Rural Electrification in Sarawak, Malaysia: Potential & Challenges for Mini-Hydro & Solar Hybrid Solutions

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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 km²) with 750km of coastline
  - Population of 2,420,009 (2010 census), 20 persons/km²
  - 4 cities: Kuching (700k), Miri (350k), Sibu (257k) & Bintulu (200k)
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 3,432MW (17%)

Other indigenous energy resources
- 1.5 billion tonnes of coal and
- 40.9 trillion s.c.f. of natural gas
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
Building SCORE: Generation Development

- **Installed Capacity (MW)**
  - 2010: 50% gas, 40% coal, 10% hydro
  - 2011: 15% gas, 10% coal, 75% hydro
  - 2012: 20% gas, 20% coal, 60% hydro

- **Years:** 2010 to 2026

- **Generators:**
  - Baleh Hydro
  - Merit Pila Coal
  - Samalaju CCGT
  - Balingian Coal
  - Tg Kiduring CCGT
  - Murum Hydro
  - Bakun Hydro
  - Existing
Building SCORE: Possible Scenario up to 2035

- **TRUSAN HEP** (Planned) – 240MW
- **LAWAS HEP** (Planned) – 38MW
- **LIMBANG 1 HEP** (Planned) – 42MW
- **LIMBANG 2 HEP** (Planned) – 140MW
- **MURUM HEP** (Commissioning) – 944MW
- **BARAM 1 HEP** (Planned) – 1200MW
- **BARAM 3 HEP** (Planned) – 295MW
- **BALEH HEP** (Planned) – 1295MW
- **PELAGUS HEP** (Planned) – 562MW
- **BATANG AI POWER STATION** – 93MW
- **MUKAH POWER GENERATION** – 248MW
- **TANJUNG KIDURONG POWER STATION** – 190MW
- **SEJINGKAT POWER CORPORATION** – 210MW
- **TUN ABDUL RAHMAN POWER STATION** – 75MW
- **MIRI POWER STATION** – 78MW
- **SAMALAJU GAS POWER STATION** (Planned) – 600-800MW
- **KIDORONG CC GAS POWER STATION** (Planned) – 400MW
- **MUKAH WEST (Planned) – 600MW
- **SARAWAK POWER GENERATION** – 310MW
- **MIRI POWER STATION** – 78MW
- **BELAGI COAL** – 600MW
- **BAKUN HEP** (Planned) – 2400MW
- **BARAM 1 HEP (Planned)** – 1200MW
- **BARAM 3 HEP (Planned)** – 295MW
- **MURUM HEP (Commissioning)** – 944MW
- **MERIT PILA COAL (Planned)** – 300MW
- **BALEH HEP (Planned)** – 1295MW
- **PECAL Expressway**
- **BELAGI HEP (Planned)** – 220MW
- **MERIT PILA COAL (Planned)** – 300MW
- **BALLY HEP (Planned)** – 1295MW
- **MUKAH WEST (Planned)** – 600MW
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- **PECAL Expressway**
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
Main objective is to replace costly diesel generation with affordable 24-hr electricity

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)
- 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

<table>
<thead>
<tr>
<th>Yet to be electrified</th>
<th>Villages</th>
<th>Households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessible</td>
<td>556</td>
<td>9,567</td>
</tr>
<tr>
<td>Need access</td>
<td>916</td>
<td>17,603</td>
</tr>
<tr>
<td>Remote</td>
<td>397</td>
<td>11,321</td>
</tr>
<tr>
<td>Total</td>
<td>1,869</td>
<td>38,491</td>
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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, 18 stations are now in operation supplying to 36 villages
  - 13 stations are under construction (37 villages)
  - 9 more stations (14 villages) at planning stage
  - About 9-10 MWp of solar PV installations
- Fully funded by government
  - Operation and maintenance responsibility by SEB
## Long Banga Microhydro Hybrid

<table>
<thead>
<tr>
<th>Household</th>
<th>136 houses</th>
<th>Turbine Capacity</th>
<th>2 x 160 kW</th>
</tr>
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<tbody>
<tr>
<td>Population</td>
<td>600+ people</td>
<td>Diesel Genset</td>
<td>1 x 80 kW &amp; 1 x 160 kW</td>
</tr>
<tr>
<td>Project components</td>
<td>Weir, intake, desilting basin, 2km penstock, 4km road access, 11km overhead lines, 2 turbines, 2 diesel gensets, powerhouse, genset house, 3 staff quarters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase 2 development plan</td>
<td>Expanding to supply to 4 nearby villages: 2 more turbines, new penstock, longer overhead lines, new operation centre</td>
<td></td>
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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
Bario Centralised Solar Hybrid Station
Cluster of 9 villages with 233 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
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

<table>
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<tr>
<th>Households per village</th>
</tr>
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<tbody>
<tr>
<td>Unknown</td>
</tr>
<tr>
<td>0-10</td>
</tr>
<tr>
<td>10-20</td>
</tr>
<tr>
<td>20-50</td>
</tr>
<tr>
<td>50-100</td>
</tr>
<tr>
<td>100-200</td>
</tr>
<tr>
<td>&gt; 200</td>
</tr>
</tbody>
</table>

• 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
Typical village @ Nanga Merit

- From Kapit town jetty to Ng Tuli (Batu Arang Jetty) - 30 minutes
- From jetty to longhouse Rh George using logging / coal mining road (2.5 hours)
- Distance from main road ~ 6 km
Option 1: Boat ride from Song to Sg Katibas (4.5 Hours)
Option 2: Using logging road from Song to Rh Ribut, Ng Serau (1.5 hours); then use boat from Rh Ribut to Karangan Rangkang (1.5 hours)
Nearby villages @ Sebauh

Rh Nyipa (14 hh)

Bintulu - Sebauh (1hour)
Sebauh - Sg Binyo (4x4 until Rh Irai).
Rh Irai - Rh Nyipa (speed boat - 90 mins)

Rh Edau (9 hh)
Solar home sys
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
Practical Challenges at Rural Sarawak

- Lack of proper access hampers construction and eventual operation and maintenance
- 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
- Sparsely distributed villages means numerous small systems (little economy of scale)
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
Conclusion: 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
Thank You

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