SPIDERS Industry Day
Implementation Considerations

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Drivers for DoD Microgrids

- Military missions are growing more dependent on state-side installations for operations and logistics
- The US power grid is becoming increasingly fragile
- Threats of physical and cyber attacks on the grid are increasing
- Prolonged utility outages due to natural disasters are occurring more frequently
- Mandates to reduce reliance on fossil fuels

SPIDERS CONOPS

SPIDERS JCTD Objectives

- Provide a Cyber-secure microgrid for Enhanced Mission Assurance
  - Increase reliability of traditional backup generation
  - Reduce fossil fuel consumption of generators
  - Integrate renewable generation in islanded mode
  - Implement a cyber-secure control system

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SPIDERS CONOPS

Do No Harm!

- Maintain reliable legacy systems
  - Existing generation assets
  - Automatic Transfer Switches (ATS)
  - Existing distribution networks
- Avoid additional failure points
- Fail-safe modes should match existing conditions

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SPIDERS CONOPS

Minimize Changes to Existing Infrastructure

- Maximize value through use of existing assets
- Utilize existing infrastructure to increase reliability and maintainability of systems
- Address existing deficiencies in power systems

Minimize Disruption to Ongoing Operations

- Critical Missions can't afford lengthy construction and testing outages
- Seamless transition to/from utility power is crucial during testing and operation

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SPIDERS CONOPS

Enhance Grid-tied Operations

- Improve generator testing capabilities through parallel operation with utility
  - Increase generator certainty
  - Reduce wet-stacking
- Support peak shaving opportunities
- Support grid services

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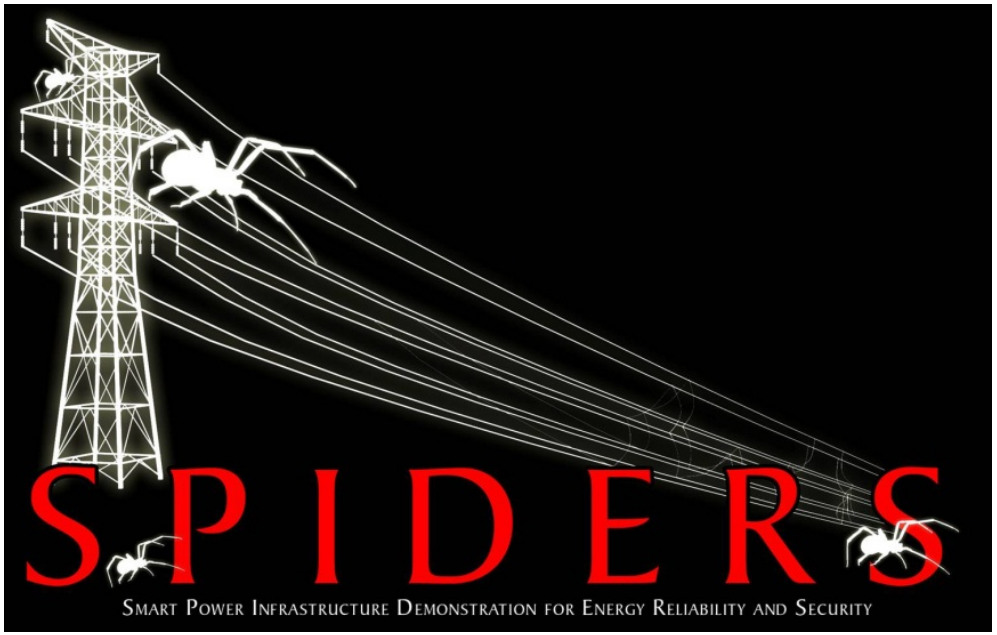
SPIDERS Phase I
Joint Base Pearl Harbor Hickam
Technical Approach



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Site Orientation

Mamala Substation

Renewable Island

WWTP

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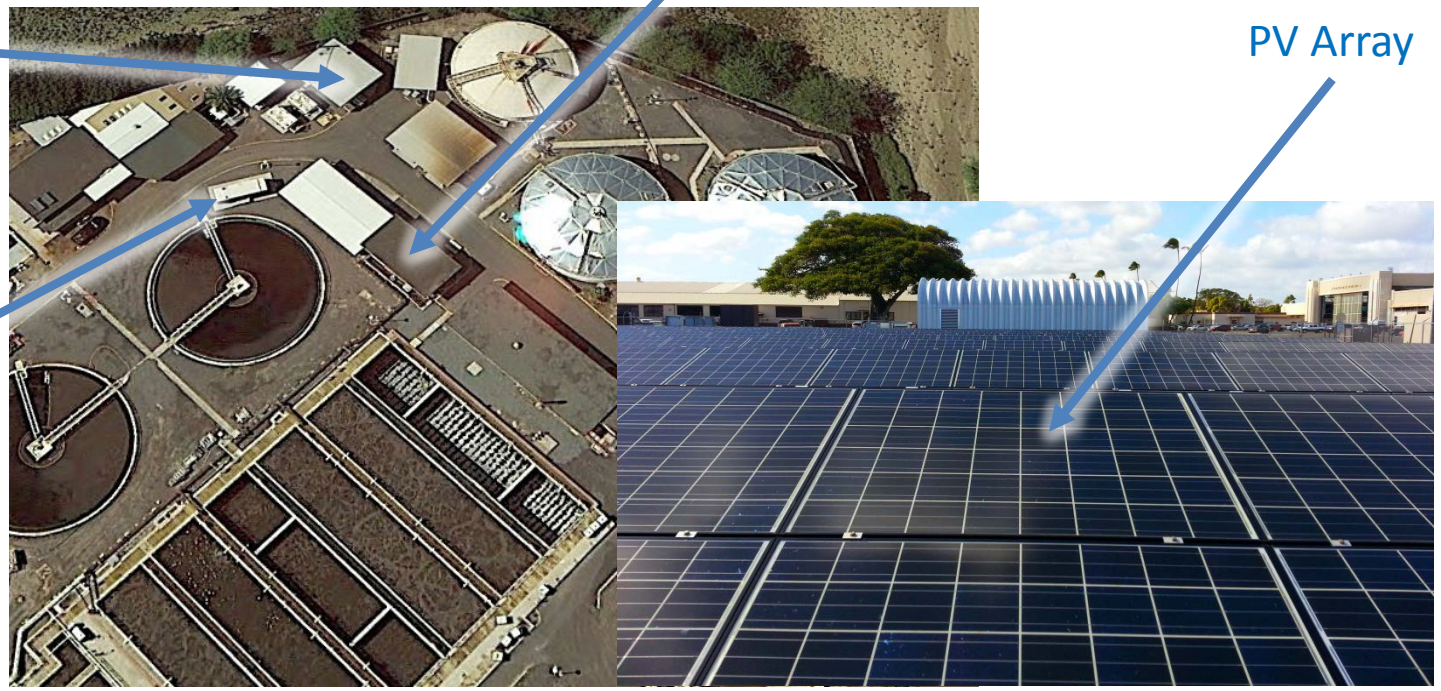
JBPHH Microgrid Overview

- Serves 400-700kW critical load (WWTP)
- Two electrically isolated generators and busses
- 150kW PV array



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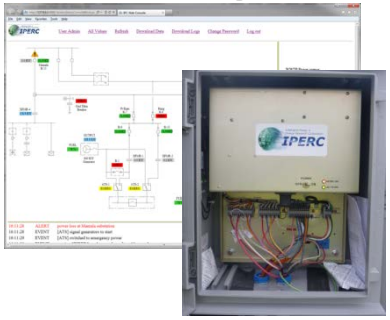
SPIDERS Phase I System

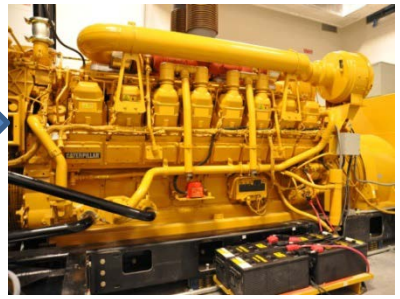
Mamala Substation



Microgrid Control System

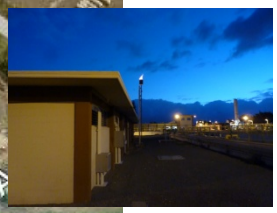
Fort Kam 15kV Feeder

1600kW Generator



Renewable Island

800kW Generator



Critical WWTP Loads

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What has SPIDERS Phase I Demonstrated?

- Stable operation of the Microgrid with PV and diesel power sources in parallel
- High penetration of renewable sources in a microgrid (up to 90% PV penetration)
- Transmission of generator load sharing control signals over long distances
- Creation of a secure control network for a Microgrid per DIACAP Guidelines (PRA Accreditation process)

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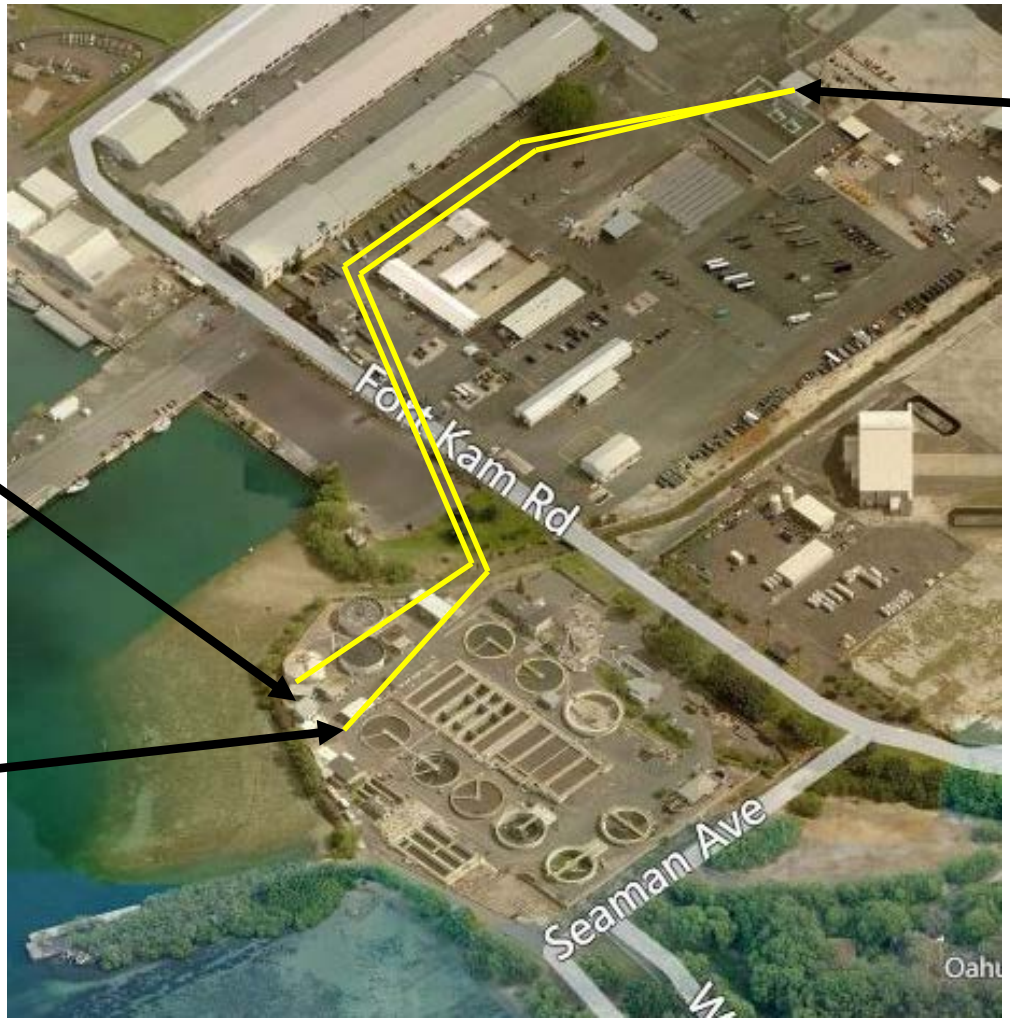
Generator Synchronization Path



Mamala Substation Breaker

1600 kW Generator Controller

800 kW Generator Controller

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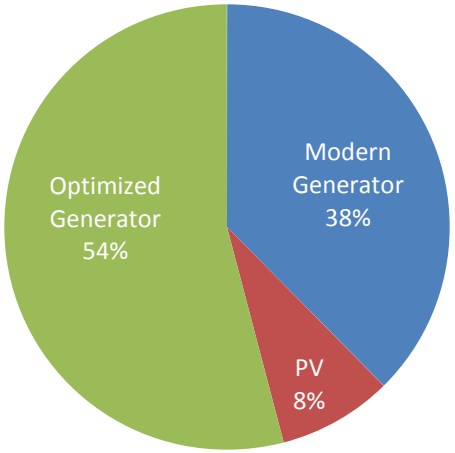
What has SPIDERS Phase I Demonstrated?

- Fail-safe control that reverts to traditional backup power modes
- Enhanced generator testing: ability to test generators at any load without interrupting WWTP
- 30% reduction in diesel fuel consumption when in SPIDERS power mode



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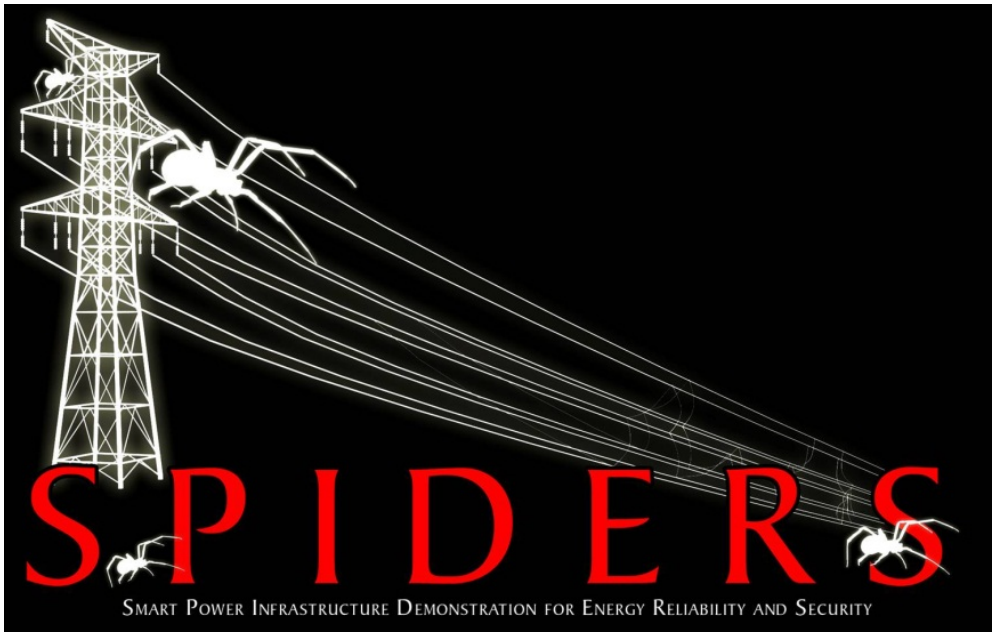
SPIDERS Phase II
Fort Carson, CO
Technical Approach



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Fort Carson Microgrid Overview

- Serves Tier 1, 2 & 3 building loads (2,000 kW) on multiple circuits
- Integrates existing generation assets
  - Three, large diesel generators
  - 2MW PV Array
- Develop bi-directional PEV charging
  - Energy storage
  - Grid services
  - Power factor correction

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Fort Carson Microgrid Overview

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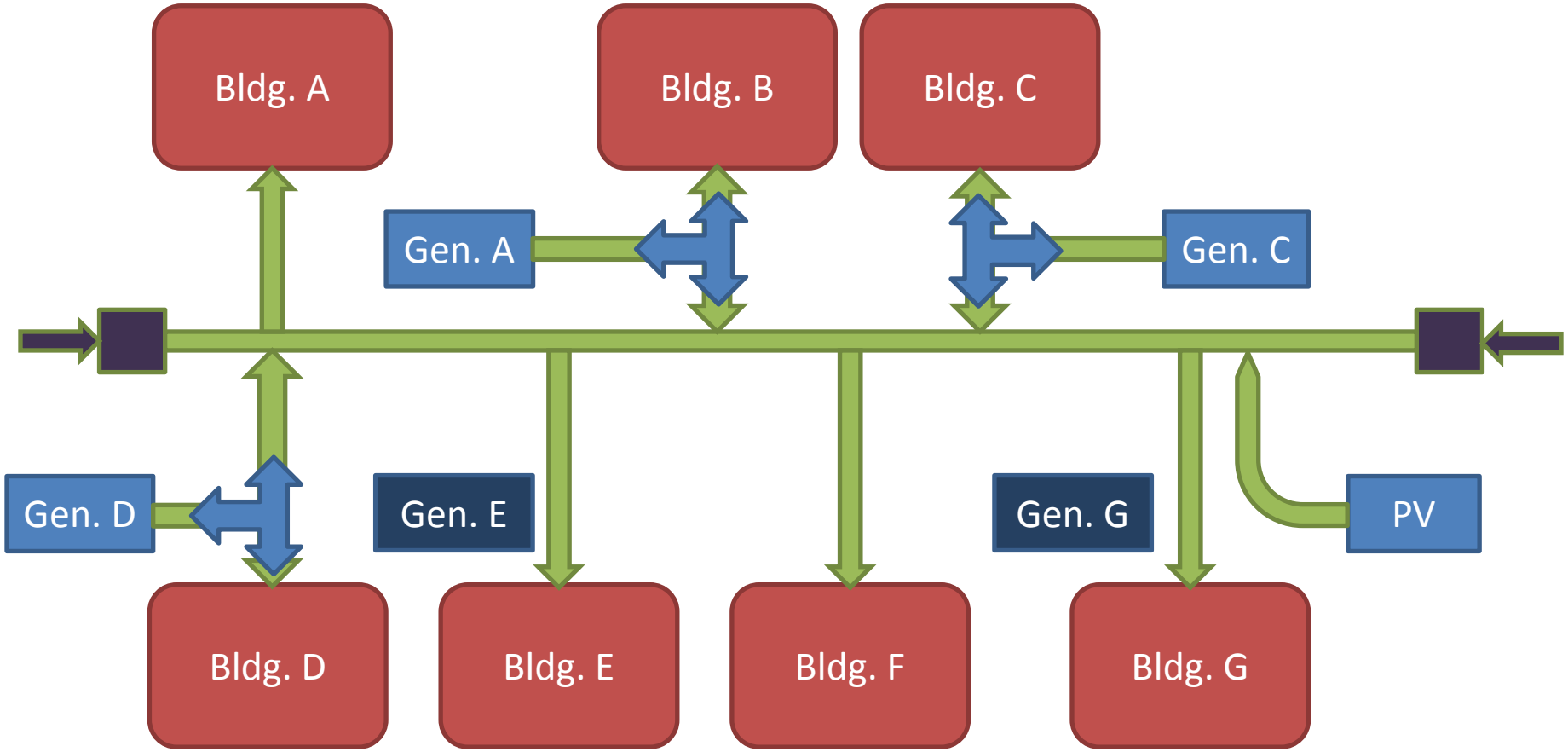
Fort Carson Microgrid Overview



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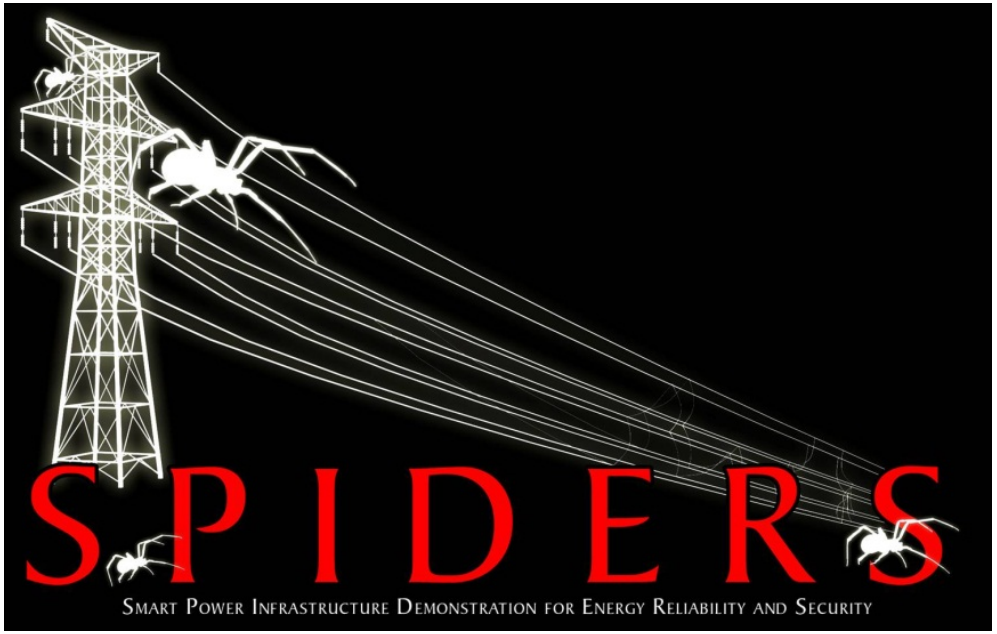
SPIDERS Microgrid
Planning & Design Considerations



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Site Data Package Requirements

- Understand existing electrical topology
  - Substation/PCC Interface (breakers or switches)
  - Certainty of distribution configuration
  - Utility load management responsibilities
  - Grounding reference points
- Prioritization of Loads
  - Based on mission criticality of operation
  - Consider cost-benefits of adding critical loads, omitting non-critical loads

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Site Data Package Requirements

- Understand load profiles
  - Peak and average loads
  - Availability of meter data
  - Ensure renewable output does not exceed load
- Control communications networks
  - Dedicated networks for cyber security
  - Ownership of data lines and pathways
  - Security and segmentation of data lines

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Site Data Package Requirements

- Utility Operations Preferences
  - Utilization of visibility provided by microgrid control system
  - Automatic or manual initiation of microgrid modes
  - Pre-emptive islanding
  - Power reliability of control stations
  - Notifications to utility providers

Codes and Standards

- Unified Facility Criteria (UFC)
- Applicable Building Codes
- Site Specific Criteria
  - Installation standards
  - Corrosive environments
  - Temperature extremes

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Changes to Codes and Standards

- For Buildings with 500kW and Larger Generators
  - Require Automatic Transfer Switches to have remote inputs to command switch to stay on emergency or normal source
  - Provide closed transition transfer switches
  - Require Generators to have load sharing capabilities
  - Require conduits for bypass breakers be installed to service transformer
  - Consider installing SPIDERS bypass breakers on generators
  - Consider standardizing on common generator size

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Changes to Codes and Standards

- For Buildings with 100kW and Larger PV Arrays
  - Require reverse power monitoring of generator to shut down PV array
  - Require remote shutdown of PV array by microgrid controller
  - Require dedicated power meter on PV array to transmit output to microgrid controller
  - Consider VAR compensation
  - Consider connecting inverters directly to main switchboard

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Interconnection Considerations

- Utility Requirements for UL-listing
  - Anti-islanding features of inverters
  - Lack of test standards for microgrid features (i.e. EVSE)
- System Stability
  - UL Listing of typical grid-tied equipment requires voltage and frequency stability for operation
  - Increased use of PV (unity power factor output) reduces power factor from utility, potentially increasing utility rates from penalties
  - Variability of many renewable types requires spinning reserve in the system to compensate for sharp drops in renewable output

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Interconnection Considerations

- Utility Requirements
  - Mixed resource microgrid can require multiple interconnect agreements
  - Work with utilities to widen operating frequencies and voltages for PV arrays
  - No clear requirements for bi-directional electric vehicle charging stations or batteries which operate at non-unity power factor

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Interconnection Considerations

- Third-party Renewable PPA's
  - Large renewable assets should be available for backup power use
  - PPA contracts should allow for microgrid control interface to system
  - PV array design should allow for segmentation of output into managable "blocks" (250kW inverters rather than 1MW blocks)
  - PPA/EUL access agreements should consider future microgrid construction/access
  - DOD must define ICS IA "ownership"
  - PV should be distributed throughout system

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IA Considerations

- Determine control system Accreditation Authority
  - Certification of ICS not standard in the DOD
- Determine control system Ownership
  - Yet to be defined for Phase II

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Questions?

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