Alternative Energy as an Engagement Opportunity in the USPACOM AOR

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16 June 2010
**Report Documentation Page**

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Palau PV Energy Information Brief Overview

- (U) Purpose
- (U) Background
- (U) Status
- (U) Issues
- (U) Way Ahead

As of 08:52 16 June 2010
Purpose of this Presentation

To raise awareness of USPACOM efforts to further develop Photo-Voltaic energy in the nation of Palau, in partnership with:

- ODUSD(I&E) Defense Environmental International Cooperation Program (DEIC)
- US Army Corps of Engineers 249th “Prime Power” Engineering Battalion
- Palau Commonwealth Improvement Program
- Palau Energy Office
- Palau Public Utility Corporation
- Palau Development Bank
- Dr. Herbert Wade, School of Renewable Energy Technology (SERT), Thailand.

![Logos]
What does PACOM have to do with PV power?

The U.S. Pacific Command was established as a unified command on January 1, 1947. PACOM is the oldest and largest of the United States' unified commands.

VISION
U.S. Pacific Command will be an engaged and trusted partner committed to preserving the security, stability, and freedom upon which enduring prosperity in the Asia-Pacific region depends.

MISSION
U.S. Pacific Command protects and defends, in concert with other U.S. Government agencies, the territory of the United States, its people, and its interests.

With allies and partners, U.S. Pacific Command is committed to enhancing stability in the Asia-Pacific region by promoting security cooperation, encouraging peaceful development, responding to contingencies, deterring aggression, and, when necessary, fighting to win.
History of Pacific Solar Power

• USDOE Territorial Energy Assessment (1982)
  – RESULTS: a few homes in SW Palau islands get 33Wp panel/lights

• IAEA/Pacific Power Association Multi-island utility-renewable energy surveys (2006) RESULTS:
  – 225 kWp grid connected solar in Palau
  – Initiation of financial incentives in Palau for solar water heating

100kW System at Capitol Building on the island of Babeldaob, Palau

125kW system installed at the hospital on the island of Koror, Palau
Overview of Palau

- Under UN/US Trusteeship until 1994
- Now a Sovereign nation with government structure similar to USA
- Palau has no military and relies on USA for defense.
- Palauan citizens may volunteer for service in the U.S. Armed Forces
- Population: 21,100.
- GNP: U.S.$8,806 per capita.

The Palau Public Utilities Corporation (PPUC) is responsible for electricity supply to all consumers in Palau.

Capacity:
- 31MW main islands,
- 2.7MW outer islands
USPACOM has continuously operated a CAT Detachment on Palau since 1968

CAT mission is three-fold:
• Provide a continuous favorable U.S. military presence
• Transfer technical skills to local residents
• Partner with Palau in basic infrastructure development

Accomplished through four execution elements:
• Community Construction Program
  – Provide construction support to the host nation
  – Apprentice Training Program
  – Assist and train Palauans in general engineering skills
• Medical Civic Action Program (MEDCAP)
  – Provide an in-camp clinic, outreach to outlying areas, and health education programs for local residents
• Community Relations Program (COMREL)
  – Provide a positive U.S. presence
  – Technical Assists
Background – Palau DEIC Mission

September 2009 – USPACOM proposal to deploy PV power at Camp Katuu selected by DEIC program.

Palau DEIC Project Mission Statement

In order to deepen US ties, strengthen alignment, and expand innovative solutions to energy challenges, USPACOM will install a photo-voltaic array at Camp Katuu, Palau in support of the Civic Action Team (CAT) detachment no later than 30 Sept 2010.

This alternative energy source will set an example to other small nations in a region of the world heavily dependent on foreign fossil fuels for electricity generation.
Palau DEIC Project Objectives

• Reduce the operating cost for Camp Katuu by lowering electrical costs (currently 25% of overhead)
• Train the 249th Engineering Battalion on an emerging technology
• Accomplishes cost savings by meshing with the host nation’s renewable energy plans with PV as the featured technology.
• Stabilizes the national grid with fungible power the PUC can manage
• Strengthen US image as a contributing partner in Palau’s economy
• Provide a showpiece within the Pacific for other island nations to visit and emulate
• Provide USPACOM an engagement activity with a small nation through technological stabilization of critical national infrastructures.
• Networking with Dr. Wade who can act as an independent advocate for USPACOM’s partnership development within the AOR.
• Strengthen the DEIC Program in the USPACOM AOR
Palau DEIC Project Status

Phase 1 Base Camp Survey (Nov 2009) –
USACE 249th Prime Power BN and Dr. Herbert Wade.

• Findings:
  – Total Peak Load: 43kW @ 1100hrs 8NOV2009
  – 3 x 60 kW Generators on Site: one is more than adequate

• Recommendations:
  – paint rooftops with aluminum spray
  – install awnings; replace windows with Low–E type windows
  – replace window A/C units with power efficient split units
  – fabricate shaded covers for A/C condenser units
  – replace washing machines with power efficient front loaders
  – remove A/C from laundry room; replace electric dryers with bottled gas units
  – replace electric range with bottle gas range
  – consolidate freezer contents and unplug units not in long term use
Palau DEIC Project Status


Determination:

• Feasible to install a PV system that can provide 30kW to 60kW usable power for Camp Katuu. Excess power would put into the grid via net-metering.

• Execution possible by a trained 249th Engineer Battalion, Prime Power Section (7 Soldiers) estimated 14-day duration. (Additional Training will be required).
Details of proposed PV array – Katuu Builder’s Shop Roof

This side of the roof will mirror the completed side above.

Roof Slope: 26 degrees

Example of how each String will be connected.

SMC 5000A Grid Tie Inverter
Manufacturer: SMA
Palau DEIC Project Issues

- The Builder’s shop roof requires structural upgrades in order to accommodate the PV load.
- The Prime Power soldiers are not fully trained in alternative energy installation.
- Manufacturers typically expect certified or pre-qualified contractors to install equipment for warranty protection.
- Maintenance responsibilities undefined.
Palau DEIC Way Ahead

- Camp Katuu will undertake the Builder’s shop roof upgrades this summer.
- Prime Power soldiers plan to take third party training in alternative energy/PV installation and inspection this summer (pending final DEIC fund approval).
- Prime Power conducting industry outreach to ascertain alternatives to sustain warranty protection. Have budgeted to fund a manufacturer’s A/QC rep to be on site during installation.
- Camp Katuu CAT developing strategic communications plan
Palau DEIC Project Desired End State

- Camp Katuu will mesh with the net-metering system and receive credit for the electrical power the CAT supplies the grid.
- This power source will also help stabilize the grid during peak hours.
- The camp will benefit since the grid will act as storage, relieving an on-site battery system requirement.
Alternative Energy as an Engagement Opportunity in the USPACOM AOR

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The Office of the Deputy Under Secretary of Defense (Installations and Environment) (ODUSD(I&E)), in partnership with the Office of the Under Secretary of Defense (Policy) and regional Combatant Commanders, uses the Defense Environmental International Cooperation (DEIC) Program as an effective and cost efficient way to:

- share environmental information;
- counter the proliferation of weapons of mass destruction;
- partner to maintain access to resources for training and readiness;
- contribute to interoperability;
- promote regional cooperation;
- foster a global military environmental ethic; and
- improve interagency processes, focus, and integration.

DEIC activities focus on building capacity to mitigate encroachment; preserve training range capabilities; and enhance regional capacity to address natural, accidental, or terrorist caused disasters.
String of 14 Panels:
329 V
6.32 A

String of 14 Panels:
329 V
6.32 A

5000W Grid Tie Inverter w/ DC Disconnect

Distro Panel

INV1
INV5
INV2
INV6
INV3
INV7
INV4
INV8

Meter

KWh
# GRID TIE INVERTER

SMC 5000A Grid Tie Inverter w/ DC Disconnect  
Manufacturer: SMA

2 Strings of 16 panels each are paralleled into the Inverter.

AC cabling then connects inverters to "Solar Distribution Panel"

<table>
<thead>
<tr>
<th>Input (DC)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. DC power</td>
<td>5750 W</td>
</tr>
<tr>
<td>Max. DC voltage</td>
<td>600 V</td>
</tr>
<tr>
<td>PV-voltage range, MPPT</td>
<td>246 V - 480 V</td>
</tr>
<tr>
<td>Max. input current</td>
<td>26 A</td>
</tr>
<tr>
<td>Number of MPP trackers</td>
<td>1</td>
</tr>
<tr>
<td>Max. number of strings (parallel)</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output (AC)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal AC output</td>
<td>5000 W</td>
</tr>
<tr>
<td>Max. AC power</td>
<td>5500 W</td>
</tr>
<tr>
<td>Max. output current</td>
<td>26 A</td>
</tr>
<tr>
<td>Nominal AC voltage / range</td>
<td>220 V - 240 V / 180 V - 260 V</td>
</tr>
<tr>
<td>AC grid frequency (self-adjusting) / range</td>
<td>50 Hz / 60 Hz / ± 4.5 Hz</td>
</tr>
<tr>
<td>Phase shift (cos φ)</td>
<td>1</td>
</tr>
<tr>
<td>AC connection / Power balancing</td>
<td>single-phase / single-phase</td>
</tr>
<tr>
<td>Efficiency</td>
<td></td>
</tr>
<tr>
<td>Max. efficiency</td>
<td>96.1 %</td>
</tr>
<tr>
<td>Euro-Eta</td>
<td>95.2 %</td>
</tr>
</tbody>
</table>
210W Solar Panel
Manufacturer: Kyocera
Model: KD210-GX-LP

2 Strings of Solar panels each consisting of 16 panels will be connected in Parallel resulting in the following output:

376 Volts
12.64 Amps
4752 Watts

**Specifications**

<table>
<thead>
<tr>
<th><strong>Electrical Performance under Standard Test Conditions (&quot;STC&quot;)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Power (P_max)</td>
<td>210W (±5% / -5%)</td>
</tr>
<tr>
<td>Maximum Power Voltage (V_{mp})</td>
<td>26.6V</td>
</tr>
<tr>
<td>Maximum Power Current (I_{mp})</td>
<td>7.90A</td>
</tr>
<tr>
<td>Open Circuit Voltage (V_{oc})</td>
<td>33.2V</td>
</tr>
<tr>
<td>Short Circuit Current (I_{sc})</td>
<td>8.58A</td>
</tr>
<tr>
<td>Max System Voltage</td>
<td>600V</td>
</tr>
<tr>
<td>Temperature Coefficient of Voc</td>
<td>$-1.20 \times 10^{-1}$ V/°C</td>
</tr>
<tr>
<td>Temperature Coefficient of I_{sc}</td>
<td>$5.15 \times 10^{-2}$ A/°C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>*<em>Electrical Performance at 800W/m², <em>NOCT, AM1.5</em></em></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Power (P_{max})</td>
<td>148W</td>
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<tr>
<td>Maximum Power Voltage (V_{mp})</td>
<td>23.5V</td>
</tr>
<tr>
<td>Maximum Power Current (I_{mp})</td>
<td>6.32A</td>
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<tr>
<td>Open Circuit Voltage (V_{oc})</td>
<td>29.9V</td>
</tr>
<tr>
<td>Short Circuit Current (I_{sc})</td>
<td>6.98A</td>
</tr>
</tbody>
</table>

*NOCT = Normalized Operating Cell Temperature, AM1.5 spectrum, cell temperature 35°C

<table>
<thead>
<tr>
<th><strong>Cells</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number per Module</td>
<td>54</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Module Characteristics</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length x Width x Depth</td>
<td>150mm x 59in x 39mm x 9mm x 19mm</td>
</tr>
<tr>
<td>Weight</td>
<td>18.5kg (40.8lbs.)</td>
</tr>
<tr>
<td>Cable</td>
<td>(+760mm x 28.5in x 1/8in</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Junction Box Characteristics</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length x Width x Depth</td>
<td>120mm x 39in x 16mm x 4.3in x 15mm x 0.6in</td>
</tr>
<tr>
<td>IP Code</td>
<td>IP65</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Others</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Operating Temperature</em></td>
<td>$-40°C \sim 90°C$</td>
</tr>
<tr>
<td>Maximum Fuse</td>
<td>15A</td>
</tr>
</tbody>
</table>

*This temperature is based on cell temperature.*