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Energy Security: The Microgrid "Systems" Answer

Session 5: Energy Security Solutions

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U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

FEMP
Federal Energy Management Program

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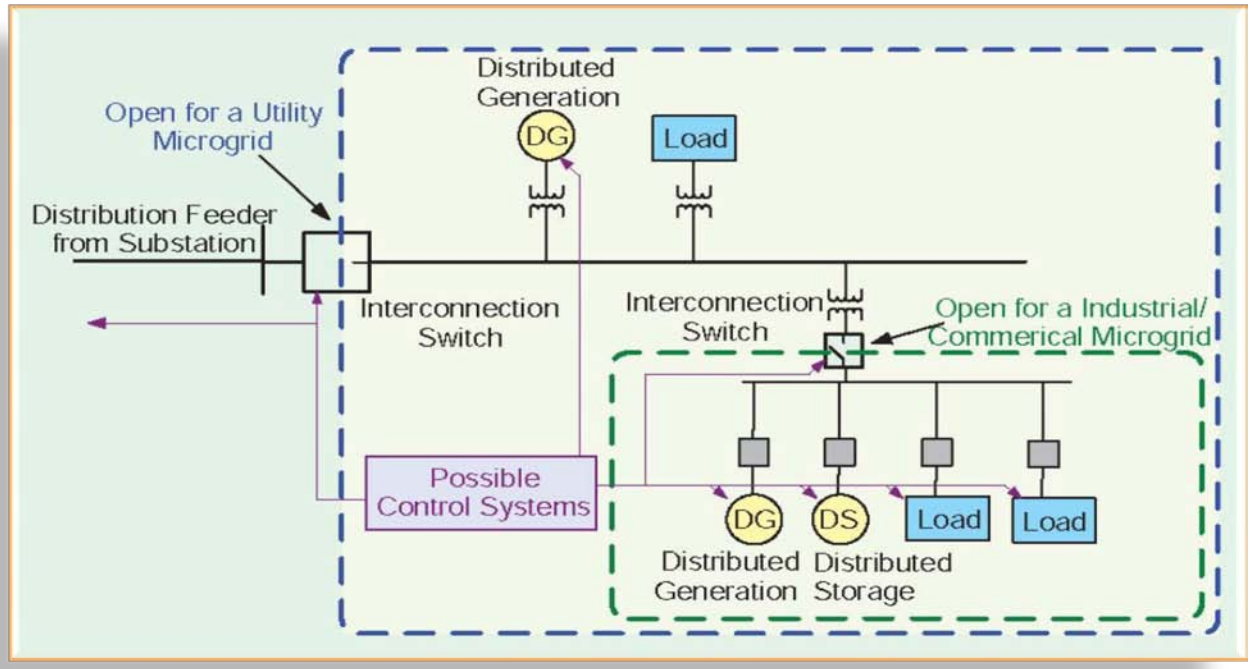
The Department of Energy's Federal Energy Management Program's (FEMP) mission is to facilitate the Federal Government's implementation of sound, cost-effective energy management and investment practices to enhance the nation's energy security and environmental stewardship.

Microgrid Definition ("System of Systems")

A **coordinated** energy and electrical distribution system capable of **independent** and **dispatchable** grid interactive operation that includes:

- **Multiple Distributed Resources** (DR) — from conventional diesel gensets to renewable energy options with storage
- **Multiple Loads** — including load shedding and energy management



Microgrid and Components (Source: Kroposki, et al. 2008)

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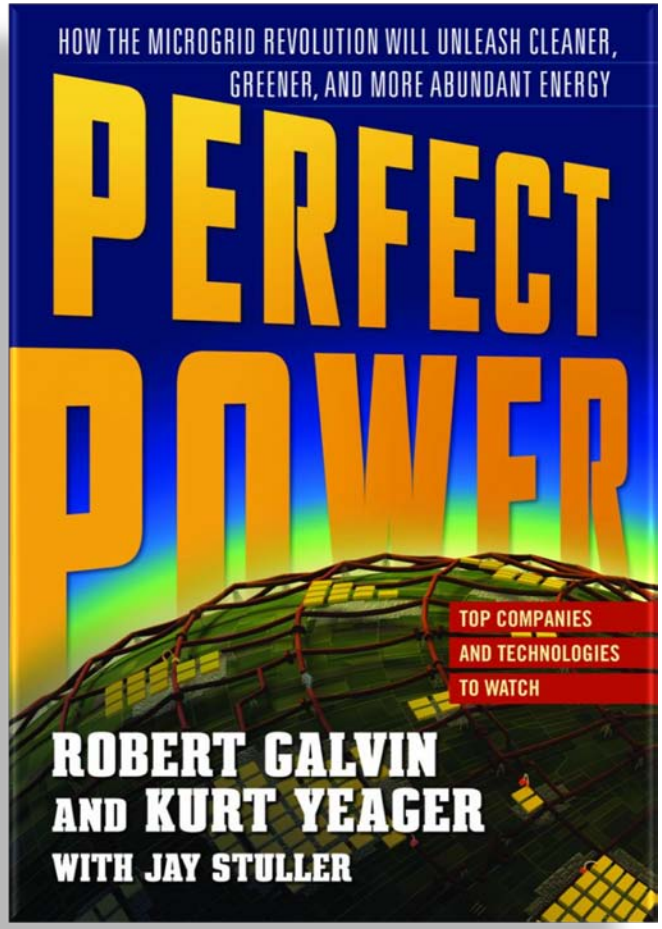
National Perspective:
Paradigm Shift to Smart Microgrids



"Galvin Electricity Initiative, Smart Microgrids"

"In the past 50 years, the electric power system (grid) has starved of innovation despite significant increases in consumer demand—one solution is to expand the role of smart microgrids that interact with the bulk power grid but can also operate independently: Distribution grids transformed from passive to active networks

- Strategy is <u>diversification</u> (decentralization) facilitated by microgrids

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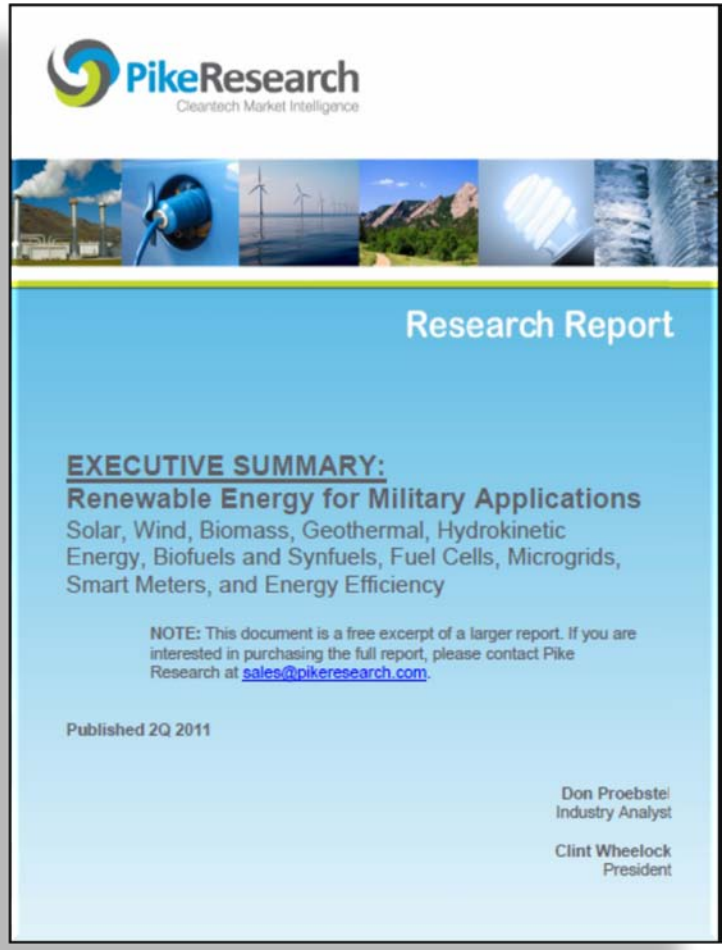
DoD Leadership



PikeResearch
Cleantech Market Intelligence

Research Report

EXECUTIVE SUMMARY:
Renewable Energy for Military Applications
Solar, Wind, Biomass, Geothermal, Hydrokinetic Energy, Biofuels and Synfuels, Fuel Cells, Microgrids, Smart Meters, and Energy Efficiency

NOTE: This document is a free excerpt of a larger report. If you are interested in purchasing the full report, please contact Pike Research at sales@pikeresearch.com.

Published 2Q 2011

Don Proebstel
Industry Analyst

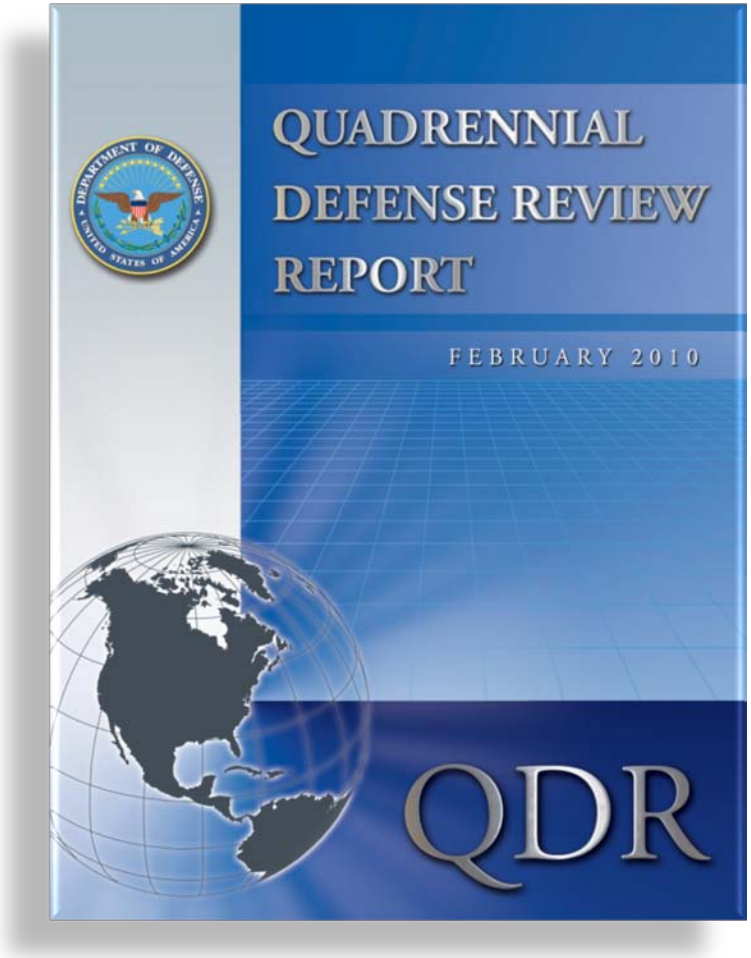
Clint Wheelock
President

"Renewable Energy for Military Applications", Pike Research, 2nd Quarter 2011

"The DoD is effectively fueling the U.S. version of the "green revolution", since the U.S. military is incapable of operating without sufficient energy resources. Accordingly, the entire perspective of national security has undergone a dramatic paradigm shift, incorporating the abstract concept of "energy independence" with the traditional tenets of military superiority defined by sheer might a power of armaments.

- DoD as a leader and key driver

Energy Security: DoD "Mandate"



"2010 Quadrennial Defense Report" (domestic facility energy security guidance)

- Energy security definition: "…assured access to reliable supplies of energy and the ability to protect and deliver sufficient energy to meet operational needs"
- Facilities guidance
  - Address energy security while simultaneously enhancing mission assurance
  - Conduct a coordinated energy assessment to prioritize critical assets
  - Ensure that critical assets are prepared for prolonged outages (natural disasters, accidents, terrorist attacks)

Microgrids: Primary Energy Security Strategy

Microgrid capabilities/benefits

- Isolate itself from the grid when outages occur and reconnect as needed
- Provide power to mission critical facilities during outages - short and longer term
- Incorporate renewables to extend the fuel supply of conventional generators and potentially provide a limitless power supply for continued operation of selected loads
- Group interconnected loads and distributed generation sources to provide enhanced operational efficiencies when connected to the grid by acting as a single controllable entity to the utility
- Provide remote locations with a more robust power supply

DoD Microgrid "State of the Practice"

- NZEI basis for microgrid design
- Microgrid activity update
- NREL microgrid planning and design experience

NZEI Facilitated Microgrid Implementation

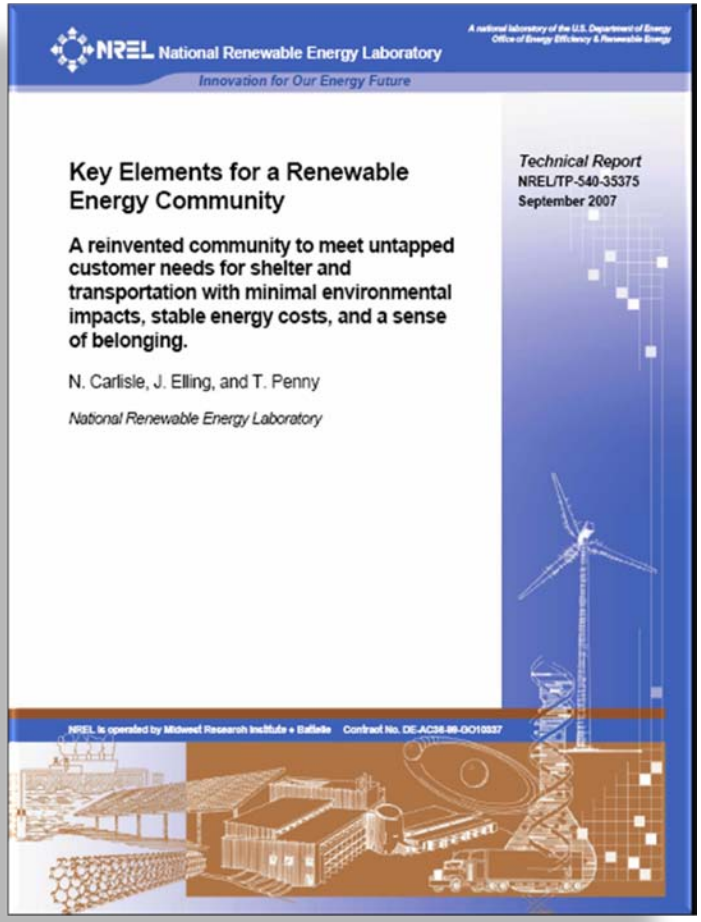
NZEI systems approach optimal for microgrid facilitation (energy and security nexus).

- Minimizes loads (buildings (retrofits and new construction), transportation, etc.)
- Maximizes use of renewable energy resources (high penetration scenario)
  - Renewable energy projects critical to NZEI and microgrid projects
- Identifies grid related opportunities (bi-directional energy flows)
  - Sale of power(arbitrage), demand response, etc.
- Characterizes microgrid (microgrid "baseline")
  - Base distribution system/grid interface (one-line electrical diagram)
  - Distributed energy resources (diesel generators/storage and renewable energy combination)

NZEI Concept

- Net Zero Energy Community (ZEC) **definition:** A community that has greatly reduced energy needs through efficiency gains such that the balance of energy needs for vehicles, thermal energy, and electric energy within the community is met by renewable energy."

- DoD-DOE NZEI Task Force NZEI **definition:** A military installation that produces as much energy on or near the installation as it consumes in its buildings and facilities (maximizing the use of renewable energy resources)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Innovation for Our Energy Future

Key Elements for a Renewable Energy Community

A reinvented community to meet untapped customer needs for shelter and transportation with minimal environmental impacts, stable energy costs, and a sense of belonging.

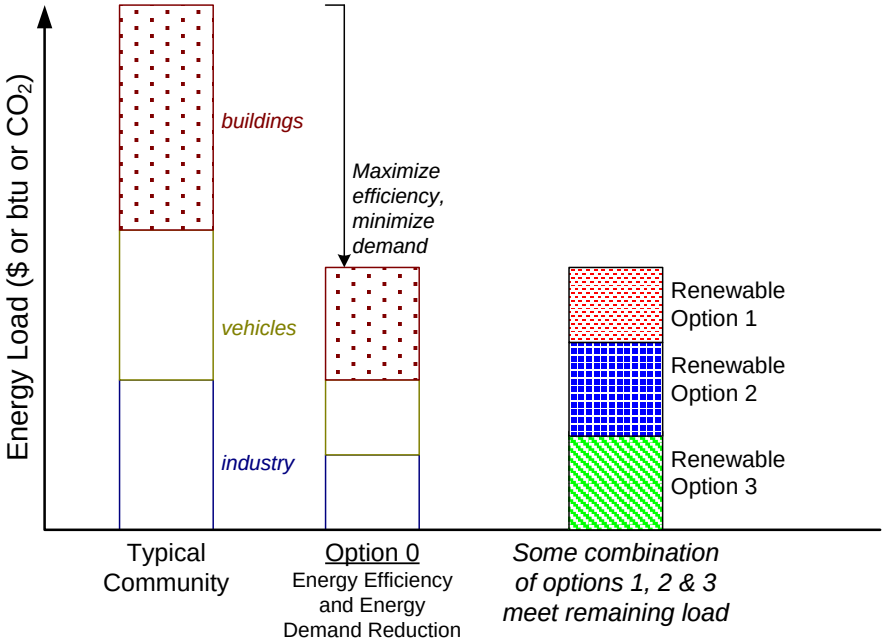
N. Carlisle, J. Elling, and T. Penny

National Renewable Energy Laboratory

Technical Report
NREL/TP-540-35375
September 2007

Approach: NZEI Systems Assessment Overview

- Baseline
  - Current energy consumption
- Energy Efficiency
  - Retrofit improvement potential
  - New construction design improvement and optimization
- Renewable Energy
  - Deployment of renewable energy
- Electrical Systems
  - Interconnection and microgrid
- Transportation
  - Reduce and replace fossil fuel use
- GHG
  - Baseline and reductions



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Approach: NZEI Assessment Support Software Tool Suite

- Efficient building retrofits
  - Pre-Engineering Analysis tool - systematic energy efficiency and renewable energy assessment
- Efficient new buildings
  - Opt E-Plus (commercial buildings)- informs/optimizes design (energy modeling) process
  - B-Opt – counterpart tool for residential (base housing) applications
- Renewable energy utilization
  - Renewable energy assessment "tool" - preliminary screening to determine the least cost combination for facility RE
- Electric grid opportunities (microgrid/secure operations)
  - Hybrid Optimization Model (HOMER) tool
    - Optimizes the system design by simulating various configurations of distributed energy resources
    - Simulates hour-by hour operation of the system and load profile to evaluate performance/ lowest cost of energy
  - Distributed Engineering Workstation (DEW) tool-power flow analysis
- Fleets
  - Fleet Optimization tool (NOVA) – identifies optimal fleet strategies

Primary NREL NZEI Projects/Activities

- DoD-DOE Initiative NZEI projects
  - Marine Corps Air Station Miramar
  - US Air Force Academy
  - Army Pahokuloa Training Center (HI)
  - Naval District of Washington: South Potomac
- Ft. Carson (NZEI and V2G assessment)
- Ft. Bliss (Army Tiger Team Net Zero/Energy Security Demo site)
- Army Net Zero program (site selection and NZEI site implementation support)
- Navy Net Zero program (site selection and implementation budget estimate support)

DoD Microgrid Activity Overview

- OSD Environmental Security Testing and Certification Program (ESTCP)
  - DoD is appropriate test bed (150 years of experience as sophisticated first use user of technology)
  - Representative projects (Ft. Bliss, Ft. Carson, Twentynine Palms, etc.)

- OSD Energy Conservation Implementation Program (ECIP):Microgrid Planning and Design related projects (MCAS Miramar, US Air Force Academy, Naval District of Washington, Joint Base Lewis-McChord, Ft. Carson (V2G) and PACOM (Camp Smith))

- DoD-DOE MOU collaborations (representative)
  - Office of Electricity (OE): DOE and DoD jointly fund development of multiple energy surety microgrid conceptual design projects
  - Federal Energy Management Program (FEMP) technical assistance: (Ft. Bliss, Ft. Carson, PACOM, etc.)

NREL Microgrid Implementation Support Projects

OSD ECIP Funding ($2.0M)

- MCAS Miramar (NZEI assessment follow-up)
  - Microgrid planning and design
- U.S. Air Force Academy (NZEI assessment follow-up)
  - Microgrid planning and design
  - Large scale storage integration

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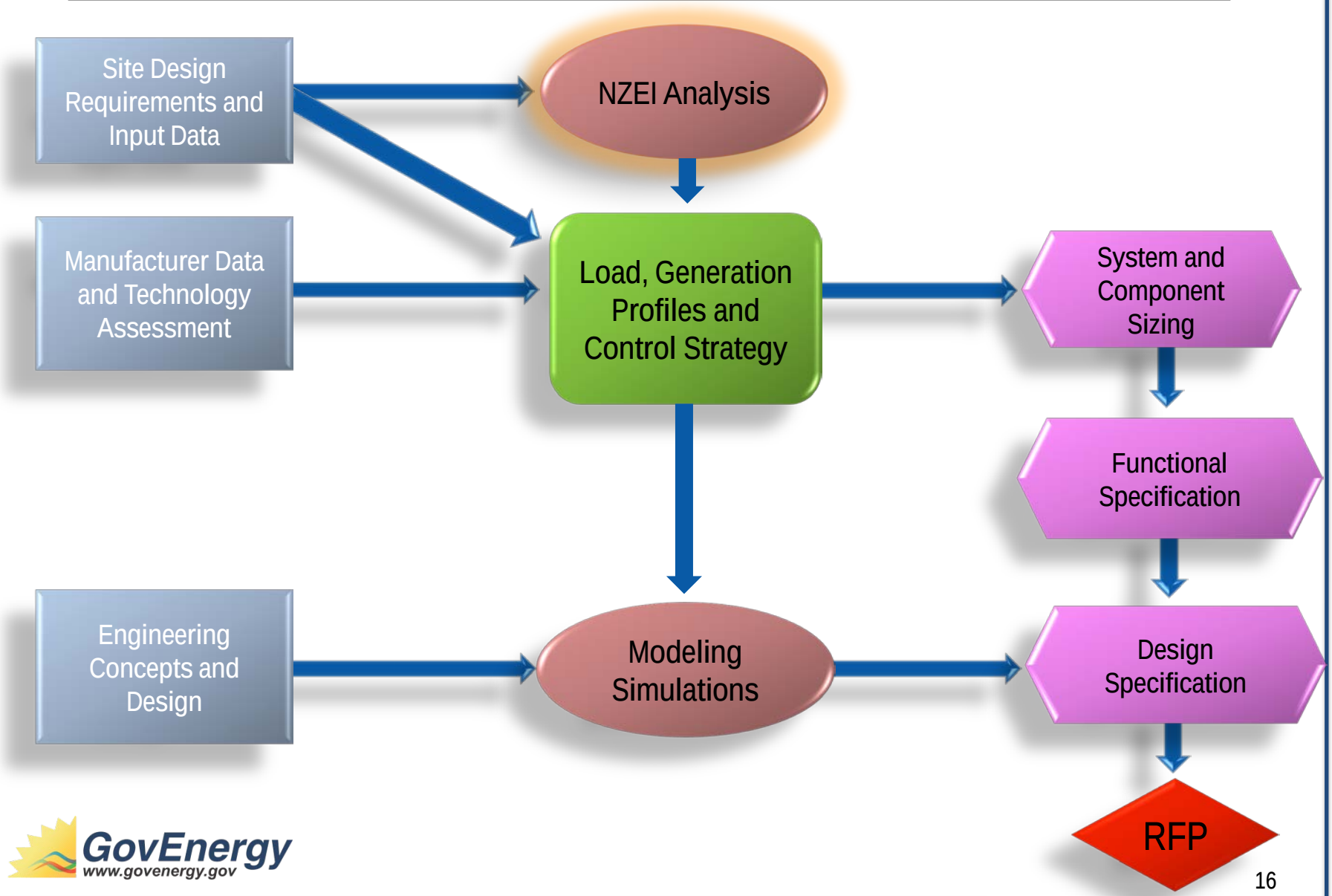
Microgrid Design Process



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Microgrid Planning & Design - Approach

- Step 1: Identify Site Requirements
- Step 2: Classify Loads
- Step 3: Classify DR - Distributed Generation (DG) & Distributed Storage (DS)
- Step 4: Evaluate Generation/Load Match
- Step 5: Develop Control Strategy
- Step 6: Determine Equipment Requirements & Develop RFP

MCAS Miramar Microgrid Project Status

- Project term: one year (start April 2011)
- NZEI project identified electrical baseline and possible critical loads to be included in microgrid; verification required
- Miramar system peak is 13.5 MW (10/2008); average is 7.6 MW; minimum load is 5.4 MW; traditional utility/owner relationship
- Critical loads total 2.4 MW
- Miramar has 3 large generators that operate in parallel and connect to the system at medium voltage primary service equipment
- Electrical distribution system at Miramar is very robust

US AFA Microgrid Project Status

- Project term one year (start July 2011)
- USAFA is in the process of turning over their campus distribution system to the local utility (Utility Privatization)
- Two substations on campus – approximately 10 MW load on West Substation & 6 MW on South Substation; minimum total site load is approx. 10 MW
- Mission essential loads have been identified (Cadet dorm, dining, & teaching area); electrical load characteristics are unknown at this time (no individual building meters)
- Many existing generators, but all are emergency/standby dedicated for specific buildings and are not designed for parallel utility operation

Related Microgrid Topics

- RE integration
- NREL Energy Systems Integrated Facility
- IEEE Standard 1547.4

NREL Distributed Energy Resource Grid Integration Capabilities Overview

Distributed Energy Resources

Fuel Cell

PV

Microturbine

Wind

Energy Storage

PHEV - V2G

Generator

Interconnection Technologies

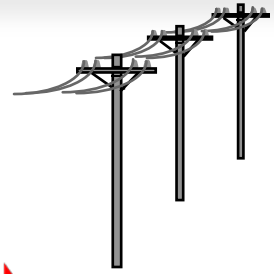
Inverter

Switchgear, Relays, & Controls

Functions

- Power Conversion
- Power Conditioning
- Power Quality
- Protection
- DER and Load Control
- Ancillary Services
- Communications
- Metering

Electric Power Systems


Utility System

Microgrids

Loads

Local Loads
Load Simulators

NREL Energy Systems Integration Facility (ESIF) Capabilities

153,400 sq. ft.
Occupancy 2012

- Research facility for testing of electrical systems
  - Renewable energy generating systems integration
  - Plug-in hybrid vehicles and electrical storage systems
  - Hydrogen energy systems, production, and storage
  - High performance computing capability (200+ teraflop) for research modeling and simulation (expansion capability to 1,000 teraflops)
  - Will allow for collaboration and industrial partnering
  - Showcase “Green Computing” Data Center

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Microgrid Standard – IEEE 1547.4

- Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems
  - Covers **intentional** islands in electric power systems (EPSs) that contain distributed resources (DR)
  - The term "DR island systems", sometimes referred to as microgrids, is used for these intentional islands
  - DR island systems have DR and load, have the ability to disconnect from and parallel with the area EPS, include the local EPS and may include portions of the area EPS, and are intentionally planned

Closing Observations/Comments

- Collaboration with the serving utility is a “must”
  - UC San Diego microgrid/SDGE outage
- Emergence of “systems integrator”
- Microgrid design observations
  - Microgrid size and complexity is limited by the amount of DR available, site mission/constraints, staff operational capabilities, and the control system’s limitations
  - Microgrid design consideration framework (redundancy, communications, cost, ultimate security need)
  - Seamless vs. “blackout” microgrid control and communications strategies
- Coordinate microgrid implementation appropriately with phase of NZEI implementation
- Robust microgrid design characterized as follows: integrated RE, enduring, and operational

Thank You!
QUESTIONS?

For more information:

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