



**Office of Electricity  
Delivery & Energy  
Reliability**



# **Microgrids and Best Practices**

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Power Systems Engineering Research and Development

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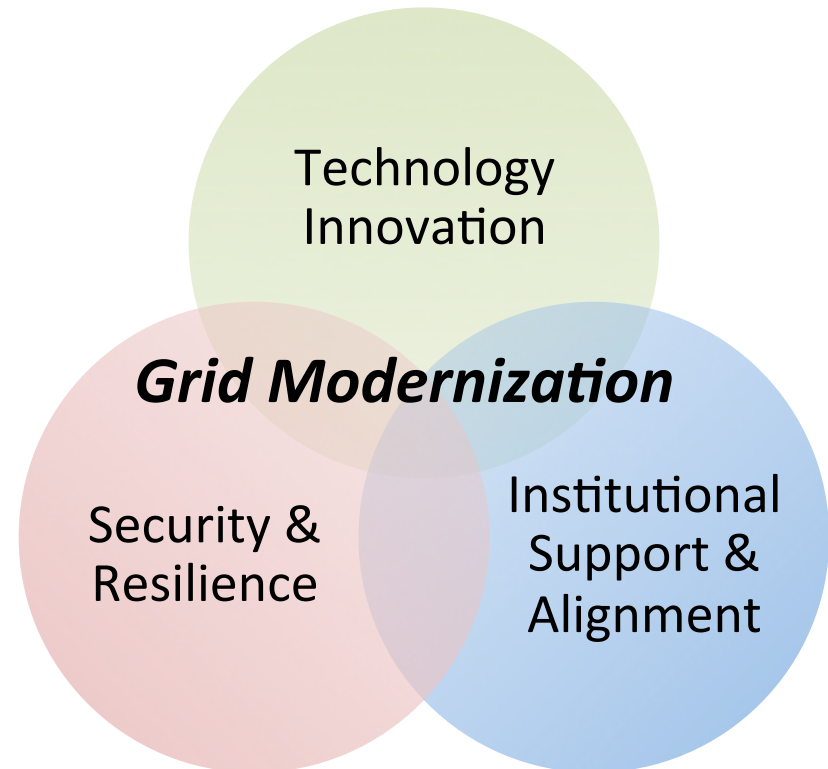
Aalborg 2015 Symposium on Microgrids



# OE Mission

**The Office of Electricity Delivery and Energy Reliability (OE) drives electric grid modernization and resiliency in the energy infrastructure.**

- OE leads the Department of Energy's efforts to ensure a resilient, reliable, and flexible electricity system.
- OE serves as the Energy Sector Specific lead for the Federal emergency response when activated by DHS/FEMA.





# Grid Modernization Vision

*The future grid provides a critical platform for U.S. prosperity, competitiveness, and innovation in a global clean energy economy. It must deliver **reliable, affordable, and clean electricity** to consumers where they want it, when they want it, how they want it.*

## Achieve Public Policy Objectives

- 80% clean electricity by 2035
- State RPS and EEPS mandates
- Access to reliable, affordable electricity
- Climate adaptation and resilience

## Sustain Economic Growth and Innovation

- New energy products and services
- Efficient markets
- Reduce barriers for new technologies
- Clean energy jobs

## Mitigate Risks and Secure the Nation

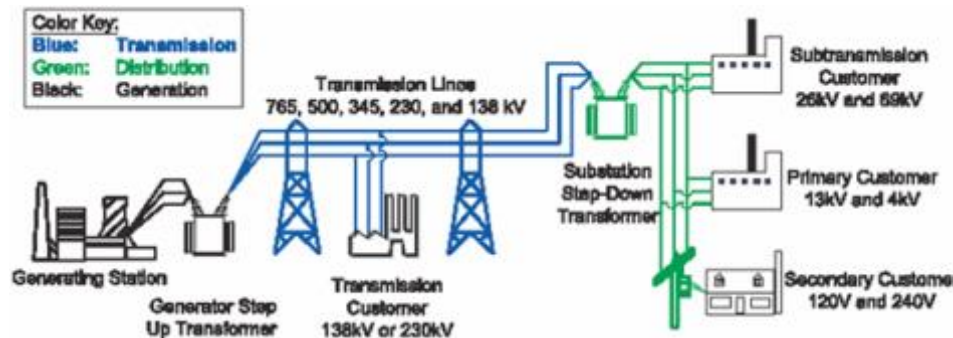
- Extreme weather
- Cyber threats
- Physical attacks
- Natural disasters
- Fuel and supply diversity
- Aging infrastructure



# Transforming the Grid

## Current System

- Monolithic
- Centralized generation
- Decisions driven by cost
- Catastrophic events
- Limited energy choices
- Vulnerable to new threats



## Future Paradigm

- Modular and Agile
- Centralized and distributed generation
- Decisions driven by cost and environmental sustainability
- Contained events
- Personalized energy options
- Inherently secure to all threats





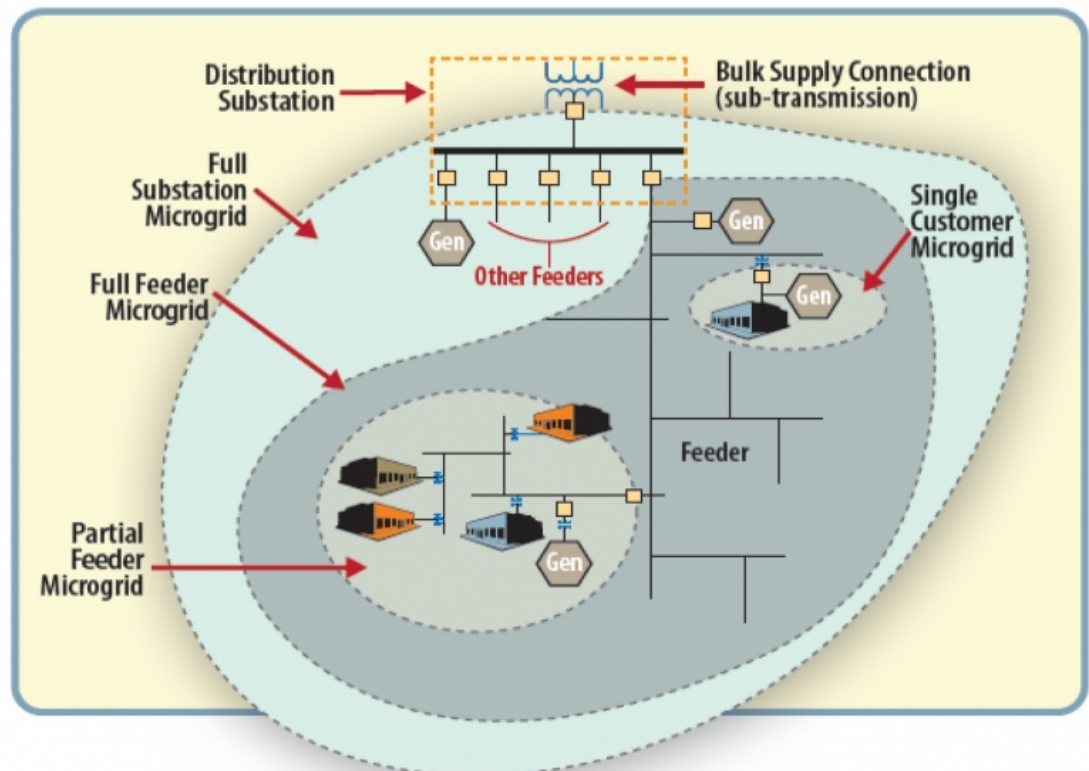


# Defining Microgrids

A **microgrid** is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid.

It can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.

Residential	Less than 10-kW, single-phase
Small Commercial	From 10-kW to 50-kW, typically three-phase
Commercial	Greater than 50-kW up to 10MW





# Microgrids

## Benefits and Technical Challenges

### Benefits

- Enables grid modernization
- Integrates multiple Smart Grid Technologies
- Enhances integration of distributed and renewable energy sources
- Meets end-user needs by ensuring energy supply for critical loads, controlling power quality and reliability at the local level
- Promotes customer participation through demand side management
- Supports the macrogrid by handling sensitive loads and supplying ancillary loads to the bulk power system

### Technical Challenges

- Reliable Operations and Control
- Energy Storage
- Component Designs and Compatibility
- Analytical Tools
- Reliability
- Communications



# Advanced Microgrid R&D Program Goal and Strategy

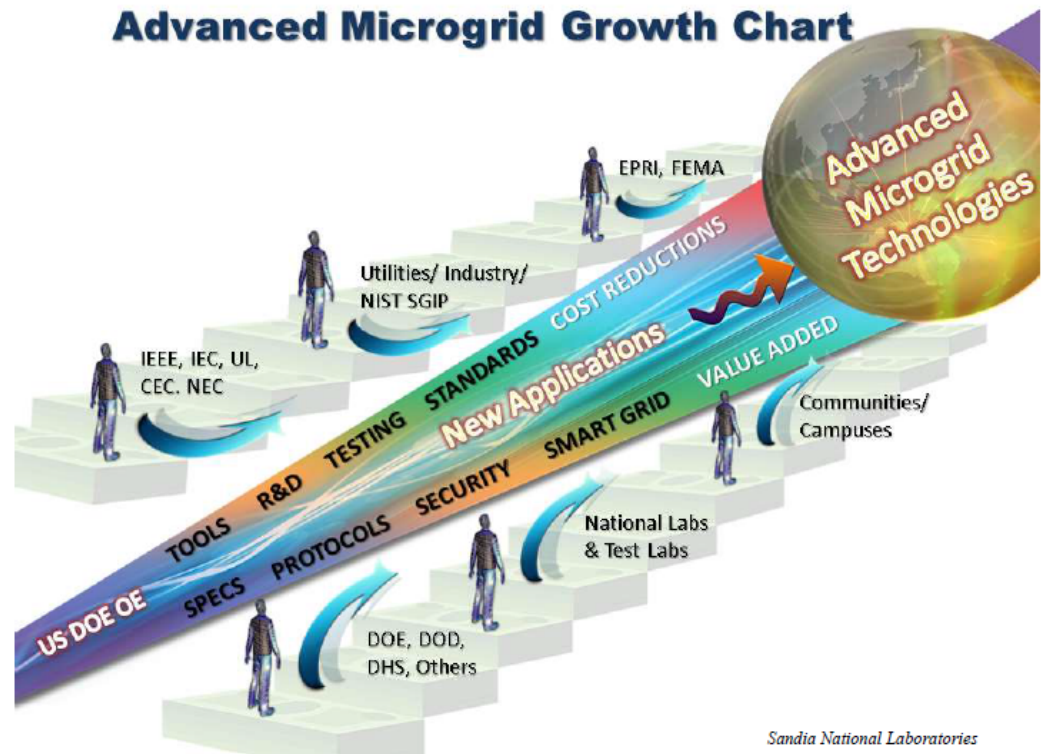
## Goal:

Develop and enable the technologies needed to increase the ranges and applications of energy efficient advanced microgrids capable of maintaining or improving the power quality, reliability and resilience of the utility grid during times of interoperability.

## Strategy:

Through a well-coordinated team of experts in applying advanced technologies, cost share, system logistics, component testing, standards, codes, and facilitating with stakeholders/customers, improve the reliability and increase the value of large, innovative microgrids (initially up to 10 MW capacity)

## Advanced Microgrid Growth Chart



Sandia National Laboratories



# Microgrid R&D Program Goals

## *Short-term*

- Partner with States (NJ, VT, CT, NY) to deploy microgrids for rebuilding electric infrastructure by providing technical assistance and advanced R&D products
  - E.g., Ongoing partnerships with NJ on TransitGrid and rebuilding electric infrastructure post Sandy

## *Mid-term*

- Expand multi-state and regional partnerships to promote microgrids for enhanced recovery and resilience of electric grid

## *Long-term*

- Fully integrate a network of microgrids at customer sites and varying scales (feeders, substations) to support achieving a self healing distribution and transmission system

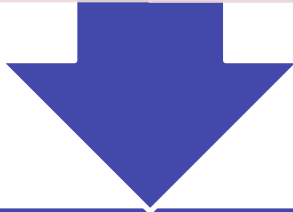


# DOE Microgrid R&D Program

## 2011 Workshop

Defined the DOE 2020 targets

Recommended further integration of component- and system-level R&D areas



## 2012 Workshop

Prioritized R&D topics in planning/design

Prioritized R&D topics in operations/control

**Develop commercial scale (<10 MW) microgrid systems capable of meeting the 2020 targets:**

- Reduce outage time of critical loads by >98% at a cost comparable to non-integrated baseline solutions (uninterruptible power supply + diesel generator)
- Reduce emissions by >20%
- Improve system energy efficiencies by >20%





# Implementation Pathways

## National Labs

- Foundational R&D
- Integrated tools for microgrid planning/design and operations/control

## Industry-led

- Commercial viability
- Community-defined resiliency objectives
- Testing to be completed in FY16; field demo in FY17+

## State/regional partnerships

- Microgrid deployment
- Individual states (NJ, VT, CT, NY) in FY 13-15
- Regional energy assurance in FY16+

## DC Microgrids

- Scoping study in FY14
- New project starts in FY15 to achieve climate-neutral buildings

## Networked Microgrids

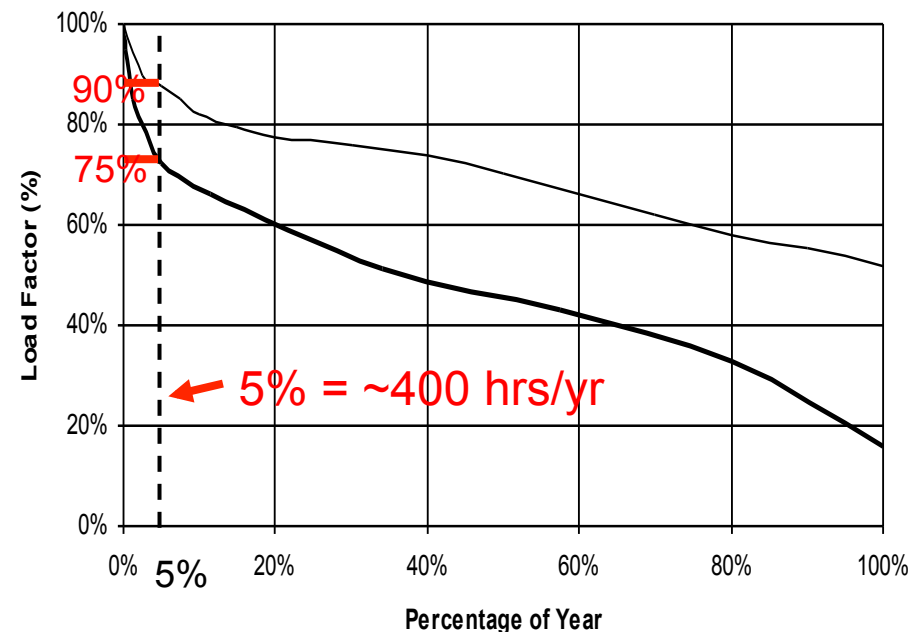
- Scoping study in FY15
- New FOA awards in FY16 for integrating a network of multiple microgrids with distribution systems



# Microgrid for Peak Load Reduction

- 25% of distribution capacity and 10% of generation capacity is used less than 5% each year
- 9 projects in 8 states on-going to integrate DER to provide >15% peak demand reduction on a feeder or at a substation
- Projects are either microgrids or are developing technologies that will advance microgrids

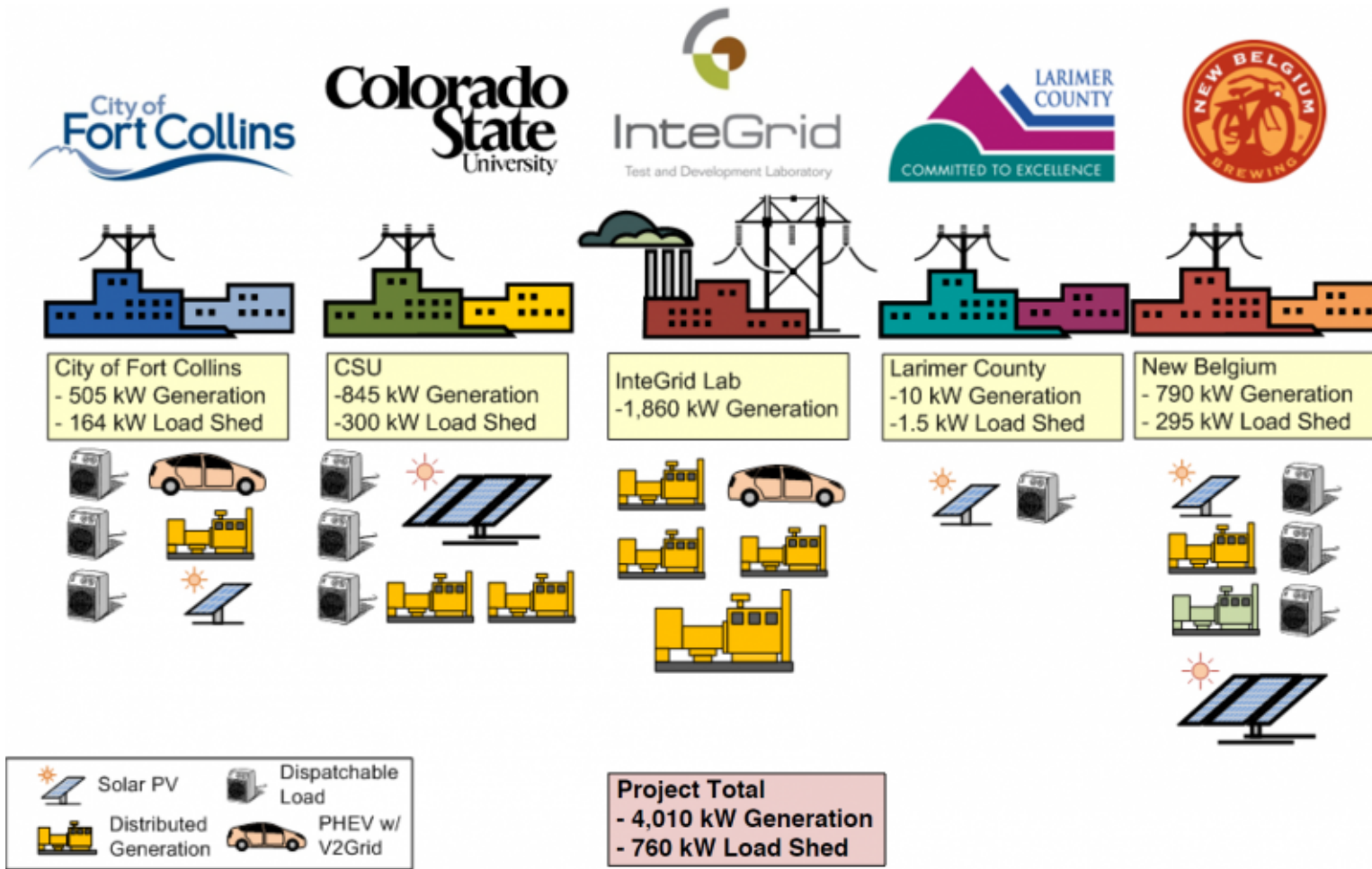
## *Lower Peak Demand Reduces Infrastructure Investments*





# Fort Collins Zero Energy District (FortZED)

Microgrid demonstrating a coordinated and integrated system of mixed distribution resources to achieve a 20-30 peak load reduction on multiple distribution feeders





# Santa Rita Jail

## *CERTS Microgrid Controller*

**Distributed energy resources management system reduces peak demand in normal-mode and operates microgrid in island-mode**

Connection to PG&E with disconnect

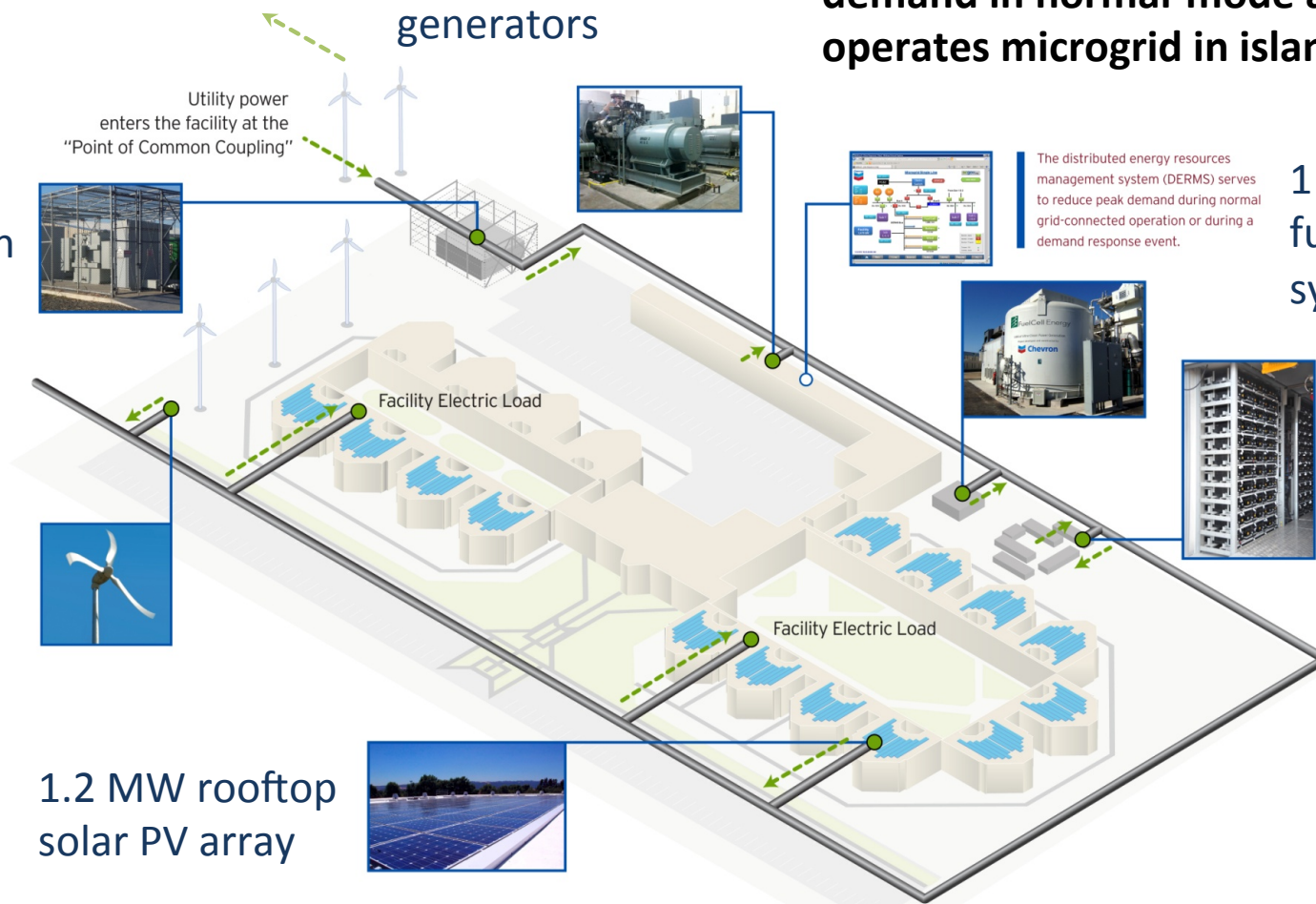
Two 1 MW backup diesel generators

1 MW fuel cell system

2 MW energy storage system

Five 2.3 kW wind turbines

1.2 MW rooftop solar PV array





Conceptual Designs/ Assessments	Small Scale Microgrid Demos	Large Scale Microgrid Demos	Operational Prototypes
<ul style="list-style-type: none"> <li>Philadelphia Navy Yard – FY11, DOE OE/PIDC</li> <li>Camp Smith – FY10, DOE FEMP</li> <li>West Point FY12, DoD/DOE</li> <li>Indian Head NWC – FY09, DOE OE/DoD</li> <li>Ft. Sill – FY08, Sandia LDRD</li> <li>Ft. Bliss – FY10, DOE FEMP</li> <li>Ft. Carson – FY10, DOE FEMP</li> <li>Ft. Devens (99<sup>th</sup> ANG) – FY09, DOE OE/DoD</li> <li>Ft. Belvoir – FY09 DOE OE/ FEMP</li> <li>Cannon AFB – FY11, DOE OE/ DoD</li> <li>Vandenberg AFB – FY11, DOE FEMP</li> <li>Kirtland AFB – FY10, DOE OE/ DoD</li> <li>Maxwell AFB – FY09, DoD/DOE</li> </ul>	<ul style="list-style-type: none"> <li>Maxwell AFB – FY09, DoD</li> <li>Ft. Sill – FY09, DoD w/ SNL serving as advisor</li> </ul>	<ul style="list-style-type: none"> <li>SPIDERS JCTD – FY11, DOE/DoD               <ul style="list-style-type: none"> <li>Camp Smith</li> <li>Ft Carson</li> <li>Hickam AFB</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>H.R. 5136 National Defense Authorization Act</li> </ul>

The map displays the United States with state boundaries labeled. Red dots indicate the locations of microgrid demonstration sites. The locations are: California (near San Diego), Colorado (two dots, one near Denver and one further south), New Mexico (one dot near the Texas border), Texas (one dot near the New Mexico border), Oklahoma (one dot), Alabama (one dot), Mississippi (one dot), Florida (one dot), and Hawaii (one dot). In the Northeast, there are several dots in New York, New Jersey, Delaware, and Pennsylvania, corresponding to the locations mentioned in the table (Camp Smith, Ft Carson, Hickam AFB, and Philadelphia Navy Yard).







# Smart Power Infrastructure Demonstration for Energy, Reliability, and Security (SPIDERS)

- SPIDERS is building three microgrids, each with increasing capability, which will function as permanent energy systems for their sites
  - Site 1 (Joint Base Pearl Harbor Hickam): Completed
  - Site 2 (Fort Carson): Completed
  - Site 3 (Camp Smith): Completed preliminary design, demo in FY15
- The project will promote adoption of microgrid technology for DoD through:
  - Design and requirements methodology
  - Cyber security architecture



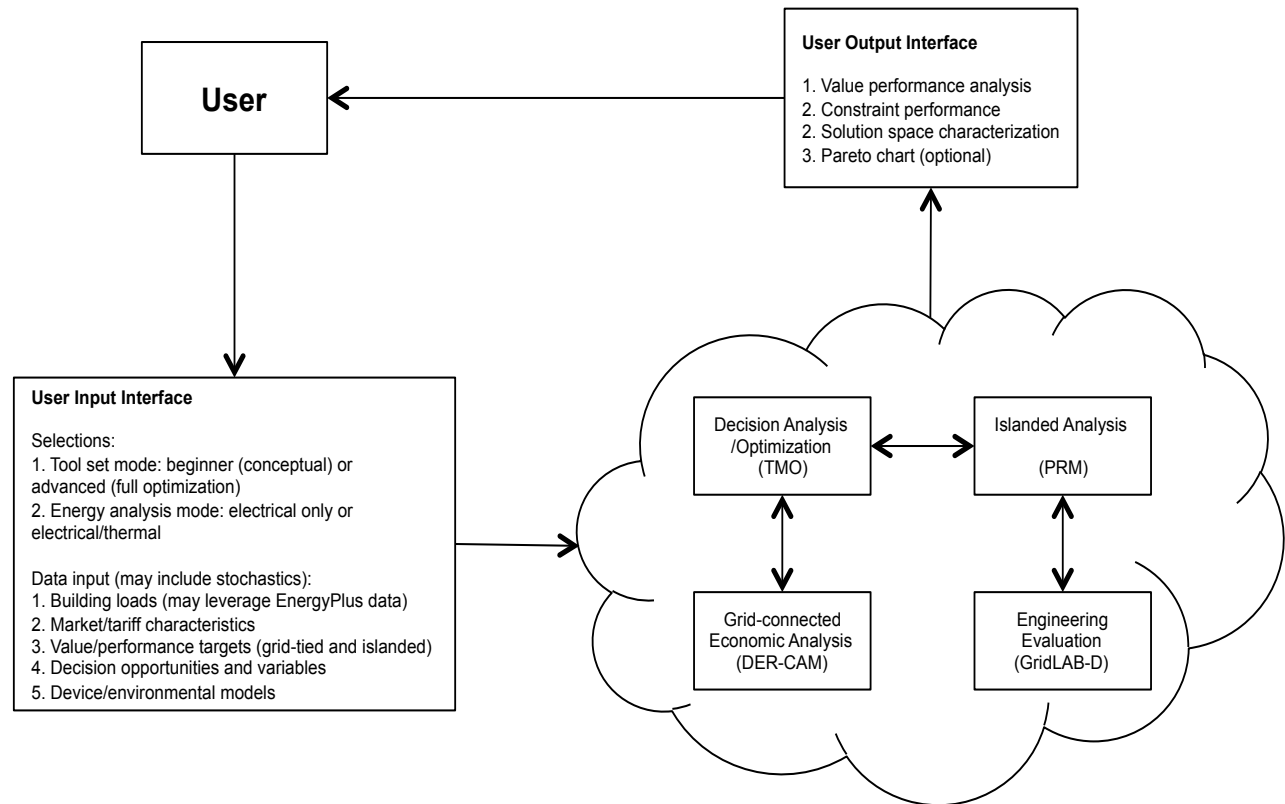


# Microgrid Design Toolset (MDT)

## Average Microgrid Cost Breakdown

- Design: **15%**
- Equipment: **50%**
- IT, Communications, and Networking: **5%**
- Operational Technology (OT): **10%**
- Installation and Commissioning: **20%**

## MDT Architecture





# Microgrids for Resilience



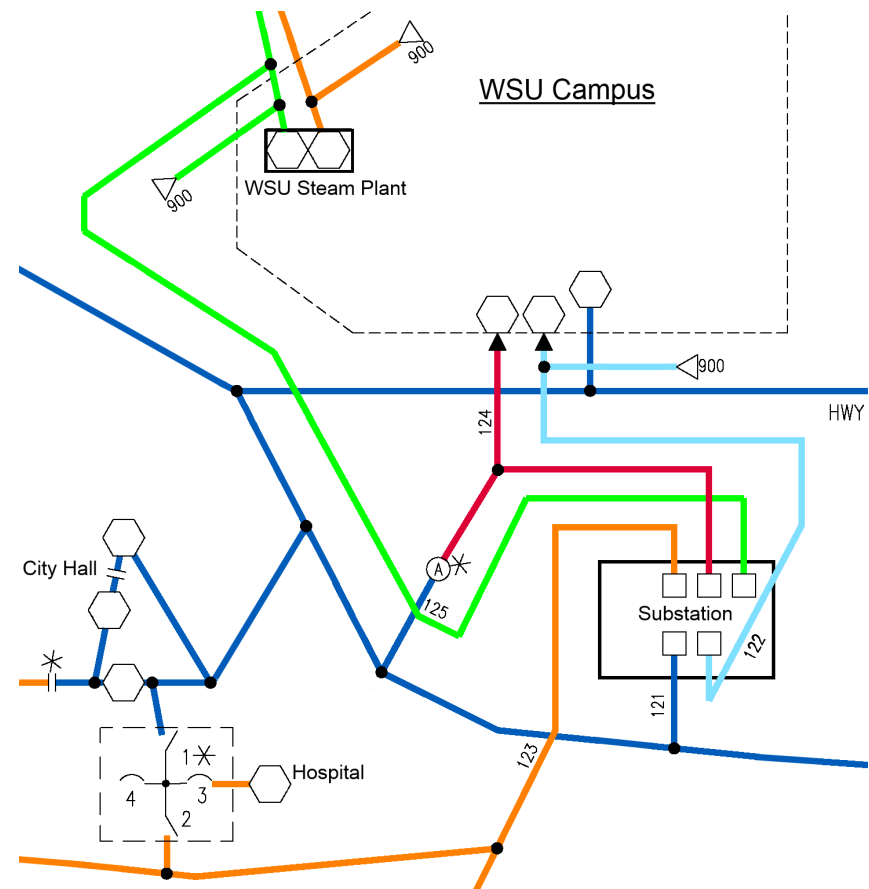
Brevoort Co-op, Manhattan

*"CERTS microgrid-co-gen system from Tecogen comes through for Greenwich Village Co-op building during superstorm Sandy."*

*"The CERTS microgrid control technology is the most radical of all options-as well as the lowest cost-as it is embedded into a 100-kW CHP system offered by Tecogen"*

Peter Asmus, Navigant

Utilizing WSU-Pullman microgrid to reduce switching operations for faster restoration and picking up more interrupted load during major outages





# State Partnerships



## NJ TransitGrid Project

- Microgrid to enhance grid-rail resiliency to serve over 900,000 riders/day
- Key evacuation service for Manhattan & N. New Jersey
- MOU between DOE and State of NJ
- **Completed the feasibility study of a microgrid to fortify the public transportation network**

## Hoboken ESDM Project

- Provide electrical power to support critical functions up to 7 days for 52,000 residents in 1.2 sq. mi.
- Key evacuation route for Manhattan
- DOE-Hoboken-BPU-Sandia-PSEG Partnership
- **Completed a microgrid conceptual design for Hoboken, NJ, to enhance system resilience post-Sandy**





# Supporting Smart and More Resilient Communities

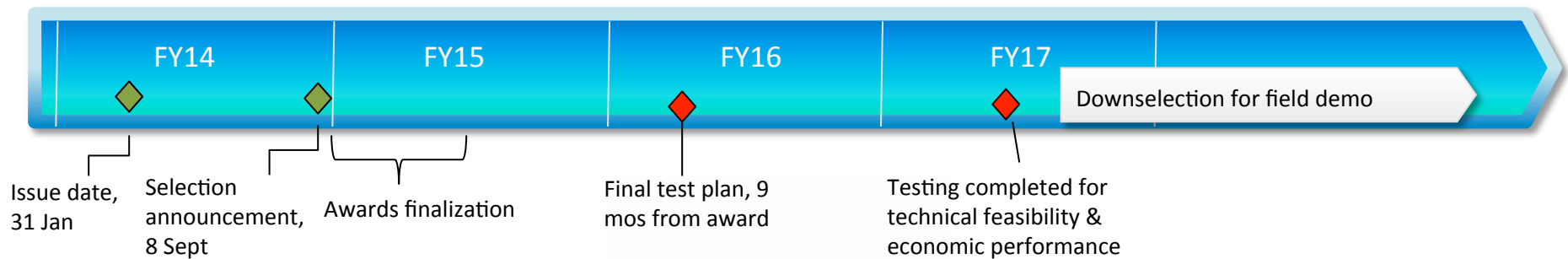
## FOA Objective:

Advance microgrid system designs (<10MW) and control functionalities to support achievement of DOE program targets and community-defined resilience objectives

## FOA Partnered Projects:

>\$12M in total investment (OE: 59%; Indian Energy: 9%; private sector: 33%);

2-year project period of performance, including 18-month R&D and 6-month testing, data collection, and analysis



GE Global Research



ELECTRIC POWER  
RESEARCH INSTITUTE

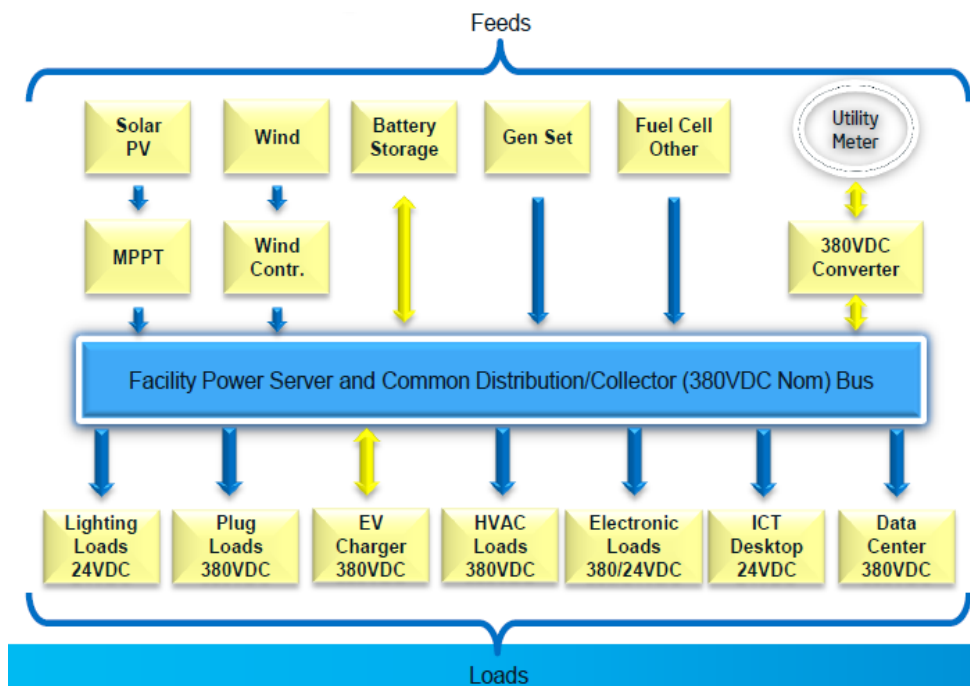






# Decision Analysis Tool for DC, DC/AC Hybrid, and AC Microgrids

Building on preliminary scoping study findings, tool will explore DC microgrids for remote off-grid applications (in FY15) and grid-connected, high survivability applications (in FY16)



Source: EMerge Alliance

**New microgrid power distribution  
topologies in buildings**

**A lab opportunity announcement  
for design tool development will  
be made:**

- Decision support analysis on all microgrid configurations for remote off-grid applications
- Prototype tool development completed within 12 months
- Applications jointly planned with Indian Energy Program and Arctic Council activities



# Microgrid Resources

Microgrids

<http://energy.gov/oe/role-microgrids-helping-advance-nation-s-energy-system>

Office of Electricity Delivery  
and Energy Reliability

<http://www.oe.energy.gov>

Sandia National Laboratory –  
Energy Surety Microgrid™

[http://energy.sandia.gov/?  
page\\_id=819](http://energy.sandia.gov/?page_id=819)

Berkeley Lab (DER-CAM and  
International Symposium)

[https://building-  
microgrid.lbl.gov/projects/der-  
cam](https://building-microgrid.lbl.gov/projects/der-cam)

Microgrid workshop results

<http://www.e2rg.com/reports>



# Questions?

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