Expeditionary Power

Intelligent Power Management
for
Off-grid and Remote Locations

Joint Power Expos
3 May 2017

Matt Baker
Director of Energy Programs
mbaker@fairleadint.com
757-287-3216

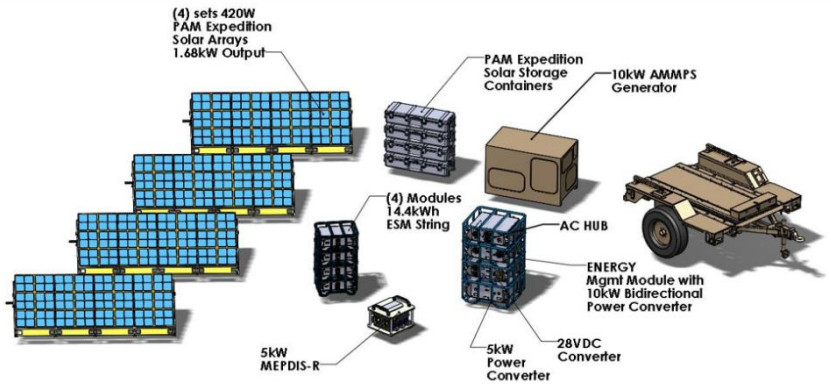
The Requirement

- Army Capstone Concept
  - A number of … technological … advances are expected to influence conditions in the future operational environment. …alternative power and energy solutions … will become more widespread and have a growing impact on effectiveness.
- Army Operating Concept
  - Logistics optimization to improve the … ability to conduct expeditionary maneuver and sustain high tempo operations at the end of extended supply lines [through] advanced and efficient … power … storage and generation from traditional and renewable sources will provide power under austere conditions
- **Army Functional Concept – Sustainment**
  - **Operational energy is the energy required for training, moving, and sustaining military forces and weapons platforms for military operations**
    - **The ability to optimize energy consumption and leverage alternative energy sources increases the endurance and resilience of the joint force while reducing the energy distribution and protection requirements of the sustainment footprint and minimizes the environmental impact while extending operational reach and endurance.**
    - **The future Army institutionalizes operational energy management, improves and expands conservation training programs and power and energy efficiency, and uses energy management plans at all levels.**

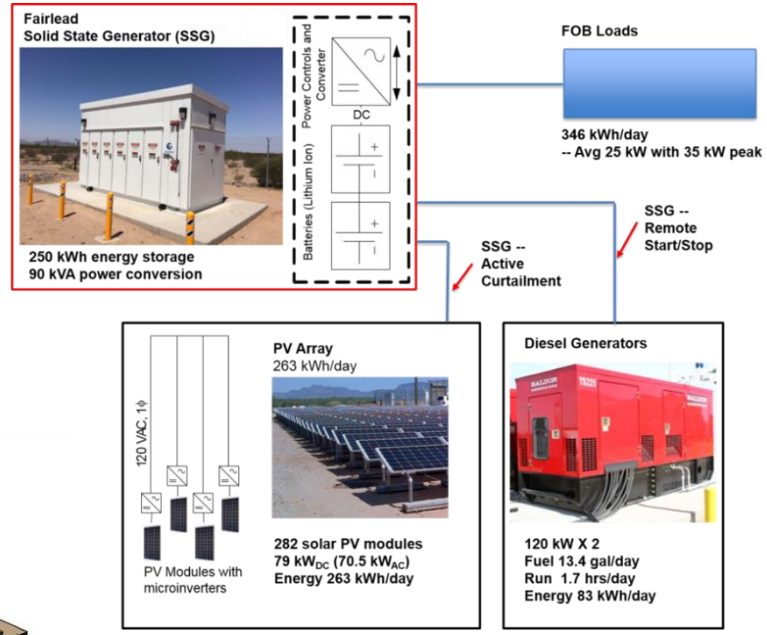
Intelligent Power Mgmt

e Army forces require the capability to produce and manage operational energy through the use of gy efficient, renewable, and intelligent power management technologies in the context of expeditionary base camp operations to prolong endurance and sustain Multi-Domain Battle.

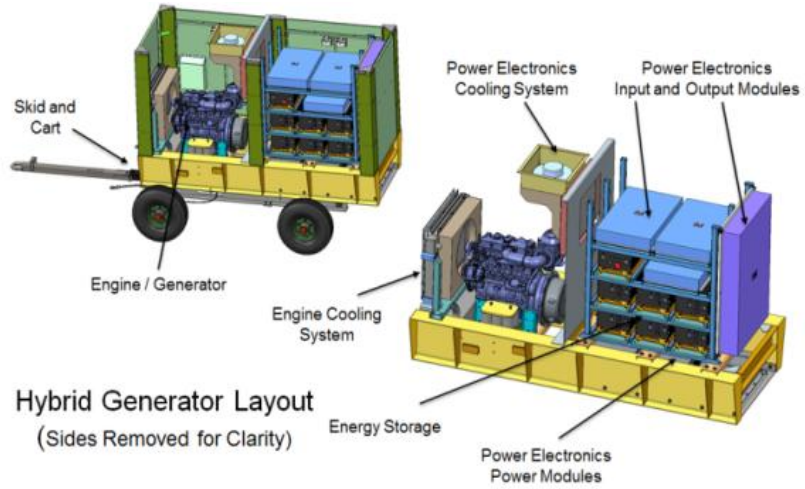
Fairlead (Earl Energy) Energy Projects



MHEES



FOB Power Project



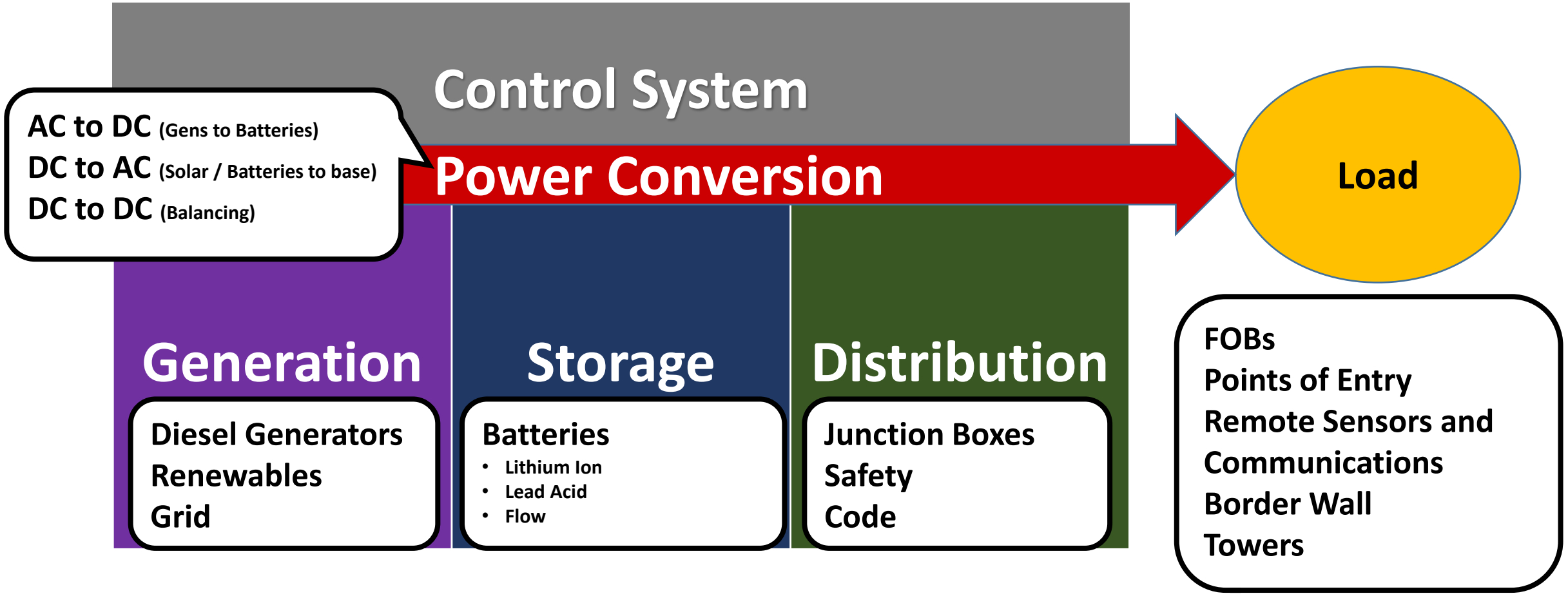
Hybrid Flightline Generator

Agenda

- Requirement
- Intelligent Power Management
- Review of FOB Power Project
- Business Case -- Operating Cost Reduction
- Lessons Learned

Intelligent Power Management

"Allows the efficient and effective production of electric power in remote conditions."



Forward Operating Base (FOB) Project

- Science and Technology / Customs and Border Protection

- MIT Lincoln Labs
  - Prime
  - Project Management
  - Data Collection, Monitoring and System

- Fairlead Integrated (Earl Energy)
  - Controls
  - Power Converter
  - Storage
    - 284 kWh storage (250 usable)

- Geo-Innovations (Remote power for Integrated Fixed Towers)
  - Renewable Generation
    - 78 kW Solar Array

- Border Patrol FME
  - Conventional Power
    - 2 X 160 kW Generators

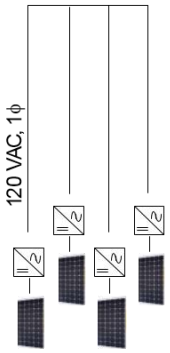
Diesel Generators

- 160 kW X 2
- 67 gal/day continuous opn
- Avg Fuel Used: 13.4 gal/day
- Avg Run time 1.7 hrs/day
- ESCS: Automatic Start/Stop

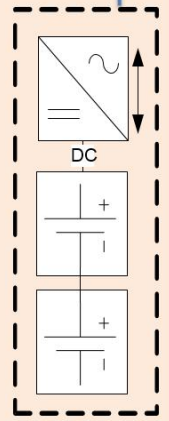
Border Patrol FOB

- Split Phase Site Load
- Avg 25 kW with 45 kW peak

Solar Array



Energy Storage and Controls System (ESCS)



- Controls
- 284 kWh Lithium Ion Battery storage
- 90 kVA power converter

Forward Operating Base (FOB) Project

- In operation since April 2016
- 79% fuel savings (Avg of 13.4 vs 65 gal/day)
  - 120 degree summer days
  - Generator run-time 2-3 hours a day vs 24 hours a day.
- Reduced environmental impact
  - Less noise pollution
  - Less air pollution
  - Reduced wildlife impact

Forward Operating Base (FOB) Project

- **Cost of fuel**
  - **Inexpensive today… Tomorrow?**
- **Reduced operating cost**
  - **Less contracted fuel deliveries / transportation cost**
  - **Less wear on dirt roads (1.5 hour transit through National Park)**
  - **Generator maintenance and service requirements reduced**
  - **Replacement requirement reduced**
- **Safety and Resilience**

= $12 / Gal

DOD Planning Factor

Annual Cost (using $12 / gal planning factor)	
Without FOB Power Project:	$284,700
With FOB Power Project:	$58,692
Savings:	**$226,008**

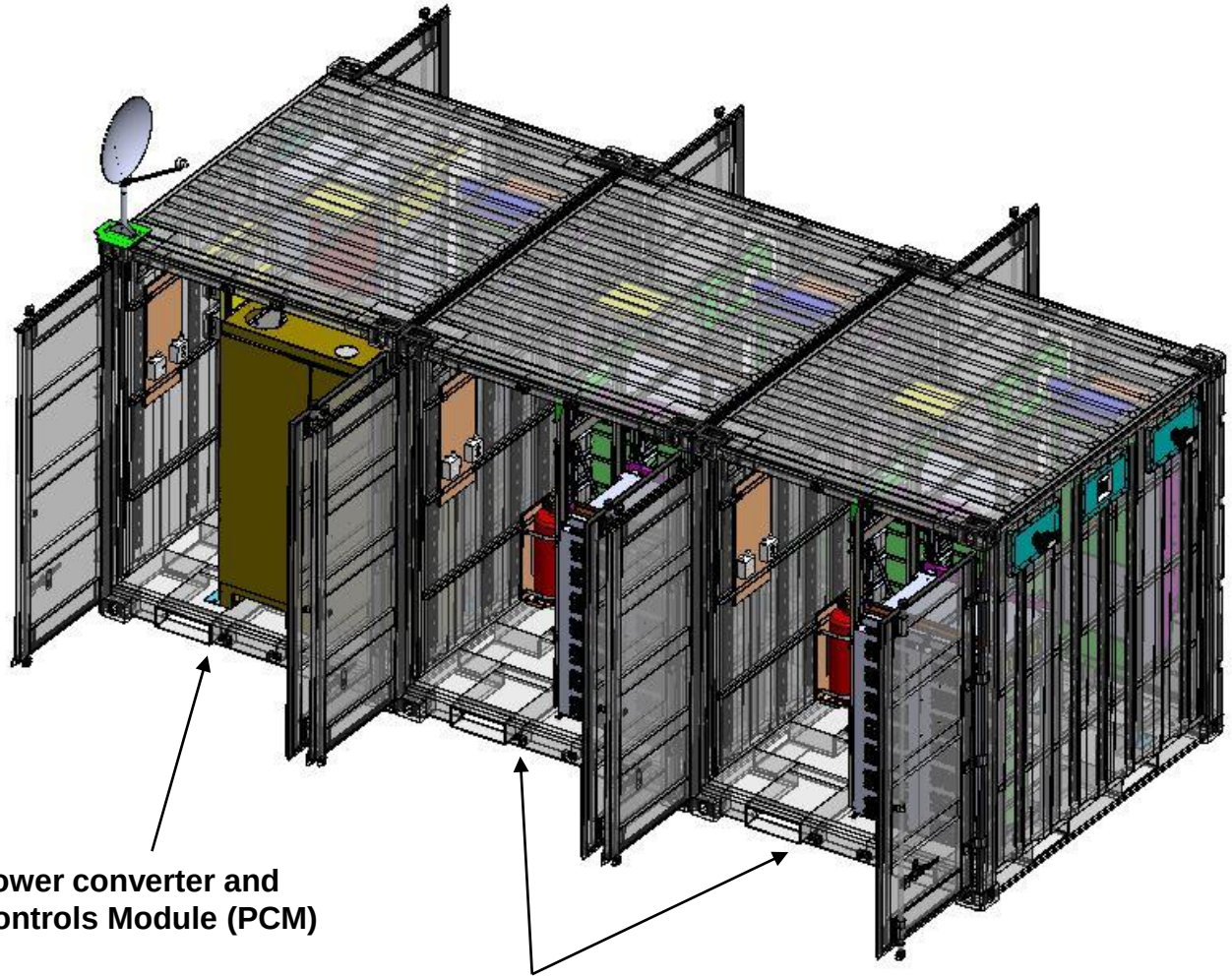
Forward Operating Base (FOB) Project

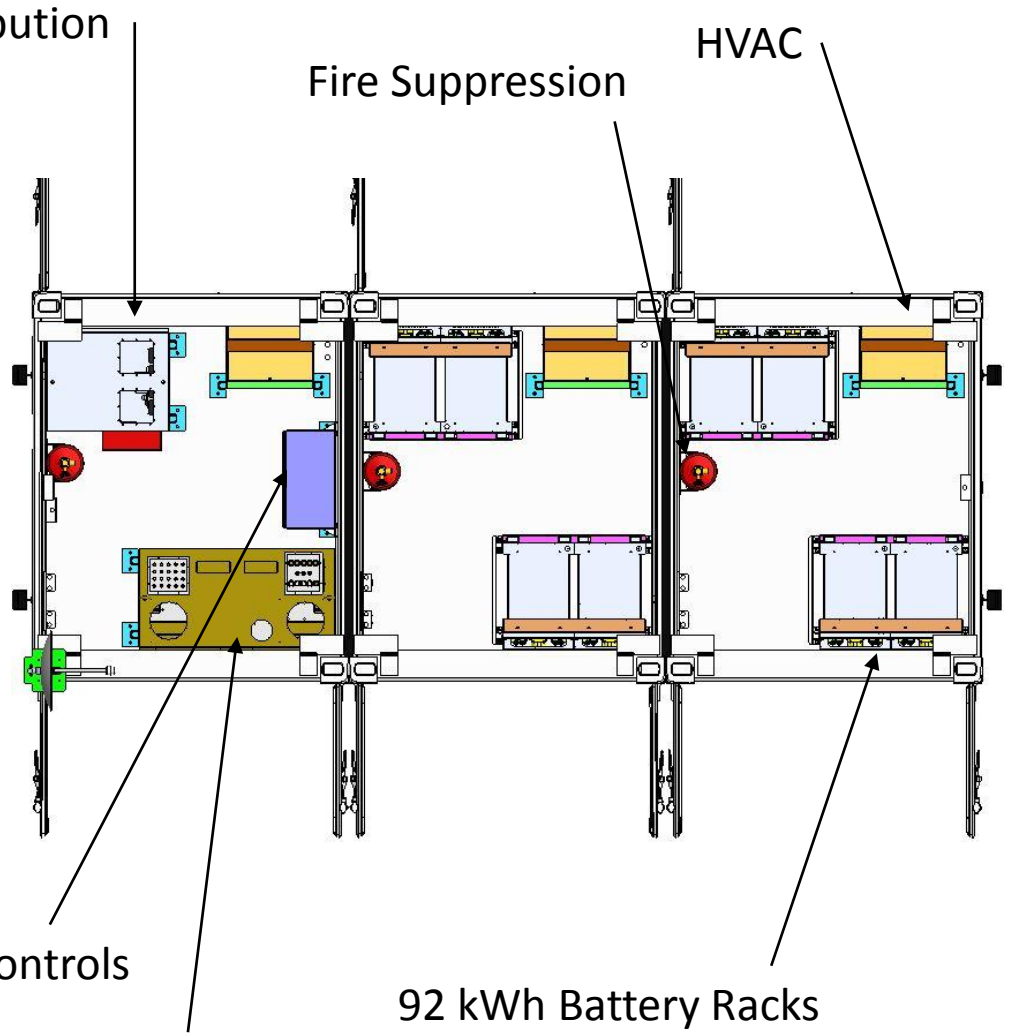
- Lessons Learned
    - Modularization and Scalability
        - Two Module Types
    - Easily Maintained and Upgraded with latest battery and generation tech
        - Constantly evolving and getting cheaper!
    - Simplified HVAC
    - Emphasis on Safety
    - Improved control algorithms
    - Two-way communication
    - Increased Functionality

Going Forward

- Value Proposition
  - Reduce management to two contractors
    - Fairlead as Integrator
    - Geo-Innovations for on-site requirements and solar
  - Utilize existing site generators
  - Service and Maintenance Contract
  - 24-hour monitoring for data and system updates

Energy Storage Power conversion and Controls





Energy Storage Power conversion and Controls

- Module 1 -- Power Converter & Controls Module (PCCM)
  - One required
- Module 2 -- Energy Storage Module (ESM)
  - One to Five depending on application
- New Technologies
  - Flow Battery
  - Advanced Solar Panels and Wind Turbines

Energy Storage Power conversion and Controls

Modularized

- Power Controls Module (PCM)
- Energy Storage Module (ESM)
- Standardized Form Factor
  - Tri-Con (8'L x 6.5'W x 8'H)
  - Forklift, RTCH or crane ready

Scalable

- (1) PCM provides:
  - Integrated control of multiple generators, solar array and grid power with battery storage
  - 150 kW Power Converter
  - 50/60 Hz, 110/240v AC, split or three phase power output (480v with 2nd PCM); 4-wire
  - 10 kW to 90 kW average continuous load (135 kW peak)
  - 50 hz and 60 hz power
- (1 - 5) ESMs based on site requirement
  - 166 kWh (usable) per ESM
  - 830 kWh (usable) maximum

Ruggedized

- ISO, OSHA and Transportation Certified
- Self-contained modules with climate control and fire suppression
- Transportable by truck -- as individual modules or as a 20-foot container (three modules bolted together)
- Minimal site preparation

Integrated Communication

- 2-way satellite internet for remote monitoring, updates and diagnostics
- DOES NOT "touch" onsite LAN / Cyber Secure / Tactical Microgrid Standards Consortium Compliant

Simplified Operation

- Fully Automated
- Touchscreen control panel, hardwired to system, provides system status
- One button trouble call
- Remote diagnostics

Planning Tool (FOB Ajo as Example)

User Variables	
Average Site Load (kW)	
Hours Per Day of Gen Power	**2**
Fuel Consumption (Gal/Day)	**67**
Real Fuel Cost	**12**
Sun light multiple	**120%**
50 HZ or 60 HZ	
System Dependent Values	
Battery Usable Percentage	90%
Solar Panel Efficiency	72%
Two Axis efficiency	5%
Max Load Spike	35 kW
Power Converter Size	130
Power Converter Efficiency	94%
Generator Charge rate offset	90%
Battery Storage Rack Size	92
Generator Efficiency	**92%**
HVAC Draw kWh	

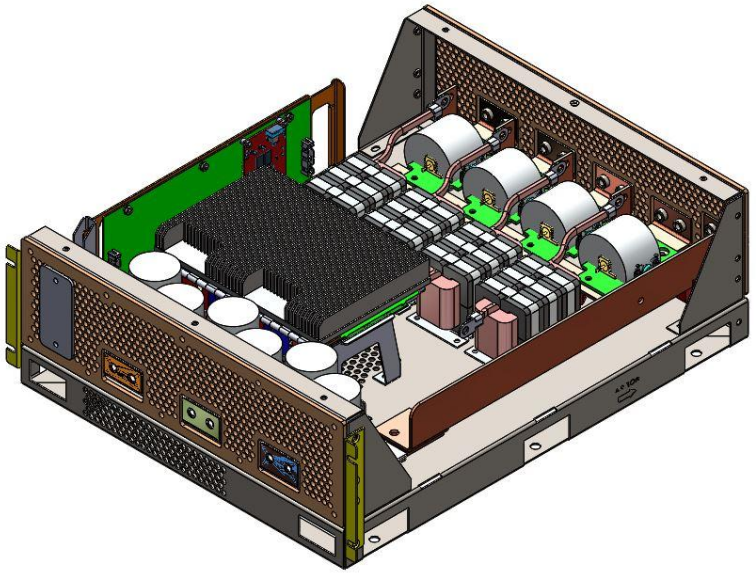
Location Dependent Variables
Peak Sun Flat Plane array at latitude angle

SIZING Estimate					
Energy Storage Requirement	174	227	240	184	**240**
Battery Capacity Required	194	253	267	205	**267**
Solar PV Power Required	75	83	84	81	**84**
Generator Size	164	158	154	151	**164**

COST Estimate				
Solid Watt System		**Total Storage**	**276 kWh**	**$461,475.92**
2	Energy Storage Modules	3	Battery Strings	
1	Power Converter Modul	$225,308.26		
Generator				**$36,000.00**
Solar Array (Note: Assumes flat panel array at latitude angle, integrated shade structure or tracking systems				**$376,838.24**
Site Prep, Power Distribution				
Total Cost				**$874,314.15**

RATE OF RETURN	
Fuel Savings Percentage (hrs run / 24 *100)	92%
Fuel Saved per day	61.4
Dollars Saved Per Year using "Real Fuel Cost"	$244,550.00
ROI in years (Includes extra gen set)	**3.12**

Smart Power Converter / IPM - ESU



IPM-ESU						
Component	Number	Unit Wt (lbs)	Total Wt (lbs)	Dimension (in)	Unit Cube (ft^3)	Total Cube (ft^3)
Power converter and Controls Pack (PCP)	2	60	120	20 X 16 X 7	1.29	2.58
Heat Sinks and Container	2	50	100		1	2
Energy Storage (Samsung Mega E2)	8	115.5	924	15 X 24 X 7	1.5	12
Controls Panel	1	5	5	10 X 8 X 2	0.1	0.1
Container Modifications	1	100	100	25 X 40 X 1.25	0.75	0.75
Total			1249			17.43
60 kW AMMPS			4063	82 X 36 X53		90.5
Excess Capacity			**2814**			**73.07**

Questions?