Design Development and Testing of the Ground Renewable Expeditionary Energy System

Eric Shields, Alex Askari
NSWC Carderock, 5/4/2011
Battery Technology Group

• Three Primary Work Areas
  – Lithium Battery Safety Testing
  – Advanced Battery Development
  – Renewable Energy Testing and Evaluation

• Personnel
  – Physicists (2)
  – Mechanical Engineers (4)
  – Chemical Engineers (3)
  – Materials Engineers (2)
  – Technicians (3)
Outline

- Program Goals
- Design Goals
- Technology Selection
- Prototype Development
- Proof of Concept Testing and Validation
- Battery Design/Development
- USMC procurement and fielding
- Conclusions
• Jointly funded renewable energy development effort (USMC, ONR)
• The scope of the work encompasses two efforts
  – Develop a 300W continuous renewable energy system
  – Test and evaluate COTS systems
• The focus of this presentation will be the developmental efforts associated with the 300W system
GREENS 300W System Design Goals

- Provides 300W continuous, 600W peak from a renewable source
  - 7.2kWh per day
  - 4.8kWh of energy storage
- Consists of individual packages weighing less than 80lbs
- Provides 24VDC and 120VAC output (true sine wave)
- Is capable of being setup in under 20 minutes by 4 Marines
- Weighs under 1000 lbs
- Is rugged enough for transport and usage
- Operates between -20°C and 55°C
- Is scalable to optimize the power supply based on a given mission
Solar vs. Wind

• It was determined at the outset that solar would be selected to best meet the requirements laid out by Marine Corps Systems Command
  – Rapid deployment
  – Deployable in nearly every location
  – Minimal required training
  – Reduced signature (No required guyed tower, no noise or EMI concerns)
Solar Power Characteristics

- Location, time of year, and deployment angle all play critical roles in determining solar energy production

*Data taken from NREL’s PVWatts calculator
http://www.nrel.gov/rredc/pvwatts/

May 3-5 2011 Joint Service Power Expo
GREENS Deployment
Concept Development
Deployment Concept Selection
Objectives:
• To demonstrate the prototype GREENS system capable of delivering 300W continuously
• To study the effect of temperature and the harsh environment of the Mojave Desert on the overall performance of the system.
Summary of Energy Generation

Design Goal
300W Continuous
7.2 kWh

- Rain all day
  Carderock, MD
  February 50 F
  1.6 kWh
- Cloudy all day
  Carderock, MD
  February 45 F
  4.0 kWh
- Partially cloudy
  Carderock, MD
  March 60 F
  6.3 kWh
- Clear day
  China Lake, CA
  July 110 F
  7.1 kWh
- Crystal clear day
  Carderock, MD
  March 65 F
  8.2 kWh

300W for 5 hr
300W for 13 hr
300W for 21 hr
300W for 24 hr
500W for 17 hr
Control Box Development

- March 09
- March 10
- May 10
- June 10

May 3-5 2011 Joint Service Power Expo
Development Timeline

GREENS Tech. demonstrator
NAWS China Lake, CA
July 2009

GREENS Prototype Camp Pendleton, CA
June 2010

GREENS Tech. Demonstrator
Ex-FOB Phase II Quantico, VA
March 2010

GREENS Prototypes Twentynine Palms, CA
July 2010

May 3-5 2011 Joint Service Power Expo
India Co. 3/5 Deploys With 7 Systems

From project start to a limited fielding in 23 months!

After August 2010
Need For Production Level System

• EPS worked concurrently during the GREENS development to identify vendors to build the production level system
• Lessons learned and performance metrics from the Prototype systems were used in the performance specification definition
• UEC and HDT were chosen to build prototypes of the production level system
• Testing of those systems is ongoing
## Production Version Improvements

<table>
<thead>
<tr>
<th></th>
<th>Prototype System</th>
<th>Production System</th>
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</thead>
<tbody>
<tr>
<td>Continuous Power</td>
<td>300W</td>
<td>300W</td>
</tr>
<tr>
<td>Peak Power</td>
<td>600W</td>
<td>1000W</td>
</tr>
<tr>
<td>Total Weight</td>
<td>1200lbs</td>
<td>900lbs</td>
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<tr>
<td>Setup time (4 marines)</td>
<td>10 minutes</td>
<td>10 minutes</td>
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<tr>
<td>Operation Range</td>
<td>0F-140F</td>
<td>0F-140F</td>
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<tr>
<td>Output</td>
<td>120VAC/24VDC</td>
<td>120VAC/24VDC regulated</td>
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<tr>
<td>Battery Technology</td>
<td>Lead Acid</td>
<td>Li-Ion</td>
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<tr>
<td>Autostart Capability</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Battery State of Charge Indicators</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>DC Charging</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>AC Charging</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Why Use Renewables?

Renewables are heavy and expensive but…

• No need to re-fuel the system (Reduced logistics burden). System can be self-sustaining in remote areas
• Short-term weight reduction benefit
• Lifecycle cost benefit
• **Silent operation**
• No mandatory MOS (Operated by the Incidental Operator)
• Reduction in maintenance (no oil/oil filter changes)
• Long lifetime (panels last 25 years)
Conclusions

• Renewable energy systems will never be able to replace conventional power sources for power levels greater than 100kW

• When selected for the appropriate use scenario, rugged renewable systems can be developed and deployed to reduce fuel consumption and benefit the warfighter

• A detailed cost benefit analysis would have to be undertaken to determine under what scenarios GREENS could provide cost savings
Acknowledgements

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Team

• Justin Govar, Matt Huffman, Evan Rule, Alex Askari, Calvin Peters, Anthony Suggs, Erick Satchell, Dave Meldrum
Questions?
Rugged Battery Case Design

- Lead Acid batteries previously connected manually with no packaging
- Prototype design packaged in a 24V configuration in cases

**Tech. Demonstrator Battery**

Die Hard Marine Deep Cycle Lead Acid
- 100Ah
- 75lbs

**Prototype Battery Design**

Optima Deep Cycle Lead Acid
- 55Ah (2 per pack)
- 110 lbs
- 60A Breaker