

# PEA Energy Storage System (ESS) and Microgrid

**Chakphed Madtharad, Ph.D.**

Power System Analysis and Planning Division

System Planning Department

Provincial Electricity Authority (PEA), Thailand

**Sep 2023**



# PEA's Projects & Plans

## R&D PEA Road map Grid Scale



- Grid deferral
- Load Aggregator

- Peak Shaving



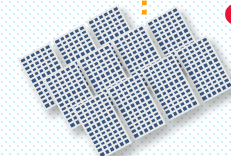
- Islanding Operation



- Power Quality

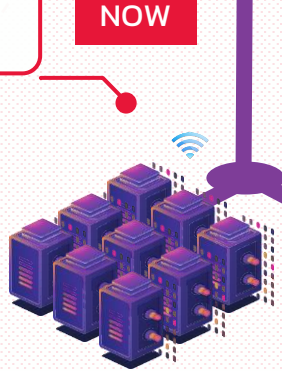


- Ancillary Services
- RE100



### NOW

- BESS: Samui Island Project
- BESS: Phrao, Chiang Mai Project

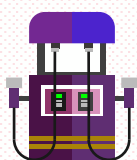


MV Distribution

Energy Storage



EV



EV Charging Station



## R&D for BESS

MOU BESS



- ติดตั้ง 2 MW/2MWh  
อ. สังขละบุรี  
จ. กาญจนบุรี  
BYD 2nd Life Battery



- ติดตั้ง 50 kW/120kWh  
จ. เชียงตรา, จ. มุกดาหาร  
30 kW EV + PV 200 kW  
SG Hydrogen Battery



- ติดตั้ง 1 MW/1MWh  
อ. อุ้มผาง จ. ตาก  
EVE LFP Battery



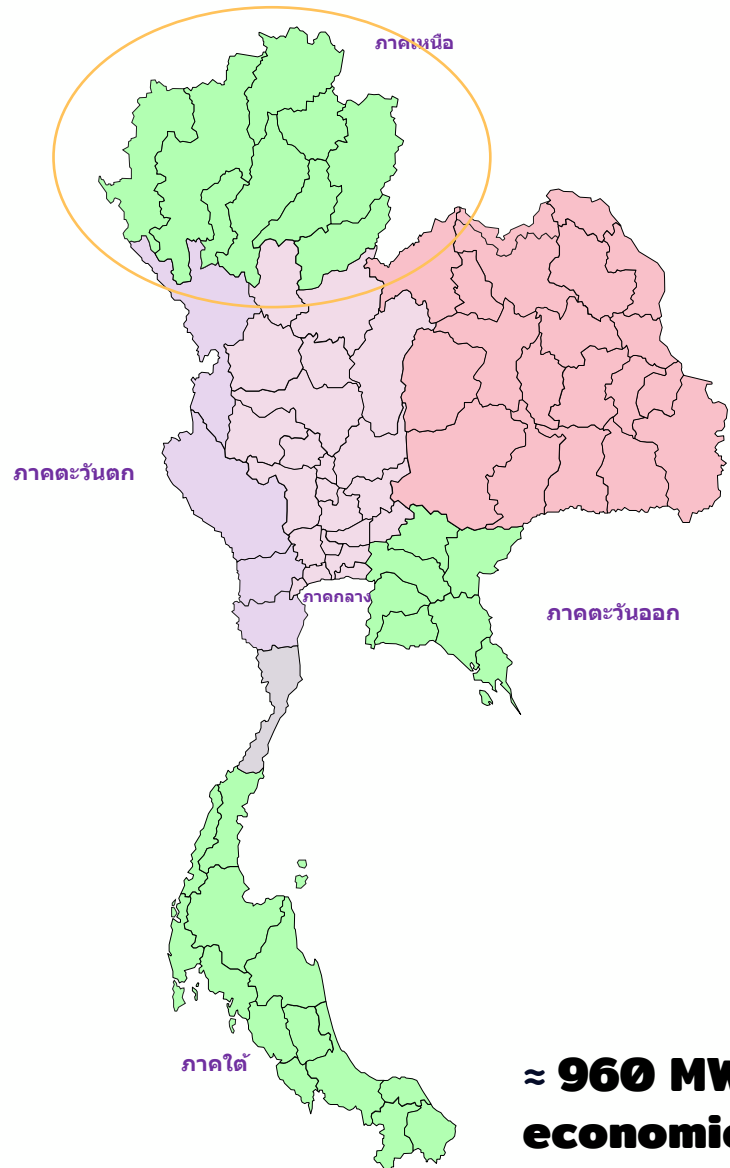
- อยู่ระหว่างลงนาม MOU  
CATL Na Battery



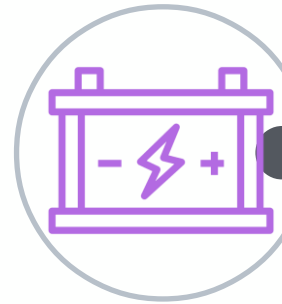
- ติดตั้ง 1 MW/1MWh  
อ. แม่พริก จ. เลย  
Vanadium Redox Flow  
Batteries



# Draft Example for BESS Sizing: Northern Area

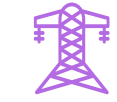


- Main Applications**
- Grid Deferral
  - Peak Shaving
  - Ancillary Service

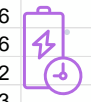


**Cost-benefit analysis**

Substation	Name	Original size		NPV in MTHB (Financial)	NPV in MTHB (Economic)	BESS size	
		MW BESS	MWh BESS			BESS MW	BESS MWh
UTA	UTTARADIT	10.58	30.86	437.76	200.49	11.00	31.00
LPA	LAMPANG 1	17.67	57.46	381.85	477.17	18.00	58.00
STA	SUKHOTHAI	13.85	39.32	393.04	467.31	14.00	40.00
WGT	WANG THONG	15.19	60.03	350.24	446.33	16.00	61.00
DCA	DENCHAI	7.84	21.93	385.78	431.26	8.00	22.00
SZA	SALOKBAT	14.48	43.89	333.31	414.50	15.00	44.00
RKA	RONG KWANG	10.33	30.75	341.94	399.26	11.00	31.00
PLC	PHITSANULOK 3	18.06	59.85	129.95	242.00	19.00	70.00
LOA	LOM SAK	23.00	79.38	78.96	208.08	23.00	80.00
KKU	KHLONG KHLUNG	6.89	19.83	159.58	200.83	7.00	20.00
PH	PHICHAI	9.00	24.00	117.80	168.49	9.00	24.00
KA	LAN KRABU	7.24	17.62	107.78	145.79	8.00	18.00
MSA	MAE SOT 1	17.05	88.27	6.26	139.42	18.00	89.00
UAA	UTHAI THANI	26.03	84.42	(5.03)	134.63	27.00	85.00
BQA	BAN RAI	8.17	15.99	63.18	98.72	9.00	16.00
QLA	PHO THALE	11.07	31.47	(11.08)	45.98	12.00	32.00
IBA	IN BURI	9.88	25.95	(14.55)	40.34	10.00	26.00
TAA	TAK 1	12.55	54.10	(68.45)	25.75	13.00	55.00
TEA	CHOM THONG	19.13	81.63	(103.64)	24.17	20.00	82.00
WPA	WIANG PA PAO	14.94	41.19	(61.44)	17.81	15.00	42.00
QRA	PHROM PHIRAM	7.11	20.53	(34.33)	8.02	8.00	21.00
NAT	NAKHON THAI	6.17	15.74	(31.27)	2.19	7.00	16.00
						<b>963.00</b>	



**Grid deferral**  
Overload management



**Peak Shaving**  
Energy Arbitrage



**Incremental sell**  
Load growth support



**Ancillary service**  
Voltage support provision



**Island operation**  
On-site power supply



**Avoided outage**  
Outage impact reduction

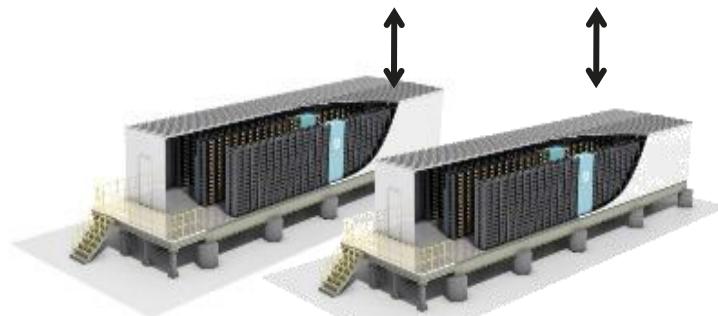
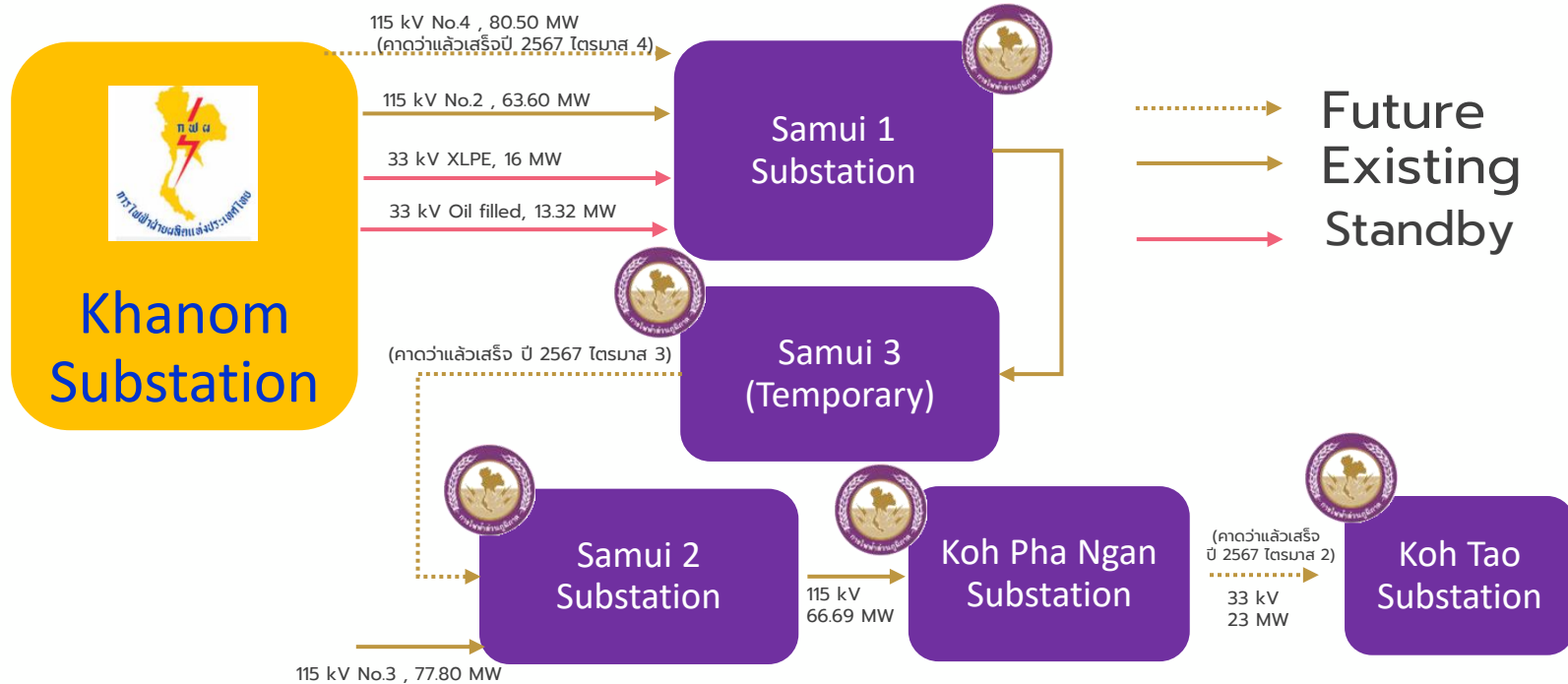
**≈ 960 MWh from 22 of 107 subs in the Northern region is economically feasible in the Northern region**



# Battery Energy Storage System: BESS Samui Island Project

## Objective

- Peak Shaving
- Submarine Cable Supporting
- Islanding Operation



**BESS**  
**(12.5MW / 25MWh) x 2 sets**





# ภาพรวมแผนการดำเนินงาน

PEA – PEA ENCOM

ลงนามสัญญา

21 ก.พ. 2566

11 พ.ค. 2566

ให้ความเห็นชอบ

กฟภ. จัดหาและ  
ส่งมอบพื้นที่ติดตั้ง  
รวมถึงสิทธิการใช้งาน

26 พ.ค. 2566

26 พ.ค. 2567

งานก่อสร้างแล้วเสร็จ  
พร้อมส่งมอบงาน

29 ก.ย. 2567

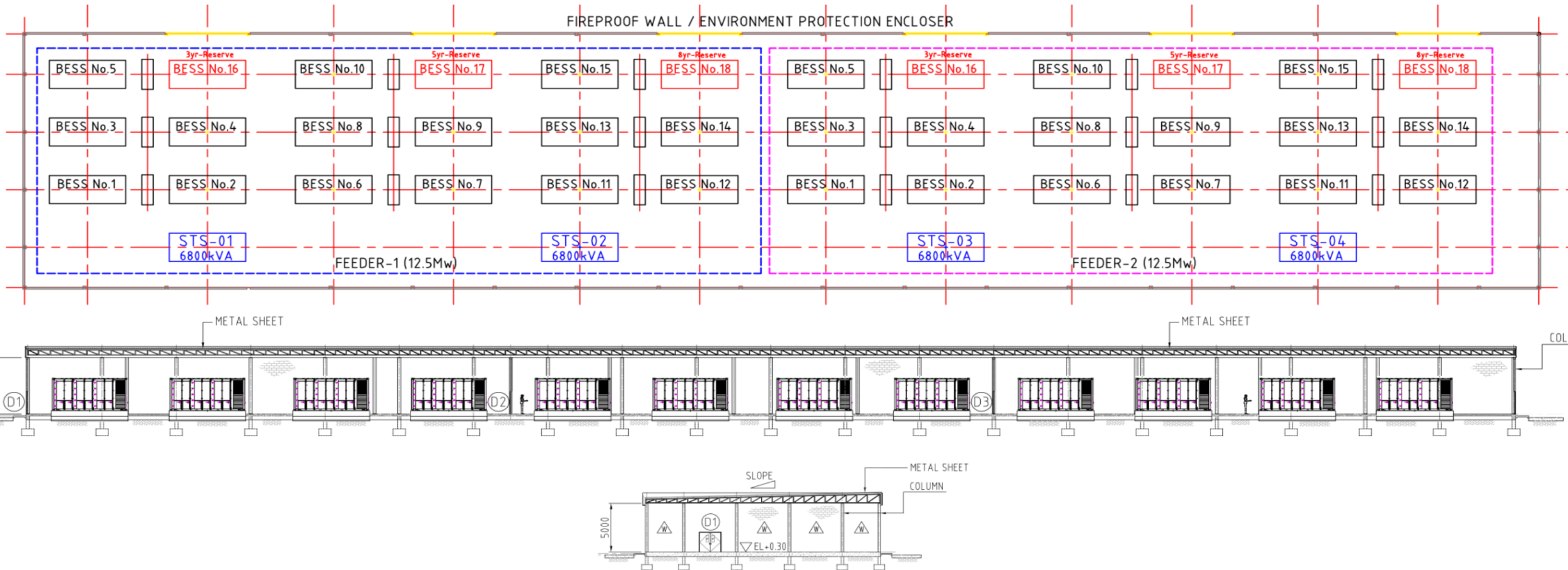
คืนสภาพ  
100%



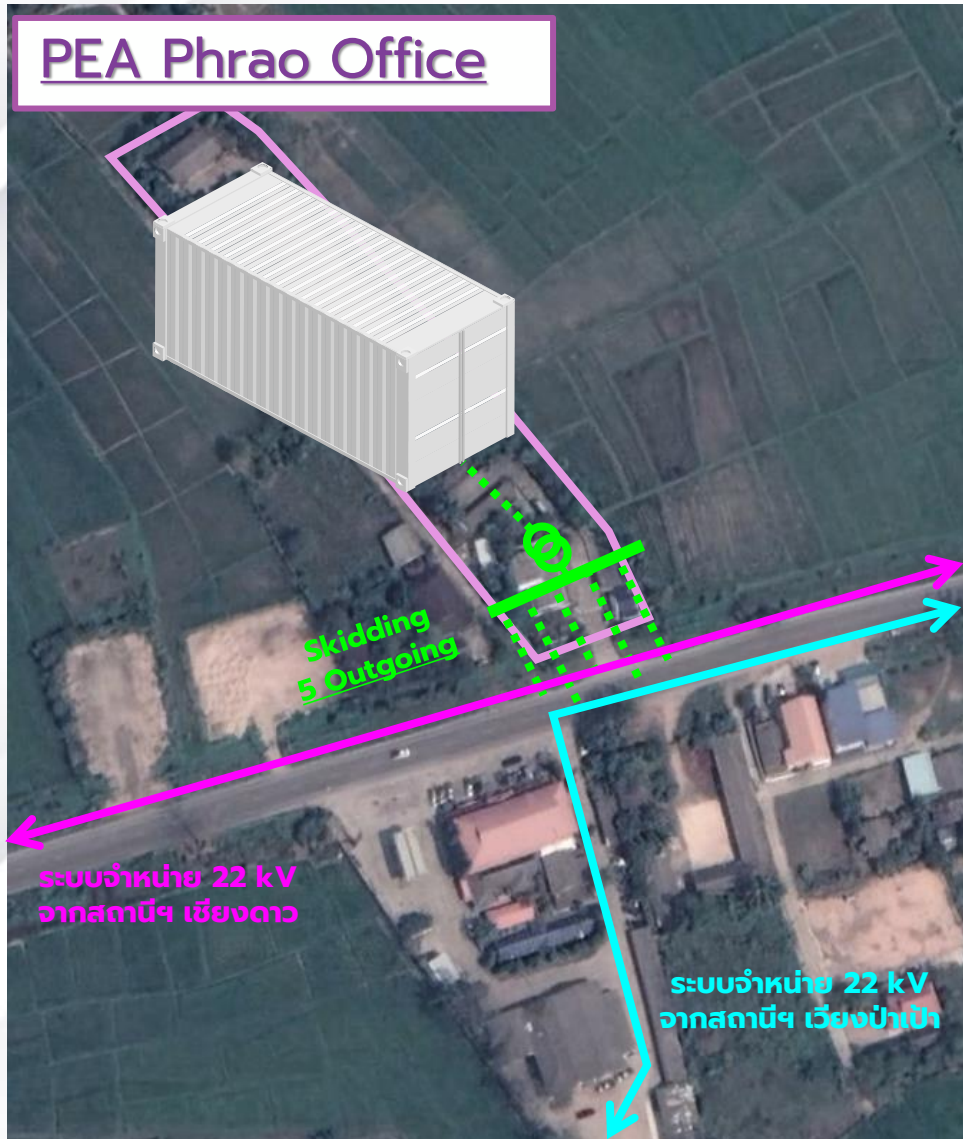
45 วัน นับถัดจากลงนามสัญญา



# รูปแบบการก่อสร้าง และแบบแปลนเบื้องต้น



# BESS: Phrao, Chiang Mai Project



สถานี เชียงดาว (CDO) ▲

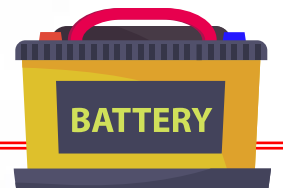
Phrao Load **5.58 MW**

Phrao Downtown Load **1.88 MW**

ระบบกักเก็บพลังงานในพื้นที่ อ.พร้าว จ.เชียงใหม่

สถานี เวียงป่าเป้า (WPA) ▲

สถานี แมริม (MRM) ▲

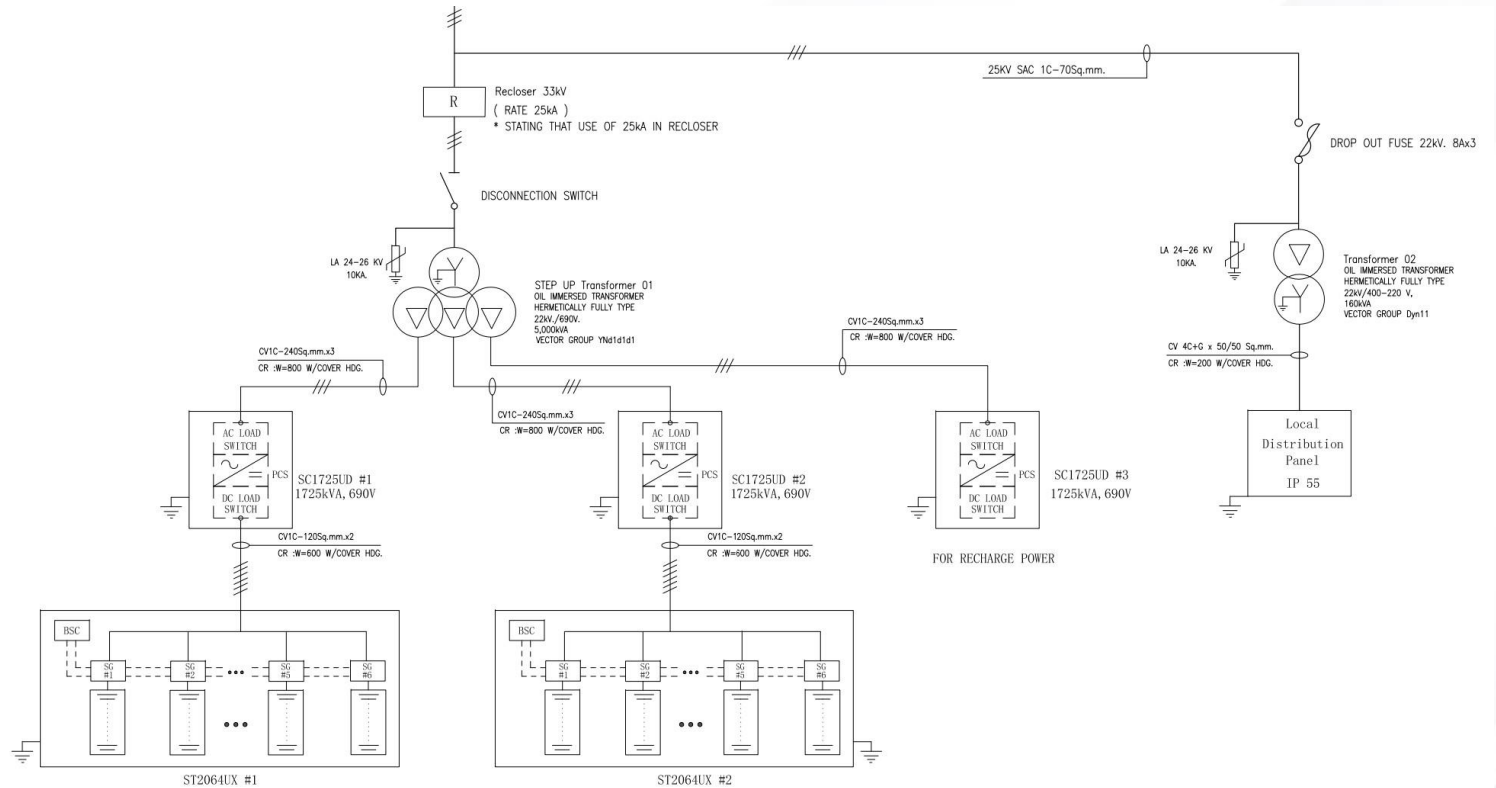
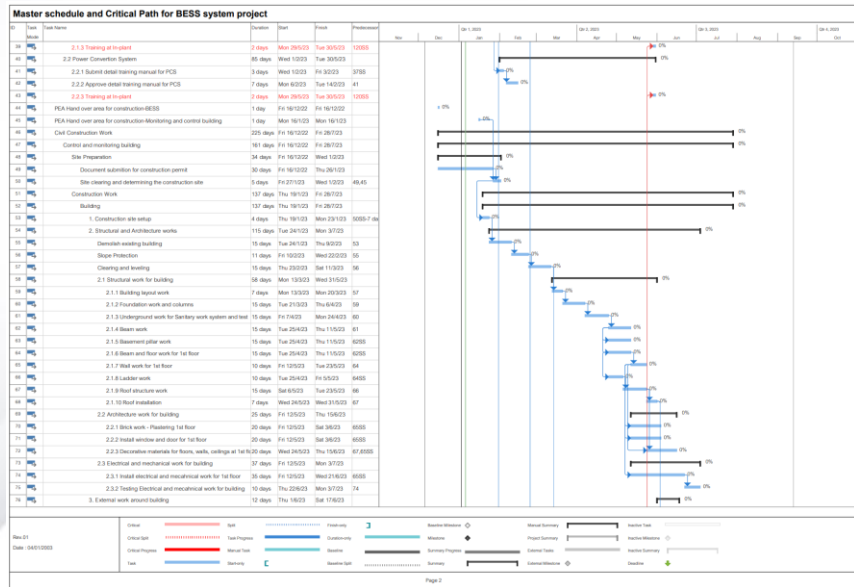
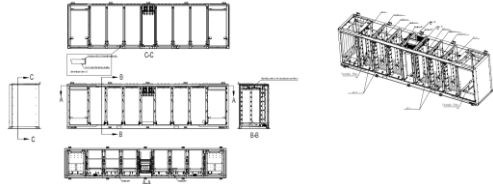


**BESS 3 MW /3 MWh (4 MWh installed)**

- Cover the whole Phrao downtown
- **Cover outage for > 90%**



# BESS: Phrao, Chiang Mai Project



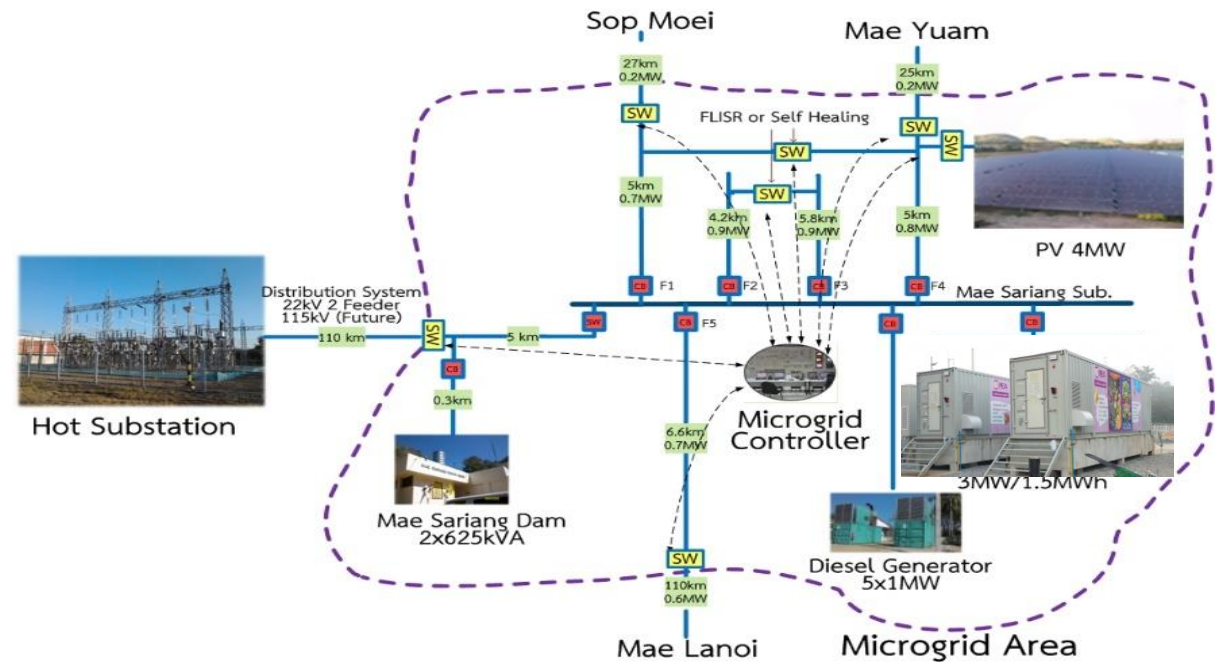
# BESS: Phrao, Chiang Mai Project

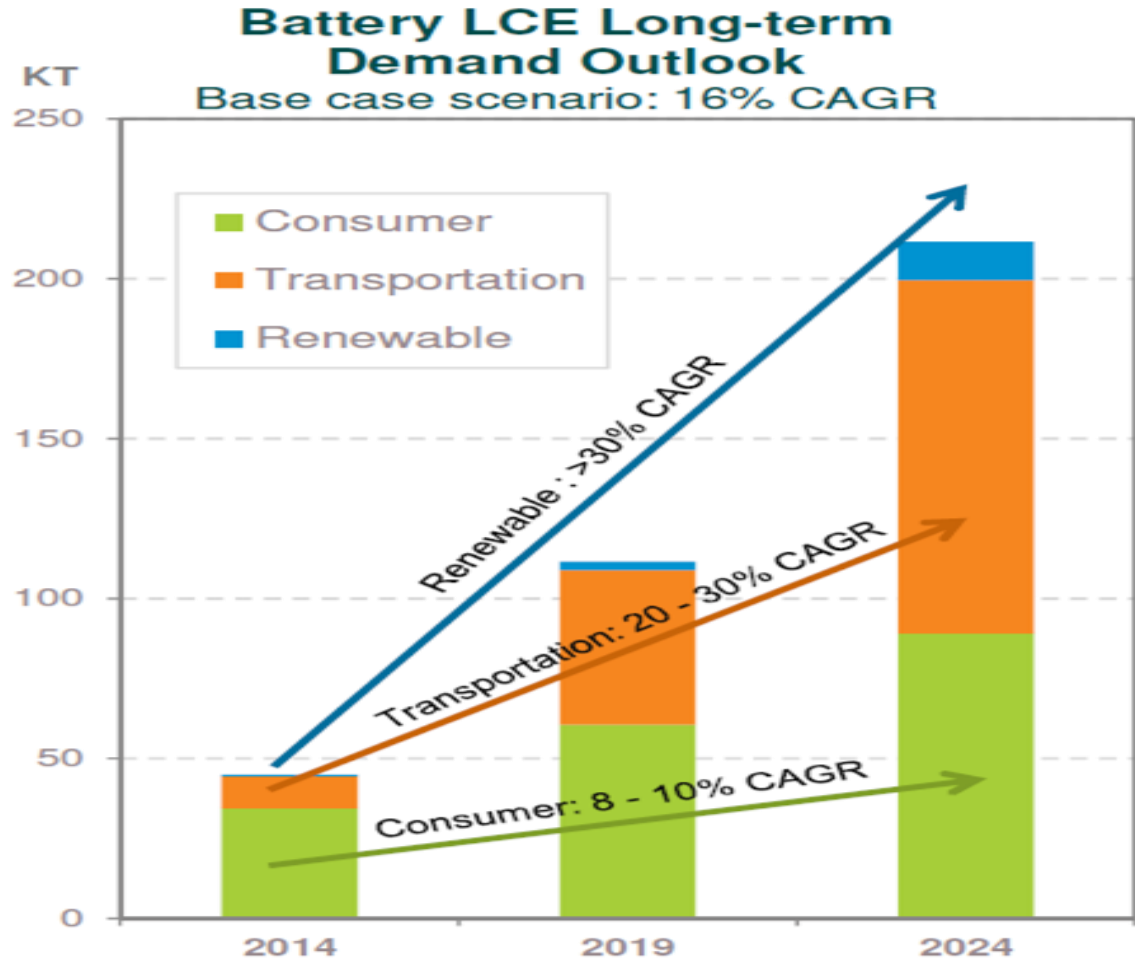




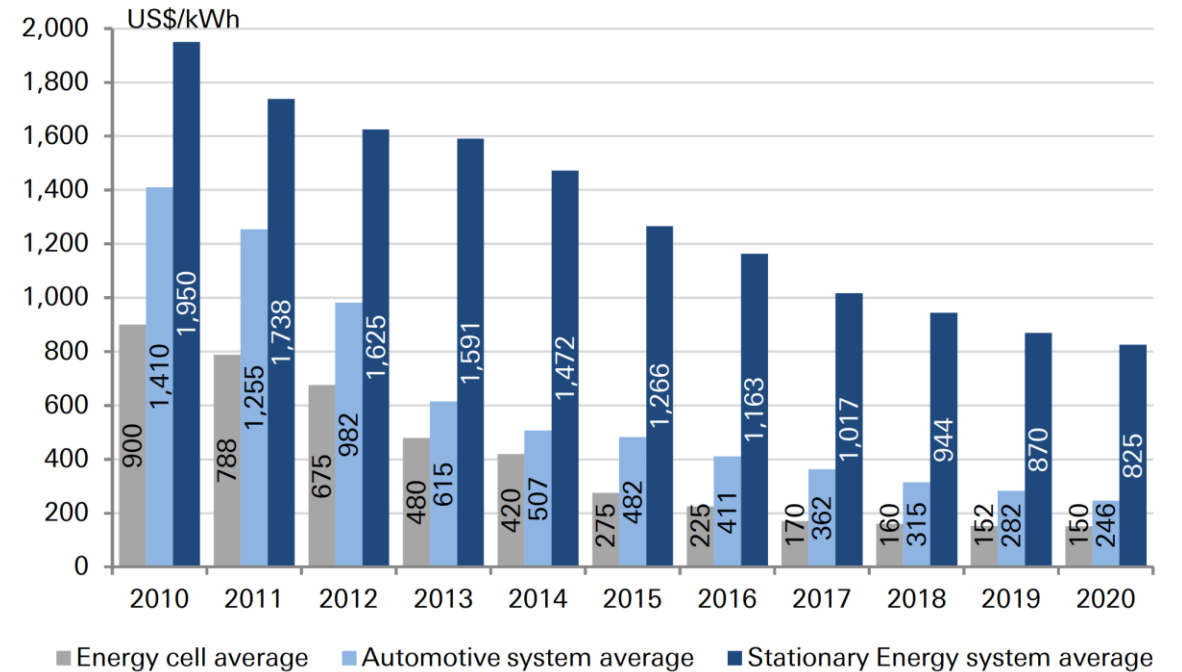
**IEC TS 62898-2-2018: group of interconnected loads and distributed energy resources with defined electrical boundaries that acts as a single controllable entity and is able to operate in both grid-connected or island mode.**

**IEEE: a group of interconnected loads and Distributed Energy Resources (DER) with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. It can connect and disconnect from the grid to enable operation in both grid-connected or island modes.**

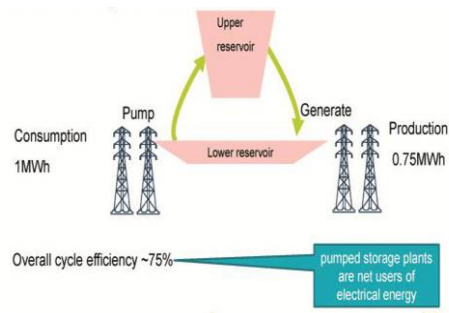




Source: SAI lithium assessment for Albemarle (2015), sector report



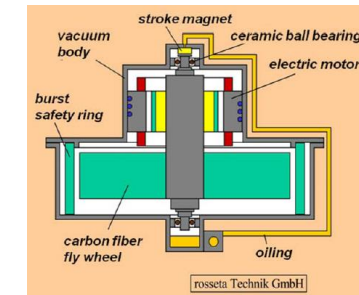
## Pumped Hydro Energy Storage



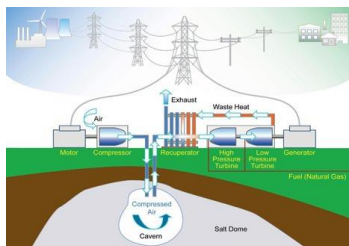
## Battery Energy Storage (BES)



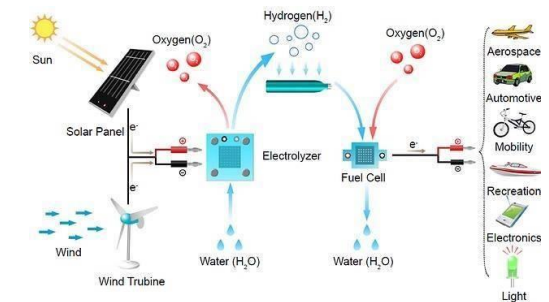
## Flywheel Energy Storage



## Compressed Air Energy Storage



## Fuel Cell Energy Storage



## Sodium Battery (Hot)

- Sodium Sulfur Battery (NaS)
- Sodium Nickel Chloride (NaNiCl)

## Lithium Battery (diff. cathode tech.)

- LiFePO4 (LFP), Nickel Manganese Cobalt (NMC), Li-Ion Nanophosphate, Lithium Titanium Oxide

## Flow Battery

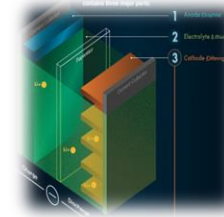
- Vanadium Redox Battery (VRB)
- Zinc-Bromine Battery (ZnBr)

## Sodium Battery

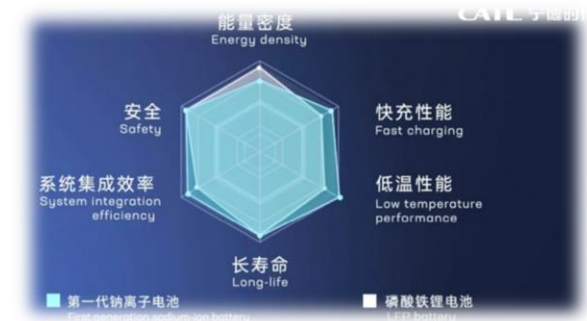
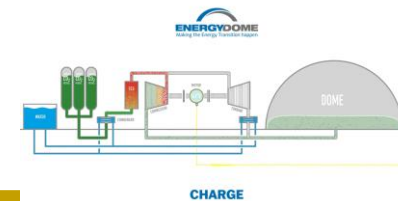
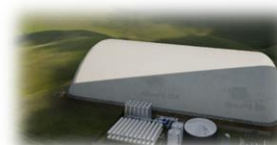
### • Sodium-ion

## CO2 Battery

- 2.5MW/4MWh 11MUSD



	Cycle (Life-time)	Efficiency (AC-AC)
Na Battery	√√	√√
Lithium Battery	√√ (√)	√√√
Flow Battery	√√√√	√



# PEA Microgrid Drivers



1. Power System Reliability and Quality



2. Supply Power to Island or Rural Area



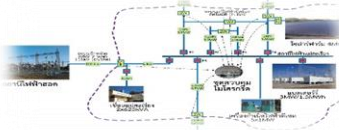
3. Intermittent Resources Integration



4. New Substation, Transmission, and Distribution Line Deferral



5. Power Losses in Distribution Line



6. Smart Grid Initiative



# Microgrid Projects

## Mae Sariang District

PV 4MW  
Diesel Gen. 5x1MW  
BESS 3MW/1.5MWh  
**Completed**



**Khun Pae (R&D)**



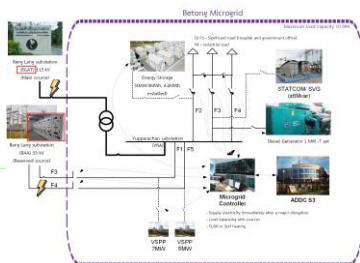
## Paluay Island

PV 1MW  
Diesel Gen. 2x300kW  
BESS 0.75MW/1.5MWh  
**Ongoing**



## Betong District

VSPP 7MW+5MW  
Diesel Gen. 7x1MW  
BESS 4MW/4MWh  
SVG 6 MVar  
**Ongoing**



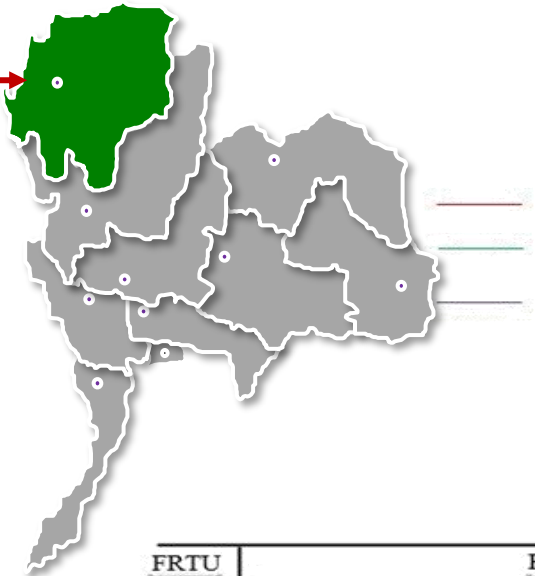
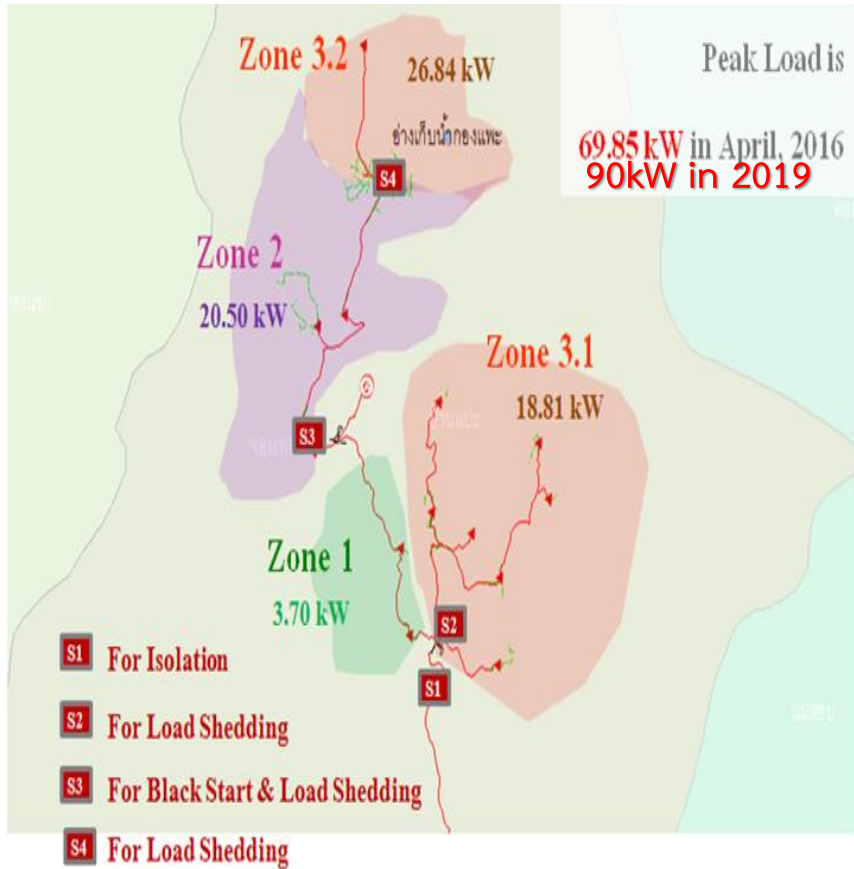
## Project Status

**Project at Mae Sariang:** The project started in 2018 and has been completed in 2021. The project aims at improving power system reliability due to long distribution line through rural area from substation to the district.

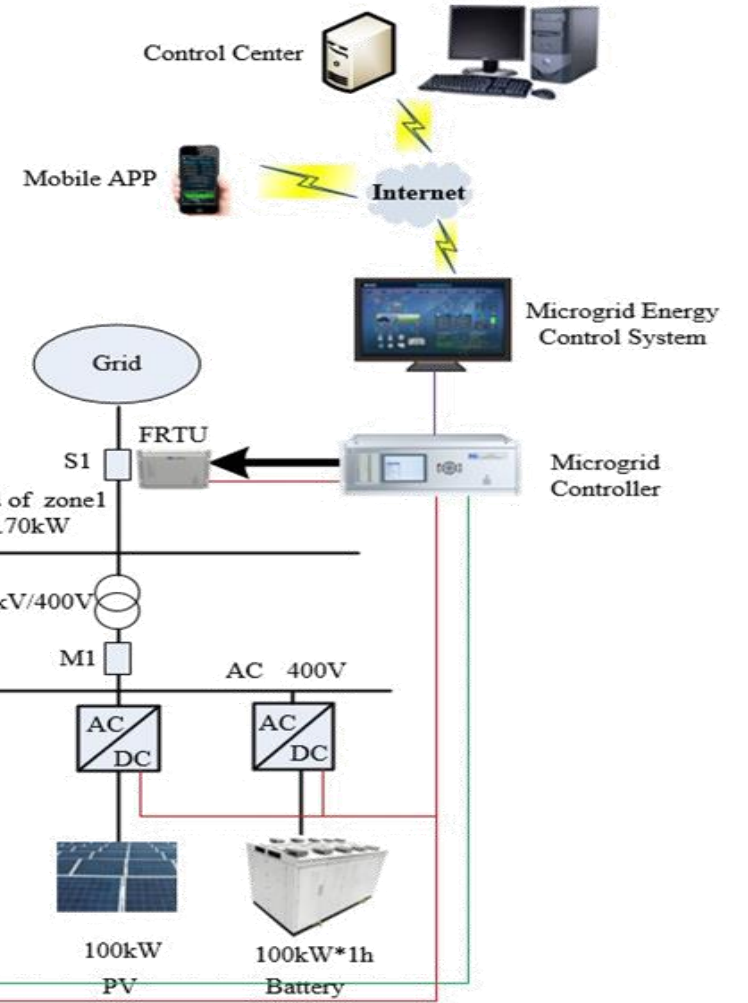
**Project at Betong:** The key objective of this project is to raise local power generation and distribution efficiency and also to reduce losses of long distribution system to remote area. It is in the implementation phase and expected to go-live by this year.

**Project at Paluai Island:** This is an off-grid microgrid project, where the island has no power system connection from the mainland. It is under the procurement process and the project is expected to be completed by 2023.

## Khun Pae



GOOSE  
OPC  
IEC103

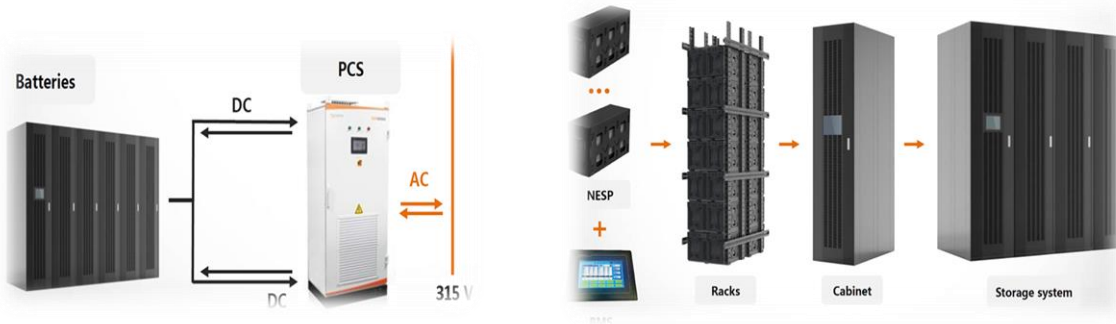




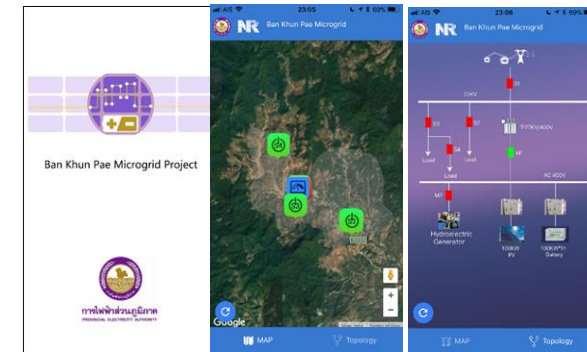
Microgrid Controller



Remote Control Switch

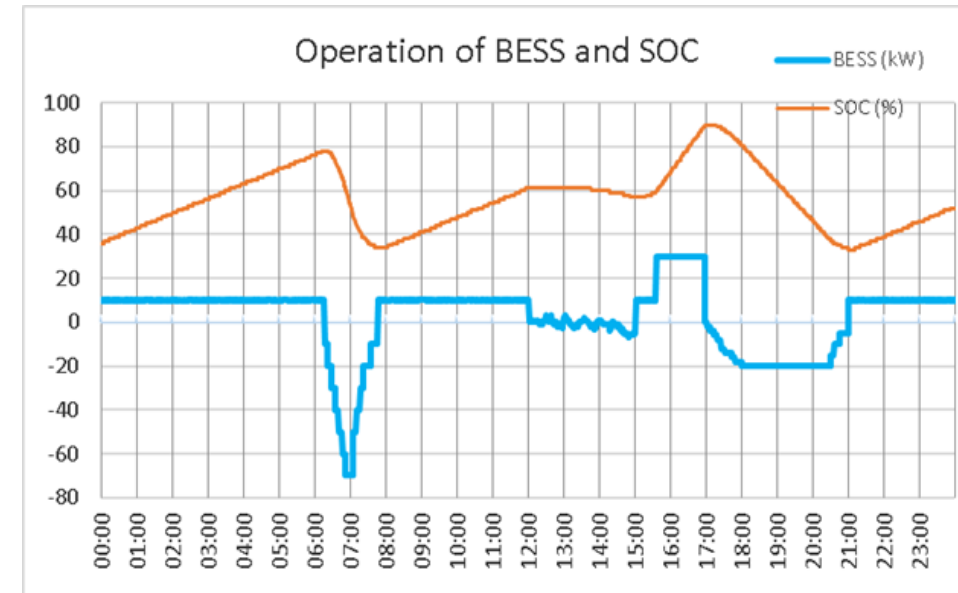
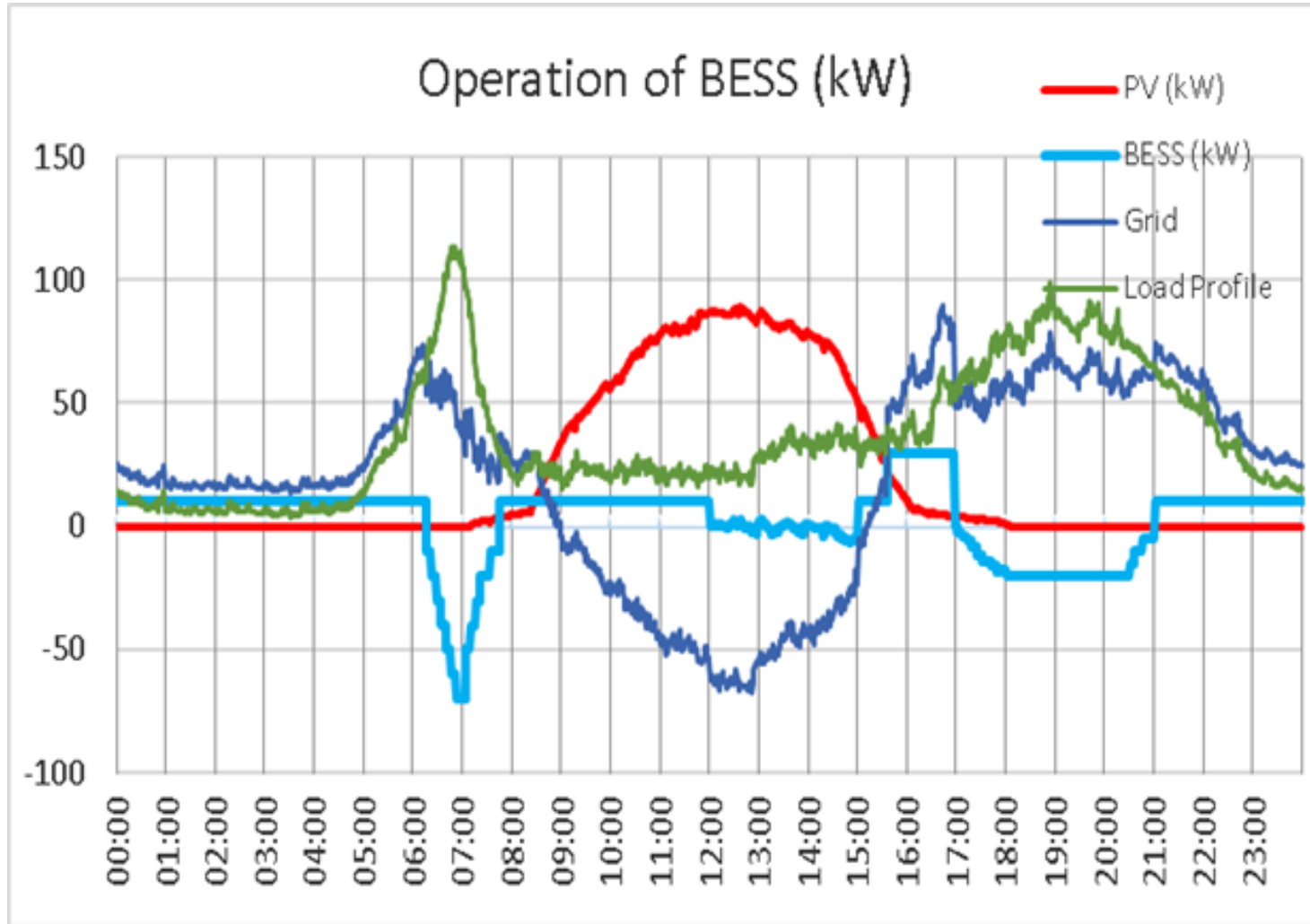


**BESS 100kW/100kWh**



Mobile App





# Microgrid at Mae Sariang



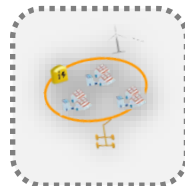
**Energy Storage**  
(3MW/1.5MWh useable)  
to cover significant load

**1 Units**



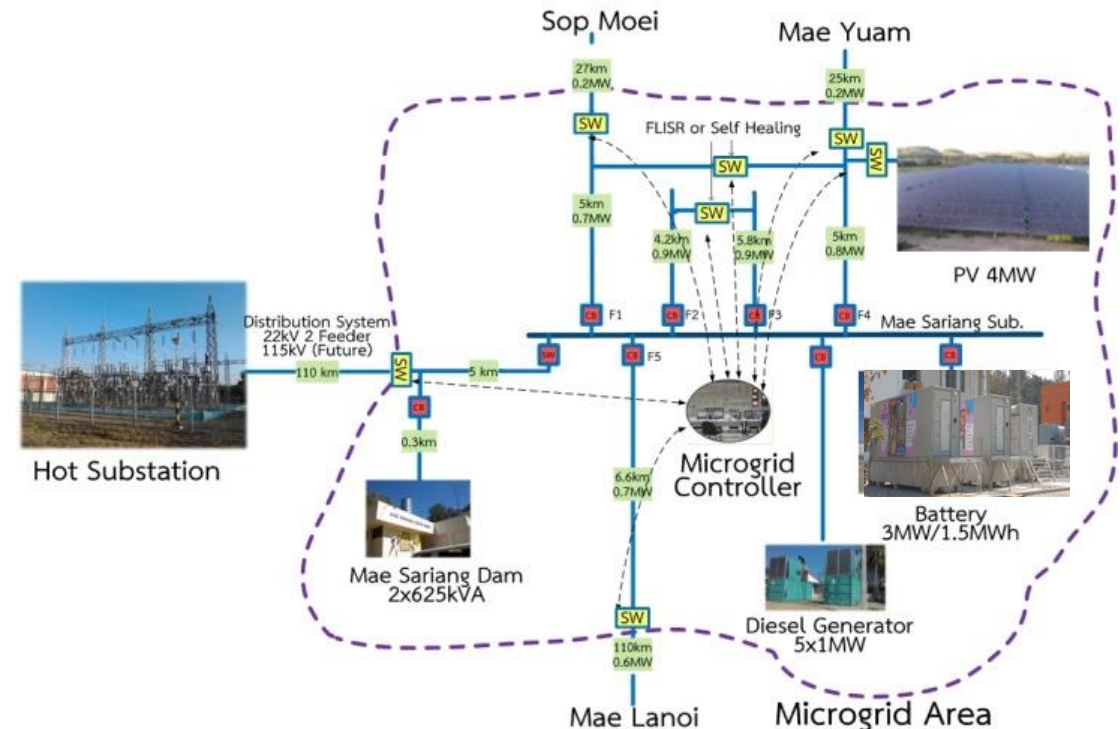
**Micro grid Controller**  
with Building Energy  
Management System (BEMS)  
and Fault Location Isolation &  
Service Restoration (FLISR)

**1 System**



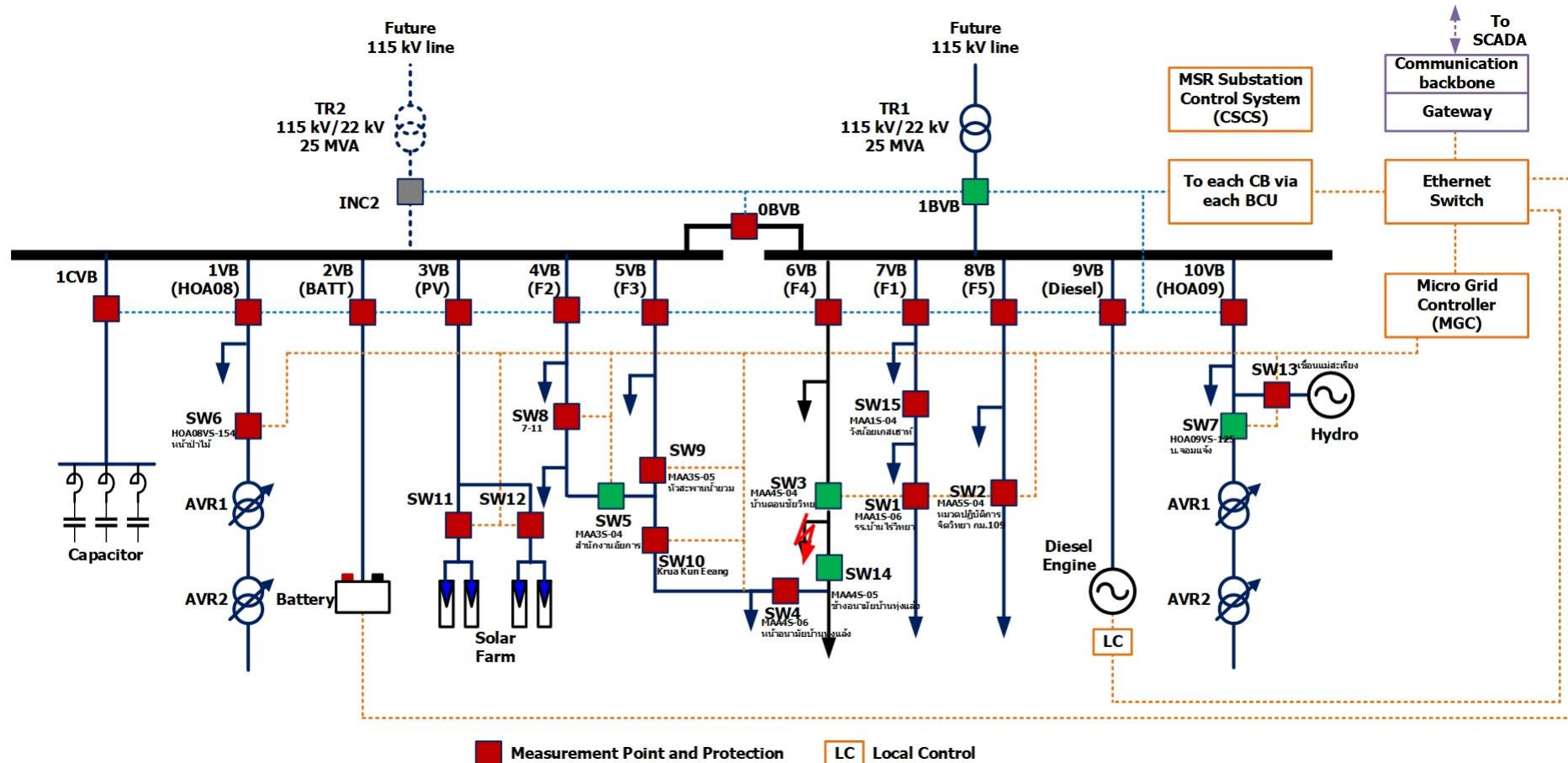
**Communication System**

**1 System**





## with Fault Location Isolation & Service Restoration (FLISR)



# Microgrid at Mae Sariang

with Building Energy Management System (BEMS)

Control Smart Devices by PEA HiVE platform







# Microgrid at Mae Sariang





## MSR Substation (สถานีไฟฟ้าแม่สะเรียง)

เป็นสถานีไฟฟ้าที่รับไฟแรงดัน 115kV จากสถานีไฟฟ้าฮอด  
ลดระดับแรงดันเหลือ 22kV จ่ายออกไปยังผู้ใช้ไฟฟ้า  
ภายในอำเภอแม่สะเรียง อำเภอสบเมย และอำเภอแม่ลาน้อย

## Diesel Generator 5x1MW

ขนาดติดตั้ง 1 MW จำนวน 5 เครื่อง  
ใช้สำหรับรองรับกรณีที่เกิดเหตุระบบไฟฟ้าขัดข้องเป็น  
ระยะเวลานาน ซึ่งแบตเตอรี่จะไม่สามารถรองรับได้



## Step Up Transformer 4 MVA

ชนิด 3 Windings 315V/22kV  
ใช้สำหรับปรับแรงดันเพื่อใช้ในการชาร์จ  
และดิสชาร์จแบตเตอรี่



## Power Conversion System (PCS) 6x500kW

ประกอบไปด้วย PCS ขนาด 500 kW จำนวน 6 Units  
(รวมเป็น 3 MW) ควบคุมการชาร์จและดิสชาร์จ  
รวมถึงระบบป้องกันต่างๆ

## Battery Energy Storage System (BESS) 2x1.1MWh Installed

แบตเตอรี่ชนิดลิเทียมไอออนฟอสเฟต (LiFePO4)  
ขนาดใช้งาน 3MW/1.5MWh สามารถจ่ายกำลังไฟฟ้าได้ 3MW ต่อเนื่อง  
ครึ่งชั่วโมง (30 นาที) ครอบคลุมทั้งอำเภอแม่สะเรียง



# Microgrid at Mae Sariang: MGC and FRTU



**FRTU**



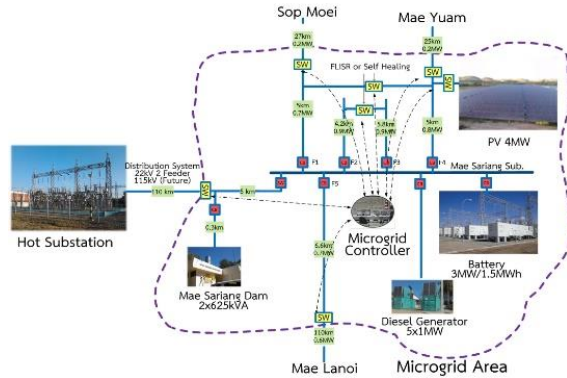
**MGC**



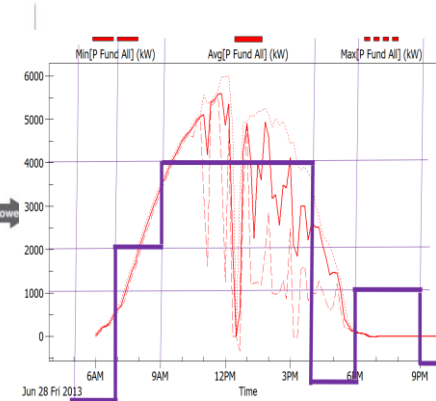
**MGC**



# Microgrid at Mae Sariang: Mode of Function

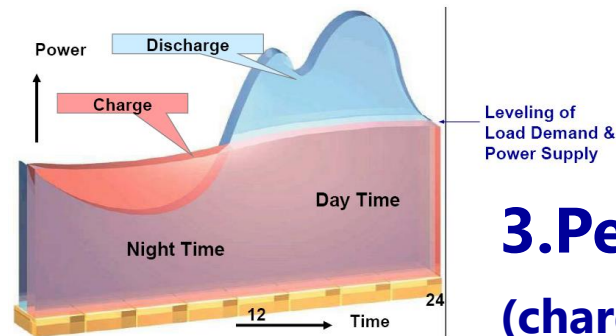


Energy storage



**1. Islanding**  
(when outage)

**2. Intermittent Resources Integration**  
(regulate and maintain voltage during intermittent of solar)

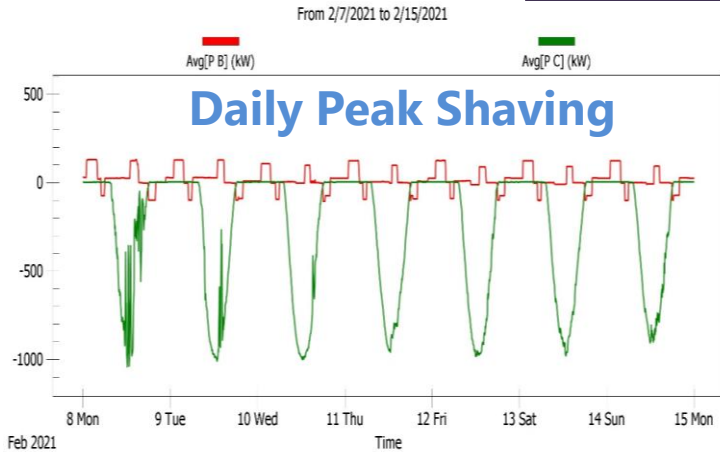


**3. Peak Shaving**

(charge surplus energy form PV to BESS and discharge to load during peak time)

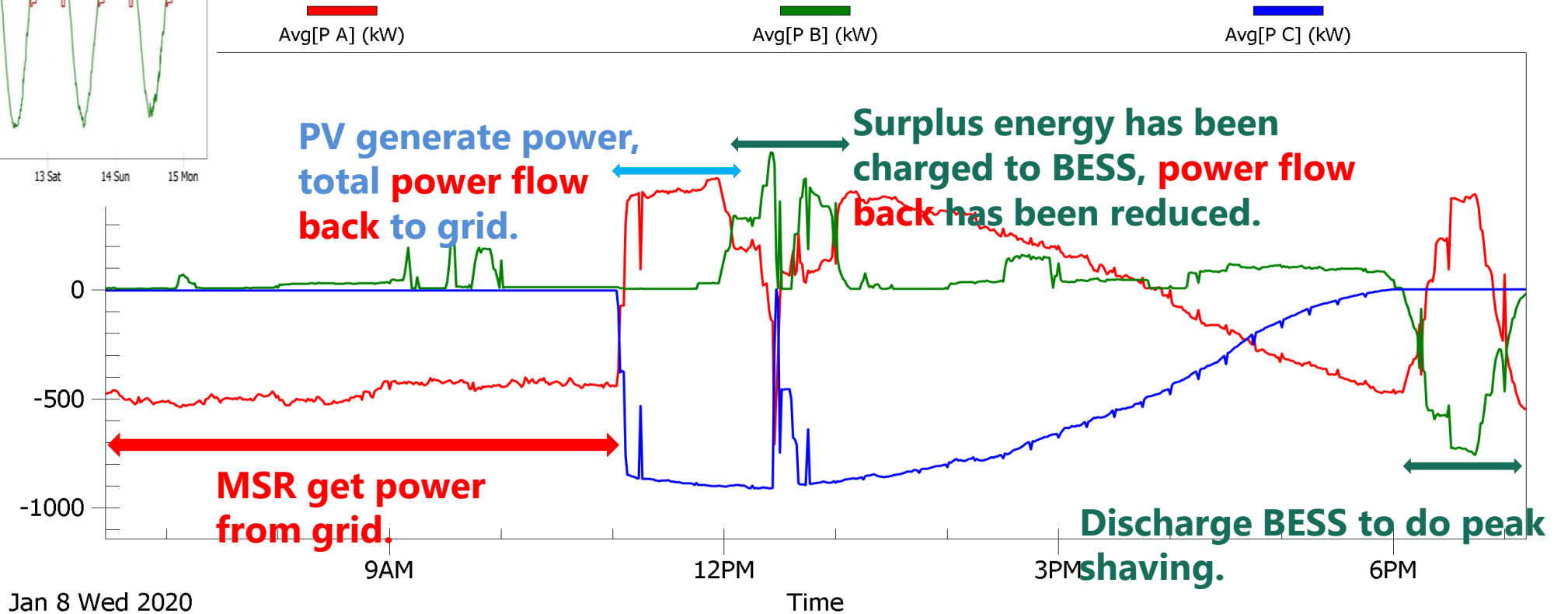
# Microgrid at Mae Sariang: Peak Shaving Example.

BESS has been charged by surplus energy form PV, then discharge during peak.



P3006282 - P A, P B, P C

From 02-Jan-20 to 10-Jan-20



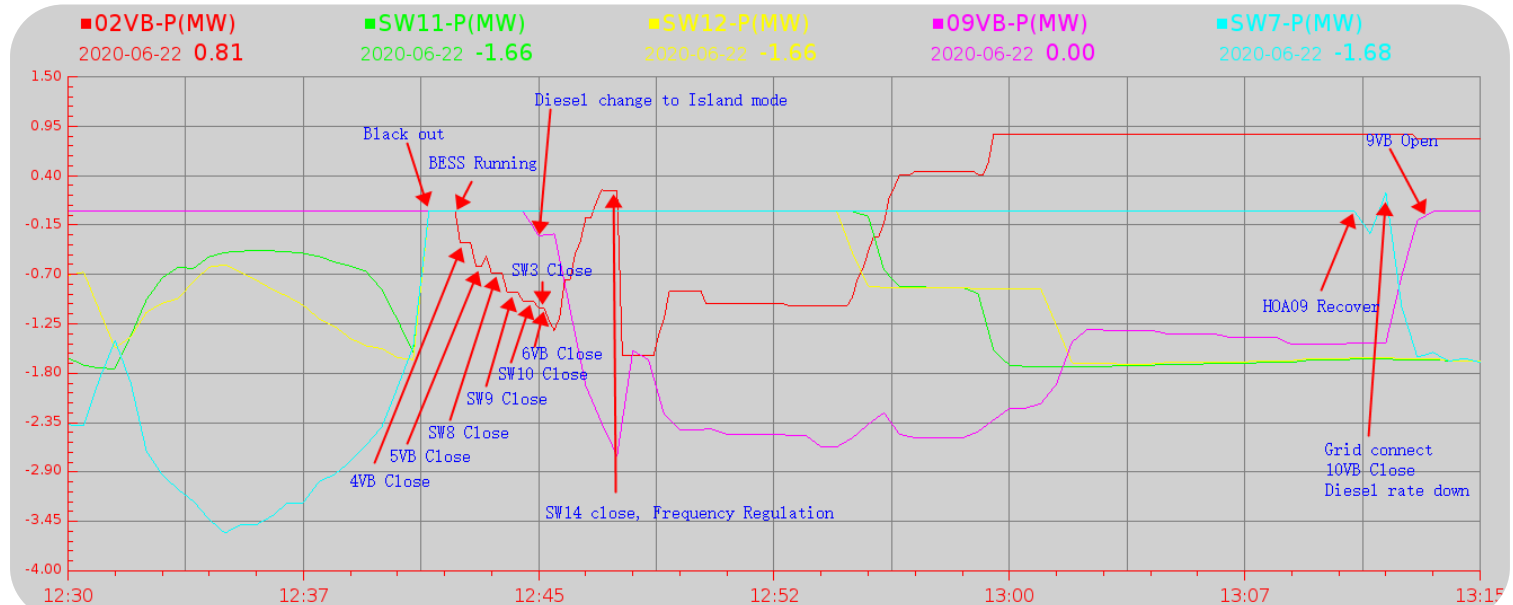
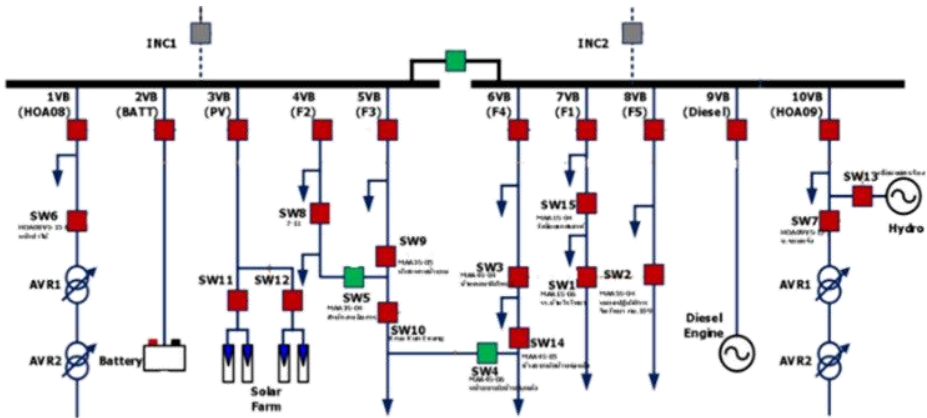
# Microgrid at Mae Sariang

## Function list

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>1 Peak Shaving</li> <li>2 Intentional Islanding</li> <li>3 Intentional Grid-Connected</li> <li>4 Fault Location, Isolation and Service Restoration(FLISR)</li> <li>5 Auto Black Start</li> <li>6 ATS Functions (ATS1-ATS5)</li> <li>7 Auto grid-Connected</li> </ul> | <ul style="list-style-type: none"> <li>Load Recovery after Grid-Connected 8</li> <li>PV Shedding during Islanding 9</li> <li>Load Shedding during Islanding 10</li> <li>Frequency Regulation 11</li> <li>Voltage Regulation 12</li> <li>PV Smoothing 13</li> <li>Energy Time Shifting 14</li> </ul> |
|---|---|

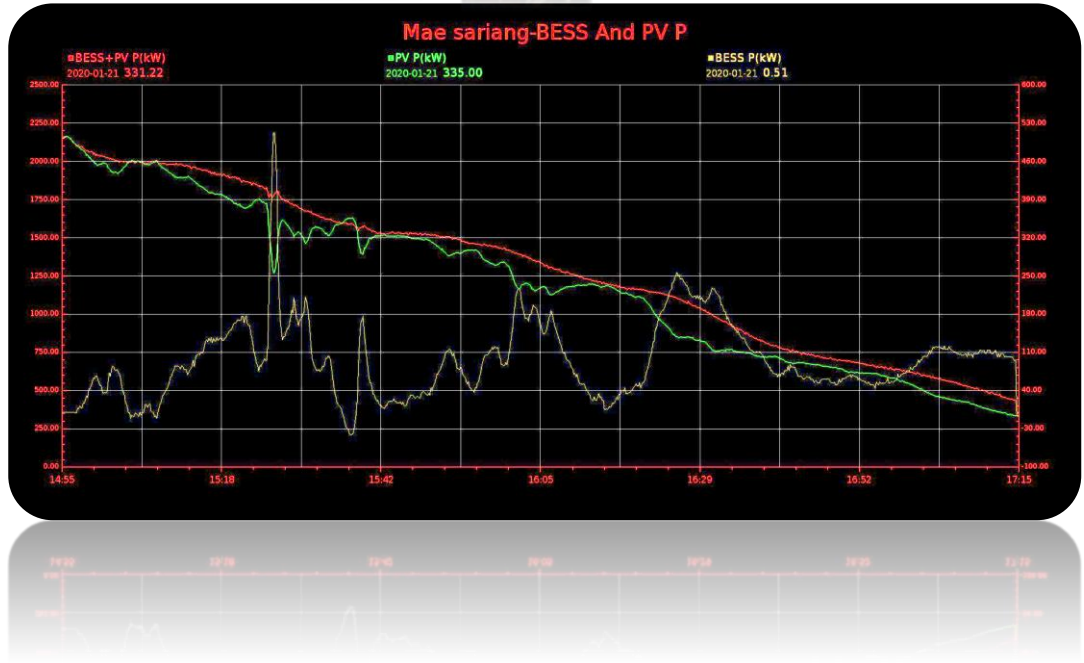
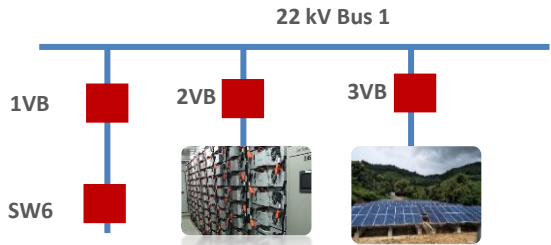
# Microgrid at Mae Sariang

## Islanding to Auto Grid-Connected



# Microgrid at Mae Sariang

## PV Smoothing\*\*



### Function Description

Supply/Absorb active power to maintain the variation of PV output





## Existing



Diesel Gen. (1MW)

7 Units

## Scope of Work



Energy Storage (4MW/4MWh,  
6.2MWh installed)  
to cover significant load

1 Units



Micro grid Controller  
with Fault Location Isolation &  
Service Restoration (FLISR)

1 System



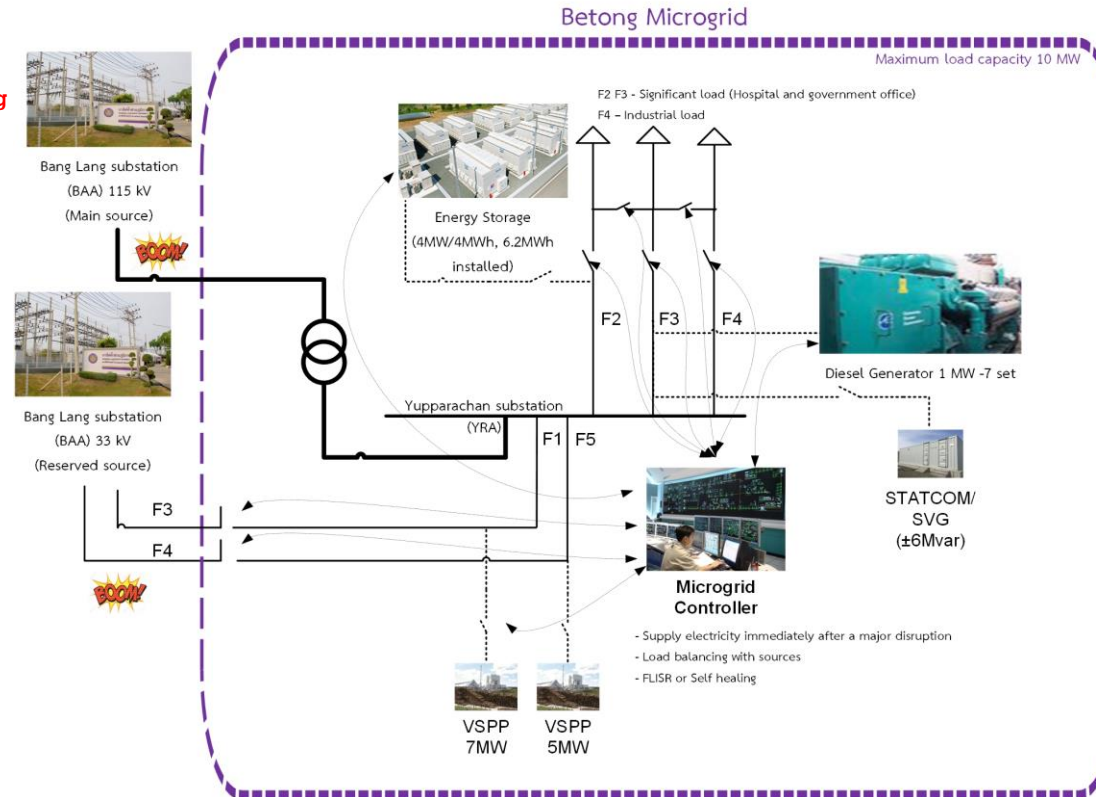
Communication System

1 System



STATCOM/SVG ( $\pm 6\text{Mvar}$ )

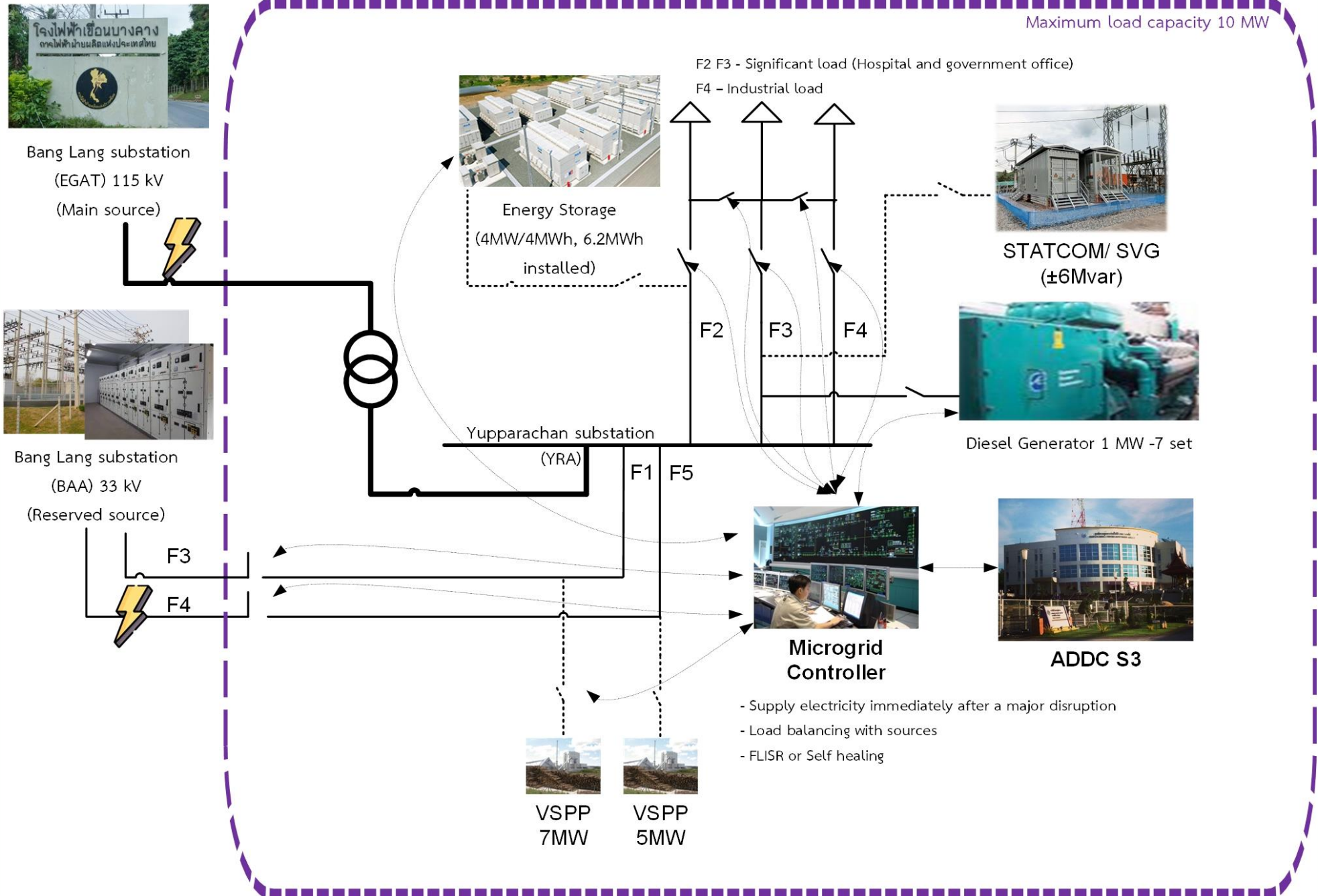
1 System



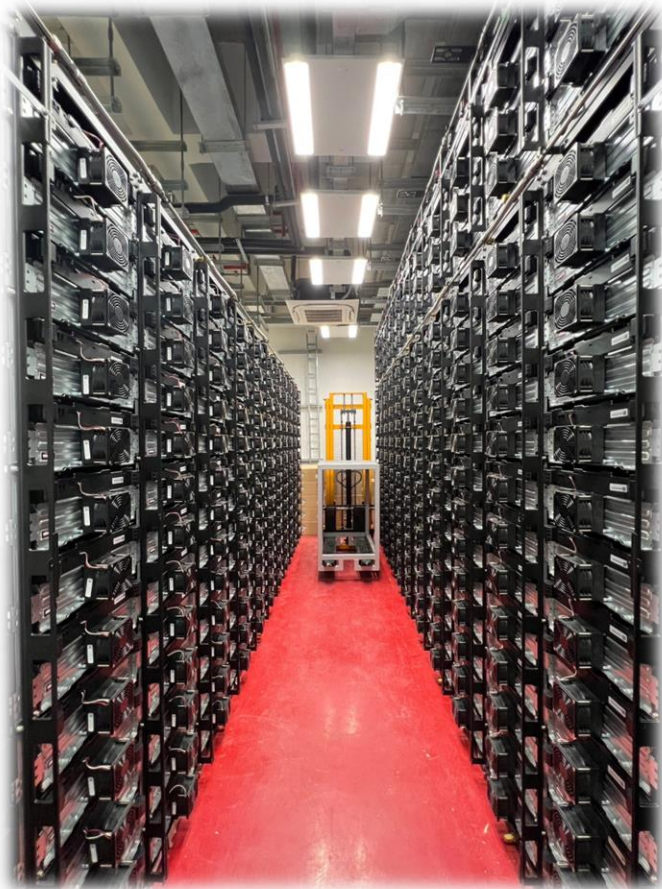


# Betong Microgrid

Maximum load capacity 10 MW

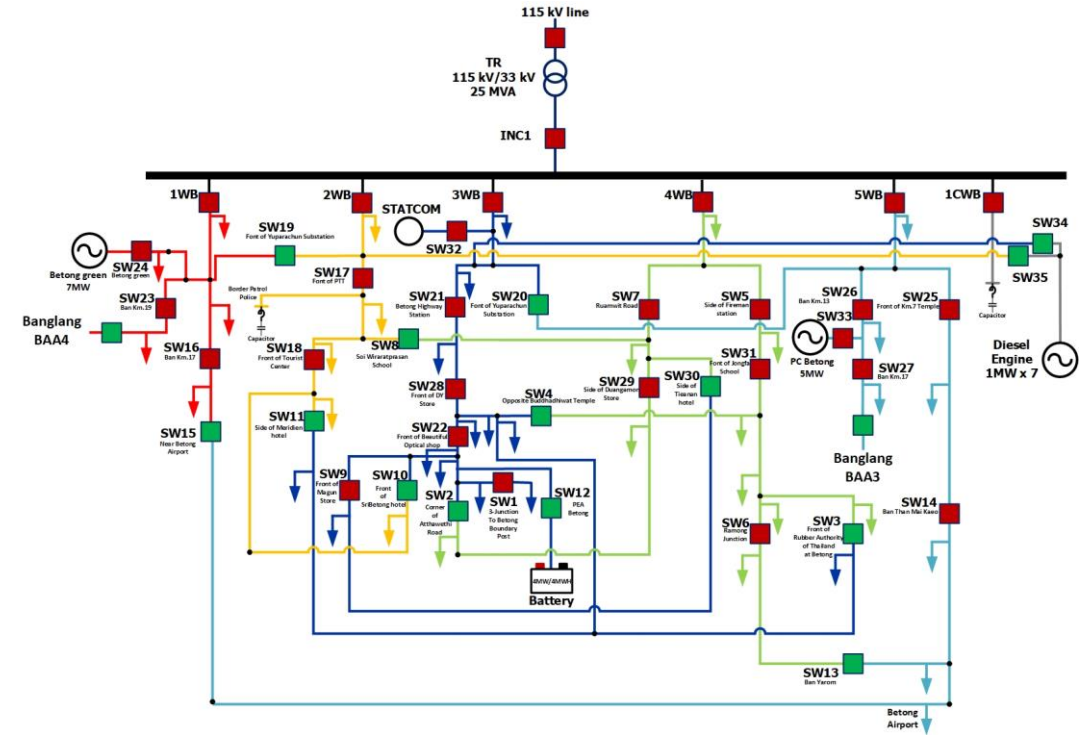
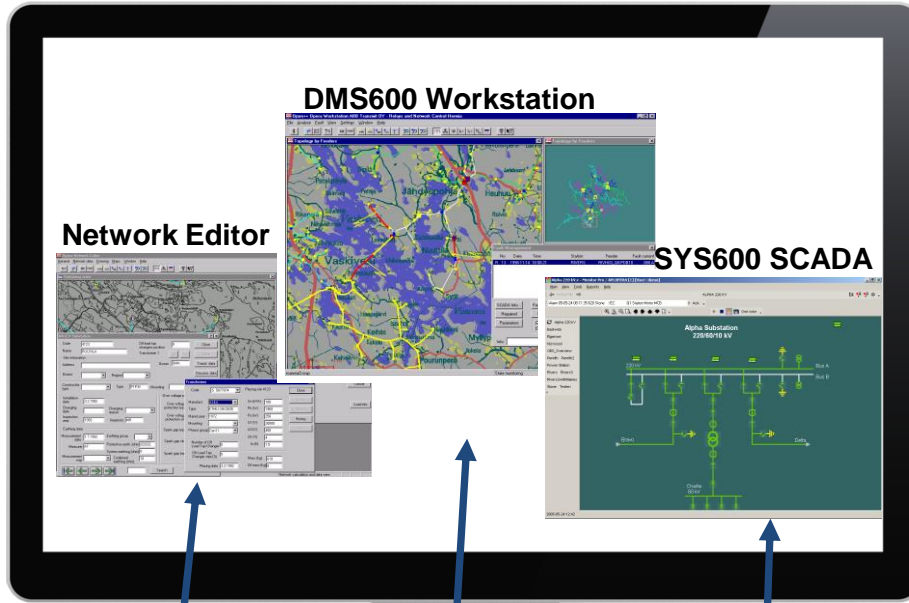


# Microgrid at Betong, Yala





# System Overview for Fault Location Isolation & Service Restoration (FLISR)



**External Network Data**

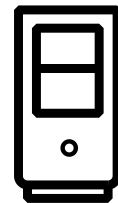
- IEC 61968 (DCIM)
- DXF Import
- SHP import
- KML Import
- Text files

Network & DMS databases

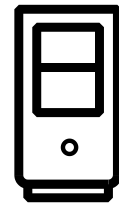


MS SQL Server  
Oracle

OPC DA



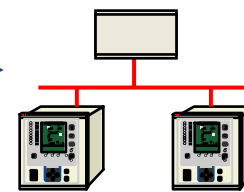
MicroSCADA X  
DMS600 Services



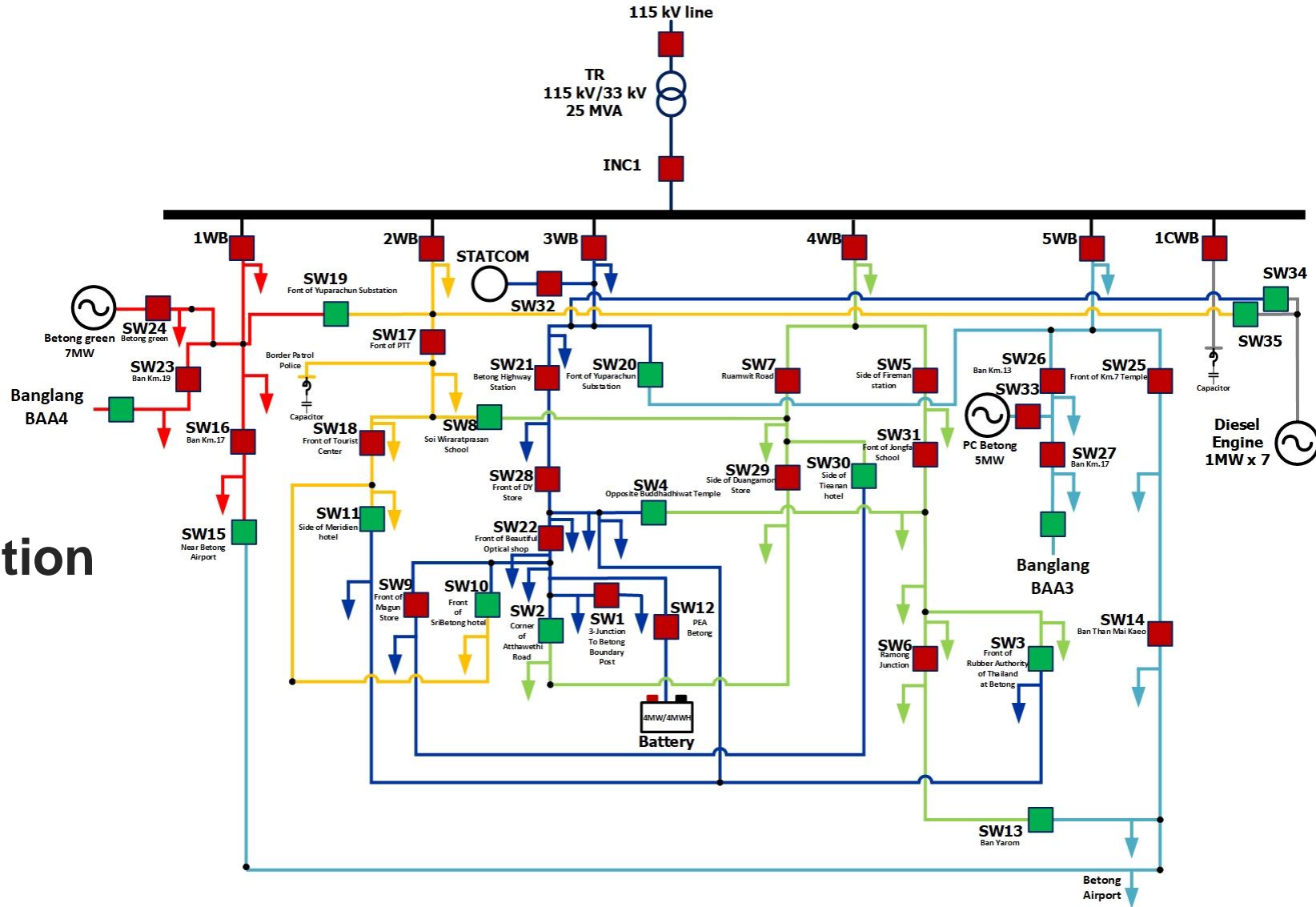
MicroSCADA X  
SYS600 Services

AMI  
Smart meters

IEDs, RTUs....



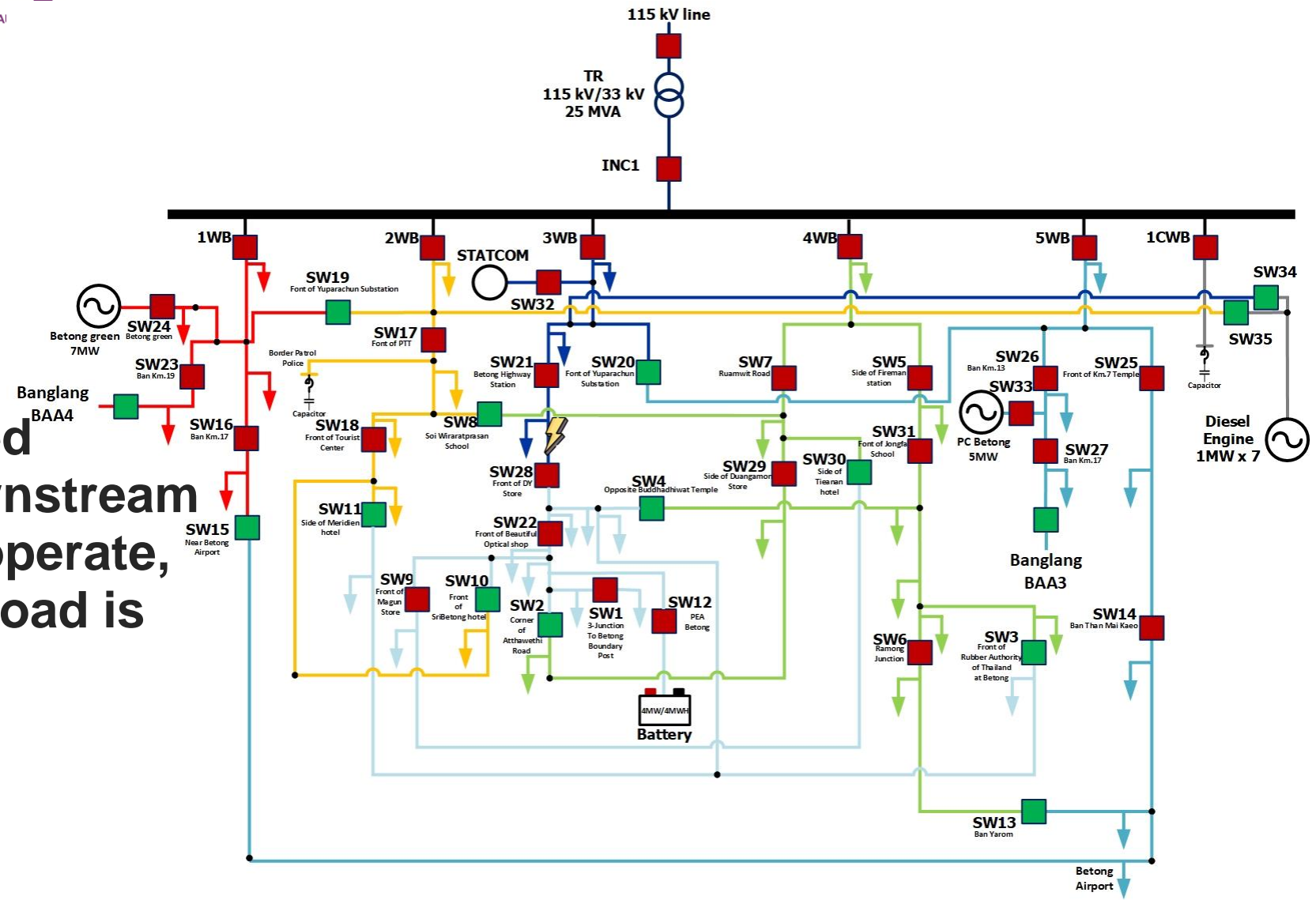
# Fault Location Isolation & Service Restoration (FLISR)



Normal Operation

# Fault Location Isolation & Service Restoration (FLISR)

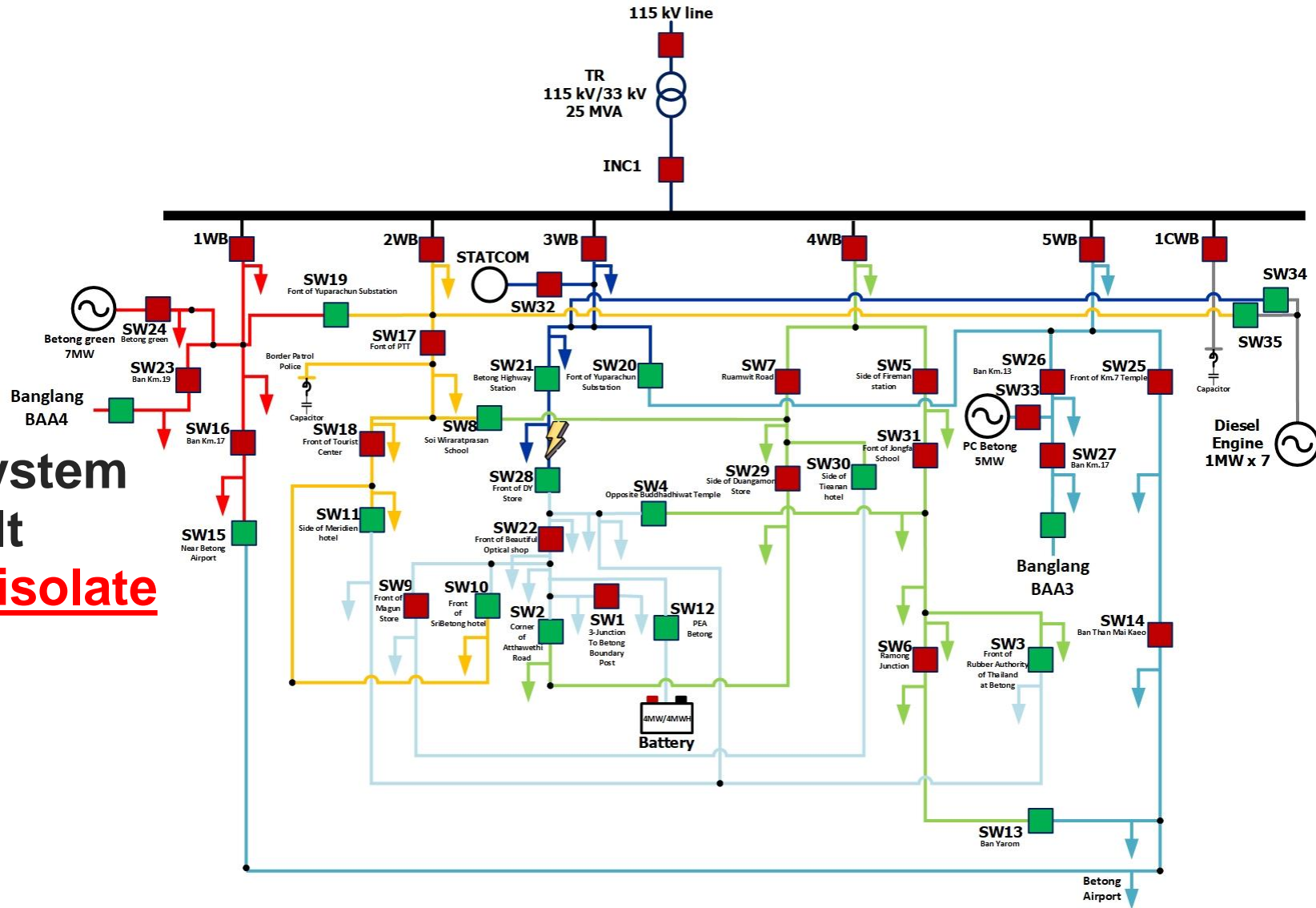
**Fault Occurred**  
**Recloser downstream**  
**of fault area operate,**  
**downstream load is**  
**outage**



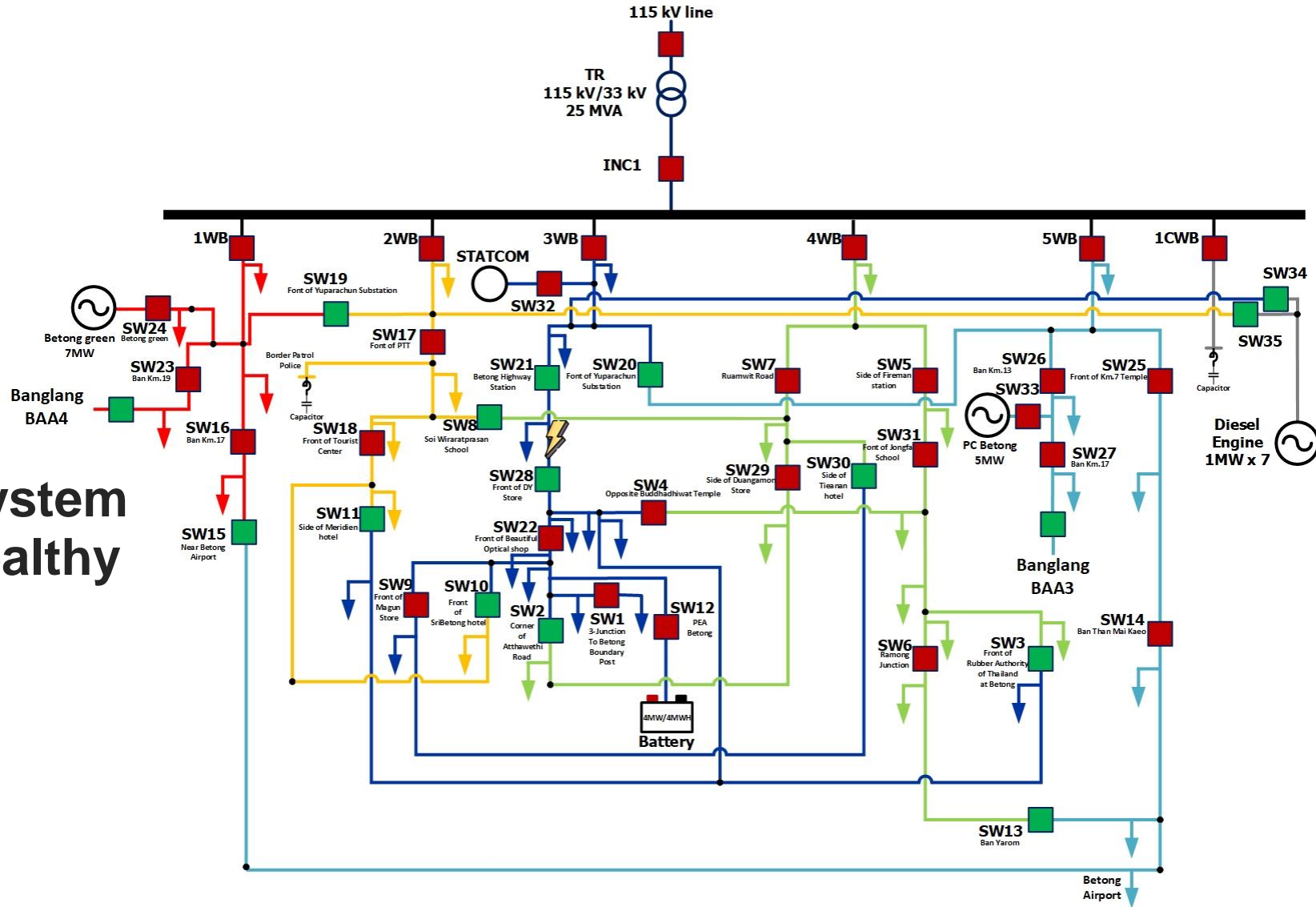


# Fault Location Isolation & Service Restoration (FLISR)

AI of FLISR system  
locate the fault  
location then isolate  
the fault area

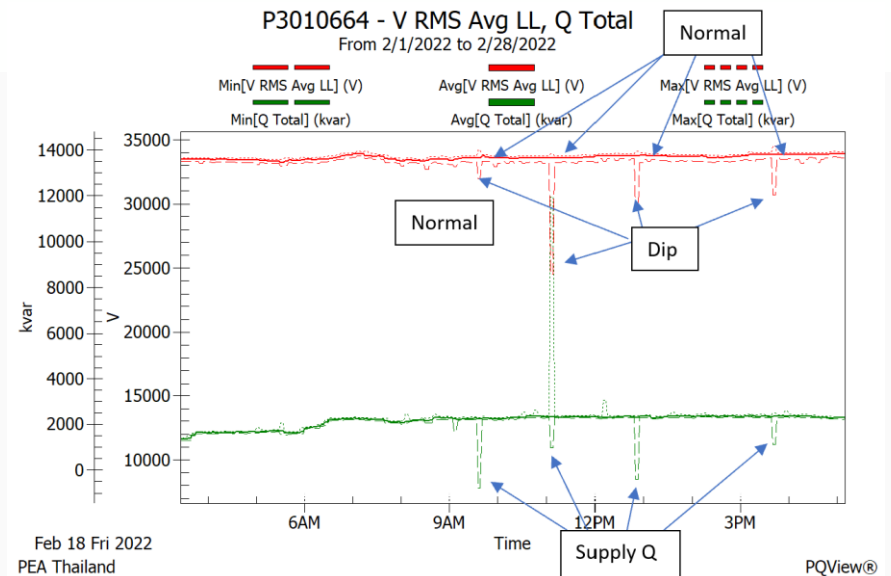
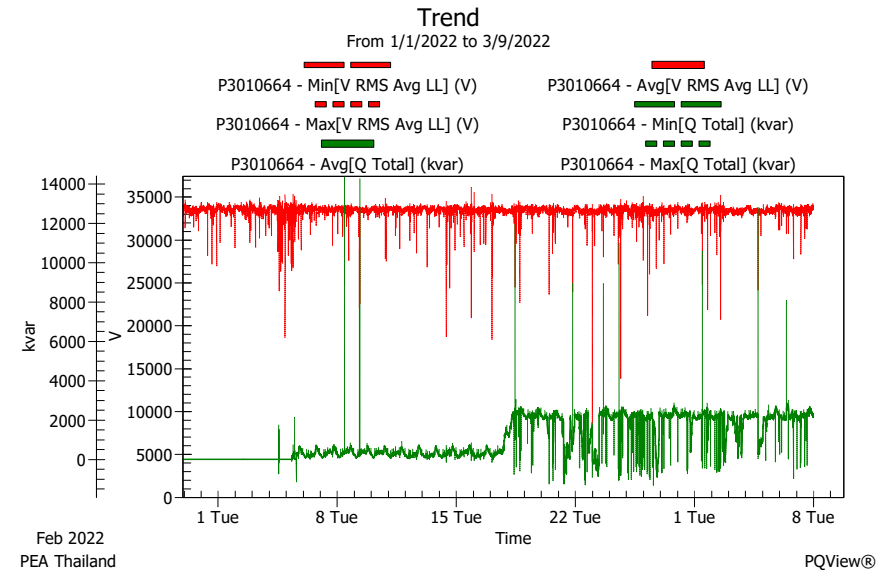


# Fault Location Isolation & Service Restoration (FLISR)



AI of FLISR system restore the healthy area

# STATCOM/Static Var Generator (SVG) Application

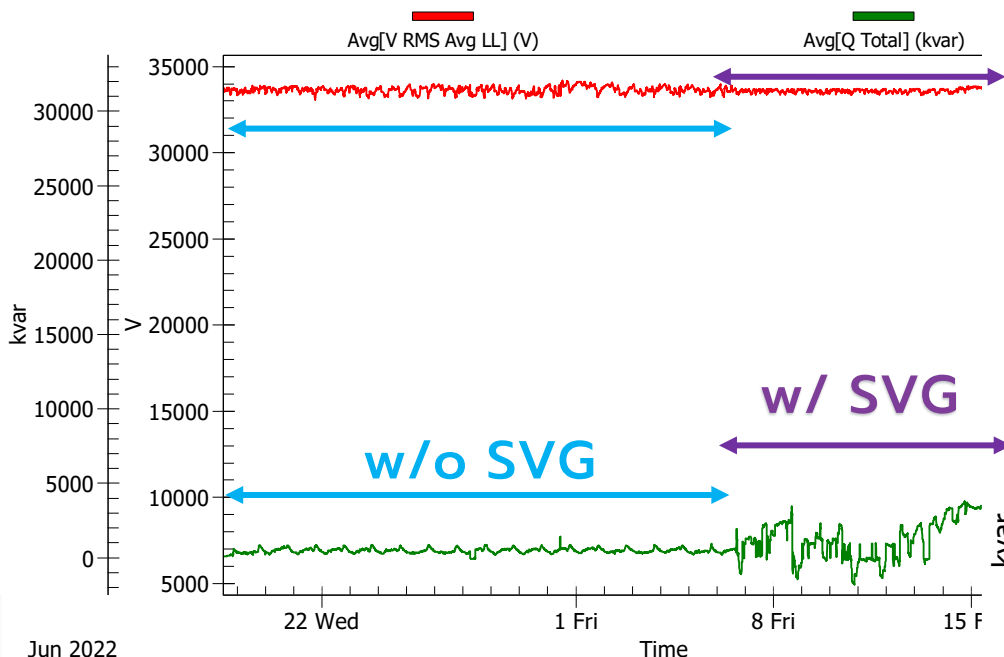




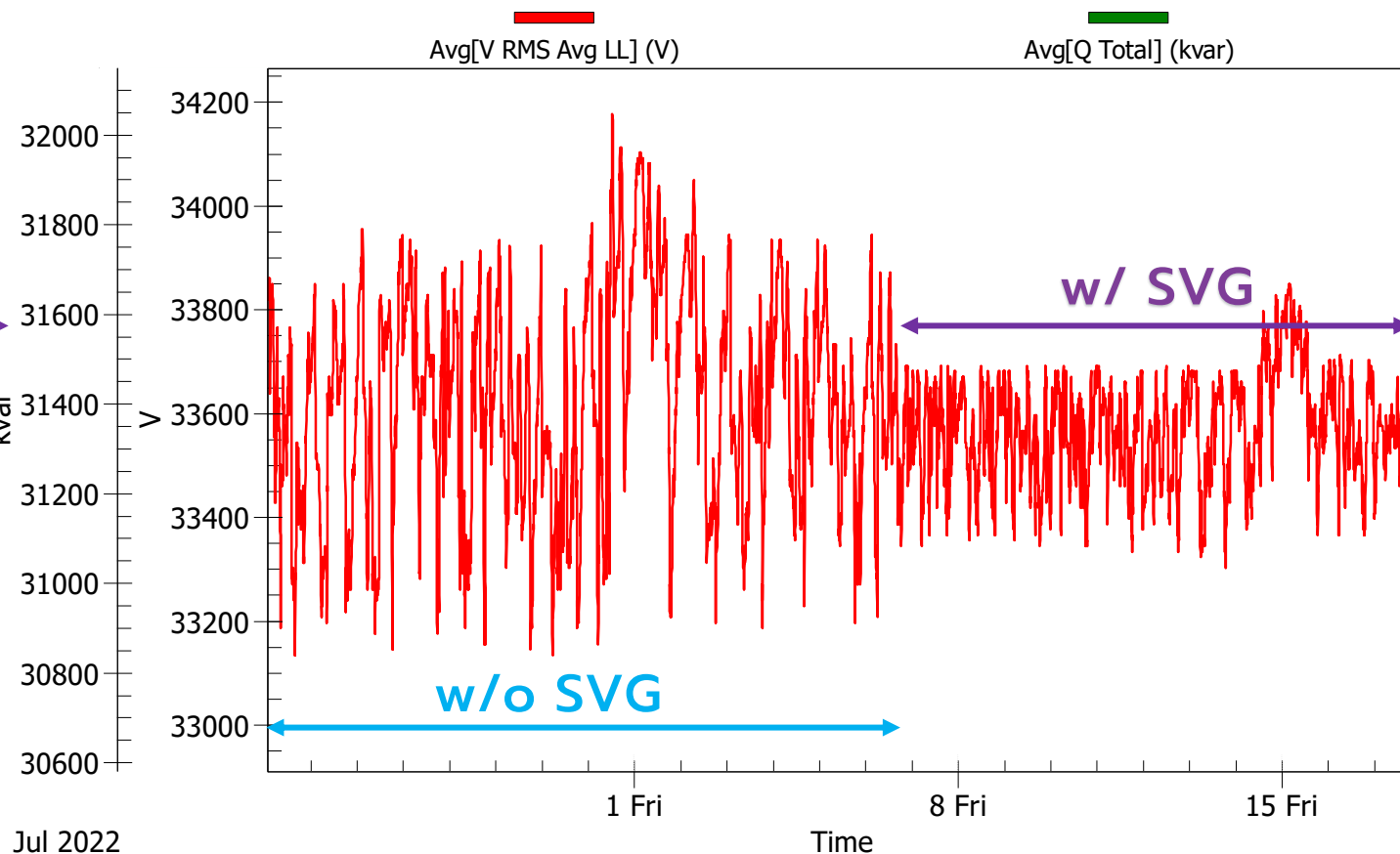
# STATCOM/SVG Application

## Voltage range variation benefit

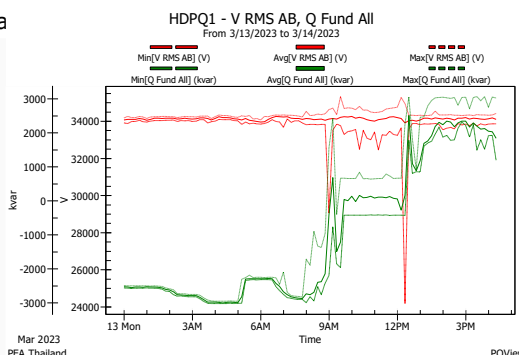
P3010664 - V RMS Avg LL, Q Total  
 From 5/27/2021 5:00:00 AM to 10/2/2022 12:00:01 AM



P3010664 - V RMS Avg LL, Q Total  
 From 5/27/2021 5:00:00 AM to 10/2/2022 12:00:01 AM



Jun 2022  
PEA Thaila



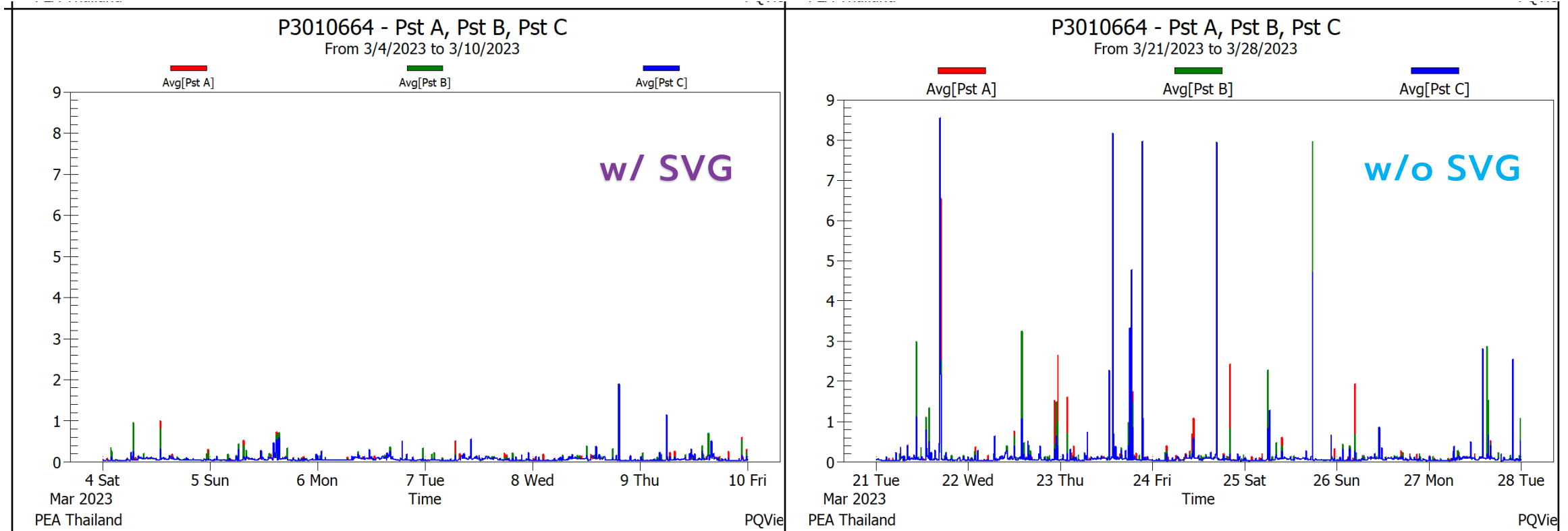
Voltage vs Reactive Power by SVG  
 13 Mar 2023: Midnight to 8 am, voltage quite stable at 34.0-34.2kV while SVG absorb at its setup limit during 2-3Mvar for maintaining the over voltage problem.

Jul 2022  
PEA Thailand

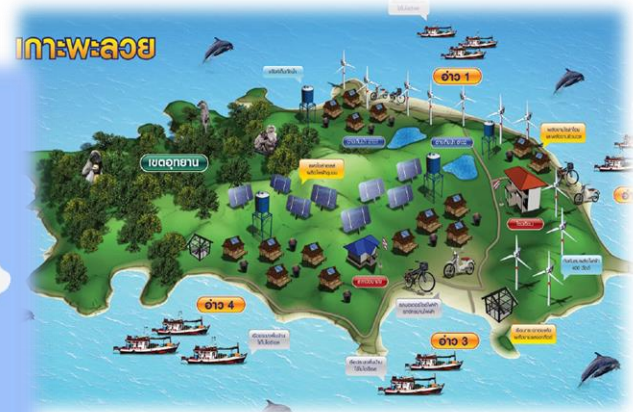
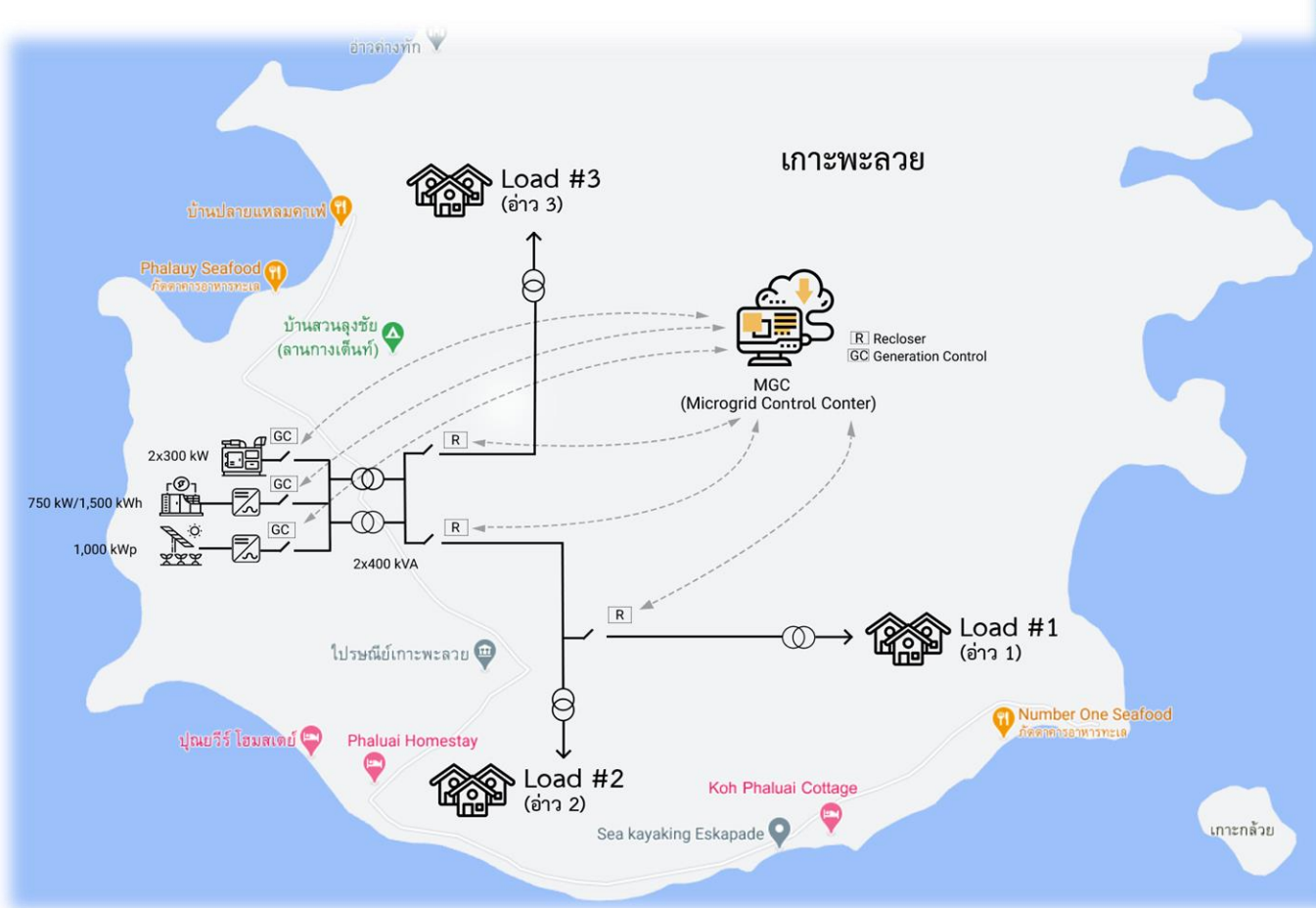
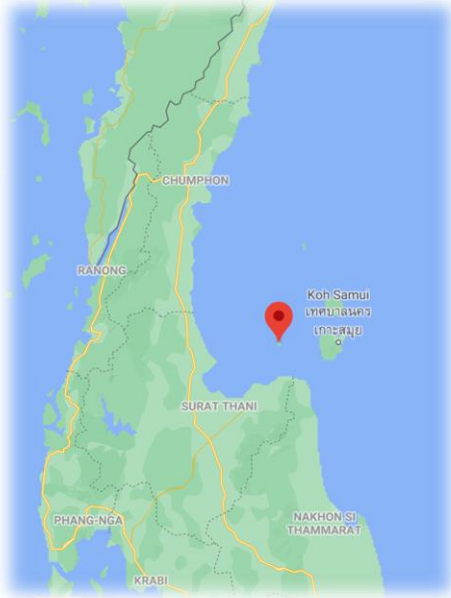
PQView®

# STATCOM/SVG Application

## Voltage fluctuation (Pst) benefit

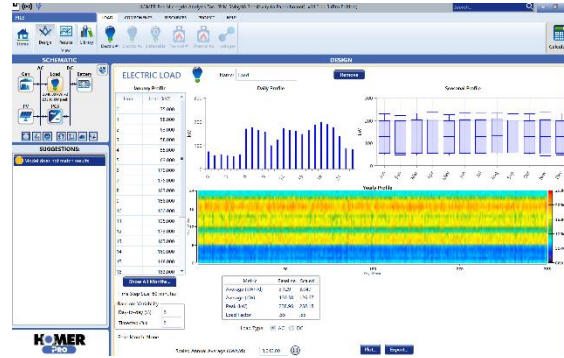


# Phaluai Island Microgrid, Surat Thani

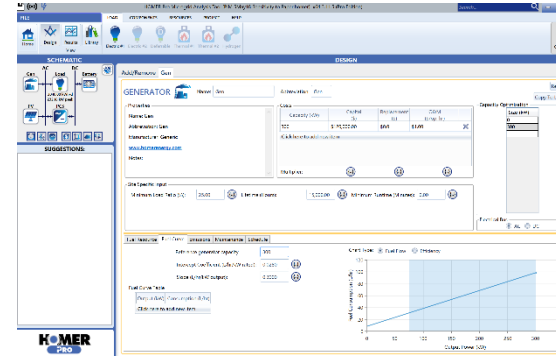




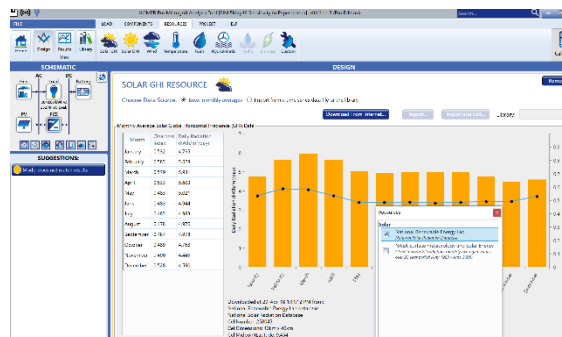
# Microgrid Design: Parameters modelling in HOMER Pro



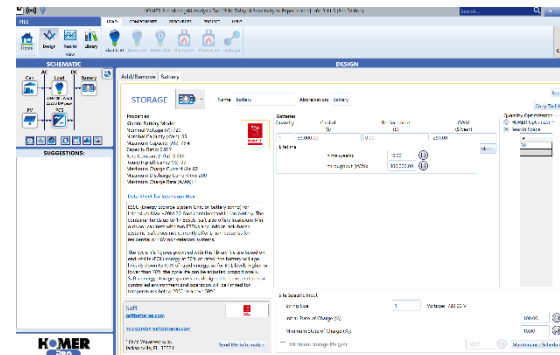
Daily load modelling



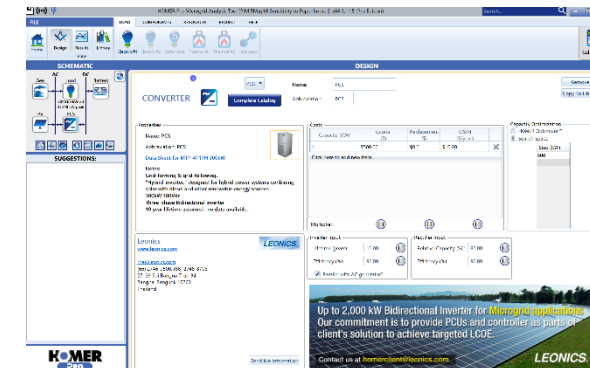
Generator modelling



PV modelling

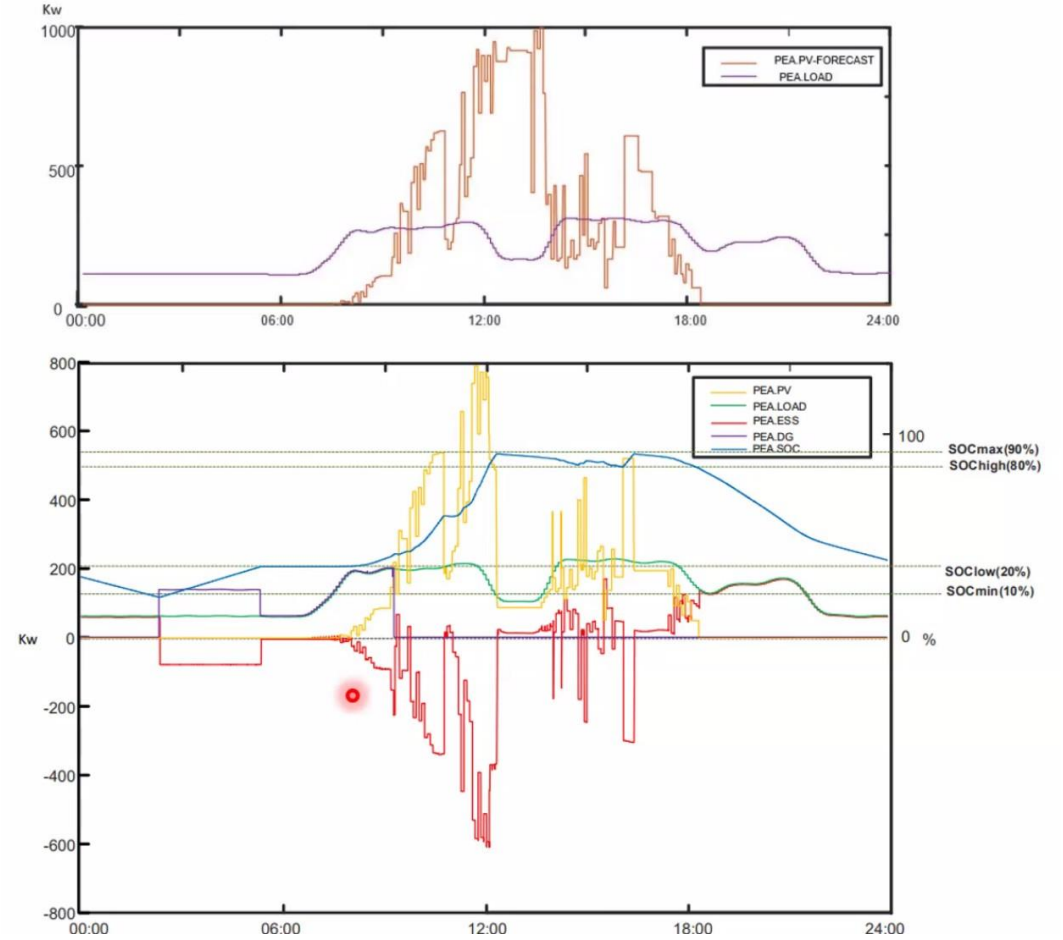
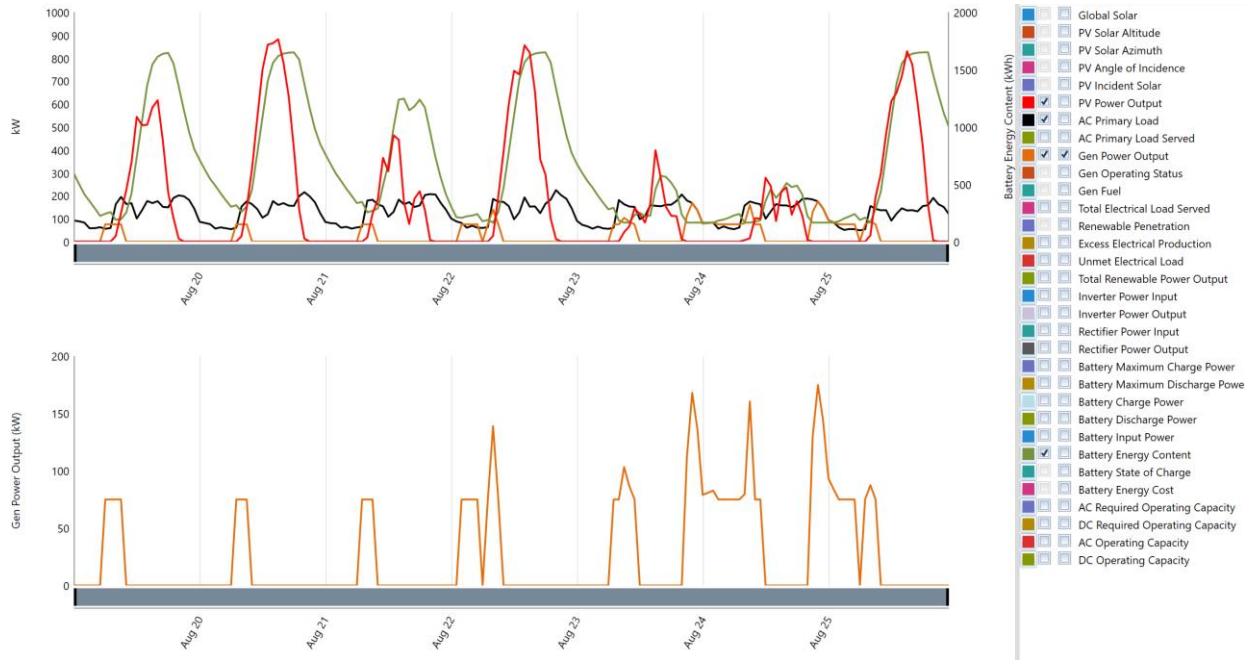


Battery modelling



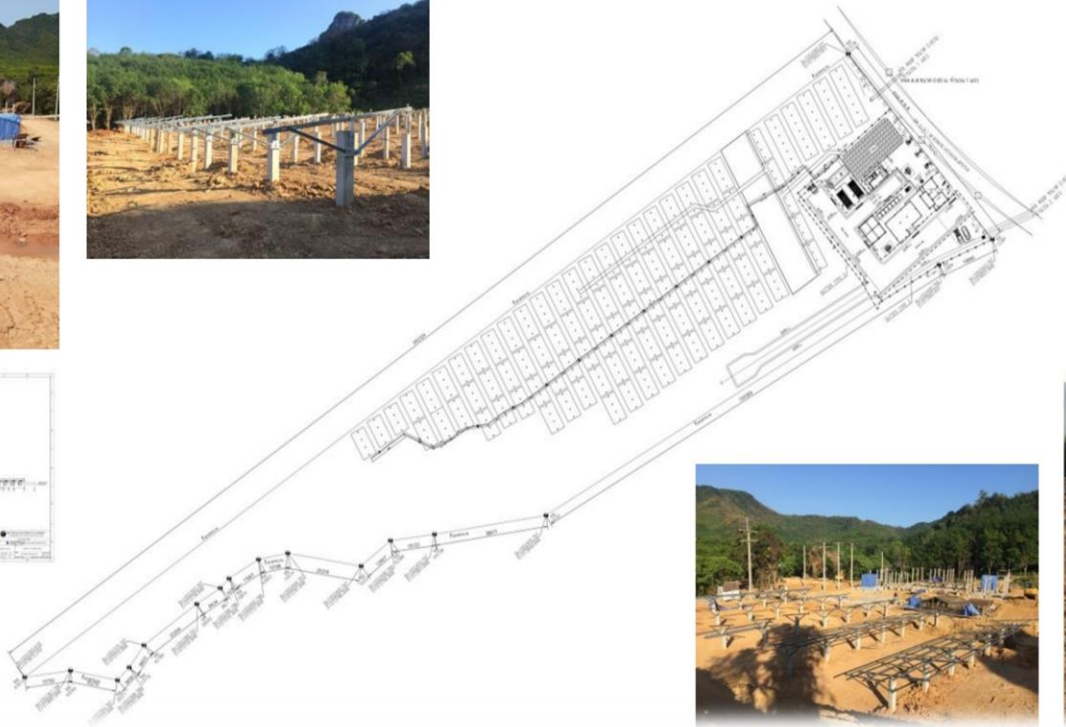
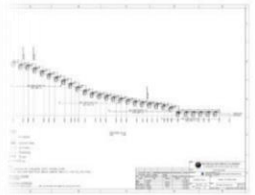
PCS modelling

# Microgrid Design: Parameters modelling in HOMER Pro



# Phaluai Island Microgrid Under Construction

## PLANT LAYOUT





# Thank You

