Off-Grid Power Applications in the Middle East

Daniel Zywietz, CEO, Enerwhere
Oman Energy & Water, May 24th 2016
Agenda

- Introduction
  - Solar hybrid applications
  - Challenges & solutions
  - Q&A
Enerwhere is a leading provider of fully financed solar solutions, headquartered in Dubai.

**OUR SERVICES**

**EQUIPMENT RENTAL & MAINTENANCE**
- Solar-diesel hybrid
- Solar-battery hybrid
- Solar only

**POWER PURCHASE AGREEMENT (PPA)**
Power supply on a per kWh basis

**APPLICATIONS**

**TEMPORARY ACCOMODATION**
- Temperary

**CONSTRUCTION**
- Construction

**OIL & GAS**
- Oil & gas

**MINING**
- Mining

**HOSPITALITY**
- Hospitality

**MANUFACTURING**
- Manufacturing
Diesel generators are a convenient but expensive source of short-term, off-grid power.
Key benefits of Enerwhere’s solar-hybrid power plants over conventional diesel generators

- **CHEAPER & CLEANER**
  Diesel fuel & emission savings of up to 30%

- **ZERO CAPEX**
  Fully-financed equipment – No upfront investment from users

- **TRANSPORTABLE**
  Fully-containerized for rapid setup & deployment

- **MODULAR & SCALABLE**
  25 kW to multi-MW based on a simple “IKEA” principle

- **PLUG & PLAY**
  Preconfigured systems for extremely simple on-site installation

- **RELIABLE 24/7**
  Through hybridization diesel-generator or battery backup
Solar-hybrid systems reduce fuel consumption, cost and emissions

**SOLAR-DIESEL HYBRID**

- Solar system produces power during the day
- Diesel generator continuously provides grid stability and backup
- Share of power supplied from solar: 30-50%

**SOLAR-BATTERY HYBRID**

- Solar system produces power during the day and charges batteries
- Batteries provide power at night; Diesel generator used only rarely
- Share of power supplied from solar: up to 100%
Solar-diesel hybrid plants combine the low cost of solar PV with the reliability of conventional diesel generators

Enerwhere solar-diesel hybrid system overview

Key components

1. Off-grid customer facility
2. Diesel generators guarantee grid stability and provide backup at night & during bad weather
3. Solar array generates cheap, clean electricity during the day
4. Hybrid control system manages solar-diesel interaction and provides remote monitoring & control capabilities

Credit: SMA
Enerwhere offers three commercial models tailored to various situations and power consumption patterns

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<thead>
<tr>
<th>Description</th>
<th>Sale + O&amp;M</th>
<th>Rental</th>
<th>PPA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Customer purchases equipment upfront</strong></td>
<td>Enerwhere installs, operates and maintains equipment</td>
<td>Enerwhere maintains equipment</td>
<td>Enerwhere maintains equipment</td>
</tr>
<tr>
<td><strong>Enerwhere installs, operates and maintains</strong></td>
<td>Enerwhere pays monthly rental regardless of load</td>
<td>Customer pays only for each kWh used</td>
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<td><strong>Permanent/long-term site, remote/or without grid connectivity</strong></td>
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<td>Short-term need, close to grid but without visibility on connectivity</td>
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<tr>
<td><strong>Funding available</strong></td>
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<td>Small sites (&lt;100 kW) with unpredictable load</td>
<td>Large sites (&gt;100 kW) and/or with predictable load</td>
</tr>
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SSV camp, Sir Bani Yas island

- 600 occupants
- Kitchen
- Laundry
- STP
- Operating 7 days per week, 24 hours per day

Solar-diesel hybrid plant:
- 350 kWp solar
- 2 MVA diesel generators (1 x 635 kVA, 2 x 500 kVA, 1 x 350 kVA)
- Enerwhere hybrid manager
Solar generation peak matches perfectly with load peak, thereby reducing peak load of the diesel generators.

**Camps & Villages: Summer load curve**
SSV camp, Sir Bani Yas island, Abu Dhabi, 17 August 2015

Load peak: 870 kVA (12:30 pm)
DG peak: 809 kVA (7:15 pm)

Solar peak: 146 kVA (12:35 pm)
Solar share is much higher in winter, dramatically reducing daytime generators loads...

Camps & Villages: Winter load curve
SSV camp, Sir Bani Yas island, Abu Dhabi, 15 February 2016

Load peak: 350 kVA (12:30 pm)
Solar peak: 240 kVA (1:35 pm)
...to the point that the hybrid manager need to reduce solar output to keep the generators running in reverse.

Camps & Villages: Winter load curve
SSV camp, Sir Bani Yas island, Abu Dhabi, 15 February 2016

DG peak: 303 kVA (8:10 pm)
DG min: 13 kVA (9:10 am)
DG max/min ratio: 23:1 !!!!
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Challenges & Solutions

Typical Solar-hybrid System Challenges

- Extreme (20x) load variation summer / winter
- Intra-day load variation (up to 5x)
- Phase balancing issues
- Impact of minimum load on generator efficiency
- High surge loads / transients

Solutions

- Careful data analysis
- Resilient design (N-1 / N-2)
- More DG sizes
- Hybrid manager
- Reactive power management
  +
- Demand management
  +
- Storage (battery / thermal)
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• Do the economics make sense?

• Do solar panels work with all the heat in this region?

• And what about the dust? How do you clean the panels?

• Can we move the system to the next site?
Thank you!