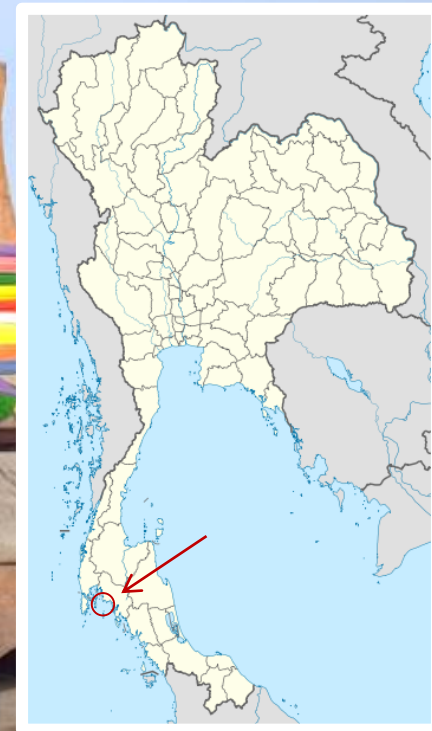




Renewable Energy Hybrid Grid Systems for Thai Islands



Koh Mak Noi – Project Summary

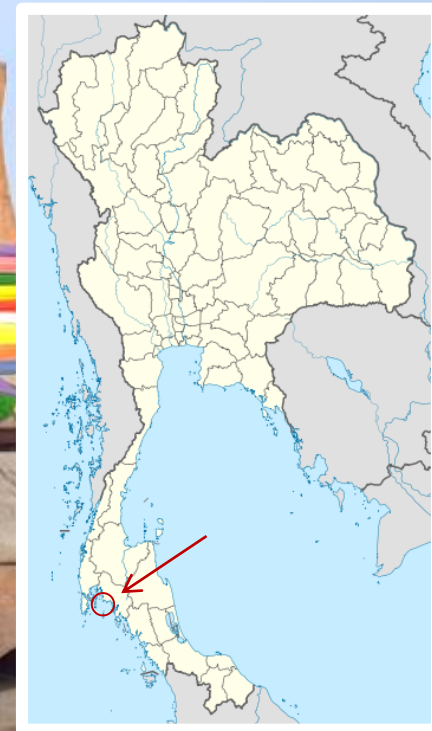


Contents – Koh Mak Noi

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



Renewable Energy Hybrid Grid Systems for Thai Islands



Koh Mak Noi – Introduction

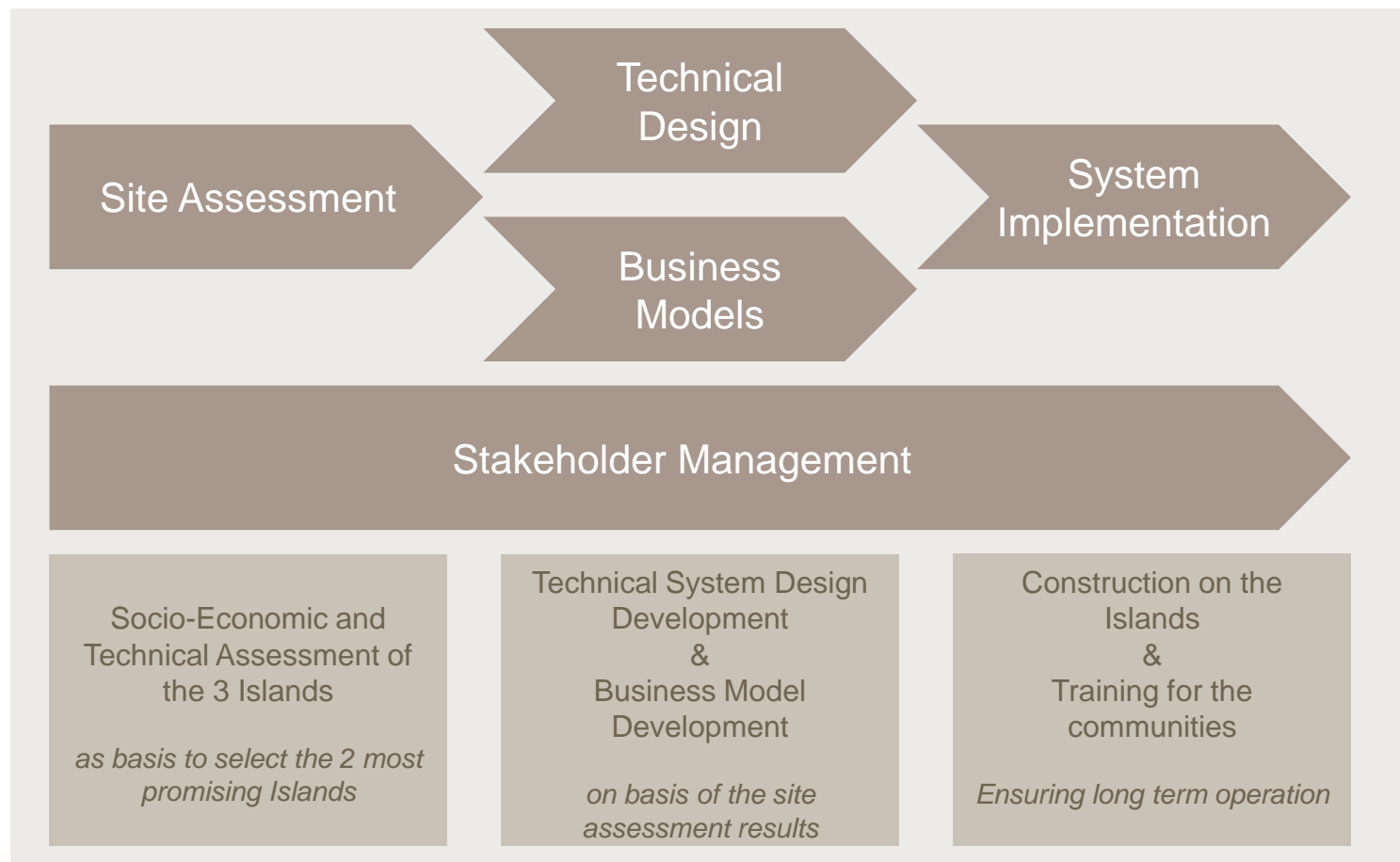


Introduction – Project Milestones



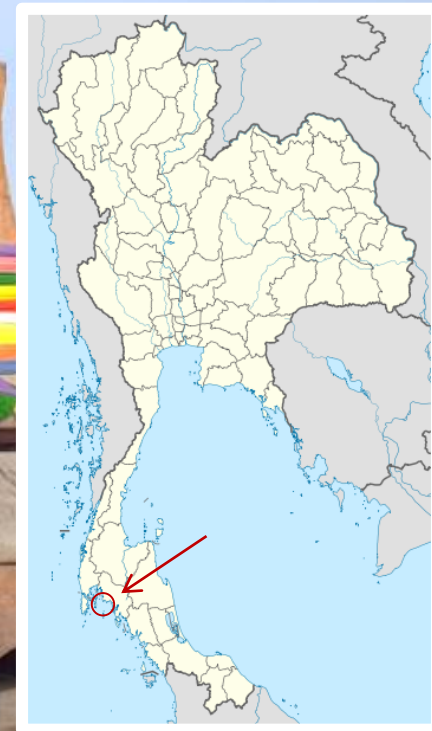


Introduction – Project Process





Renewable Energy Hybrid Grid Systems for Thai Islands



Koh Mak Noi – Site Assessment Summary



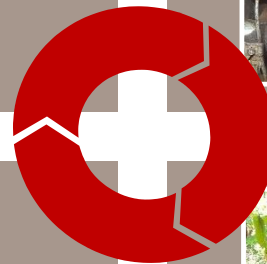
Site Assessment - Approach



Meeting with
community
representative
&
Island walk



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



Community Meeting



Survey
&
GPS mapping



Koh Mak Noi – Impressions



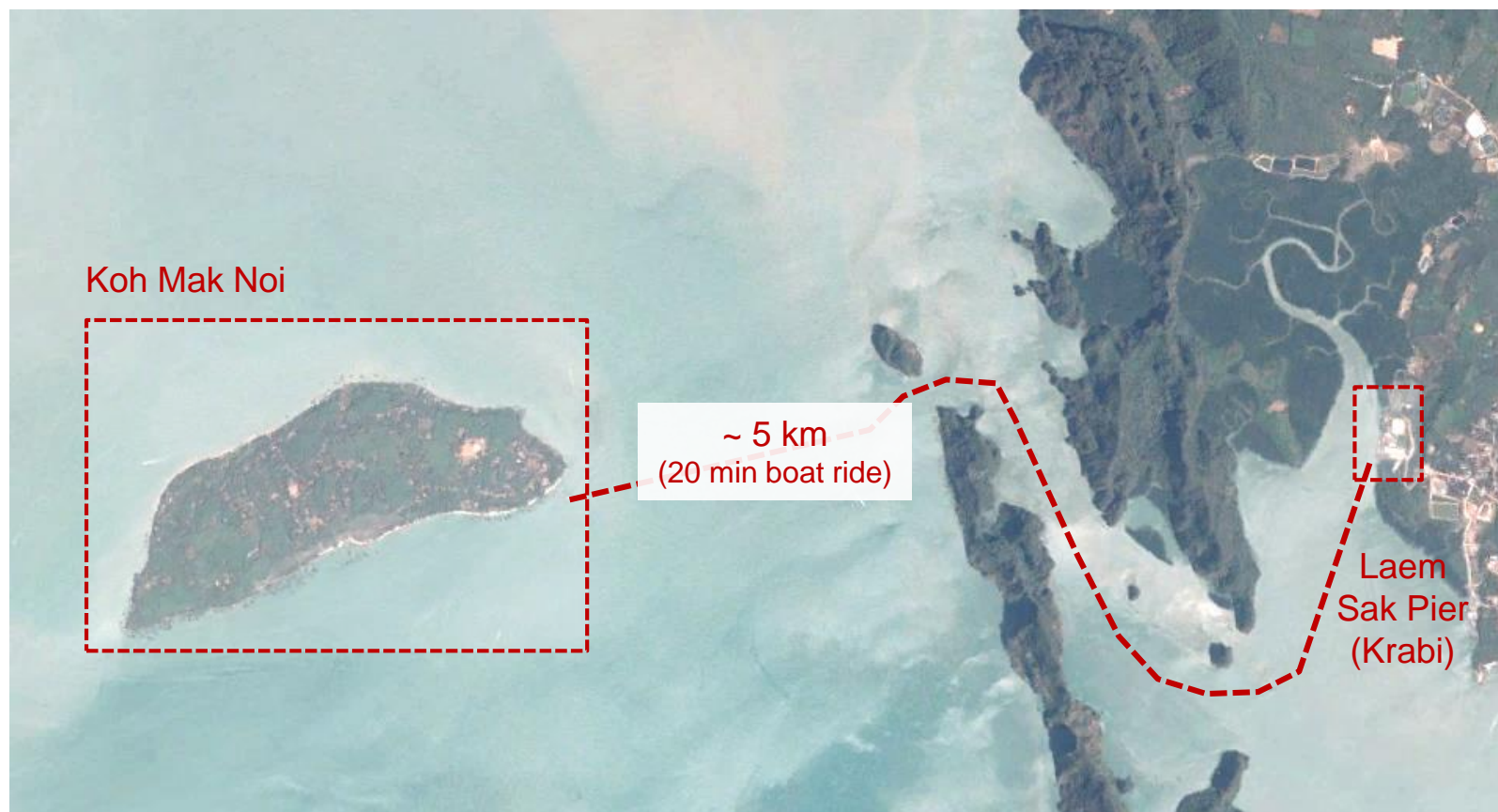


Overview of Koh Mak Noi





Overview of Koh Mak Noi





Overview of Koh Mak Noi



- **5 main diesel generators**
- Supply electricity to customers via 5 standalone grids
- 18:30 – 22:00



- **48 small diesel generators**
- owned by some households as back-up



- Existing RE systems
- 4 PV + 1 PV/wind system



- Fishery and agricultural village
- Population considered as stable
- Different types of household (Low-load, high-load)
- Income range: 1,000 – 90,000 THB/month (average 7,500 THB/month)
- Low touristic potential



- Proper road infrastructure



Overview of Koh Mak Noi

Mosque



School



Health center



Tele. comm. tower



Pier



Water tower



Water pond



General Information

Population	1,400
No. of households	250
Area	2.4 km ²



Power Generation – Overview

- There are **5 main DG grids** (4 different owners) supplying electricity to 236 households.
- There are around **48 small diesel generators** owned by households
- There are **5 main solar systems** (one system with small wind turbines)
- App. **100 SHS** are still in operation

- Electricity tariffs: **THB 500 – 600 per month** (flat rate, independent of actual electricity consumption)



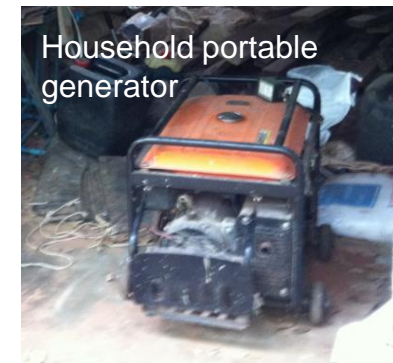
Power Generation – Diesel Generators

5 main diesel
gen.
(113 kW)



	Reference No.	Capacity	No. of HH
■	#40	40 kW	100
■	#41	40 kW	70
■	#68	15 kW	38
■	#66	15 kW	20
■	#62	3 kW	8

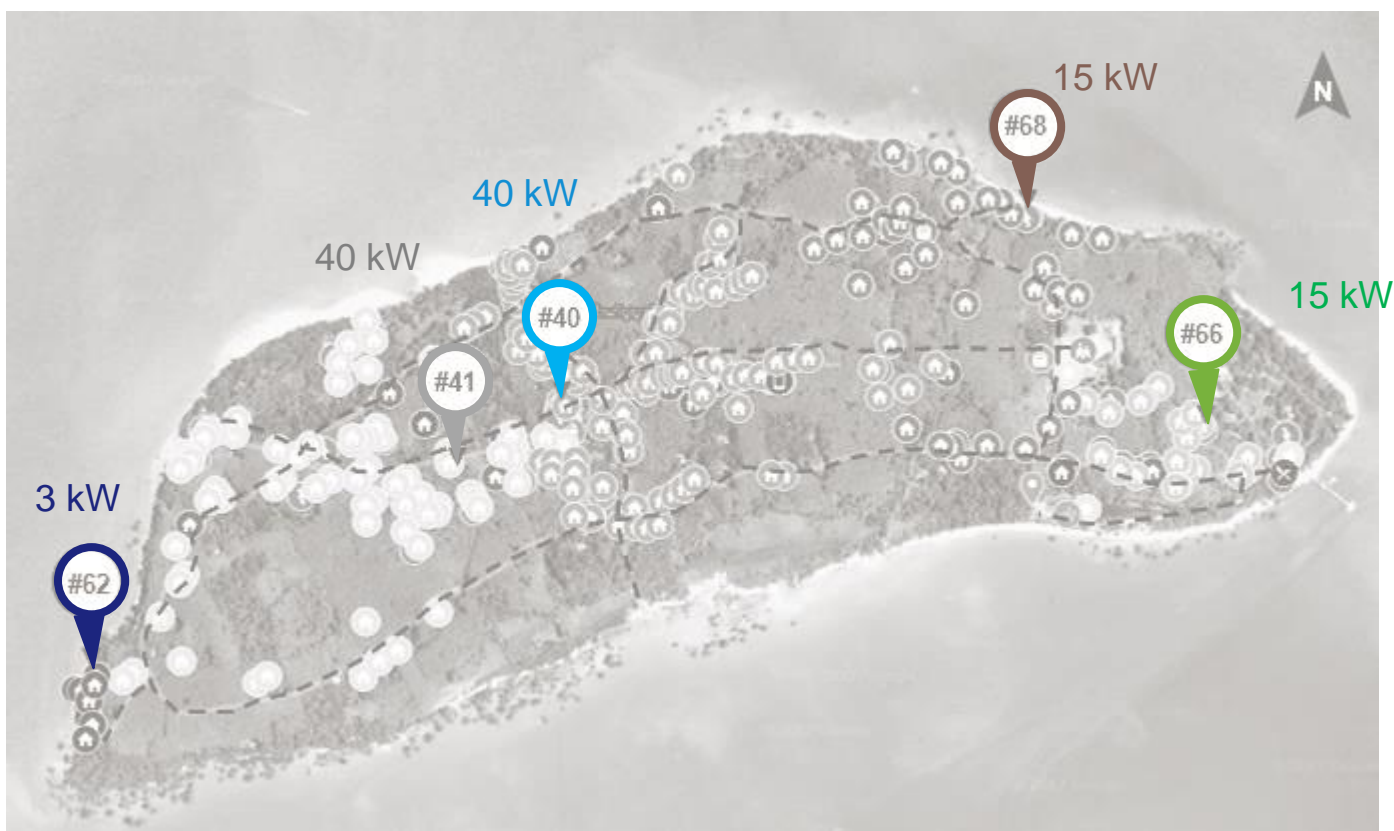
48 small diesel gen.



- Owned by several households
- Used as a back-up / daytime operation



Power Generation – Main Generators





Power Generation – Solar Home Systems (SHS)



250 SHS were distributed by the government:

- 120 Wp PV modules
- 100 Ah, 12 V batteries

- approx. 100 are still in operation



Power Generation – PV (& Wind) System

Mosque PV system

1.245 kWp (PV)



School PV system

5.12 kWp



Telecomm. PV system

12.98 kWp



Public health centre PV system

2.00 kWp



PV-Wind Hybrid system

5.08 kWp (PV)
5.00 kW (wind)





Power Generation – PV (& Wind) System

5 main solar PV / wind power systems



Tele comm. PV-system



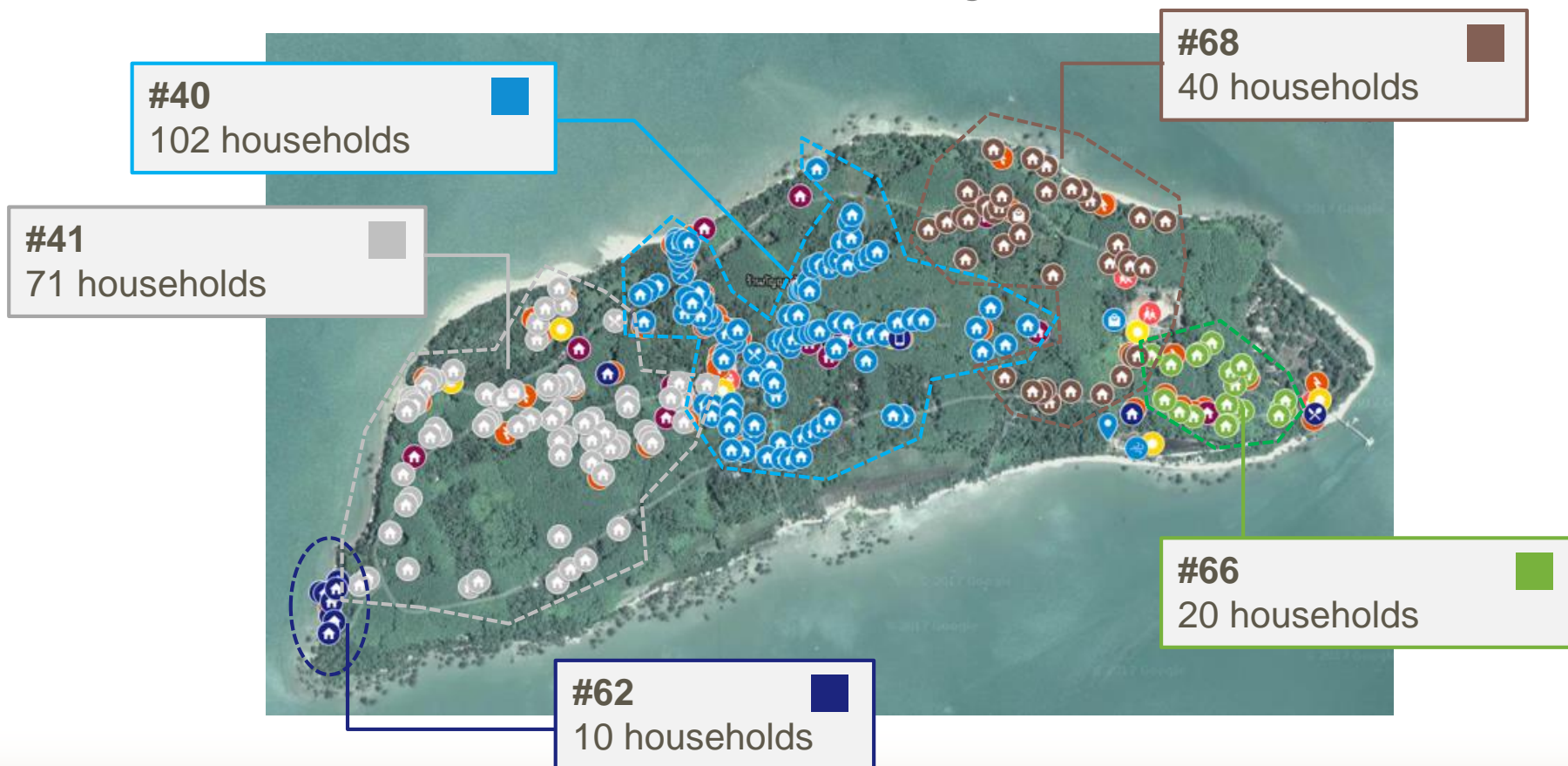
School PV-battery system

Location	Capacity [kWp]
1. Mosque	1.25
2. BTS tower	12.98
3. School	5.12
4. Health center	2.00
5. PV-wind hybrid system	5.08 solar 5.00 wind



Grids – Main Generators

236 households are connected to 5 main grids





Grids – Infrastructure

Cables are mostly anchored on wooden sticks and trees & the cable type is not suitable for outdoor usage





Power Demand

Households



Low-load household

Light bulbs, TV, mobile phone, fan



High-load household

Same appliances as low-load household
+ washing machine, rice cooker, iron

Public building

(i.e. Mosque, school, health center)



Light bulbs, TV, fan, computer, printer, speaker



Current Tariffs and Willingness to Pay

Current Tariffs

- **Residential type I :**
8.81-14.69 USD/month
300-500 THB/month
- **Residential type II :**
2.94-26.44 USD/month
100-900 THB/month
- **Residential Type III :**
11.75-17.63 USD/month
400-600 THB/month
- **Households + Small Businesses**
Shop, Restaurant, Boat Repair
8.81-60.81 USD/month
300-2,070 THB/month

Willingness to Pay

- **Residential type I :**
14.69-17.63 USD/month
500-600 THB/month
- **Residential type II :**
14.69-28.20 USD/month
500-960 THB/month
- **Residential Type III :**
14.69-17.63 USD/month
500-600 THB/month
- **Households + Small Businesses**
Shop, Restaurant, Boat Repair
11.75-60.81 USD/month
400-2,070 THB/month



Infrastructure – Road



Road condition:
Concrete, 3 – 3.5 m in width



Island's main road network



Infrastructure – Vehicle

Usual mode of transportation

Motorbike with side car



2-3 persons on side car

Motorbike without side car



Few pick-up trucks were observed on the island





Infrastructure – Boats

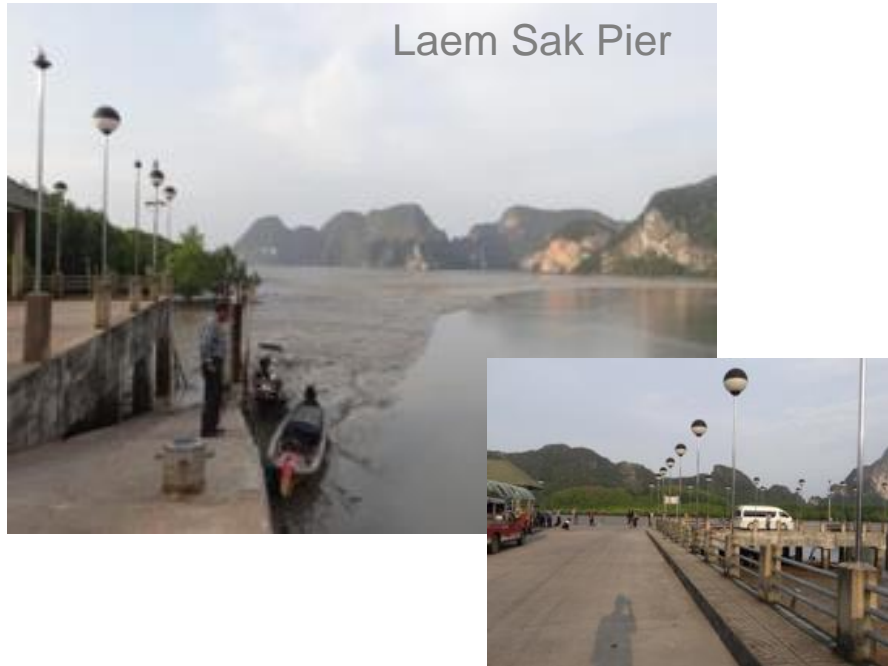
Capacity of ~ 20 persons





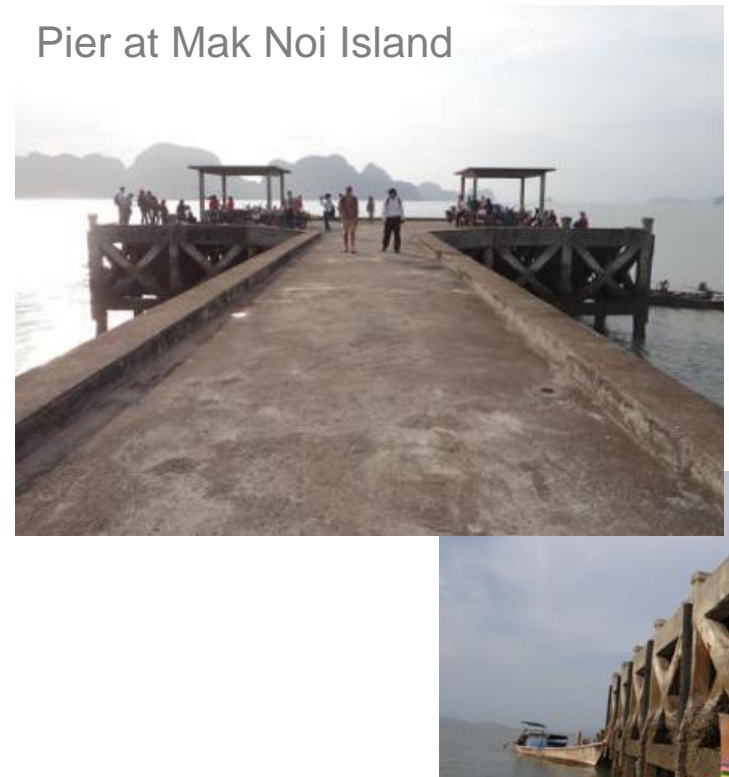
Infrastructure - Pier

Laem Sak Pier



- Concrete pier / accessible from main road
- Suitable for shipment of heavy goods during high tide

Pier at Mak Noi Island



- Concrete pier / accessible from main road
- The edge of the pier is always minimum 2m above sea level independent of the tide

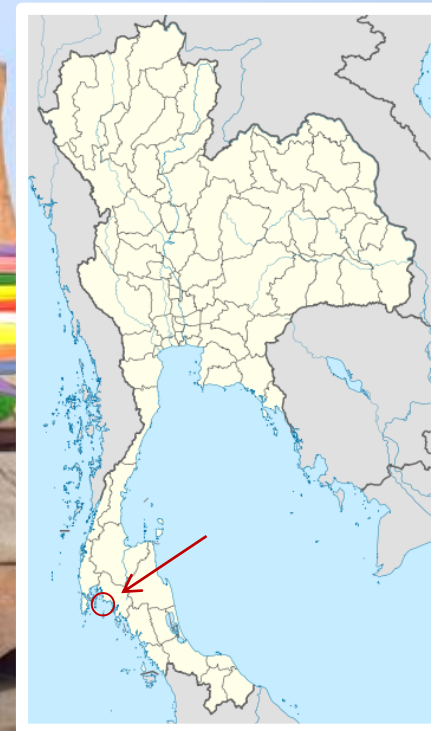


Other Issues – PEA Submarine Cable

- Submarine cable to Koh Mak Noi is part of PEA's network extension plan (2019 – 2021)
- Long process is foreseen:
 - Investment F/S >> Cabinet to approve >> Budget allocation >> EIA/EHIA study >> Procurement & construction
- PEA showed interested to implement a RE-diesel mini-grid as alternative to the submarine cable (close collaboration between GIZ and PEA was established)
- PEA is in a decision-making process



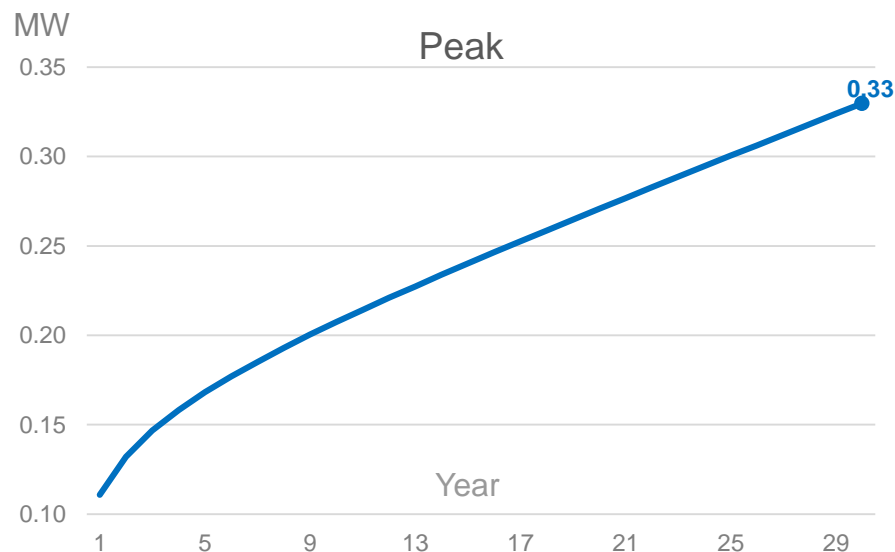
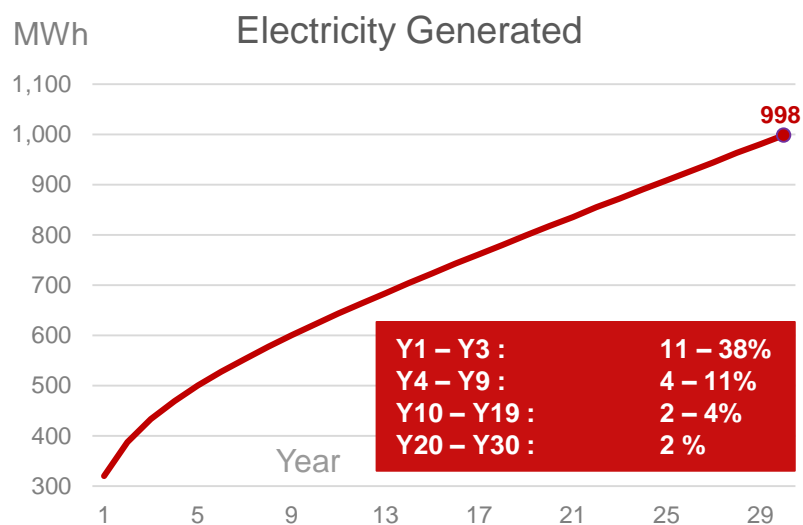
Renewable Energy Hybrid Grid Systems for Thai Islands



Koh Mak Noi – Proposed System Design



Load Profile – Forecast (PEA)



Year	2018	2022	2027
Energy Demand [MWh/a]	294	463	576
Energy Generated [MWh/a]	317	498	619
Peak Demand [kW]	90	140	170



Distribution Grid

22 kV & 220 V
9.5 km
5 Transformers

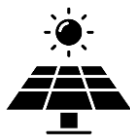
Diesel generator

3 x 80 kW



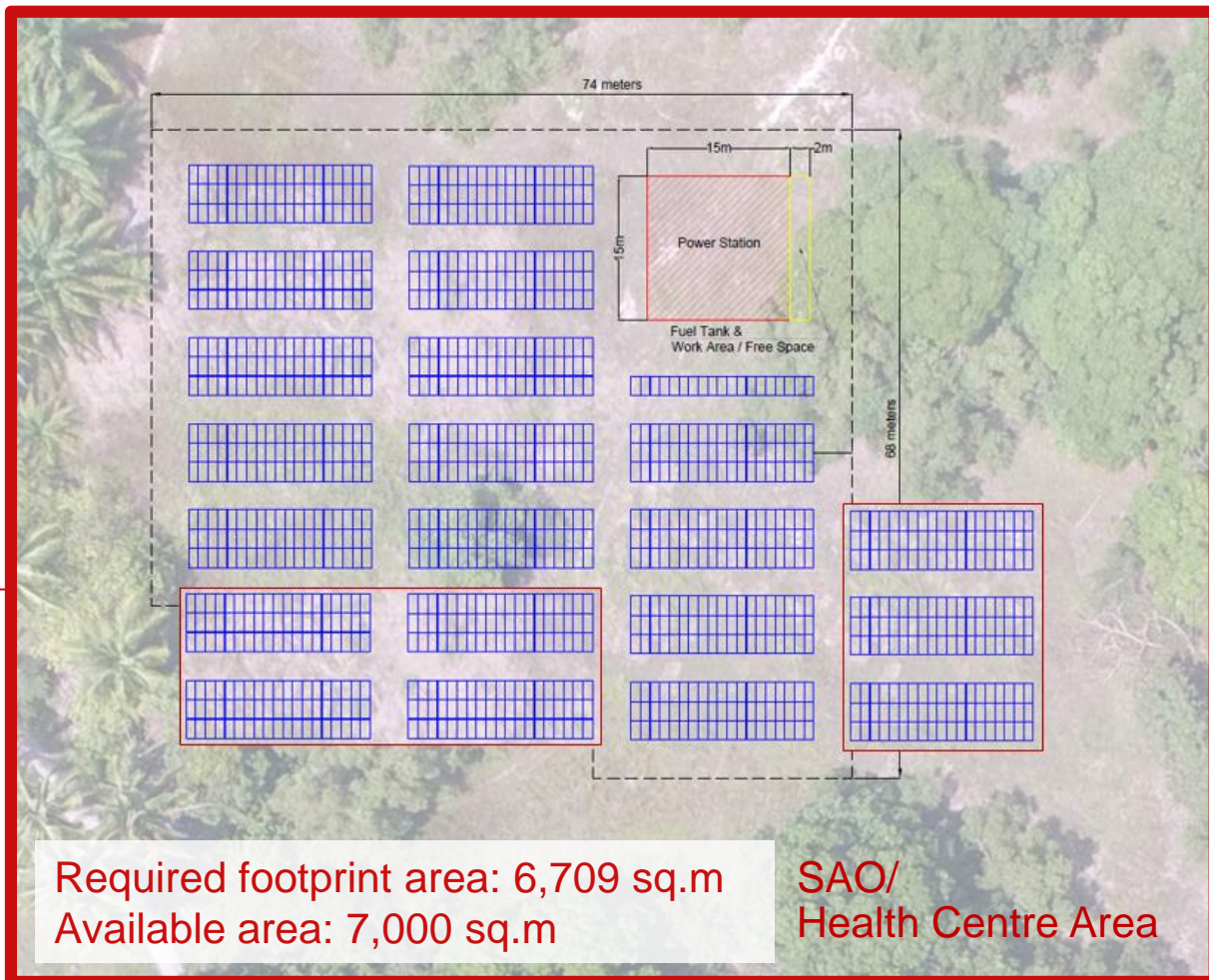
Solar PV

400 kWp



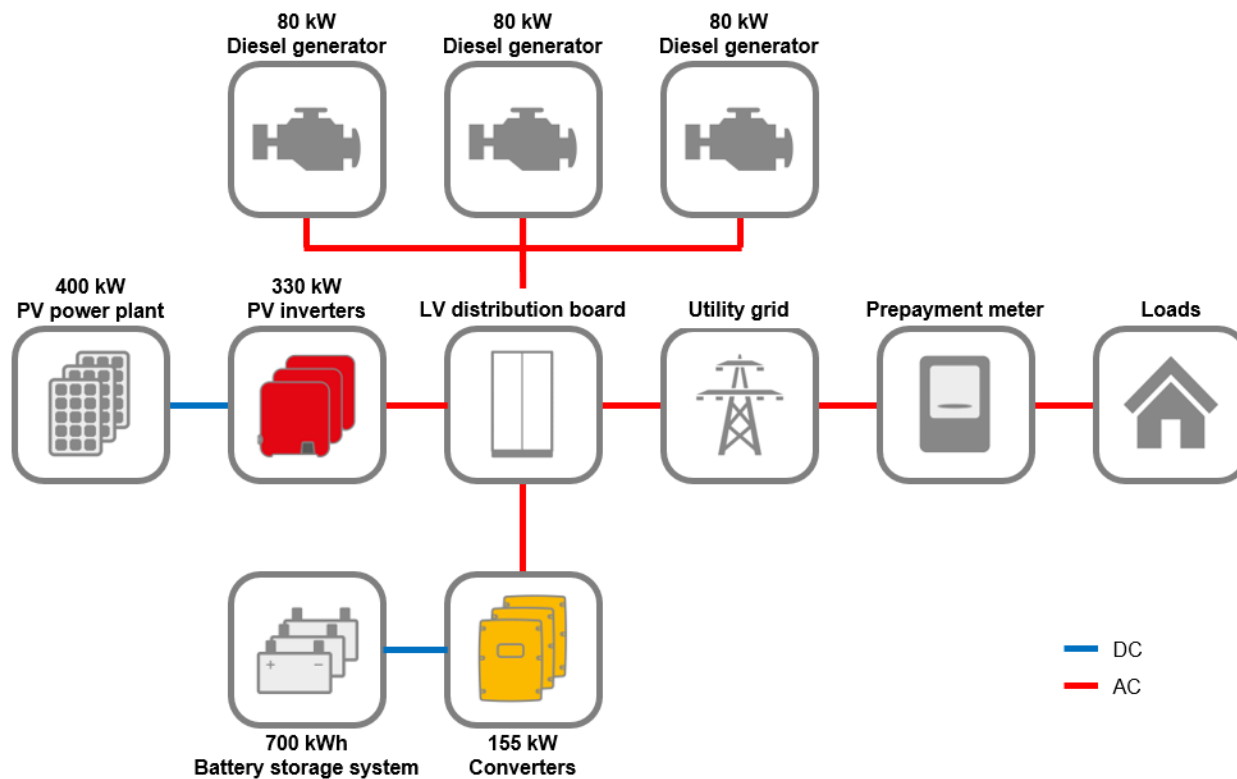
Li-Ion Battery

700 kWh





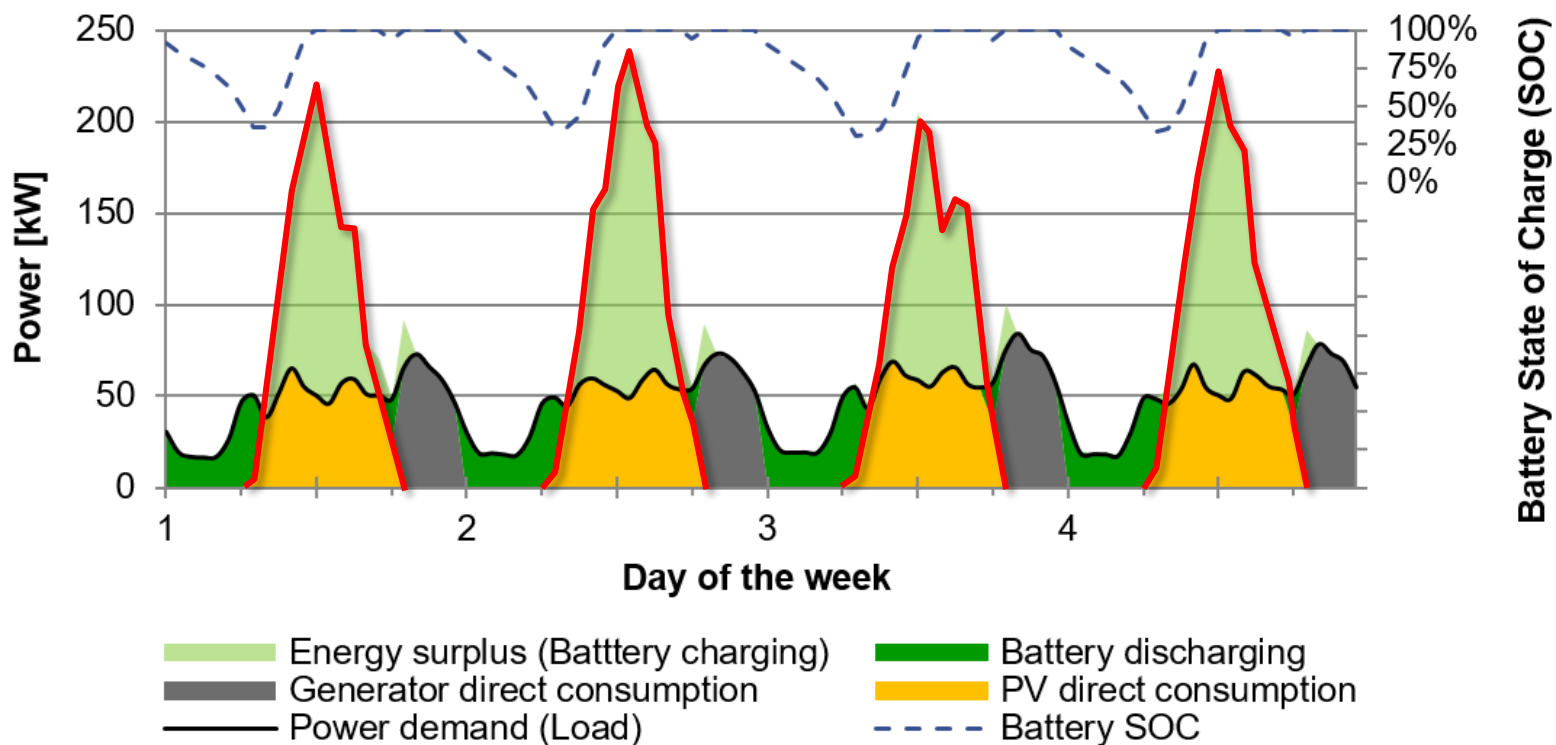
System Design – Overview





System Design – Operation Mode

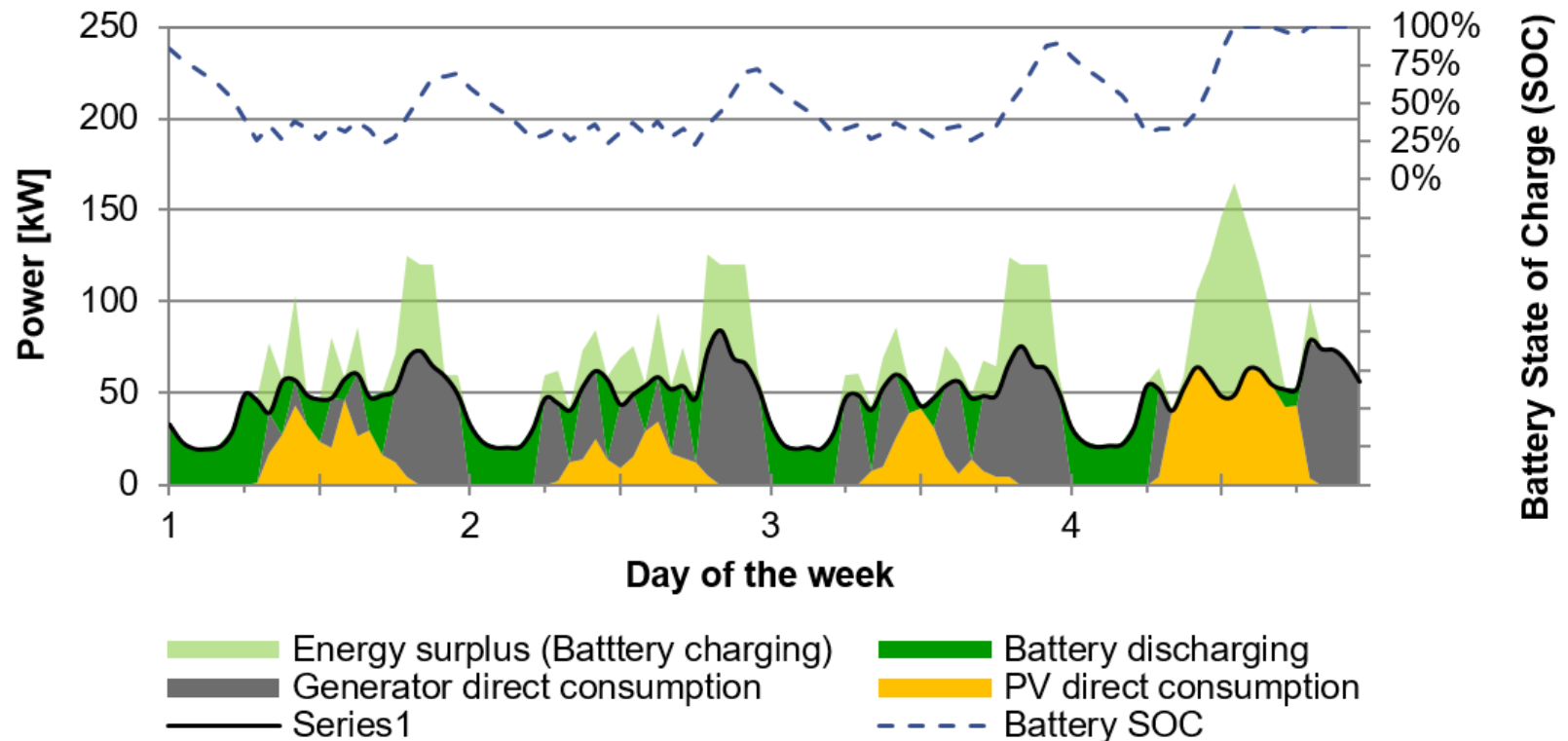
4 consecutive good days





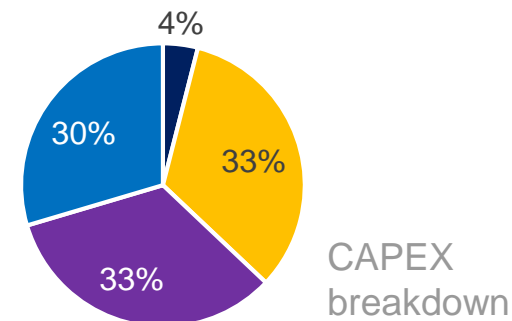
System Design – Operation Mode

3 consecutive bad days and 1 good day





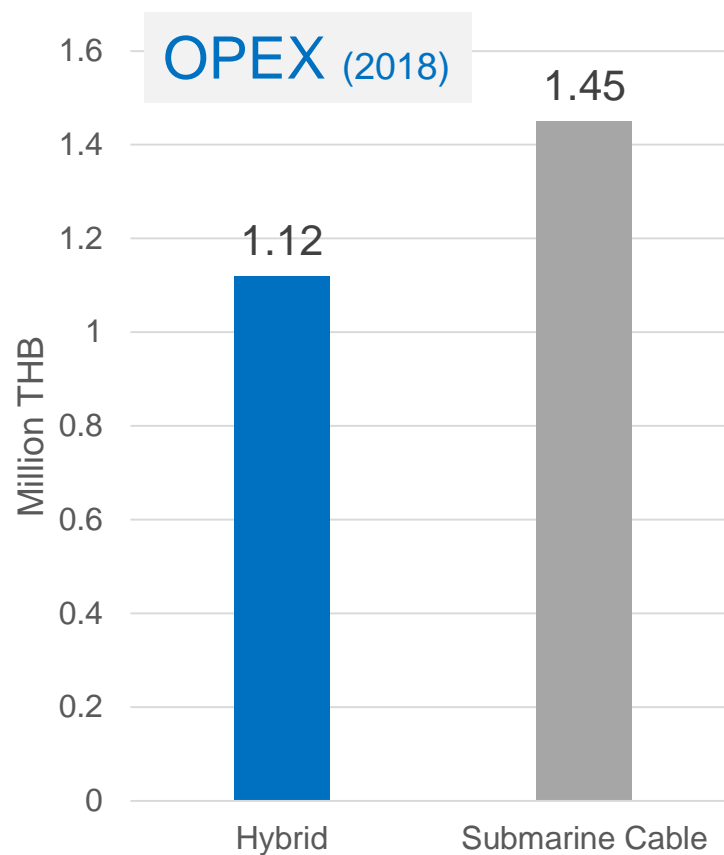
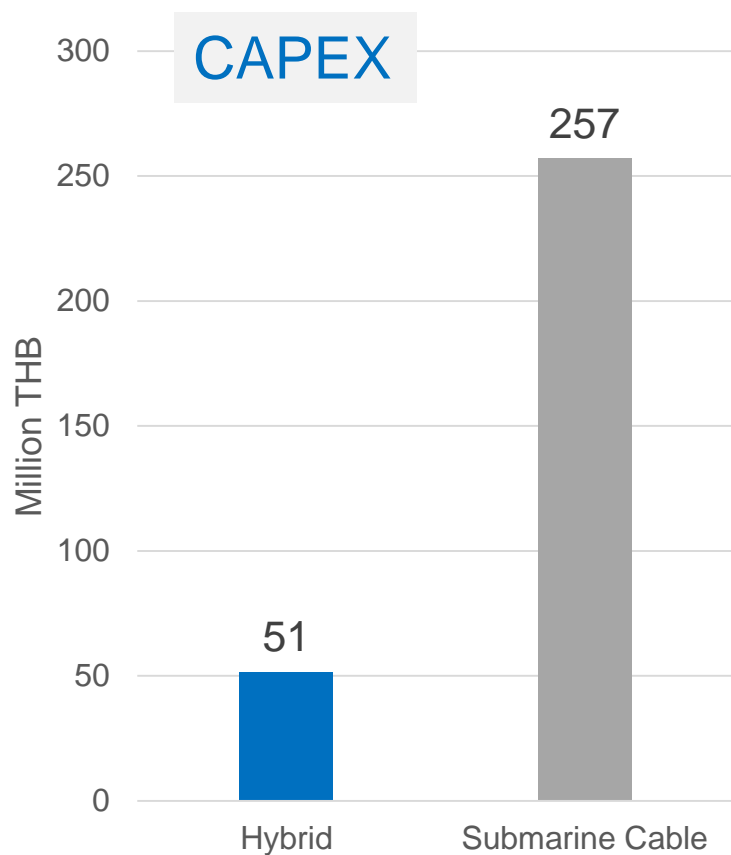
Financial Figures – CAPEX & OPEX



Components	CAPEX	OPEX	No. of Replacement
 Diesel Generators	2,042,400 THB	3.74 THB/kWh (500,438 THB in 2018)	6
 Solar PV	17,020,000 THB	272,320 THB	Inverter: 1
 Battery	17,156,160 THB	291,655 THB	Battery: 3 Inverter: 1
 Others (i.e. grid, meters, etc.)	15,219,284 THB	51,060 THB	-
Total	51,437,844 THB		



Financial Figures – Comparison



CAPEX & OPEX of submarine cable source: PEA



Financial Figures – Comparison

Current Situation (CS)

Decentralized setup (here calculated for Khun Abdullah's Grids); 4,5 hrs. of supply

$$\text{LCOE}_{\text{CS}} = 25.15 \text{ THB/kWh}$$

Submarine Cable

24/7 supply; 30-years project lifetime

$$\text{LCOE}_{\text{SC}} = 44.33 \text{ THB/kWh}$$

RE-Diesel Hybrid Scenario (RE)

24/7 supply; 30-years project lifetime

$$\text{LCOE}_{\text{RE}} = 16.61 \text{ THB/kWh}$$



Economic and Environmental Impact

RE/Diesel Hybrid LCOE	Submarine Cable LCOE	LCOE Reduction ¹	RE Fraction (RE/Diesel Hybrid)	CO2 Reduction ¹
THB/kWh	THB/kWh	%	%	t/a
16.61	47.00	64.7	57	183

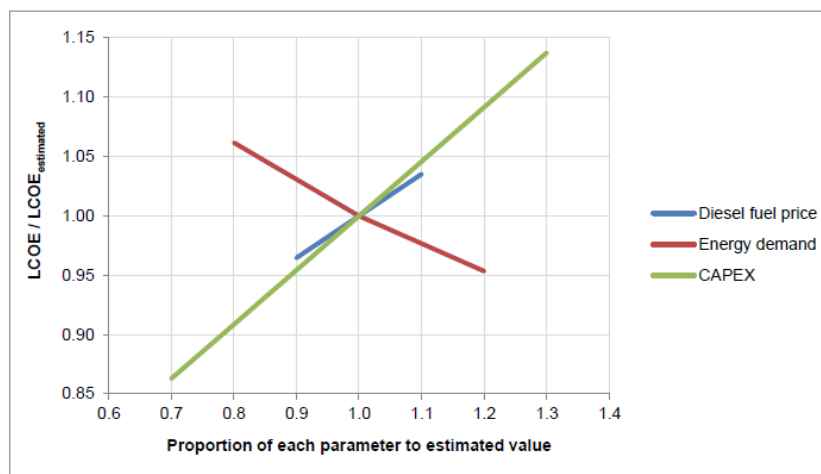


Sensitivity Analysis

CAPEX $\pm 30\%$ variation in CAPEX leads to a $\pm 13.73\%$ variation in LCOE.

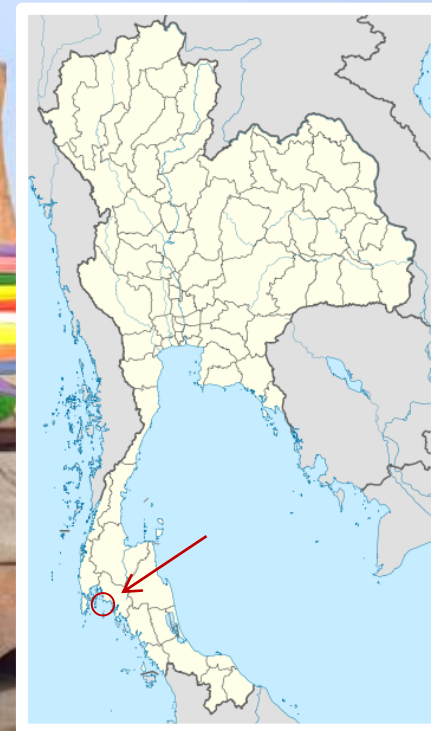
Energy Demand
+ 20% variation in energy demand leads to a $- 4.66\%$ variation in LCOE.
- 20% variation in energy demand leads to a $+ 6.18\%$ variation in LCOE.

Fuel Price $\pm 10\%$ variation in fuel price leads to a $\pm 3.53\%$ variation in LCOE





Renewable Energy Hybrid Grid Systems for Thai Islands



Koh Mak Noi – Business Model



Utility Model



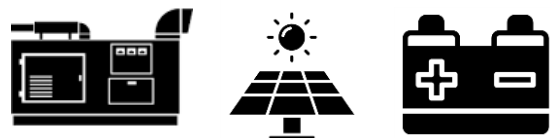
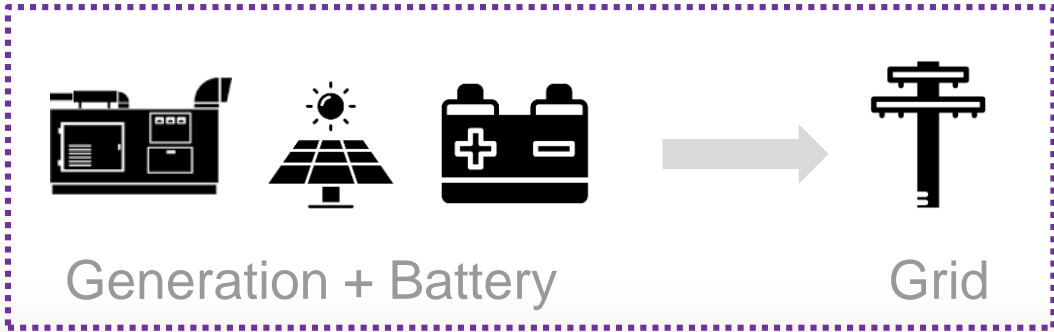
การไฟฟ้าส่วนภูมิภาค
PROVINCIAL ELECTRICITY AUTHORITY



Invest, operate, maintain

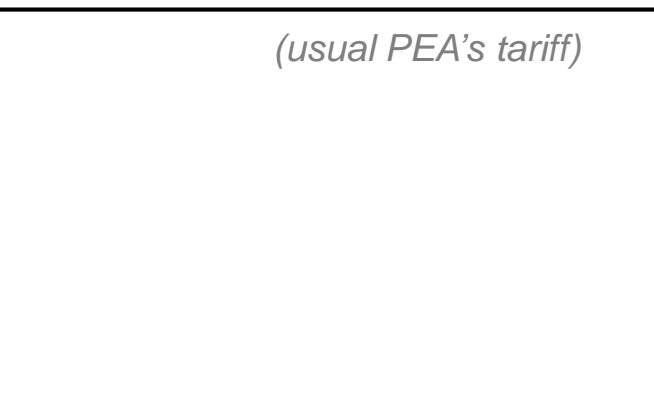
Buy electricity from PEA

(usual PEA's tariff)



Generation + Battery

Grid



Consumers



Utility Model – Explanation

Model Explanation:

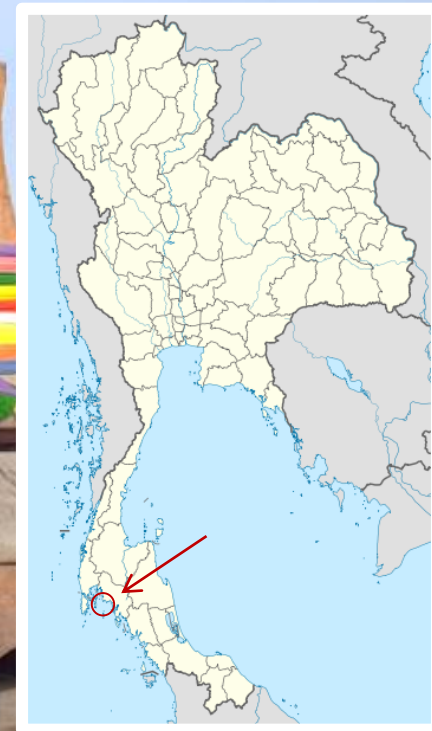
- PEA owns and operates the mini-grid system
- The community buys electricity from PEA; revenues are flowing back to PEA
- The community benefits from low tariffs (PEA's usual tariff)
- PEA benefits from lower CAPEX and OPEX cost in comparison with a submarine cable scenario

Financing Options:

- CAPEX: PEA
- OPEX: PEA



Renewable Energy Hybrid Grid Systems for Thai Islands



Koh Mak Noi – Next Steps, Impact & Outlook



Next Steps (prelim.)

GIZ Support

PEA	▪ Internal decision-making and approval processes and project development unit)	Q3-4 2017 (forecast)
	▪ Formally clarify Land Use Rights (supported by GIZ) with SAO	Q4 2017
	▪ Project Proposal to Board	Q4 2017
	▪ Approval by Board	Q1 2018
	▪ Project Proposal & Layout Plan: Public Hearing/Community Meeting	Q1 2018
	▪ Detailed layout plan and tender process	Q1-3 2018
	▪ Construction and Commissioning	Q3-4 2018
Community	▪ Support the process and construction period	Q4/17-Q4/18
	▪ Provide relevant data to PEA	Q4/17-Q4/18
SAO	▪ Further endorsement and political support of the project	Q4/17-Q4/18
	▪ Formally approve Land Use Right	Q1 2018



Impact

PEA as major partner can be a lever for mid-sized island electrification

- PEA expressed high interest to explore mini-grid applications on islands in general, chose the Rockefeller/GIZ activities as exemplary case
- Is looking to apply the mini-grid model to other islands and asked for further support from GIZ (limited/no expertise on their side); upscaling potential
- Sustainable island electrification increasingly considered to respond to requests from political stakeholders



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>

