Office of Electricity Delivery & Energy Reliability

US DOE Microgrid R&D Program

Dan Ton

**Power Systems Engineering Research and Development**

September 15, 2015

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.

Technology Innovation

Grid Modernization

Security & Resilience

Institutional Support & Alignment
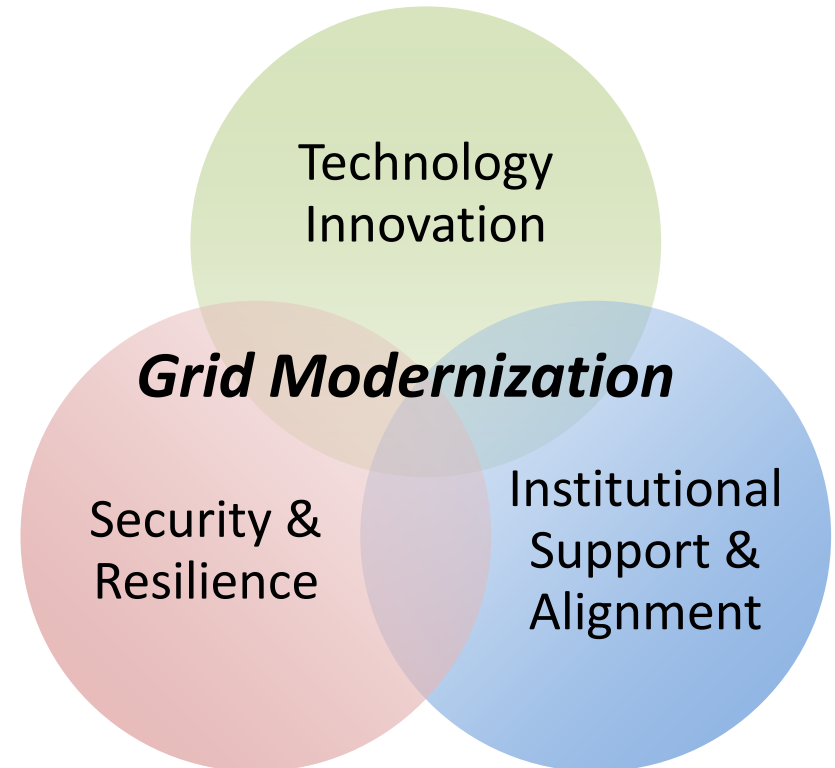
Grid Modernization Vision

*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

Smart Grid R&D Focus Areas

Microgrid R&D
For commercial viability, reliability, and resiliency

Continue R&D pathway to support achieving the DOE program goals (in reliability, efficiency, CO_2 reduction, and cost effectiveness) and implementing the DOE CAP strategy, leading to creating a smarter and more resilient grid and community.

Advanced Distribution Management System (ADMS)
Providing better control and visibility

Develop architectures that integrate new & existing applications across the utility enterprise to accommodate rapid and complex communications/interactions between D&T; develop operational control strategies using advanced analytics.

Resilient Electric Grid R&D
For enhanced grid resilience

Implement high-priority R&D projects identified in the resilient grid roadmap, developed in a broad stakeholder workshop in 2014 and finalized during the QER in 2015.

Market-Based Control Signals
Enabling economical and flexible stability

Develop simulation tools for the impact of transactive control, establish valuation basis for customer-delivered and grid-delivered energy services, and assess how to achieve a more distributed customer-driven grid.

Smart Grid R&D Program

Modernizes distribution grid through advanced control and distribution management and control systems and new operational paradigms (integrated microgrids and DER controls)

Supports increasing demand for renewable energy integration and grid reliability and resiliency at regional, state and local levels

FY 2014 and Prior

- Microgrids
- DER/DR/PEV Integration
- Distribution Automation

FY 2015/ FY2016

- Microgrids
- Advanced Distribution Management Systems
- Restoration Strategies
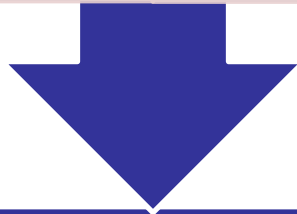- Resilient Distribution Grid

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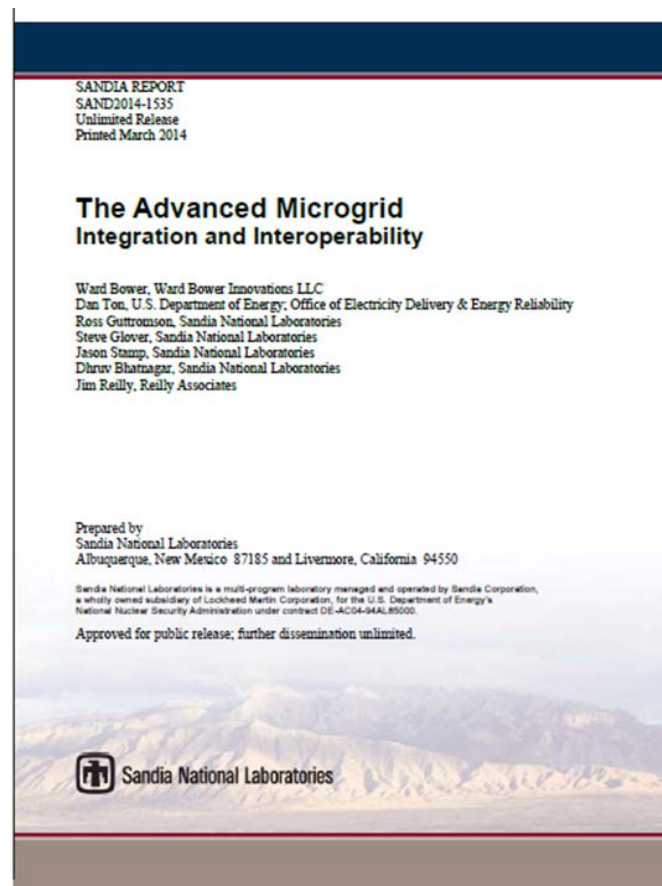
- Reduce outage time of critical loads by >98% at a cost comparable to non-integrated baseline solutions (uninterruptible power supply + diesel generator)

- Reduce emissions by >20%

- Improve system energy efficiencies by >20%
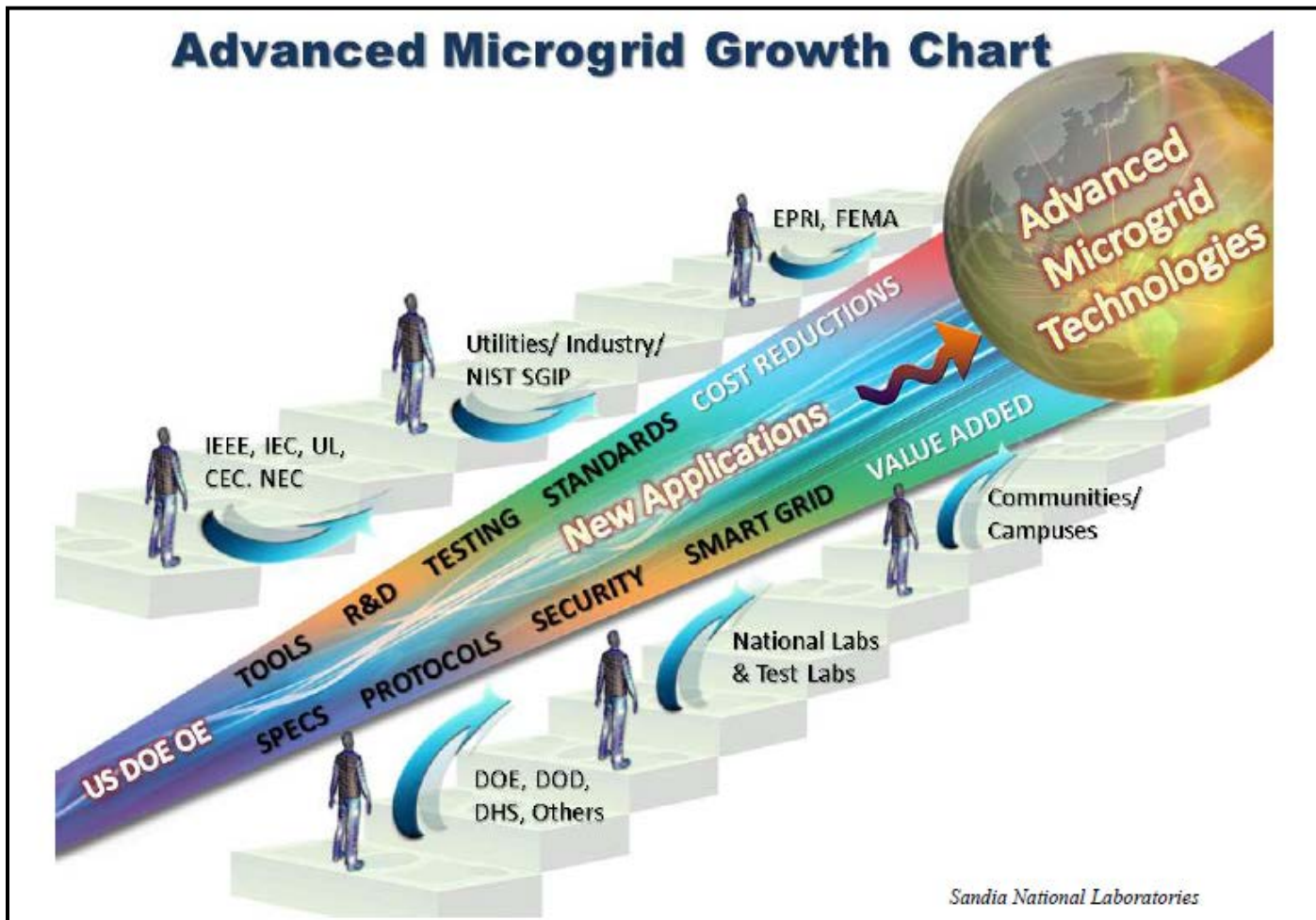
Advanced Microgrid

SAND 2014-1525

- Objectives
- Operational modes
- System architecture
- Technical challenges
- Development impact areas
- Ownership of microgrids
- Microgrid applications
- Standards and codes
- Microcontrollers
- References

SANDIA REPORT
SAND2014-1535
Unlimited Release
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The Advanced Microgrid
Integration and Interoperability

Ward Bower, Ward Bower Innovations LLC
Dan Ton, U.S. Department of Energy; Office of Electricity Delivery & Energy Reliability
Ross Guttromson, Sandia National Laboratories
Steve Glover, Sandia National Laboratories
Jason Stamp, Sandia National Laboratories
Dhruv Bhatnagar, Sandia National Laboratories
Jim Reilly, Reilly Associates

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

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Sandia National Laboratories

"An advanced microgrid is one that provides functions at the PCC beyond basic islanding (disconnect) and synchronization (reconnection) functions. An Advanced Microgrid interacts with the larger grid (macrogrid) cooperatively managing power flows across the PCC optimizing benefits for both the microgrid and macrogrid."

A well-coordinated team of technical experts and stakeholders/customers, applying advanced technologies, cost sharing demonstration projects, developing standards and codes.

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.
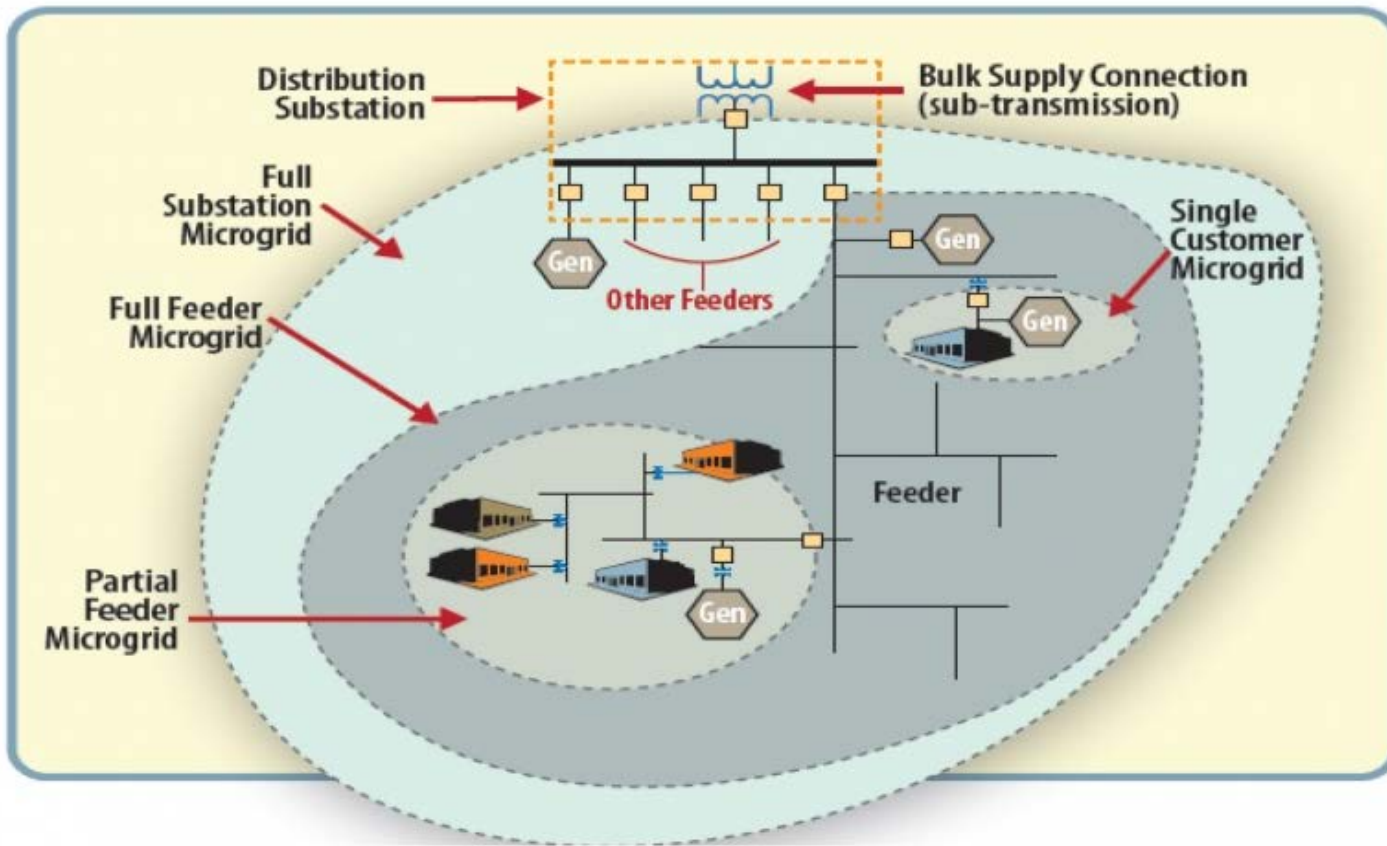
Benefits

- Enables grid modernization
- Integrates multiple Smart Grid Technologies
- Enhances integration of distributed and renewable energy sources
- Ensures energy supply for critical loads; controls 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 services to the bulk power system

Challenges

Technical/Economic

- Microcontrollers
- Energy Management Systems
- Interoperability
- Costs
- Return on Investment (business case)

Regulatory/Policy

- Market entry requirements
- Tariffs
- Interconnection rules
- Investment incentives

Vision

The Integrated μGrid R&D Program foresees the technical requirements for advancing the microgrid to a fully integrated entity within the distribution system, interacting seamlessly with the Distribution System Operator.

Design and Planning Tools

- ❖ Microgrid Design Optimization Using DER-CAM
- ❖ Technical Resource Exchange to Support Microgrid Development
- ❖ Impact Analysis of Interactive Operations of Microgrid and Distribution System

System Control and Power Flow

- ❖ Guidelines for DMS for Grid Modernization
- ❖ Grid Interactive Microgrid Controllers & Aggregated DER
- ❖ Microgrid Integrated Controls (CSEISMIC)
- ❖ Virtual Microgrid & Reference Design for Sectionalized/Islanded Feeders
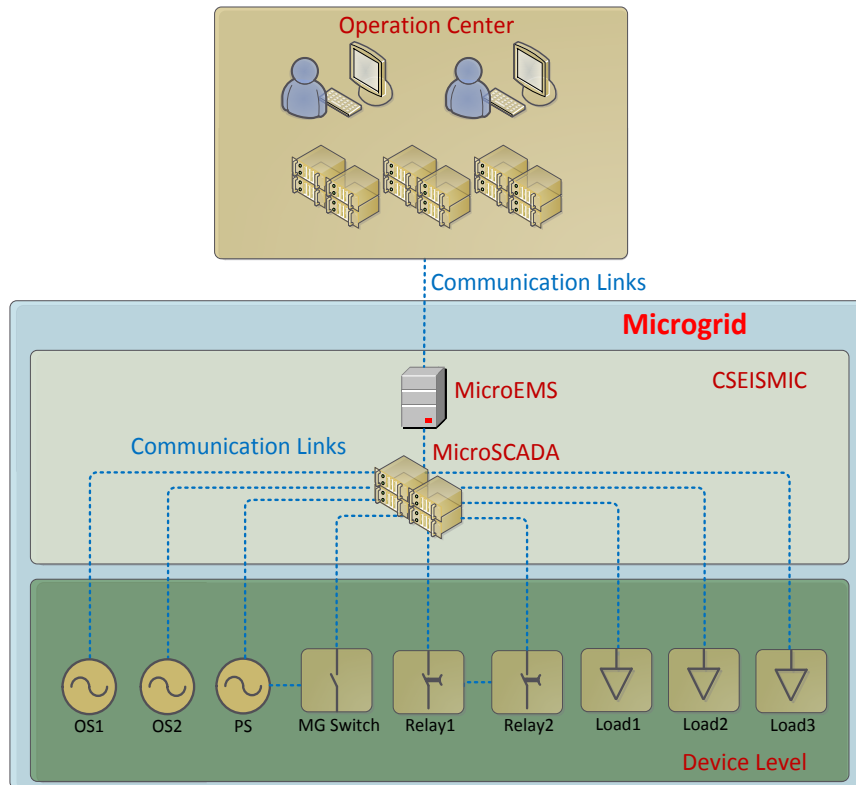
Device and Integrated Testing

- ❖ Microgrid Controller HIL Test Bed (simulation- uGrid EMS and DMS)
- ❖ Grid Self-Aware Elastic Extensible Resiliency (Grid-SEER) Platform

Standards

- ❖ IEEE p2030.7 Standard for Specification of Microgrid Controllers
- ❖ IEEE p2030.8 Standard for Testing of Microgrid Controllers

- Microgrid Supervisory Control And Data Acquisition (MicroSCADA) for sources, loads, microgrid switch, protection relays, etc.

- Volt/freq control and transition control are performed at device level with control modes and setting points dispatched by MicroEMS.

- Single-point interface between microgrid and system operator/energy market to participate in utility operation and energy market activities.

Year-end targets: Complete standardized microgrid communication development, load shedding testing, and protection scheme testing

Real Time Digital Simulator (RTDS)-Based Hardware-in-Loop (HIL) Microgrid Test Bed

Flexible platform for testing, verification, and assessment of microgrid components and controllers for system operation, energy management, and protection under different operation scenarios

Purposes

- Provide standardized and independent testing
- Reduce deployment cost for new devices and solutions
- Perform research
- Investigate safety issues
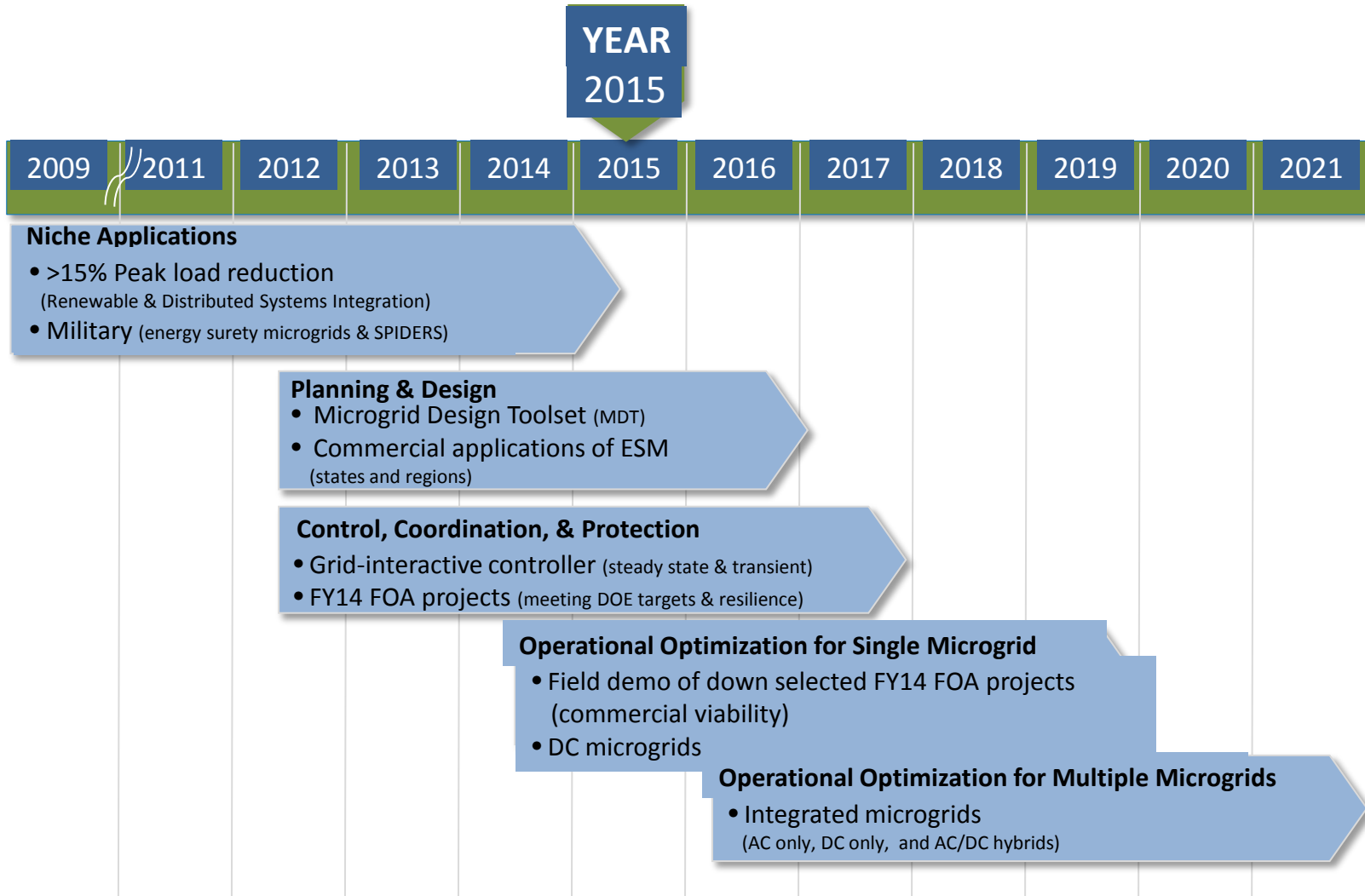- Facilitate standards development

Conduct testing of:

- Both system level and device level
- Microgrid energy management
- Microgrid control and operation (CSEISMIC testing in FY15)
- Communication
- Protection

Microgrid R&D Timeline

YEAR
2015

| 2009 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |

Niche Applications
- \>15% Peak load reduction
  (Renewable & Distributed Systems Integration)
- Military (energy surety microgrids & SPIDERS)

Planning & Design
- Microgrid Design Toolset (MDT)
- Commercial applications of ESM
  (states and regions)

Control, Coordination, & Protection
- Grid-interactive controller (steady state & transient)
- FY14 FOA projects (meeting DOE targets & resilience)

Operational Optimization for Single Microgrid
- Field demo of down selected FY14 FOA projects
  (commercial viability)
- DC microgrids

Operational Optimization for Multiple Microgrids
- Integrated microgrids
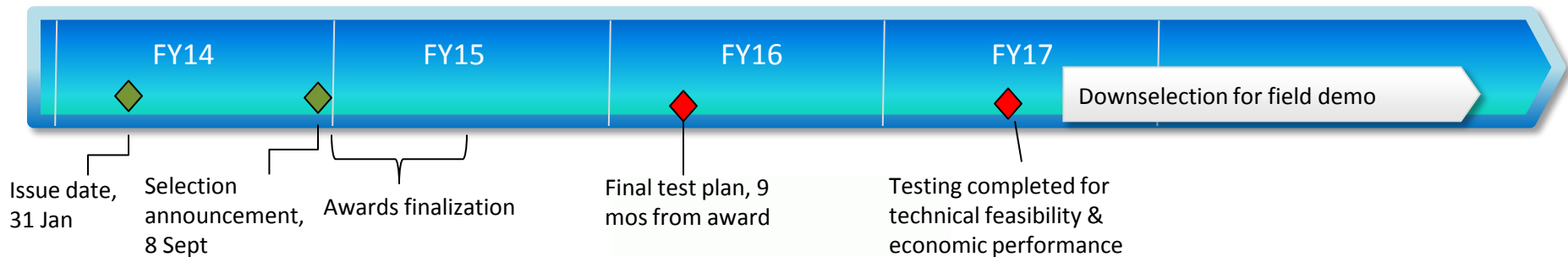 (AC only, DC only, and AC/DC hybrids)

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


Timeline: FY14 | FY15 | FY16 | FY17 — Downselection for field demo

- Issue date, 31 Jan
- Selection announcement, 8 Sept
- Awards finalization
- Final test plan, 9 mos from award
- Testing completed for technical feasibility & economic performance

Partners: GE Global Research · ComEd (An Exelon Company) · EPRI Electric Power Research Institute · ALSTOM Grid · TDX power (a tanadgusix company) · Microgrid Institute · UCI University of California, Irvine

Decision Analysis Tool on DC and AC Microgrids for Remote Off-Grid Applications (RC-ROMDST-2015)

Building on preliminary scoping study findings to explore DC microgrids for remote off-grid applications (in FY15-16) and grid-connected, high survivability applications (in FY17)
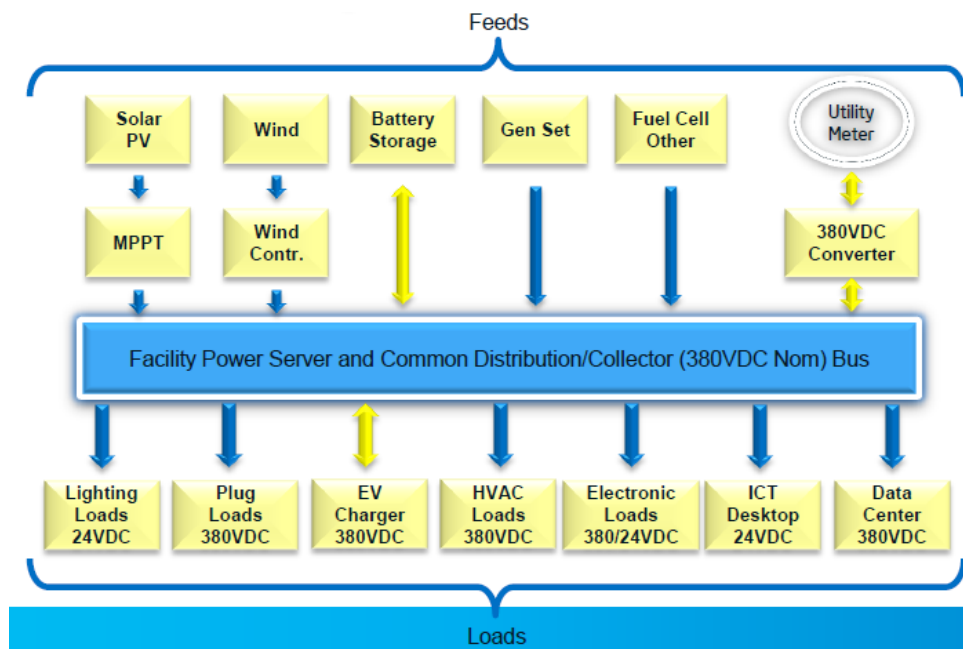
Source: EMerge Alliance

New microgrid power distribution topologies in buildings

A lab call in Mar 2015 for development of a design tool for remote off-grid microgrids

- Tool with decision support analysis on AC and DC microgrids

- Two projects selected in August 2015 for prototype development (12 mos)

- Down-selection of one tool in FY16 to proceed into testing and transition of use by remote communities

Standards for Microgrid Controllers and Testing

IEEE P2030.7 *Standard for the Specification of Microgrid Controllers*.

- PAR Approved by IEEE SA on June 11, 2014
- Working Group formed – FOA Awardees encouraged to participate
- Projected Completion Date – August 2017

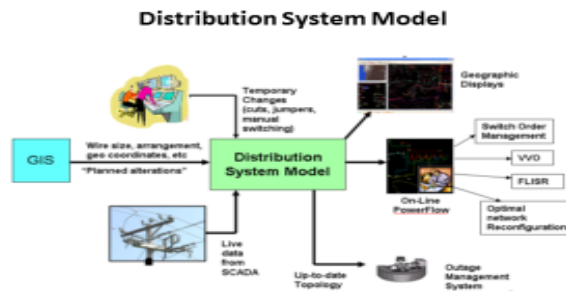**IEEE P2030.8** *Standard for the Testing of Microgrid Controllers.*

- PAR Approved by IEEE SA on June 11, 2015
- Working Group being formed – FOA Awardees encouraged to participate
- Projected Completion Date – May 2018

DMS + Microgrid Controls

- Distribution management system (DMS) plays a critical role in control and management of distribution systems

- Distribution systems have to manage high penetration distributed energy resources (DERs) and microgrids

- The integration of DERMS and microgrid controllers with the ADMS offers a solution

Guidelines for Distribution Management Systems for Grid
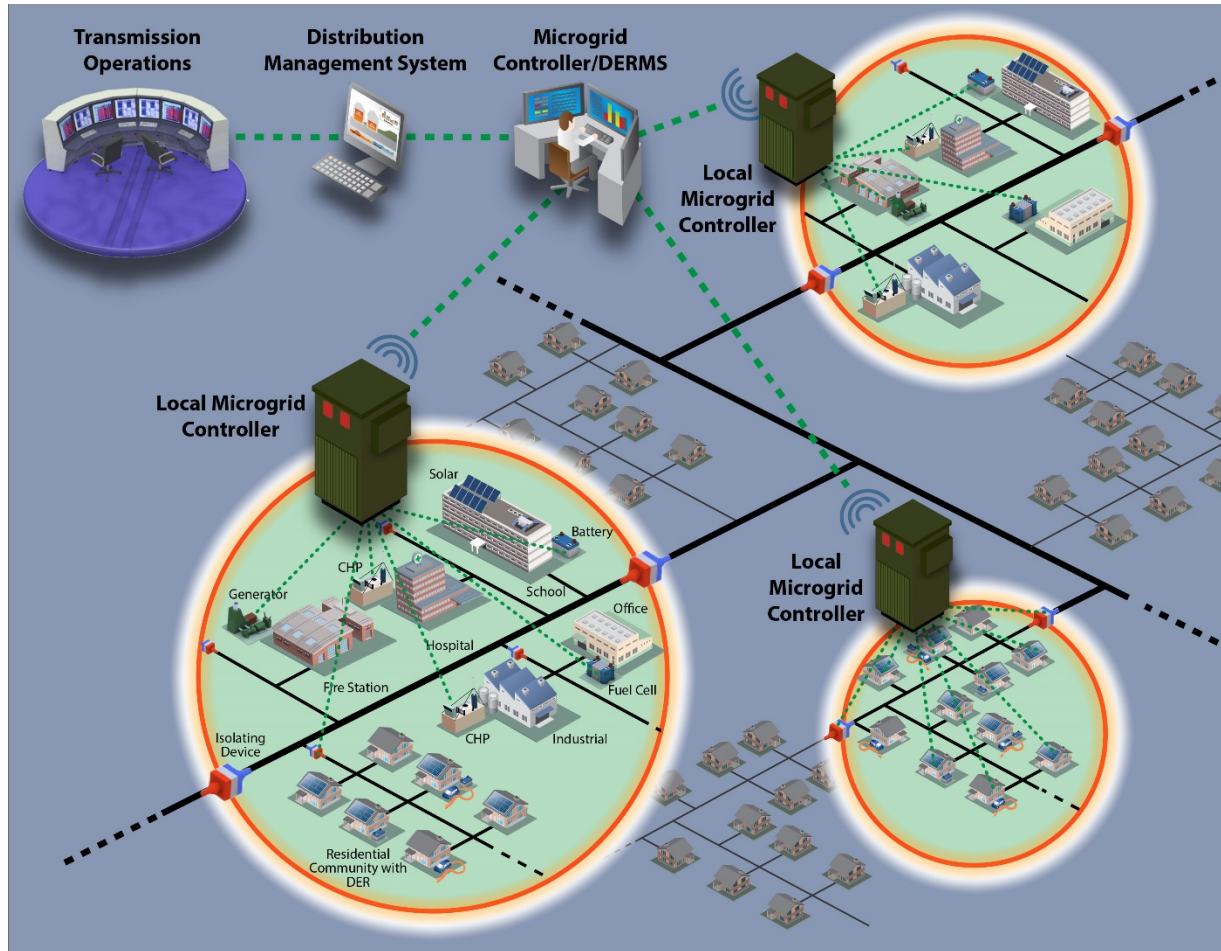
Distribution System Model

The objective of this project is to identify the functional gaps of DMS and propose a guideline for DMS development and implementation for grid modernization.

The scope of the project is divided into tasks that address the needs for DMS, requirements for DMS for integration of microgrids and DERs, and standardization of the guidelines.

Source: Robert Uluski, EPRI

Source: EPRI

Microgrid Resources

Office of Electricity Delivery and Energy Reliability
http://www.oe.energy.gov

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

Sandia National Laboratory – Energy Surety Microgrid™
http://energy.sandia.gov/?page_id=819

Berkeley Lab (DER-CAM and International Symposium)
https://building-microgrid.lbl.gov/projects/der-cam

Microgrid workshop results
http://www.e2rg.com/reports