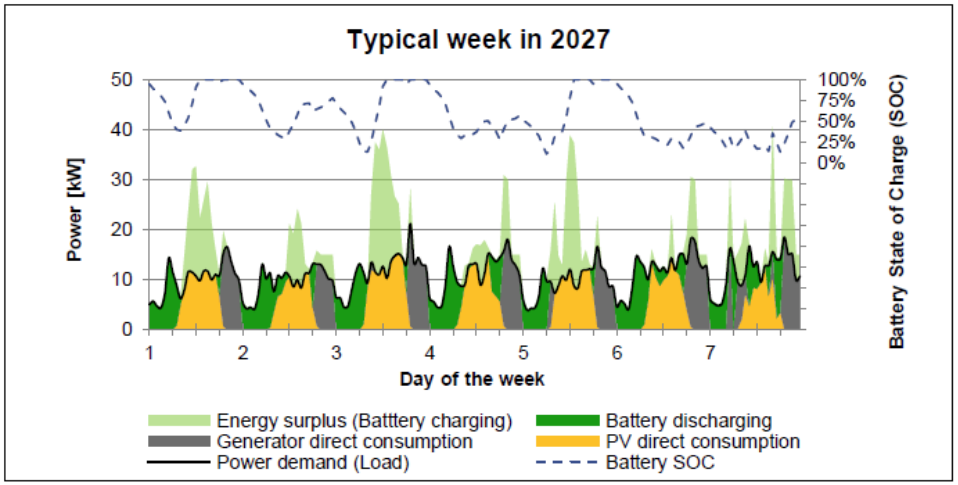
System Design – Overview



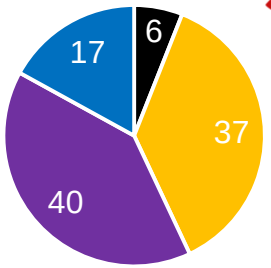
System Design – Operation Mode







Financial Figures - Overview



CAPEX breakdown

	CAPEX	OPEX	No. REPLACEMENT
Diesel generator	373,950 THB	3.74 THB/kWh (e.g. 2018: 93,276 THB)	5
PV	2,253,073 THB	34,662 THB/a	1
Battery	2,393,280 THB	40,686 THB/a	Battery: 3 Battery Inverter: 1
Other	1,028,778 THB	3,324 THB/a	-
Total	**6,049,081 THB**	**e.g. 2018: 171,948 THB**	

Project Lifetime

- **10-years** — **$LCOE_{10}$ = 18.21 THB/kWh**
- **20-years** — **$LCOE_{20}$ = 16.13 THB/kWh**
- **30-years** — **$LCOE_{30}$ = 16.44 THB/kWh**

Financial Figures - Comparison

Transition Phase (TP)

Decentralized setup (here calculated for Jae-Sen's generator); 4,5 hrs. of supply

$LCOE_{TP}$ = 63.69 THB/kWh

100 % Diesel Scenario (DS)

24/7 supply; 30-years project lifetime

$LCOE_{DS}$ = 22.53 THB/kWh

RE-Diesel Hybrid Scenario (RE)

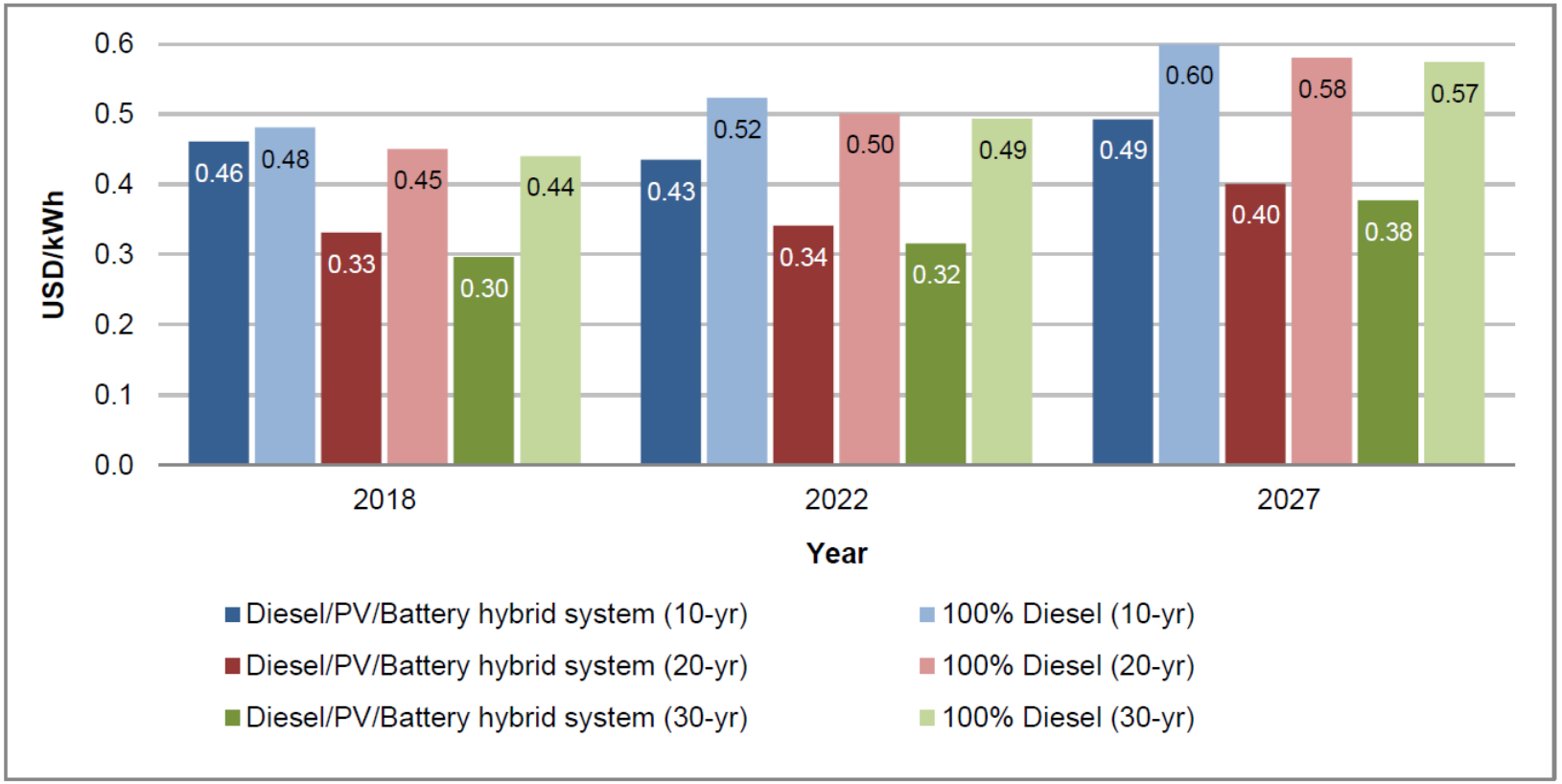
24/7 supply; 30-years project lifetime

$LCOE_{RE}$ = 16.44 THB/kWh

Financial Figures - CAPEX

	Amount	Cost per Unit [THB]	Total Cost [THB]	Cost per Unit [USD]	Total Cost [USD]
PV	52.14 kW	44,239	2,306,621	1,300	67,782
Battery	100 kWh	23,983	2,398,300	720	72,000
Diesel	15 kW x 3	8,508	381,240	250	11,250
Grid	150 m	298,232	298,232	-	8,800
Pre-paid Meter	81 units	5,105	411,763	150	12,150
Powerhouse	1	340,300	340,300	-	10,000
Total CAPEX:			6,136,456		181,982

Financial Figures - Real Generation Cost



Financial Figures - Generation Cost & Willingness to Pay

	Residential type I	Residential type II
Willingness to pay	14.69 – 29.38 USD/month (500 - 1,000 THB/month)	8.81 – 44.07 USD/month (300 – 1,500 THB/month)
Current electricity expenses	12.78 – 42.30 USD/month (435 – 1,440 THB/month)	12.78 – 63.45 USD/month (435 – 2,160 THB/month)
Generation costs according to 1st year of operation (2018) for 20-year lifetime scenario		
▪ Basic appliances (light, fan, mobile phone charger, TV)	10.30 USD/month (350.59 THB/month)	19.63 USD/month (668.04 THB/month)
▪ Rice cooker	7.37 USD/month (250.84 THB/month)	
▪ Fridge	5.30 USD/month (180.41 THB/month)	
▪ Washing machine	1.86 USD/month (63.24 THB/month)	
▪ Computer	2.82 USD/month (96.04 THB/month)	

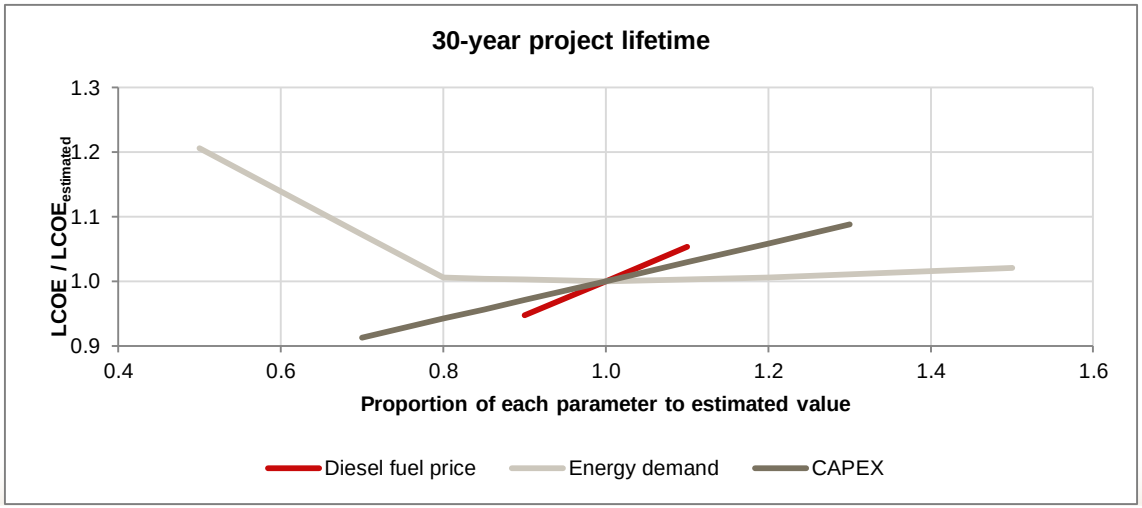
Economic and Environmental Impact

Project life time/ scenario	RE/Diesel Hybrid LCOE	100 % Diesel LCOE	LCOE Reduction[1]	RE Fraction (RE/Diesel Hybrid)	CO2 Reduction[1]
Unit	USD/kWh THB/kWh	USD/kWh THB/kWh	%	%	t/a
10-years	0.535 18.21	0.545 18.55	1.83	62	48
20-years	0.474 16.13	0.594 20.22	20.20	54	53
30-years	0.483 16.44	0.662 22.53	27.04	47	55

1: in comparison with 100 % Diesel Scenario

Sensitivity Analysis

CAPEX	± 30% variation in CAPEX leads to a ± 8.74% variation in LCOE.
Energy Demand	+ 50% variation in energy demand leads to a + 1.0 % variation in LCOE. – 50% variation in energy demand leads to a + 1.2 % variation in LCOE.
Fuel Price	± 10% variation in fuel price leads to a ± 5.27% variation in LCOE



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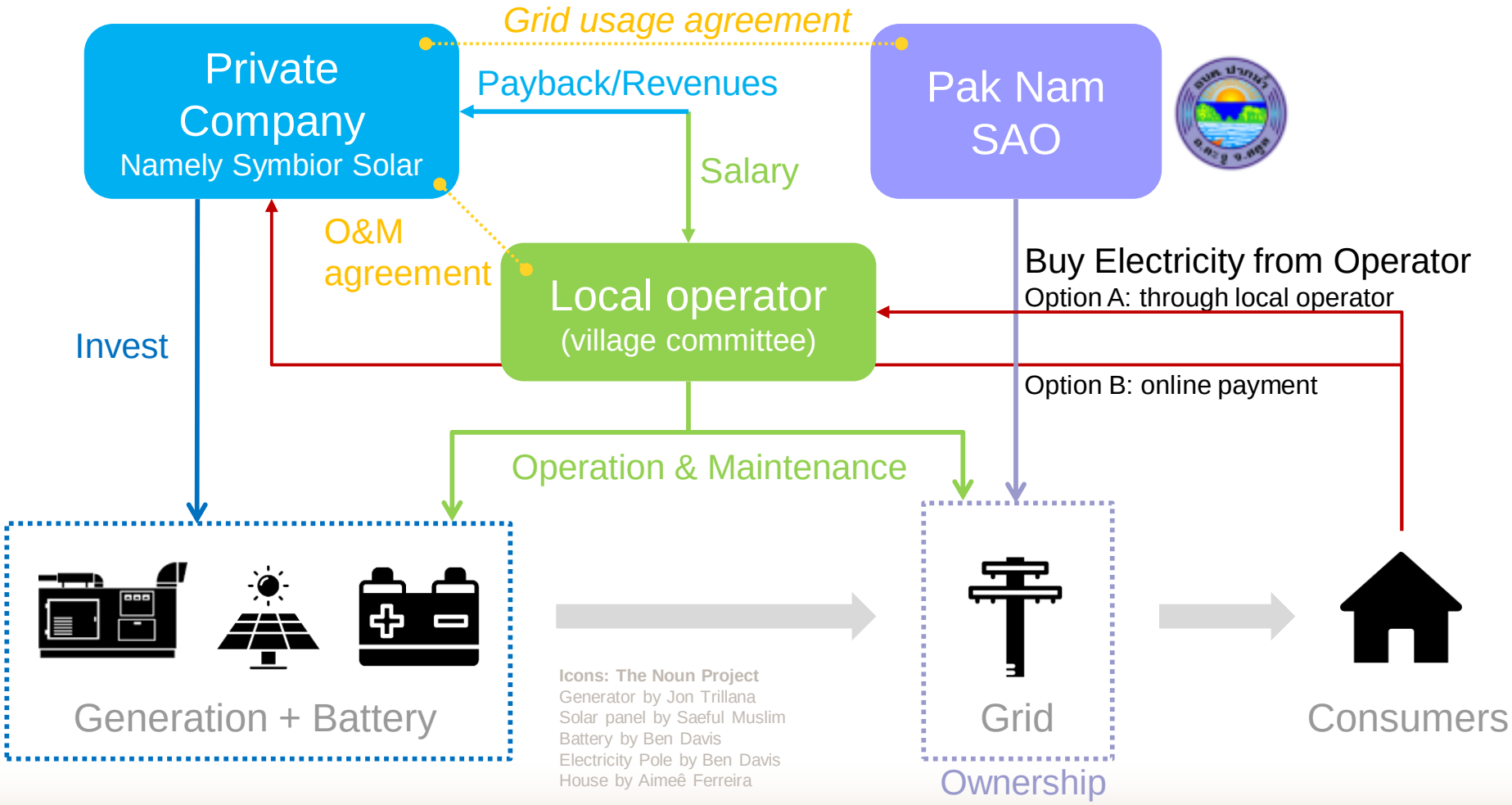
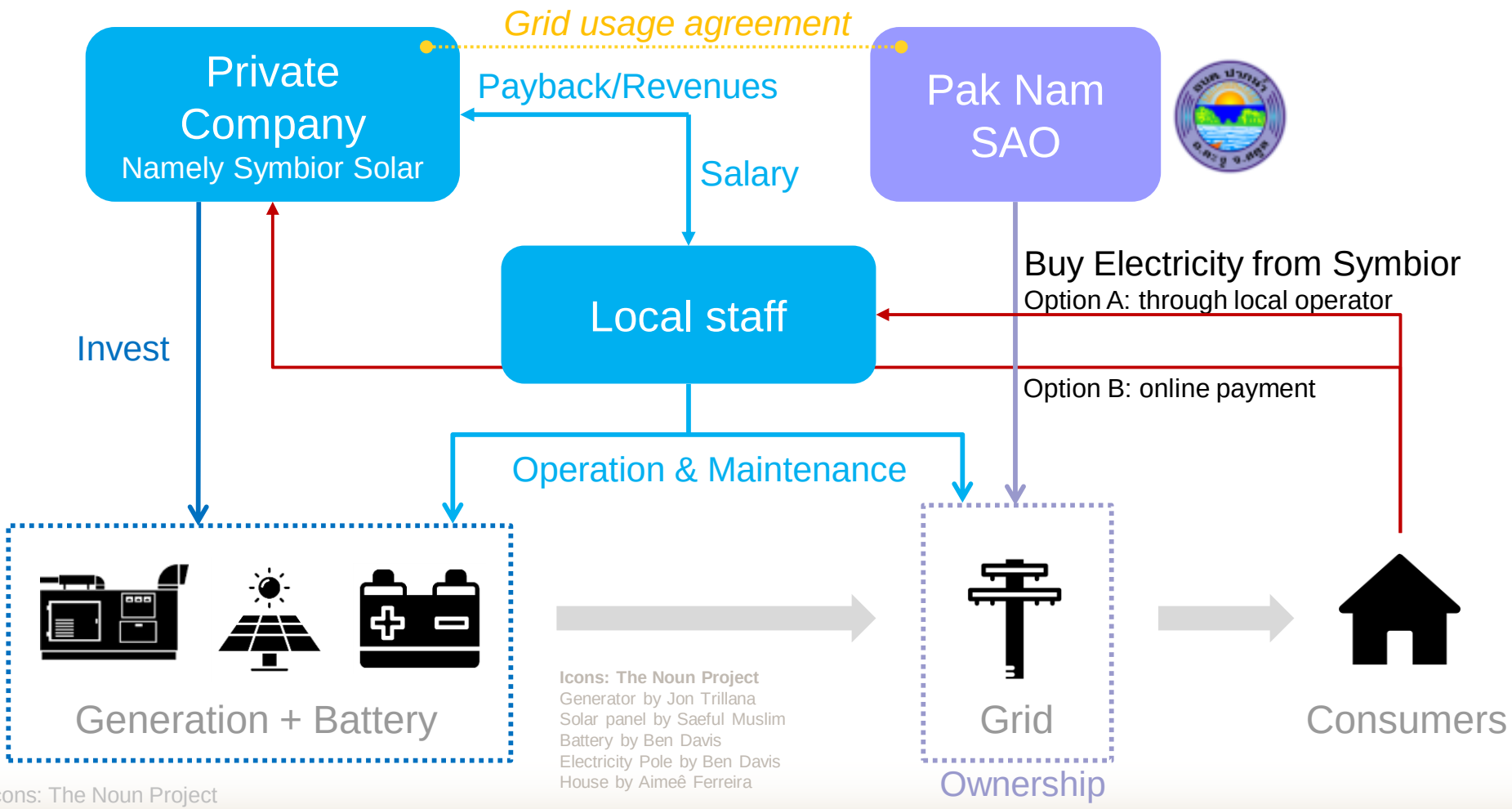
Koh Bulon Don – Business Model

Public Private Partnership - Option A



Public Private Partnership - Option B



Icons: The Noun Project

Public Private Partnership – Model Explanation

Model Explanation:

- the private company invests in the generator, PV and bettery system as well; they own and operate the system A) through a community operator or B) through a local staff member
- the community operator/staff member is also responsible for accounting and maintenance (and gets paid by the private company
- SAO financed and owns the grid
- Concession agreement between SAO and private company to utilize the existing grid

Financing Options:

- CAPEX by company's own sources and financing institutions & SAO (grid)
- OPEX covered by revenues generated through operation of the system (electricity tariffs)
- After app. 10 years of operation, the system will be handed over to the local community who is then experienced enough to run the system

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Renewable Energy Hybrid Grid Systems for Thai Islands

Koh Bulon Don – Next Steps, Impact & Outlook

Next Steps (prelim.)

GIZ Support

Symbior Solar

- Financial Calculation; Tariff & Payment Structure; Legal Setup — Q3 2017
- Project Proposal to Community — Q3 2017
- Written Project Proposal to Ko Mu Phetra National Park — Q4 2017
- Grid Concession Agreement SAO — Q4 2017
- Capacity Building Measures — Q1-4 2018
- Construction & Commissioning — Q1-2 2018

Community

- Feedback on Tariff & Payment Structure — Q3 2017
- "Community Electricity Committee" or local staff representative — Q1 2018
- Participate in capacity buildings measures & support construction — Q1-2 2018

Pak Nam SAO

- Further political support of the project *& grid concession agreement* — Q4 2017
- Transfer 50 kW d. generator to Bulon Lae after system implementation — Q2 2018

National Park

- Deliver information on Koh Mai Pai Office — Q3 2017
- Add supporting comments to the project proposal — Q4 2017
- Ask for approval from central National Park Office — Q4 2017

Impact

EPPO

- Asked GIZ to look into a strategic approach to electrify the remaining off-grid island communities in Thailand and present this to EPPO

  Might have a major impact on the mini-grid policy and reduce market barriers; mini-grid projects will develop faster

Symbior (Private Company)

- Interested to develop further island projects and create a pipeline of mini-grid projects

  Potential to scale up and benefit from lessons-learnt

Other Private Companies

- Showed interest in mini-grid projects on bigger scale (pipeline of projects or bigger project size)

Outlook

Reaching the last mile…

- RE hybrid grid systems are the perfect match to electrify more Thai islands
- the need is identified and methodology developed; scalability is proven
- project served as inspiration to propose a large scale project

Any questions…?

Contact

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Further Information:

http://www.thai-german-cooperation.info