Microgrid R&D Program Updates

Program Manager: Dan Ton

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Program Scope and Major Activities

Grid-connected Microgrids

Develop integration approaches, tools, and technologies into distribution systems to meet the DOE performance targets and community resiliency objectives

- ➢ Standard, modular **microgrid building blocks**
- ➢ Integration platform (generation mixes, T&D)
- ➢ **Microgrid protection and control**

Resiliency Modeling

Develop **advanced models and approaches** for pre-event preparation, during-event detection and mitigation, and post-event response, recovery, and remediation

- ➢ Simulation and analysis of microgrids for critical facilities (ports, urban centers)
- ➢ Tools for assured power solutions at critical defense facilities

Networked Microgrids

Develop advanced capabilities of sharing loads and resources - including self-assembly or dynamic boundaries of microgrids - that support critical loads under extreme events, while attaining optimized performance under normal operating conditions

- ➢ Tool for resilient operations of networked microgrids
- ➢ **Dynamic microgrids** as a building block for the future grid

Standards and Institutional Framework

Support developing and implementing microgrid standards, test methods, best practices, and enabling regulatory and business models

- ➢ IEEE microgrid-related standards
- ➢ NARUC-NASEO Microgrid State Working Group
- ➢ Technical assistance (resilient communities)

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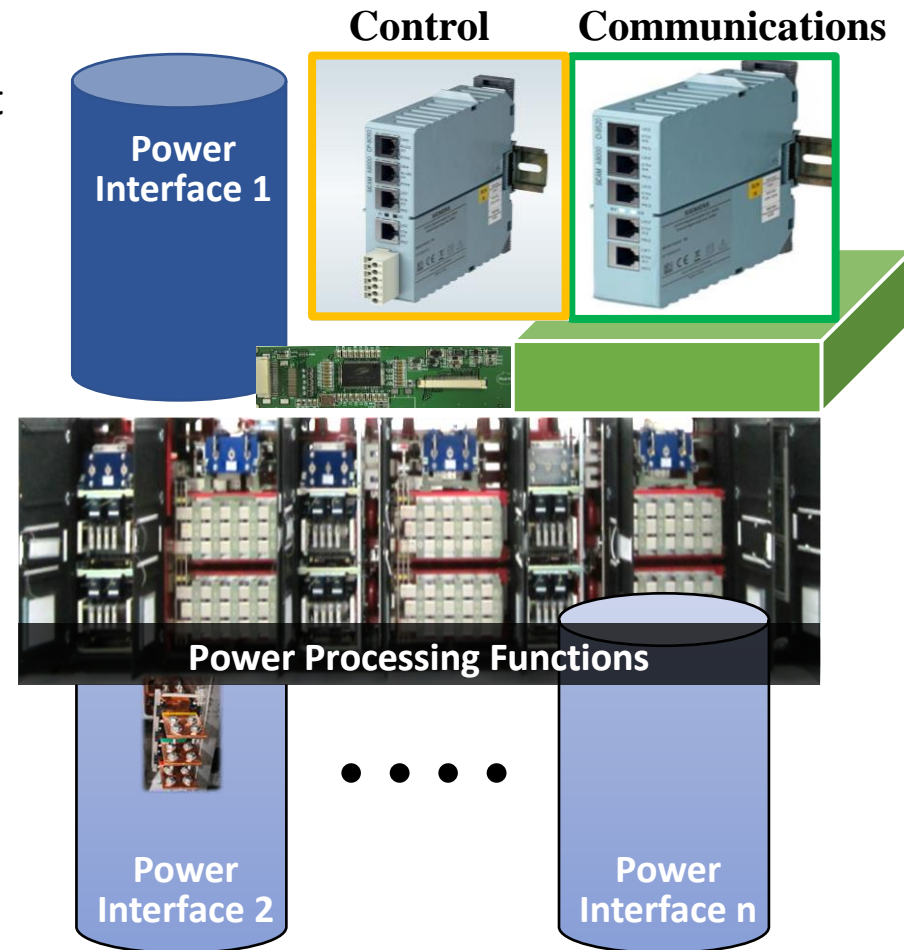U.S. DEPARTMENT OF ENERGY

Microgrid Building Blocks (MBB)
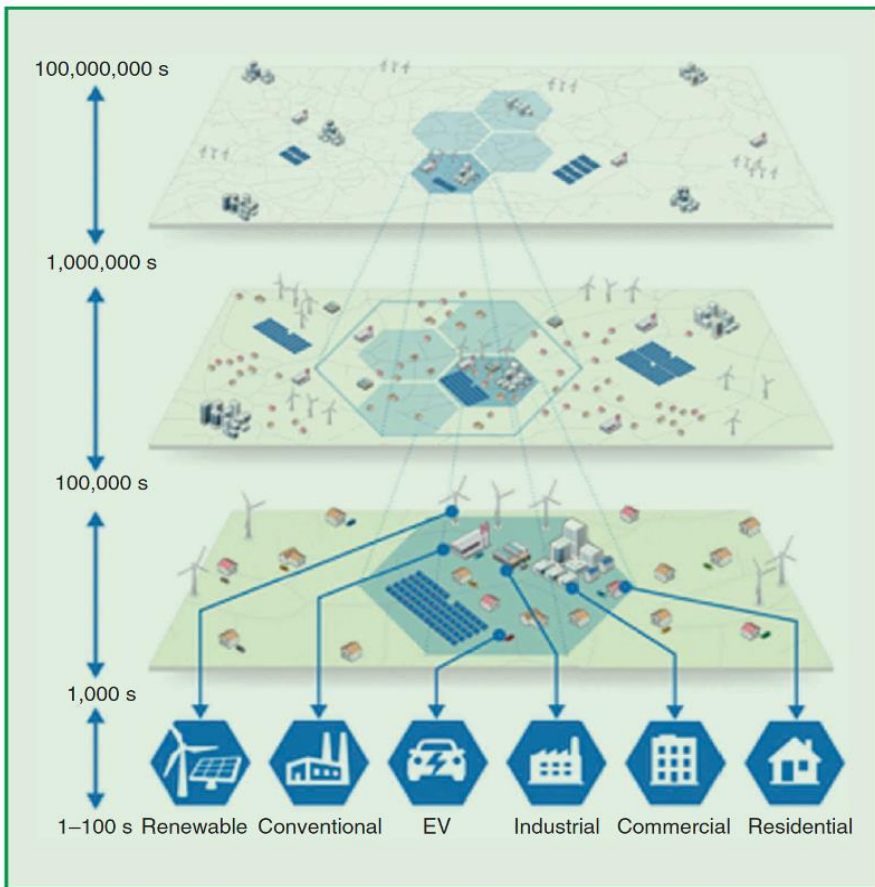
Modular and standard design of MBB to:

- Reduce cost and time of microgrid deployment
- Interface with utility systems as well as generation, load, and controls
- Provide a low-cost standard approach for a wide range of microgrids

Technical Scope

- MBB design and prototype development
- Modeling and simulation of MBB, Performance requirements and evaluation
- MBB modularization, standardization, validation and testing
- MBB Demonstration
- Planning of technology transfer and commercialization

Control **Communications**

Power Interface 1

Power Processing Functions

Power Interface 2 • • • • **Power Interface n**

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Dynagrid: A concept to enable dynamic formation of microgrid boundaries for optimized operations

Develop a framework for dynamic formation of networked microgrids for optimized operations under both normal and emergency conditions. This project **addresses major research challenges**:

- improve T&D system real-time **resilience**
- integrate and efficiently leverage large amounts of **renewables and DERs**
- allow wide-scale **electrification**
- increase **distributed and decentralized decision making**
- improve **equity and energy justice**

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Microgrid R&D for Underserved and Indigenous Communities in Remote and Islanded Regions

Working with the national labs, research centers, other DOE programs, and community stakeholders to define the needs and technical requirements for the following topic areas

- Modular microgrid systems with standardized control/communication functionalities for a range of system sizes and renewable contributions

- Multi-port medium voltage DC (MVDC) converter R&D for integration of microgrids and clean energy

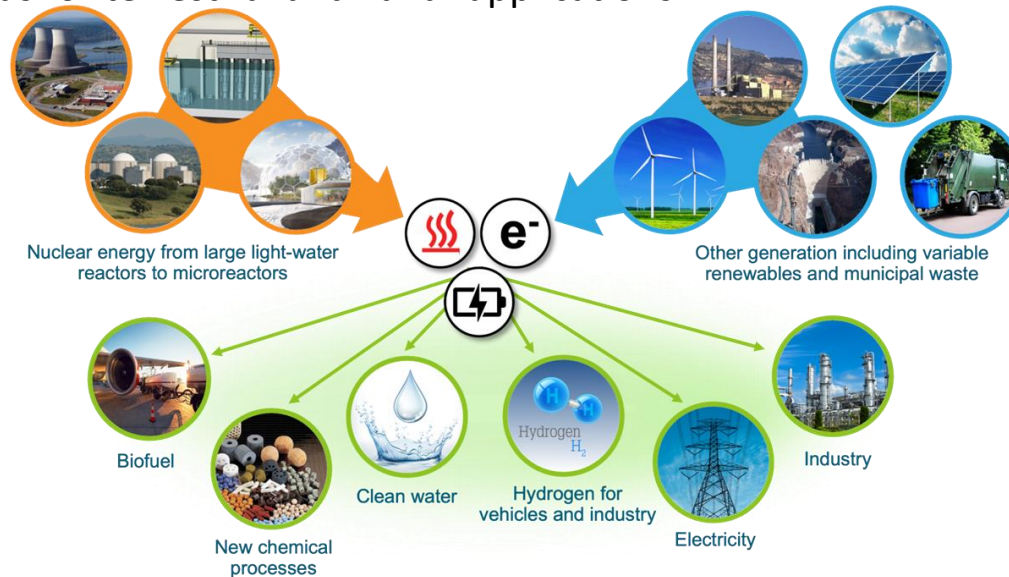- Regional initiatives to support microgrid deployments within underserved and indigenous communities

A Notice of Intent to issue the Funding Opportunity Announcement in Nov 2022, followed by the release of the FOA for ~$9.1M total in awards

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Conduct cross-cutting research to accelerate the removal of carbon-emitting generation from microgrids

- Model microgrid with microreactor module for use cases with multiple DER configurations
- Initiate dynamic modeling and simulation of microreactors in microgrids
- Identify operational issues related to microgrids with microreactor provisioning of grid services

Future Plan: Develop, demonstrate, and validate power and energy management systems for SMR-integrated microgrids for terrestrial and Lunar applications
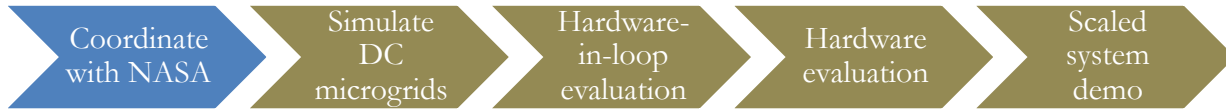

Nuclear energy from large light-water reactors to microreactors

Other generation including variable renewables and municipal waste

Biofuel

New chemical processes

Clean water

Hydrogen for vehicles and industry

Electricity

Industry

Robust, Autonomous and Fault-tolerant DC Microgrid Development

Project Scope: Utilize microgrid design, simulation tools, and dynamic models previously developed for rural islanded grids (St. Mary's) and DC microgrids (electric ships, Kirtland AFB DC microgrid) to develop robust, autonomous, and fault-tolerant *hierarchical DC Microgrids* for sustained living, transportation, and surface exploration activities in space.

Goal: Evaluate system performance of *hierarchical DC microgrids* for space-based applications to ensure operations under "blue sky" and "black sky" scenarios

- Develop appropriate asset/load models (with NASA)
- Develop *autonomous control schemes* robust to comm. latency/failure
- Utilize Sandia HIL/hardware *testbeds* to validate controls/models
- Evaluate fault tolerance on Kirtland DC demo microgrid
- Demonstrate flexible routing of power to critical nodes (space/time) on Kirtland microgrid

NASA's PLAN FOR A LUNAR BASE — THE ARTEMIS PROGRAM

Coordinate with NASA → Simulate DC microgrids → Hardware-in-loop evaluation → Hardware evaluation → Scaled system demo

NASA Goal: Crewed Lunar operations by 2024 (Artemis)

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Microgrid R&D in Outyears

- Implementing the DOE Microgrid Strategy to enable microgrids as a key part of the future Electric Delivery System
  - Current DER wave: PV, smart buildings/appliances
  - Next DER wave: energy storage, EVs, IoT
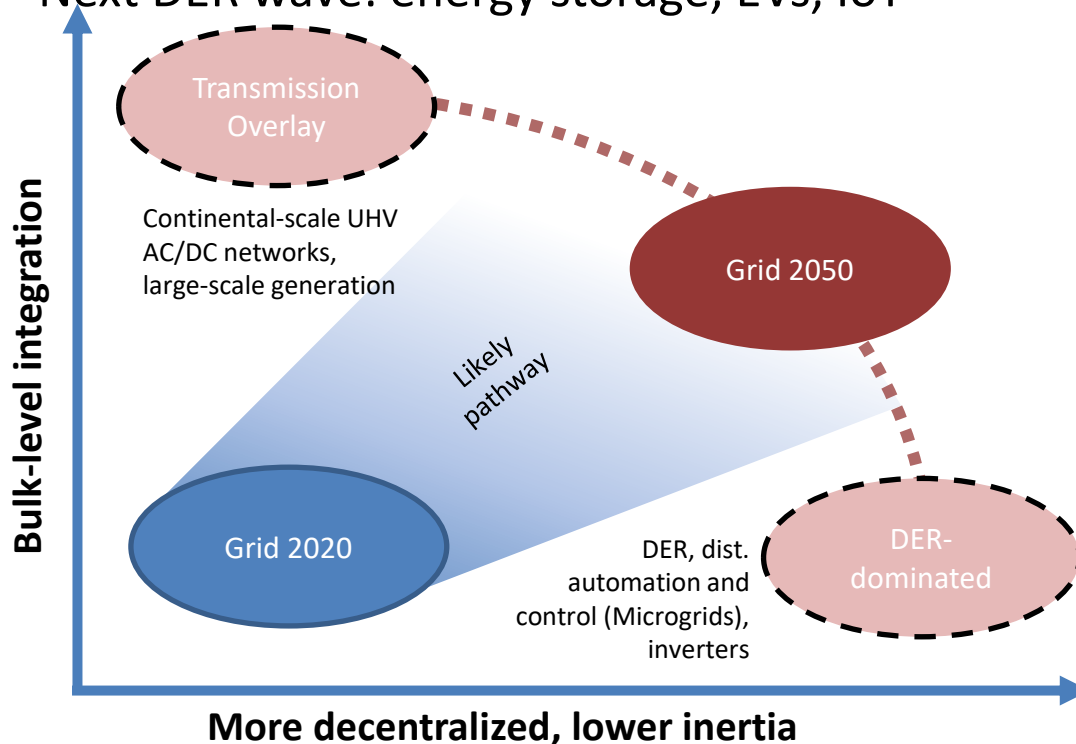
- *Microgrids are poised to become the default platform for the integration and operational optimization of DER*

- *Microgrids are evolving from niche applications to becoming integral to a modern grid of the future*

Implementing Strategic R&D Areas in Outyears

Six Strategic R&D Areas, each with defined targets for the
next 5-10 years

1. Building blocks for microgrids

2. Microgrids as a building block for the future grid

   → Modular, standardized, universally interoperable

3. Advanced microgrid control and protection

   → High penetration of renewables; secondary network

4. Integrated models and tools for microgrid planning, designs, and operations

   → Integration of models and tools for microgrid applications

5. T&D co-simulation of microgrid impacts and benefits

   → Analysis and tools; institutional challenges

6. Enabling regulatory and business models for broad microgrid deployment

Broader stakeholder engagement: (1) Held *DOE Microgrid Strategy Symposium* in July 2022 to engage broader stakeholder groups on the Strategy; (2) Posted the Strategy papers for public comment