HOMER as a Marine Corps Pre-Deployment Tool To Evaluate Power Solutions

Brandon Newell
Captain, USMC

Advisor: Dr. Sherif Michael

Co-Advisor: Dr. Dan Nussbaum

NPS Electrical & Computer Engineering
Monterey, California

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
JUN 2010		**00-00-2010 to 00-00-2010**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
HOMER as a Marine Corps Pre-Deployment Tool To Evaluate Power Solutions	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School,Electrical & Computer Engineering,Monterey,CA,93943**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Presented at the NDIA Environment, Energy Security & Sustainability (E2S2) Symposium & Exhibition held 14-17 June 2010 in Denver, CO.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**32**	

MY BACKGROUND

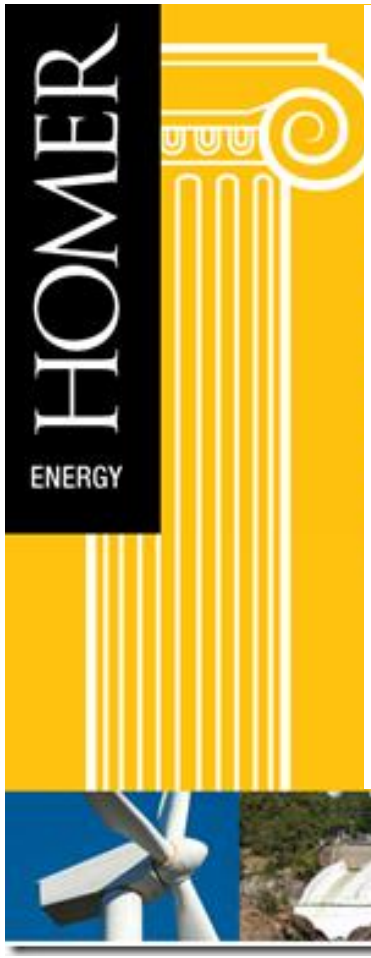
- NPS - June ’08
- NREL Internship – Summer ’09
- Afghanistan MEAT – Sept ’09
- Expeditionary Energy Office – Oct ‘10

Expeditionary Energy Office (*E^2O*)

- Commandant's Vision: "Be the premier, self-sufficient expeditionary force, instilled with an ethos, that efficient use of vital resources equate to increased combat effectiveness."

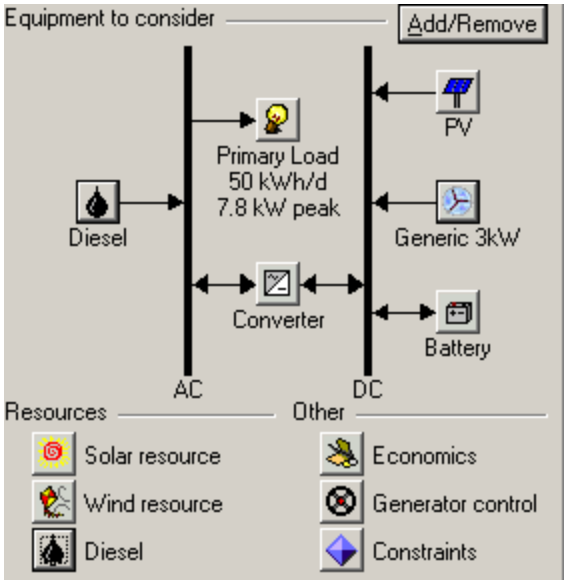
- Reduce Fuel/Water Moved Around the Battlefield

- ExFOB

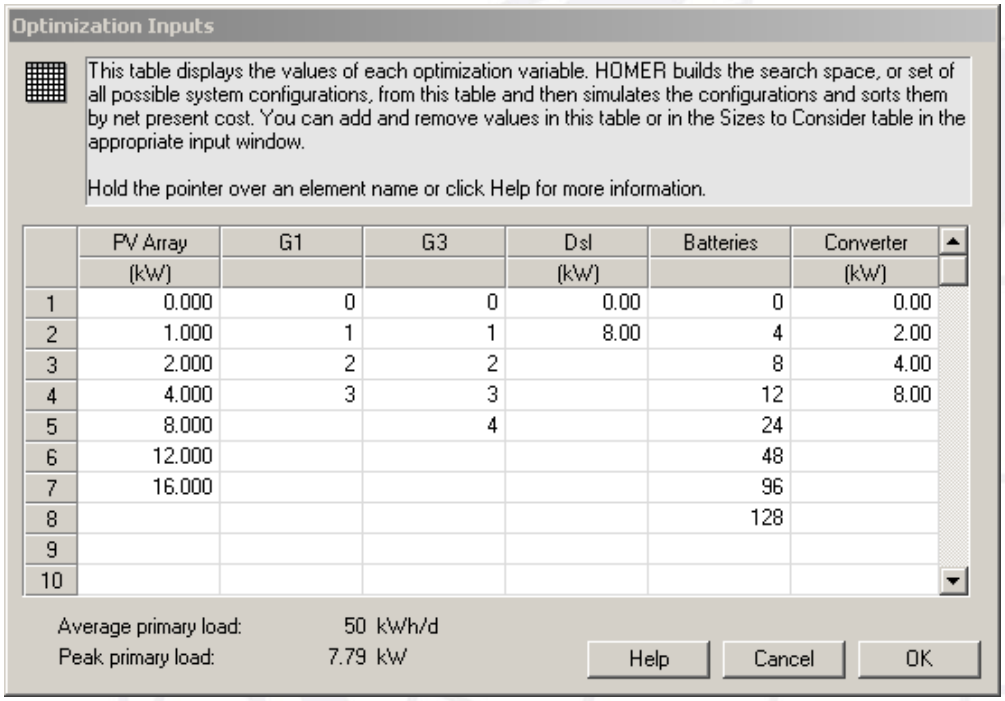


- Micropower Optimization Tool
  - Developed at NREL
    - Now privately owned
  - Simulation of micropower systems
  - Optimization driven by cost analysis

Schematic Diagram



Solution Space



	PV Array (kW)	G1	G3	Dsl (kW)	Batteries	Converter (kW)
1	0.000	0	0	0.00	0	0.00
2	1.000	1	1	8.00	4	2.00
3	2.000	2	2		8	4.00
4	4.000	3	3		12	8.00
5	8.000		4		24	
6	12.000				48	
7	16.000				96	
8					128	
9						
10						

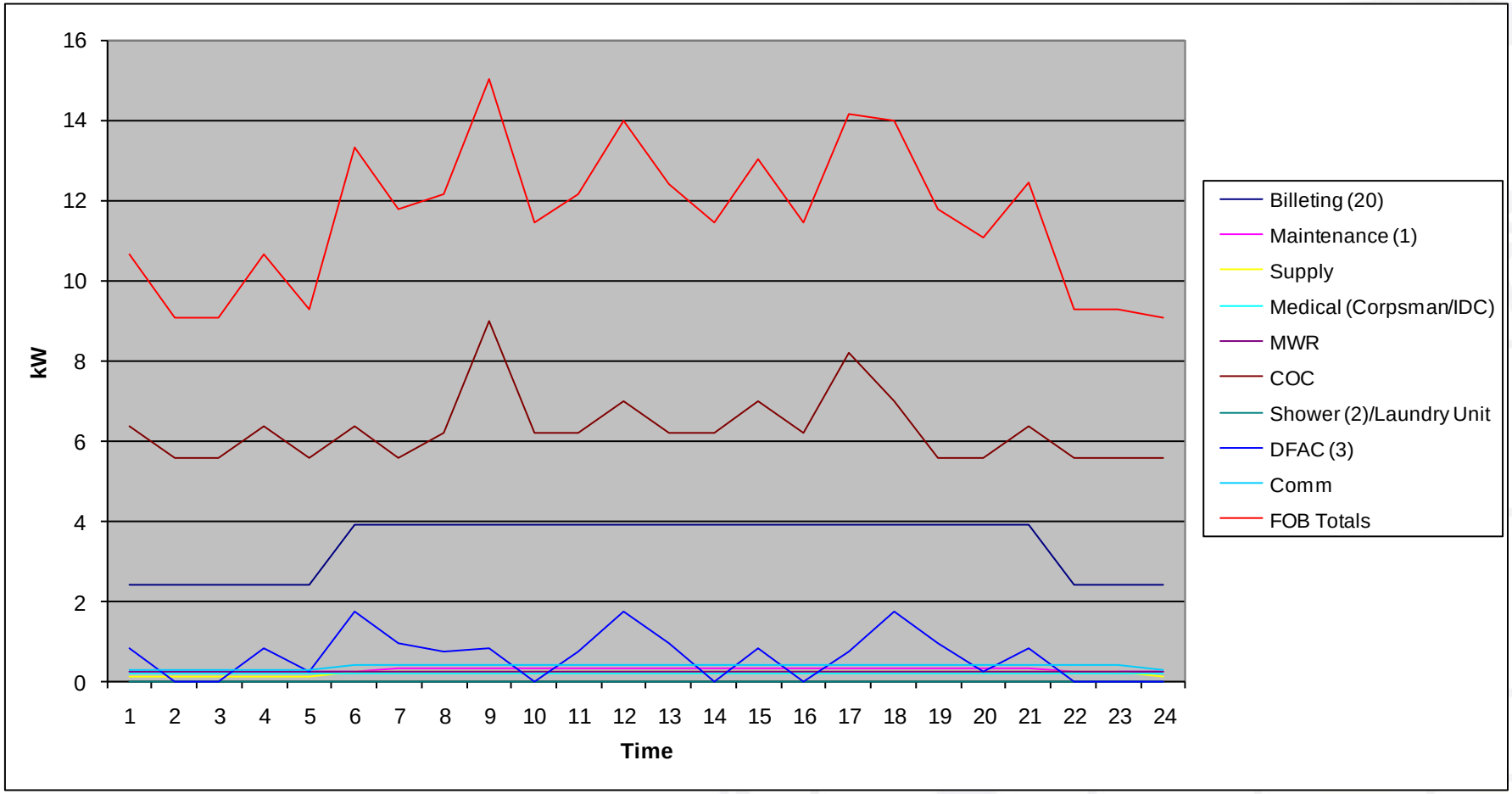
THESIS

- Thesis Question: Can HOMER be utilized as a pre-deployment tool to meet the Marine Corps' need to evaluate power solutions for unique locations?

- Answer: YES, If it is CALIBRATED

Company Power Profile

Austere



Controlled Experiments

Two Experiments – on campus

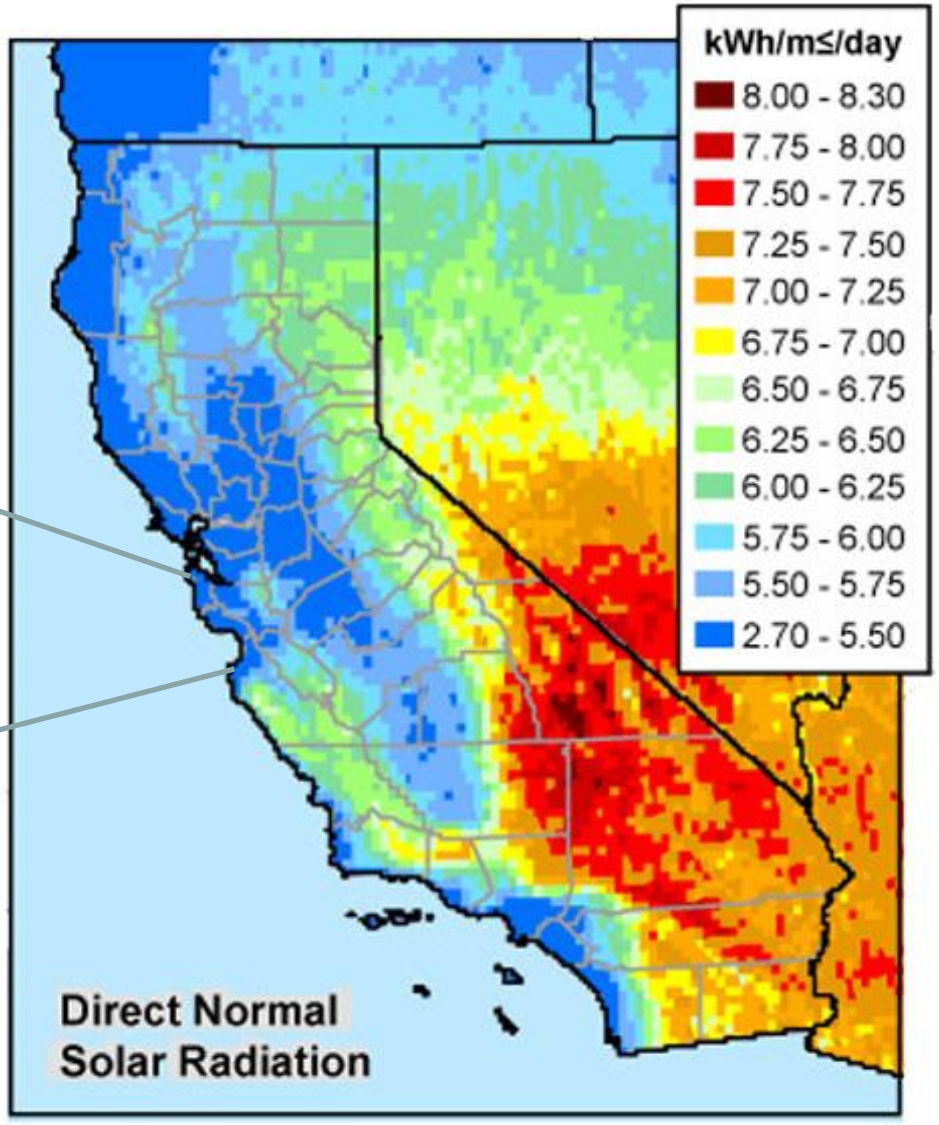
Objectives:

- Measure power production over one month and compare HOMER's modeled production.
- Calibrate HOMER's variables to the particular system.

Controlled Experiments

San Francisco

Monterey



Controlled Experiments

- Grid-tied-PV system
  - 11.48kW PV
  - Pacific Gas &Electric

- Wind-PV system
  - 60 W PV panel (Powerfilm)
  - 50 W PV panel (Kyocera)
  - 400 W wind turbine (AirX)

Grid-tied-PV

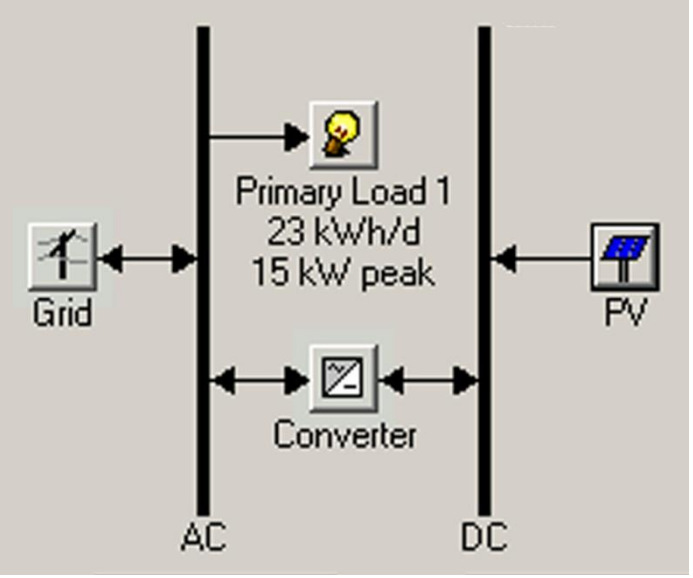
- Period – Apr 2 – May 1, 2010
- Equipment – (56) Kyocera 205W panels

  (3) SunnyBoy SB3800U Inverters

  - Assembled in 2006.
- System Rated Power – 11.48kW
- Measured Energy:
  - 1270 kWh for the month

Grid-tied-PV

Critical Variables



Azimuth	231 degrees
Slope	15 degrees
Temp Effects	Ignored
Economics	Ignored
Solar Resource	NASA (monthly avg)
Converter Eff.	94.5%
Derating Factor	80%

Grid-tied-PV

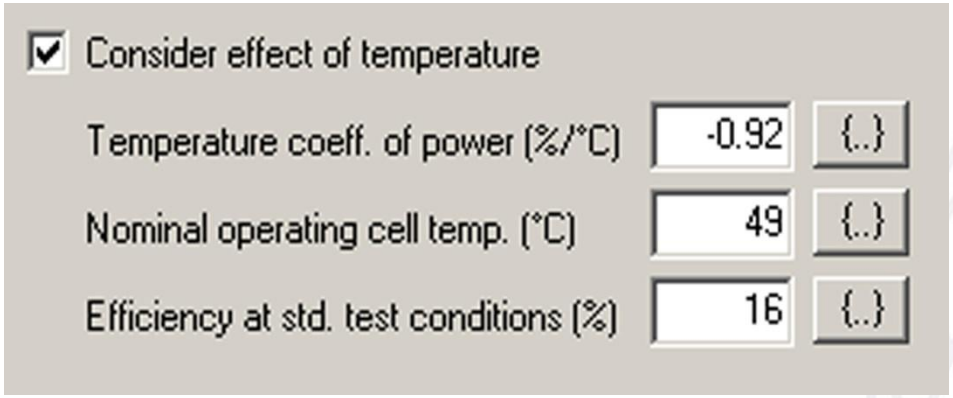
	PV Usable Energy (kWh)	Accuracy
Measured Data	1270	
HOMER Model	1612	+27%

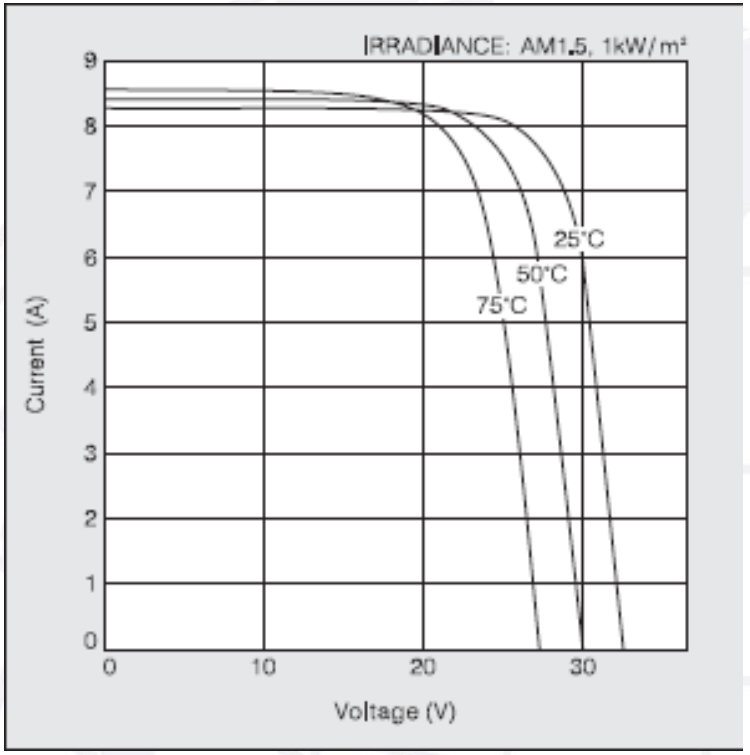
- Possible Sources of Inaccuracy:
  - Temperature Effects
  - Solar Irradiance Estimates
  - Performance of System

Grid-tied-PV

Kyocera KD205GX Data Sheet

Homer Inputs:

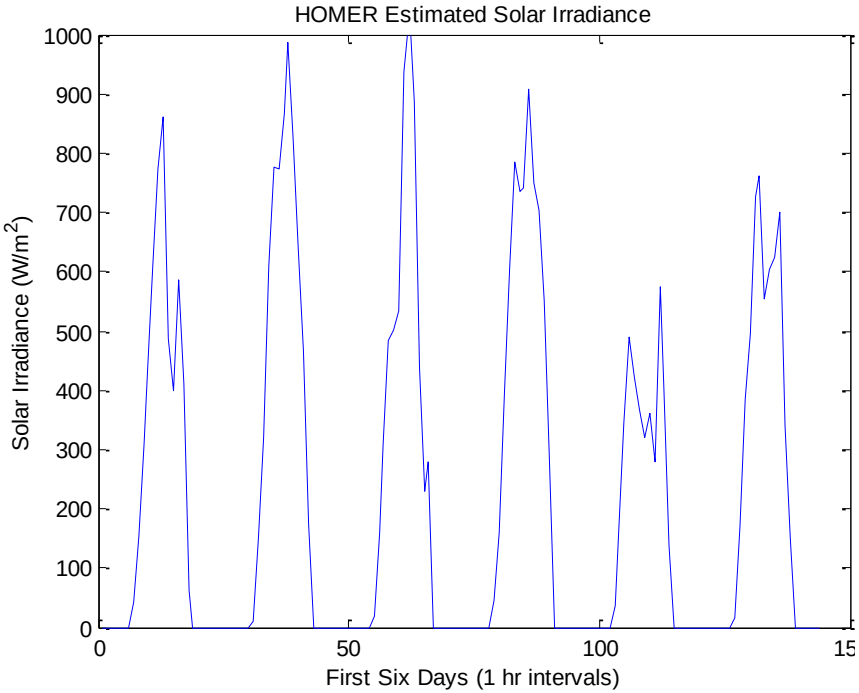


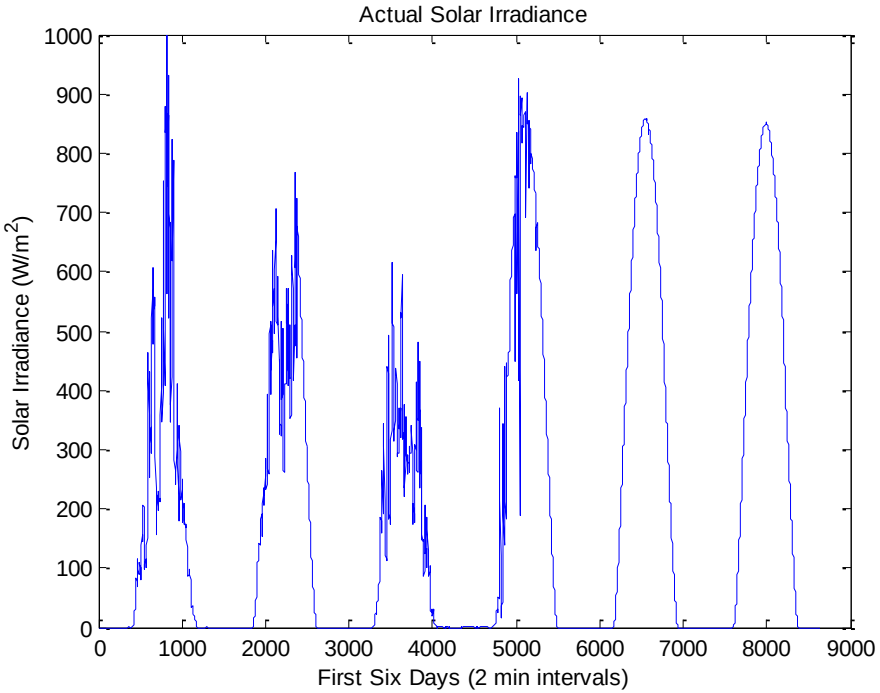


Grid-tied-PV

	PV Usable Energy (kWh)	Accuracy
Measured Data	1270	
HOMER Model	1612	+27%
Add Temp Effects	1539	+21%

Grid-tied-PV





Compare HOMER's Estimated Irradiance to Actual Irradiance:

HOMER is 9% Higher.

Grid-tied-PV

	PV Usable Energy (kWh)	Accuracy
Measured Data	1270	
HOMER Model	1612	+27%
Add Temp Effects	1539	+21%
Add True Solar Irradiance	1483	+17%

Grid-tied-PV

Derating Factor (DF) in HOMER

- Accounts for:
  - Dust on the panels
  - Wiring losses
  - Deviation from optimal power point
- Default: 80%

Precise Calibration – Vary DF

- Outcome: 68.5%

Grid-tied-PV

	PV Usable Energy (kWh)	Accuracy
Measured Data	1270	
HOMER Model	1612	+27%
Add Temp Effects	1539	+21%
Add True Solar Irradiance	1483	+17%
Vary Derating Factor	1270	--

ExFOB

Experimental Forward Operating Base (ExFOB)

"Simulate forward deployed force energy and water demands and to test and evaluate alternative solutions to meet their needs."

- Demand Reduction
- **Alternative Power**

Selected Power Equipment

PowerShade Solar Field Shelter

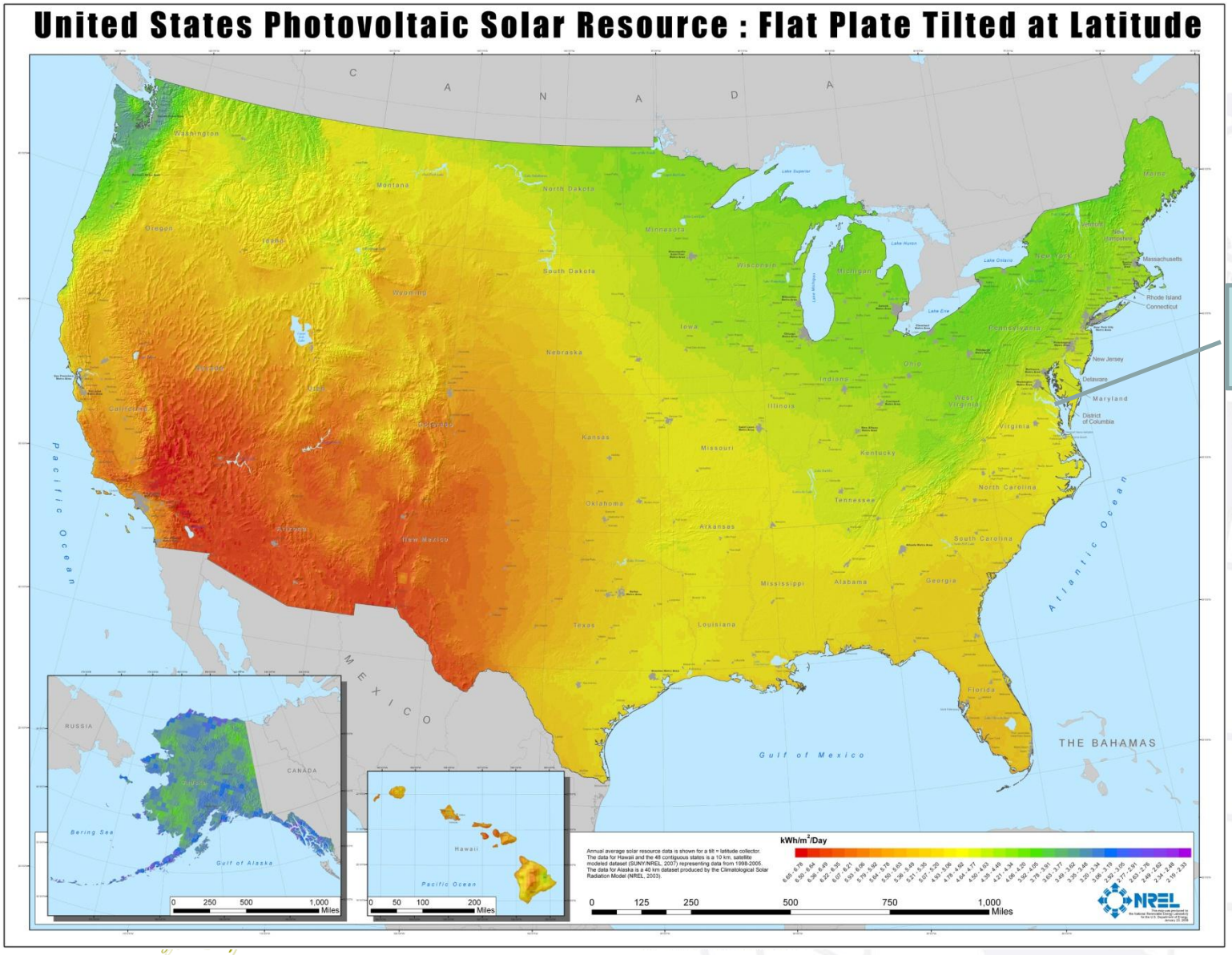
ZeroBase Energy Regenerator

GREENS Solar Power System

NEST Solar Light Trailer

COMPANY EQUIPMENT

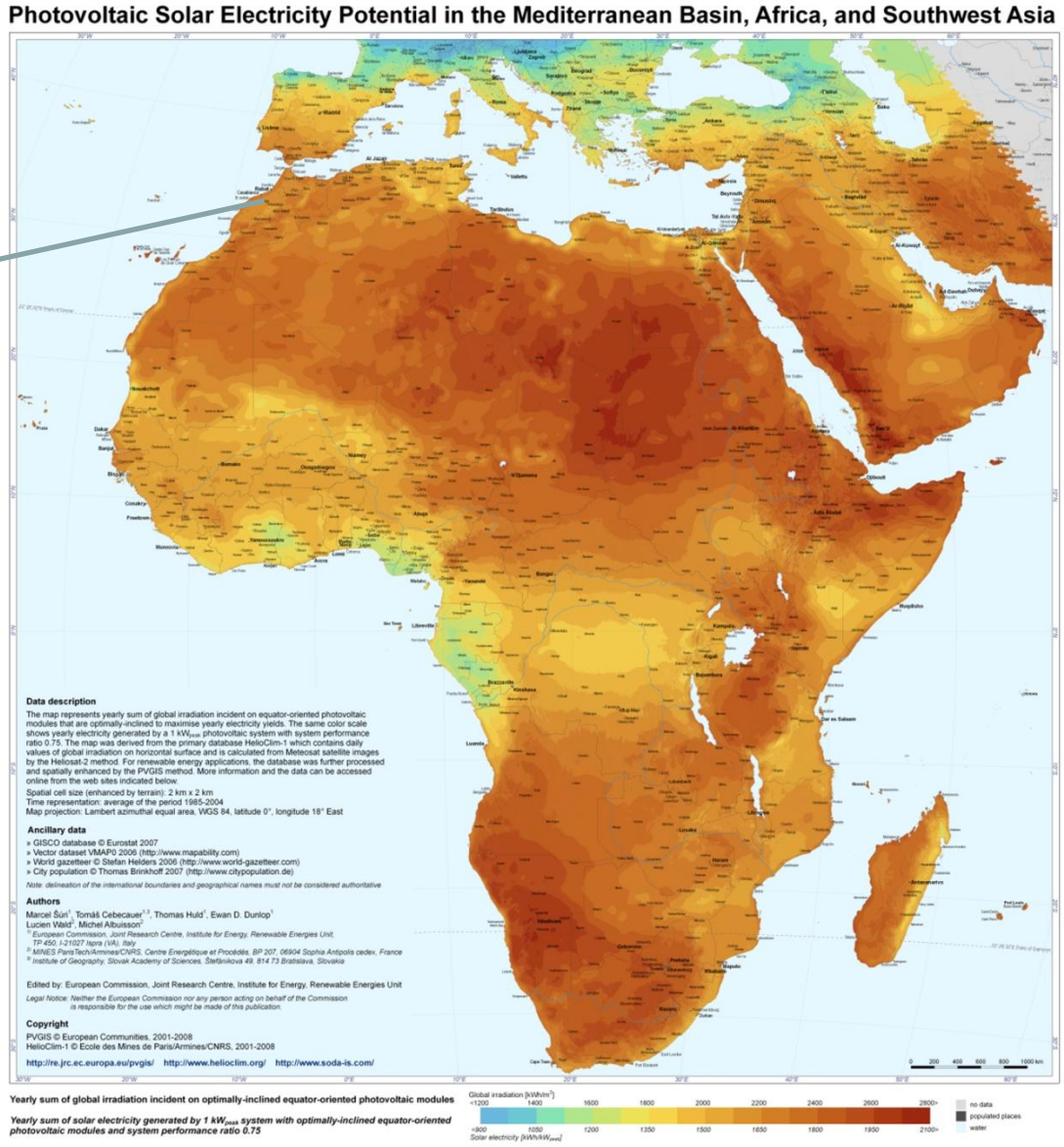
	Rated Pwr	No. of Panels	Pwr/System	No. of Systems	Pwr/Company
PowerShade	1 kW	1	1 kW	2	**2 kW**
GREENS	200 W	8	1.6 kW	3	**4.8 kW**
ZeroBase	240 W	5	1.2 kW	3	**3.6 kW**
NEST	175 W	4	.7 kW	10	**7 kW**
				Total	**17.4 kW**



Selection: March

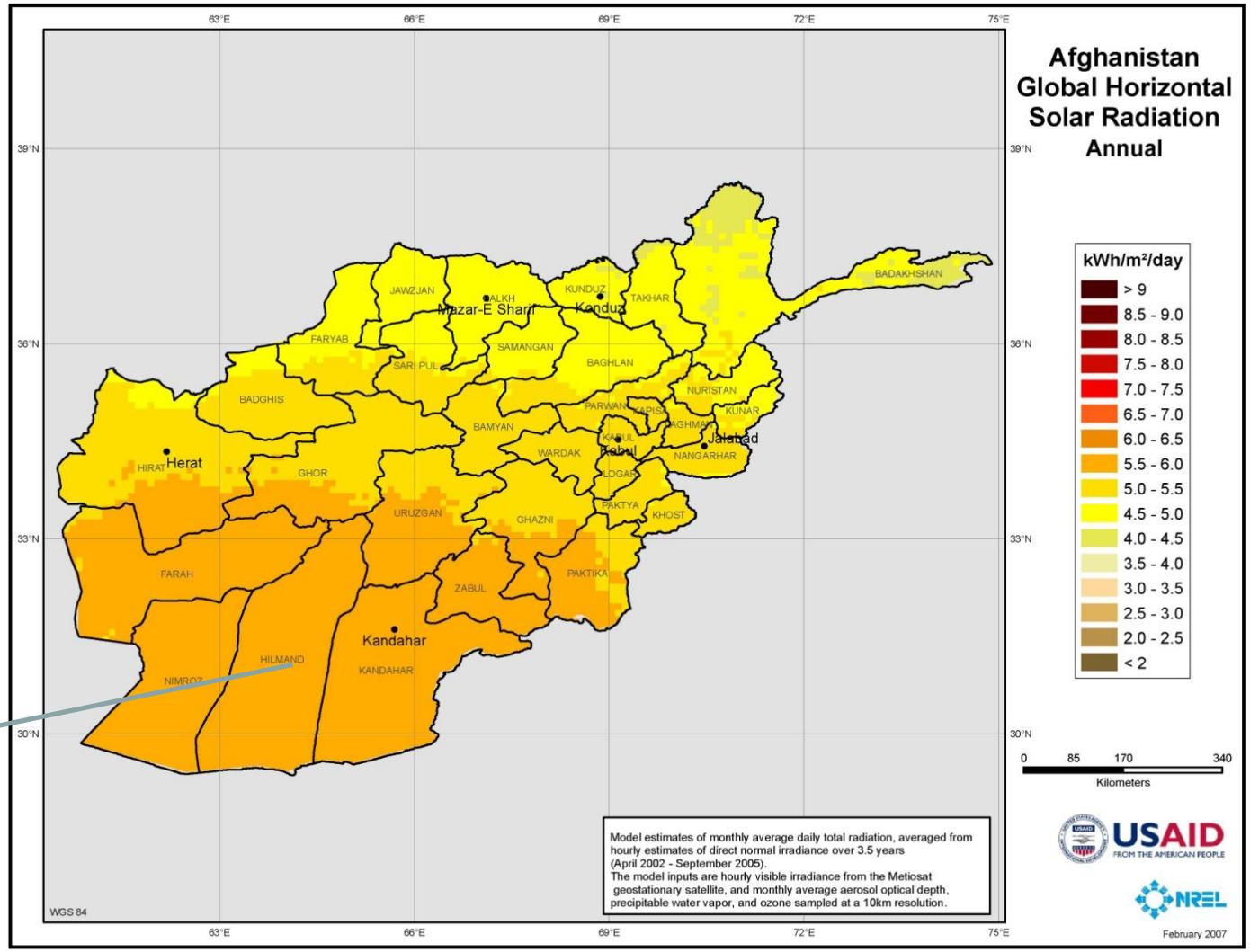
Demonstration: May

Morocco

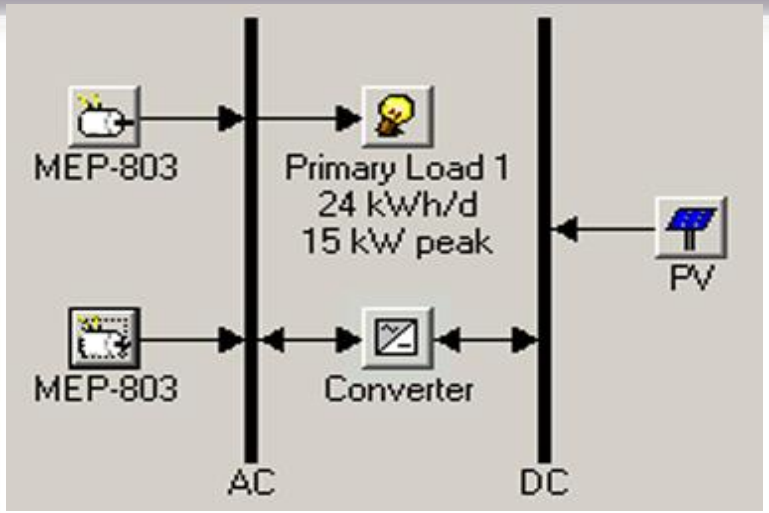


NPS Electrical & Computer Engineering
Monterey, California

Deployment: October



Helmand Province



Combine All 4 Systems

- Slope 0^o
- No Temp Effects
- Inverter Efficiency (90%)

= LOW BOUND

ExFOB Results

	Quantico (kWh)	Morocco (kWh)	Afghanistan (kWh)
PV Combined	**1645**	**2074**	**1984**
Percent of Load	19%	24%	23%

Model Each PV System Separately:

	Slope	Temp Effects	Inverter Efficiency
Solar Shade	0°	N	Default
GREENS	30°	Y	92%
ZeroBase	45°	N	Default
NEST	55°	N	Default

ExFOB Results

	Quantico (kWh)	Morocco (kWh)	Afghanistan (kWh)
PV Combined	**1645**	**2074**	**1984**
Percent of Load	19%	24%	23%
Individual			
Solar Shade	191	223	240
GREENS	671	726	769
ZeroBase	430	449	501
NEST	822	839	940
	2114	**2272**	**2484**
Percent of Load	24%	26%	29%

Why Does It Matter?
23% vs 29% of the Monthly Ld?

Fuel

ExFOB Results

	Afghanistan (kWh)
PV Combined	**1984**
Percent of Load	23%
Individual	
Solar Shade	240
GREENS	769
ZeroBase	501
NEST	940
	2484
Percent of Load	29%

Method	Fuel (L)	
23%	3402	8.2% Increase in Fuel Demand
29%	3145	

-Reduction in fuel demand = reduction in risk of IED

-Critical Information to Logisticians and Cost Estimators

SUMMARY

- HOMER should be utilized as a pre-deployment tool
  - Calibration is the key
- Effective use of HOMER throughout the ExFOB process could have contributed to a more effective evaluation of equipment

Questions?