

# ***Brief to Industry***

## ***Mobile Electric Hybrid Power Sources***

### ***(MEHPS)***



**31 Jan 13**

**Expeditionary Energy Office (E<sup>2</sup>O)**

**E2O website: [www.hqmc.marines.mil/e2o](http://www.hqmc.marines.mil/e2o)**

**Video link: [www.dvidshub.net/video/280493](http://www.dvidshub.net/video/280493)**

Unclassified / Pre-Decisional



# Agenda

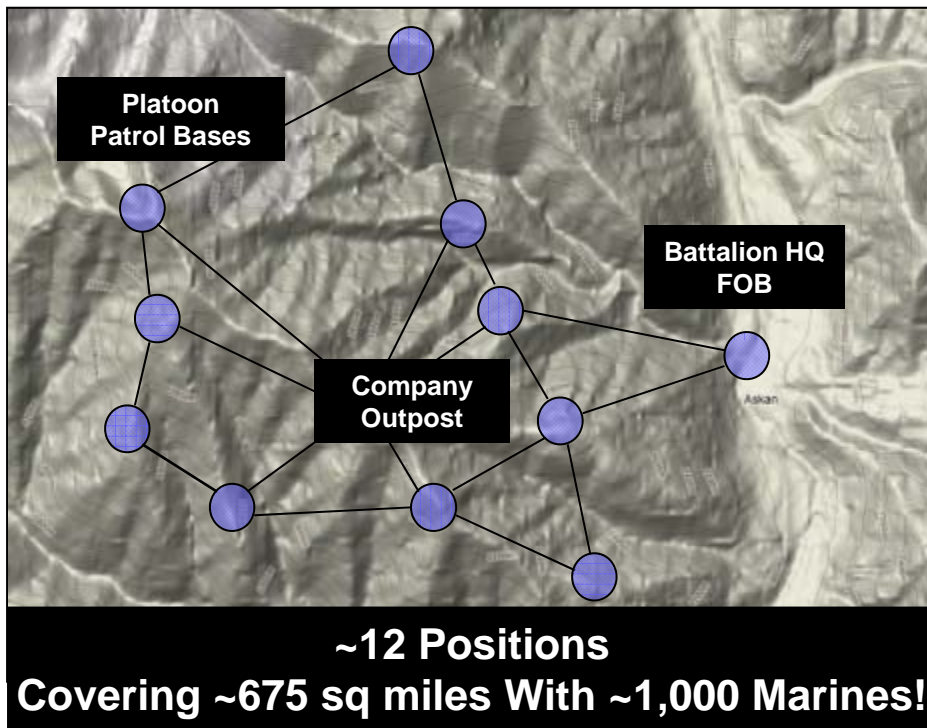
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- Admin Remarks
- MEHPS AoA
  - MEHPS Lightweight
  - MEHPS Medium
  - MEHPS Micro-Grid Medium
  - MEHPS Micro-Grid Heavy
- Break (20 min)
- Q&A (30 min)

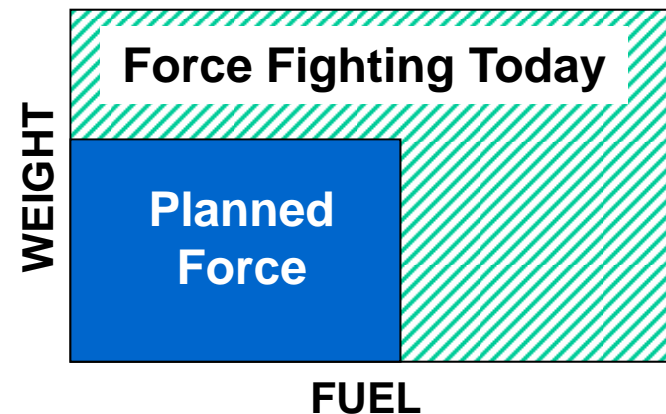


# Distributed Operations Enabled by Technology...



## USMC Battalion since 2001

- 250% Increase in Radios
- 300% Increase in IT/Computers
- 200% Increase in # of Vehicles
- 75% Increase in Vehicle Weight
- 30% Decrease in Miles Per Gallon



**More Lethal...Increased Logistics Risk  
“No Free Lunch”**

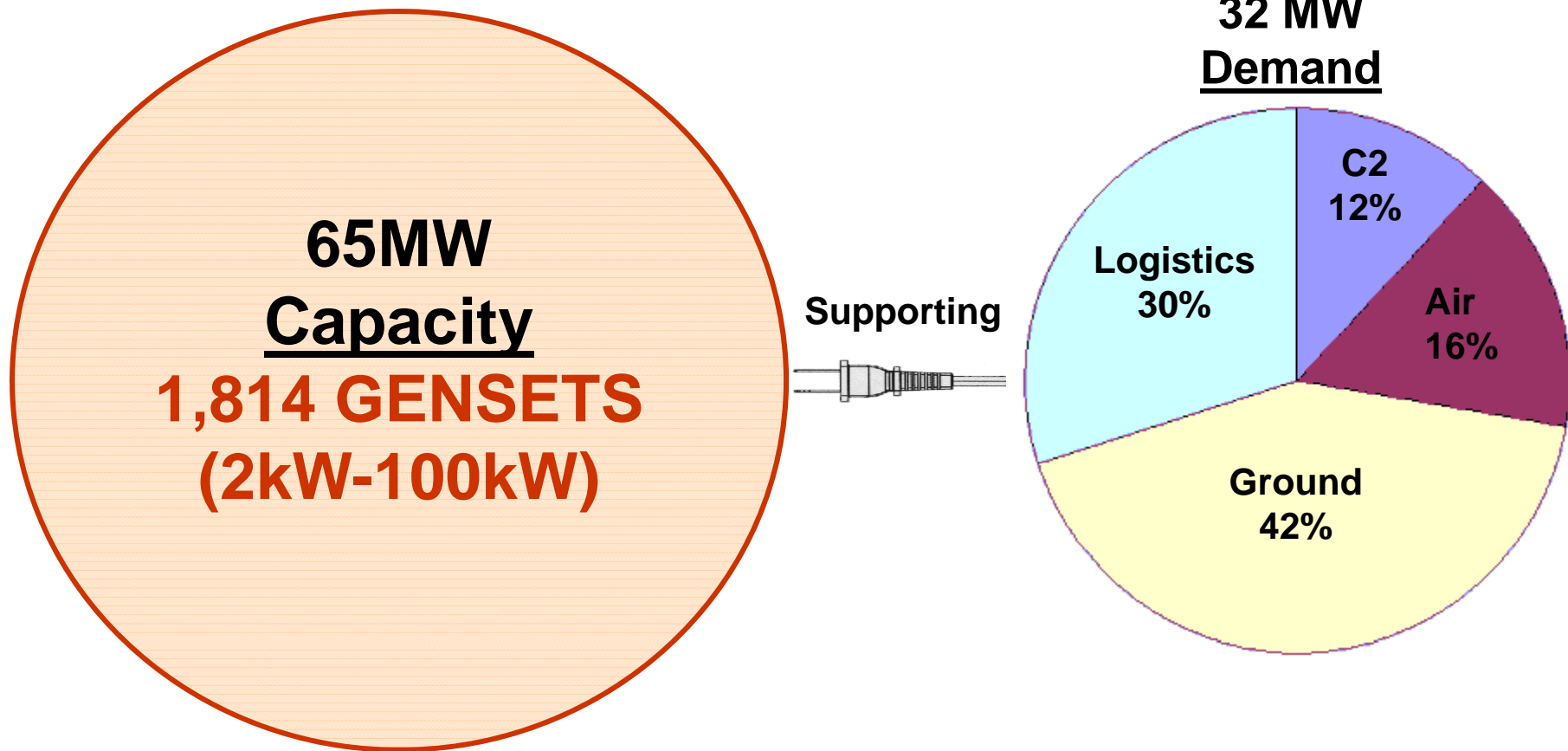


# ...Today's Solution..

(More Generators)



- I-MEF (FWD) Approved Capacity Requirement Exceeds Demand by more than 2X:





# ...Causes...Efficiency and Maintenance Issues



**Problem 1: Inefficient Use (Multiple large generators at FOBs, all operating inefficiently)**



10% load

**Problem 2: Increased Maintenance Demands at Tactical Edge with Limited Support**



Unclassified / Pre-Decisional



# Ultimate Cost



## Logistics Causalities Study, 24 Mar '10 - 30 Jun '10\*

- 299 Fuel/Water Convoys (98 Days)
- **6 Marines WIA** hauling Fuel/Water
- **1 Marine WIA** per 50 Fuel/Water Convoys
- **1 IED Incident** per 17 Fuel/Water Convoys



*\*Note: Numbers are USMC only; contractors, other Services not included.*

# *The Experimental Forward Operating Base (ExFOB)*

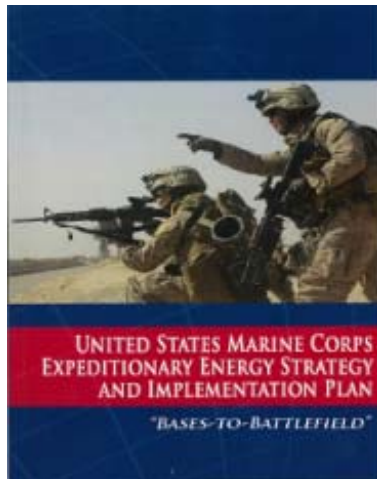




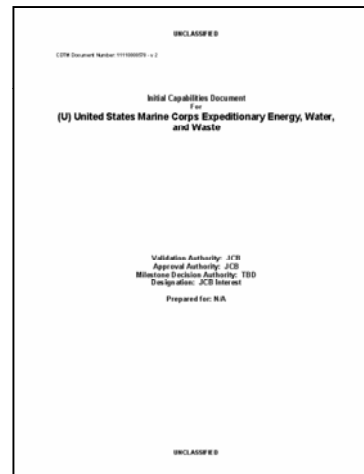
# ExFOB Mission



**Identify, evaluate, and accelerate** the Marine Corps' ability to **increase energy efficiency**, as stated in the **USMC Expeditionary Energy Strategy and Implementation Plan**.



**Expeditionary Energy Strategy**



**Expeditionary Energy, Water, and Waste ICD (152 Gaps)**



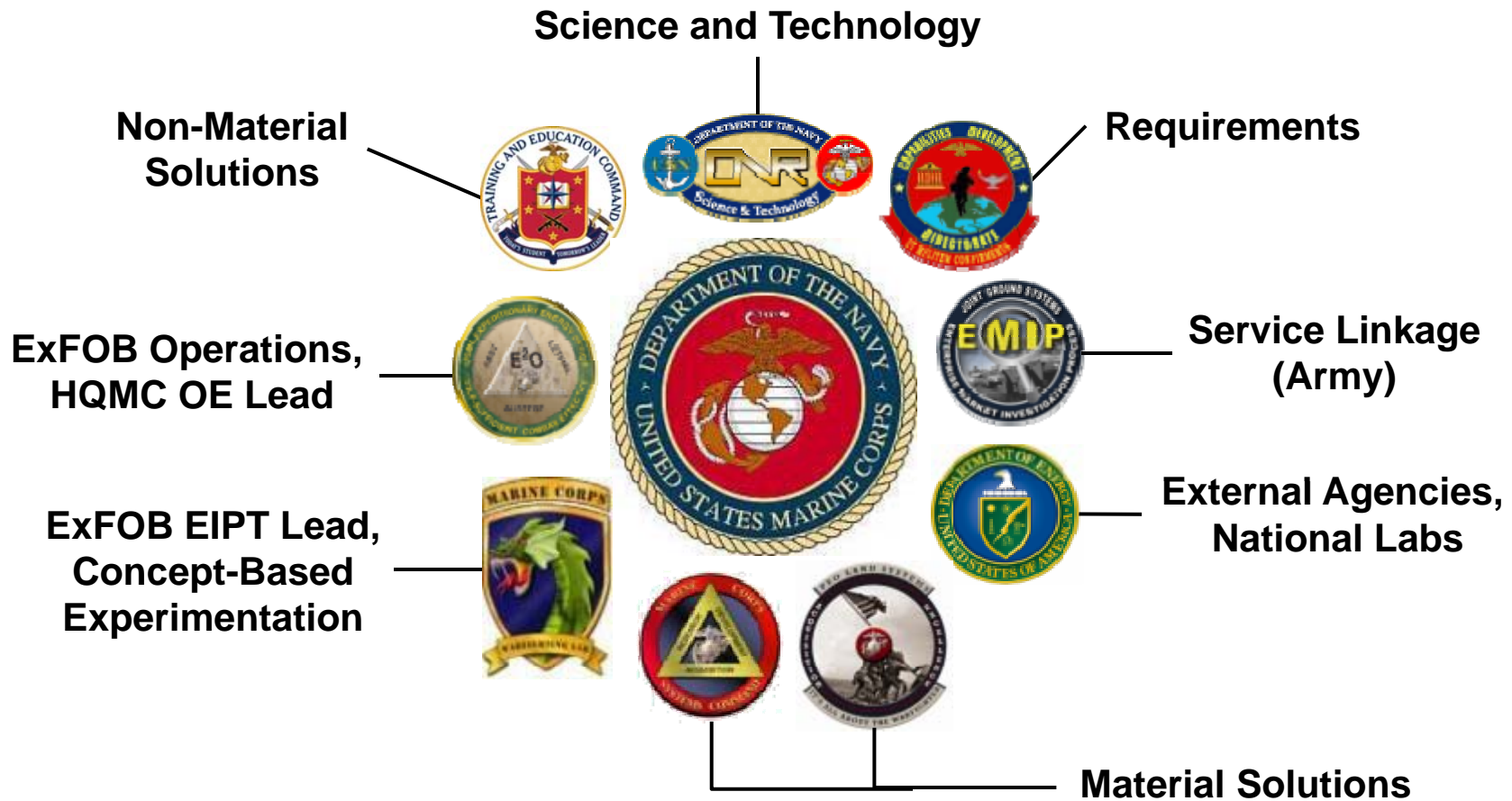
**USMC S&T Strategic Plan**

**Inform Requirements / Mitigate Investment Risk / Build Confidence in New Technology**





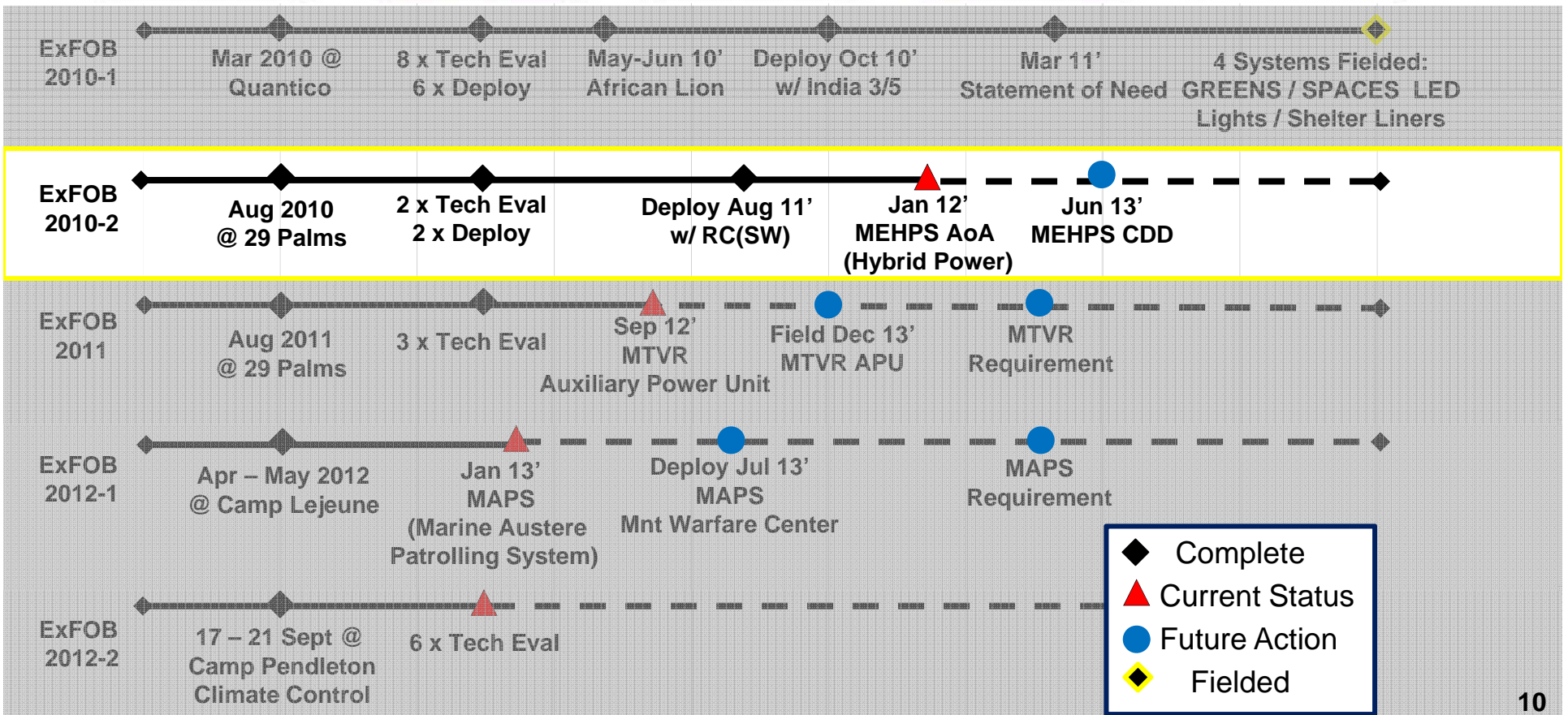
# ExFOB Team – Leading Change



**Multi-Functional Stakeholder Team Focused on the Mission**



# Concepts-to-Military Capabilities





# ExFOB 2010-2: First Look at Hybrid Power



- ExFOB demo at MCAGCC Twentynine Palms, CA (Aug 2010)
- Deployed RC-Southwest (Aug 2011)
  - Location: PB Boldak, Afghanistan
  - Results: Loads >6kW
    - 52% Reduction in fuel required
    - 80% Reduction in GENSET run time
- Way Ahead
  - Analysis of Alternatives (AoA)



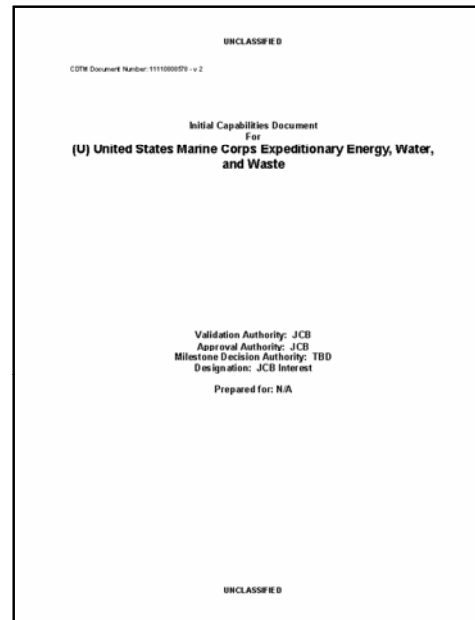
Great Results...However....System is too big and too heavy!

# ***Mobile Electric Hybrid Power Sources (MEHPS) AoA***





# Initial Capabilities Document (ICD)

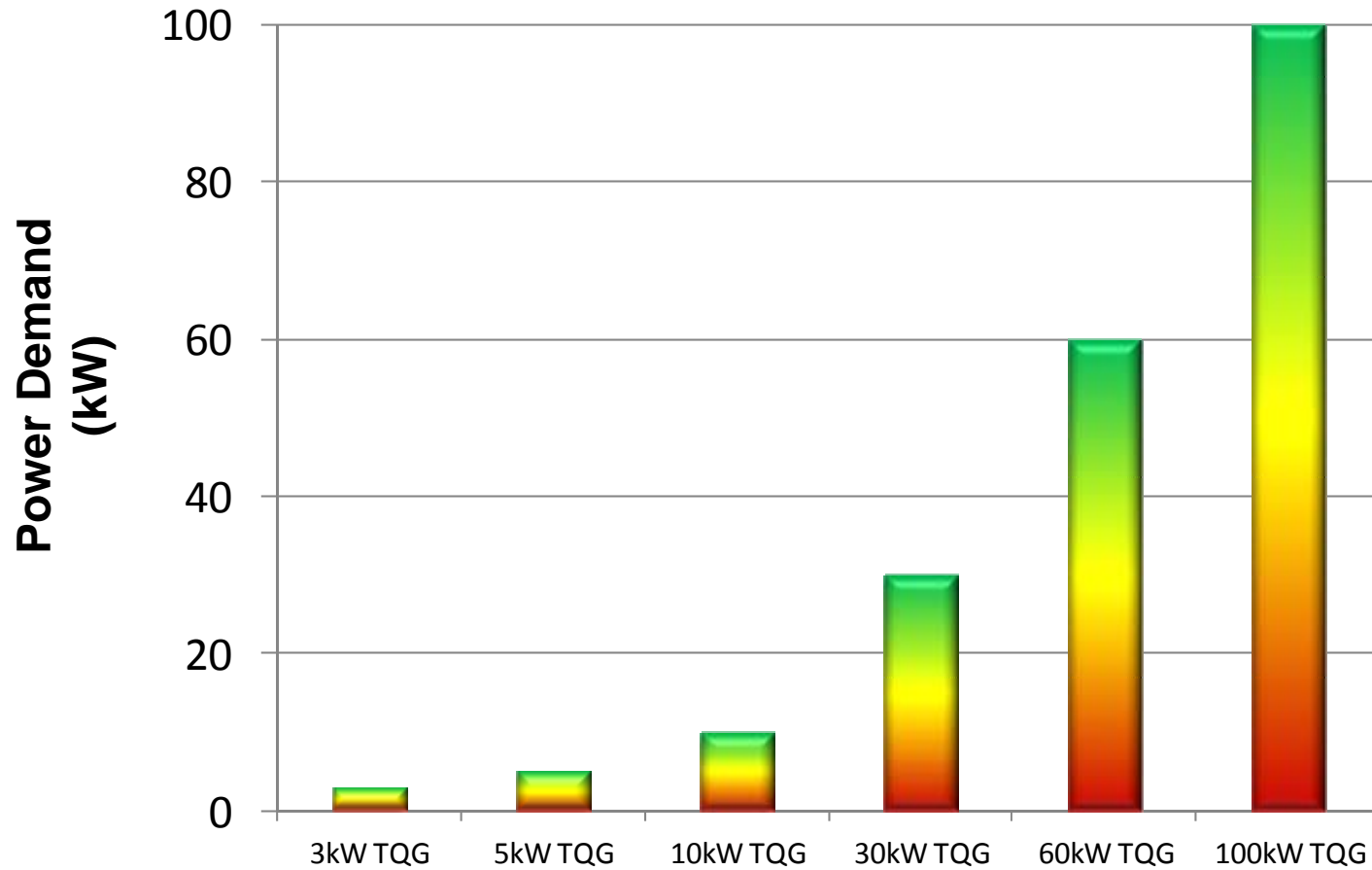


## **Expeditionary Energy, Water, and Waste ICD 5 of 152 Gaps Addressed by MEHPS)**

- Lack of existing capability to automatically match load to demand (3.LC.1)
- Lack existing capability to autonomously and automatically match power production to consumption (6.LC.1)
- Lack existing capability to efficiently integrate multiple energy sources (6.LC.2)
- Lack of common and/or renewable power source (14.LC.1)
- No scalable expeditionary energy storage capability (22.LC.1)

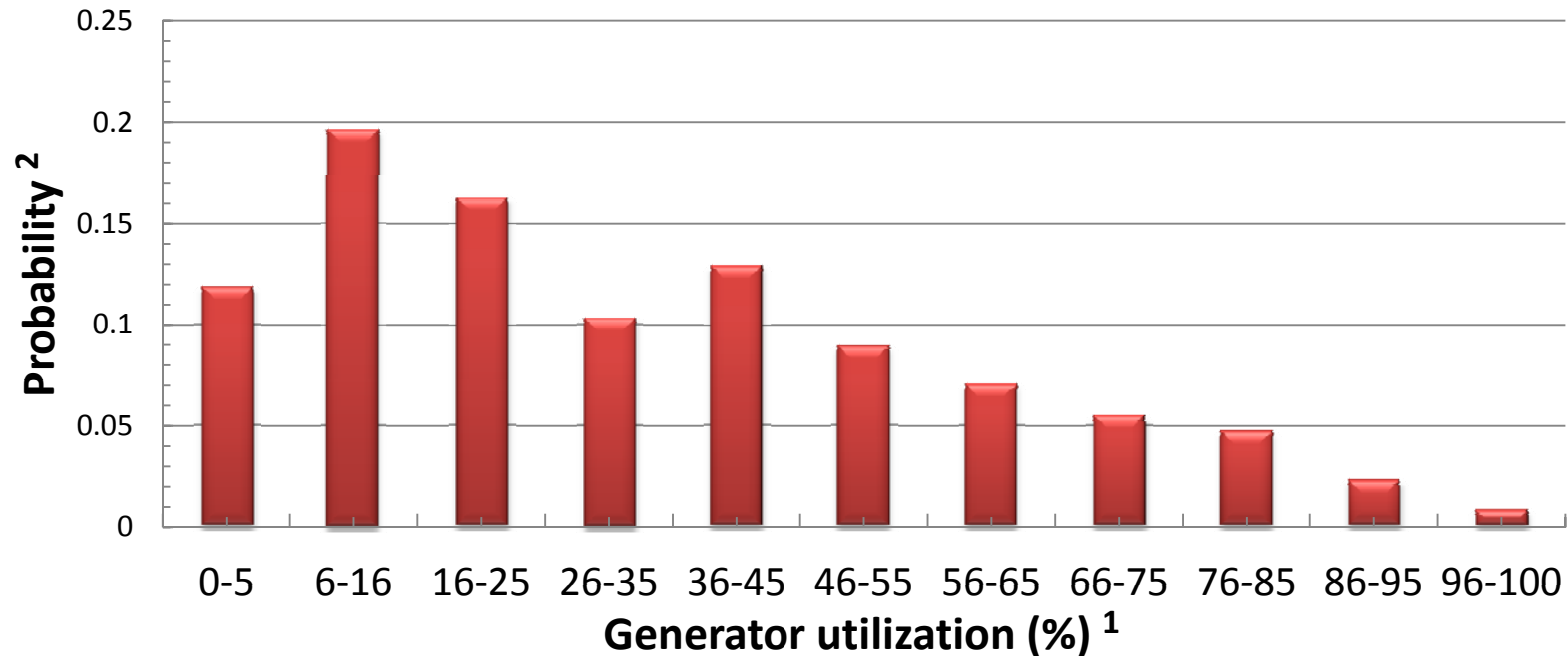


# Actual Employment of Generators





# Why Hybrids are the Solution— Probability Profiles



**Expeditionary variability =  
Generators operate at sub-optimal loads the majority of the time**

**Notes:**

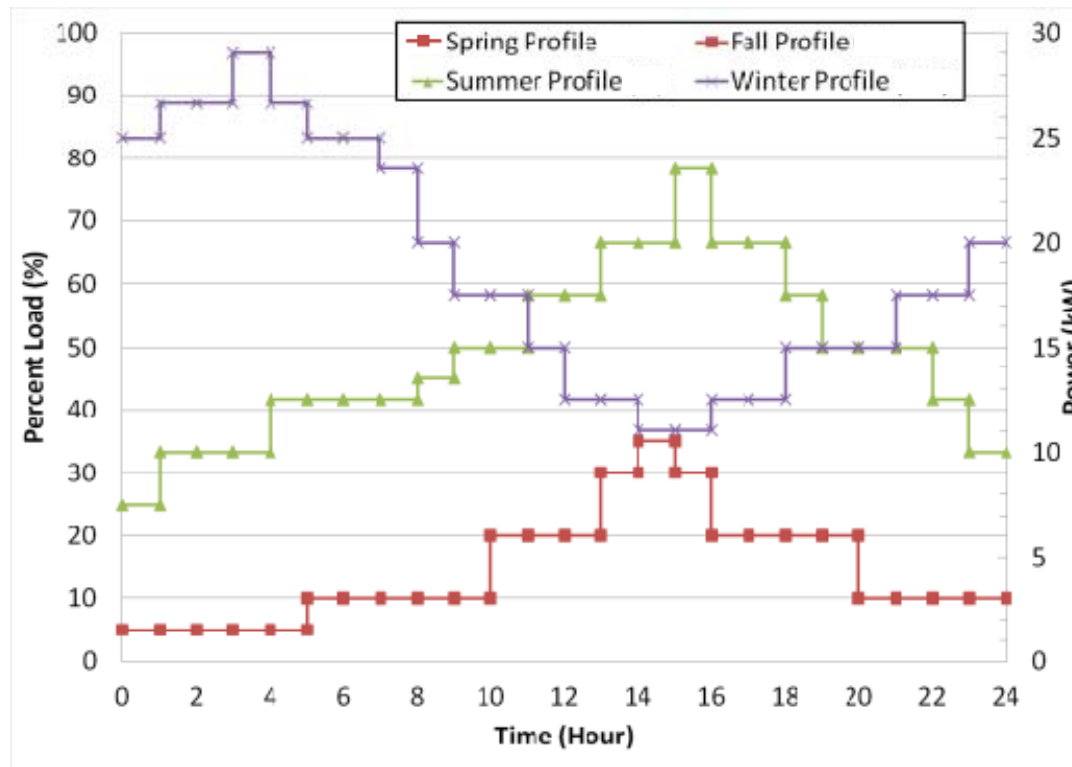
<sup>1</sup> Loads from real world historical data (767 data points)

- Includes: 10, 30, 60, 100 kW Tactical Quiet Generators (TQGs)

<sup>2</sup> Likelihood a given generator will meet a % load during a notional operating year



# 30kW Peak Power



- 6 distinct seasonal load profiles created based on the following peak power demands:
  - 10, 30, 60, 100, 250, 800 kW





# AoA Background

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- Mission Duration – 120 days
- Predict Performance Anywhere We Might Deploy:
  - Vary locations, seasonal loads, and PV solar resource
- Modeling
  - HOMER Micropower Optimization Tool
- All Results are an Aggregate of Location/ Season
  - Afghanistan (April – July)
  - North Korea (Jan – April)



# AoA Measures of Effectiveness



<b><i>Specific Fuel Consumption</i></b>	Training
Renewable Impact	Manpower Burden
<b><i>Mission Weight</i></b>	Transportability
Variable Output	Supportability
Load Priority and Shedding	Scalability
Vehicle Input	Modularity
Multiple Generator Connections	Noise
Local Grid Power	<b><i>Employed Footprint</i></b>
Renewable Input	



# ***MEHPS AoA Preliminary Results*** ***(Draft AoA in Routing)***

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- No POR Solutions to Close E2W2 ICD GAPS
- No COTS Solutions to Close E2W2 ICD GAPS
- Optimizing solutions for Load Profiles is a balance between Power Controls, Battery Storage, and Renewables (Where Applicable)
- MEHPS will increase MAGTF energy performance, lighten the load, reduce the need for multiple GENSETS, and provide a reasonable breakeven.

**5 of the top 152 ICD Gaps can be addressed with hybrid power systems**

# ***MEHPS***

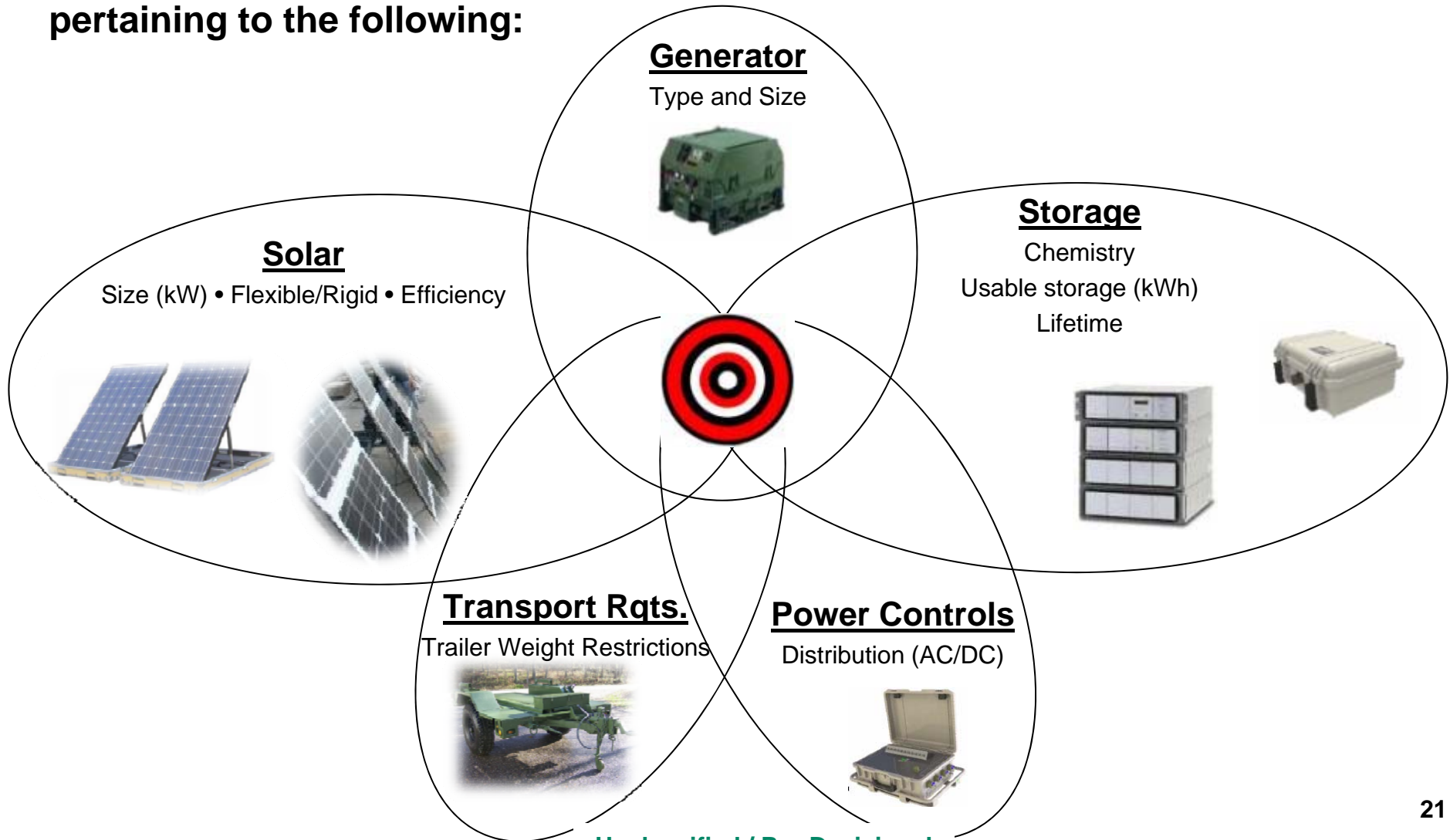
## ***Sensitivity Analysis***





# Sensitivity Analysis

**Goal:** Model subcomponents to identify “knee in the curve” for details pertaining to the following:



Unclassified / Pre-Decisional



# MEHPS Family of Systems



Attributes	Peak Power	Attributes	Transport Requirements*
<b>MEHPS</b>			
<b>MEHPS Lightweight</b>	3 kW	-Auto-Control of Single Generator <b>-Energy Storage</b> <b>-PV Solar</b>	Four Man Lift
<b>MEHPS Medium</b>	10 kW	-Auto-Control of Single Generator <b>-Energy Storage</b> <b>-PV Solar</b>	All Components on a Light Tactical Trailer (LTT)
<b>MEHPS Micro-Grid Medium</b>	60 kW	-Auto-Control of Multiple Generators <b>-Energy Storage</b>	Controls and Energy Storage on LTT (GENs Not Included)
<b>MEPHS Micro-Grid Heavy</b>	300 kW	-Auto-Control of Multiple Generators	Forklift (GENs Not Included)

\*Refer to MIL-STD-1472G, available here: [http://www.everyspec.com/MIL-STD/MIL-STD-1400-1499/MIL-STD-1472G\\_39997/](http://www.everyspec.com/MIL-STD/MIL-STD-1400-1499/MIL-STD-1472G_39997/), for definitions of Four Man Lift, Light Tactical Trailer.

# ***MEHPS Lightweight***





# MEHPS Lightweight

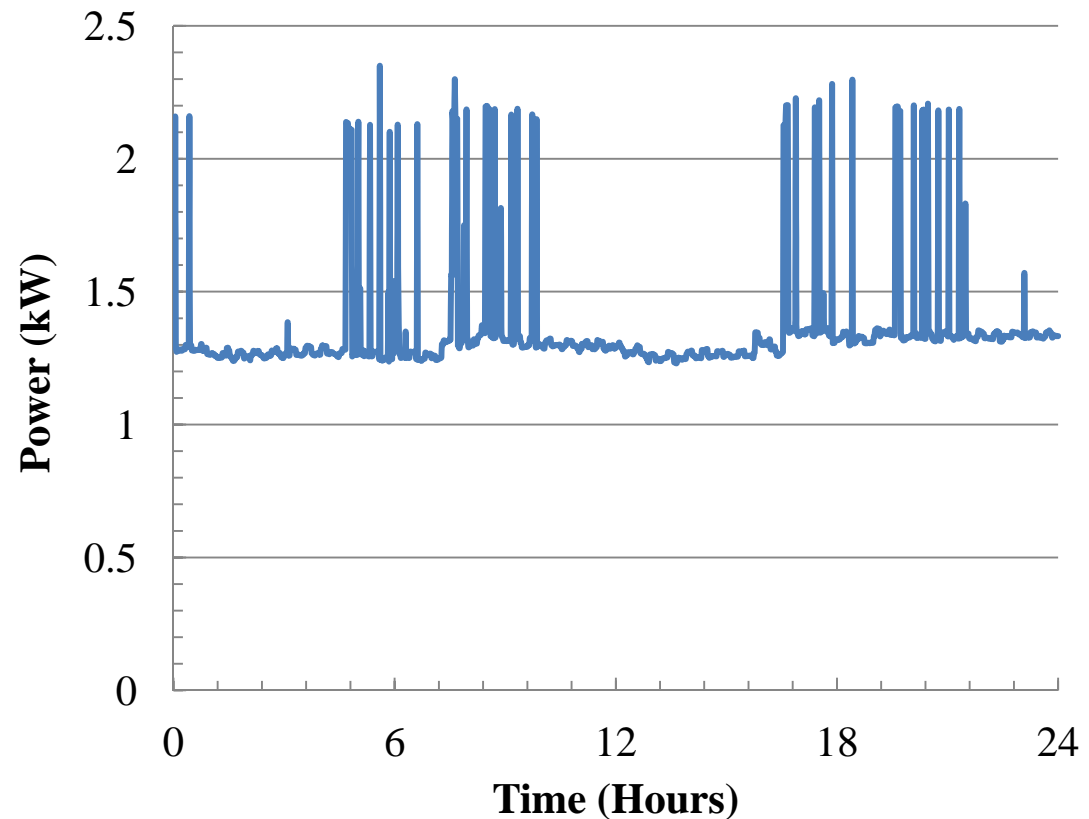


## Attributes Considered

- Generator
  - Type and Size
- Storage
  - Chemistry
  - Usable storage (kWh)
  - Lifetime
- PV Solar
  - Size (kW)
  - Flexible/Rigid
  - Efficiency

## Attributes Not Considered

- Power Controls
  - Distribution (AC/DC)
- Transport
  - Trailer Weight Restrictions



- **Average 1.3kW**
- **Max Peak 2.4kW**





# MEHPS Lightweight - Sample Equipment Powered



Battery Chargers



VOIP/SVOIP



Tactical Hand-held Radios /  
VRC-110 Amplifier



Coffee Pot



AN/PRC-117

GBOSS Heavy w/Suite



- Max Peak 2.4kW
- Steady State 1.3kW

Laptops



Expeditionary Lighting



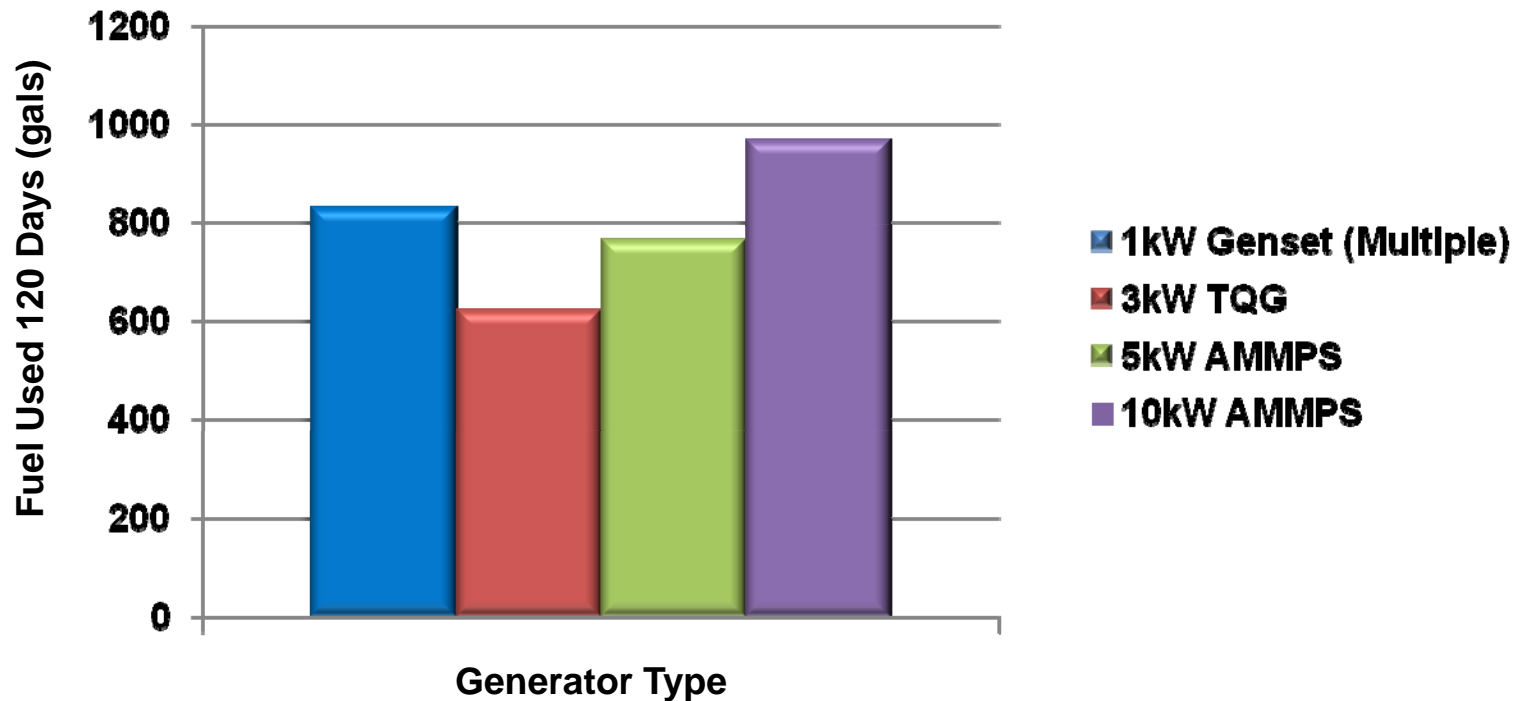
No ECUs



# MEHPS Lightweight - Powered by POR Equipment



### Fuel vs POR Gensets



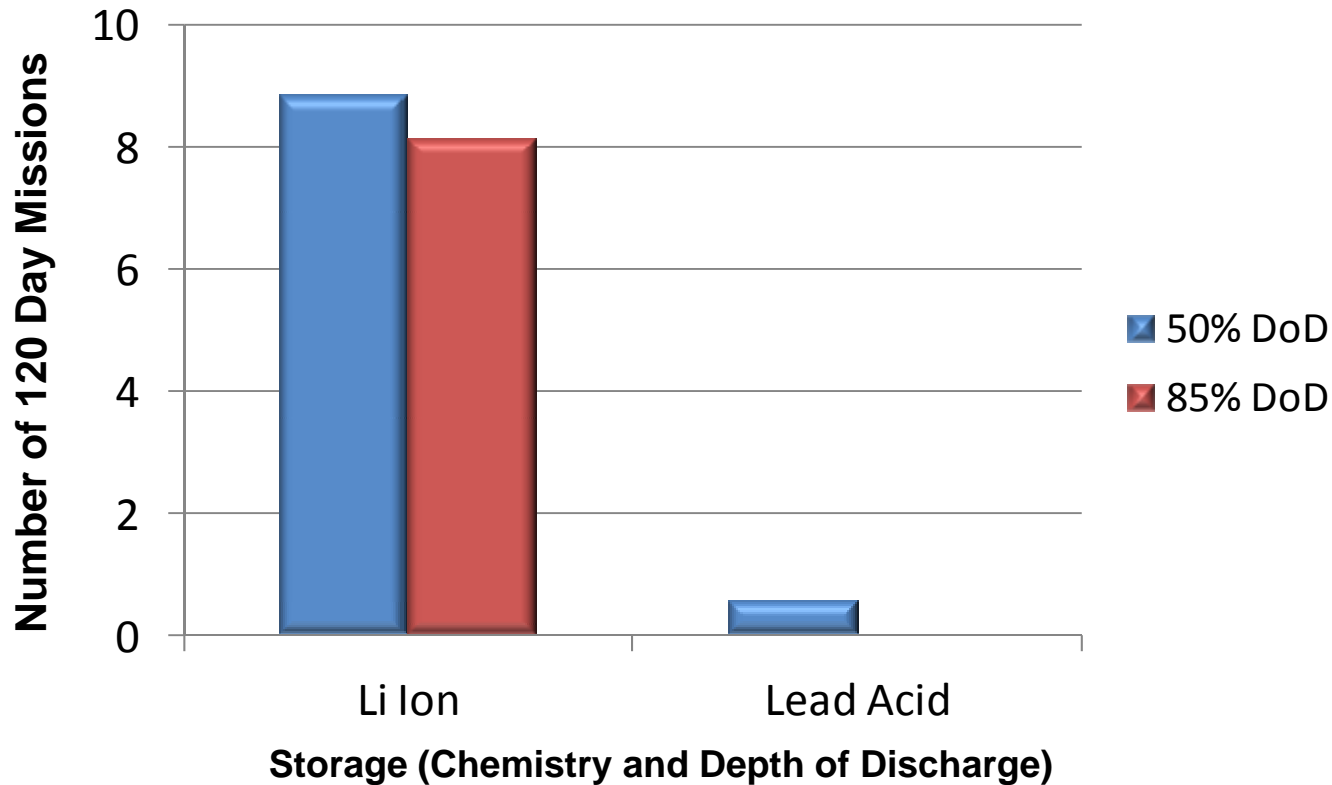
**3kW TQG uses the least fuel for a 120 Day Platoon profile**



# MEHPS Lightweight - Impacts of Battery Chemistry



### Lifetime vs Depth of Discharge (DoD)



Using 2.64kW Solar Array with Aggregated Solar Resources Available



# MEHPS Lightweight – Current State of PV Solar

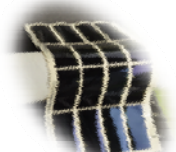
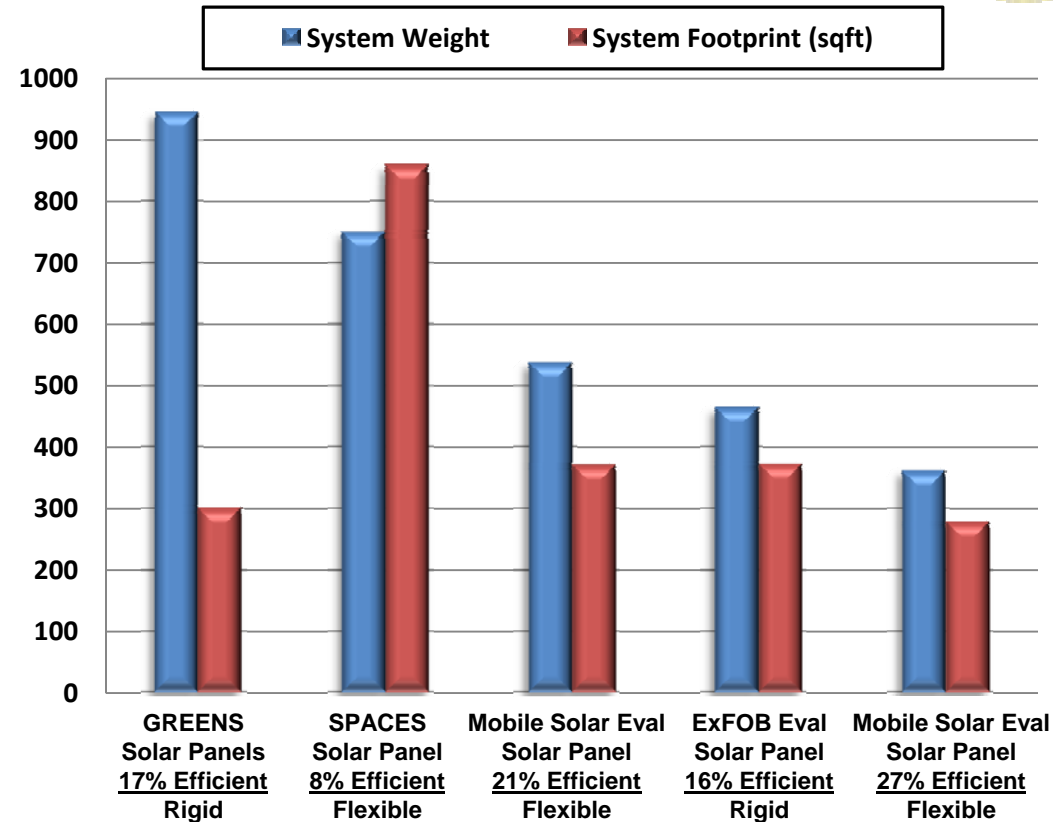


- PV Solar Drivers

- Efficiency
- Total Weight
- Total Size

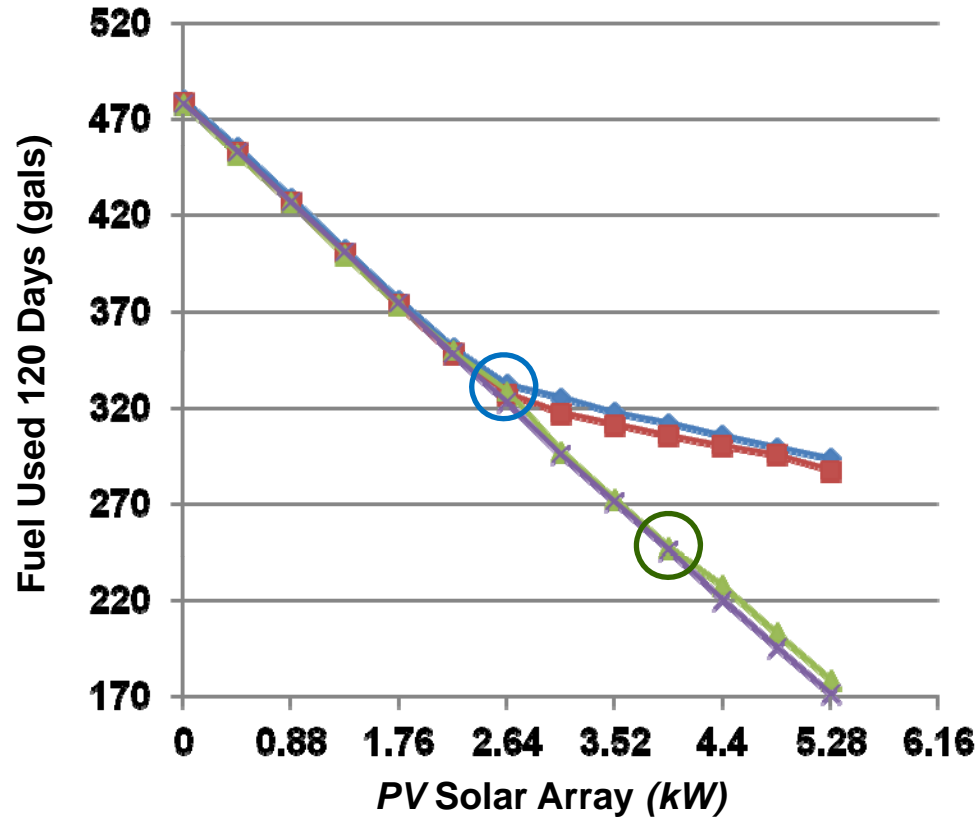
- USMC Way Ahead

- Improved Solar Panels
- RFP Open on fbo.gov thru 6 Feb '13





# MEHPS Lightweight - Compared to 3kW TQG



## # Batteries Silent Watch

- 4 3hrs
- 8 6hrs
- 10 8hrs
- 13 10hrs



### 3kW TQG (Non MEHPS):

- No Silent Watch  
619 gal  
2,880 hrs

### 3kW MEHPS:

- 3hr Silent Watch:  
2.64kW PV Solar / 4 x Batteries  
332 gal (46% reduction)  
1,108 hrs (62% reduction)
- 8hr Silent Watch:  
3.96kW PV Solar / 10 x Batteries  
248 gal (60% reduction)  
904 hrs (69% reduction)



# MEHPS Lightweight - Summary



Attributes	Peak Power	Attributes	Transport Requirements
MEHPS			
MEHPS Lightweight	3 kW	Auto-Control of Single Generator Energy Storage (4.8 – 12 kWh) PV Solar (2.5 – 4 kW)	Four Man Lift*

\*Refer to MIL-STD-1472G, available here: [http://www.everyspec.com/MIL-STD/MIL-STD-1400-1499/MIL-STD-1472G\\_39997/](http://www.everyspec.com/MIL-STD/MIL-STD-1400-1499/MIL-STD-1472G_39997/), for definition of Four Man Lift.

# ***MEHPS Medium***





# MEHPS Medium - 5kW Peak Power

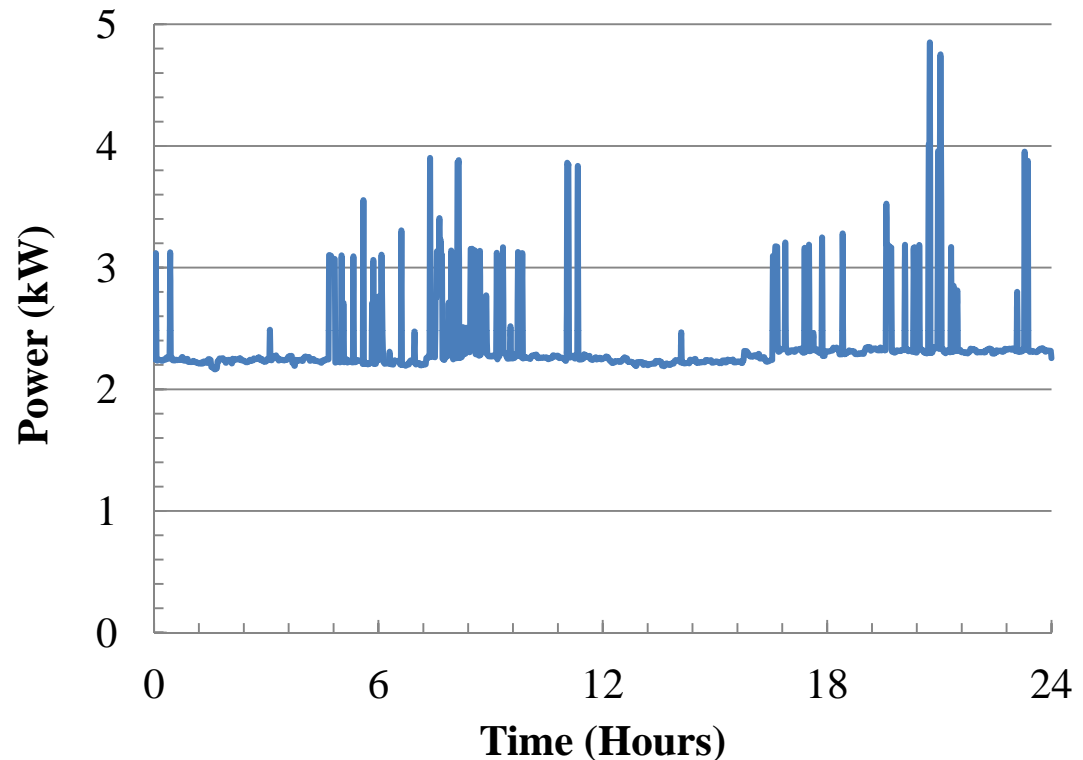


## Attributes Considered

- Controls
  - Distribution (AC/DC)
- Generator
  - Size and Types
- Storage
  - Usable storage (kWh)
- PV Solar
  - Size (kW)
- Transport
  - Light Tactical Trailer

## Attributes Not Considered

- Gridding of GENSETs



- **Average 2.2kW**
- **Max Peak 5kW**





# MEHPS Medium - Sample Equipment Powered



## Company COC ("Reinforced")

## GBOSS Heavy w/Suite

**Battery Chargers**



**VOIP/SVOIP**



**Laptops**



**Expeditionary Lighting**



**Tactical Hand-held Radios/Amplifiers**



**Blue Force Tracker**



**PRC-150**



**19" Flatscreen**




## Coffee Pot



## Microwave



- Average 2.2kW
- Max Peak 5kW



# MEHPS Medium - 10kW Peak Power

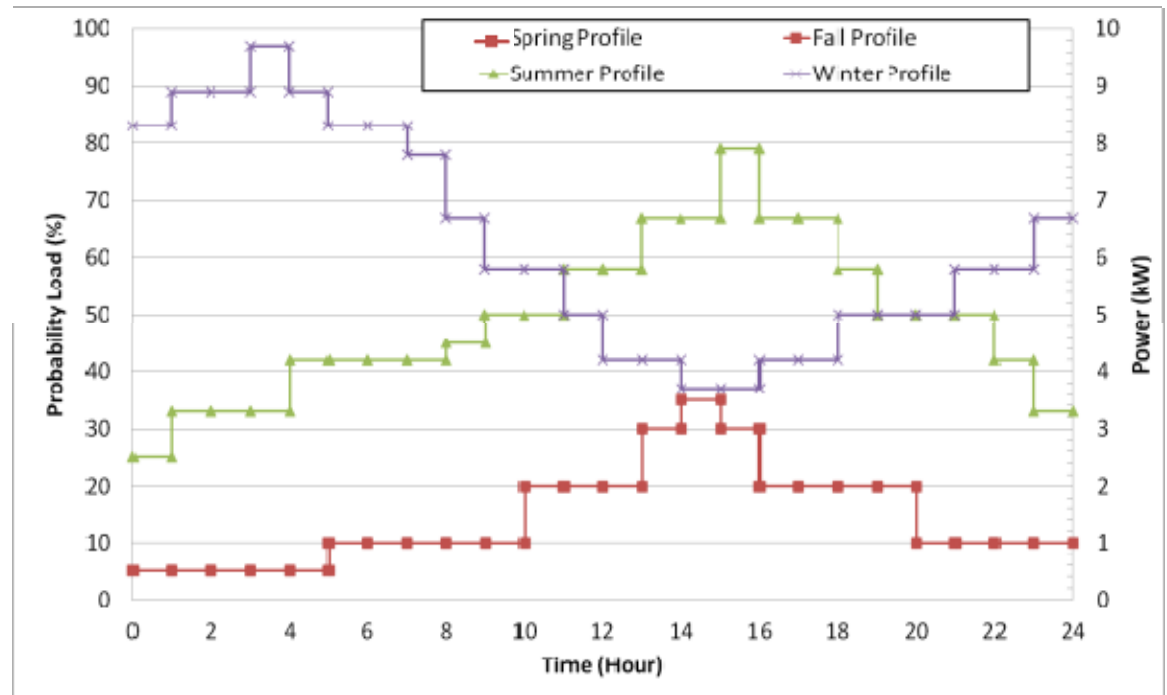


## Attributes Considered

- PV Solar
  - Size (kW)
  - Flexible/Rigid
  - Efficiency
- Storage
  - Usable storage (kWh)
- Transport
  - LTT Weight Restrictions

## Attributes Not Considered

- Generator
- Gridding of GENSETs



- Average 3.2kW
- Max Peak 10kW (Winter)



# MEHPS Medium - Sample Equipment Powered



## Company COC ("Reinforced")

**Battery Chargers**

**VOIP/SVOIP**

**Expeditionary Lighting**

**Tactical Hand-held Radios/Amplifiers**

**Laptops**

**Blue Force Tracker**

**PRC-150**

**19" Flatscreen**



## GBOSS Heavy w/Suite



Coffee Pot



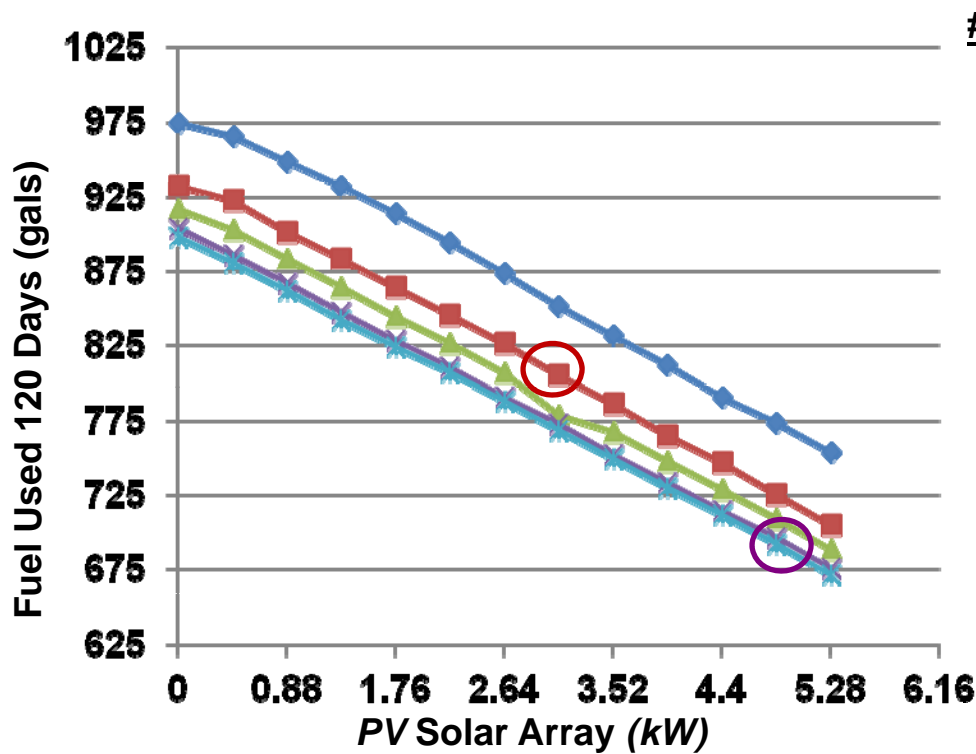
Microwave



- Average 3.2kW 35
- Max Peak 10kW (Winter)



# MEHPS Medium - Compared to 10kW AMMPS



## # Batteries Silent Watch

- ◆ 7 2hrs
- 10 3hrs
- ▲ 19 6hrs
- ✖ 25 8hrs
- ✧ 32 10hrs

### 10kW AMMPS (Non MEHPS):

- No Silent Watch  
1304 gal  
2,880 hrs

### 10kW MEHPS:

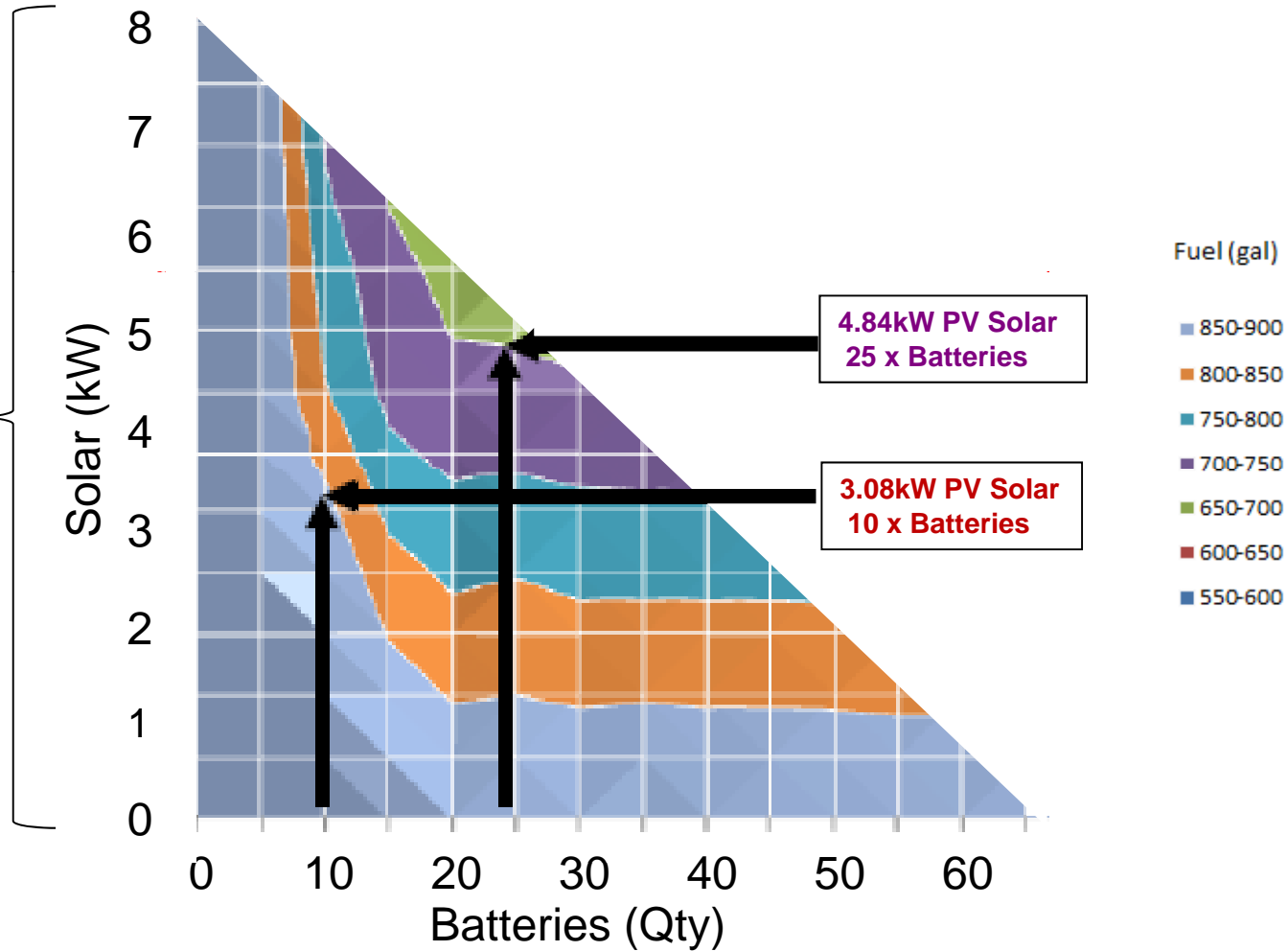
- **3hr Silent Watch:**  
3.08kW PV Solar / 10 x Batteries  
806 gal (38% reduction)  
1,110 hrs (62% reduction)
- **8hr Silent Watch:**  
4.84kW PV Solar / 25 x Batteries  
696gal (47% reduction)  
880 hrs (69% reduction)



# MEHPS Medium - On Light Tactical Trailer



Will Fit  
On Light  
Tactical  
Trailer  
(LTT)\*



\*10 kW AMMPS and Controls also on board

Unclassified / Pre-Decisional



# MEHPS Medium - Summary



Attributes MEHPS	Peak Power	Attributes	Transport Requirements
MEHPS Medium	10 kW	Auto-Control of Single Generator  Energy Storage (12 - 30 kWh)  PV Solar (3 - 5 kW)	All Components on a Light Tactical Trailer (LTT)*

\*Refer to MIL-STD-1472G, available here: [http://www.everyspec.com/MIL-STD/MIL-STD-1400-1499/MIL-STD-1472G\\_39997/](http://www.everyspec.com/MIL-STD/MIL-STD-1400-1499/MIL-STD-1472G_39997/), for definition of Light Tactical Trailer.

# ***MEHPS Micro-Grid Medium***





# MEHPS Micro-Grid Medium - 30kW Peak Power

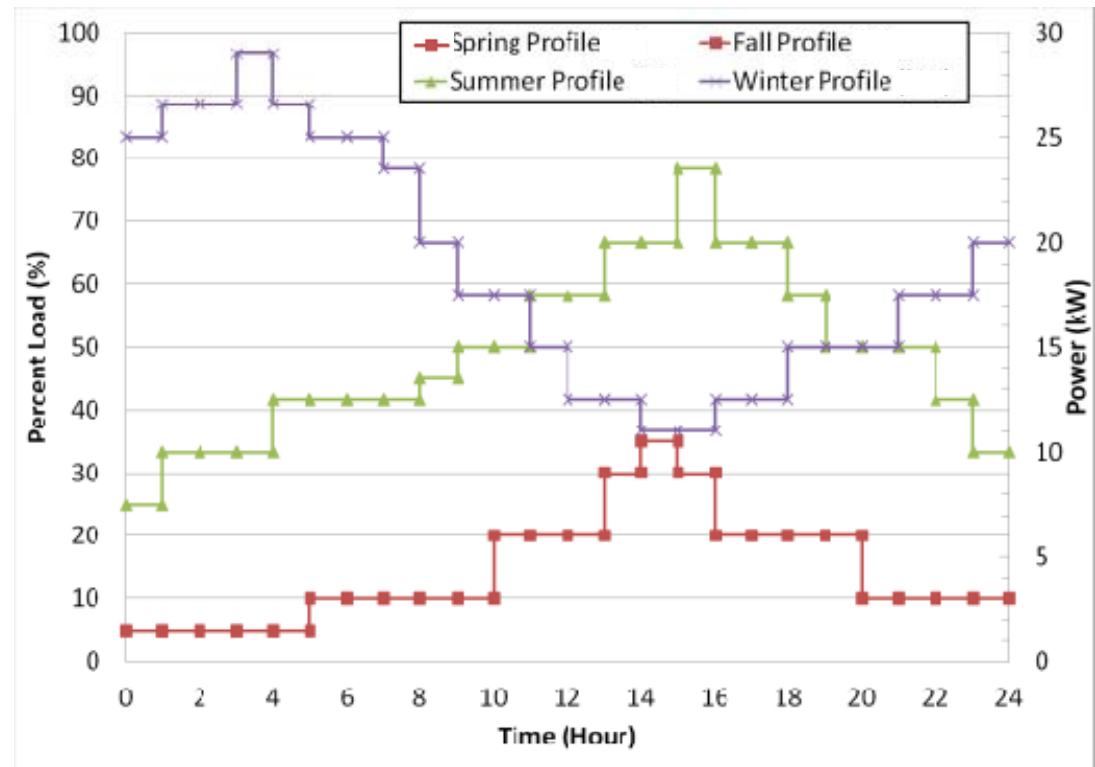


## Attributes Considered

- Multiple GENSETS
- Smart Controls
- Storage and Controls on LTT

## Attributes Not Considered

- PV Solar



- Average 9.6kW
- Max Peak 30kW (Winter)





# MEHPS Micro-Grid Medium - Sample Equipment Powered



## Battalion COC

## GBOSS Heavy w/Suite

**Battery Chargers**

**VOIP/SVOIP**

**Laptops**

**Printers**

**Expeditionary Lighting**

**SIPR Switch**

**Copier**

**Tactical Hand-held Radios/Amplifiers**

**Projector**

**PRC-150**

**Blue Force Tracker**

**Video Processor**

**22" Monitors**

**Smartboard**



## ECU



## Coffee Pot



## Microwave



- Average 9.6kW 41
- Max Peak 30kW (Winter)

Unclassified / Pre-Decisional



# MEHPS Micro-Grid Medium - 60kW Peak Power

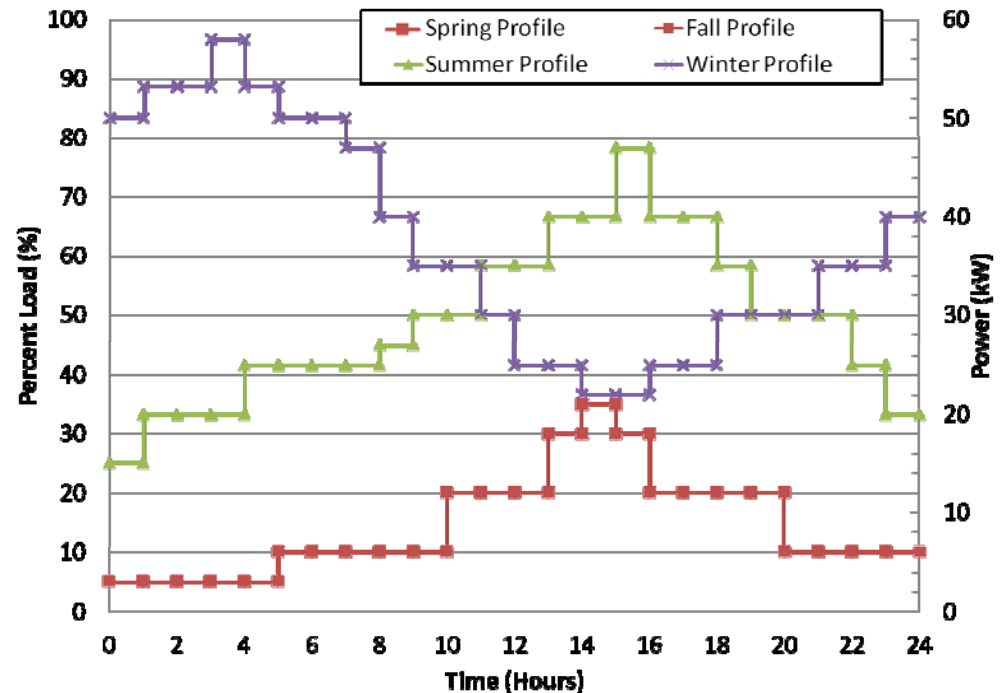


## Attributes Considered

- Multiple GENSETS
- Smart Controls
- Storage and Controls on LTT

## Attributes Not Considered

- PV Solar



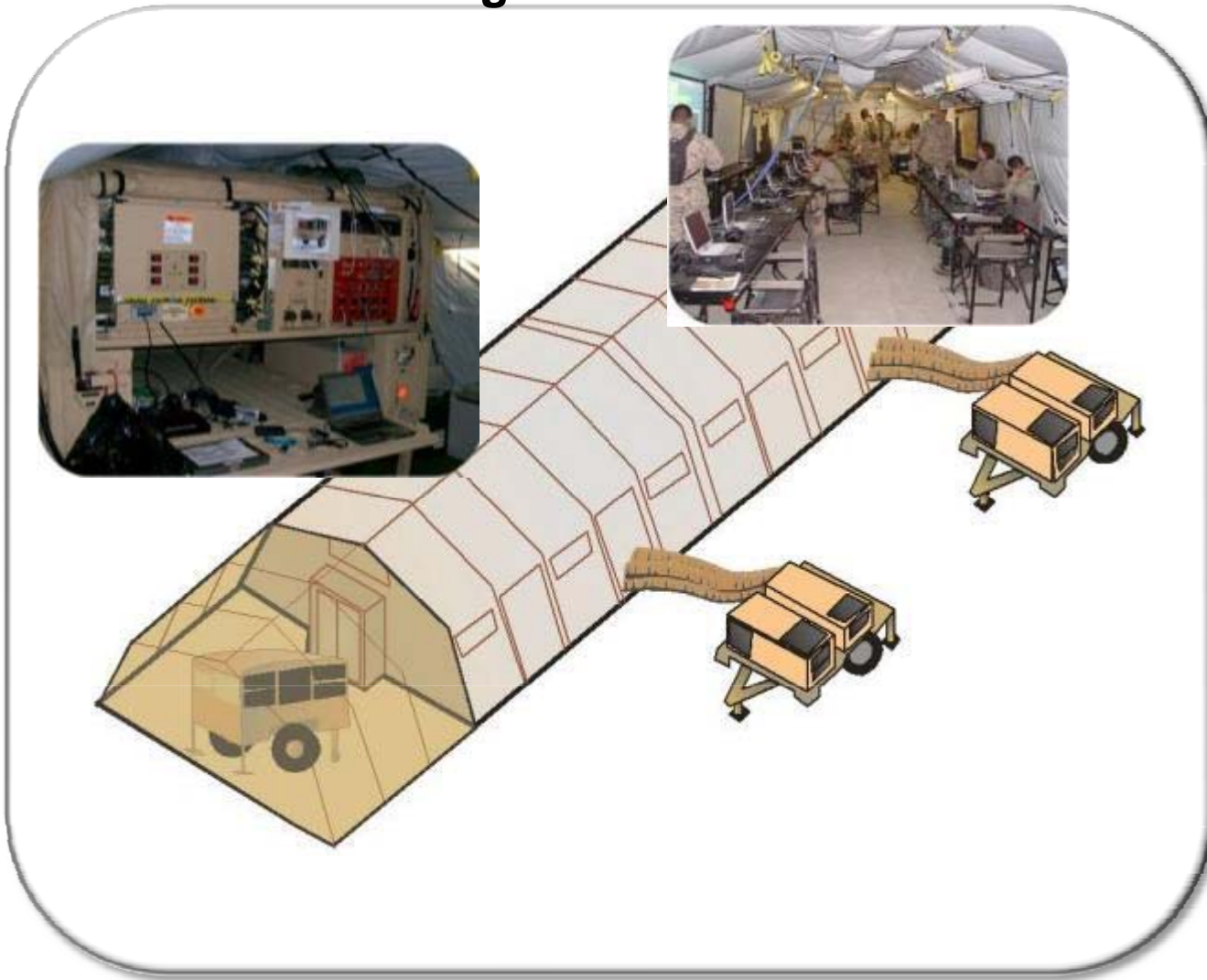
- Average 19.2kW
- Max Peak 60kW (Winter)



# MEHPS Micro-Grid Medium - Sample Equipment Powered



## Regimental COC



## GBOSS Heavy w/Suite



## ECUs (2x10-TON)



## Coffee Pot



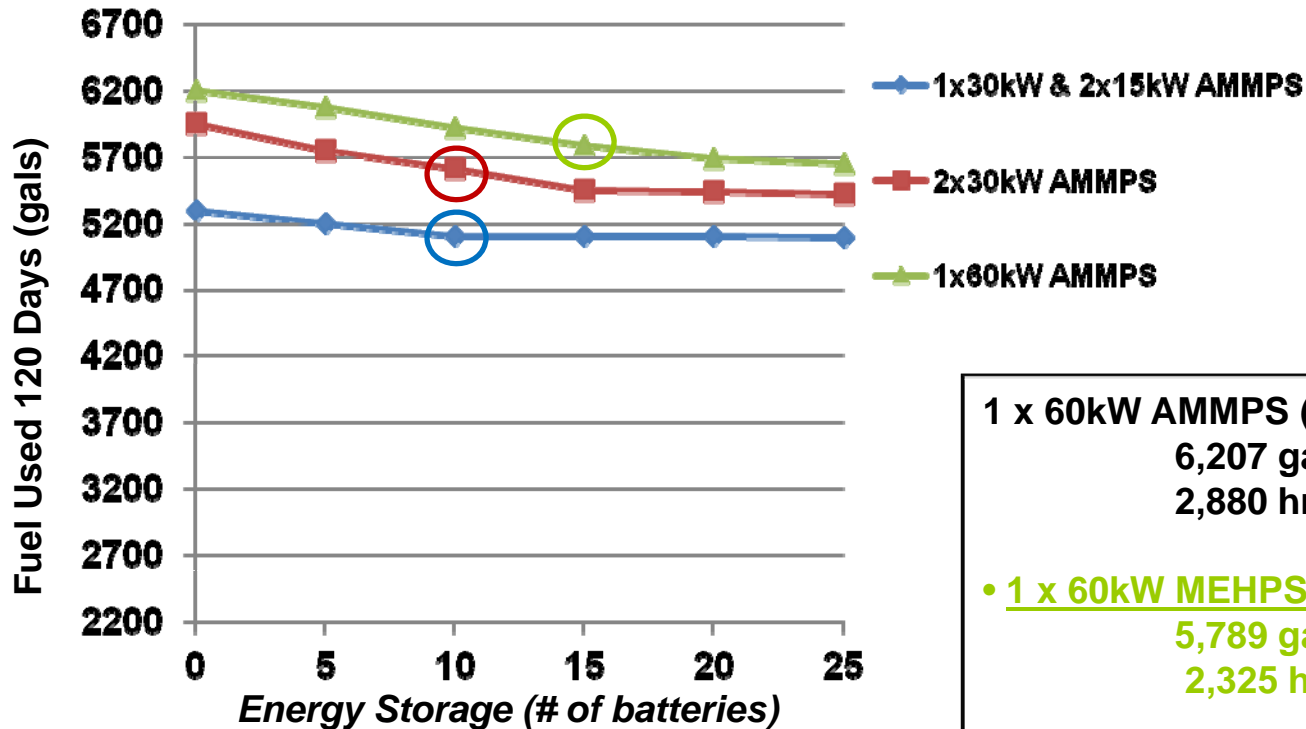
## Microwave



- Average 19.2kW 43
- Max Peak 60kW (Winter)



# MEHPS Micro-Grid Medium - 60kW Peak Power



1 x 60kW AMMPS (POR) :  
6,207 gals  
2,880 hrs

• 1 x 60kW MEHPS (15xBatt):  
5,789 gal (7%)  
2,325 hrs (19%)

• 2x 30kW MEHPS (10xBatt):  
5,619 gal (9%)  
1,522 hrs. / GENSET (47%)

• 1 x 30kW & 2 x 15kW MEHPS (10xBatt):  
5,106 gal (18%)  
1,456 hrs. / GENSET (49%)



# MEHPS Micro-Grid Medium - Summary



Attributes	Peak Power	Attributes	Transport Requirements
MEHPS			
MEHPS Micro-Grid Medium	60 kW	Auto-Control of Multiple Generators <b>Energy Storage (7 – 15 kWh)</b>	Controls and Energy Storage on LTT* (GENs Not Included)

\*Refer to MIL-STD-1472G, available here: [http://www.everyspec.com/MIL-STD/MIL-STD-1400-1499/MIL-STD-1472G\\_39997/](http://www.everyspec.com/MIL-STD/MIL-STD-1400-1499/MIL-STD-1472G_39997/), for definition of Light Tactical Trailer.

# ***MEHPS Micro-Grid Heavy***





# MEHPS Micro-Grid Heavy - 100kW Peak Power

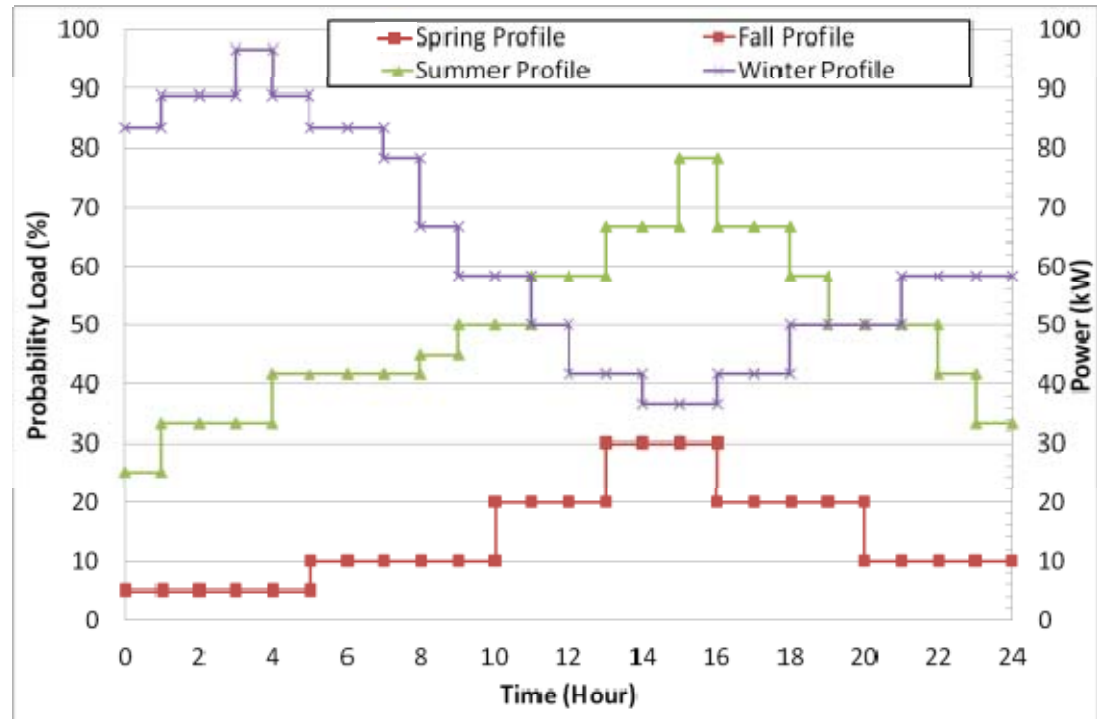


## Attributes Considered

- Multiple GENSETS
- Smart Controls

## Attributes Not Considered

- Storage
- LTT
- PV Solar



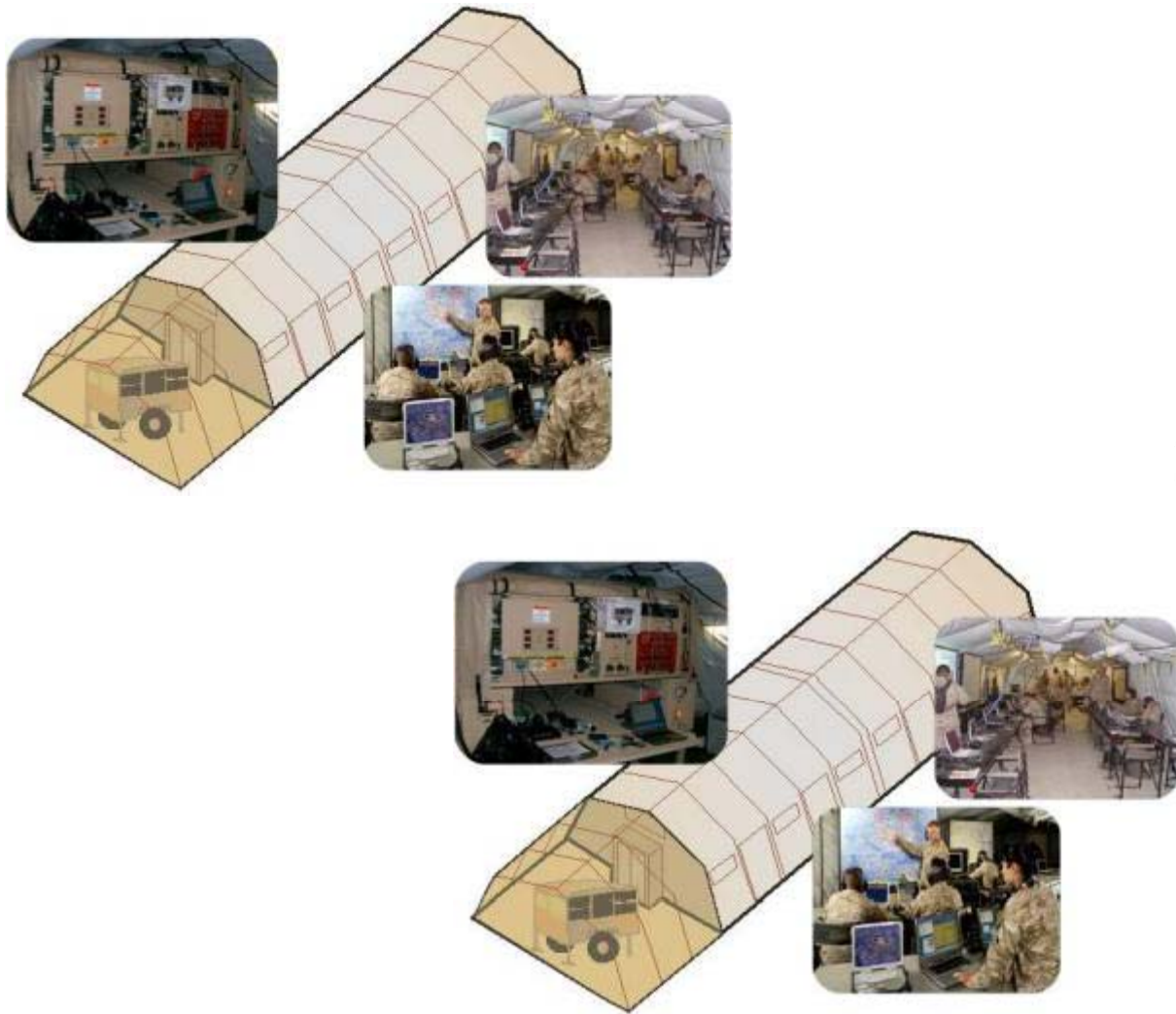
- Average 32kW
- Max Peak 100kW (Winter)



# MEHPS Micro-Grid Heavy - Sample Equipment Powered



Marine Expeditionary Unit COC



GBOSS Heavy w/Suite



ECUs (4x10-TON)



Coffee Pot



Microwave



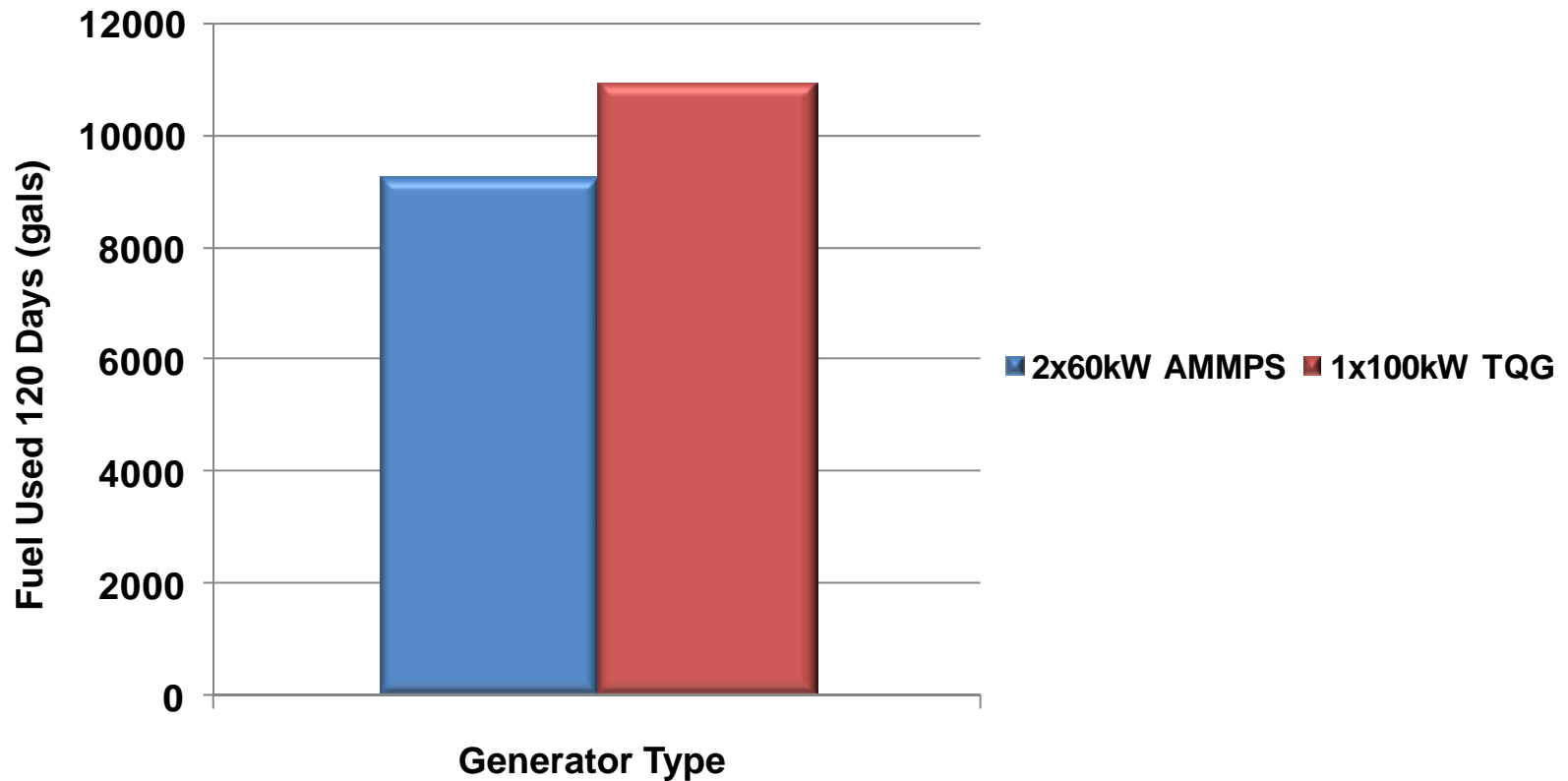
- Average 19.2kW 48
- Max Peak 60kW (Winter)

Unclassified / Pre-Decisional





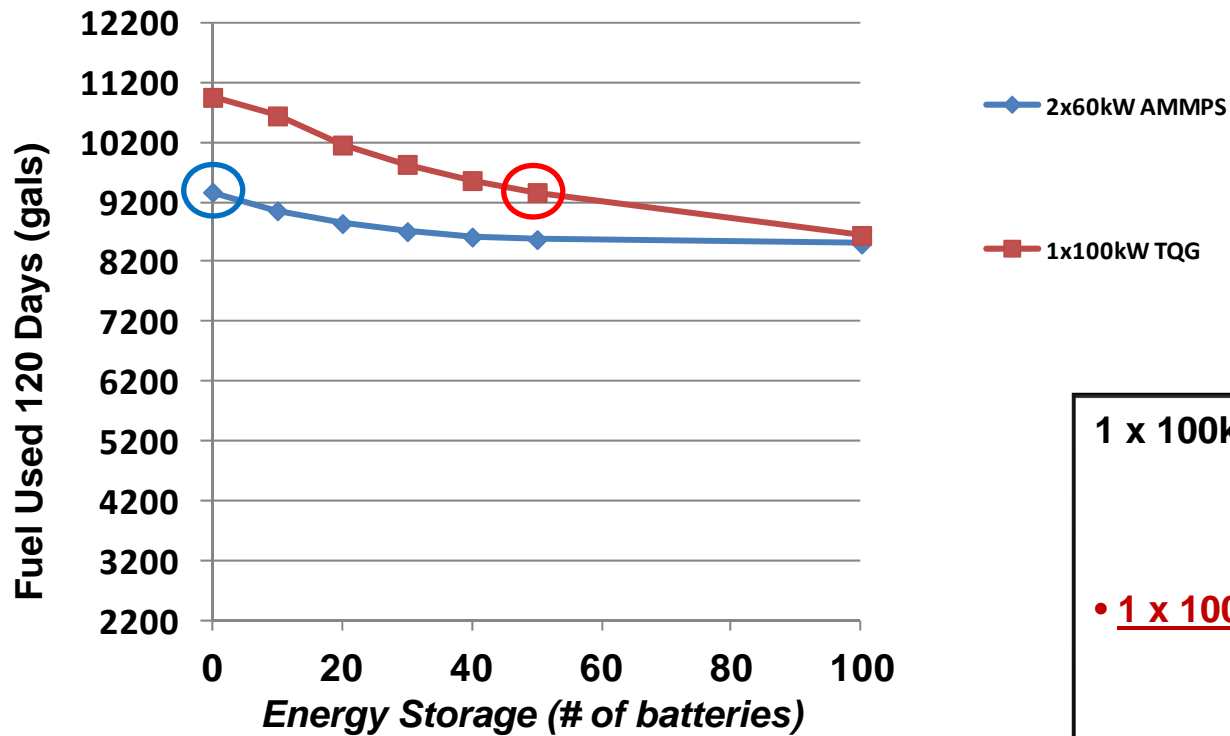
# MEHPS Micro-Grid Heavy - 100kW Peak Power



**2x60kW MEHPS configuration uses the least fuel  
for a 120 Day 100kW profile**



# MEHPS Micro-Grid Heavy - 100kW Peak Power



- 1 x 100kW TQG (POR) :  
10,955 gals  
2,880 hrs
- 1 x 100kW MEHPS (50xBatt):  
9,363 gal (14%)  
1,898hrs (34%)
- 2 x 60kW MEHPS (No Storage):  
9,368 gal (14%)  
1,444 hrs / GENSET (49%)



# MEHPS Micro-Grid Heavy - 300kW\* Peak Power

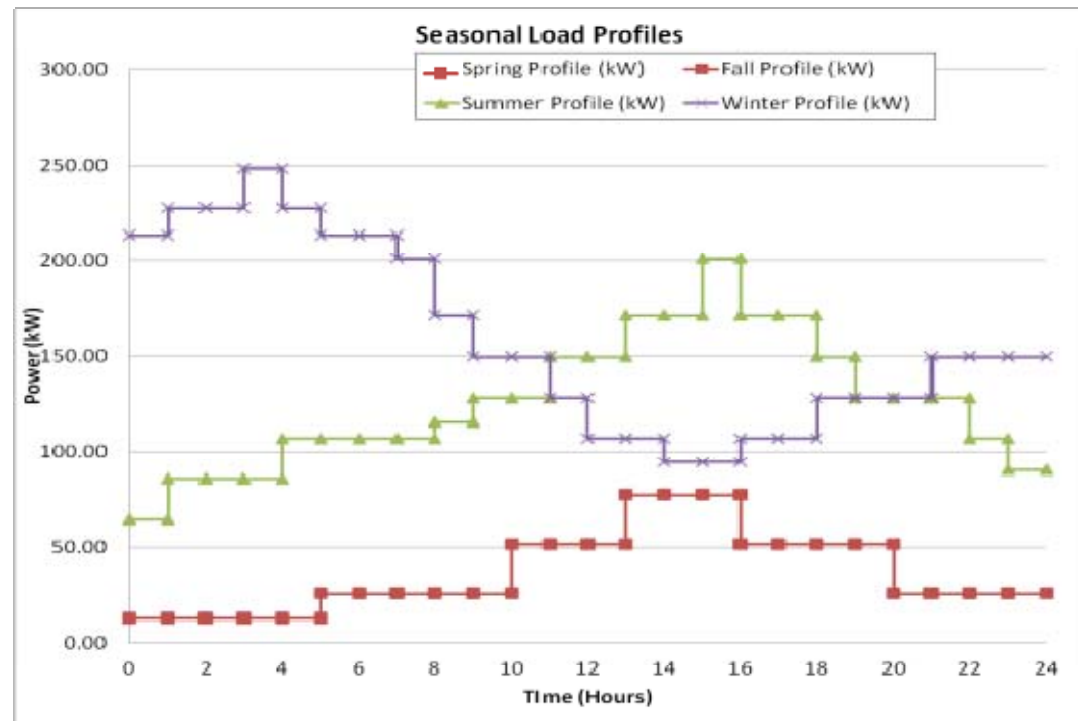


## Attributes Considered

- Multiple GENSETS
- Smart Controls

## Attributes Not Considered

- Storage
- LTT
- PV Solar



- Average 80kW
- Max Peak 250kW (Winter)

(\*Note: 300kW used as peak due to generator inventory options)



# MEHPS Micro-Grid Heavy - Sample Equipment Powered



Marine Expeditionary Brigade COC



GBOSS Heavy w/Suite



ECUs (10 x 10-TON)



Coffee Pots



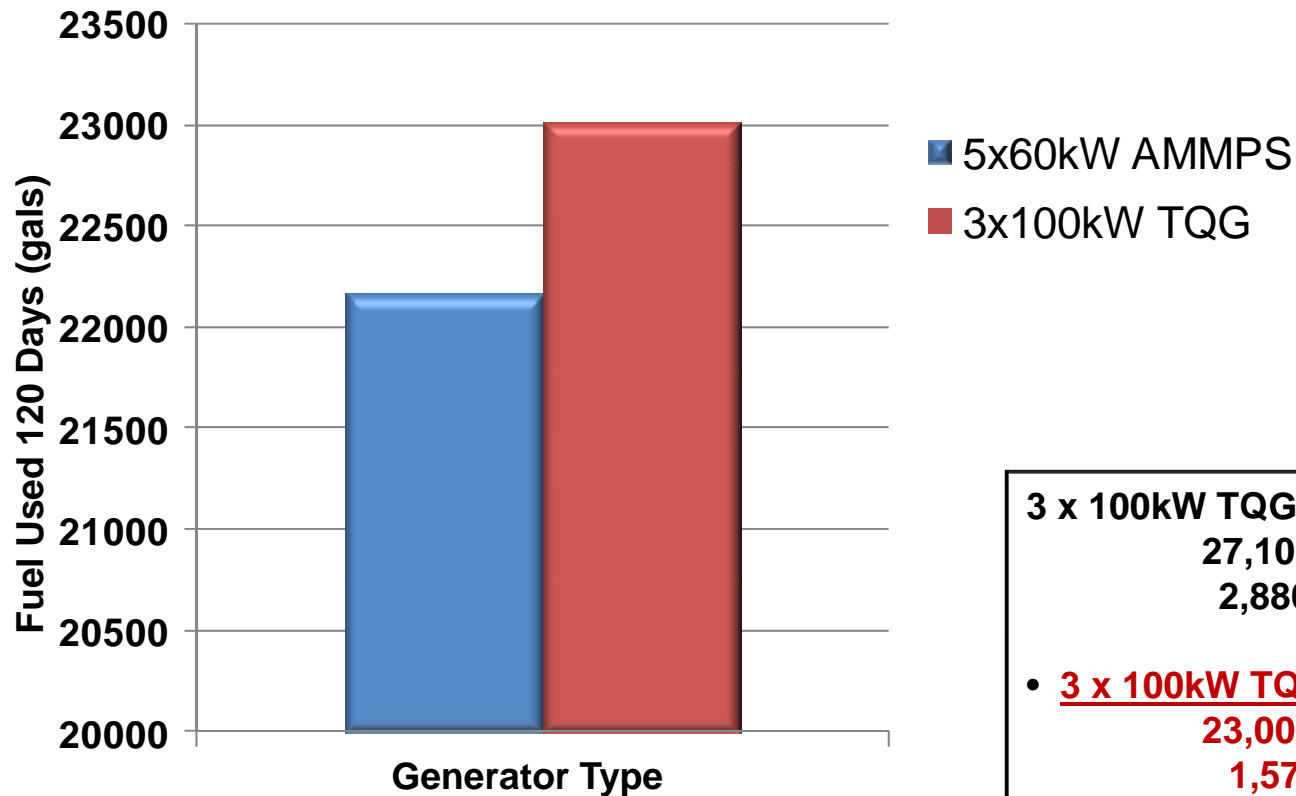
Microwaves



- Average 80kW
- Max Peak 250kW (Winter)



# MEHPS Micro-Grid Heavy - 300kW Peak Power



3 x 100kW TQG (POR) :

27,100 gals

2,880 hrs / GENSET

• 3 x 100kW TQG MEHPS (No Storage):

23,006 gal (15%)

1,577 hrs / GENSET (45%)

• 5 x 60kW AMMPS MEHPS (No Storage):

22,153 gal (18%)

1,136 hrs / GENSET (61%)



# MEHPS Micro-Grid Heavy - Summary



Attributes	Peak Power	Attributes	Transport Requirements
MEHPS MEPHS Micro-Grid Heavy	300 kW	Auto-Control of Multiple Generators	Forklift (GENs Not Included)

# Conclusions





# MEHPS Family of Systems



Attributes	Peak Power	Attributes	Transport Requirements
<b>MEHPS</b>			
<b>MEHPS Lightweight</b>	3 kW	-Auto-Control of Single Generator <b>-Energy Storage</b> <b>-PV Solar</b>	Four Man Lift
<b>MEHPS Medium</b>	10 kW	-Auto-Control of Single Generator <b>-Energy Storage</b> <b>-PV Solar</b>	All Components on a Light Tactical Trailer (LTT)
<b>MEHPS Micro-Grid Medium</b>	60 kW	-Auto-Control of Multiple Generators <b>-Energy Storage</b>	Controls and Energy Storage on LTT (GENs Not Included)
<b>MEPHS Micro-Grid Heavy</b>	300 kW	-Auto-Control of Multiple Generators	Forklift (GENs Not Included)

\*Refer to MIL-STD-1472G, available here: [http://www.everyspec.com/MIL-STD/MIL-STD-1400-1499/MIL-STD-1472G\\_39997/](http://www.everyspec.com/MIL-STD/MIL-STD-1400-1499/MIL-STD-1472G_39997/), for definitions of Four Man Lift, Light Tactical Trailer.

Unclassified / Pre-Decisional

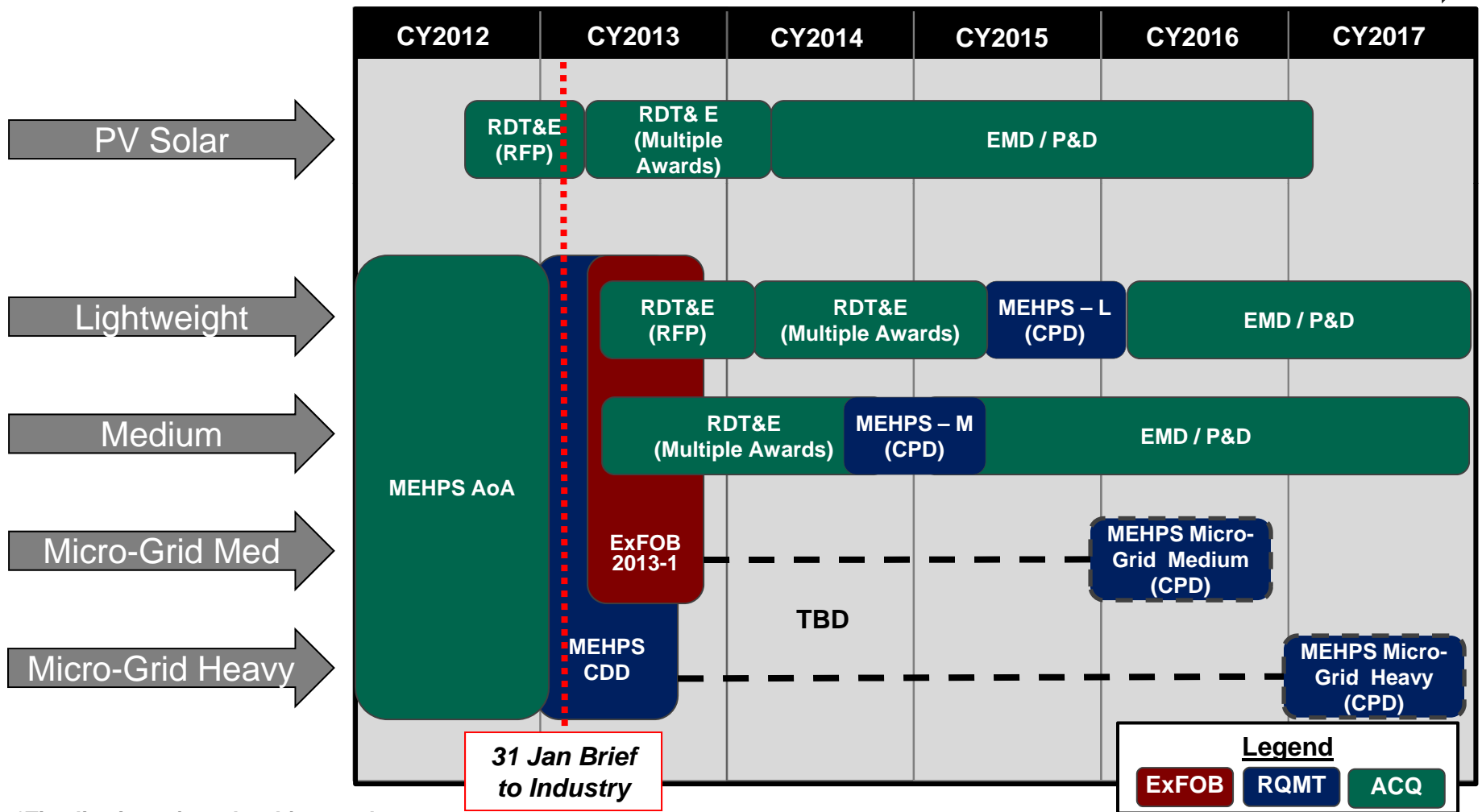




# Mobile Electric Hybrid Power Sources (MEHPS) Family of Systems



**“Concepts - to - Military Capabilities”**



\*Timeline is projected, subject to change

Unclassified / Pre-Decisional

