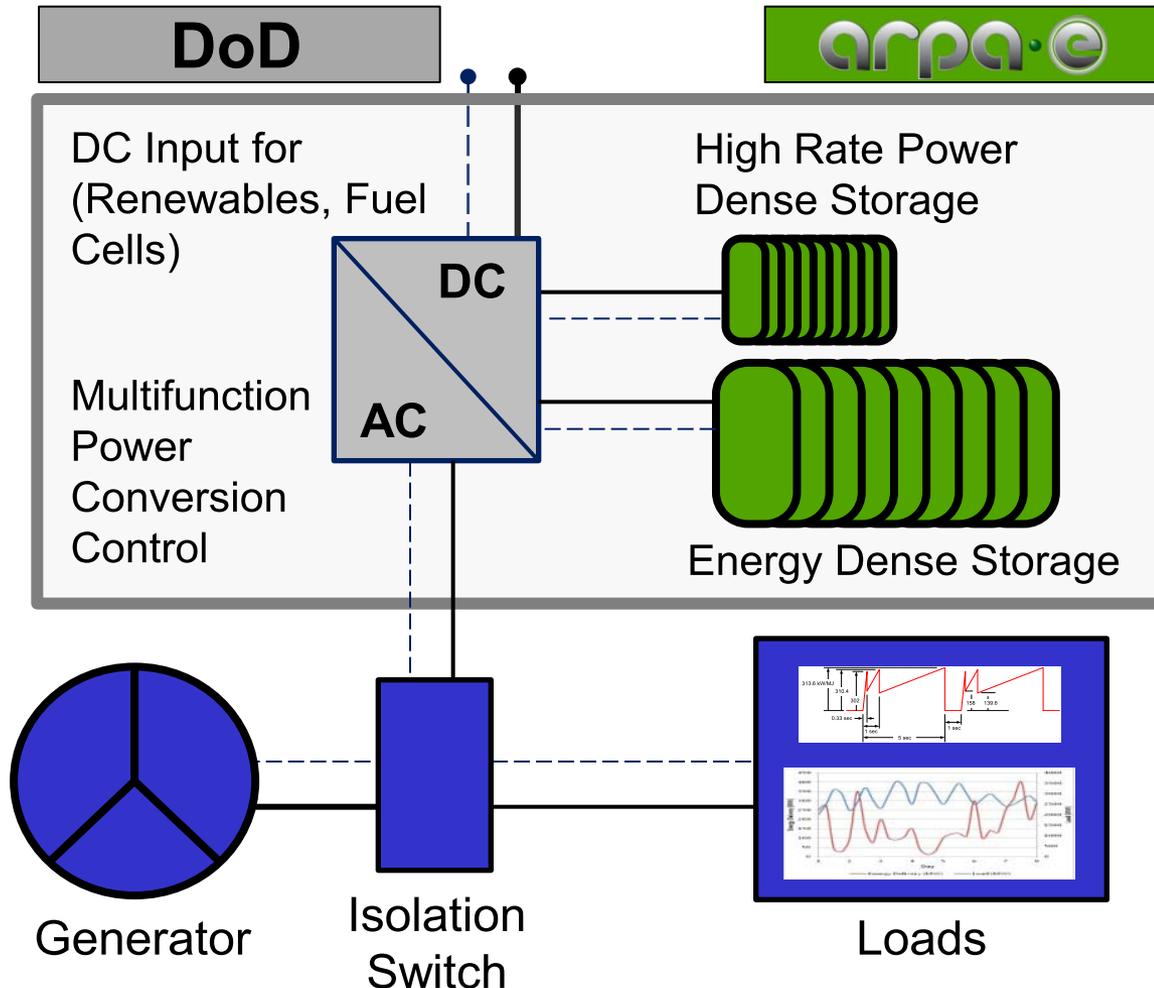


Hybrid Energy Storage Module (HESM)



HESM Unit



Technologies

- **Storage**
 - **Advanced Energy Storage Device(s)**
 - High Rate Batteries
 - Metal Air Batteries
 - High Energy Flywheels
 - Flow Batteries
 - Capacitors
- **Multifunction Power Conversion Control**
 - Multi Rate Control & Energy Storage Management
 - Thermal Tolerant Power Conversion for Continuous Operation
 - Energy Storage “Agnostic” Interface
- **HESM System Design**
 - Lightweight System Safety & Containment
 - Robust Thermal Architecture & Interface

Tactical Energy Storage (kW to 10's kW)

- Operation close to power generation source
- Functionality: Energy Mgt, Power Quality
- DC Input for High Efficiency Renewables, Fuel Cell Generators

Commercial Application: Home Energy Management

DoD Application: Patrol Base, Combat Outpost



Distributed Energy Storage (100's kW to MW)

- Operation distributed in electric architecture
- Functionality: Energy Mgt, Power Quality
- DC Input for High Efficiency Renewables, Fuel Cell Generators

Commercial Application: Utility Distributed Generators

DoD Application: FOB, Super FOB, Ships

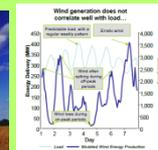


Pulse Energy Storage

- Operation for specialty applications
- Functionality: Energy Mgt, Power Quality, High Pulse Capability

Commercial Application: Utility Grid Level Storage

DoD Application: Ships, Aircraft, Vehicles





- **Based on concept, are specifications feasible (Easy or Hard)?**
 - Identify how specifications should change and why
- **Does this application require multiple storage technologies or can it satisfied with a single device?**
- **What are the system (module) configuration, interface, and control challenges?**
- **What safety, reliability, environment issues exist for the concept system?**
- **What are other commercial or military applications that could use this technology?**
- **What enabling technology do you wish could be invented**

Tactical Power Concept

Maximize for System Efficiency



HESM Unit

Potential Configuration	(1-2) 3kW AC generator, (1) 3kW 28VDC Alternative Energy Source (e.g. Solar)
Total Power Output	5kW continuous, 7kW peak, 120/240 VAC, single-phase, three-wire, 60 Hz
Storage Capability	5kW, 7kWhrs
Source Input	(1-2) 3kW (120/240 VAC, single-phase, three-wire, 60 Hz), (1) 3kW (28VDC)
Ambient Operating Temperature	0C threshold (-32C objective) to 55C operating range required
Cooling Media	Air Cooled (ambient temperature air)
Volume	3.5 ft3 (objective), 5ft3 (threshold)
Dimensions not to exceed:	15.6" w x 22"l x 26" h
Electrical Characteristics	Compliance with MIL-STD-1332B Table II (Class 2C) AC output required
Environmental Conditions	Meet Mil-Std-810 requirements

- **Concept: Compact, light, integration of generators and renewables with controlled operation to support loads**
- **Input: (2) 3kW TQG (120/240 VAC, single-phase, three-wire, 60 Hz), (1) 3kW DC renewables (28VDC)**
- **Output: 5kW continuous, 7kW peak @ 120VAC 1ph**
- **Storage – 5kW power, 7kWh energy**
- **Contactor signal output to each engine: Turn engine on/off, close contactors signals (for each source)**
- **Qualification ready for platform specifications and requirements**

Distributed Power Concept

Maximize for System Efficiency



HESM

ESM Operation	Utilize multiple 200kW HESM units on system architecture. Integrates external DC source (renewables/fuel cell generators) on to bus. Provides generator optimization for MEP units.
Electrical Interface	Electrical Bus: Bi Directional Interface: 440/480VAC, 3ph External DC Input: 200-300VDC (Renewables/Fuel Cell Generators)
HESM Power Output	200kW continuous, 10-100% load step and maintain output, Galvanically isolated, Current limit capable, 1.5 pu for 2 seconds
Storage Capability	300kW peak, 75kWhrs depending upon DC source need (fuel cell/renewable)
Ambient Operating Temperature	0C threshold (-32C objective) to 55C operating range required
Cooling Media	System Interface: Air Cooled (ambient temperature air) LRU Interface: As Required
Volume	System: 75ft ³ (w/75kWh system storage)
Electrical Characteristics	Compliance with MIL-STD-1332B or 1399 as req'd
Environmental Conditions	Meet Mil-Std-810, MIL-S-901,



- **Concept: Parallel storage capability to operate with single or reduced generators, renewables, fuel cell generators**
- **Combines with smart load/monitoring to enable more substantial operations with low-inertia grid.**
- **440/480V AC Interface-based**
- **DC Interface for renewable/fuel cell generator input to grid**
- **Modular Design**
 - Individual, hot swappable LRU approach
- **Qualification ready for platform specifications and requirements**

Pulsed Power Concept Intermediate Storage System



HESM System

ESM Operation	Provides intermediate storage for PFN and aligns architecture for optimized generator scheduling/single generator operations
Electrical Interface	Electrical Bus Bi Directional Interface: 440/VAC, 3ph DC Interface Bus: 1000VDC (Dual DC - to Storage and to PFN)
Total Power Output	DC: 11000kW for 5-sec waveform, >80% duty cycle, continuous cycles up to stored energy AC: 4000kW Continuous DC-AC conversion
Storage Capability	11000kW Peak, 1000kWh
Ambient Operating Temperature	0C to 65C operating range required
Cooling Media	System Interface: Water (40C)
Volume	System: 420ft³
Electrical Characteristics	Compliance with MIL-STD-1399
Environmental Conditions	Meet Mil-Std-810, MIL-S-901,

- **Concept: Support high transient operations at substantial power levels with large energy requirements.**
- **Utilize stored energy to support other lower-power requirements as needed**
- **ISO container installed**
- **450V AC Interface-based to distribution, 1000VDC to PFN**
- **MW-scale Modular Design**
- **Qualification ready for platform specifications and requirements**