

The Quest for the Holy Grid

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Introduction

- Ensuring power availability, Security, efficiency, quality and significant reduction in fossil fuel consumption are some of the goals DoD hopes to achieve to ultimately save energy and lives in theater.

“Army Energy Security Mission

Make energy a consideration in all Army activities in an effort to reduce demand, increase efficiency, seek alternative sources, and create a culture of energy accountability, while sustaining or enhancing operational capabilities”

- Power generators are the biggest fuel users during contingency operations



Introduction (Continued)

- In theater tactical trucks and transport aircraft use more fuel to transport fuel for the generators.
- Fuel convoys are vulnerable to insurgents attacks and life and equipment will be at risk for distributing fuel.
- In general the nation and DoD would like to be less dependent on fossil fuel particularly of the imported variety.
- All of the above has prompted DoD to embark on a “Quest for the Holy Grid”, if there were such a thing.

The Basics

- Diesel generators run most efficiently at maximum capacity.
- In real life use they are mostly run at low/partial capacity hence inefficiently.
- The goal is to operated as few sets as possible at any given time for a given total load.
- This requires the right combination of sets, load sensing and intelligent generator control.

Solution Approaches

- Solutions range from very simple to very complex depending on many factors, mainly cost, time and application type.
- Application: For the DoD there are two types of application, Stationary and Mobile Tactical.
- Stationary applications are for large bases and installations, such as Fort Irwin, CA, 29 Palms MC Base, Fort Shafter HI,.....
- Mobile Tactical as the name implies is for mobile units where a different set of requirements come into play

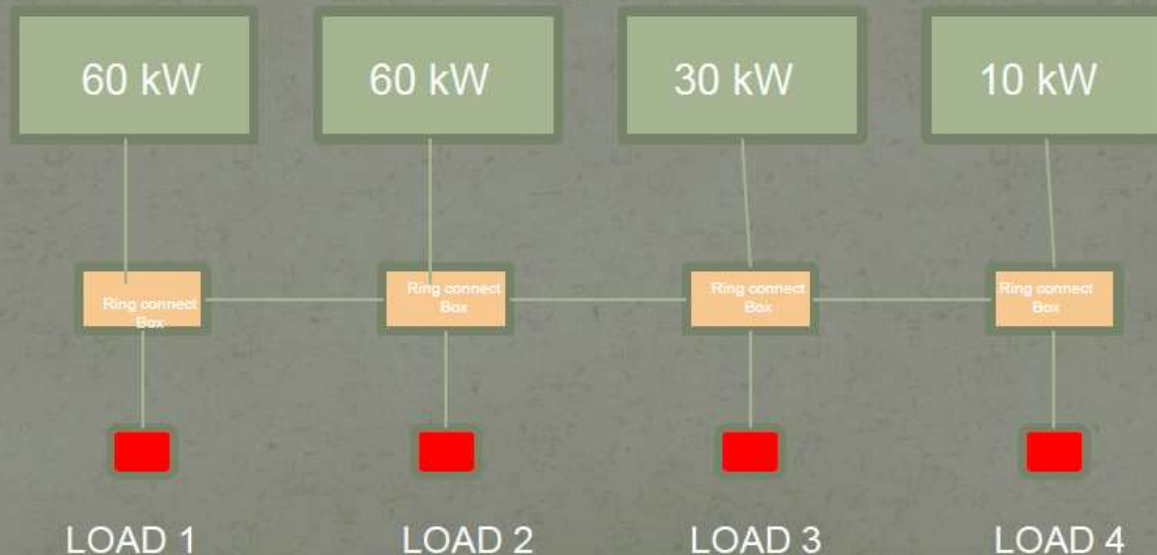
Solution Approaches Continued

- Stationary systems usually include a regional grid tie. Also renewable energy sources are used where possible with the emphasis on fossil fuel use reduction.
- With Tactical Mobile systems the emphasis is on power availability, quality and system deployability (weight, Volume)

Solution Examples

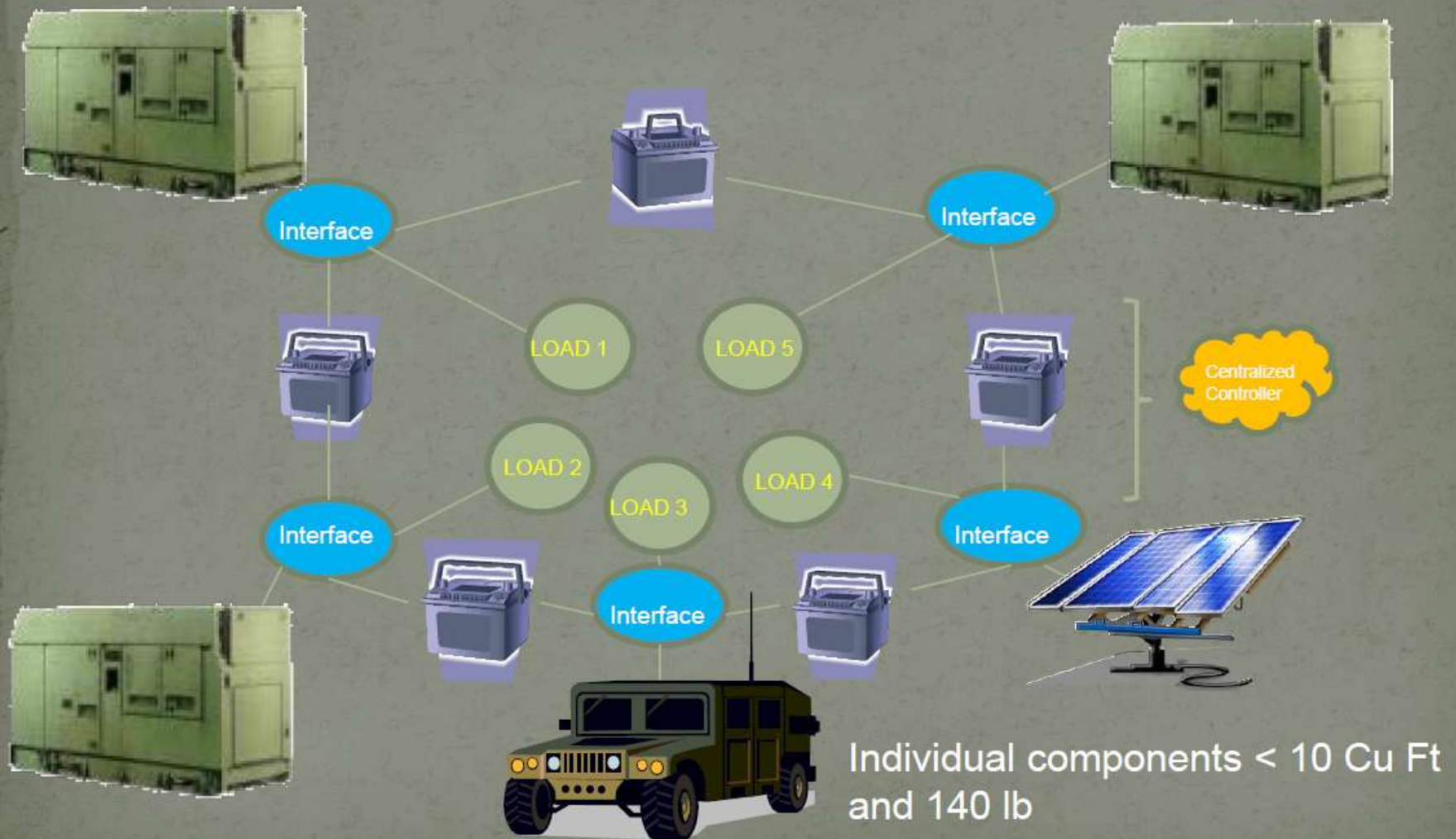
Basic

- A good example of a simple yet effective Tactical Mobile grid is a setup with generators in sizes that allow a variety of total power output combination, automatic On/Off control boxes and distribution units. The below arrangement theoretically offers a load range from 4 kW to 140kW



Solution Examples Continued

More Comprehensive



Installation Set Up

Sources



HI-Power provides...

- **Plug & Play connectivity**
 - Sources
 - Loads
- **Intelligent control**
 - Source management
 - Load management
 - *Load shedding*
 - *Load scheduling*
 - *Load prioritization*
 - *Phase balancing*



Data

Power

Loads



System Diversity

- **EPPC (Next Energy):** 250kVA/500kVA system, integrated solar and wind <1kW , includes load prioritization and shedding , communication over Ethernet, has a very large package volume and weight (ISO container based), it is currently located at the National Training Center.
- **Power Systems and Controls Microgrid (PS&C):** Uses commercial off the shelf engine controllers, automatic identification of source via frequency keying, is very large and heavy (Container based), PV only supplies 460 VDC, no load controls or energy storage, currently at National Training Center.
- **Basic Expeditionary Air Field Resources Smart- Microgrid System (BEAR-SMS)** by Lockheed Martin: This Microgrid focused on renewable energy, synchronizing identical 750kW, 4160 VAC sets, is a fixed in place system, components are rated for 120kW, 208 VAC, 60 Hz, it incorporates load prioritization and shedding.
- **SCMG (Smart Charging Microgrid** by Honeywell): 250 kW at 480 VAC, uses solar sources (25 kW stationary and 10kW mobile) has utility connection, sheds load at overload conditions, incorporates vehicle to grid tie for 4 vehicles at 33kW total interface
- **PM FSS demonstrator** (L3 Communication and Electricore): This is a basic system comprising source TQGs with On/Off control, and distribution boxes. The system allows running the least number of sets for any given total load based on pre-set points selected by the user for their particular application. It does not include load control, renewables, vehicle interface or storage devices.

The Hybrid Intelligent Power (HI Power)

- The program started in 2008 as a 6 year \$30 M R&D effort sponsored by the Office of the Secretary of Defense (OSD).
- To date several R&D contracts for system development and demonstration and studies have been awarded.
- Currently there are two on going Microgrid efforts developing intelligent tactical mobile grids, one due to complete in late FY 11 and one in mid FY12.
- Based on demonstration and testing of these systems and various studies to date a system would be specified and transitioned to the Product Manager Mobile electric Power (PM MEP) at Milestone B of the acquisition cycle.
- R&D will continue and new capabilities will feed into the Engineering and Manufacturing Development process (EMD).

HI Power Objectives

- Develop a standard, scalable, tactical Microgrid based a specific size Tactical Operation Center (TOC) that enables utilization and control of legacy and commercial power generation assets, renewable sources, vehicle power, and advance storage devices to:
 - Enhance tactical grid reliability, power availability and ultimately reduce logistics footprint and fuel consumption.

HI Power Challenges

- Hardware
 - Interfacing with low voltage DC sources
 - Interfacing with legacy generator equipment
 - Interfacing with sources of differing frequencies (50Hz, 400Hz... over the standard 60Hz)
 - Power Line Carrier or other communications solution
 - Size and weight of individual pieces and the overall system
 - Controls/Communications between units
- Renewable Sources & Energy Storage
 - Mobility of high power renewable sources
 - Energy storage requirements (Weight Size, operating temperature, life, capacity, recovery time, ability to handle transients....)
 - Types of energy storage necessary to achieve goals.

HI power Challenges

- Controls:
 - User Interface structure/information
 - Standard communication protocol
 - Controls/Communications between units
 - Source/load identification
 - Information Assurance
 - Firmware
 - Load management (prioritization/shedding)

The Holy Grid?

- Last count there were 24 Government sponsored and 9 commercially funded Microgrid programs.
- The collective knowledge gained from these efforts can be very valuable.
- To date no such knowledge base has been created.
- For DoD, Microgrids can be put in two categories:
 - Installation (Stationary) and Tactical (Mobile)
- Solution approaches for the above are very different other than the very basic requirements.

There is no “Holy Grid”

- There is no one solution to address all situations.
- In general running least number of diesel sets closest to their maximum capacity for any given total load provides the bulk of the fuel saving needed.
- Distribution and control (Software) coupled with maximum use of storage devices, solar and/or wind can ensure further reduction of fossil fuel consumption, power quality and availability.
- For tactical, mobile systems power availability, quality and system deployability are the predominant requirements.