Environment, Energy Security, and Sustainability (E2S2) Symposium and Exhibition

Microgrid with Solar Power and Fuel Cell Technology

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Microgrid with Solar Power and Fuel Cell Technology

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OVERVIEW

- Background
- Terminology
- Project Objective
- Requirements
- Microgrid System
- Planned Testing
Background

• One of the primary energy challenges identified in the February 2008 Defense Science Board Task Force on Department of Defense (DoD) Energy Strategy was
  – “Military installations are almost completely dependent on a fragile and vulnerable commercial power grid, placing critical military and homeland defense missions at unacceptable risk of extended power outage.”

• Tasked by the United States Air Force (USAF) Advanced Power Technology Office (APTO) to develop a Microgrid using Solar Panels and Fuel Cell Technologies
Terminology

• General Definition
  – An integrated energy system consisting of interconnected loads and distributed energy resources that can operate in parallel with the grid or in an intentional island mode.

• Key Defining Characteristics
  – Integrated distributed energy resources (DERs), capable of providing sufficient and continuous energy to mission critical loads
  – Independent controls; island and reconnect with minimal disruption
  – Flexible configuration and operation of the power delivery system
  – Optimized local DERs, large network loads, and broader power system
Project Objective

• Design, integrate, test and sustain a DC based 50 kW microgrid with multiple power sources which will demonstrate:
  – Reliably supply power to dedicated loads in a prioritized fashion
  – Supply excess power to the grid, when appropriate
  – Make intelligent decisions when the PV array (and other sources) should directly supply power to the load
  – Make intelligent decisions when the PV array (and other sources) should supply power to charge the battery energy storage system
  – Make intelligent decisions when none of the options are available and allow the load to be sourced via a grid connection or the government furnished back-up generator.
Requirements

• Ability to run grid tied or islanded
• High reliability electrical supply to identified loads
• Load prioritization
• Effectively manage energy storage to maximize energy supply to critical loads
• Control system to monitor loads and sources, and effectively manage these loads and sources to attain high reliability supply to critical loads
• Data collection to determine metrics of system operation
• Supply a maximum of 50 kW output
Requirements - Site

• Environmental and weather concerns
  – Lightning protection
• Stand-off distances from tents and specific equipment
• Footprint, size, and overall weight of equipment
• Ability to cover, conceal, and protect interconnecting wiring and cable from damage or safety concerns
Microgrid System – Schematic View
Microgrid System – Layout
Microgrid System Sources – PV Array

- 140 individual 175 W modules
- 14 strings of ten modules each
- Peak power rating of 24.5 kW @ an operating voltage of approximately 360 VDC
- Footprint 111’ x 20’
Microgrid System Sources – Fuel Cell

- 5 kW output
- 48VDC
- Proton Exchange Membrane (PEM)
- Up to 16 hours of full load operation w/ fuel storage
Microgrid System Sources – Diesel Generator

- MEP-805A generator
  - 30 kW, 120/208 volts AC (VAC), 3 phase, 60 Hz
Microgrid System Sources – Energy Storage

• Selected Zinc Bromide:
  – Improved cycle life; 30 years before stack replacement
  – Reasonable round-trip efficiency (70-80%)
  – Deep cycle (allows full capacity from 100% to 0% charge)
  – Environmentally acceptable
  – Commercial units - scalable to large systems

• 100kWhr/50kW capacity
Microgrid System Sources – Electrical Energy Management System

- Flow battery
- Source power conditioning
- Output power conditioning
- Isolation transformers
- Metering

- 1741 compliant 200 Amp electrical utility connection point
Microgrid Control System

- Programmable Logic Controller based supervisory control.
- PC-based operator interface and data acquisition to provide oversight, configure testing, and capture operational data.
Microgrid Loads

• Environmental Control Unit (ECU) 17 kW
• Lighting 1.8 kW
• Convenience Receptacles 3.6 kW
• EV Charging Receptacles 6 kW
• Control Power / Control Panel AC < 4 kW
Microgrid Testing

• Determine and quantify operations performance characteristics
  – Efficiency of various components to produce or process energy
  – Quantifying the reliability of the microgrid configuration
  – Validate the benefits of energy storage
  – Prioritized load management
Microgrid Testing

- Interaction of subsystems
  - Diesel Generator Load changes w/ energy storage
  - Diesel Generator Efficiency w/ & w/o energy storage
  - Islanded PV and energy storage
  - Control system and algorithms
Benefits

• Improved Reliability
  – Critical load support
  – Integration of multiple generation sources (legacy and renewable)

• Risk Mitigation / Improved Energy Security
  – Eliminate dependence upon local utility
  – Integrating available energy sources for backup power

• Electrical Cost Reduction
  – Intelligent control for peak shaving
  – Renewable Energy Integration
  – Improved asset utilization by integrating distributed sources
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