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Microgrid Conceptual Design Methodology

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RESILIENCE WEEK

U.S. DEPARTMENT OF ENERGY

NNSA

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Grid Modernization @ SNL

1980s

- Distributed Energy Technology Laboratory (DETL) Opens
- Sandia designs first battery test facility hosted by PSE&G in NJ

1990s/ 2000s

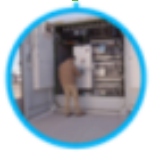
- Sandia starts interconnected PV systems work
- DOE designates Sandia as US Rep to IEC TC57, (Standards for information exchange for power systems)

2003/ 04

- Sandia Publishes DOE/EPRI Electricity Storage Handbook
- National SCADA Test Bed (NSTB) established

2009

- R&D 100: SiCPower Module
- DETLY modernized to enable high penetration experimentation on distributed generation
- Energy Surety Microgrid (ESM) Methodology



2010

- Energy Storage Test Pad established as the fist facility to test 1MW class storage systems at a national lab
- Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) established

2011

- R&D100 Award Winners: Ultra-high-voltage Silicon Carbide Thyristor
- R&D100 Award Winners: The Demand Response Inverter
- Secure, Scalable Microgrids Grand Challenge and Hardware Testbed Facility Initiated

2013

- Sandia developed the DOE/SNL Global Energy Storage Database

2014

- Grid Modernization Laboratory Consortium established & Sandia participates in 29 GMLC projects

2015

- Smart Grid International Research Facility Network (SIRFN) established
- R&D 100: Sandia and United Silicon Carbide, Inc. create new high voltage switch

2016

- Resilience Node Cluster Analysis Tool (RelNCAT) developed
- Control and Optimization of Networked Energy Technologies (CONET) Laboratory established
- First version of WNTR – Water Network Tool for Resilience

2017

- R&D 100: Control System for Active Damping of Inter-area Oscillations

2018

- QuESt, an open source energy storage simulation and analysis suite, publicly released
- Energy Storage controls and Analytics Laboratory (ESCAL) created

2019

- Sandia-developed Grid Damping Control Strategy at CONET

2020

- Advanced Power Electronics Conversion Systems (APEX) Laboratory established

2021

- Resilient Energy Systems Mission Campaign: Corporate internal research investment in energy resilience begins

Resilience complements Reliability

A resilient energy system **supports critical community functions** by preparing for, withstanding, adapting to, and recovering from disruptions

1. Focuses on hazards with low probability but potential for high consequence
   - Naturally fits within a risk-based planning approach…
   - …but difficult to capture this type of risk with high confidence
2. Resilience is contextual – defined in terms of threats or hazards
   - A system resilient to hurricanes may not be resilient to earthquakes

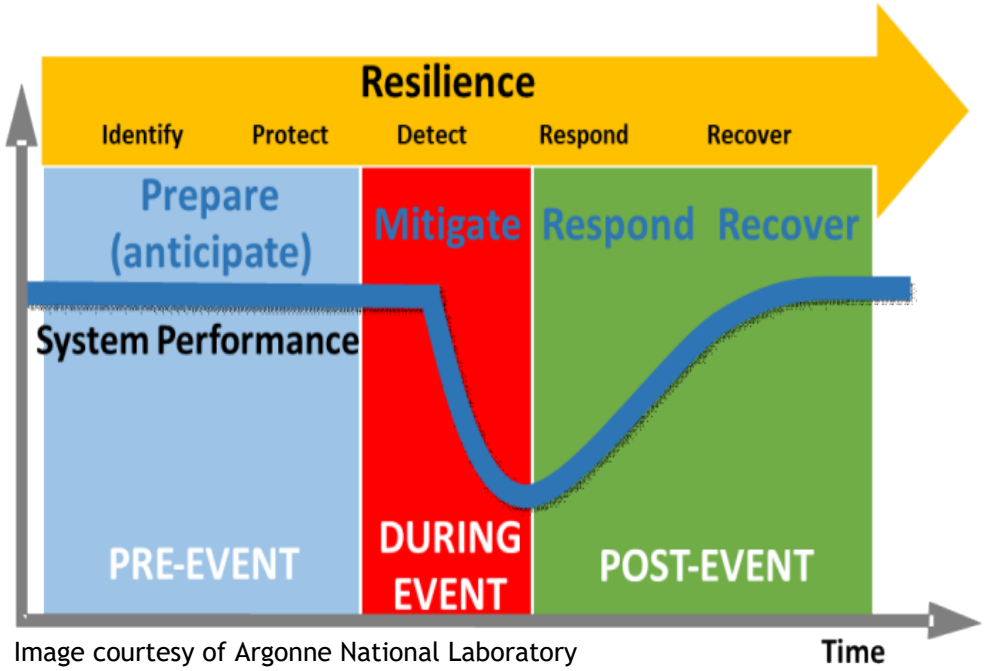
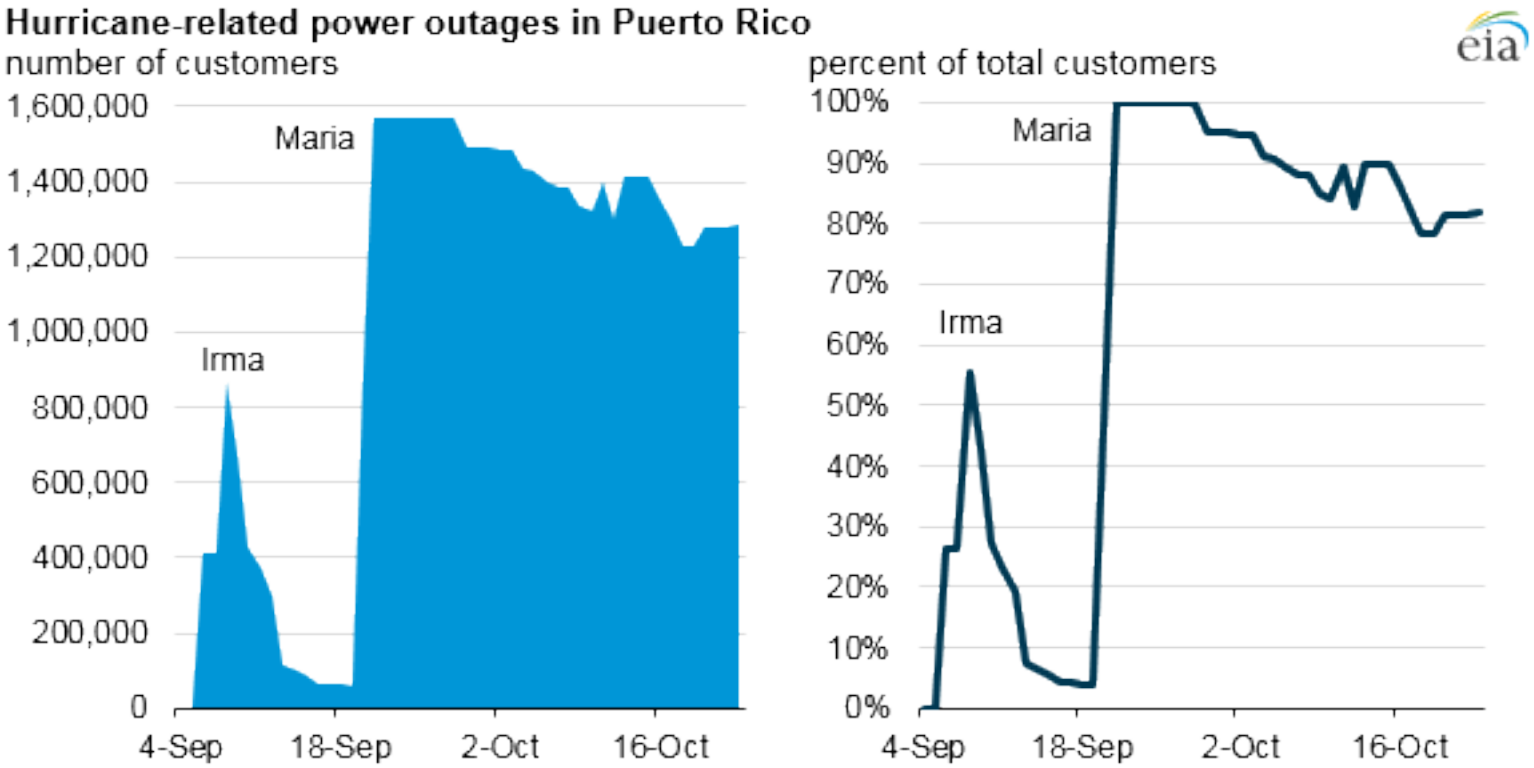


Image courtesy of Argonne National Laboratory

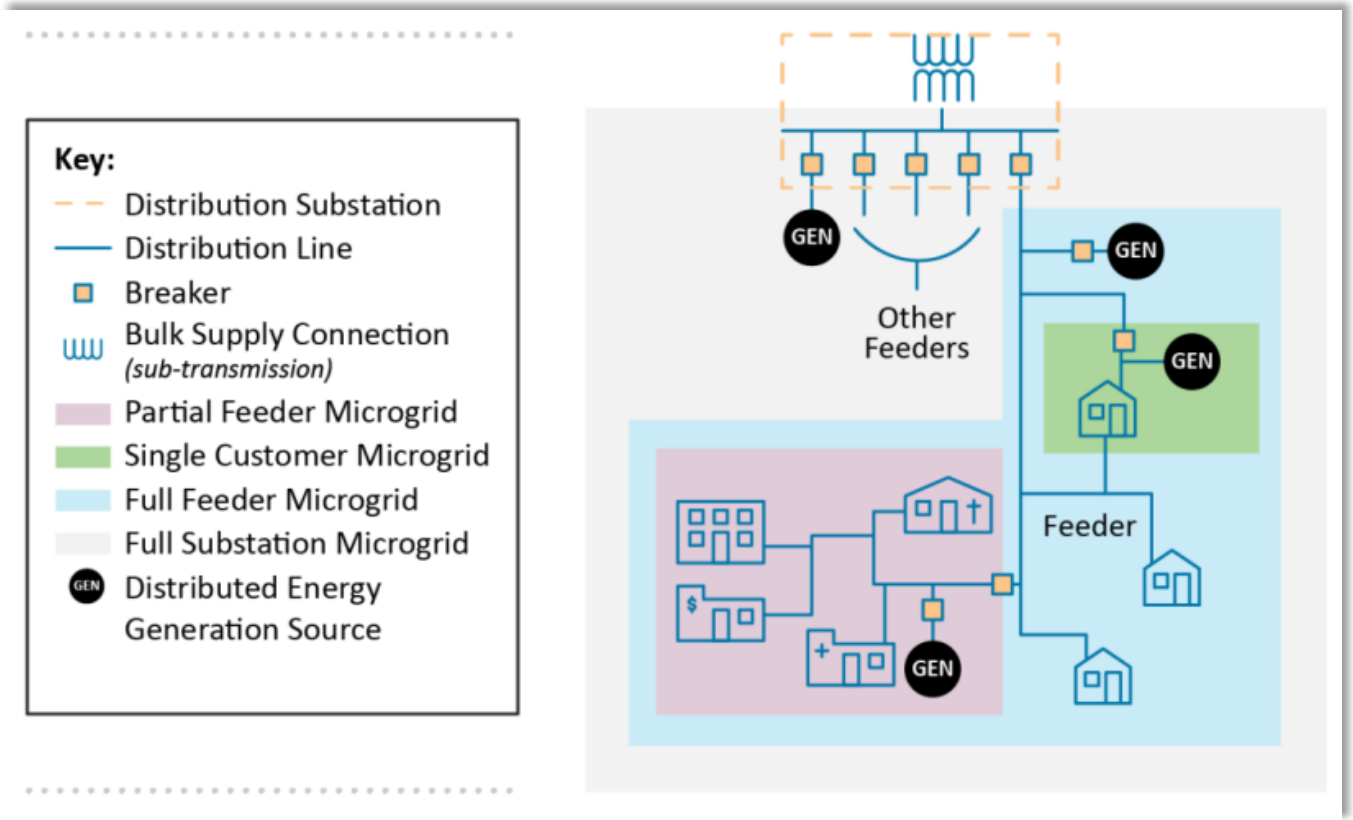
Bulk power can be slow to restore



Outage-causing event may disrupt fuel supplies, transportation, communication and other elements needed for recovery.

What is a microgrid?

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

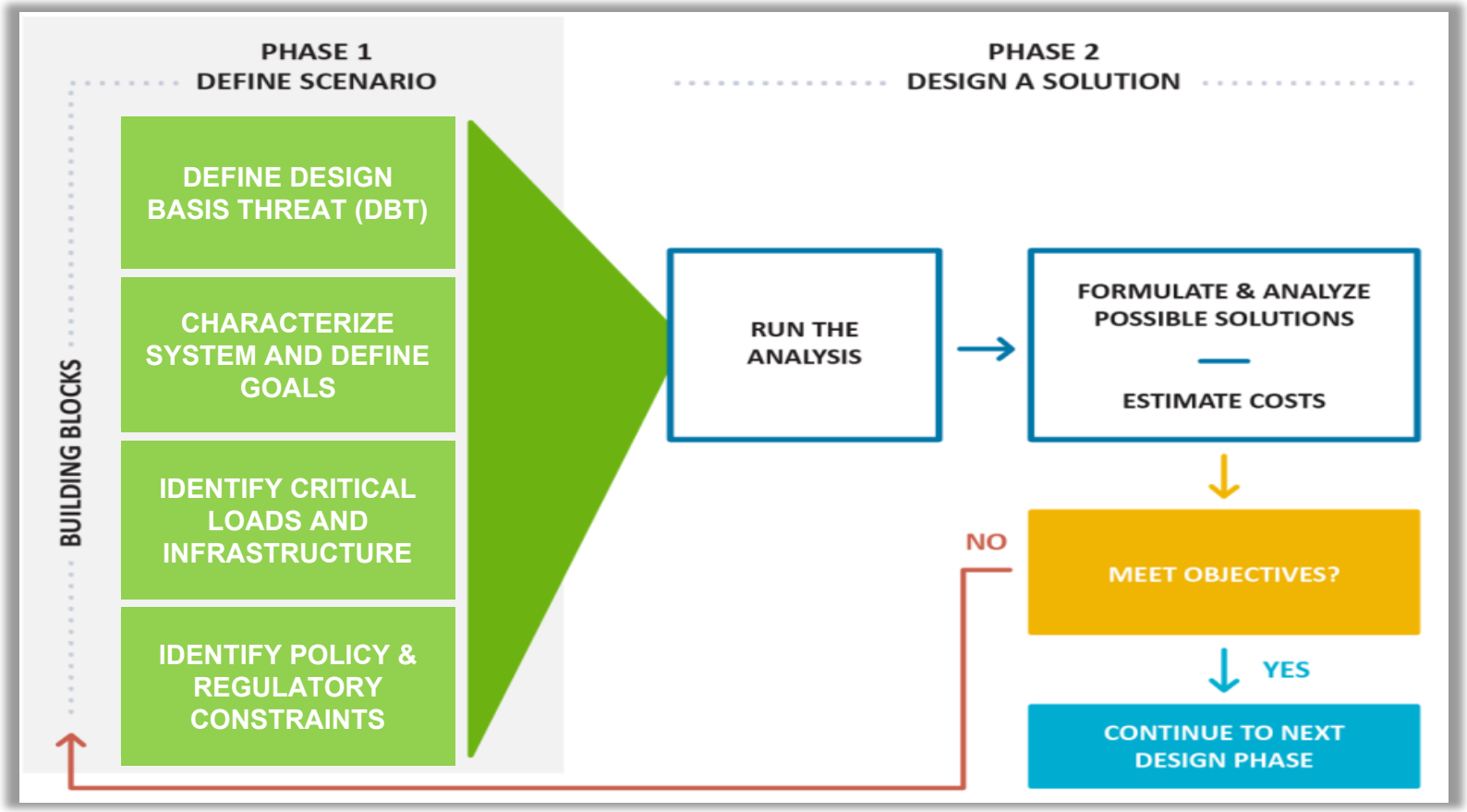


typical size – 1 MW, but can be much bigger or much smaller

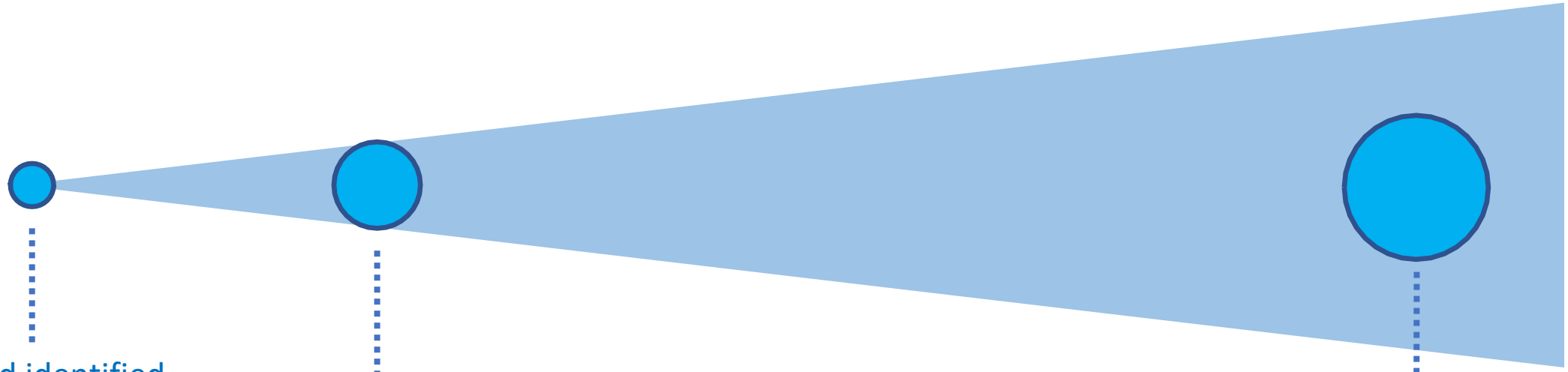
Opportunity for microgrids

- Reliable electric power is critical to health, safety, and productivity
- Historical practice of providing power security based on back-up generators has been problematic
  - Frequently over-sized and under-maintained, low probability of start (<60%)
  - Dedicated to one building or facility
  - Operations for extended periods problematic
- Advanced microgrids are an energy assurance solution
  - Local generation reduces possible modes of failure
  - Renewable energy can be incorporated, improving sustainability and reducing fuel dependencies
  - Generation matches load, reducing costs
  - Designs considering threats can improve resilience

Sandia Conceptual Design Methodology Framework



Scope of the framework



Microgrid identified as a solution to energy challenges

10% to 20% conceptual design: site-specific needs are estimated and a microgrid solution is conceptualized including generation type, scale and distribution

100% design: microgrid is fully engineered with final specifications, it is environmentally permitted, and ready to be built

Scenario definition: the Design Basis Threat

DBT **impact** on grid outage: **frequency and duration**

DBT **impact** on DERS: **probability of failure, time to repair**

WORSE

BAD

meh

Scenario definition: system and goals

Evaluate:

- What is the **geographic footprint / system boundary**?
- What types of **services and assets** do we want to target for energy resilience?
- For what **duration** (days, weeks, longer) do we want to provide these services and assets?
- What types of **generation resources** should we consider (e.g., diesel, gas, generators, cogeneration, renewables like PV or wind)?
- In addition to providing emergency services, do we want to consider **ancillary benefits** like providing grid services to the utility, meeting renewable energy goals, etc.?
- What **funding sources** are available (federal, city, state, private purchase agreements, etc.)?

Scenario definition: critical loads & interdependencies

EVALUATE THE **CRITICAL INFRASTRUCTURE** PRIORITIZATION

- Develop a rubric for evaluating **critical infrastructure**.
- Consider outage duration as a factor in **critical ranking**.
- Get community input and feedback for enhanced resiliency and **equitable outcomes**.

Scenario definition: policy and regulatory constraints

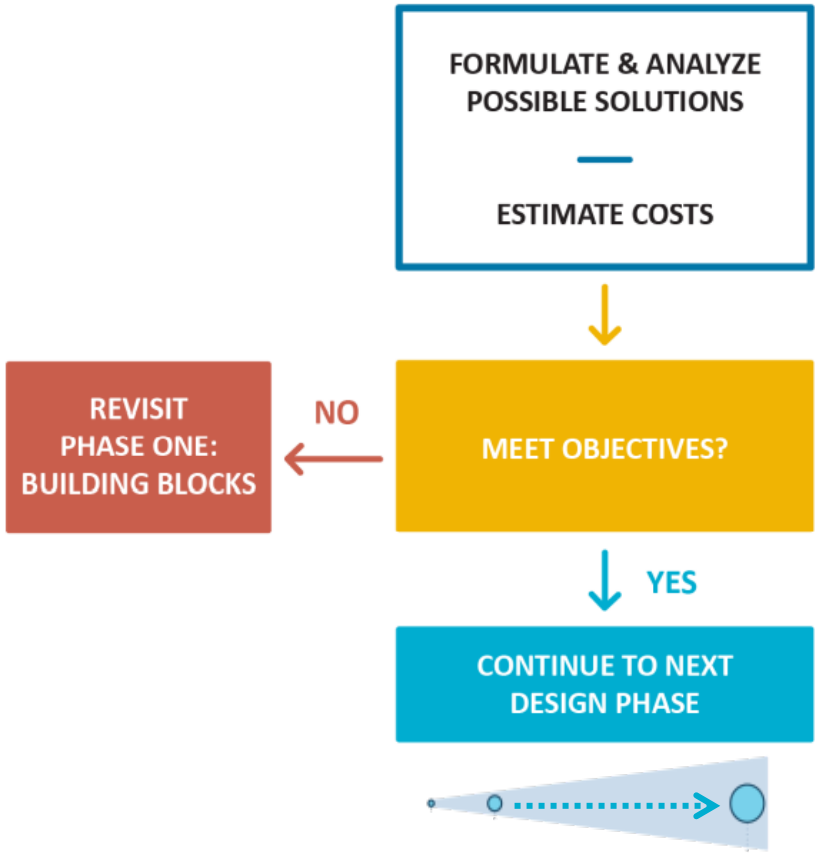
CAPTURE THE **POLICY AND REGULATORY CONSTRAINTS** WITHIN THE JURISDICTION OF THIS MICROGRID LOCATION

Evaluate:

- **Regulatory requirements and limitations** to grid-tied microgrids (e.g., Puerto Rico “Microgrid Rule” 75% to be independent of PREPA ← will determine footprint)
- Consider audience: utility, regulator, developer
- Consider **funding requirements** if known

Formulate and analyze solutions: process

- **Site generation sources and capacity** goals
- Potential **tie-in points** if microgrid is not stand-alone
- Groups of users – **look at clusters that might yield higher resilience** opportunities (economies of scale, impacting the most users with a single microgrid)
- Sketch **proposed feeders and switch locations**
- Estimate **DER options**, consider fuel, assess equipment types and quantities

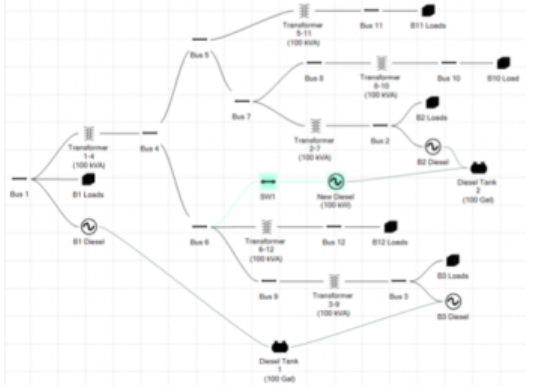


Formulate and analyze solutions: tools

DBT

Technology Options + Fuel Supply

Target Performance

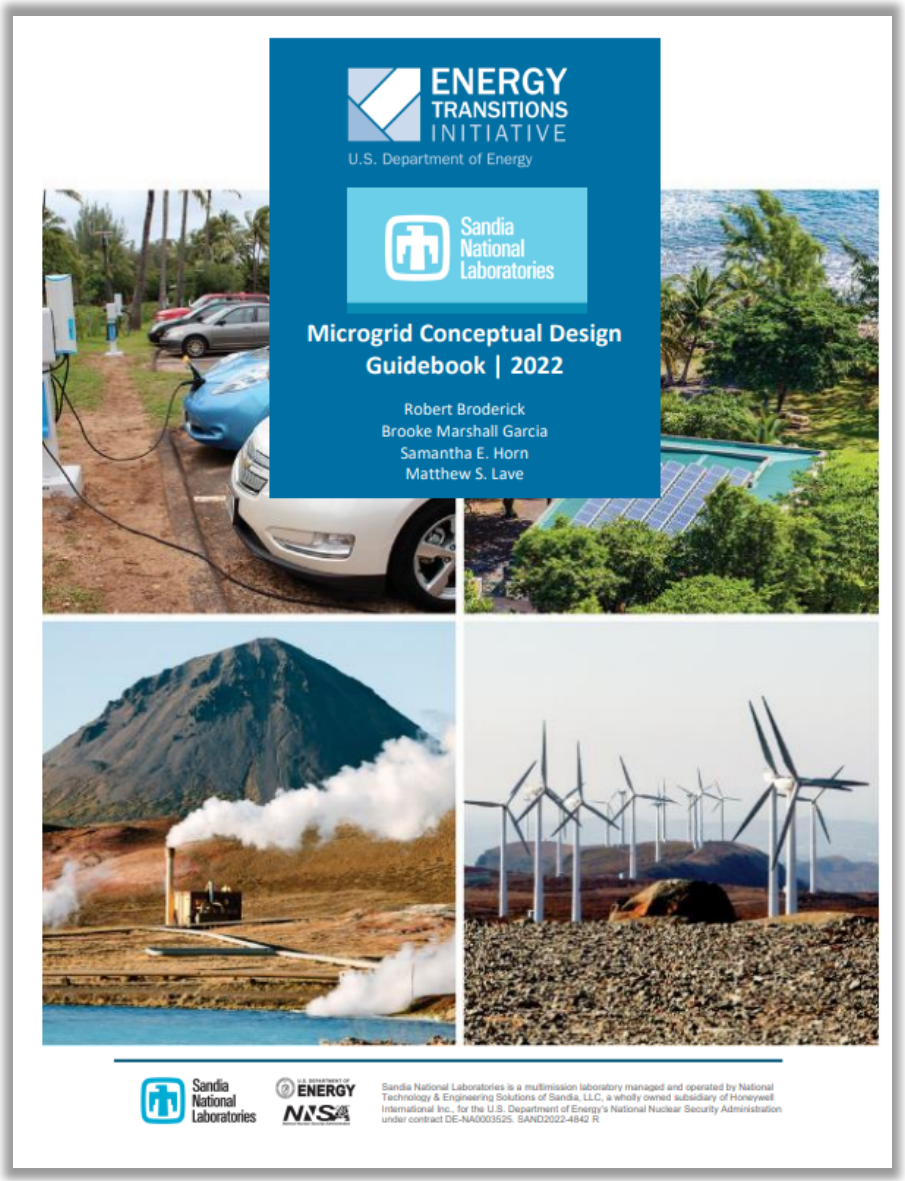


solution options and comparison tools

The 2022 Guidebook

1. Introduction to Electric Power Systems and Energy Resilience
2. Sandia's Energy Resilience Frameworks
3. Microgrids
4. Microgrid Conceptual Design Activity
5. Business Models
6. Tools – DOE Lab sampling
7. Appendices

Available at: https://energy.sandia.gov/wp-content/uploads/2022/04/ETI_SNL_Microgrid_Guidebook_2022_SAND2022-4842-R_FINAL.pdf



Summary

- Reliable power is the backbone of infrastructure and enables the provision of critical services.
- A resilient energy system supports critical community functions by preparing for, withstanding, adapting to, and recovering from disruptions.
- Microgrids are one option to enhance reliability and resilience to power outages – and beyond.
- Sandia's Microgrid Conceptual Design Methodology developed to guide communities through developing and evaluation their vision for microgrids as solutions for their particular energy needs.
- Sandia's latest Microgrid Conceptual Design Guidebook released in April 2022, publicly available to provide communities a starting place to investigate microgrid design.
- Sandia tools, such as MDT, support the conceptual design process, providing quantitative information to allow options evaluation.

Thank you
Questions | Comments

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