Power to Grow

Microgrid Experiences for rural electrification in Sarawak

Sarawak Energy And Taiwan SmartGrid Exchange Symposium,
NTUH International Convention Center

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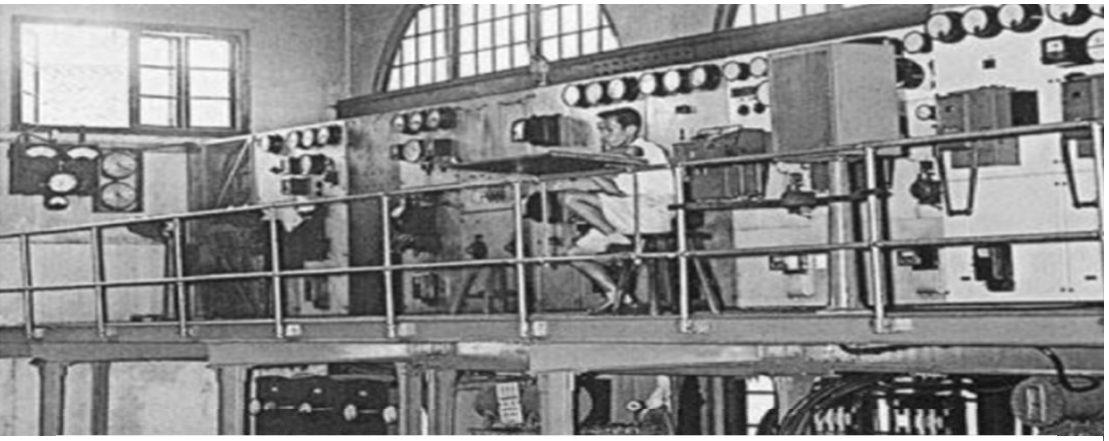
Sarawak, Malaysia

- One of three territories in Malaysia
  - Bumi Kenyalang: "Land of the Hornbills“ on north of Borneo island
- Large geographical area (124,450 km^2) with 750km of coastline
  - Population of 2,420,009 (2010 census), 20 persons/km^2
  - 4 cities: Kuching (700k), Miri (350k), Sibu (257k) & Bintulu (200k)



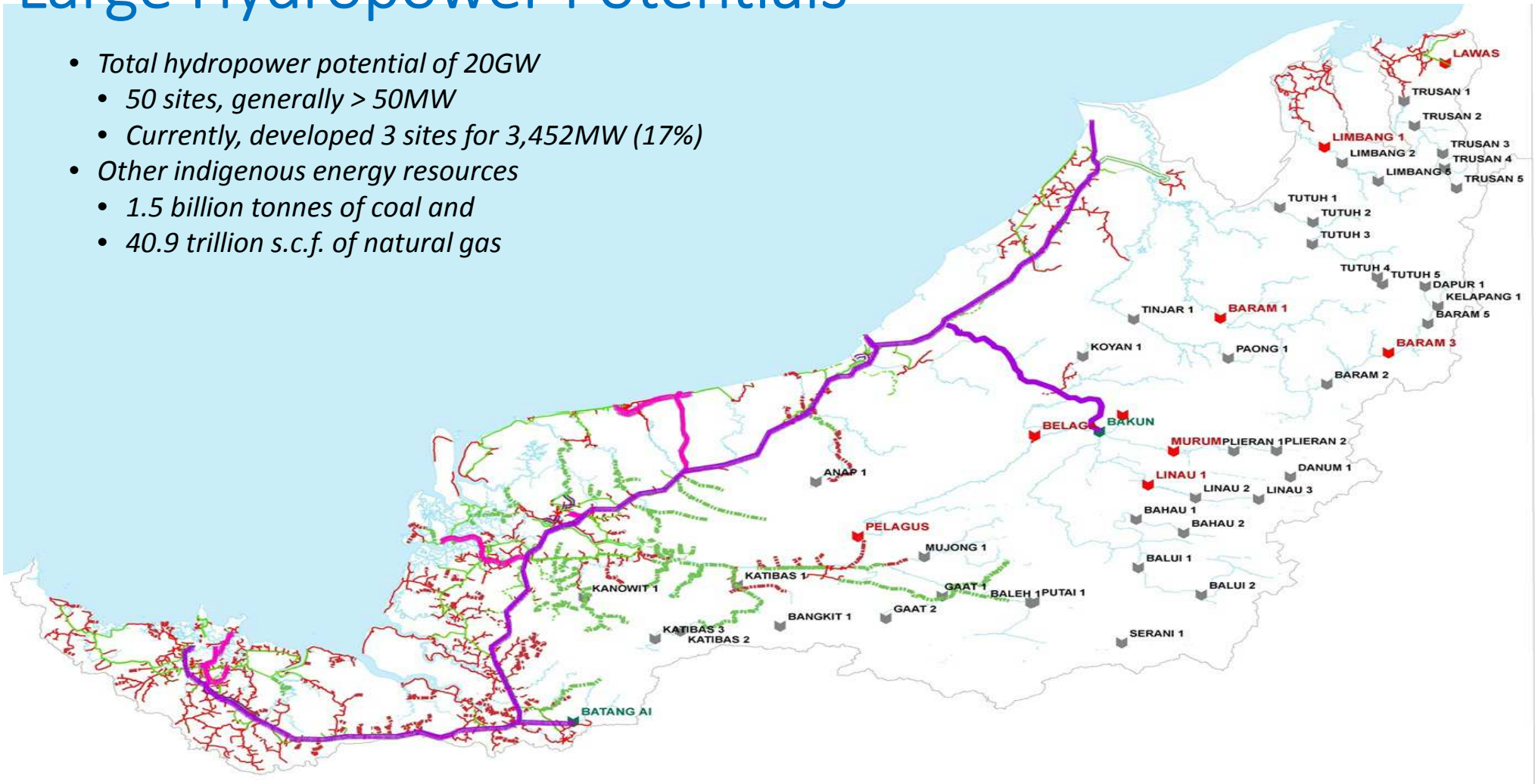
sarawak energy

Sarawak Energy is fully owned by the State Government and has a proud history over 70 years .

A fully integrated electric utility, Sarawak Energy is the sole entity responsible for transmission and distribution of electricity, and the main entity responsible for electricity generation, in the state of Sarawak.

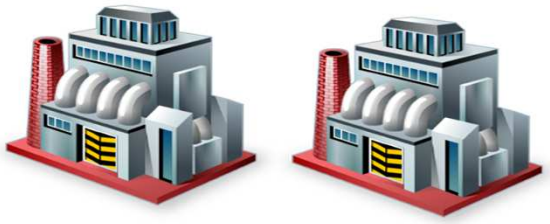
Large Hydropower Potentials

- *Total hydropower potential of 20GW*
  - *50 sites, generally > 50MW*
  - *Currently, developed 3 sites for 3,452MW (17%)*
- *Other indigenous energy resources*
  - *1.5 billion tonnes of coal and*
  - *40.9 trillion s.c.f. of natural gas*



SARAWAK SCORE
CORRIDOR OF RENEWABLE ENERGY

SCORE was developed to propel the economy to a new level of income and development. Principal objective of SCORE is to harness Sarawak's sustainable strategic advantage in the production of bulk electricity at globally competitive prices to attract investment to the State.

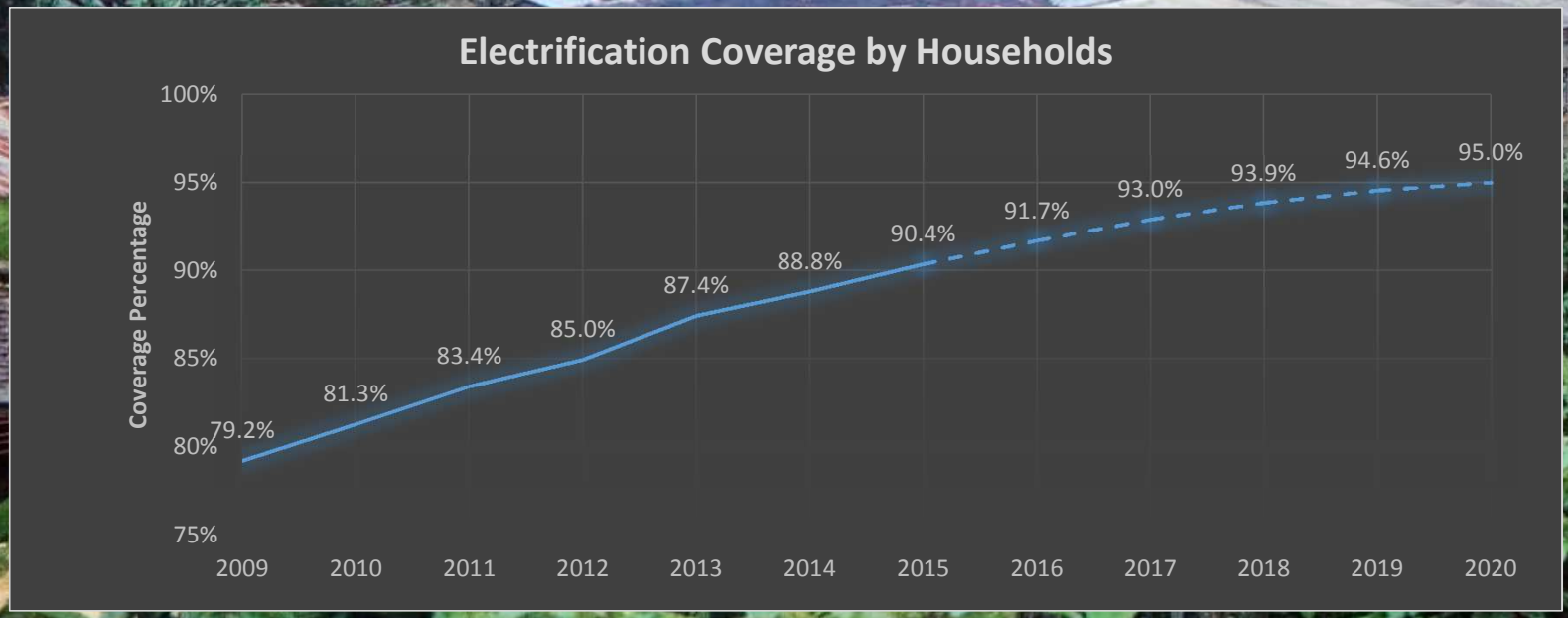


6 Objectives of SCORE

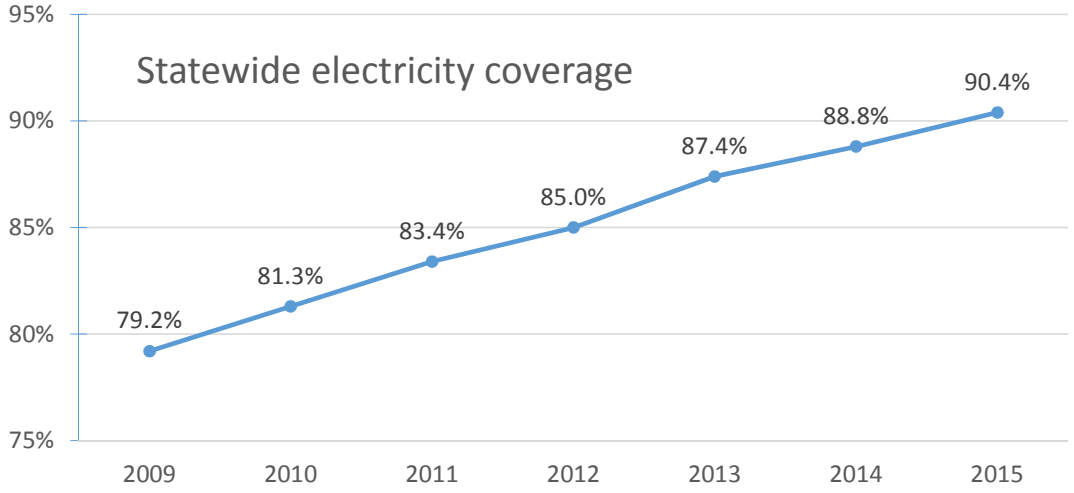
1. To create new sources of wealth
2. To move State's economy up to the value chain
3. To achieve higher per capita income
4. To enhance quality of life
5. To achieve balanced regional development
6. To eradicate poverty

Rural Electrification in Sarawak

- Urban/rural ratio 52%:48% with 1.2 million people living in rural settings: 6,235 villages, about 200,000 homes
- 1,919 (30%) of villages yet to have 24-hr electricity
  - Some 40,000 homes and 250,000 people



Rural Electrification Achievements 2009-2016



Yet to be electrified	Villages	Households
Accessible	556	9,567
Need access	916	17,603
Remote	397	11,321
Total	1,869	38,491

- Statewide electricity coverage has climbed above 90% in 2015 from below 80% in 2009
- Substantial funding since 2009 until 2016,
  - Grid expansions: RM2,965 million for about 80,000 households
  - Off-grid schemes: RM 818 million for over 3,000 households

Rural Electrification Requirement & Strategy

Element of subsidy to maintain equity with urban dwellers

- Charged at the same tariff
- Given similar level of service, reliability and quality

Wherever possible, connect village to main grid

- Off-grid mini/micro grid schemes reserved for remote/isolated villages
- Those without road access or too far for grid connection

Multi-stage expansion strategy

- Villages close to grid (< 30km) and with road access
- Villages close to grid (< 30km) but need road access
- Remote villages (> 30km)

Rural Electrification Programs

Legend

- Category 1 : Grid Connectible (V : 564 / HH : 10,514)
- Category 2 : Grid Possible but Need Access (V : 927 HH : 18,038)
- Category 3 : Remote Not Grid Connectable (V : 428 / HH : 12,452)

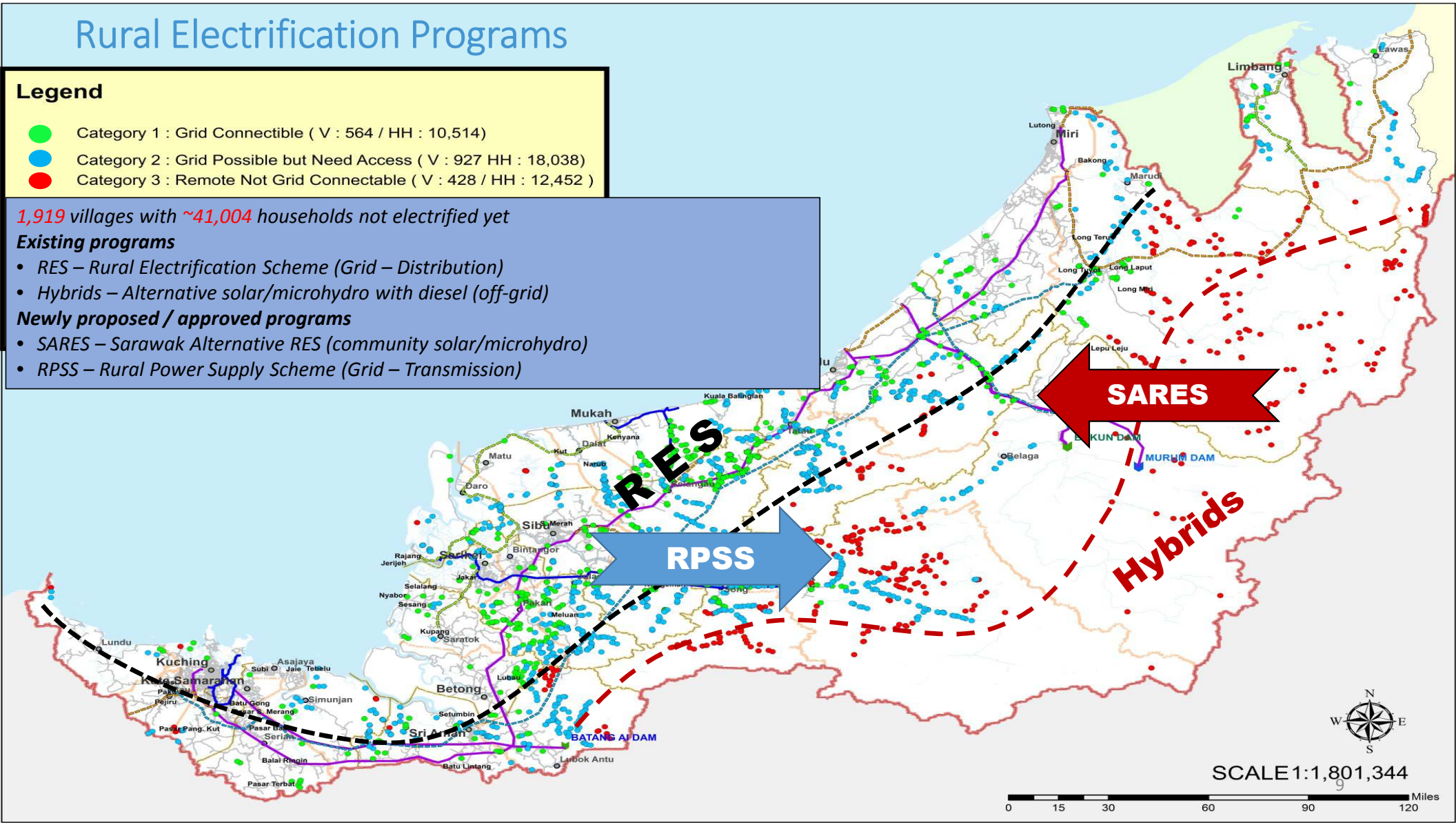
1,919 villages with ~41,004 households not electrified yet

Existing programs

- *RES – Rural Electrification Scheme (Grid – Distribution)*
- *Hybrids – Alternative solar/microhydro with diesel (off-grid)*

Newly proposed / approved programs

- *SARES – Sarawak Alternative RES (community solar/microhydro)*
- *RPSS – Rural Power Supply Scheme (Grid – Transmission)*



Microhydro & Solar Hybrid Stations

Alternative schemes for villages deemed too far for grid connection within the next 5 years

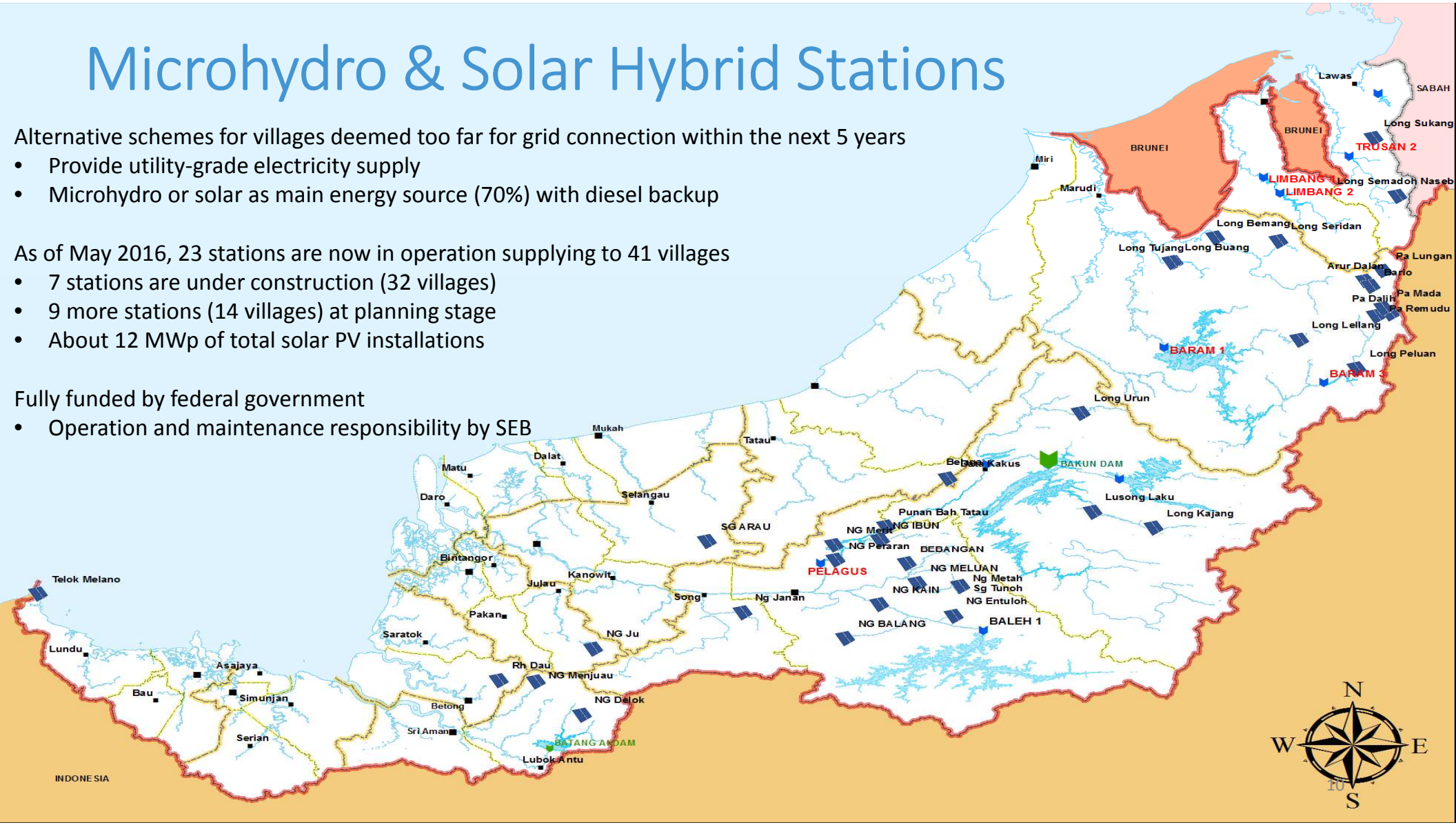
- Provide utility-grade electricity supply
- Microhydro or solar as main energy source (70%) with diesel backup

As of May 2016, 23 stations are now in operation supplying to 41 villages

- 7 stations are under construction (32 villages)
- 9 more stations (14 villages) at planning stage
- About 12 MWp of total solar PV installations

Fully funded by federal government

- Operation and maintenance responsibility by SEB



Single Village Utility Solar Hybrid Scheme

Households: 26 (and a school)
Population: 114
Solar: 129.6 kWp
Battery: 5 x 2250 Ah @ 48V
Diesel generator: 2 x 58 kW

- Unmanned autonomous operation
- Remote condition monitoring

Rumah Dau, Sri Aman
Solar Capacity: 129.6kW


Pa Mada


Long Lellang


Lusong Laku


Long Sukang

Bario Centralised Solar Hybrid Station

Cluster of 11 villages with 250++ households, shops, offices & various buildings

403.2kWp AC coupled

483.84kWp DC coupled

Battery Inverter
600 kW

Batteries
3 x 2150 Ah @ 480V

Solar inverters
500kW + 600kW

Diesel set x 4
(126.4 – 360 kW)

Skid tanks x 4

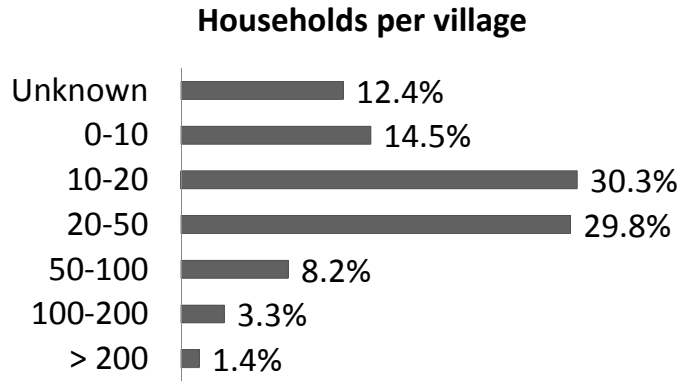
Distribution lines
11kV (~20 km)

Bazaar & various
administrative offices

Bario AC-DC coupled Hybrid System

Design and Practicality Considerations

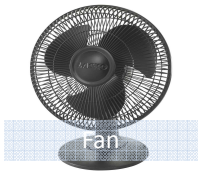
- Villages are widely spread and small
  - Over 50% have less than 50 families, with most having 10-50 families
  - Separated by 5-10 km distance
  - Many situated by rivers & water ways
  - Communities are attached to surrounding lands



- Utility-operated versus community-operated
  - Prohibitive to construct utility-grade systems for all 400+ villages
  - Self-help “community-operated” solutions for small villages
  - Simple-to-operate based on standardized / modularized (plug & play) designs for villages with < 50 families

Community Based Plan for Remotest Villages

Expensive, slow in expanding utility systems	• Initiate a new community partnership program • Utility company to design and construct • Community to own, operate & maintain
Microhydro if there is potential	• Capable of full capacity for 6-8 months / year • During dry months, power reduces according to water availability
Solar for other locations	• Solar home system is more cost effective for small villages (≤ 10 hh) • Solar centralized system for larger villages (> 10 hh)
Sufficient for a typical rural household	• Capacity of about 700 – 1,000 W / household • Usage of 2 kWh / household per day
5-year plan	• RM 500 million for 2016-2020 • Cover 300+ villages with about 9,000 households
Modest community designs than utility schemes	• 2 kWh / day instead of 8kWh • Single renewable source against hybrids (diesel backup) • Self-operate at no charge in lieu of tariff



Community Solar Home System

Commissioned and handed over to community in 2014

17 households, 40 population

5.44kW in total or 320 W / home

Lightings, TV, radio, video player, satellite decoder, fan, computer & phone charger

Community microhydro

- 30 kW for 30 households
- Weir with self-cleaning intake
- HDPE pipes for penstock
- Single turbine with changeable nozzle
- Simple electrical load-dump regulation
- Standard distribution systems

Sares launched for full electricity coverage

- The Sarawak Alternative Rural Electrification Scheme (SARES) was launched in June 2016 by State of Government to speed up efforts towards full electricity coverage in the state by utilising renewables like solar and micro-hydro in Sarawak's interior.

- 323 isolated villages comprising 8,708 households located in remote areas of Sarawak will benefit from the SARES's implementation over the next five years through a funding of RM500 millions.

No	2016	2017	2018	2019	2020
Households	1332	1844	1844	1844	1844
Funding Allocation	RM80 millions	RM105 millions	RM105 millions	RM105 millions	RM105 millions

SARES Phase 1a Completed Projects


Rh Alan, Bkt Mabong


Rh George, Ulu Pelagus


Rh Jana, Bkt Mabong


Rh Remong, Ulu Skrang


Karangan Rangkang, Katibas


Rh Juan, Ulu Skrang

SARES Phase 1B in Progress


Long Tepen


Long Urang


Long Lunyim


Long Jenalong


Long Latei


Long Leng

SARES Phase 1 Implementation

Centralized system

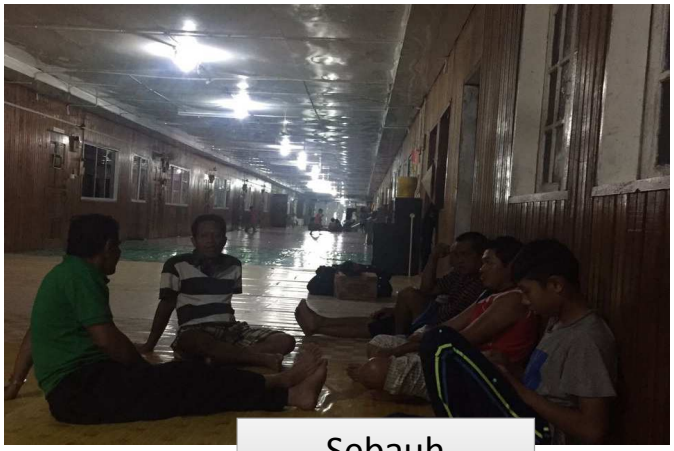
SARES Phase 1A Energised Communities

Song

Ulu Pelagus

Bkt Mabong

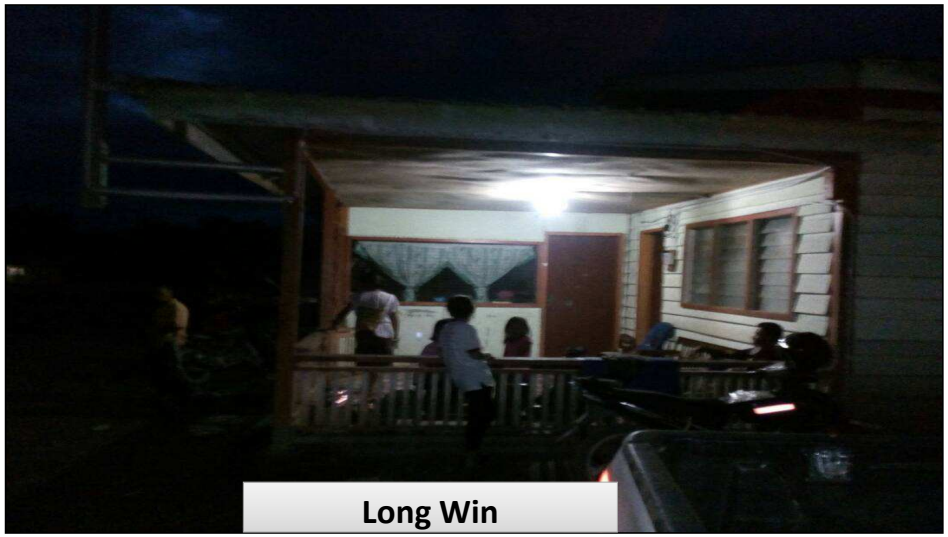
Ulu Skrang



Sebauh

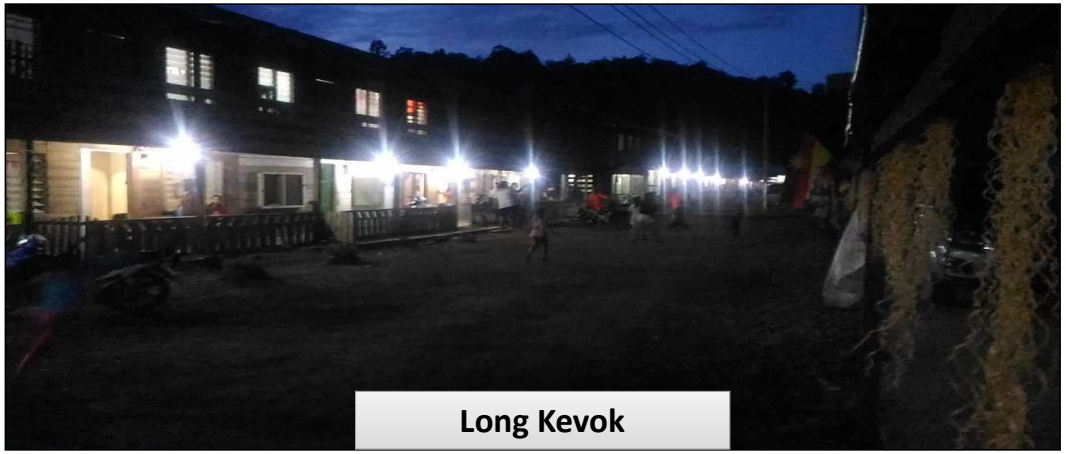
Limbang

SARES Phase 1B Energised Communities



Long Win

Long Jenalong



Long Kevok

SARES Phase 2 – Communities Engagement

Rh Jinggong, Katibas

Long Kawi, Telang Usan

Rh Lawan, Sg Gaat

Rh Kanyan, Tatau

Community Engagement (March – May 2017)

- Site visit to villages in Phase 2 list (65 villages)
- Briefing communities on SARES
- Solar sites identification and consent to use the land
- Acceptance of SARES project

Site Visit by SEB and Contractor (June 2017)

- Site visit to villages in Phase 2 list (36 villages)
- Finalise solar site selection
- Contractor to inspect site and local conditions

Practical Challenges at Rural Sarawak

Financial constraint limits progress (off-grid schemes costing over RM200k / household)

Lack of other infrastructures and amenities such as water supply and telecommunications

Few activities and limited opportunities makes rural areas unattractive to technically skilled

Lack of proper access hampers construction and eventual operation and maintenance

Sparsely distributed villages means numerous small systems (little economy of scale)

O&M challenges

- Remoteness of the stations
- Difficulties in stationing personnel at site
- Mainly these stations are designed to operate autonomously without on-site crew
- Require centralized system to monitor the equipment condition and performance of systems remotely.
- Lower O&M cost by reducing the number of site visits by SEB staffs

Journey to the Sites

Implementation & Logistic Challenges

Monitoring Center via Cloud Platform

- Develop monitoring and control system for asset health assessment and management of the hybrid stations.
- Provide the cloud-based user interface system application with the display of all site location on a single map.

Bario

• Main • PV-DG report • Energylog • 3D Layout

Diesel Generator
Total DG 1366 kVA

Gen No.1
Gen No.2
Gen No.3
Gen No.4
Gen No.5

OC EF
OC = Over current
EF = Earth Fault

Meteorological Data

Iraradiance	931.00	w/m²
Irradiation	2.10	kWh/m²
PV temp	184.00	˚C

PV Array
402 kWp

GTP No.1
GTP No.2
GTP No.3
GTP No.4

Total

Load	67.71	kW
DG	0.00	kW
GTP	75.72	kW
SCM	445.83	kW
MTP	-5.30	kW

Village

Total DG
GEN

L1	0.00	kW
L2	0.00	kW
L3	0.00	kW
Total	0.00	kW

GTP#1,2,3,4

	GTP#1	GTP#2	GTP#3	GTP#4	
L1	7.85	8.79	8.71	0.00	kW
L2	7.47	8.46	8.59	0.00	kW
L3	7.82	8.98	9.05	0.00	kW
Total	23.14	26.23	26.35	0.00	kW

Load
Over curent
Earth fault

Grid Connected Inverters
APOLLP GTP-507,4 Units

75.72 kW

67.71 kW

Control PV

-7.59 kW

PV Array
483.84 kWp

SCM
SCM#1
SCM#2
SCM#3
SCM#4
SCM#5
SCM#6
SCM#7
SCM#8

Solar Charge Controller
SOLARCON SCM-480200FD,8 Units

SCM-480200

PV	835.00	A
PV	445.83	kW
Charger	604.90	A
Charger	323.63	kW

Operation Mode: Inverter

External 596.00 A
Total 323.63 kW

-5.30 kW

MTP
ISC
MTP-P No.1
MTP-P No.2
MTP-P No.3

Three Phase Parallel Inverters
APOLLO MTP-6113H-P,3 Units

	MTP-P#1	MTP-P#2	MTP-P#3	
L1	0.00	0.40	0.10	kW
L2	0.00	-3.70	-0.30	kW
L3	0.00	-1.80	0.00	kW
Total	0.00	-5.10	-0.20	kW

Battery bank 1-3
9000 Ah

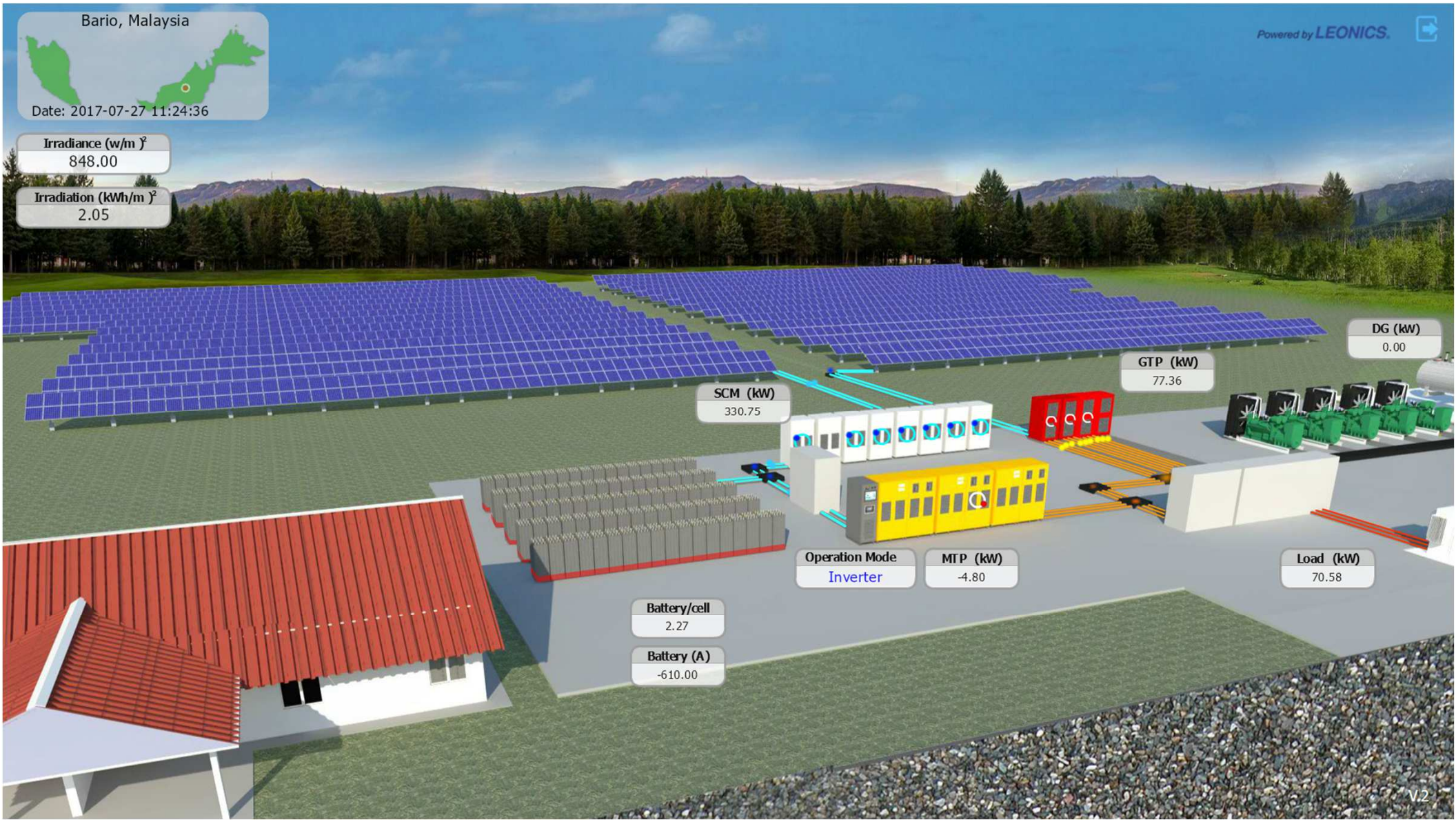
Battery	2.26	V/Cell
Battery	543.00	V
Battery	-594.00	A

Standby
Running/normal
Fault
Comn Error

Date 27-Jul-17 Time 11:23:18

Alarm Message *** Communication Error **

LEONICS.


Bario, Malaysia
Date: 2017-07-27 11:24:36
Irradiance (w/m)²
848.00
Irradiation (kWh/m)²
2.05
Powered by LEONICS.
DG (kW)
0.00
GTP (kW)
77.36
SCM (kW)
330.75
Operation Mode
Inverter
MTP (kW)
-4.80
Load (kW)
70.58
Battery/cell
2.27
Battery (A)
-610.00
V.2

Design requirements and compromises

Solar and hybrids system requirements

- AC coupled solar (daytime load) and DC coupled solar (evening load)
- Battery equalization: diesel savings against battery life
- Maintain SOC to preserve battery condition

Microhydro design requirements

- Large water level fluctuations including flash floods
- Wet versus dry seasons: ease in changing setup parameters
- Manual versus automatic operation mode
- Weir, intake and desilting basin

Construction versus operation constraints

- Design conducive for implementation at rural locations
- Adapted for ease of operation by non-skilled villagers
- Contractors construct or under community partnership concept

3M Success factors

Man

- Community buy-in and capability to participate
- Trained personnel for design, implementation, T&C, O&M…
- Develop local contractors, competencies, training and certification

Machine

- Appropriateness of designs & specifications (tailored complexity)
- Major equipment with proven track records (supported by warranty)
- Attention to auxiliary devices (esp. condition monitoring)

Method

- Long term sustainability – maintenance KPI & supports
- Well defined roles & responsibilities of all stakeholders
- Strategy to sustain good products, contractors & introduce new ones

Way forward for collaboration work with TSGIA

- Energy management system
- System optimization design
- Integrated communication
- Data logging and monitoring system
- Power converter techonologies
- Advanced energy storage and generation system
- Renewable distributed generation


sarawak energy
Thank You