Inverter Technologies in Microgrid and Isolated Microgrid

8th Meeting of the ASIA SOLAR ENERGY FORUM : ADB HQ Manila, June 15 2015

Dr. Wuthipong Suponthana, PhD.
IEC TC82 JWG1, WG3, WG6, Leonics Co., Ltd. Thailand.
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Established	: **1991 , 23 Years in Business**
Years in Solar Energy	: **15 Years in Hybrid Microgrid systems**
Paid up Capital	: **1.72 millions USD fully paid in 1993**
Total Assets	: **22.1 millions USD at (end of fiscal year 2013)**
QA System	: **Certified ISO 9001 by UL since 1997**
	: **Certified TIS/ISO 9001 since 2001**
EM System	: **Certified TIS/ISO 14001 since 2001**
Employees	: **1 PhD.** in Renewable Energy (Hybrid System)
	2 PhD. Candidate in Renewable Energy (PV-DG Hybrid)
	2 MS. in Renewable Energy
	5 Master Degree in Engineering and Management
	226 Employees (Degree in Engineering and Science 12%)

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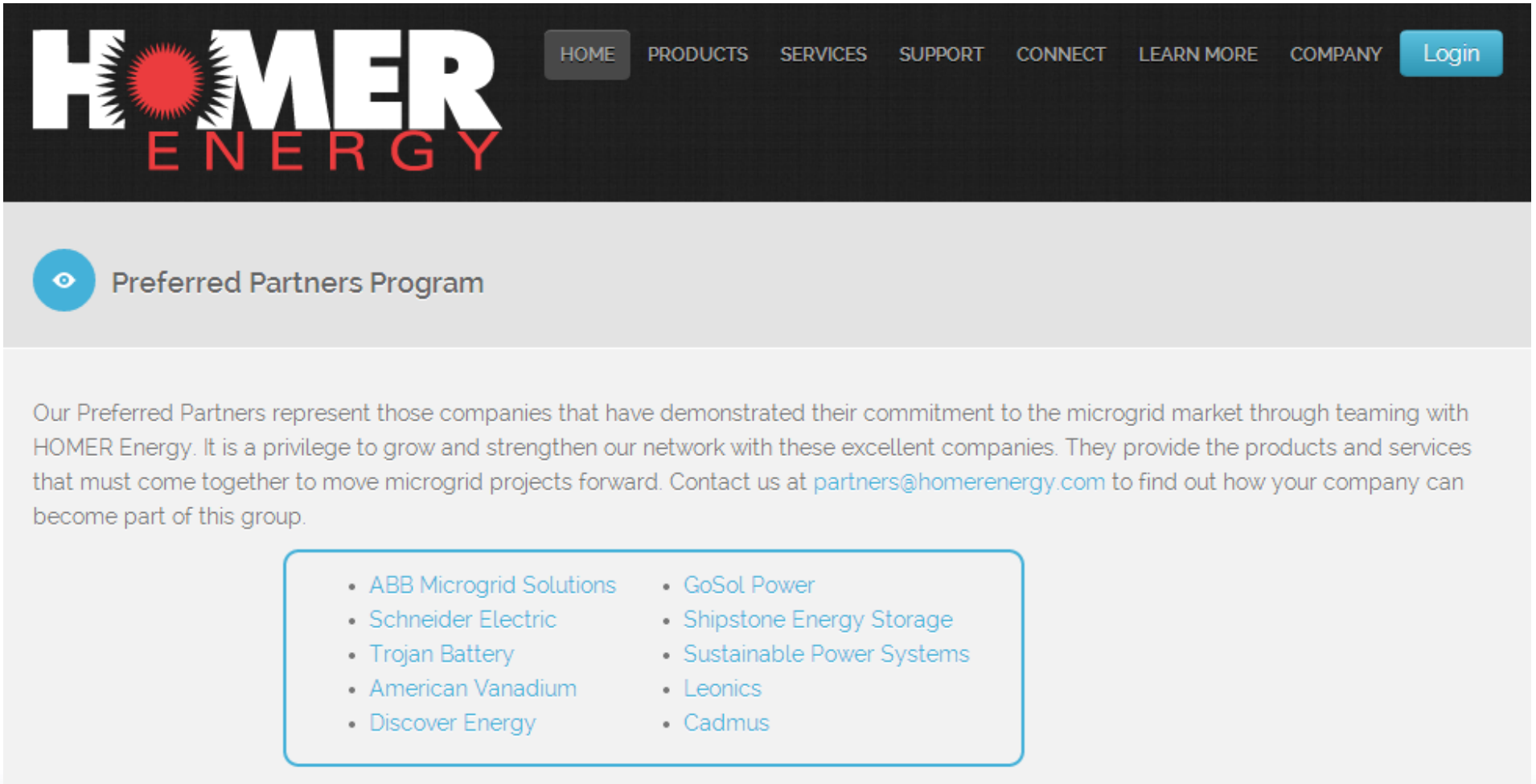
Leonics is the First and only Asia equipment manufacture in HOMER's Industrial Partners & Component Partners



TC8 IEC 60050-617 :

Systems aspects of electrical energy supply, Draft Definition IEV 617

Definition of ***Microgrid***

"Group of interconnected loads and distributed energy resources with defined electrical boundaries that acts as a single controllable entity and is able to operated in both grid connected or island mode."

Definition of ***Isolated Microgrid***

"Microgrid currently not capable of being connected to wide electric power system"

Electrical Power System

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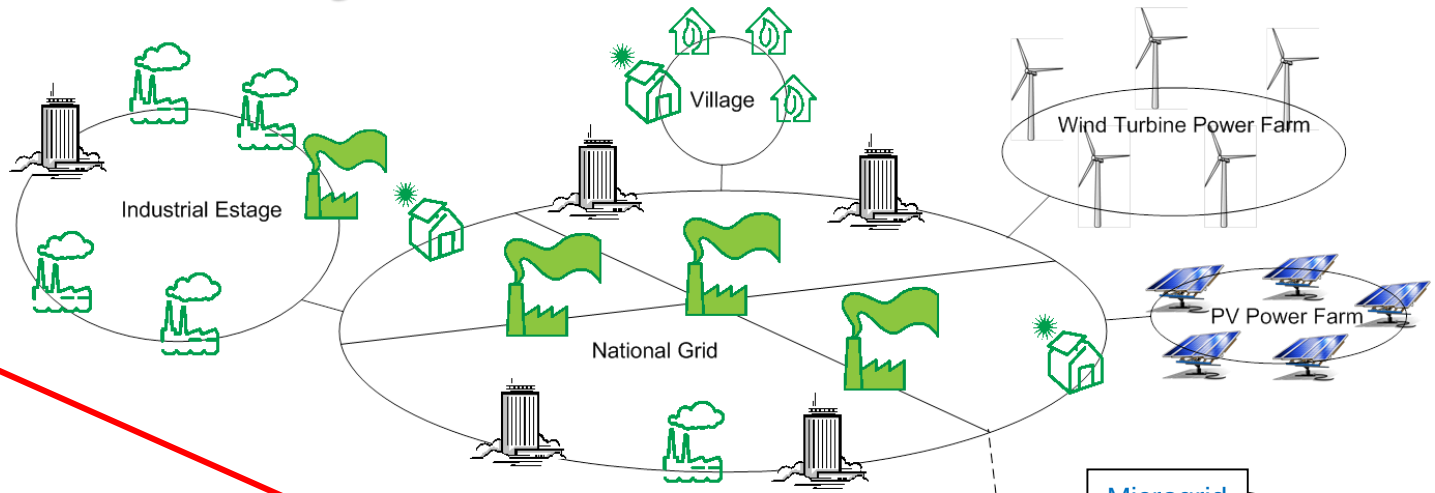
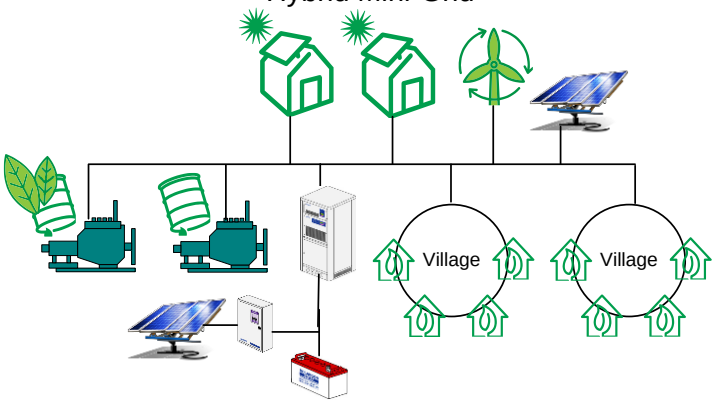
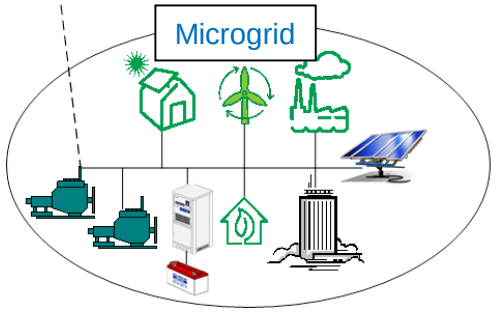
Urban Area Power System



Remote Area Power System

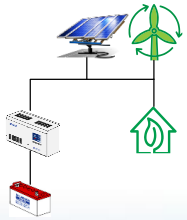
AC-DC Coupling
Stand Alone PV-WT-DG Hybrid Mini-Grid = Microgrid





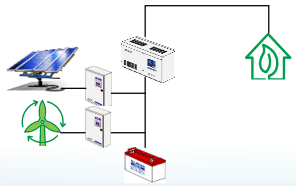
Has capability to connect to wide electrical system

AC coupling Stand Alone PV-WT Hybrid System



Isolaed Microgrid

DC coupling Stand Alone PV-WT Hybrid System

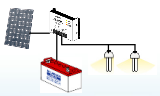


Isolated Microgrid

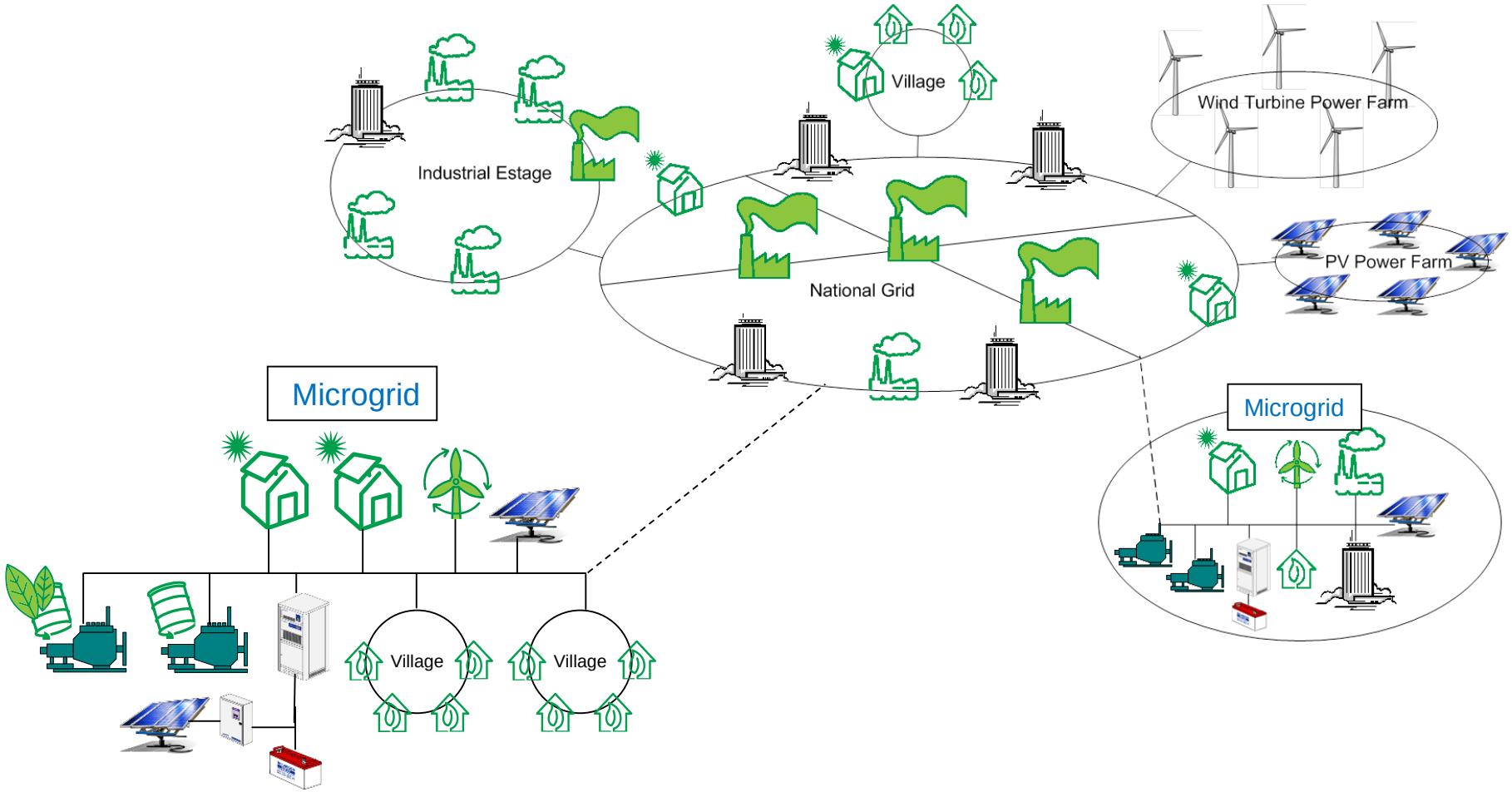
AC SHS

Isolated Microgrid

DC SHS



Isolated Microgrid


Industrial Estate
Village
Wind Turbine Power Farm
National Grid
PV Power Farm
Microgrid
Microgrid
Village
Village

Type of PCE (Inverter) in Solar Photovoltaic Energy System

Battery Inverter :

Convert DC-AC, AC-DC, Bidirectional

Voltage Source Inverter : Grid Forming - Stable V – f

Applications
- Remote Area Power System
- Minigrid/Microgrid

PV-Battery Inverter (Dual Modes Inverter, Grid connect and Stand alone)

Convert DC-AC, AC-DC, Bidirectional, Fast Transfer switch

Voltage Source Inverter : Utility OK - Grid Connect - Follow V-f
Utility fail - Grid Forming - Stable V-f

Applications
- Grid Connect with Back up (Grid Interactive)

Battery Grid Connect Inverter

Convert DC-AC, AC-DC, Bidirectional

Voltage Source Inverter : Grid Connect with transient support to stable V-f of Power Generation Sources eg. Diesel Generaotr

Applications
- Grid Connect with Back up (Grid Interactive)

PV Grid Connect Inverter

Convert DC-AC, Unidirectional

Current Control Voltage Source : Grid Connect

Applications
- Grid Connect
- Micro Inverter in ACmodule

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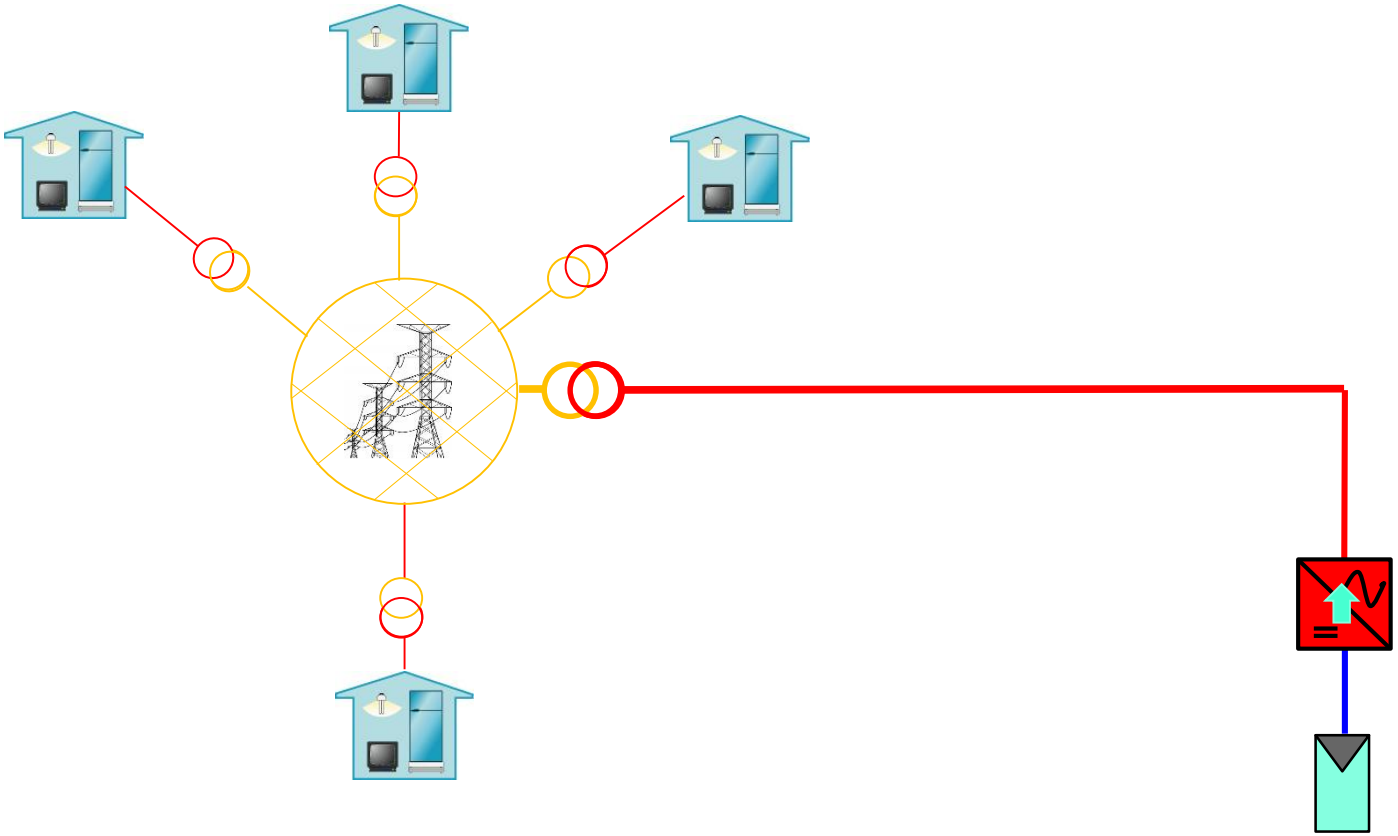
Urban Area Power System
Grid Connect Inverter

PV Grid Connect Inverter



Grid Interactive 100kW x 10 Units in a Factory
Tamil Nadu, India

(Inverter work as Grid Connect when Uitlity line or DG is operate
And in Stand-Alone with uninterrupted power when Utility Power fail)

PV-Battery Grid Interactive Inverter

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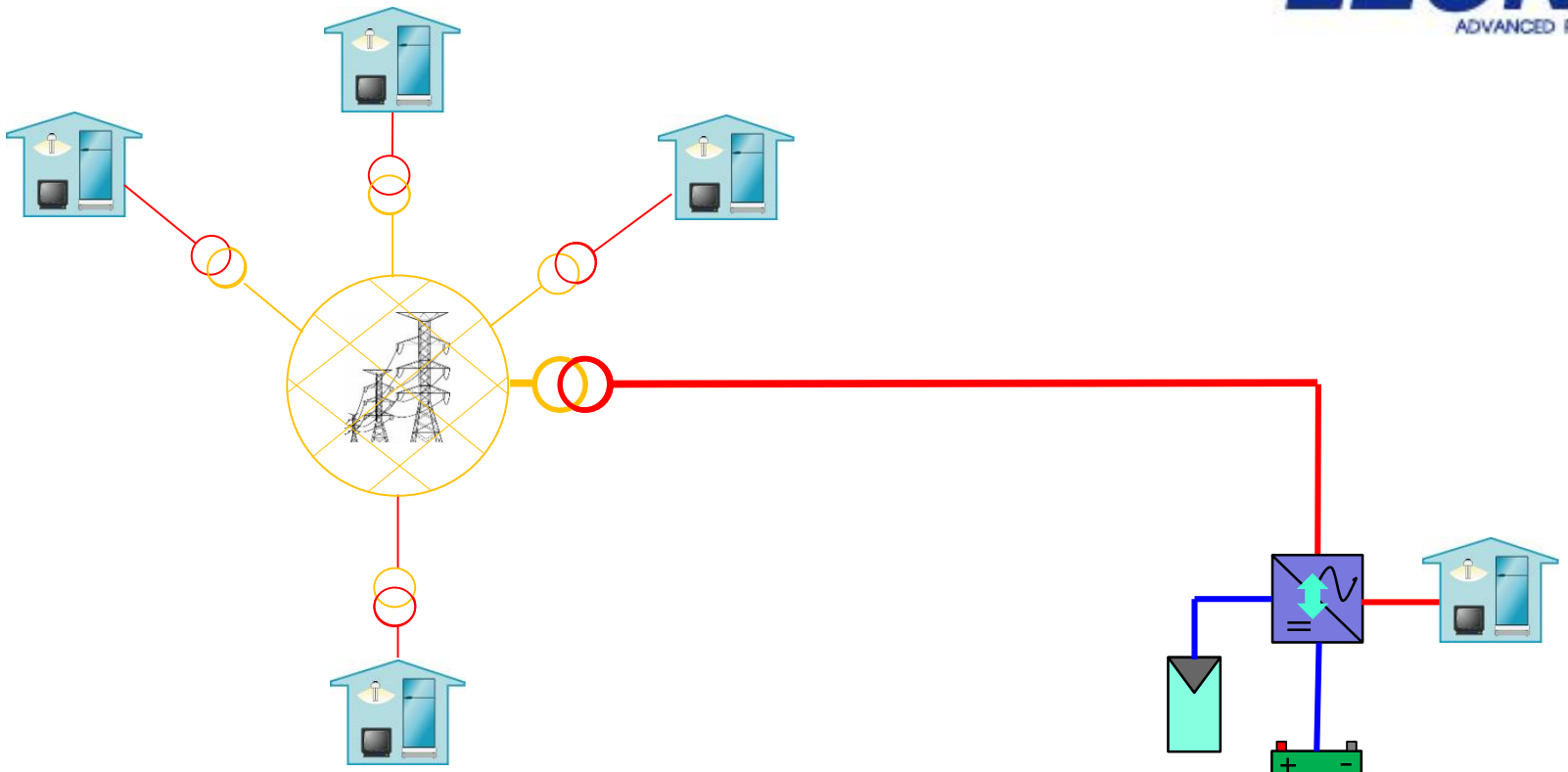

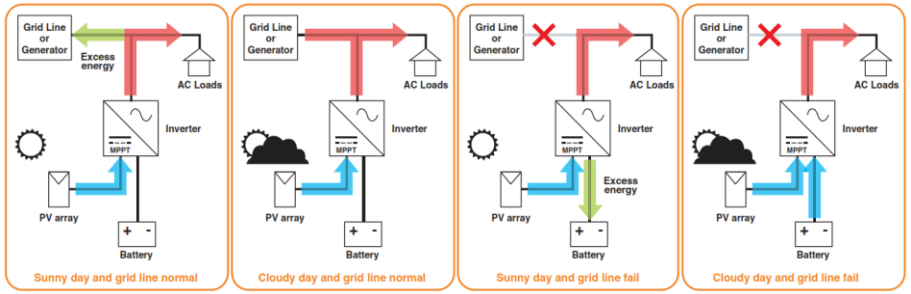

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Remote Area Power System

IEA PVPS Classify PV Hybrid in Minigrid (Microgrid) system

3.3 MW and 4.2 MW Stand-alone PV / diesel hybrid mini grid systems in Malaysia.

Stand-Alone PV Hybrid System Control Method	Supervisory Control	Communication
1. Rotating machine dominate system 1a. Single rotating machine 1b. Multi rotating machine 2a. Single rotating machine + Storage 2b. Multi rotating machine + Storage	a. Genset Operation Control a1. Set reference Voltage and Frequency to system a2. Alternate operation of diesel units a3. Parallel genset operation with load sharing, a4. Reserve and transients covered by diesel	i. Communication Line i1 Hardware / Protocol a. RS485 / Modbus + Proprietary b. CAN / CANopen i2 IEEE P1547.3 guide line i3 IEC 61850-7-420 i4 UESP developed by CiA
2. PCE dominate system 2a. Single PCE master 2b. Multi PCE master & slave	b. Genset Dispatching Control b1. Schedule genset b2. SOC-based diesel operation b3. Load-based diesel operation	ii. Gird Line Characteristic ii1. Frequency shift power control ii2. Frequency & Voltage Droop
3. Single switch master (rotating & PCE)	c. For PCE with out storage c1. PV supply load and use excess energy to charger battery c2. Power limit control/Back feed control c3. Dummy Load dispatching c4. Deferrable Load dispatching	iii. On-Off Signal
4. Multi-master Inverter dominate	d. For PCE with Storage d1. Set reference Voltage and Frequency to system d2. transient support d3 PV and diesel genset-base battery charging d4. PV battery charging only	

Stand-Alone PV Hybrid System Control Method	Supervisory Control	Communication
1. Rotating machine dominate system 1a. Single rotating machine 1b. Multi rotating machine 2a. Single rotating machine + Storage 2b. Multi rotating machine + Storage	a. Genset Operation Control a1. Set reference Voltage and Frequency to system a2. Alternate operation of diesel units a3. Parallel genset operation with load sharing, a4. Reserve and transients covered by diesel	i. Communication Line i1 Hardware / Protocol a. RS485 / Modbus + Proprietary b. CAN / CANopen i2 IEEE P1547.3 guide line i3 IEC 61850-7-420 i4 UESP developed by CiA
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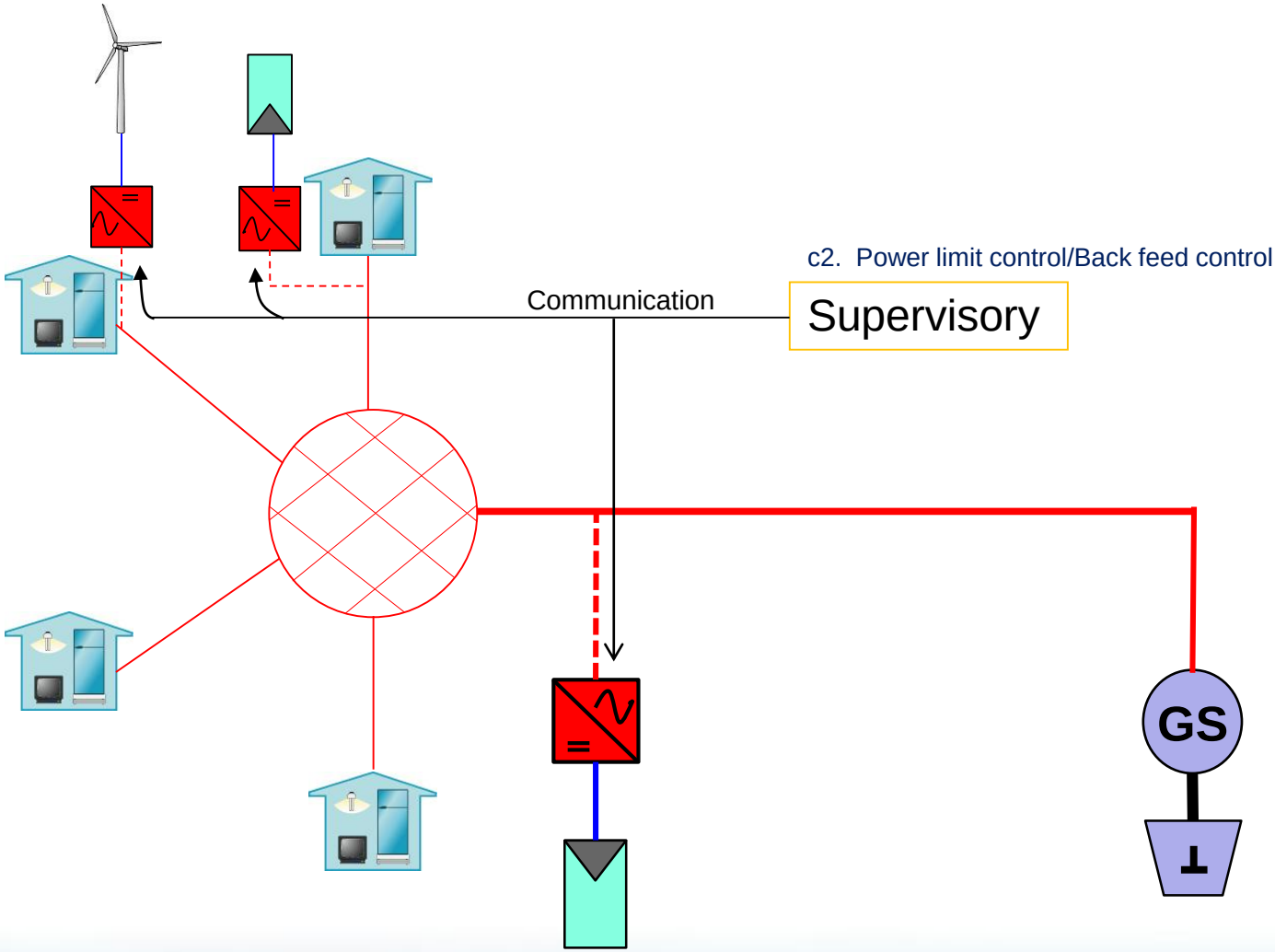
1a. Single Rotating Machine Dominate



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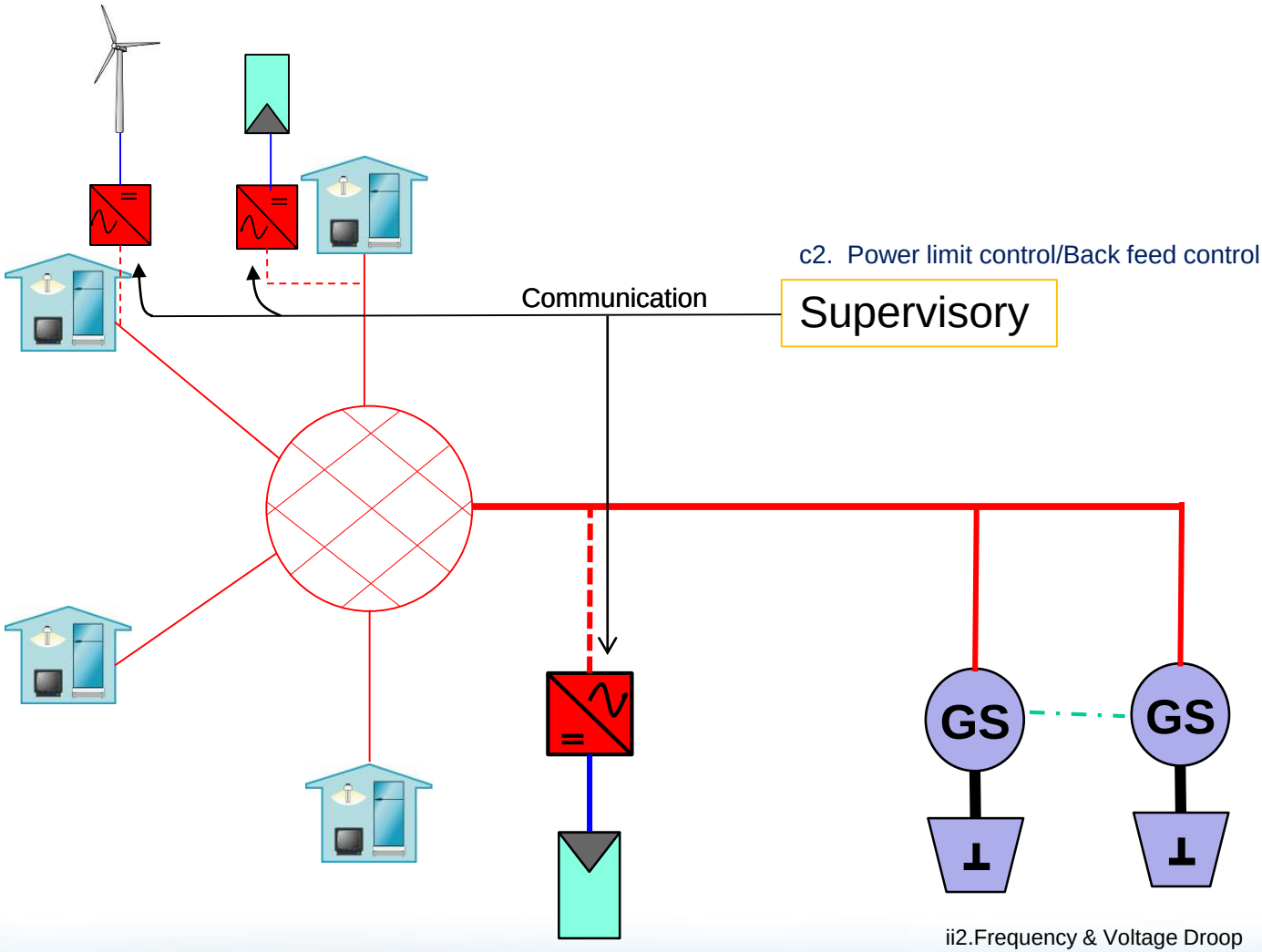
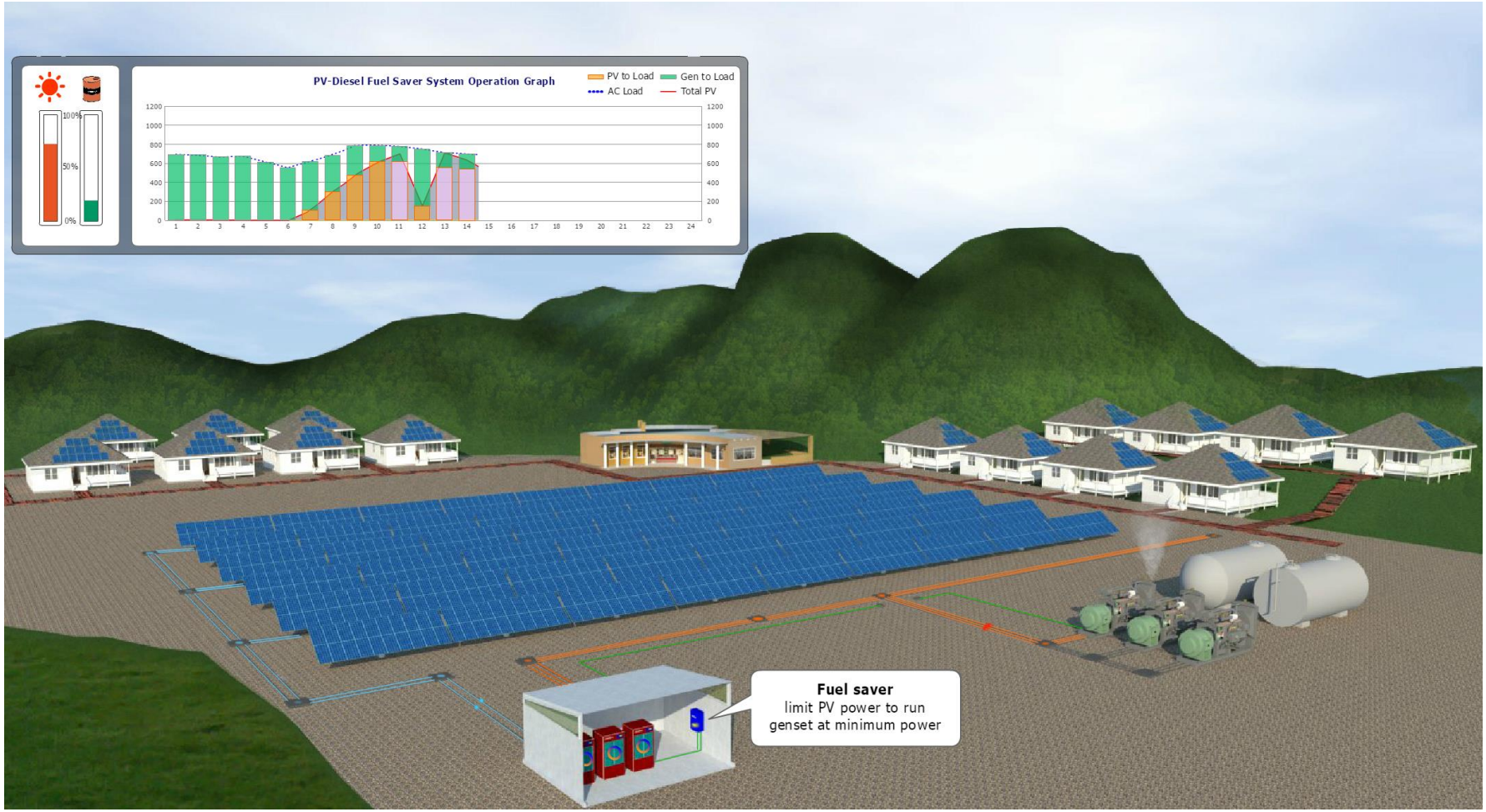
1b. Multi Rotating Machine Dominate




PV-Diesel Fuel Saver System Operation Graph
PV to Load
Gen to Load
AC Load
Total PV
100%
50%
0%
1200
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Fuel saver
limit PV power to run
genset at minimum power

Stand-Alone PV Hybrid System Control Method	Supervisory Control	Communication
1. Rotating machine dominate system 1a. Single rotating machine 1b. Multi rotating machine 2a. Single rotating machine + Storage 2b. Multi rotating machine + Storage	a. Genset Operation Control a1. Set reference Voltage and Frequency to system a2. Alternate operation of diesel units a3. Parallel genset operation with load sharing, a4. Reserve and transients covered by diesel	i. Communication Line i1 Hardware / Protocol a. RS485 / Modbus + Proprietary b. CAN / CANopen i2 IEEE P1547.3 guide line i3 IEC 61850-7-420 i4 UESP developed by CiA
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PV Grid Connect Inverter

Bidirectional Battery Grid Connect Inverter

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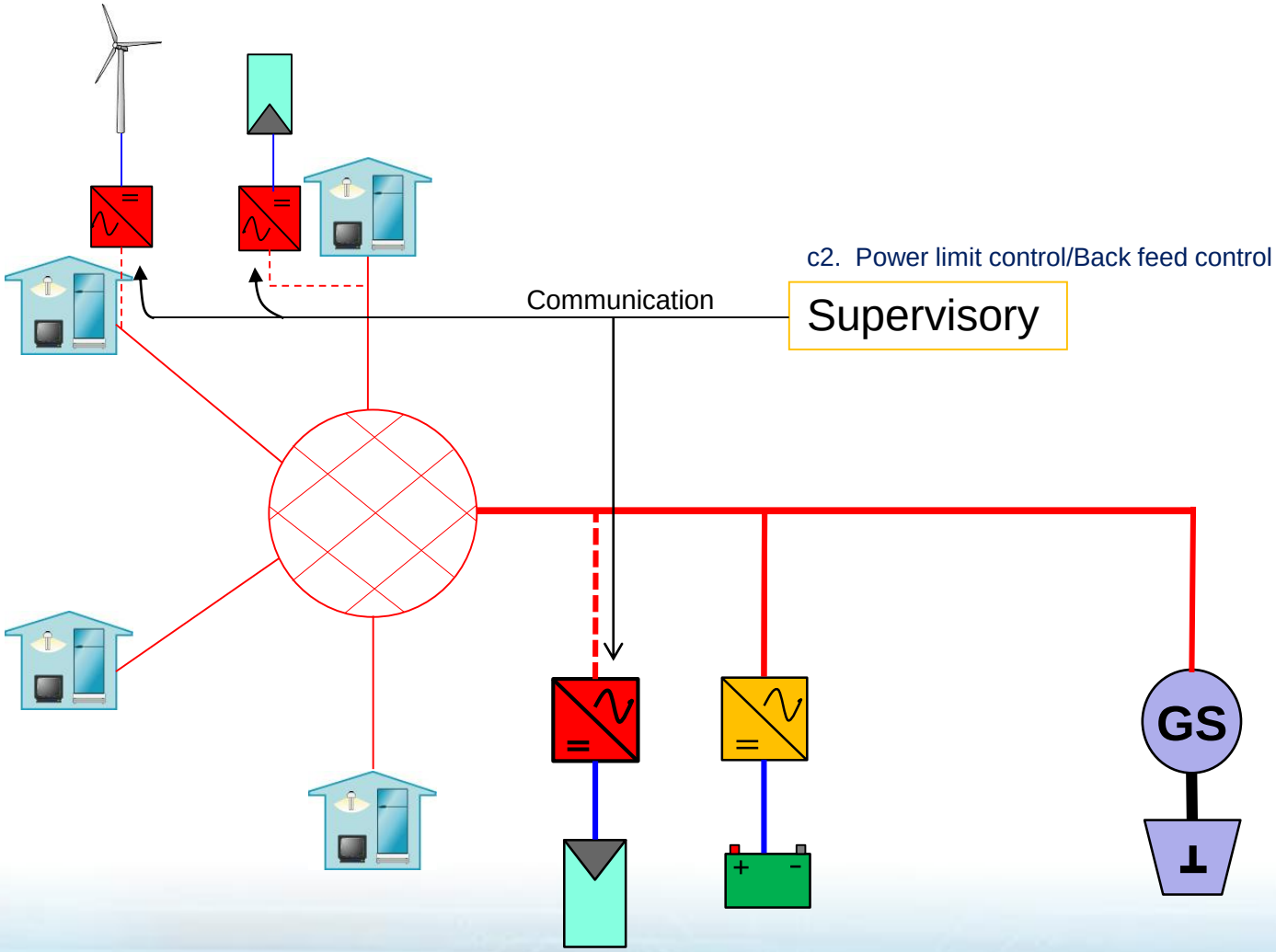
1a. Single Rotating Machine Dominate



PV Grid Connect Inverter

Bidirectional Battery Grid Connect Inverter

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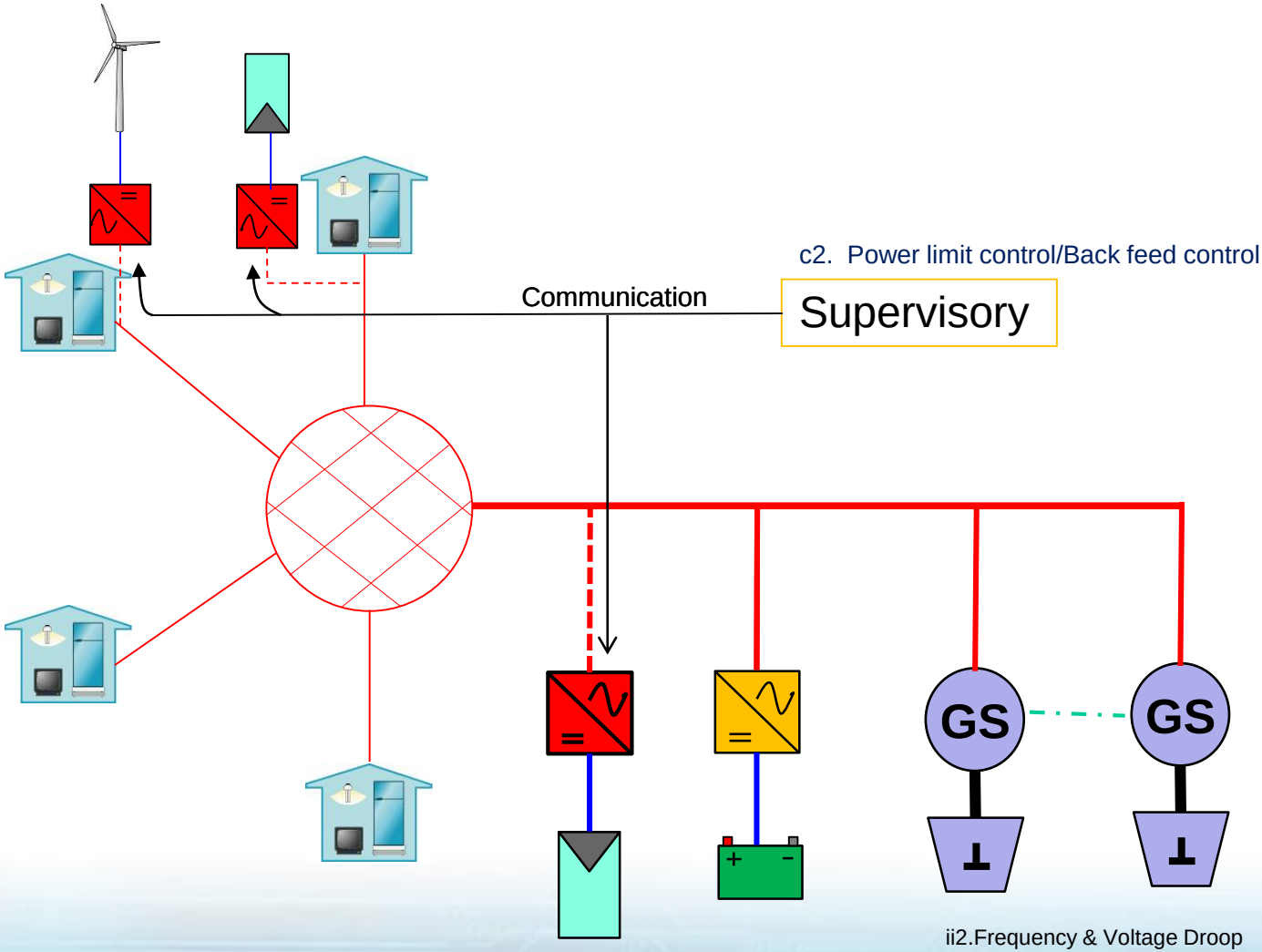
1b. Multi Rotating Machine Dominate



Stand-Alone PV Hybrid System Control Method	Supervisory Control	Communication
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PV Grid Connect Inverter

Bidirectional Battery Inverter

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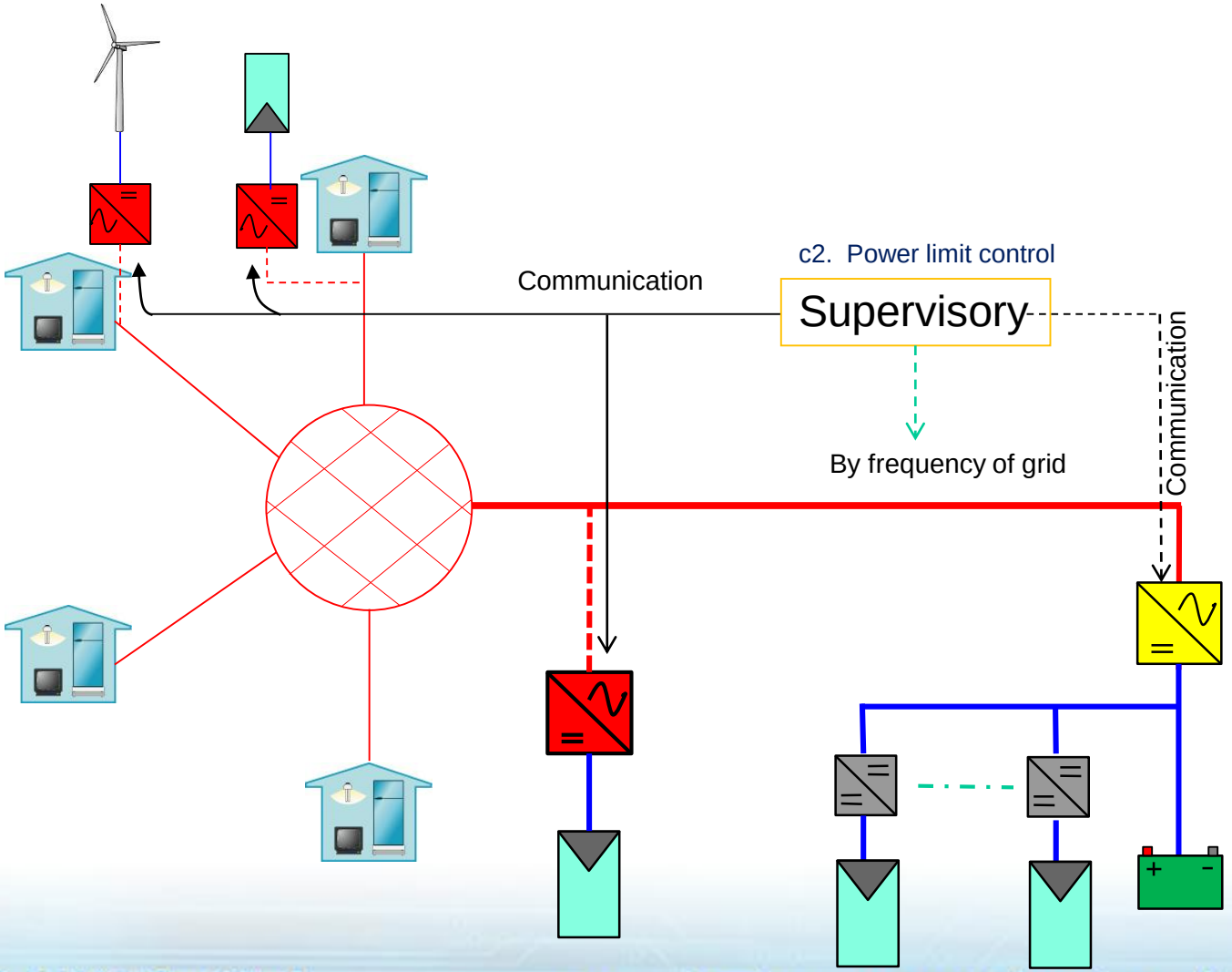
2a. Single PCE Dominate



PV Grid Connect Inverter

Bidirectional Battery Inverter

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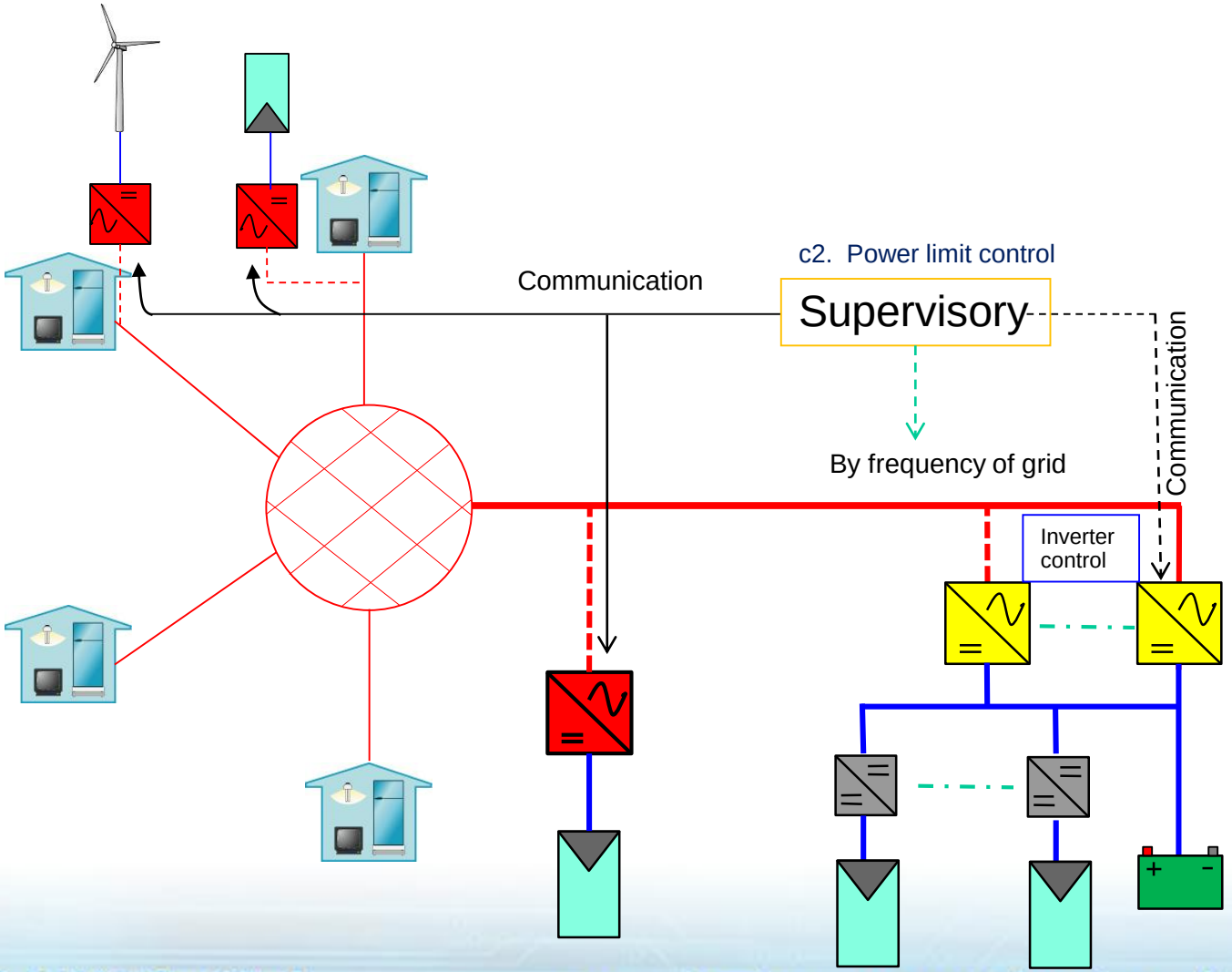
2b. Multi PCE Dominate



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PV Grid Connect Inverter

Bidirectional Battery Inverter

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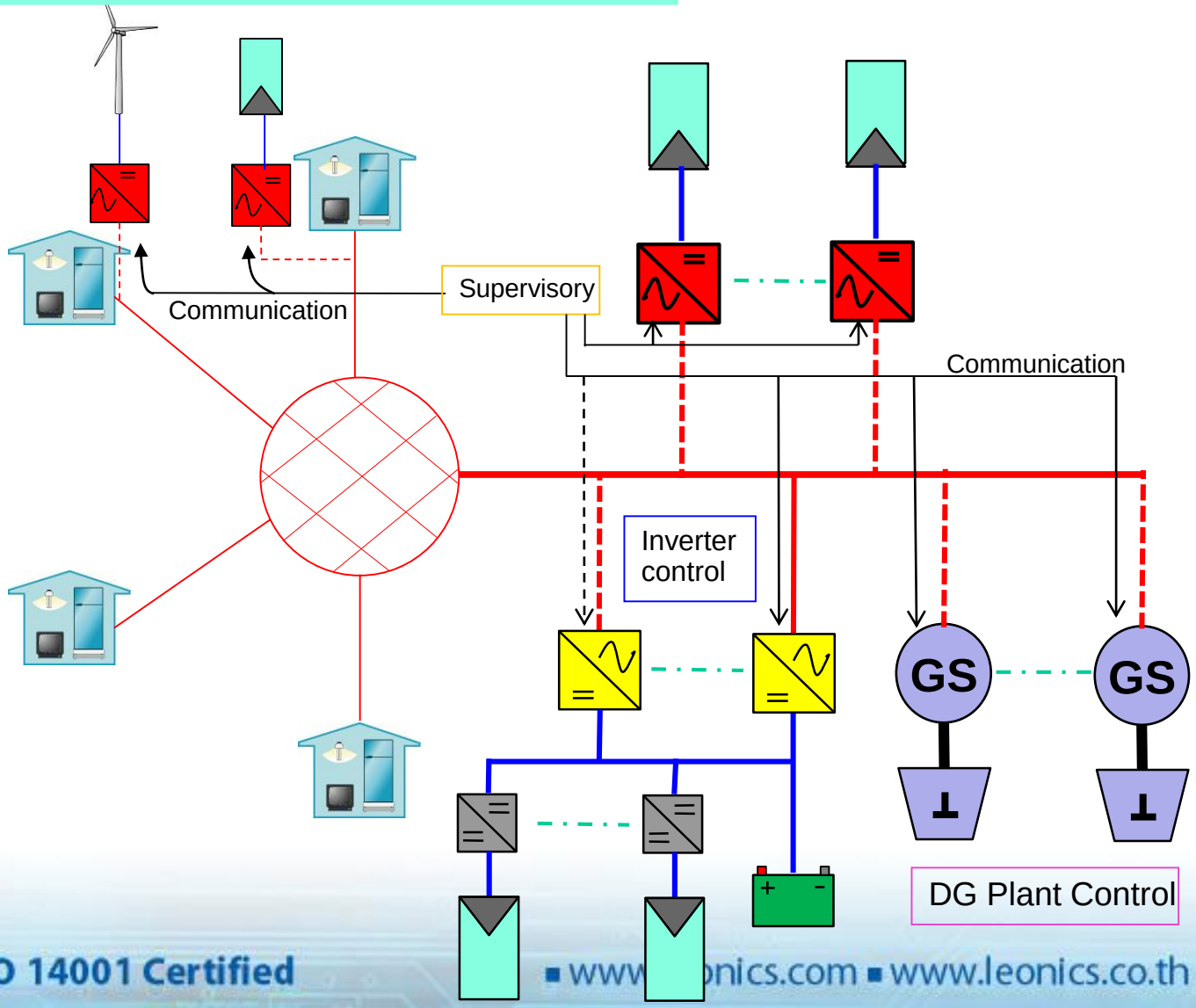
3. Single Switch Master (Rotating Machine & PCE)



MW scale Stand-Alone Hybrid Mini-Grid System

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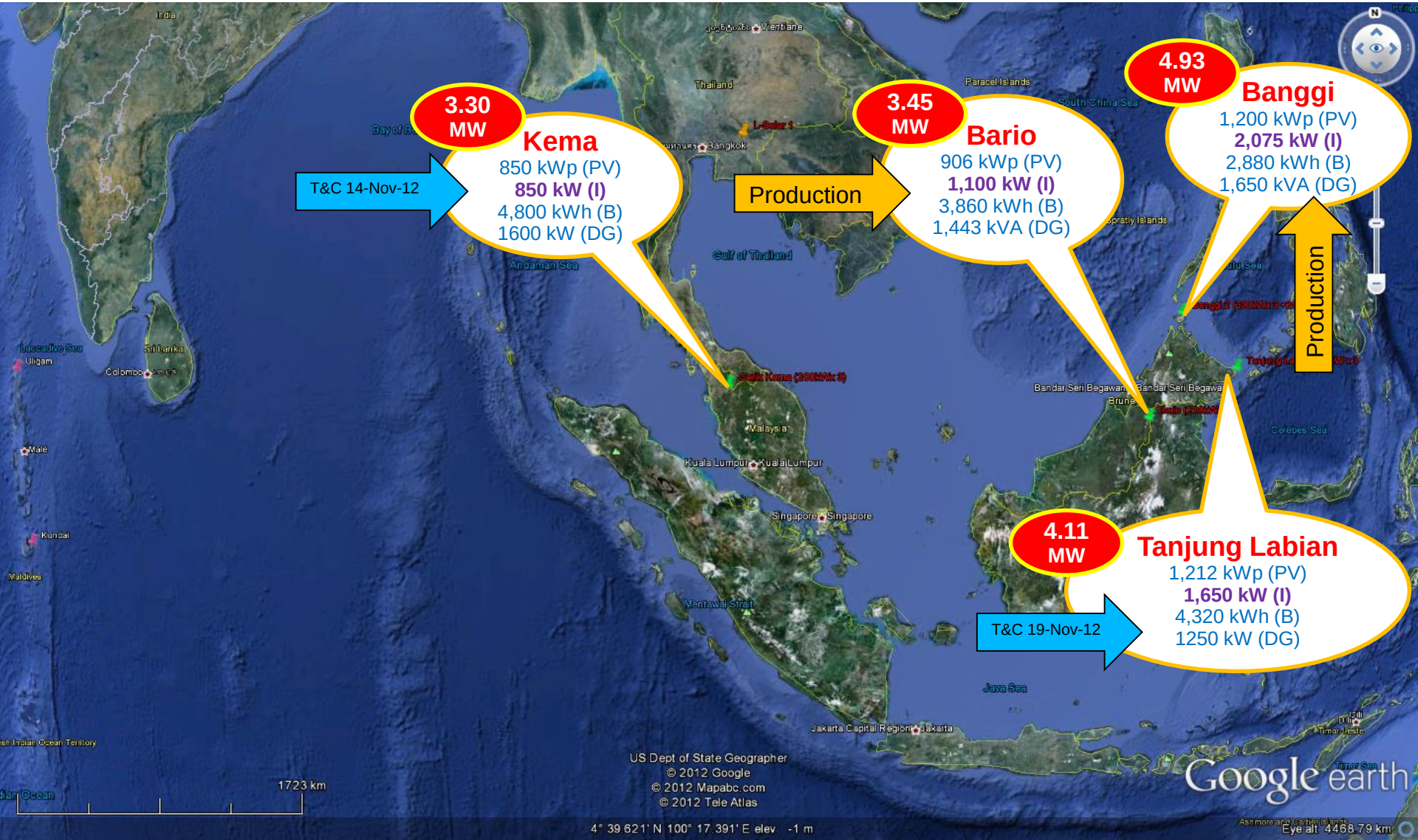
(PV) = Photovoltaic Module,
(B) = Battery,
(I) = BDI + GCI,
(DG) = Diesel Generator

X.xx MW Total Power of INV+DG+PV



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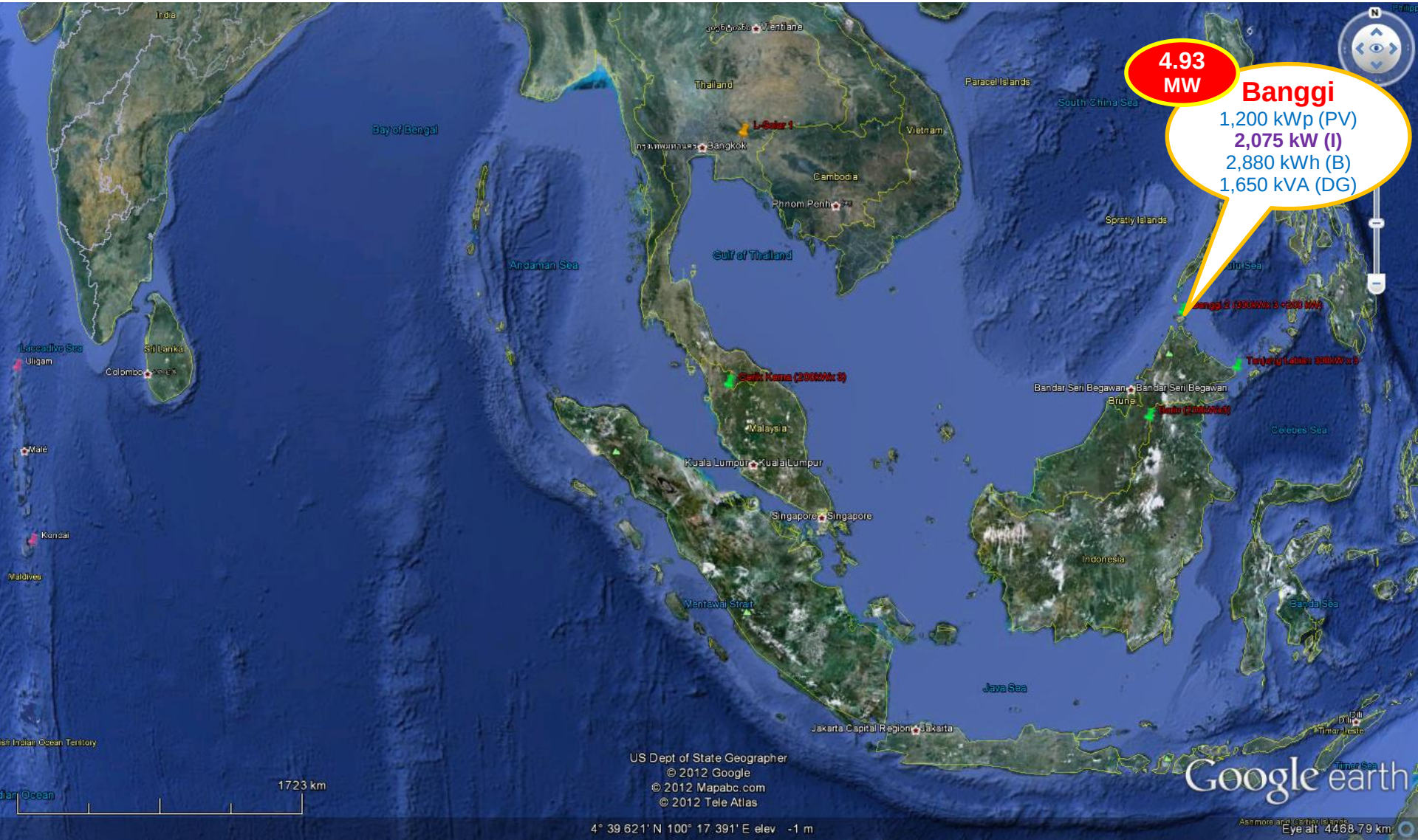

Main Contractor : USAHA SIRIMAS SDN. BHD.
COD on : 25 January 2014

4.93 MW PV-DG Hybrid System, Banggi Island 2, Sabah, Malaysia

(1,200kWp, 1100kW$_{inv}$, 975kW$_{GC\ inv}$, DG 1,650kW)

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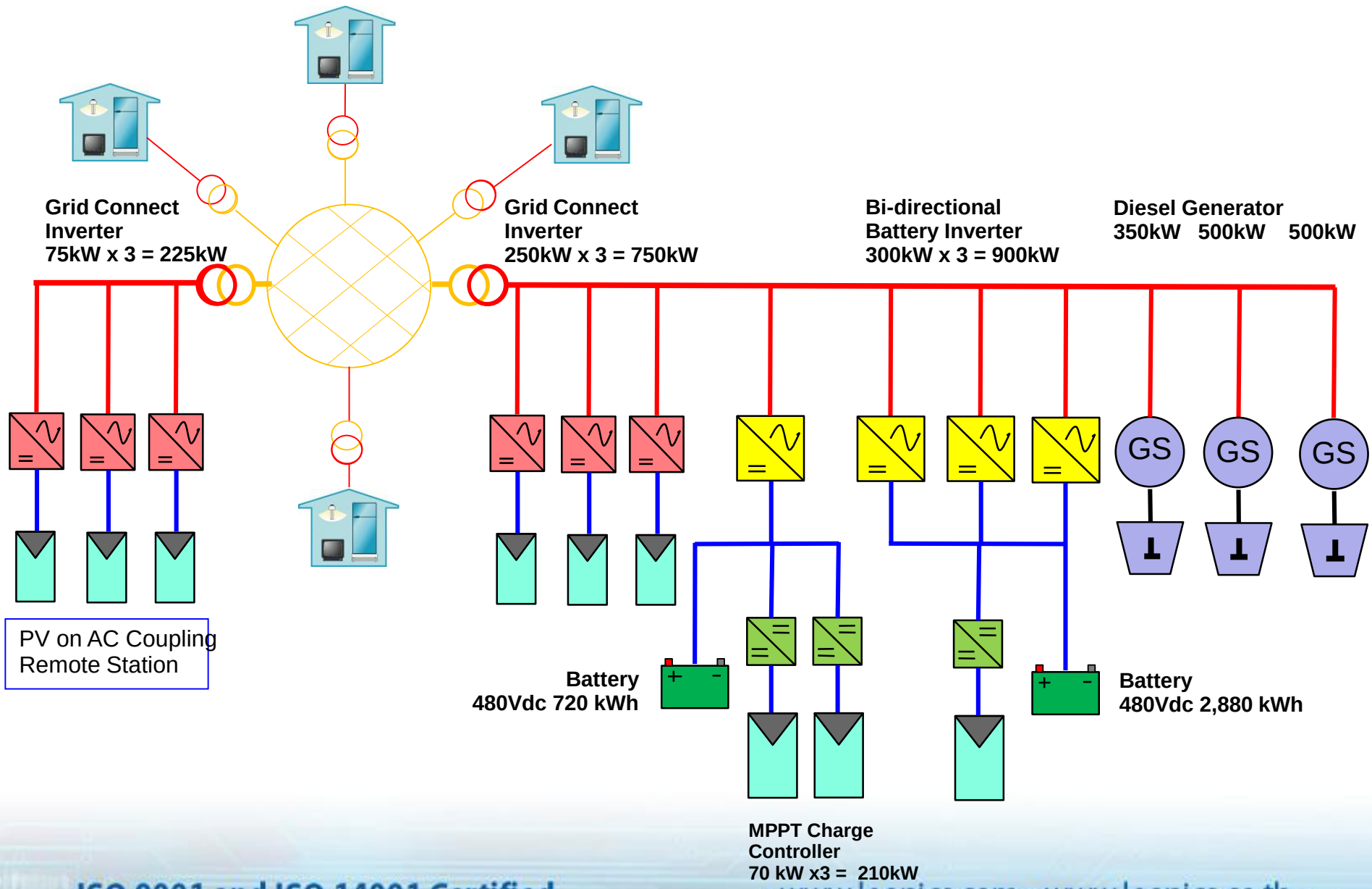

PV Module 1,000 + 200 kWp


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LEONICS
LEONICS
BDI 3
BDI 2
BDI 1
Charge Controller


LEONICS
LEONICS
LEONICS
GCI 1
GCI 2
GCI 3


SMU 1
HCCU
ISC


Battery Bank 3
Battery Bank 1
Battery Bank 2


DG 5
400kW
DG 4
400kW
DG 3
250kW
DG 2
200kW
DG 1
200kW

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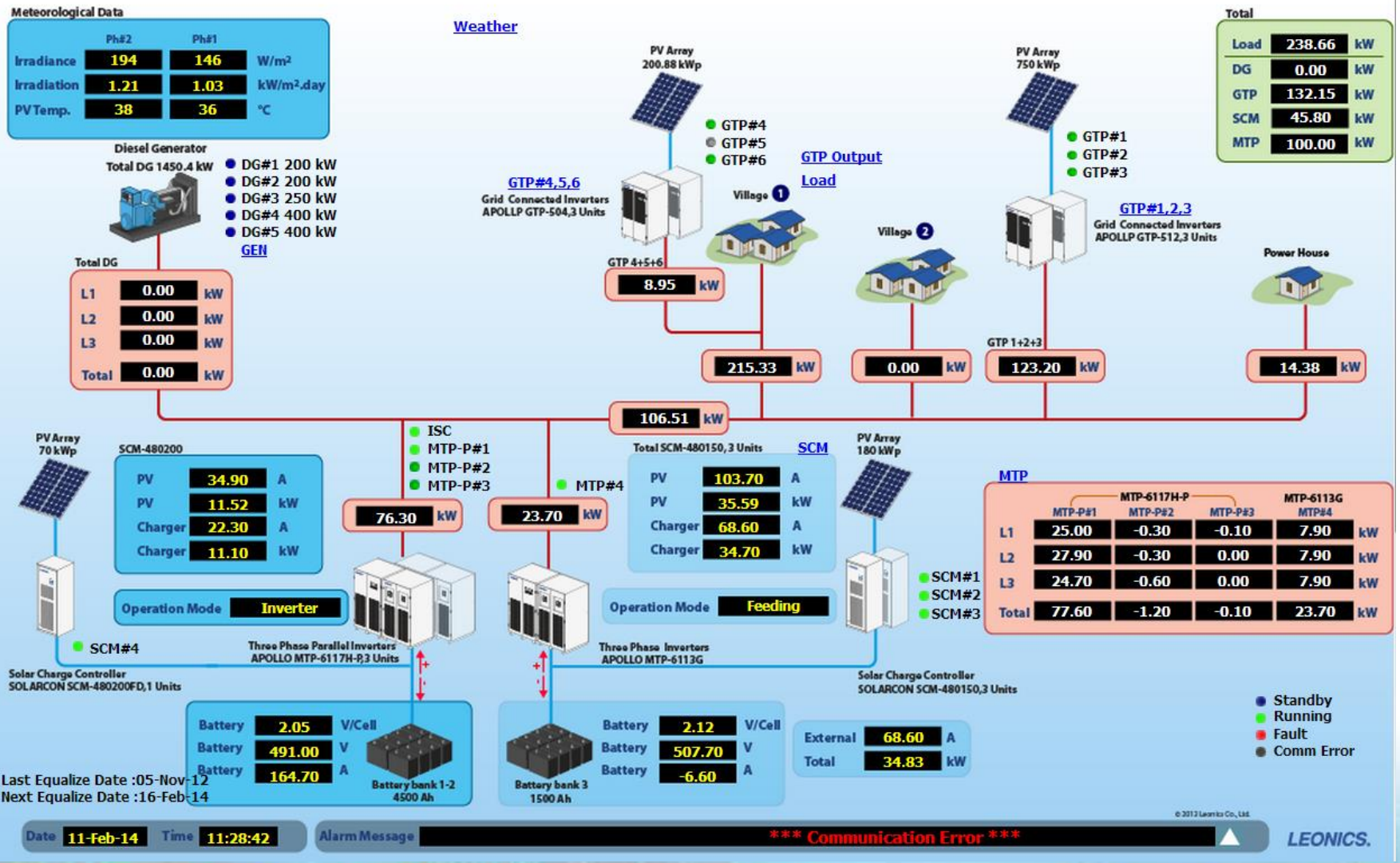
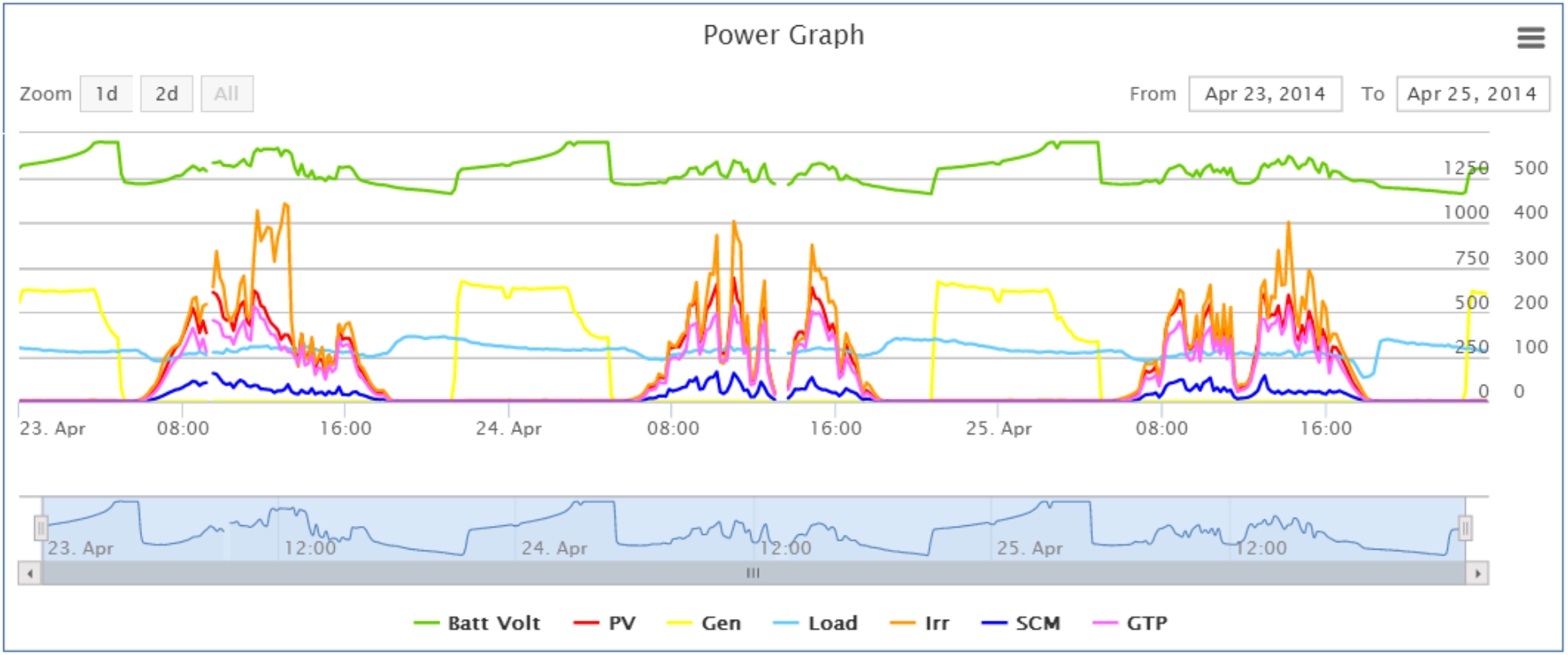
PV Power Farm | Hybrid | Commercial | Residential | BTS | Special | Warroom

LOGOU

Banggi2

• Main • Graph • Battery Graph • Download



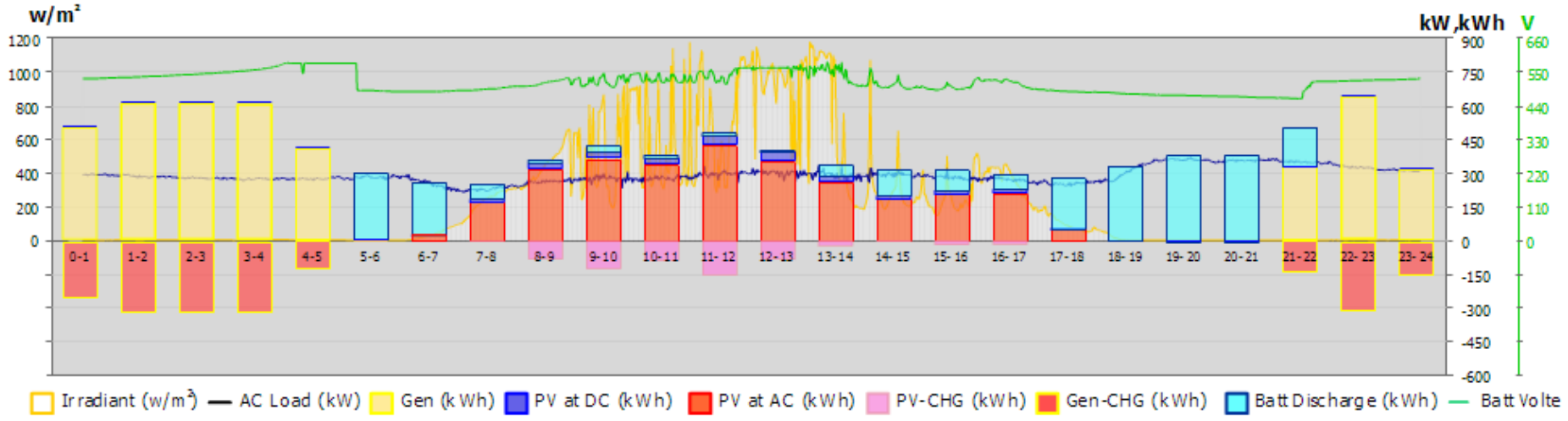

Power Graph
Zoom 1d 2d All
From Apr 23, 2014 To Apr 25, 2014
1250 500
1000 400
750 300
500 200
250 100
0 0
23. Apr 08:00 16:00 24. Apr 08:00 16:00 25. Apr 08:00 16:00
23. Apr 12:00 24. Apr 12:00 25. Apr 12:00
Batt Volt PV Gen Load Irr SCM GTP

Banggi2

Date : 2014 ▽ 04 ▽ 23 ▽ Go!

Hybrid System Operation Graph

2014-04-23



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PV Grid Connect Inverter

Bidirectional Battery Inverter

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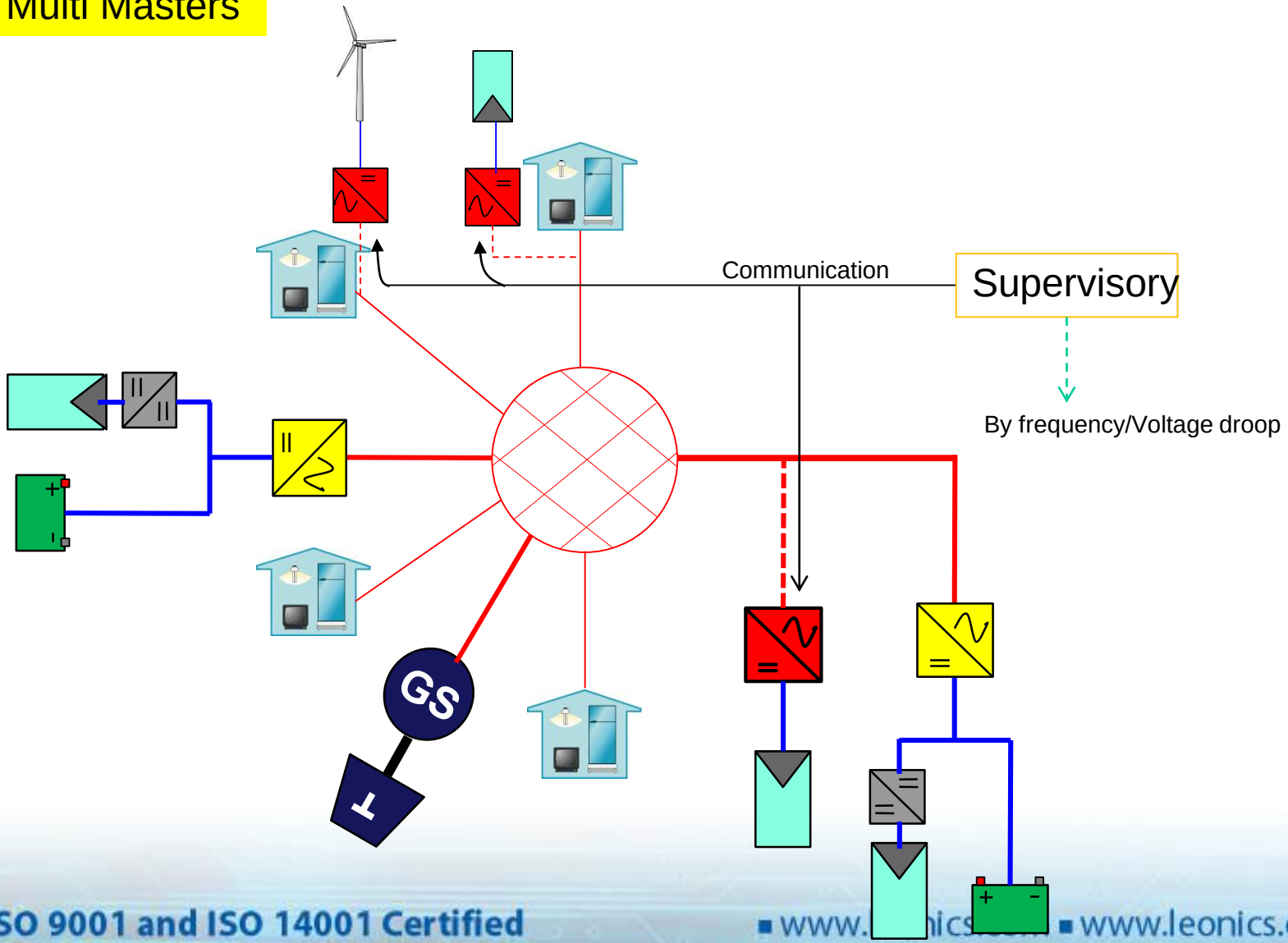
4. Multi Masters



A village of 7 in Papua, one of 96 PLTS sites, ESDM-Project 2012,

→ Bring Light for Life →

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PLTS Gerbang

Thank you

Any Questions are welcome