



# New Mexico Research Spotlight Forum

10.17.2019 Grid Resiliency

## Welcome

Anne Jakle, NM EPSCoR

SAND2019-13650 PE



Sandia  
National  
Laboratories

Georgia Institute  
of Technology

**NM** THE UNIVERSITY OF  
NEW MEXICO

**I** ILLINOIS

**NM**  
STATE  
UNIVERSITY

**PURDUE**  
UNIVERSITY

**NEW MEXICO TECH**  
SCIENCE • ENGINEERING • RESEARCH UNIVERSITY

THE UNIVERSITY OF  
**TEXAS**  
— AT AUSTIN —

SAND2019-13650 PE

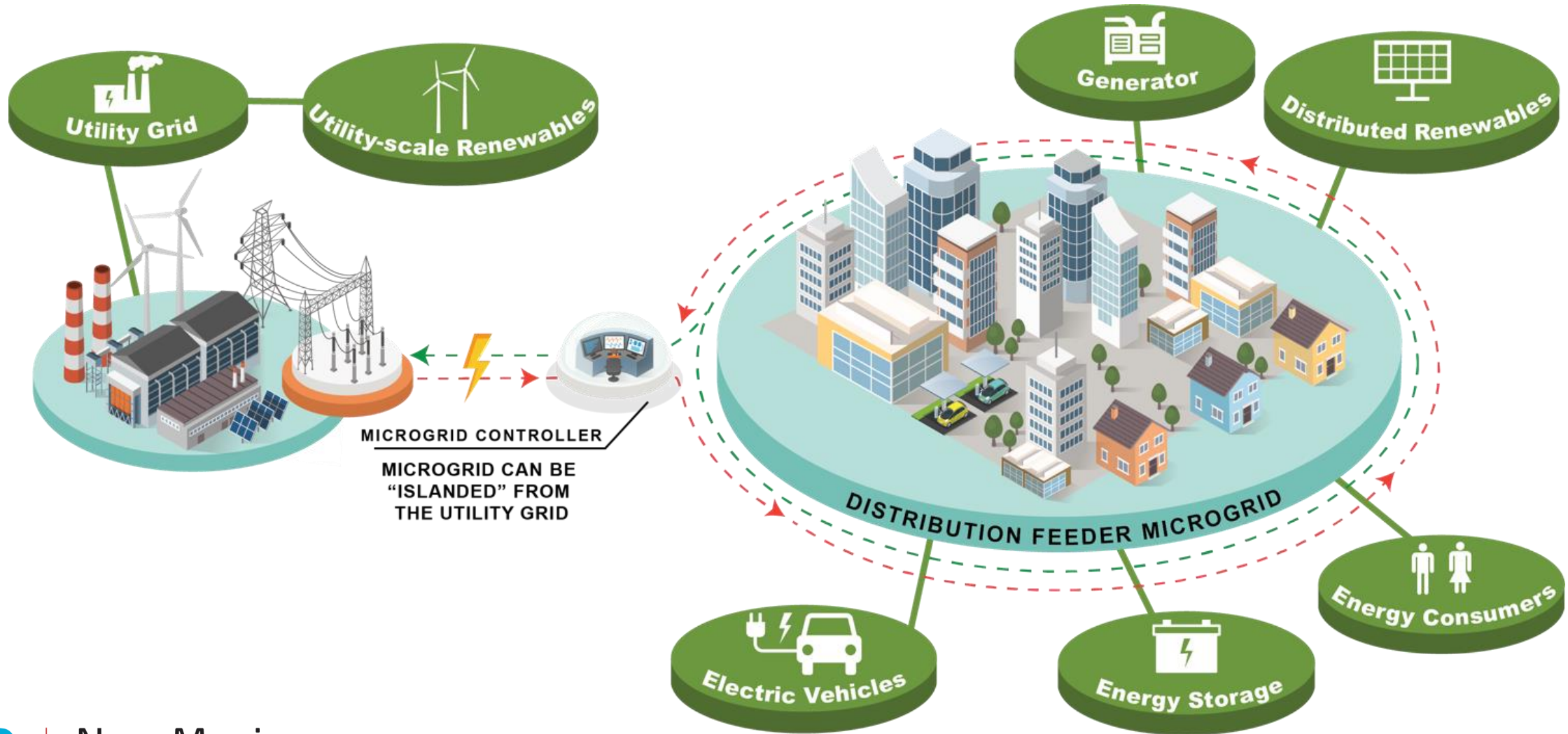
# What is EPSCoR?

Established  
Program  
to  
Stimulate  
Competitive  
Research



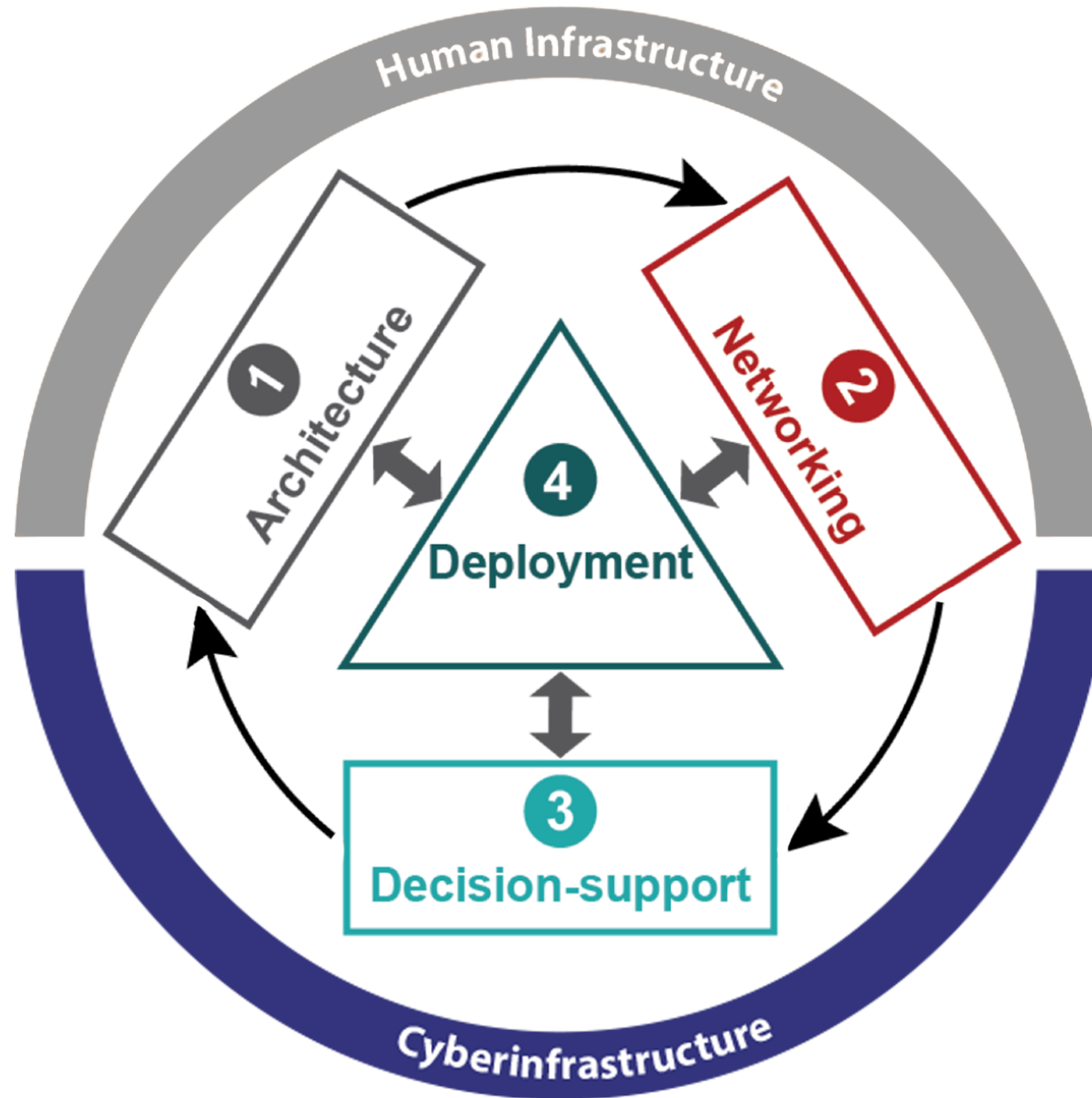
# The NM SMART Grid Center

Sustainable, **M**odular, **A**daptive, **R**esilient, **T**ransactive





# NM SMART Grid Center Research Areas



# Participating Institutions

- 3 research universities
- 1 community college
- 2 national laboratories
- 1 museum
- 1 non-profit
- Industry partners



ORACLE



40  
1977 - 2017



ELECTRIC POWER  
RESEARCH INSTITUTE



# Ways to Collaborate/Coordinate/Engage

- Individual researcher connections (handout of faculty expertise)
- Strategic partnering on new funding opportunities (e.g., GMLC)
- Propose LDRD projects through core and/or Academic Alliance/Campus Executive funding
- Engage with students: Host graduate student externs (EPSCoR funded), serve on committees, co-advise, hire them post-graduation
- Lead/participate in Collaboration Innovation Working Group
- WFD/Education Programs: e.g. Team Science Leadership Training (Jan 8-10, 2020); Explora Science Communication Fellowships







# New Mexico Research Spotlight Forum

10.17.2019 Grid Resiliency

## Overview: Grid Modernization Research at Sandia

### PRESENTED BY:

Charles Hanley, Sr. Manager, Grid Modernization and Energy Storage  
Programs

[cjhanle@sandia.gov](mailto:cjhanle@sandia.gov); 505-844-4435

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**Sandia National Laboratories**  
Program Overview



# SANDIA'S ENERGY PROGRAMS HAVE GROWN FROM OUR CORE CAPABILITIES

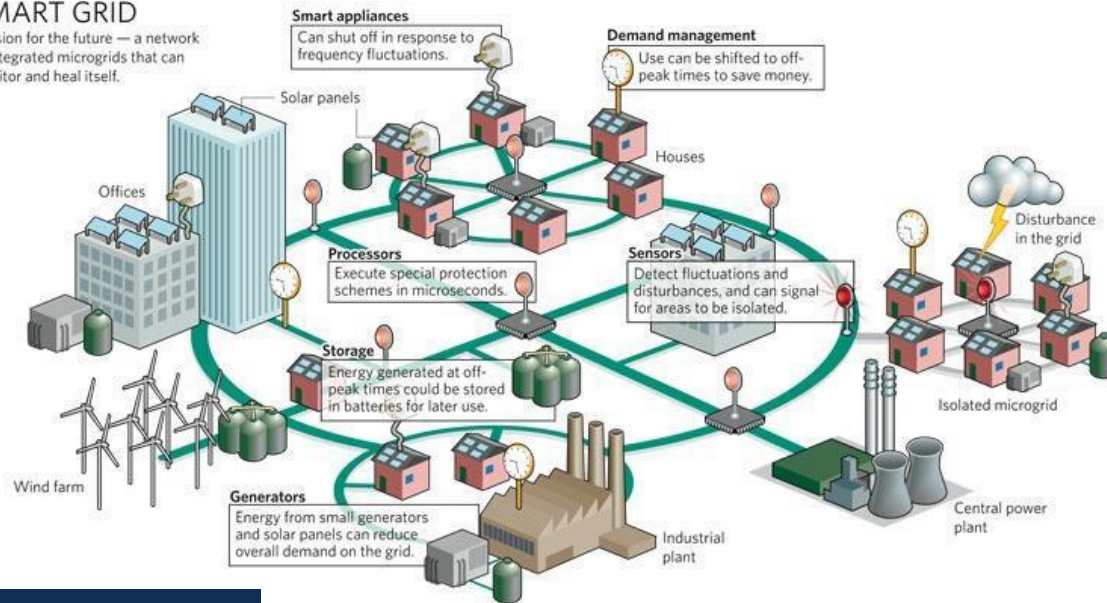




*A world of interdependent and variable distributed systems that are optimized at multiple scales – including transmission – to maximize local resources in providing secure, resilient, and clean energy to all users at all times.*

## SMART GRID

A vision for the future — a network of integrated microgrids that can monitor and heal itself.



Picture courtesy of: Smart Grid 2030

Our capabilities support this vision:

- ▶ DER and renewable energy integration
- ▶ Power electronics and controls
- ▶ Secure and scalable microgrids
- ▶ Advanced grid analytics/complex systems
- ▶ Infrastructure interdependencies
- ▶ Cyber and physical security
- ▶ Embedded sensors, information processing, and secure manufacturing
- ▶ Energy storage systems

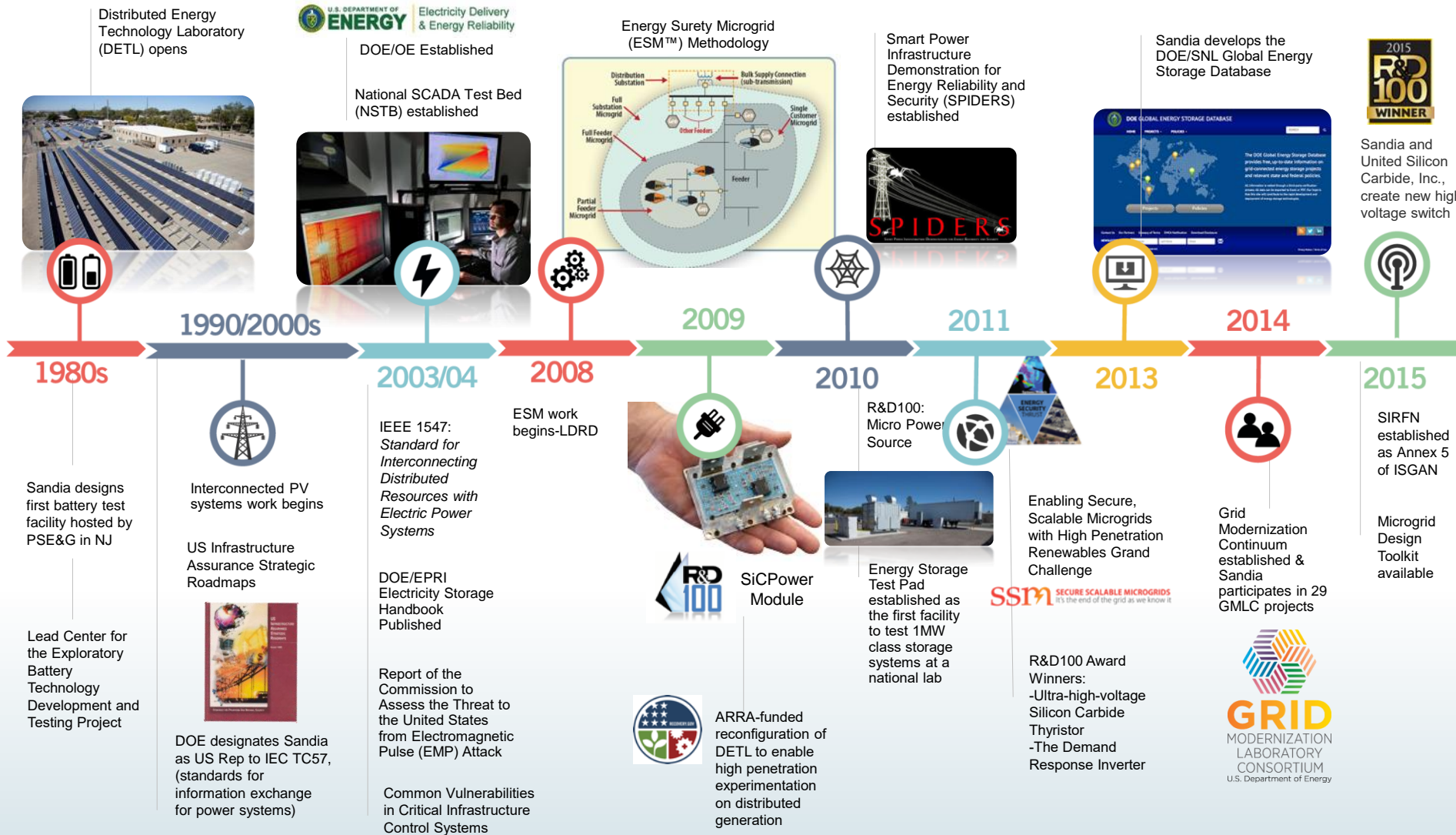
# SANDIA GRID MODERNIZATION AND ENERGY STORAGE

## Program Leadership

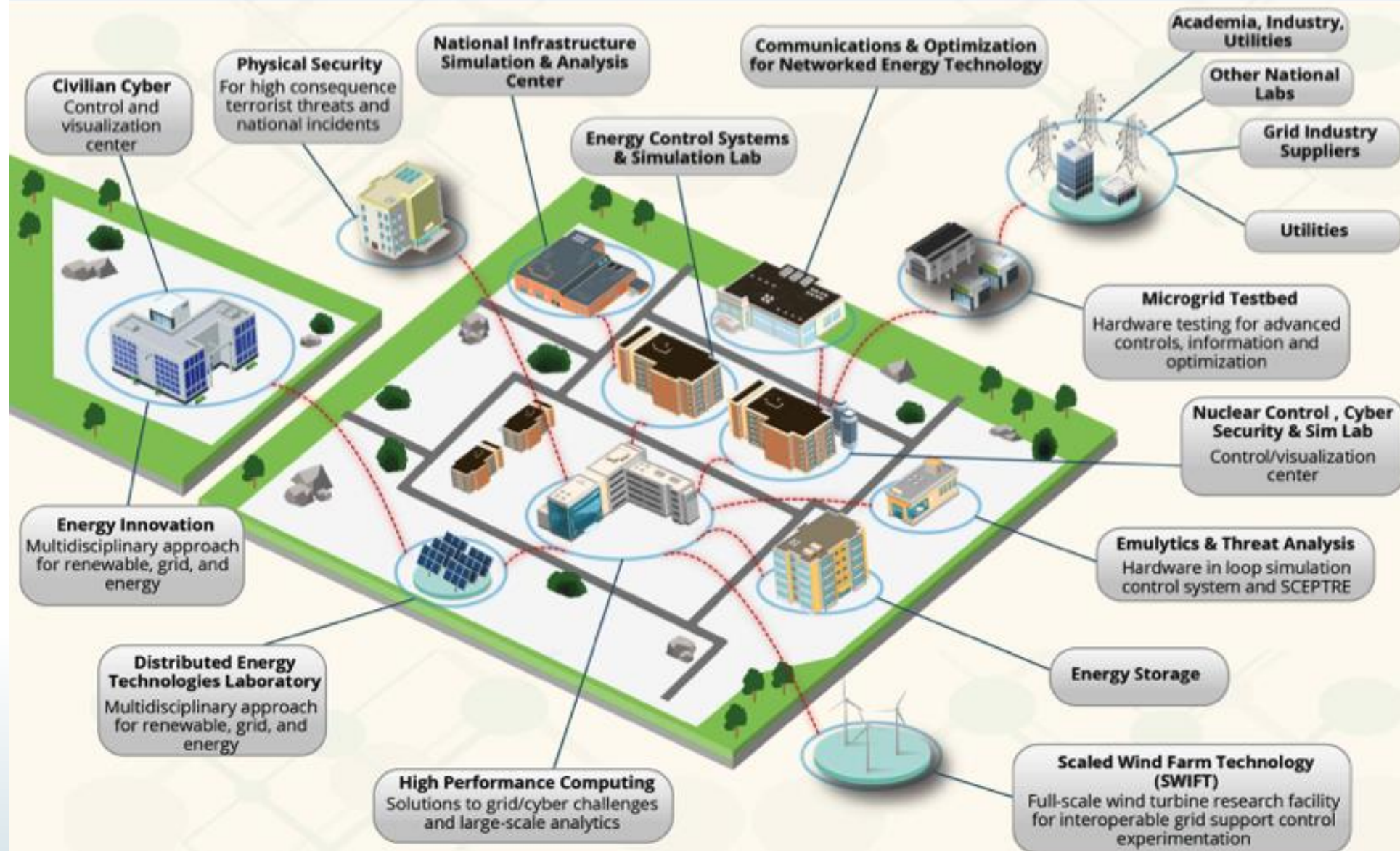




# TIMELINE: SANDIA GRID MODERNIZATION



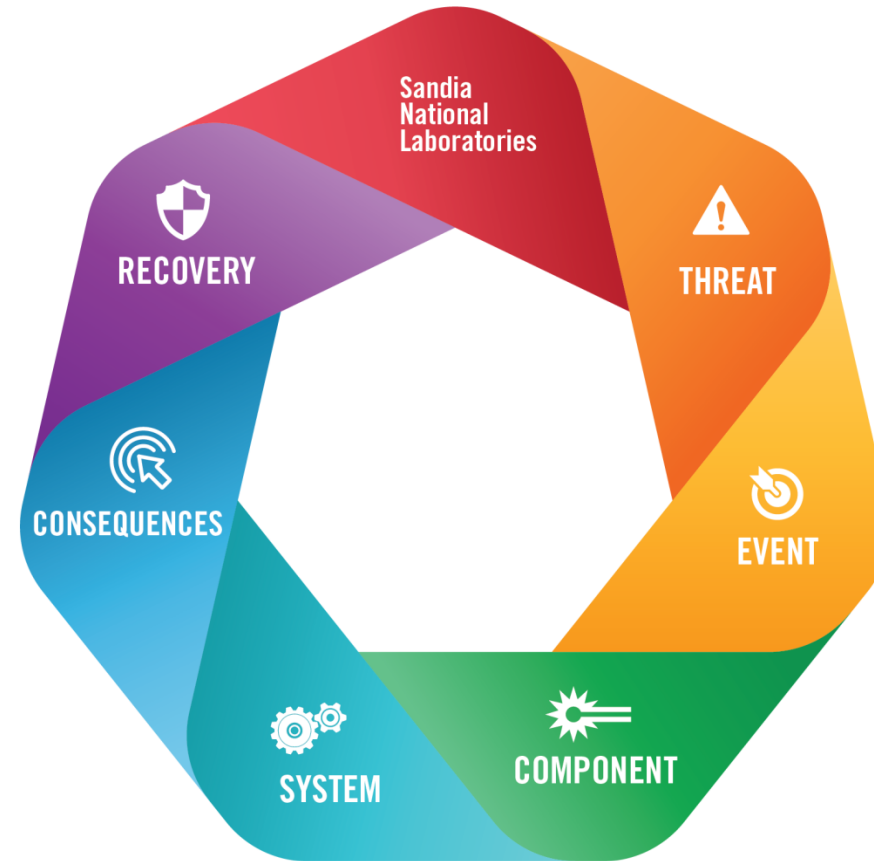
# Sandia's Integrated Energy Control System R&D Campus





# Sandia's approach to resilience combines capabilities that cover the full threat spectrum

- Integrated cyber-physical
- Combining models and physical systems
- Probabilistic and consequence-based



# Sandia's Electromagnetic Pulse (EMP) Facilities

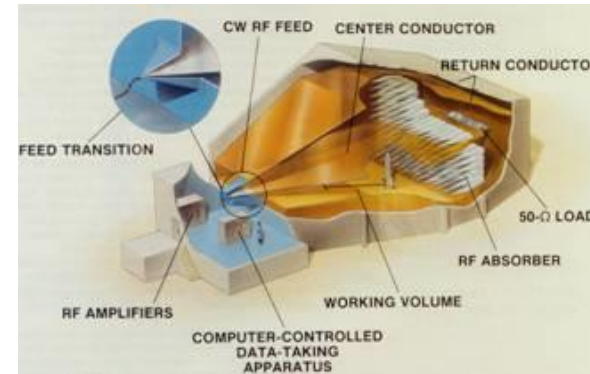
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## *Unique EM Test/Experiment Capabilities are Required for our Mission Space*



**Mode-Stir Chamber**

- CW (220 MHz – 40 GHz)



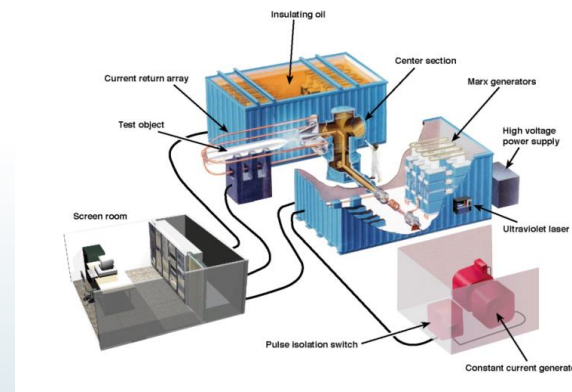
**EMES Facility**

- CW (100 kHz – 250 MHz)  
125 V/m
- EMP (1 ns risetime)  
250 kV/m



**Gigahertz Transverse ElectroMagnetic (GTEM)**

- CW (DC – 1GHz) >130 V/m
- EMP (1 ns risetime) > 130 kV/m, HPM

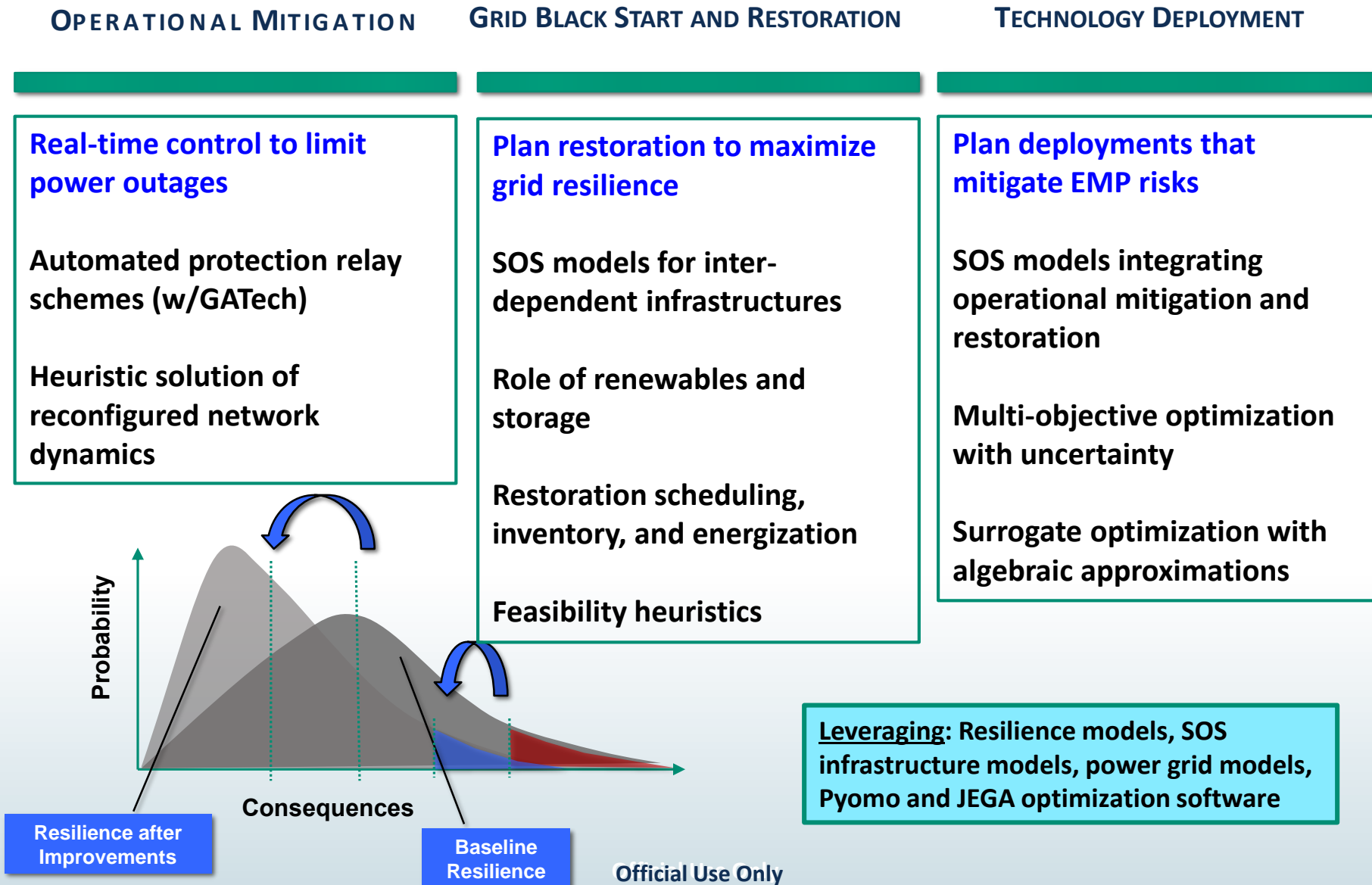


**Extreme Lightning Simulator**

- 200 kA peak
- Two pulse w/ continuing current (600 A)



# EMP/GMD Mitigation Strategies Being Developed



# Machine Learning for Grid Stability



## Objectives

- Build decision-support tool to restore grid from near blackout
- Use machine learning to map grid state to stability margins

## Novelty of Approach

- Reinforcement learning facilitates near optimal restoration of the grid
- Also allows us to characterize potential grid vulnerabilities

## Recent Accomplishments

- Using Mini-WECC grid model
- Building deep neural network for continuous space model of grid state/stability margin mapping

## Key Partners

- Southern Company

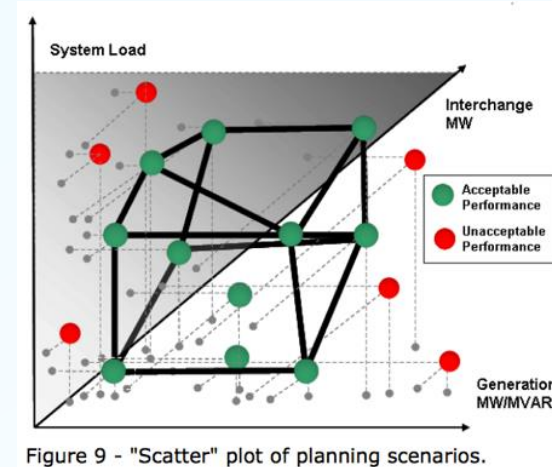
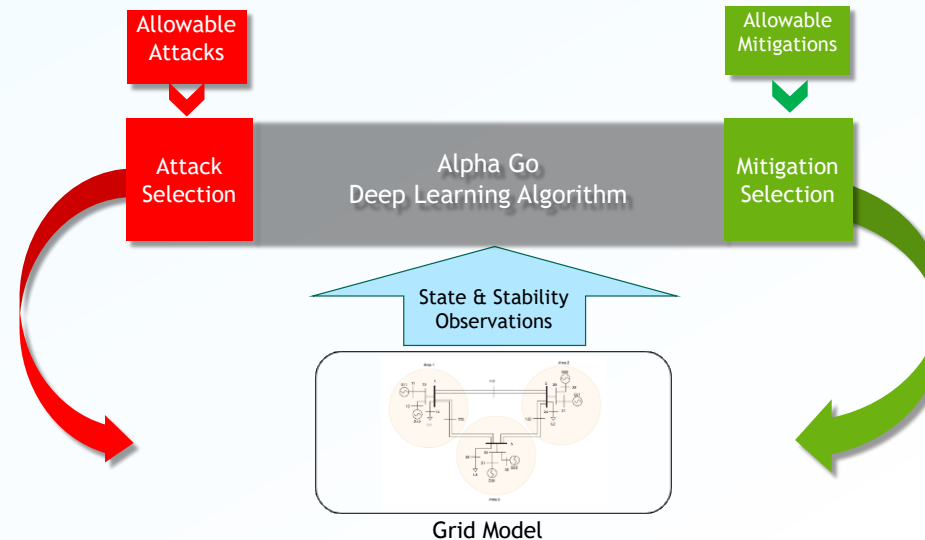


Figure 9 - "Scatter" plot of planning scenarios.

Decision-support tool for situations outside normal operation



Proposed reinforcement learning framework for grid restoration decision support



# Providing New Pathways for Distributed Resources and Cybersecurity



- Cybersecurity roadmap developed for distributed PV is being adapted across DOE renewable programs
- Methods to study complex interactions of power/cyber/controls of distributed energy systems
  - Aggregators, adaptive networks, restoration
- Apply capabilities in information and operational technology (IT/OT) security to develop new grid security paradigms
  - Data analytics, machine learning, HPC

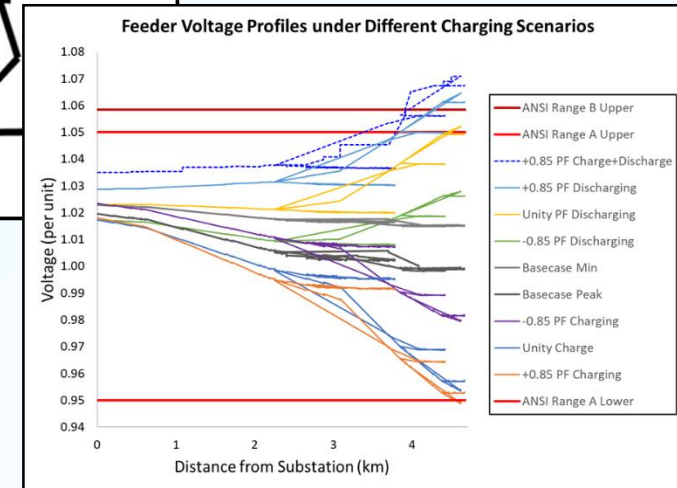
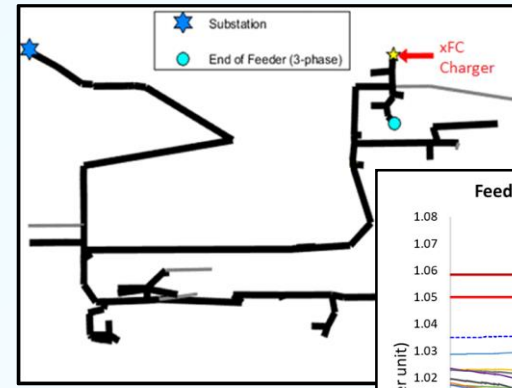


Proposed cybersecurity R&D framework for distributed systems

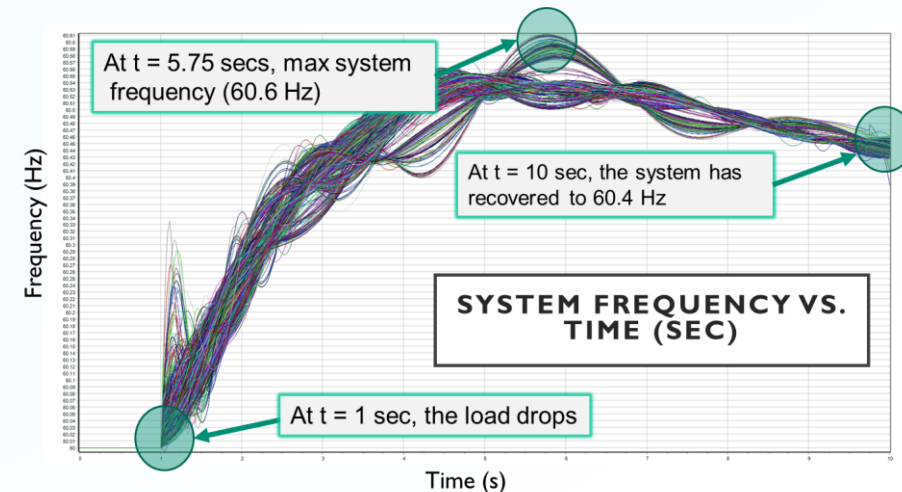
# Securing Vehicle Charging Infrastructure



- Objective: Create a cybersecurity threat model and perform a technical risk assessment of electric vehicle supply equipment (EVSE)
- Novelty of Approach: Team is conducting red team assessments of EVSEs and analyzing power system impact for different attack scenarios
- Recent Accomplishments:
  - Drafted data flow model for EV charging
  - Completed first distribution and transmission simulations for coordinated EV cyber attacks
  - Completed reconnaissance of EVSE production environment
- Key Partners: PNNL, ANL, BTCPower, NMFTA, DOT



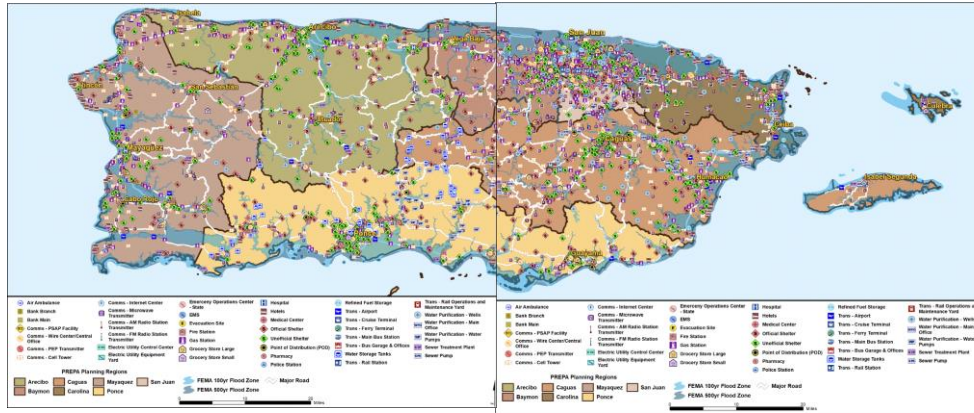
Distribution Simulations of EV Cyber Attacks



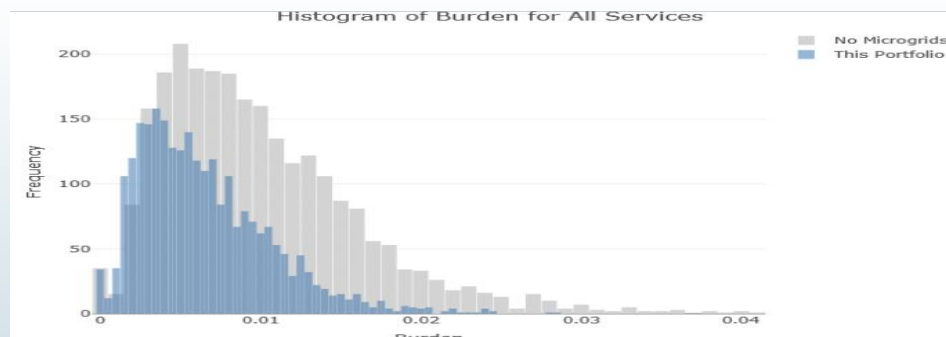
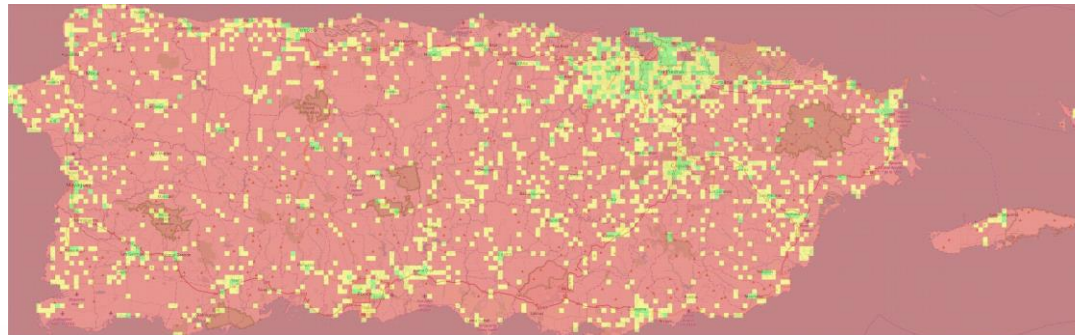
Transmission Simulations of EV Cyber Attacks



# Puerto Rico: Critical Infrastructure Locations for Resilient Microgrids



100-yr Flood



- Create 3-D rendition of critical infrastructure, service locations
- Develop maps of optimal microgrid locations under various threat scenarios
- Compare histograms of consequence or “burden” impacts

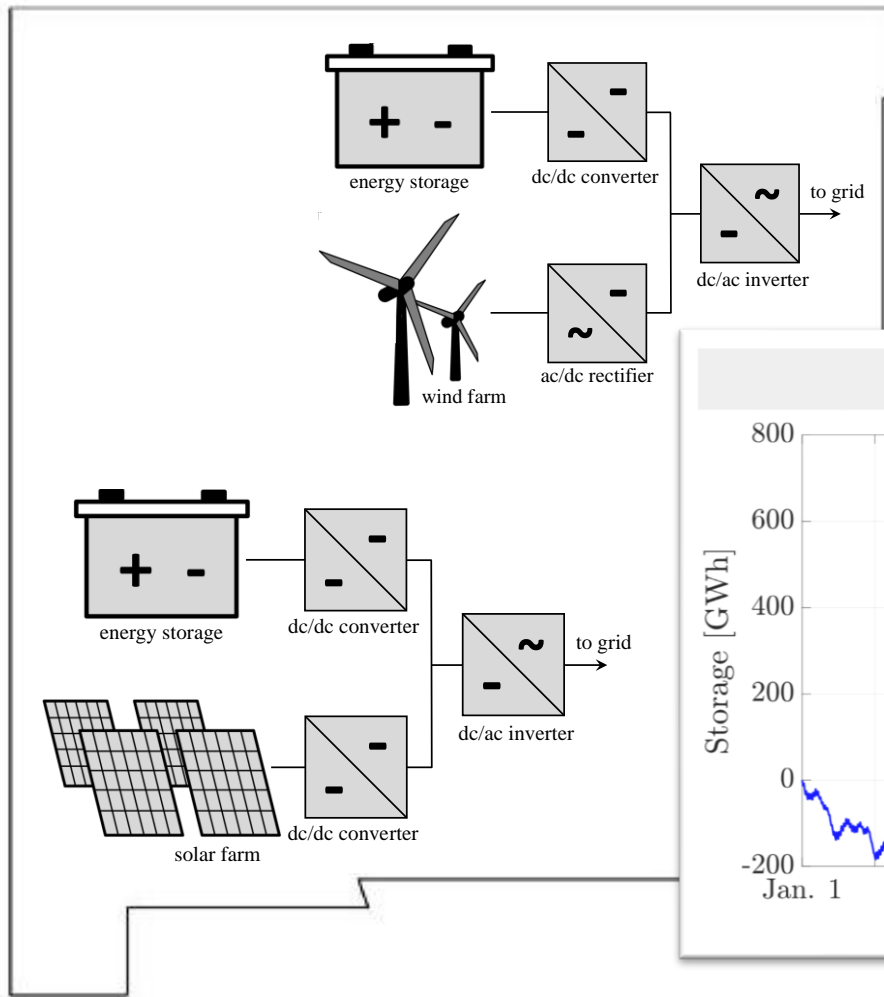
# 100% Carbon-Free New Mexico Analysis



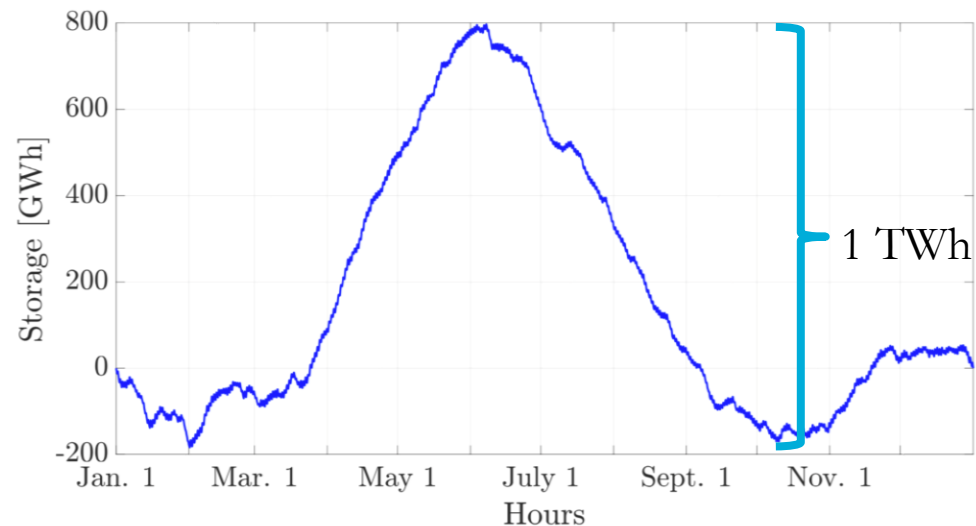
**New Mexico aiming for 100% carbon-free electric generation by 2045.**

Significant changes required to mitigate renewable intermittence and stochastic demand:

➤ What should the generation mix be (solar/wind)?



NM energy storage requirement



➤ Where to site resources and build transmission infrastructure?

➤ How much energy storage?



# Integrated Mission Assurance with DOD Partners: Malmstrom Missile Silo Energy Surety - 60 Day Study

## Objectives

- Investigate use of Sandia's Resilience Analysis Methodology for energy security of the ICBM Missile Launch sites assigned to Malmstrom Air Force Base

## Novelty of Approach

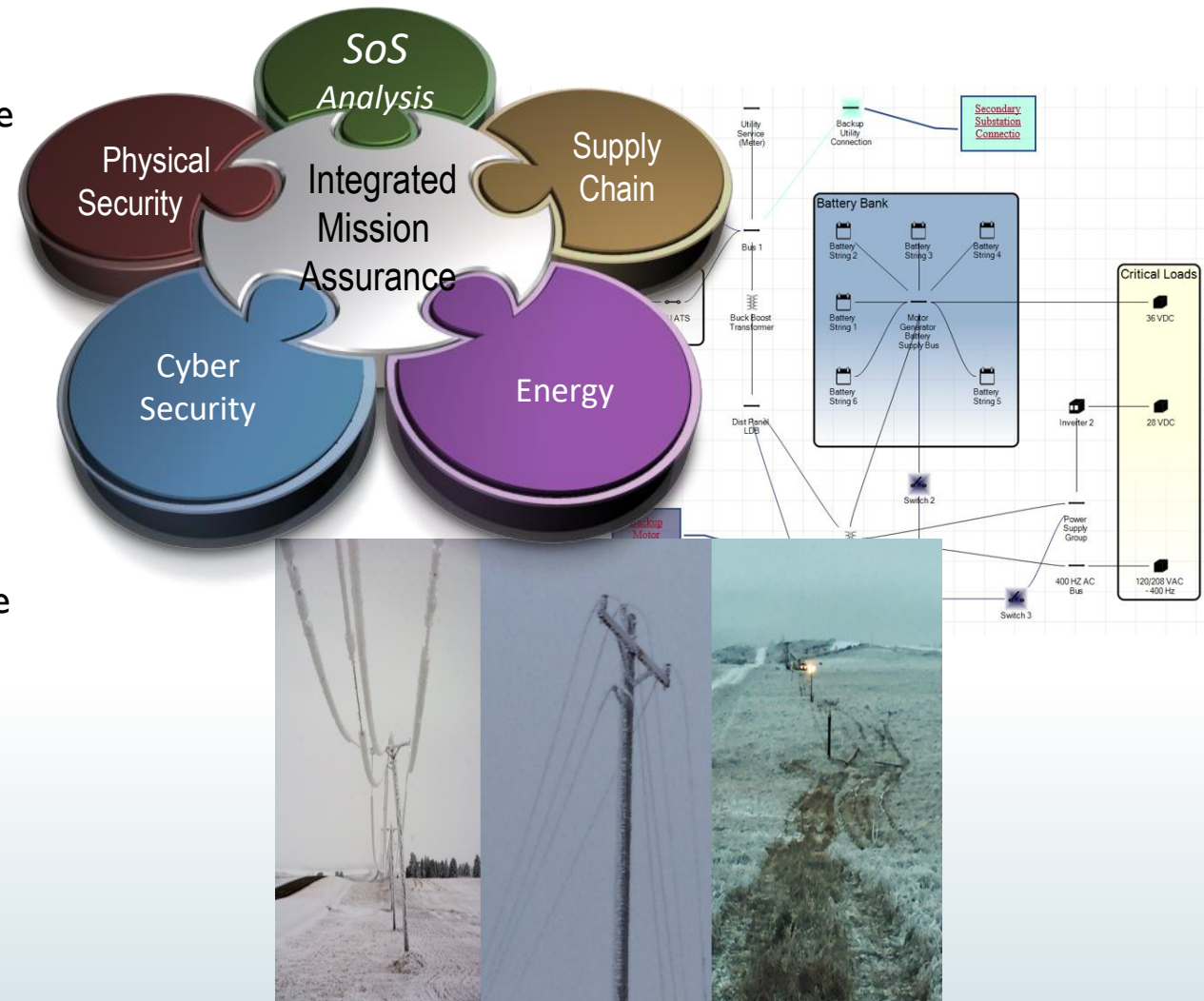
- Use of Sandia's Microgrid Design Toolkit
- Address both site and utility issues
- Consider resilience (high consequence, low probability) events.

## Recent Accomplishments

- OUO Study Completed and recommendations made

## Key Partners

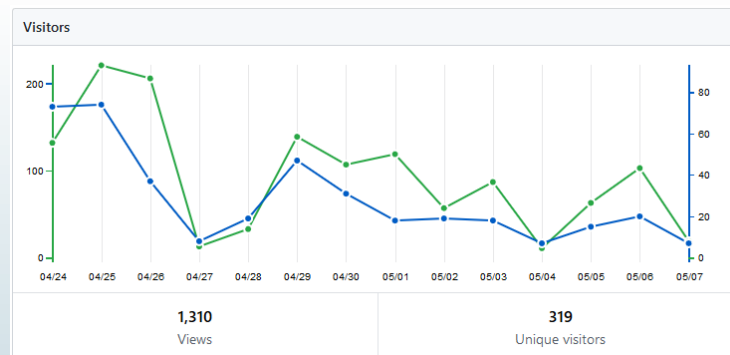
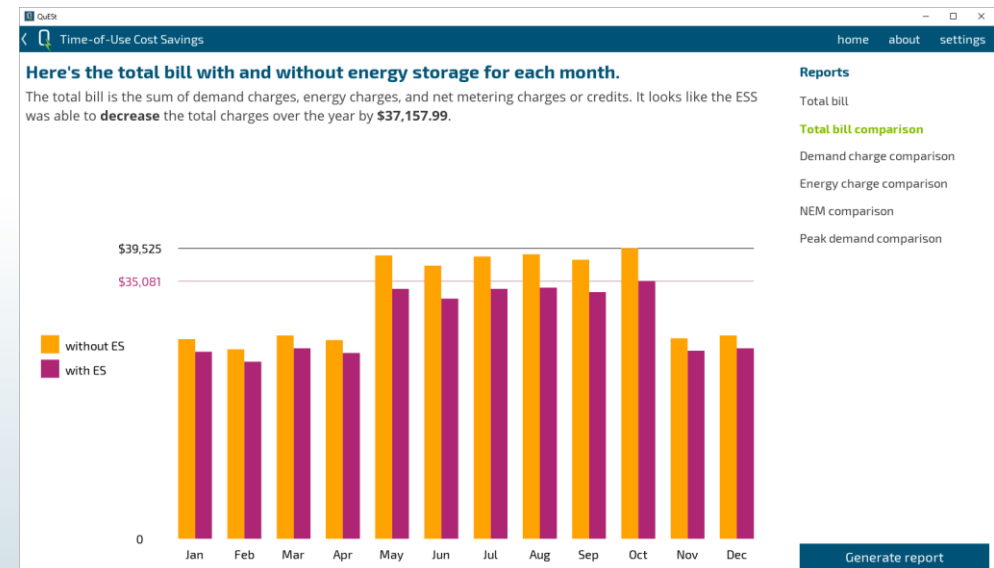
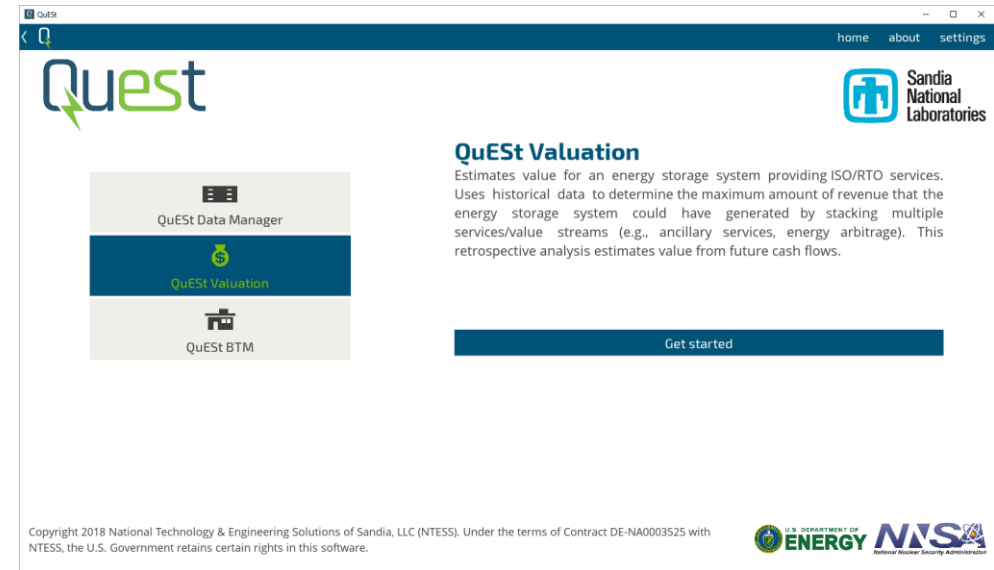
- NNSA
- Malmstrom Air Force Base
- Air Force Nuclear Weapons Center
- Air Force Global Strike Command



# QUEST: Open Source Energy Storage APP Suite



- A free, open source software tool for energy storage valuation designed to be run from the desktop
- Initially released in September 2018 with update releases in November and March
- Uses public domain data to estimate value potential of energy storage via retrospective analysis of value stacking
  - Energy arbitrage
  - Ancillary services
  - Other ISO/RTO services
- Latest version includes QuEST BTM with a tool for estimating cost savings for time-of-use customers using energy storage
  - Demand/energy charge reduction; net metering credits
  - Onsite solar + storage facility configurations

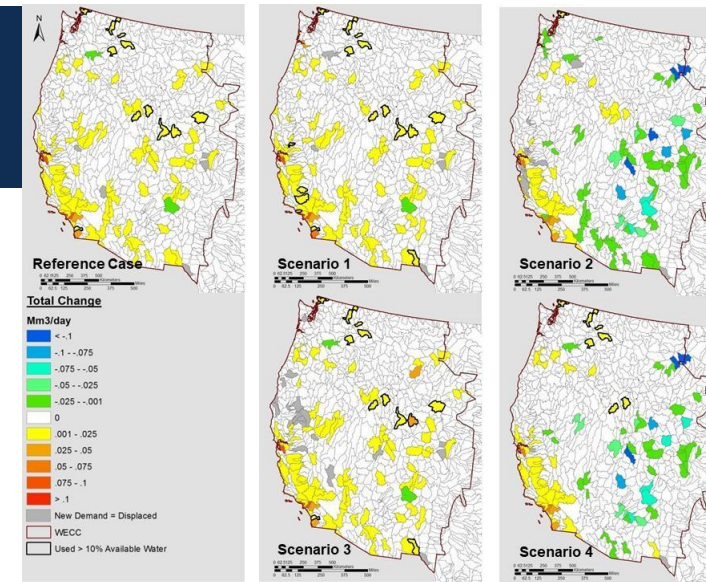




*Limiting the impacts of an uncertain water future on the reliability and resilience of the electric power system*

- ▶ Developing advanced technologies to make new sources of water available at competitive costs.
- ▶ Supporting the nation's interconnections with integrating water into their long-term transmission planning.
- ▶ Modeling and analysis to improve the resilience and reliability of coupled energy-water systems.
- ▶ *Water Atlas*, a database of critical water supply, demand and policy information.
- ▶ Tools for water distribution system resilience to natural and human-caused events.

Water footprint of different WECC transmission expansion scenarios



# New Mexico Can be a National Security Model

## Leadership in Clean Energy, Water Security, Education, and Job Creation



### RESILIENT ENERGY:

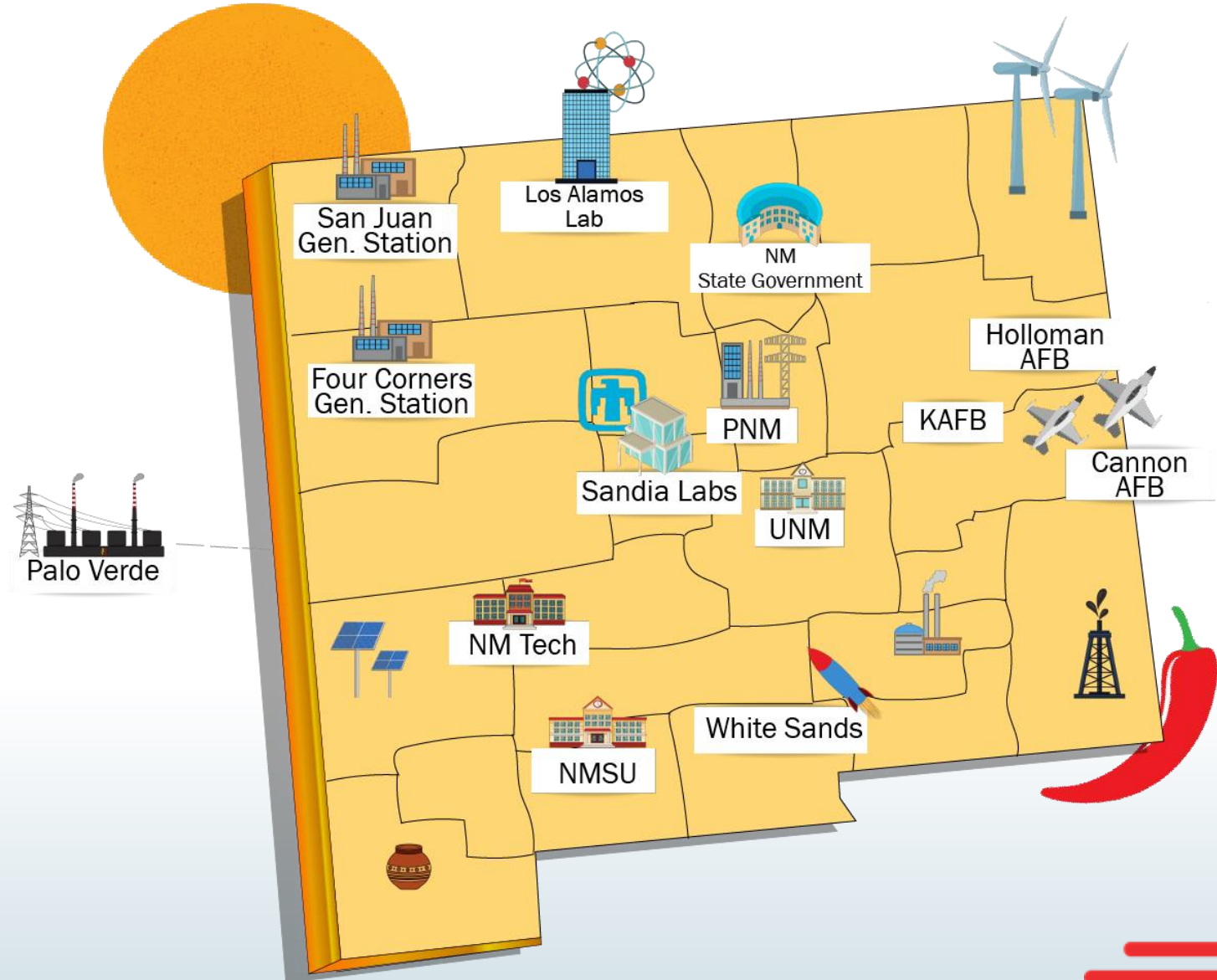
- Physical Security
- Cyber Security
- Energy/Resource Security

### TECHNO-ECONOMIC APPLICATIONS:

- Energy Storage
- Microgrids
- Blackout Recovery
- Fossil Retirement
- Renewables Integration
- Energy/Water Infrastructure
- Disaster Response (natural/human caused)
- Transportation
- Hydrogen

### BUILDS ON SANDIA WORK:

- California
- Alaska
- Hawaii
- Puerto Rico/US Virgin Islands
- Texas







- **Multi-Scale Energy Storage Technologies:**
  - Develop, deploy, and assist in the scale-up of safe, reliable storage systems to enable a grid transformation.
- **Control Systems and Optimization:**
  - Integrated controls and optimization across transmission, distribution, and advanced microgrids to employ new operational paradigms and asset aggregation schemes.
- **Power Conversion Systems:**
  - Employing advanced power devices and controls in highly efficient converters that provide greater autonomy at multiple physical scales.
- **Grid Security:**
  - Apply Sandia's extensive capabilities in information and operational technology (IT/OT) security to develop new grid security technologies; apply our technology developments in physical security for nuclear and defense installations for the grid.
- **Resilience Methods:**
  - Develop and deploy data-analytical methods to measure and improve overall resilience for communities, defense installations, and other stakeholders.
- **Electromagnetic Pulse and Geomagnetic-Induced Currents:**
  - Lead the nation in determining potential impacts of EMP/GMD and effective mitigation strategies.