Future Naval Capability: Advanced Power Generation

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Agenda

- Future Naval Capabilities: Advanced Power Generation overview
- Marine Portable Generator (MPG)
  - Product overview
  - Current status
- Ground Renewable Expeditionary Energy System (GREENS)
  - Product overview
  - Current status
- Questions

Advanced Power Generation Overview

Marine Portable Generator (MPG)

- Lunchbox-sized, JP-8 fueled 500-1000W generator

Ground Renewable Expeditionary Energy System (GREENS)

- 300W expeditionary renewable energy system
- Renewable energy system tool box

R&D Program Funding Level:
FY06-FY11: ~$16.5M

Time Line: FY06 → FY11

TRL: Start 3 → Transition 7

Planned Transitions

1. Mid FY09: 300W expeditionary renewable energy system
2. End of FY11: single person portable generator and renewable energy system tool box

Warfighting Payoff:

- Power C4I equipment
- Reduce logistical burden
- Reduce life cycle cost
- Fills power source void:
  - Bigger than a battery
  - Smaller than a generator (< 2kW)

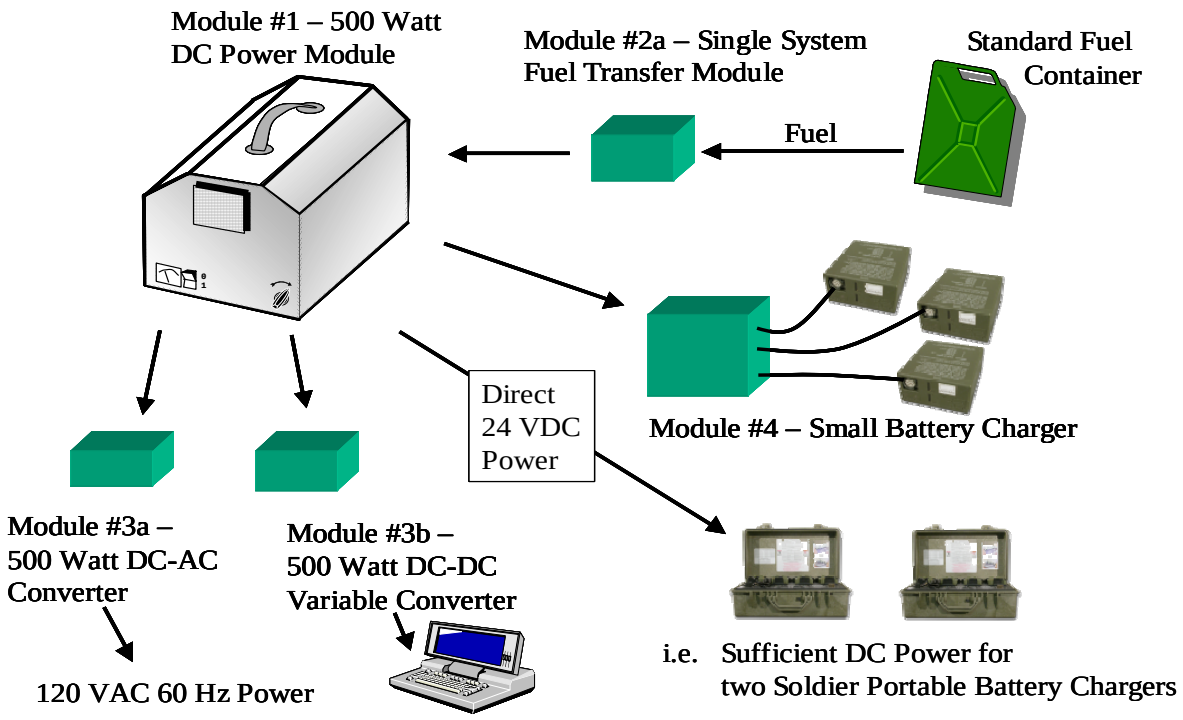
Marine Portable Generator (MPG)

Objective

Develop & demonstrate a single-person portable power unit

Desired Capabilities

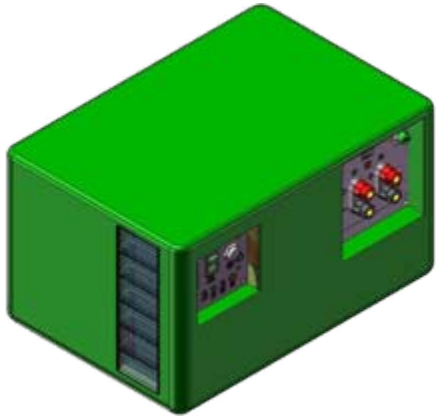
- TQG quality power
- Low cost of ownership
- Weight - <15 lbs
- Volume – lunch box size person portable
- <70 dB at 7 meters
- 500W - 1000W output power
- Field operational
- JP-8 fuel with > 1500 ppm of sulfur
- 1 hr internal fuel
- 600 hours before major maintenance
- Start-up in <10 minutes



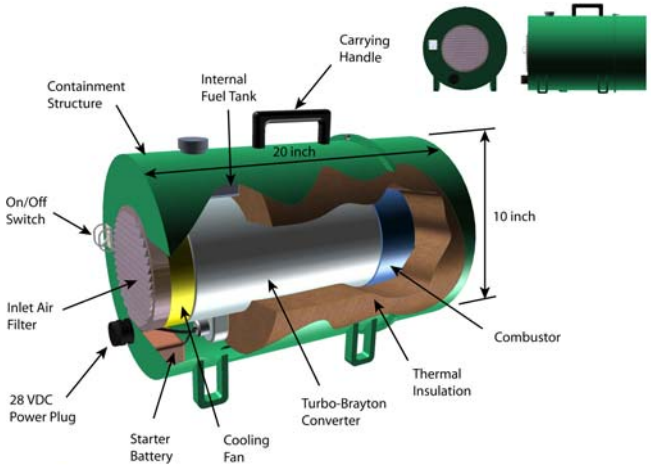
MPG Project Plan

- BAA released in FY06
  - Phase 1 – detailed design – TRL 3-4
    - Teledyne, D-Star, Creare, L-3 & FEV, Tiax
  - Phase 2 – prototype development & demo – TRL 5-6
  - Phase 3 – product evaluation and field test
  - Phase 4 – production & delivery of field units – TLR 6-7
- SBIR Development Transition
  - Further develop existing fuel cell portable generator SBIR topic
    - Altex, InnovaTek
- Program plan
  - 1st prototype demo in FY10
  - Transition TLR 6-7 to MARCORSYSCOM in FY11

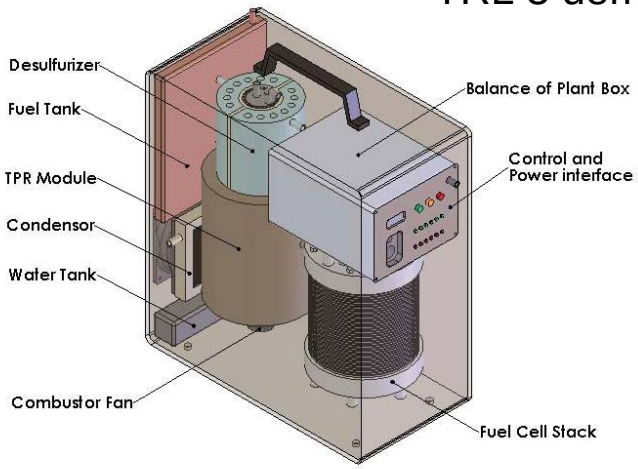
500-1000 W Single Person Portable Generator Product



D-STAR – Modified COTS 4-Stroke Engine
- 19% efficiency
- 14lbs, 0.4ft^3, 1kW
- TRL 5 demo early FY10



Creare - Turbo-Brayton Power System
- 24.3% efficiency
- 21.5lbs, 0.5ft^3, 538W
- TRL 5 demo early FY10

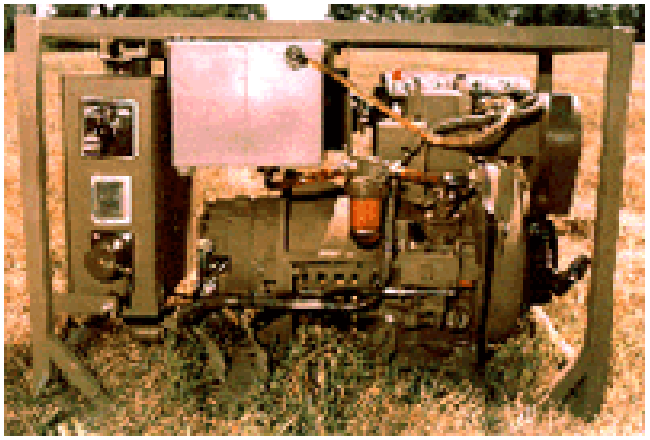


Altex – High Temperature PEM Fuel Cell/PJF-GEN unit
- >30% efficiency
- 17.6lbs, 0.5ft^3, 500W
- TRL 5 demo late FY09

D-Star
(4-Stroke Diesel Engine)

Revolutionary Research . . . Relevant Results

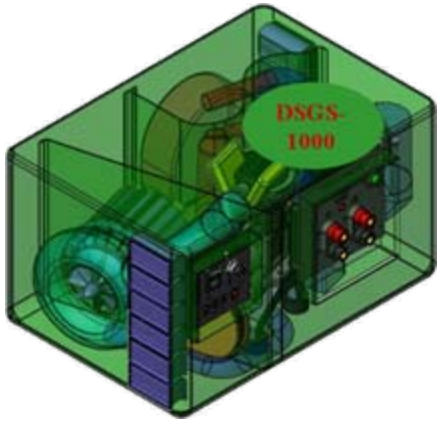
Currently Fielded System



2 kW Generator Set
30” x 16” x 22”
> 6.0 cu. ft.
158 lbs
77 - 79 dB(A) @ 7m

6x Pwr./Wt.
8x Pwr./Vol.
9 – 12 dB Quieter

Future USMC MPG System

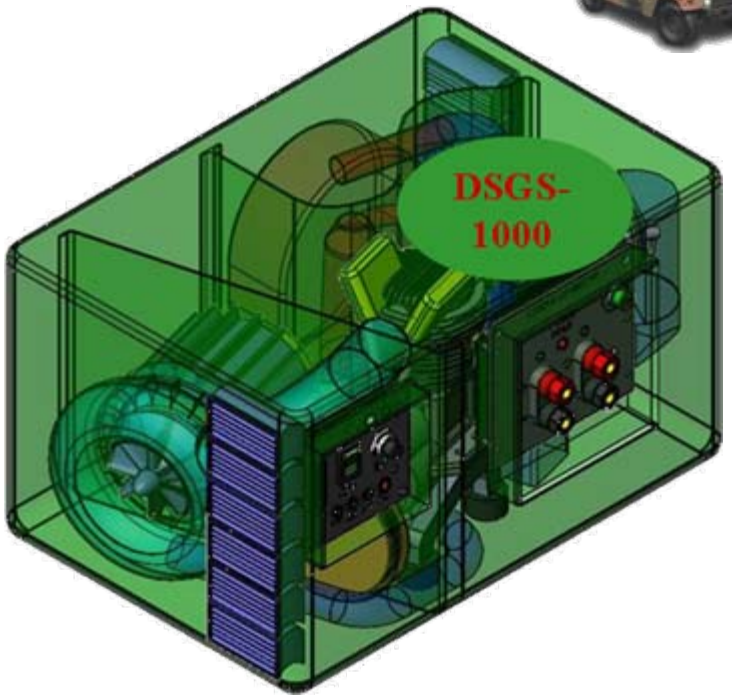


1 kW Generator Set
12” x 8” x 6.5”
< 0.4 cu. ft.
14 lbs
65 - 68 dB(A) @ 7m

Benefits of
(4-stroke Engine Design)

Technical Highlights

- High-Speed (9,000 – 11,000 RPM) 4-stroke Heavy Fuel Engine
- Enhanced Heavy Fuel Atomization, Closed-Loop (Wet Sump) Lubrication
- Combustion Management, Material Substitutions
- Noise-Suppressing Casing

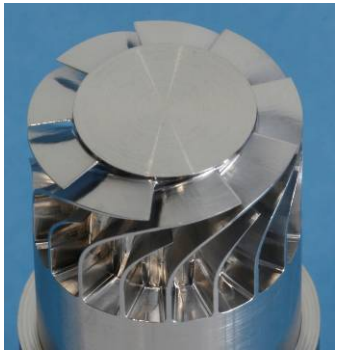


Benefits

- Low cost
- High power to weight and volume ratios
- Instantaneous power demand changes
- Reduced wet stacking issues

Creare
(Closed-loop Turbo-Brayton, Open-loop Combustion)

- Development Team
  - Creare Incorporated – *Lead integrator*
  - Cascade Designs Incorporated – *Combustion/Fuel systems*
  - M.S. Kennedy Corporation - *Electronics*
  - UTC Pratt & Whitney Rocketdyne – *Production cost*
- Status and Plans
  - PDR complete
  - CDR - June 2009
  - System testing - May 2010
  - Prototype delivery - September 2010



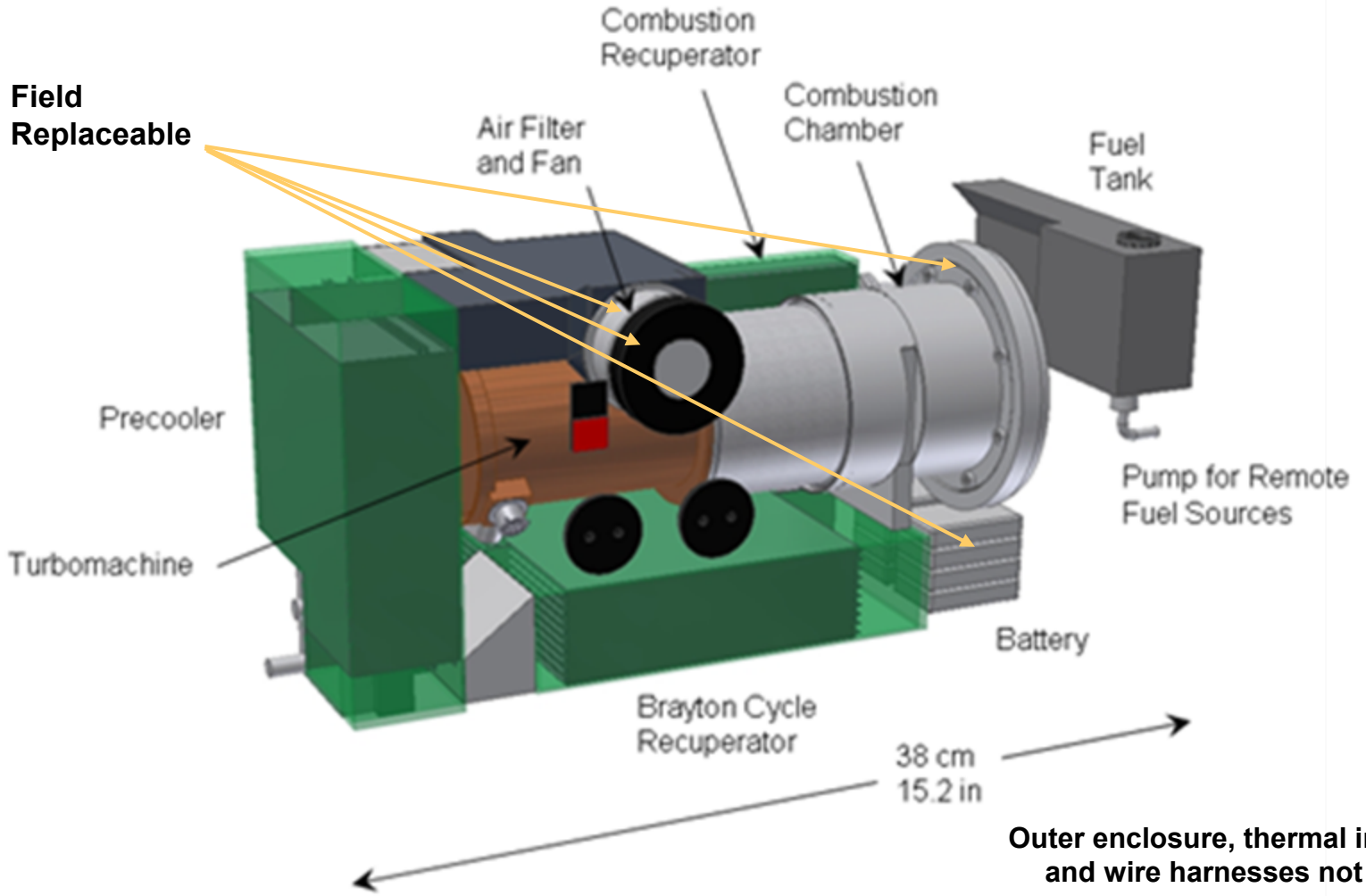
Turbine Rotor Fabrication Trial

Compressor Impeller Fabrication Trial

Benefits of
(Turbo-Brayton Design)

- High efficiency at reduced power levels
- High power to weight and size ratios
- Efficient – 24.3%
- Reliable with simple maintenance
- Long mean time between failures
- Quiet

Mechanical Layout



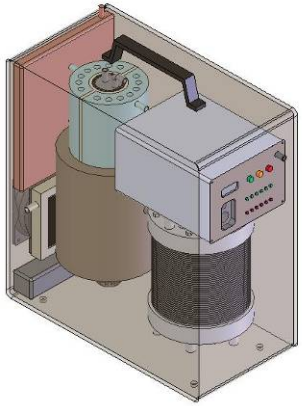
Outer enclosure, thermal insulation, and wire harnesses not shown

Altex

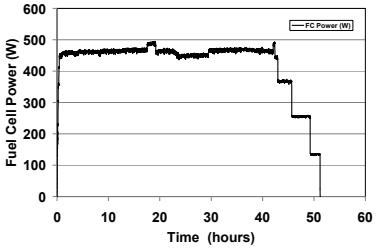
(High Temperature PEM JP-8 Fuel Cell)

Revolutionary Research . . . Relevant Results

Concept



TRL 4 – Lab Test



TRL 5 – Delivery

TRL4

TRL5

9 / 2006

6 / 2008

6 / 2009

Benefits of
(High Temperature PEM JP-8 Fuel Cell)

- High efficiency at reduced power levels
- Efficient >30%
- High power to weight and size ratios
- Quiet
- No wet stacking issue

Ground Renewable Expeditionary Energy System (GREENS)

- 300W Renewable Expeditionary Energy System
  - Prototype currently being built
  - Initial Deployment of 10 -15 system late FY09 – Early FY10
- Renewable energy system tool box
  - Transition at the end of FY11
  - Toolbox of renewable components
    - (energy collectors, batteries, power managers, cabling) will be vetted against varying Marine Corps environments and usages (i.e., experimental data collected on COTS hardware) to enable system optimization for different deployment strategies and power usages

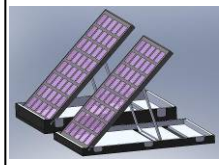
Ground Renewable Expeditionary Energy System (GREENS)

Revolutionary Research . . . Relevant Results

S&T OBJECTIVES

- Develop & demonstrate a 300W portable renewable power system
  - ➢300 W output power
  - ➢Field operational
  - ➢Breaks down to <80lbs cases
  - ➢1000W peak power
  - ➢HMMWV Transportable
  - ➢Stackable system

apply rapid prototyping toolbox to determine optimum renewable and storage component combination for required mission


energy collection


power management


energy storage


cables & connectors

individual modules packaged for man transportability

construct renewable 300 W power system

APPROACH

- Assemble highly qualified team
- Design, build and test 300W system (Q2 FY09)
- Transition 300W system (Q3 FY09)
- Evaluate available renewable tool box components
- Develop renewable energy tool box program
- Demonstrate renewable energy tool box
- Transition renewable energy tool box (FY11)

RESULTS/IMPACT/READINESS

- Results – System-level design trades underway
  System-level integration design underway
  Tool box population started
- Impact – Renewable energy can reduce logistic fuel burden and increase remote power capability
  – Addresses urgent needs request from troops in Iraq
- Readiness – Fundamental component technologies being evaluated, System-level build and testing next step

(300W, 24h System)

- Need 7200Wh
- Need 1.6kW rated solar capability
  - Solid panels
  - at near optimal angel, one angle set point
  - Winter/spring rating
  - Moderate solar climate
  - Sun 8 hours a day = 7.2kWh
    - 4.8kWh of energy storage (minimum)
    - 2.4kWh during light hours
- DC/DC converter, DC/AC inverter, safety and control electronics
- Transport and ruggedization

300W System

- 900 lbs → Ruggedized for expeditionary use
  - Breaks into 80 lbs single man portable cases
- 1.6kW rated solar
  - 7200Wh solar/day in Washington DC in January
- 300W continuous (600 max power)
- Output – 120VAC, 24VDC
- Cost <$35K

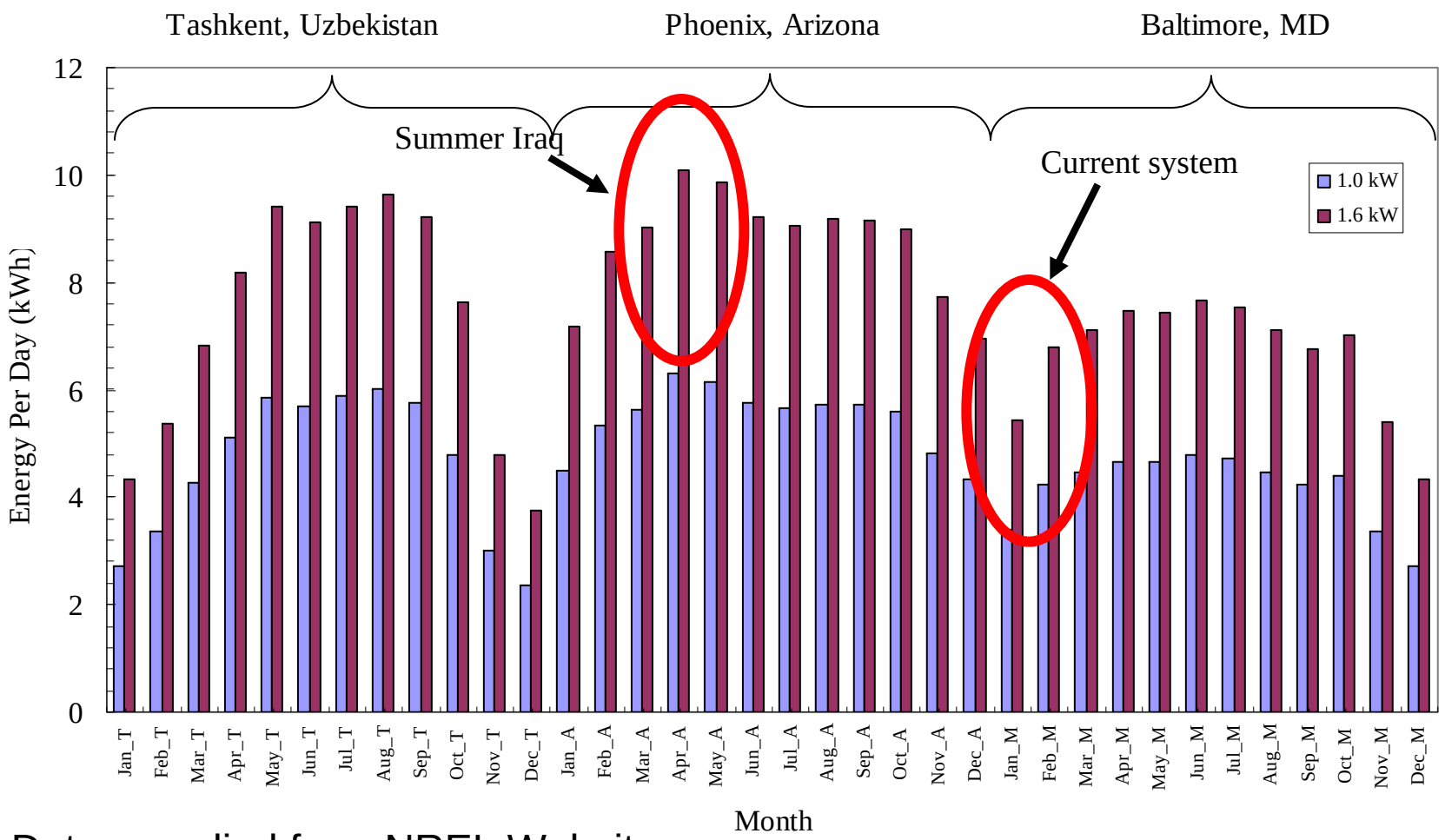
Weight vs. Power

Mission	Total Energy (Whr)	2590 Batteries (lbs)	Solar Weight (lbs)	Converter Weight (lbs)	Total Weight (lbs)
100W const (8hrs/day)	800	(1)3	23	5	31
100W const (16hrs/day)	1600	(5)15	46	5	66
100W const (24hrs/day)	2400	(10)30	69	5	104
200W const (8hrs/day)	1600	(2)6	46	5	57
200W const (16hrs/day)	3200	(10)30	92	5	127
200W const (24hrs/day)	4800	(20)60	138	5	203
300W const (8hrs/day)	2400	(3)9	69	10	88
300W const (16hrs/day)	4800	(15)45	138	10	198
300W const (24hrs/day)	7200	(30)90	207	10	317
With Packaging and deployment					1000 lbs
400W const (8hrs/day)	3200	(4)12	92	10	124
400W const (16hrs/day)	5400	(20)60	155	10	225
400W const (24hrs/day)	9600	(40)120	276	10	406
500W const (8hrs/day)	4000	(5)15	115	15	145
500W const (16hrs/day)	8000	(25)75	230	15	310
500W const (24hrs/day)	12000	(50)150	345	15	510

Solid panels are derated 50%; BB2590's are used as battery baseline

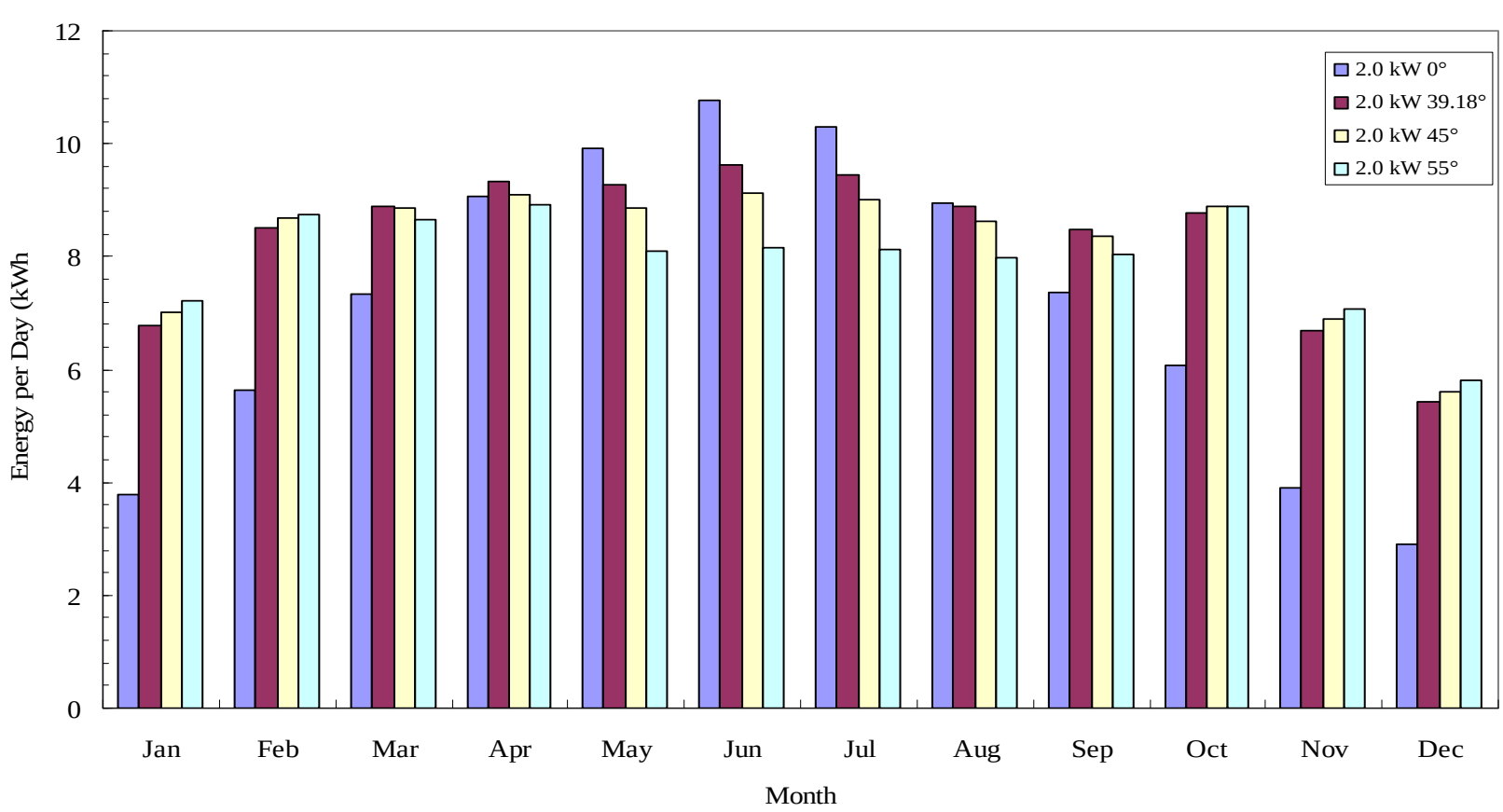
Solar Data (Various locations)

Energy vs. Location



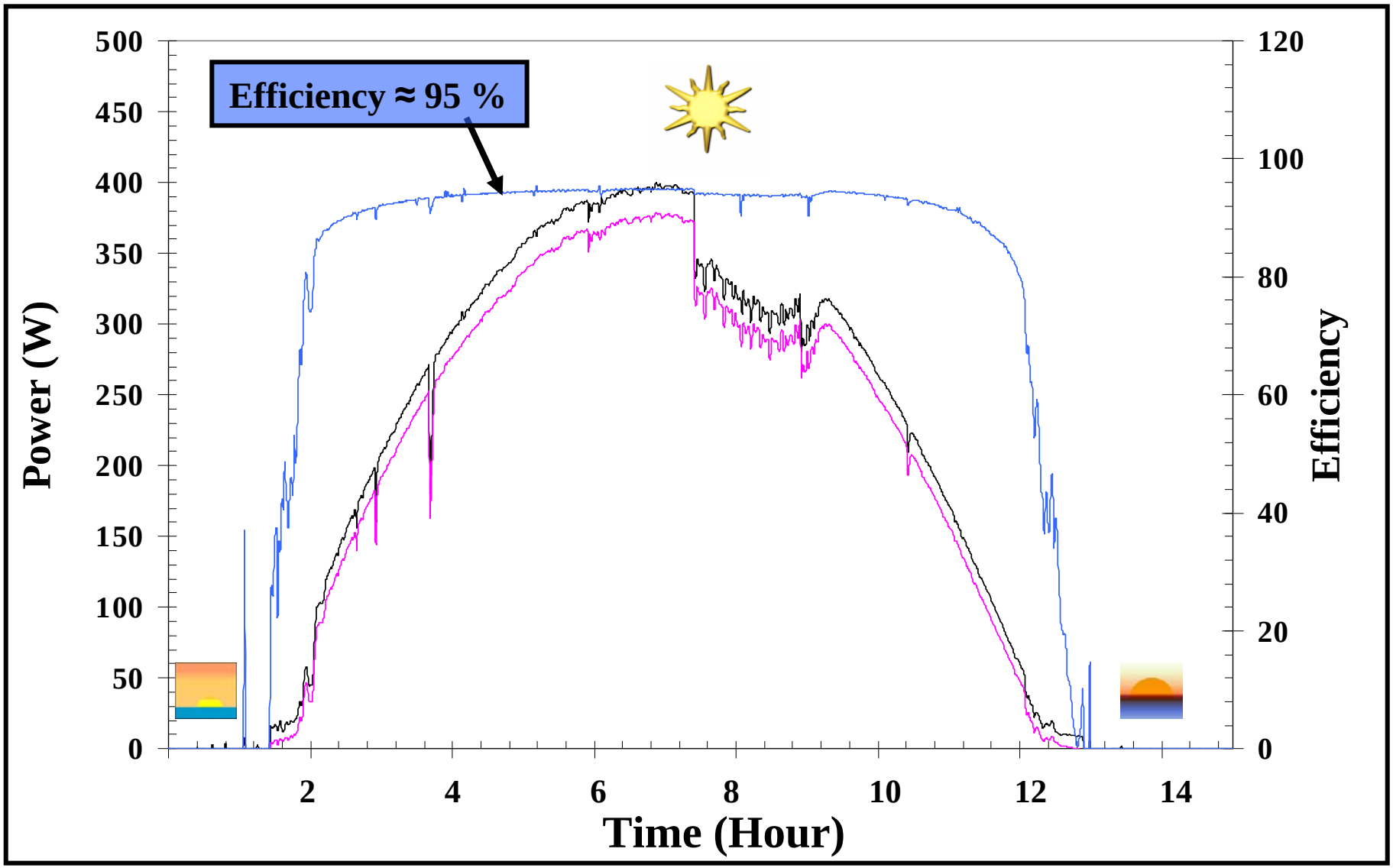
* Data complied form NREL Website

Angle vs. Months

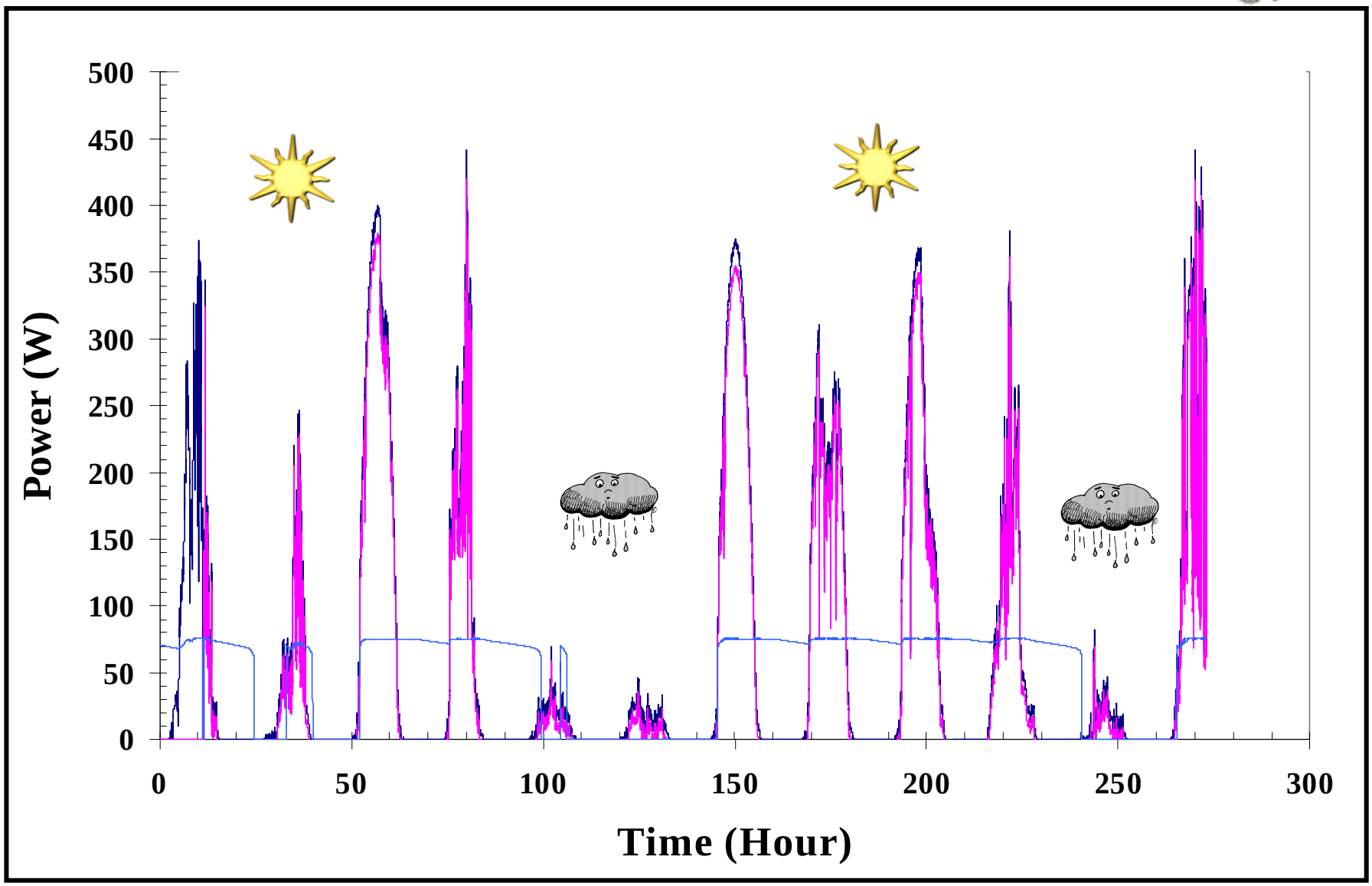


* Data complied form NREL Website

Solar Battery Charging



Power Reliability



GREENS Tool Box

- Tool to rapidly design a tailored renewable energy system, from a list of tested components, for specific deployment scenarios
  - Program
    - Interactive data base
    - Mission Requirements in → Renewable system design out
  - Tested components will include:
    - Energy collectors, batteries, power managers, cabling, packaging
    - Will be vetted against varying Marine Corps environments and usage requirements

Wrap-up

- Any companies that have components they would like to submit for evaluation for inclusion in the GREENS toolbox please contact NSWC Carderock or MARCORSYSCOM.

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