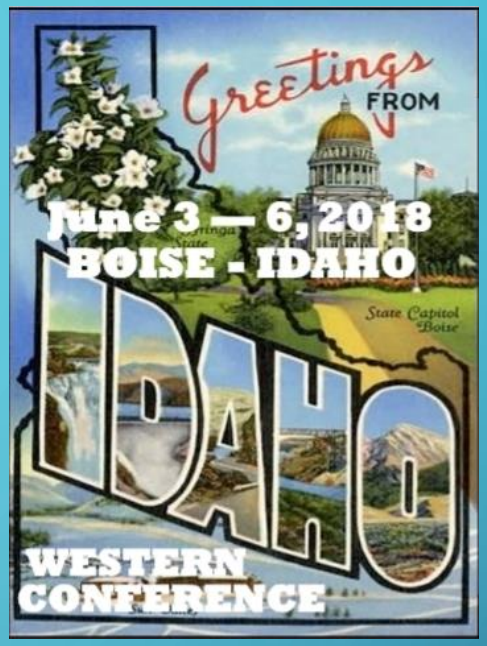
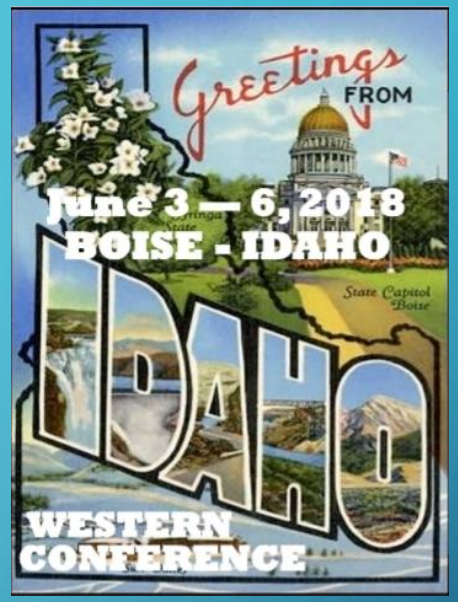


RESILIENCY:

RESPONDING AFTER A DISASTER

Resiliency:

Responding after a disaster



Moderator: Honorable Ann Rendahl
Washington Utilities and Transportation Commission

Panelists:

Dr. Rob Hovsapian —Department Manager, Power and Energy Systems, Idaho National Laboratory

Matt Kessel — Vice President of Regional Operations, E.ON

Mark Milburn— Vice President, LS Power

Sarah Van Cleve – Energy Policy Advisor, Tesla Motors

Resilience by Design New Approach to Microgrid Solutions

Rob Hovsapian, Ph.D.
Department Manager, Power & Energy Systems
Idaho National Laboratory

June 5, 2018

www.inl.gov

Idaho National Laboratory

Reliability is important,
resilience is vital

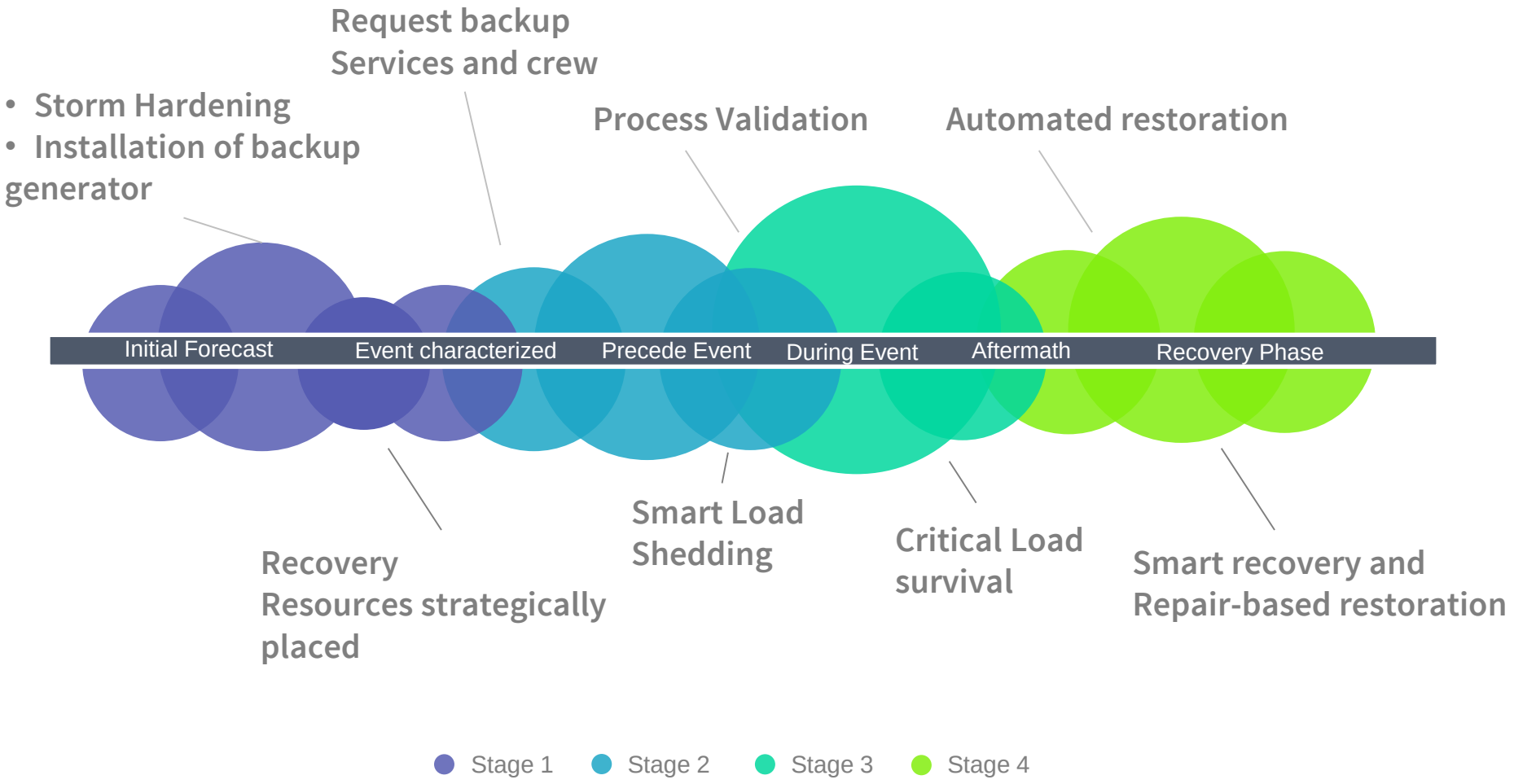
What cannot be done?

- Overpower extreme natural forces
- Know cyber-attack perpetrators

What can be done?

- Predict, prepare, protect critical infrastructure
- Keep lights on critical loads and shelter homes during and after on-going events
- Identify most vulnerable areas of infrastructure, to adequately install defense mechanisms to storm-harden them
- Optimize resources during recovery and restoration to minimize downtime and costs
- Keep cyber-attackers at bay

Resiliency enabling process is dynamic



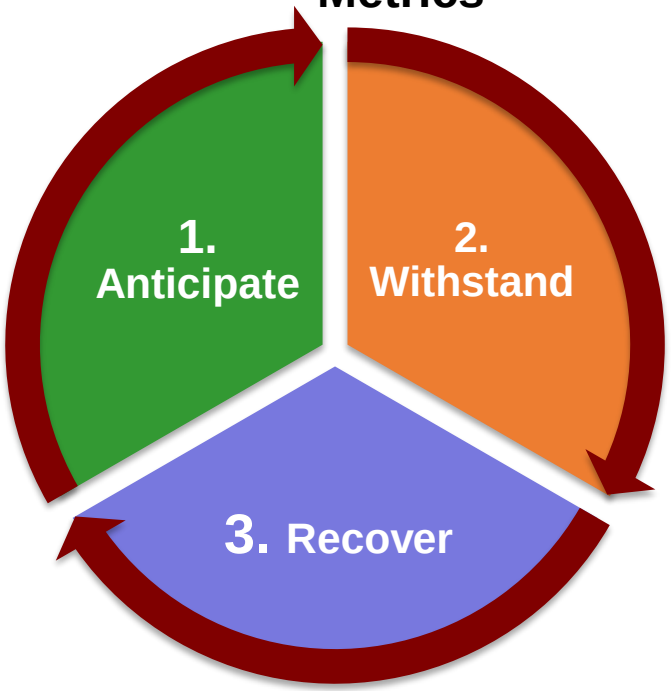
Calculating Resiliency Metrics

Building upon software tools developed in GMLC 1.3.9, CANVASS, resiliency metrics will be calculated based on threat at a nodal as well as a network level.

Anticipate	Withstand	Recover
Develop a threat model Know the infrastructure Anticipate impact of threat on the infrastructure	Ability of an infrastructure component or infrastructure to endure an high-impact event, may be storm hardening, or backup individual generators	Minimum spanning tree and critical-first restoration strategies and resource optimization to enable maximum resilience and minimum downtime

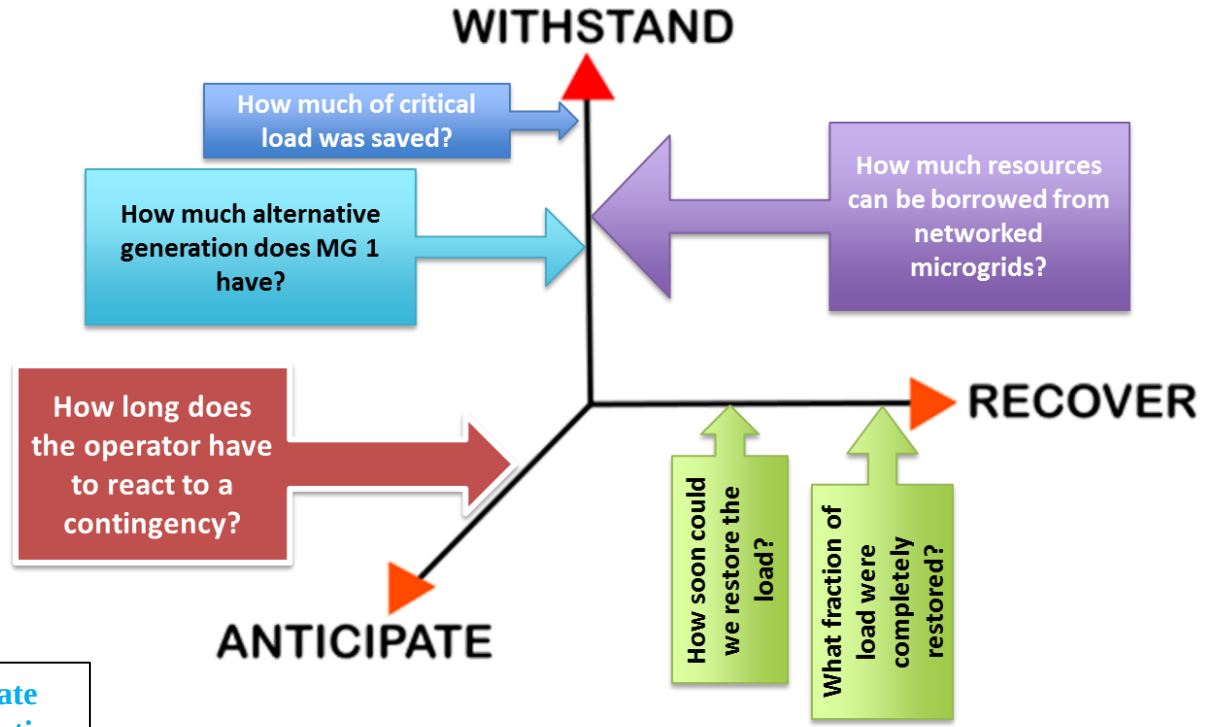
Architecture Design – Resiliency Framework

Quantifying Resilience of Power Distribution Systems using Metrics



Anticipate – Ability to forecast disruption or relocate dependence, make proactive decisions using prediction
Withstand - If an unforeseen unfavorable event has occurred, capability to optimize resources, such that only minimum functionality is lost
Recover – Robust distribution system automation to quickly return to a pre-contingency operating state by overcoming the adversary or attack

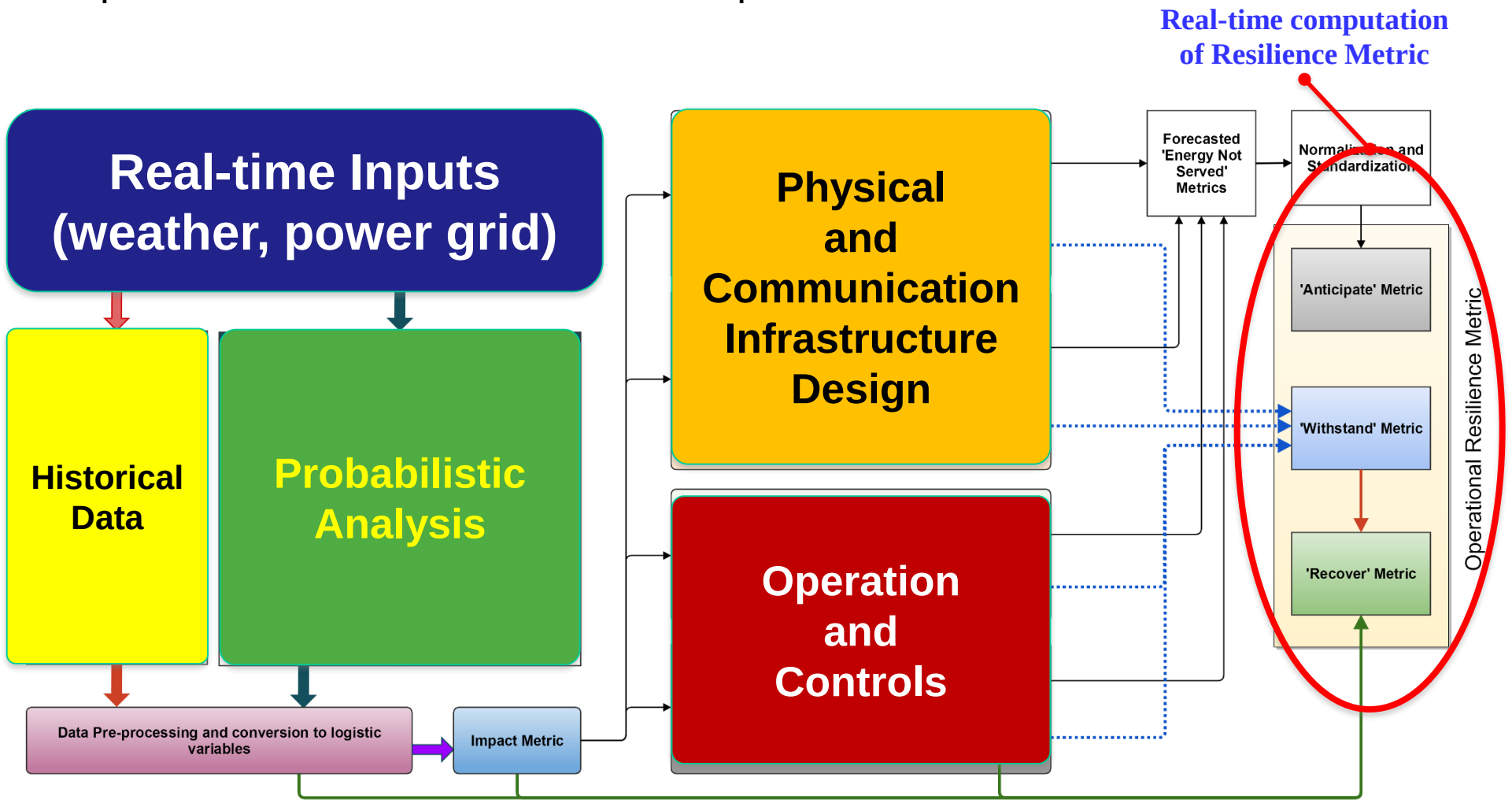
Multi-Dimensionality of Resilience Metrics



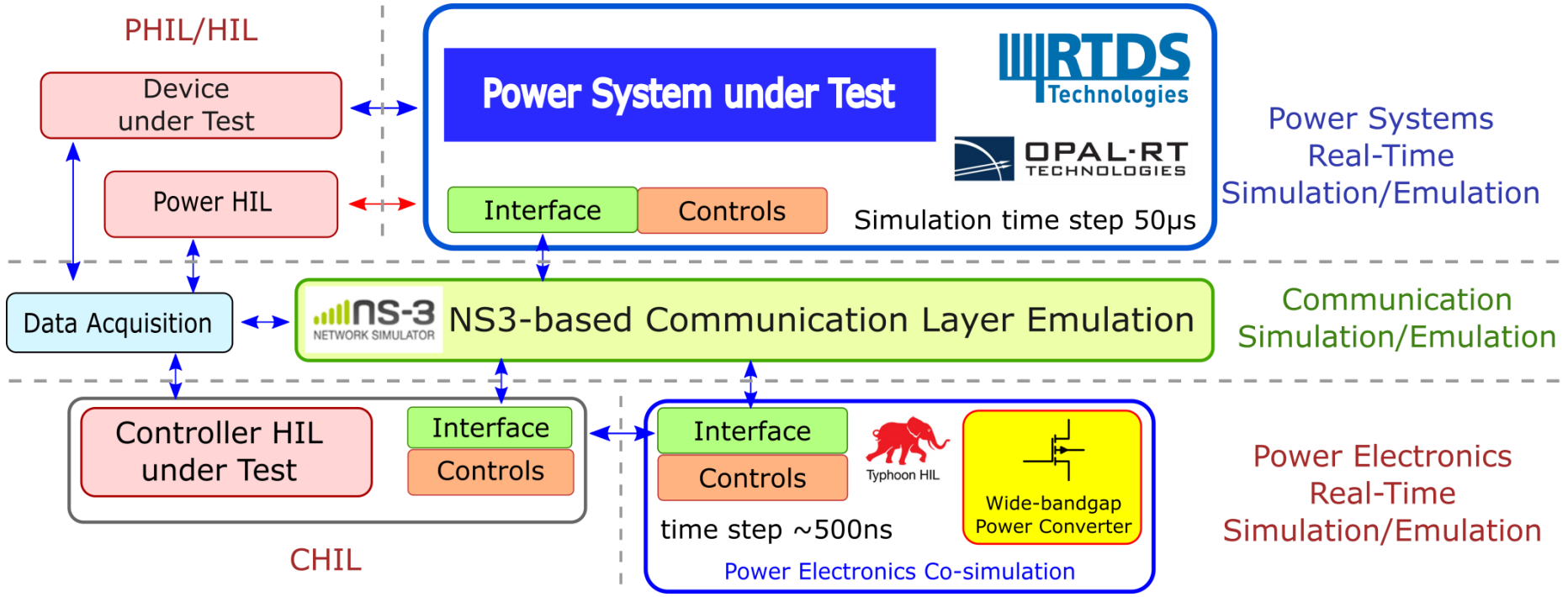
$$M = f(\text{anticipate}, \text{withstand}, \text{recover})$$

Architecture Design – Resiliency Framework

- Operational Resilience Metrics Computation Flowchart



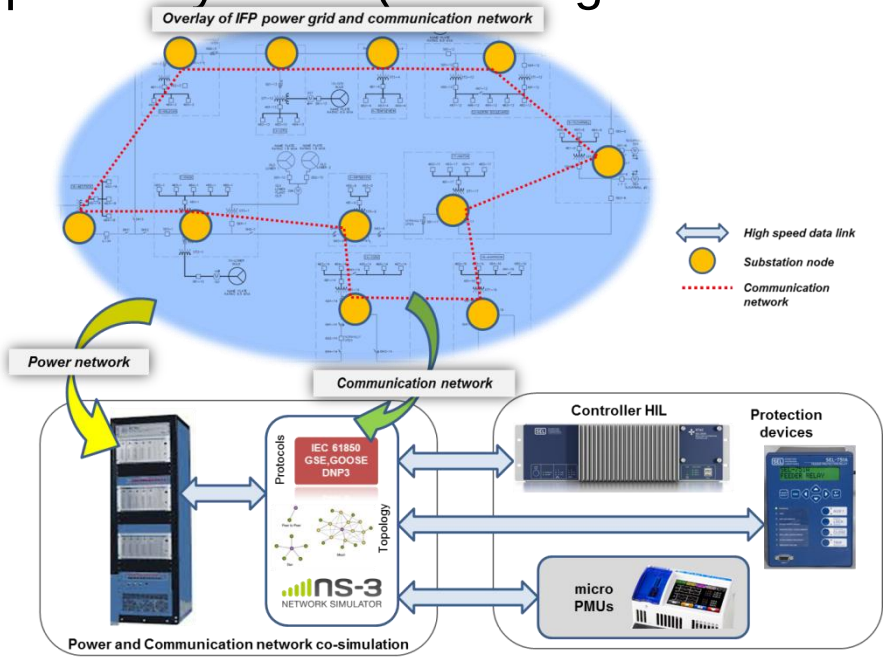
Integrated Resiliency Multi-Scale Real-Time Simulation Test-bed

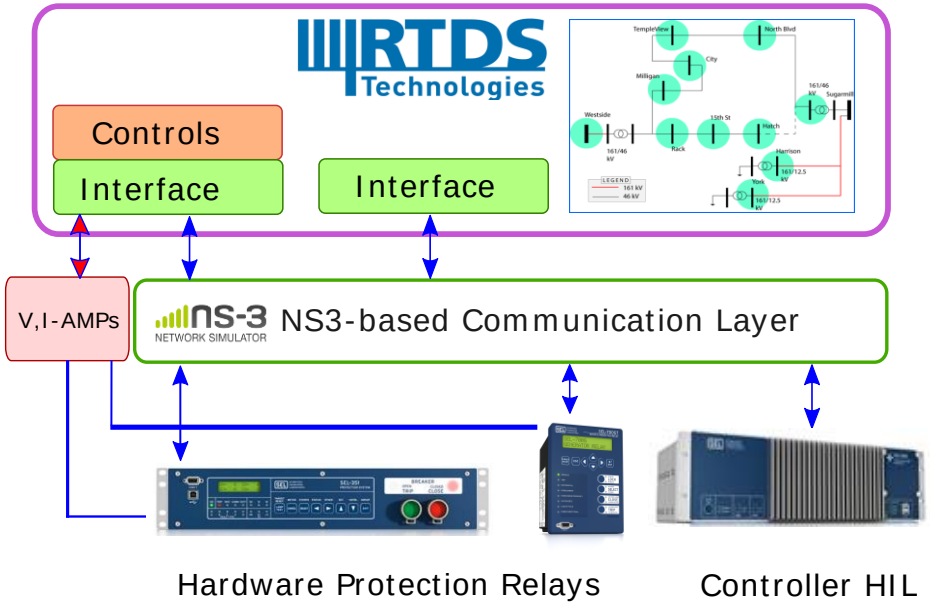


Real world PHIL & CHIL testing capabilities.

Next Generation Microgrid Design Tools

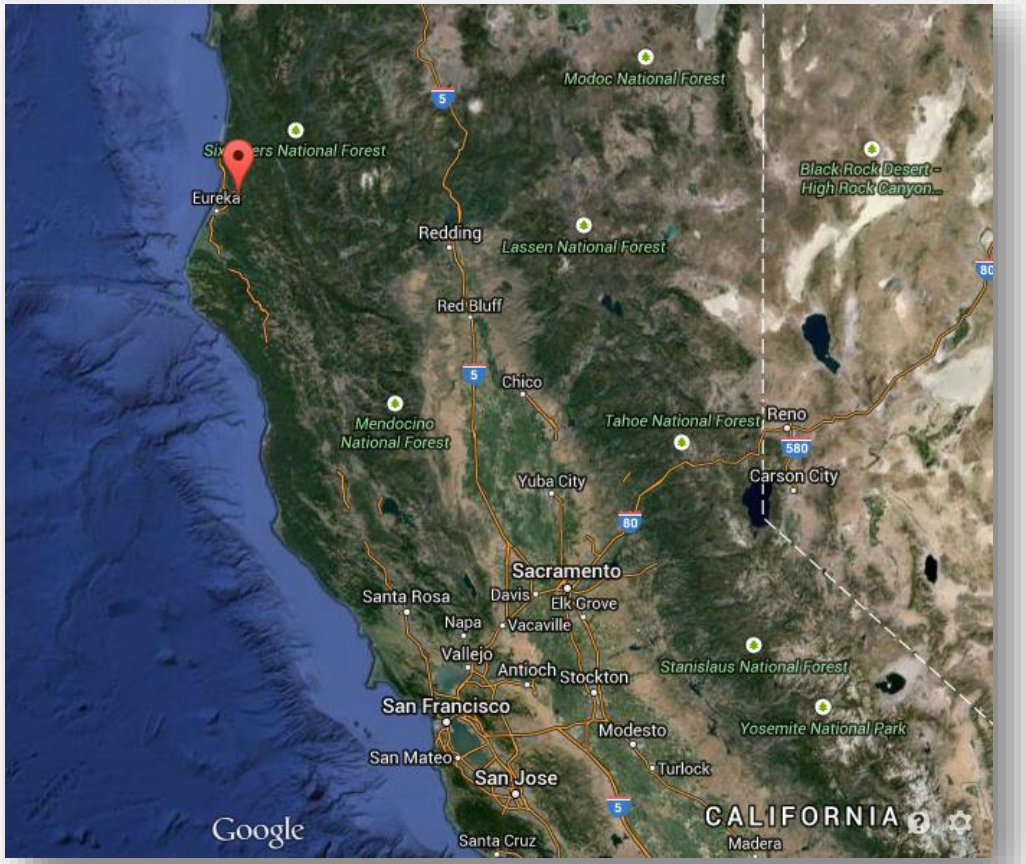
- Next generation of microgrid design tools
  - Communication emulation
  - Co-simulation of
    - **communication**,
    - **power electronics** (including SiC-based devices),
    - power systems (including real-time emulation of protection system)





Next Generation Microgrid Controller for a Red-Cross Evacuations Route

BLUE LAKE RANCHERIA



Funded by California Energy Commission's Electric Program Investment Charge

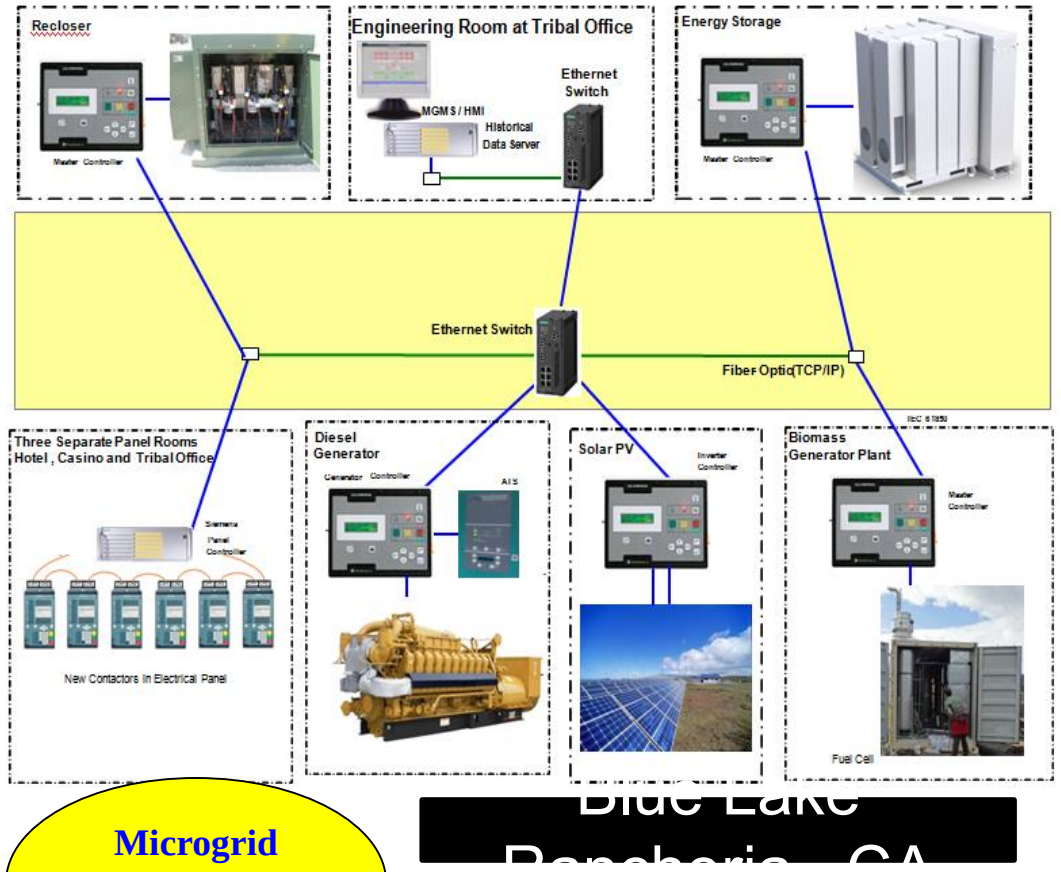
- **Program Goal:** Demonstration of Low Carbon-Based Microgrids for Critical Facilities

- Our Partners:

HUMBOLDT STATE UNIVERSITY 1913 · ΘΩΣ ΑΛΗΘΕΙΑ · SIEMENS PG&E TESLA

CEC- Project Architecture

Blue Lake Rancheria

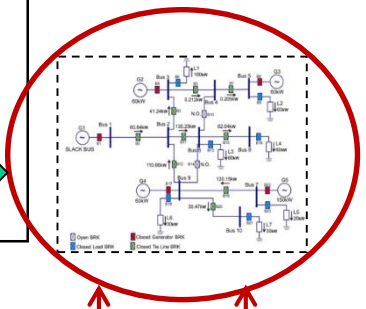


Microgrid Went Live 04/28/2017

Microgrid Modes of Operation:

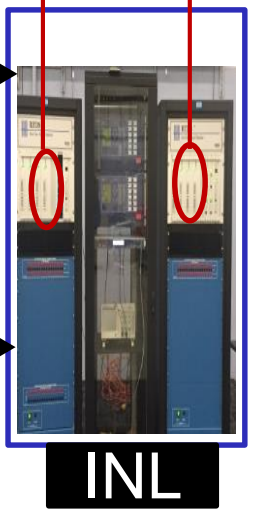
1. Grid connected
2. Black start transition
3. Off-grid operation
4. Resynchronization to PG&E network
5. Transition to Islanded Operations with MGMS Unresponsive

PG&E Power System Network



Controller in the Loop (CHIL)

Power Hardware in the Loop (PHIL)



Value Addition: Simulation of multiple *what-if* scenarios before field deployment

Resilient Alaskan Distribution system Improvements using Automation, Network analysis, Control and Energy storage (RADIANCE)

- Tsunamis
- Avalanches
- Power outages disrupting fishing business

Cordova, AK, serves as a perfect microcosm for prototyping innovations for the entire power grid across the nation

RADIANCE Project Overview

1

Resilience Metrics Framework for Design and Operation

Develop and demonstrate practical use **of resilience metrics** for coordinated operation, design to minimize outages, financial losses

2

Multiple Networked Microgrids in Distribution System

Leverage rotational and virtual inertia of microgrids assets including **hydro**, diesel, energy storage, and **micro PMU-based sensing** to enhance resilience of the overall regional distribution network

3

Cyber-security Architecture and Rapid Prototyping of Controls

Rapid prototyping of controllers as HIL and cyber-vulnerability testing in a **real-time cyber-secure environment**

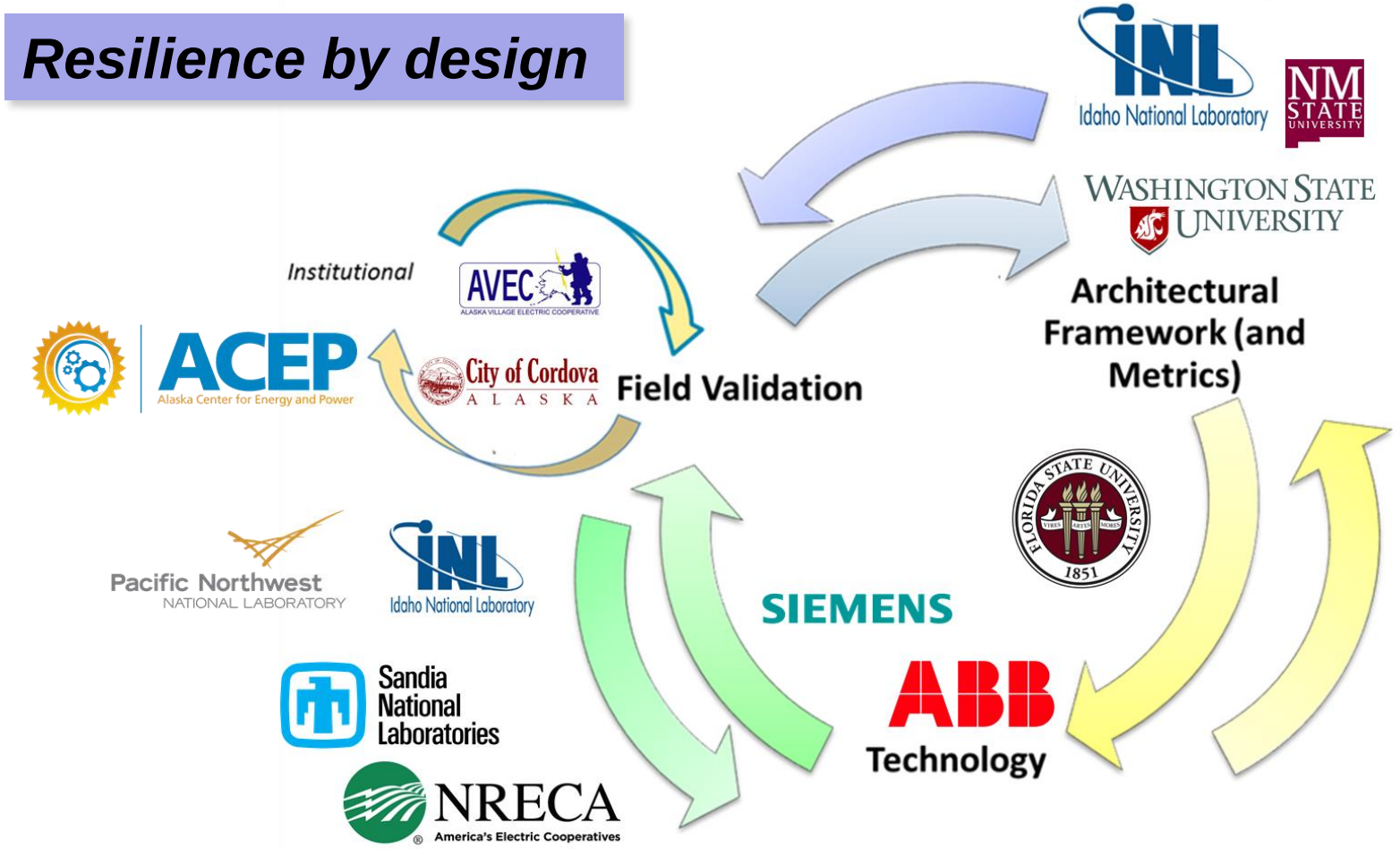
4

Field Validation of Resiliency Enhancement Methods

Field validation of increasing resiliency of the overall distribution system by leveraging resources from **multiple networked microgrids**

The Team

Resilience by design



THANK YOU

BACKUP SLIDES

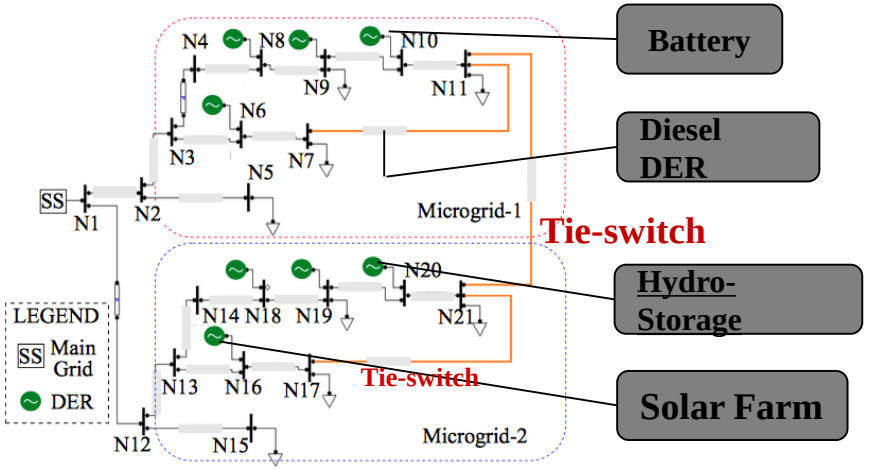
Resilience is enabled through Data-Driven Distribution Automation (D3A) technologies

- Spanning-tree & Critical-First Restoration Algorithm
- Deployment of advanced sensors and micro-PMUs
- Smart Switch and recloser placement to minimize outages
- Proactive Reconfiguration
- Big Data and Machine Learning
- Outage management optimization

Design of Networked Microgrids – Zonal Approach

Tightly-coupled Microgrids

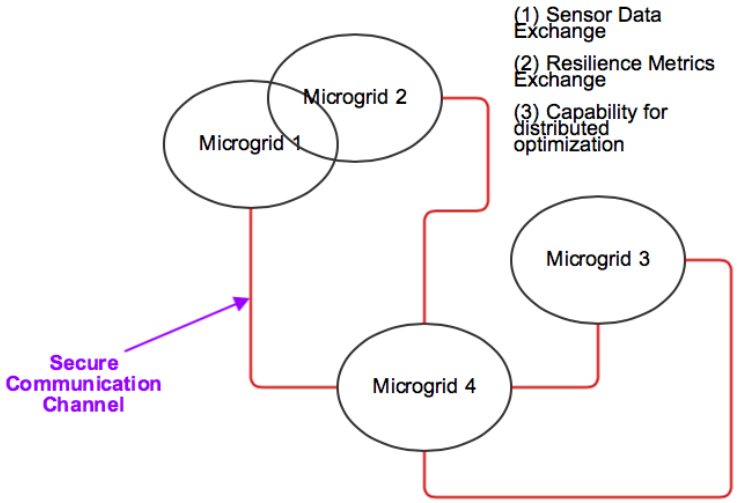
[as the case of City of Cordova, Cordova Electric Coop]



- Data and energy/storage resource exchange between components of two or more closely located microgrids (within few miles)
- Connected physically using local tie-switch or transfer switches, that operators/automated algorithm can close or open to increase overall resilience

Loosely-coupled Microgrids

[geographically dispersed Alaskan villages]



- Data communication-based coordination
- Zero (minimal) physical power exchange over Medium Voltage network. Thus, microgrids be physically very far from each other (100x miles)
- Resilience Metrics shared between each individual microgrid such that overall distribution network resilience can be improved

Zonal architecture: Unfavorable events in one location can be secured by resources in another

Team and Resources

Idaho National Laboratory, *Lead* **POC/ PI: Rob Hovsapian** Digital Real-time Simulation, HIL, rapid prototyping, cyber-vulnerability and security analysis testbed, virtual rotational inertia controls, flow batteries	**Sandia National Laboratory,** *Partner* **POC/ PI: Abe Ellis** Microgrid design (MDT – Microgrid Design Toolkit) and control testbed, inverter controls, stability, energy storage, protection systems, field deployment	**Pacific Northwest National Laboratory,** *Partner* **POC/ PI: Jim Follum** Micro-PMUs and sensor placement, fault propagation, communication networks testbed and protocols, IEC61850, IEC 62351, GridLab-D integration

City of Cordova ALASKA

Demonstration site, Engineering and deployment

AVEC ALASKA VILLAGE ELECTRIC COOPERATIVE

58 remote village communities in AK

SIEMENS

Energy Storage Management System

Microgrid design, controls vendor for networked architecture, protection

ACEP Alaska Center for Energy and Power

University partner, rural microgrid research, microgrid and communication design, field deployment, utility interaction

CEC

Utility partner, engineering support, field deployment

NRECA America's Electric Cooperatives

Rural electrification leadership, outreach

WASHINGTON STATE UNIVERSITY

Resilience metrics, valuation analysis, baseline

NM STATE UNIVERSITY

Microgrid design, stability analysis

FLORIDA STATE UNIVERSITY 1851

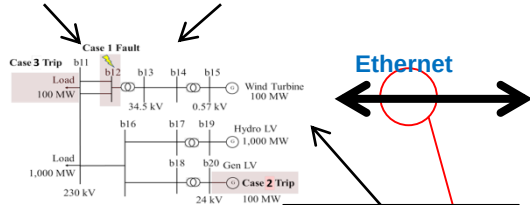
Micro-PMU testbed

Cyber-vulnerability Detection using Real-time Co-simulation Testbed

Simulation Environment

DER Controller

DER Monitoring



Network Simulator

Dynamic Power System Model

Ethernet

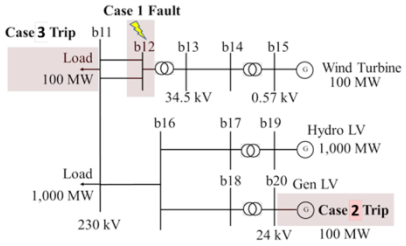
Geographically Distributed Simulation for Larger Power Systems

TCP/IP

MGC-1

MGC-2

Co-Simulation Environment with Hardware-in-the-Loop



Dynamic Power System Model

Ethernet

RTDS

Power Hardware

Control Hardware

Allows cyber-vulnerability testing

LS POWER

Bulk Electric System Transmission Development

June 2018

LS Power

Power generation and transmission company formed in 1990

39,000+ MW

Power generation development, construction or operations experience

$39+ billion

Capital raised to finance and support investments in energy

$1+ billion

High voltage transmission placed into operations since 2013

$500+ million

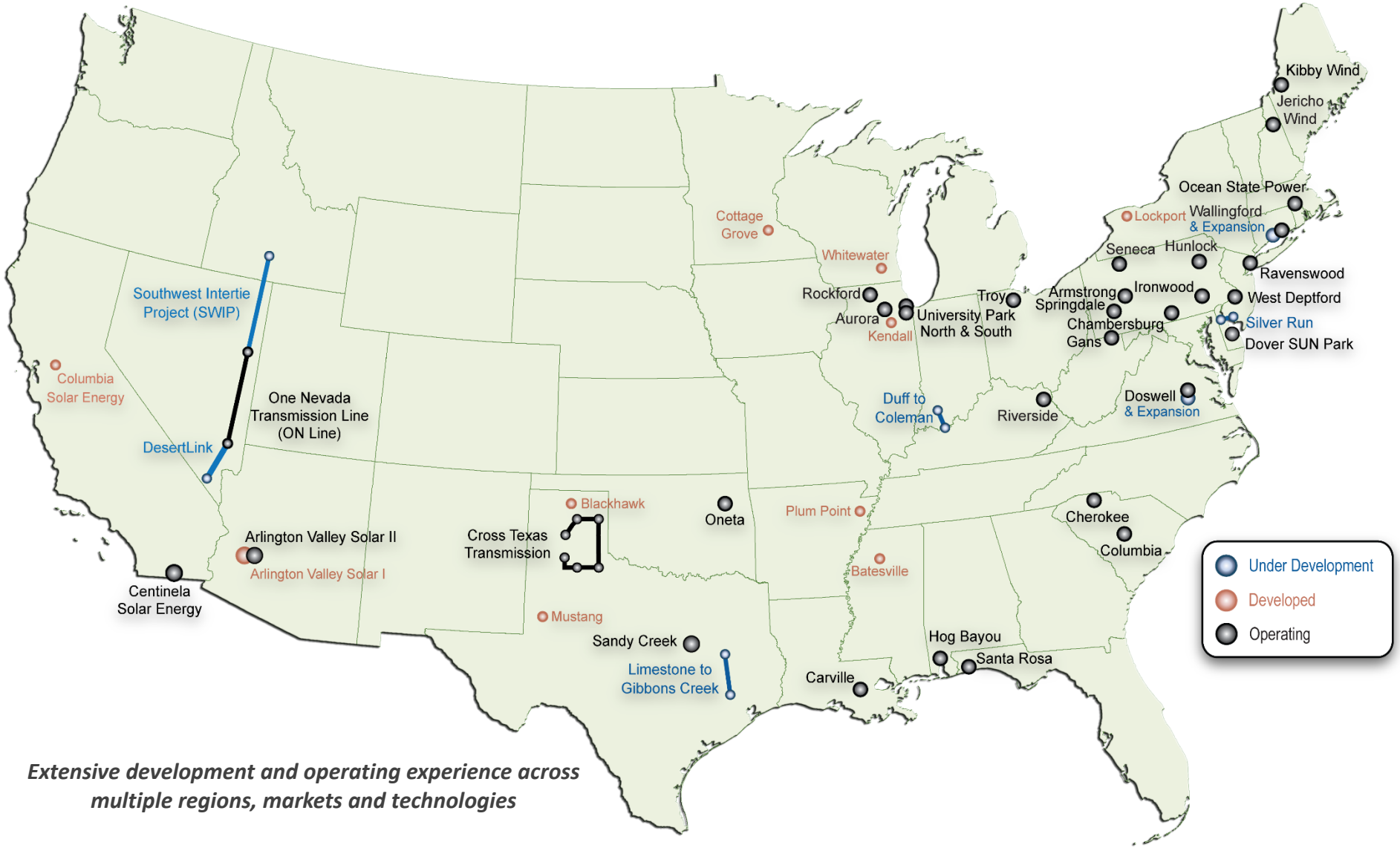
High voltage transmission in permitting or construction

CAISO, ERCOT, MISO, PJM, NYISO

Transmission competitively awarded to LS Power

LS POWER

Project Portfolio

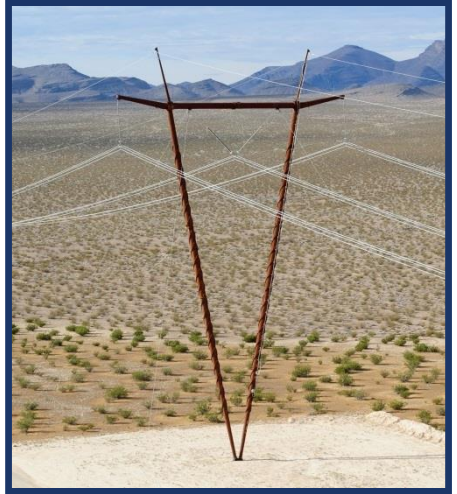


Extensive development and operating experience across multiple regions, markets and technologies

LS POWER

LS Power Transmission

One Nevada Transmission



Partnership with NV Energy

231 miles 500 kV transmission
8 miles 345kV transmission
EHV substation

$500+ million construction cost

First connection between northern and southern Nevada

Cross Texas Transmission

Selected by PUCT

260 miles 345 kV transmission
4 EHV substations

$500 million rate base

Public Utility in Texas

Silver Run Electric

Selected by PJM in first competitive process

3 mile 230 kV Delaware River crossing, EHV substation

$146 million construction cost cap

Republic Transmission

Selected by MISO in first competitive process

31 miles 345kV transmission

$58 million cost cap

Public Utility in Indiana

DesertLink

Selected by CAISO in a competitive process

60 miles 500 kV transmission

$145.5 million construction cost cap

Limestone – Gibbons Creek

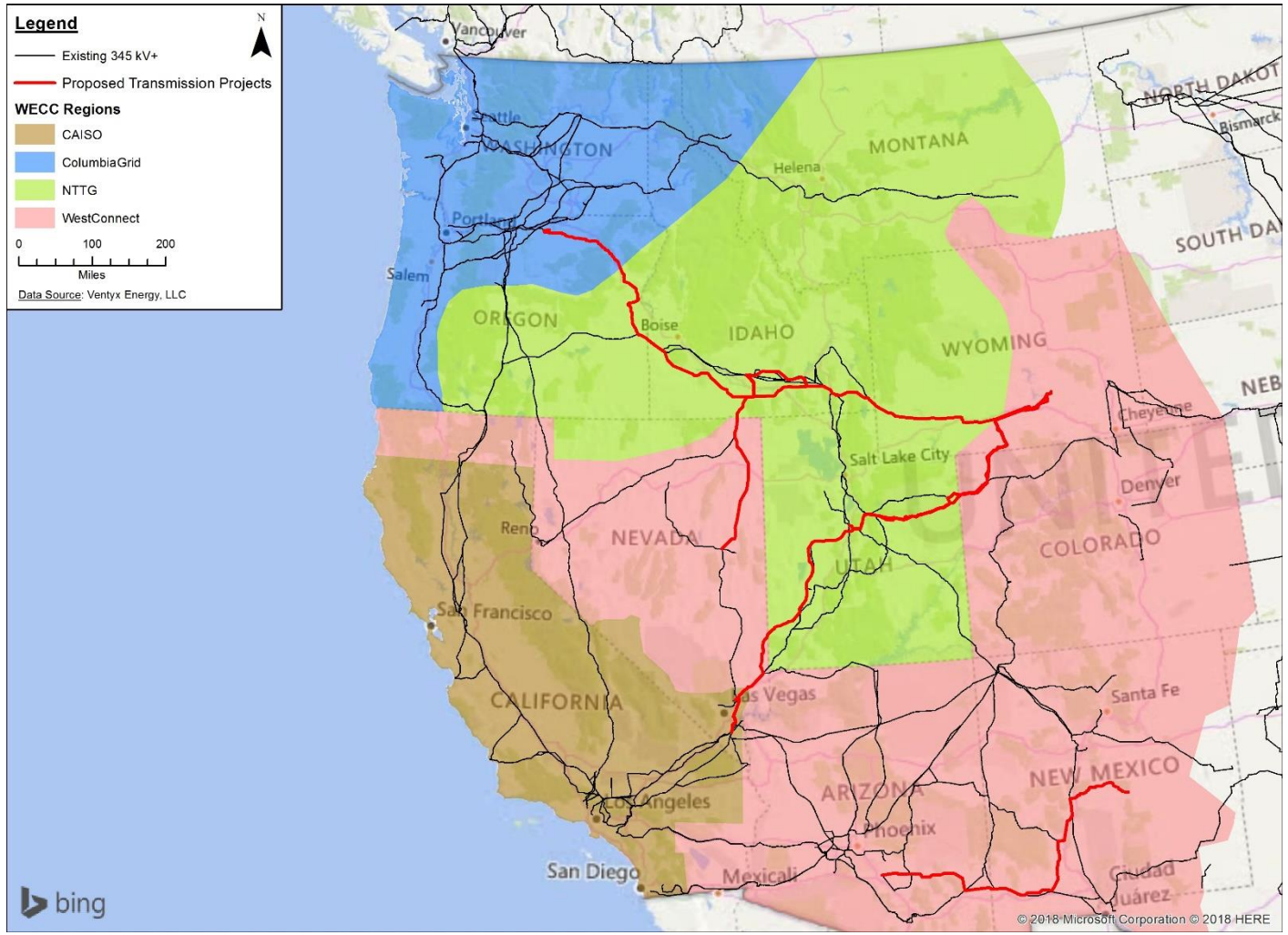
Partnership with Garland Power & Light

67 miles 345 kV transmission

$200+ million construction cost

LS POWER

WECC Planning Regions



Region boundaries are approximate for illustrative purposes only

LS POWER

Western Conference of Public Service Commissioners

Resilience Panel

June 2018

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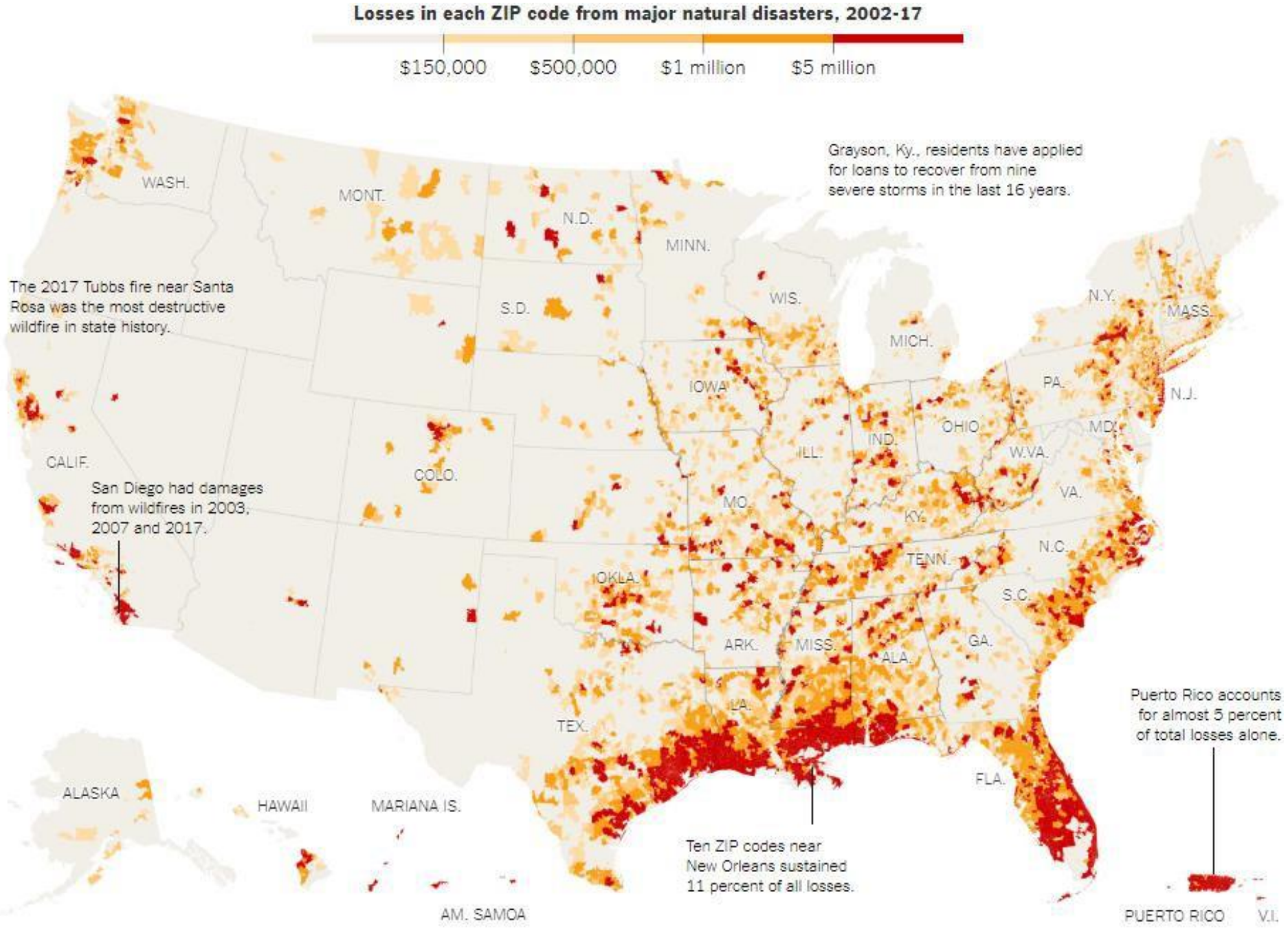
NATURAL DISASTERS ON THE RISE



Source: New York Times, May 24, 2018

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GREEN MOUNTAIN POWER RESIDENTIAL AGGREGATION, VERMONT

Location
Homes across Vermont

Project Size
1.6 MW | 3.2 MWh

Applications
Backup power
Peak shaving
Reduce T&D costs

Commissioned
2016 - 2017

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PUERTO RICO POST HURRICANE MARIA

Location
Critical facilities throughout Puerto Rico

Project Size
662+ projects of various sizes

Applications
Back-up power
Diesel abatement

Commissioned
2017 - 2018

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SOUTHERN CALIFORNIA EDISON MIRA LOMA STORAGE “PEAKER”

Location
Ontario, California

Project Size
20 MW | 80 MWh

Applications
Local Capacity / Reduced Nat Gas Reliance
Wholesale Market Services

Commissioned
2016
3 months from deployment to operation

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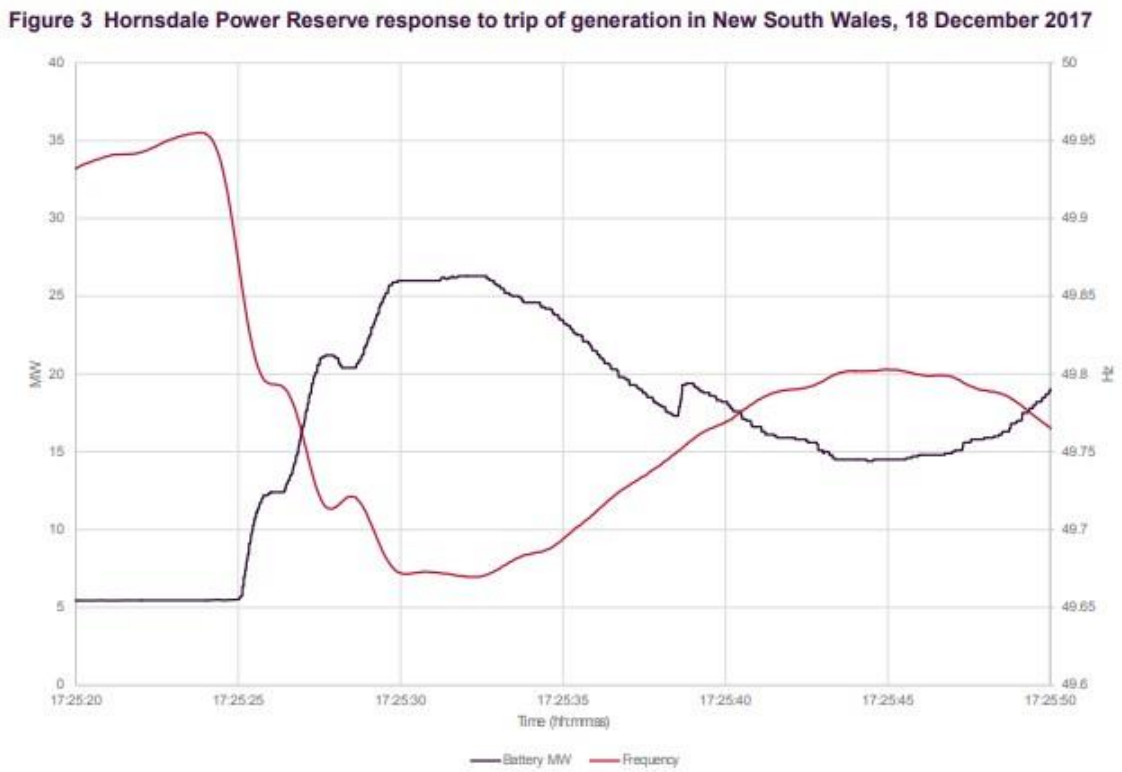
NEOEN HORNSDALE POWER RESERVE, AUSTRALIA

100 MW / 129 MWH

Near-Instantaneous Response to Frequency Events



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RESILIENCY:

RESPONDING AFTER A DISASTER

Enjoy the activities this afternoon!

And don't forget about the reception and dinner at the Basque Block, just one block east of here. You do not want to miss it!