GridWise Alliance Technology Council Meeting Agenda

Advanced Grid Modeling for Resilience

August 23, 2023 @ 3:00 PM ET

I.	Welcome & Antitrust Guidelines	**Josh Steinhardt**, Operations Director
II.	Presentation on the North American Energy Resilience Model (NAERM) Program	**Jason Fuller**, Pacific Northwest National Laboratory
III.	Questions and Discussion	**All**

GRIDWISE ALLIANCE

GridWise Alliance
Antitrust Compliance Program Guidelines

It is the policy of the GridWise Alliance to comply fully with the antitrust laws. The Sherman Act and other applicable antitrust laws are intended to promote vigorous and fair competition and to combat various restraints of trade.

Each person who participates in GridWise Alliance activities has a responsibility to his/her employers and to the GridWise Alliance to avoid any improper conduct from an antitrust standpoint. The following guidelines will assist in meeting this responsibility:

1. GridWise Alliance meetings and discussions generally cover topics related to the generation, transmission and distribution of electricity. Should related discussions ever have any potential for competitive impact, all due care shall be taken to avoid such discussion between competitors.

2. In view of antitrust considerations and to avoid any possible restraints on competition, the following legally sensitive subjects must be avoided during any discussion between competitors:

   (a) Future marketing plans of individual competitors should not be discussed between competitors;

   (b) Any complaints or business plans relating to specific customers, specific suppliers, specific geographic markets or specific products, should not be discussed between competitors;

   (c) Purchasing plans or bidding plans of companies in competition should not be discussed (except privately between two parties with a vertical commercial relationship such as supplier and customer); and

   (d) Current and future price information and pricing plans, bidding plans, refund or rebate plans, discount plans, credit plans, specific product costs, profit margin information and terms of sale should not be discussed between competitors. All of the above are elements of competition.

3. Any question regarding the legality of a discussion topic or business practice should be brought to the attention of the GridWise Alliance legal counsel or a company's individual legal counsel for advice.

U.S. DEPARTMENT OF ENERGY

North American Energy Resilience Model (NAERM) Program

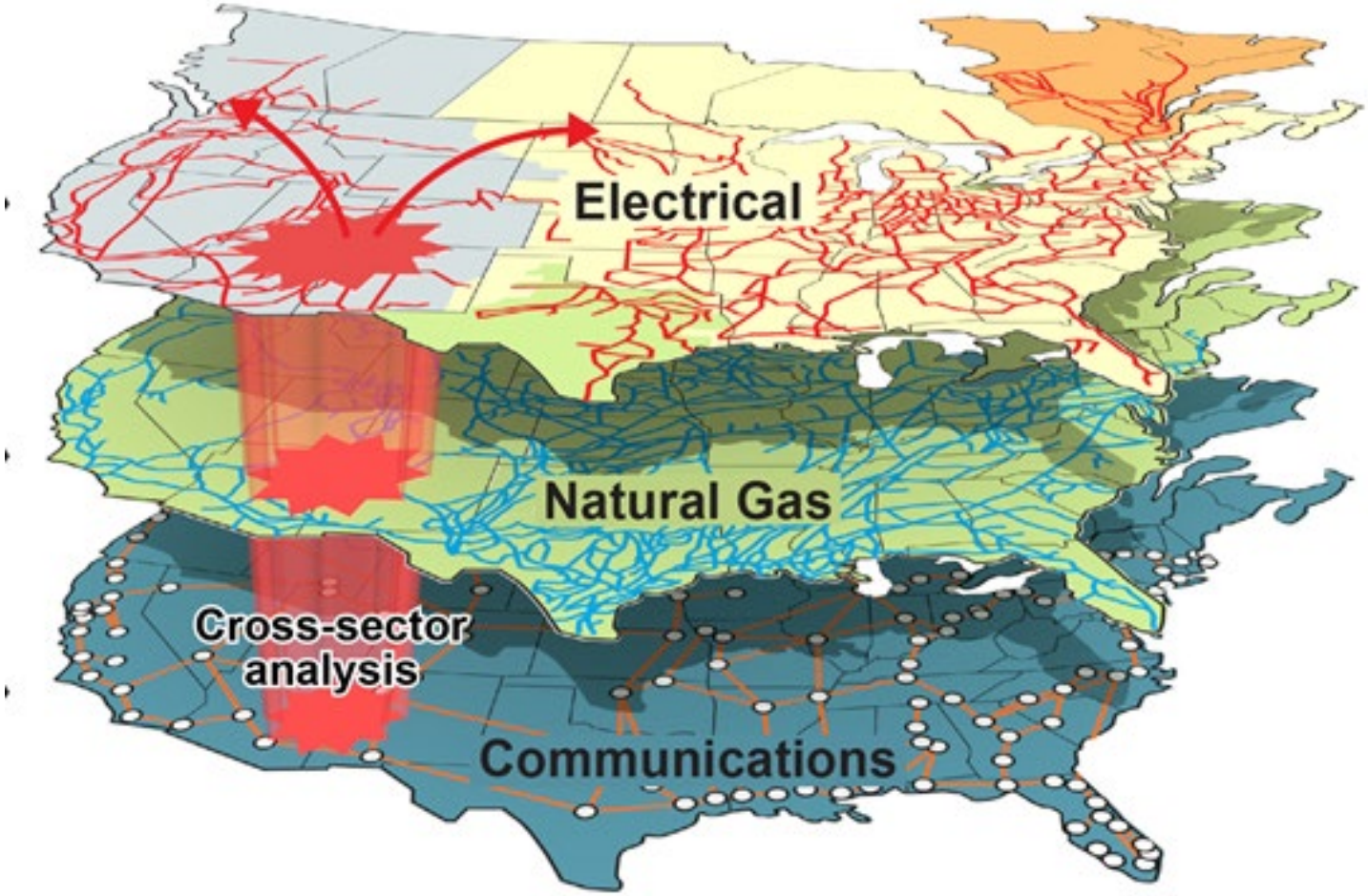
Jason Fuller, Pacific Northwest National Laboratory

DOE Office of Electricity launched the North American Energy Resilience Model (NAERM) Program in 2018

Vision - Rapidly predict energy system interdependencies, consequences and responses to extreme events at a national scale

Mission - Develop and deploy engineering-class modeling and analysis platform for planning and resilience analysis

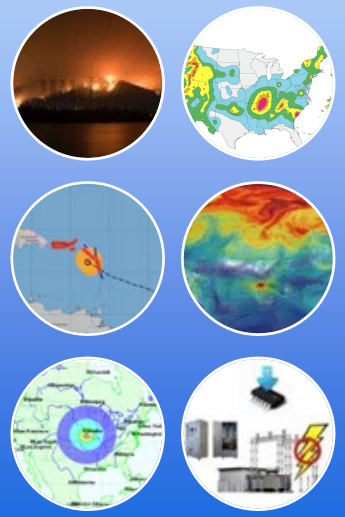
Key Objective – Catalyze partnerships with industry, national labs, states, tribes, territories, and other federal agencies to enhance coordination to support energy resilience



Team: DOE OE, LLNL, PNNL, ORNL, LANL, ANL, SNL, NREL, INL

NAERM integrates industry, open source and DOE tools and data to support a wide range of resilience analysis

Threats and Hazards



Integrated Modeling & Analysis Environment

- Electric Grid Models
- Pipeline System Models
- Communications Systems Models

HELICS Code Coupling / Adv. Contingency Tools / …
Front-Ends / Computing / Archives / Security

Data Infrastructure

Model DBs	Gen and Loads	Infra-structure	Asset Info	Weather / Climate	Sensor Data

- Predict Outages & Other Impacts
- Post-event Analysis
- Operational Planning Options
- Resilience Enhancement Assessments

NAERM Leadership

Program Lead:
Ali Ghassemian
DOE Office of Electricity

Electric Grid

Teja Kuruganti (ORNL)

DIA Lead

Natural Gas

Mark Petri (ANL)

Economics

Clayton Barrows (NREL)

Software (A&I)

Matt Pearson (LLNL)

A&I Lead

Communications

Brad Nelson (INL)

Management

John Grosh (LLNL)

Project Lead

Jason Fuller (PNNL)

IM Lead
GDO Lead

Russell Bent (LANL)

NG Lead
VVUQ Lead

JP Watson (LLNL)

Wildfire Lead
UCED Lead

Jereme Haack (PNNL)

A&I Lead

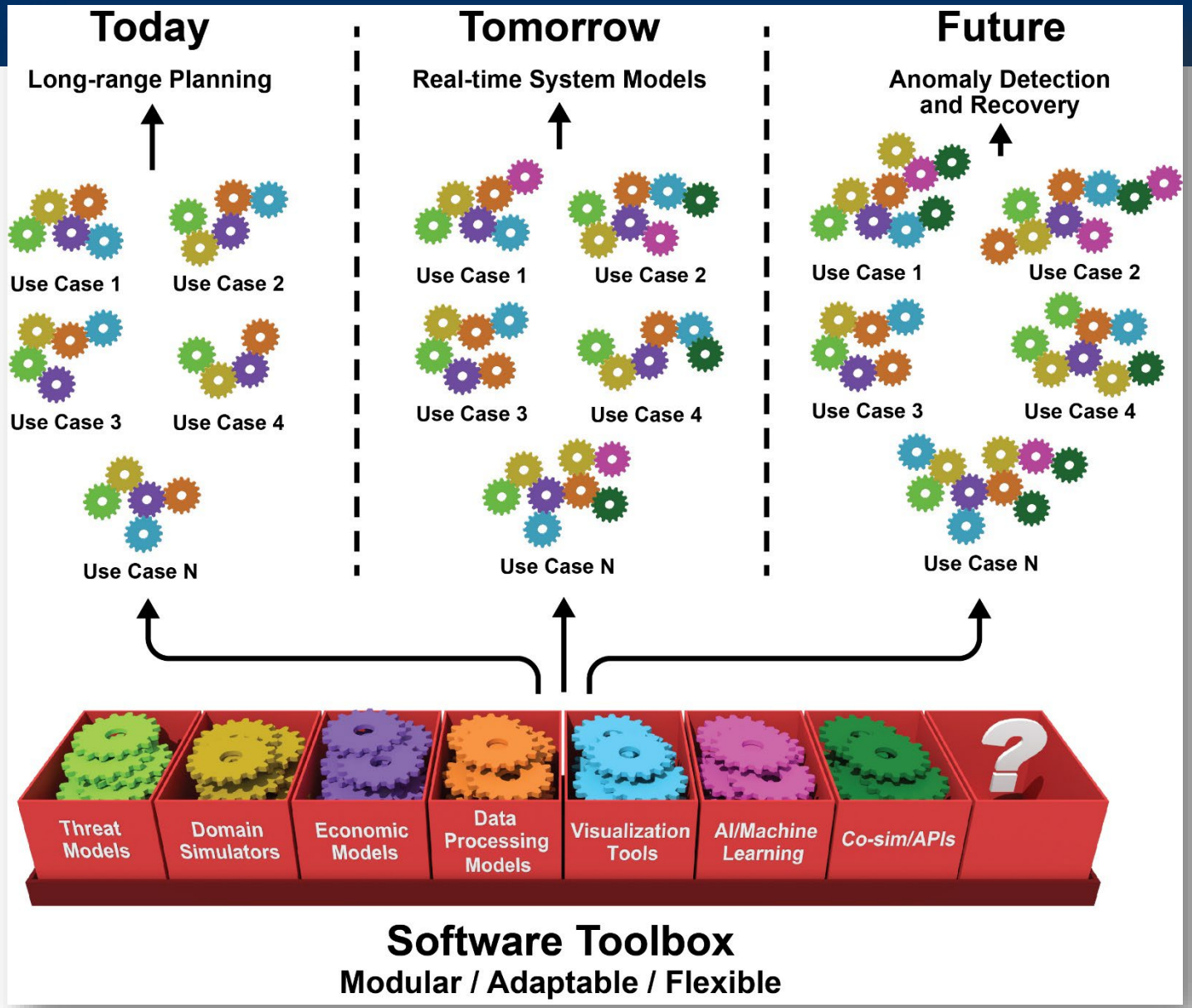
Security / A&I

Tom Kroeger (SNL)

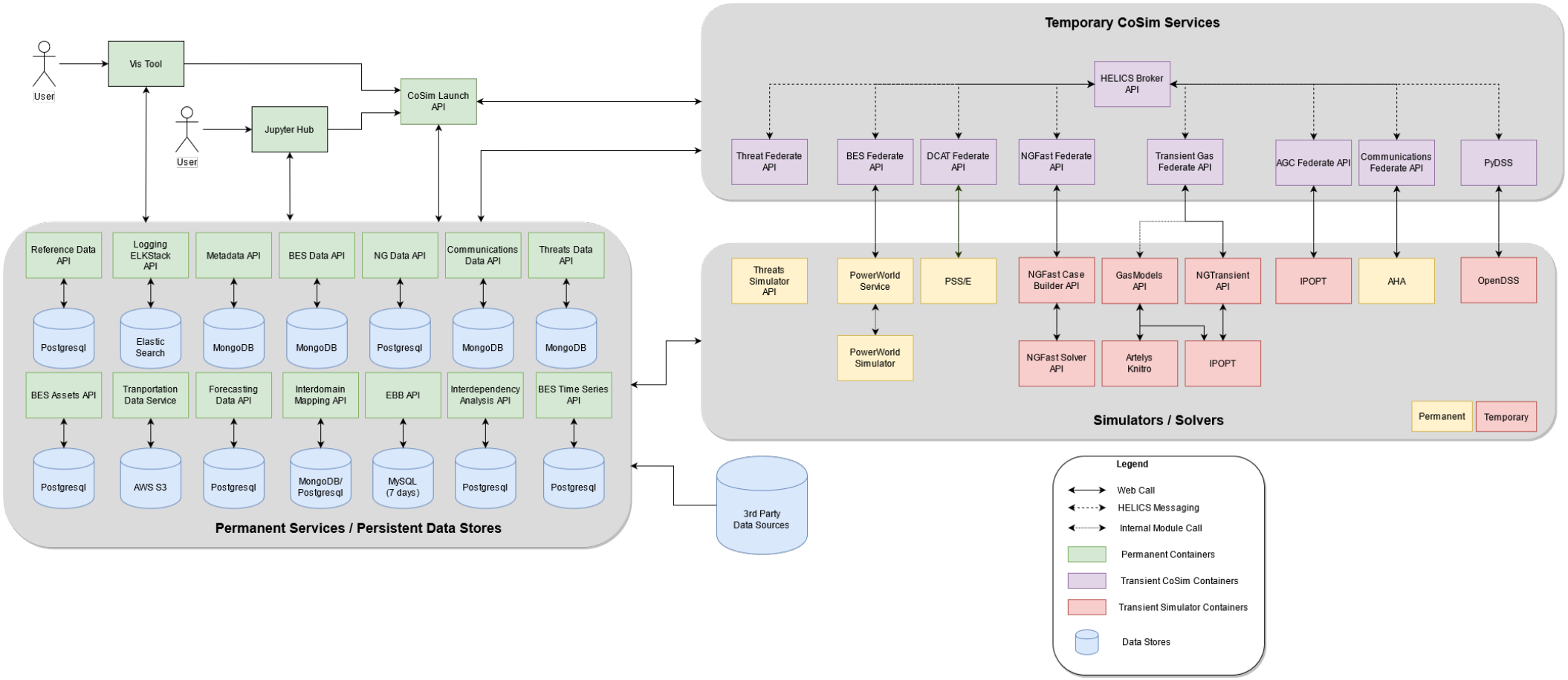
Chris Kelley (BRCG)
Jimmy Ly (BRCG)

NAERM is a "toolbox" of interactive, modular software elements

The different elements are assembled in relation to the use cases being addressed. We have created the initial framework to support this.



NAERM is a flexible and extensible software platform to integrate modeling and analysis tools and data



Tech Stack

AWS
Python 3.8
React
Jupyter
Microservices
HELICS
MongoDB
Postgress
mySQL
Gitlab
JIRA
Confluence
Zephyr
Azure AD MFA

Bulk Electric System Modeling

<u>Commercial and lab tools:</u>

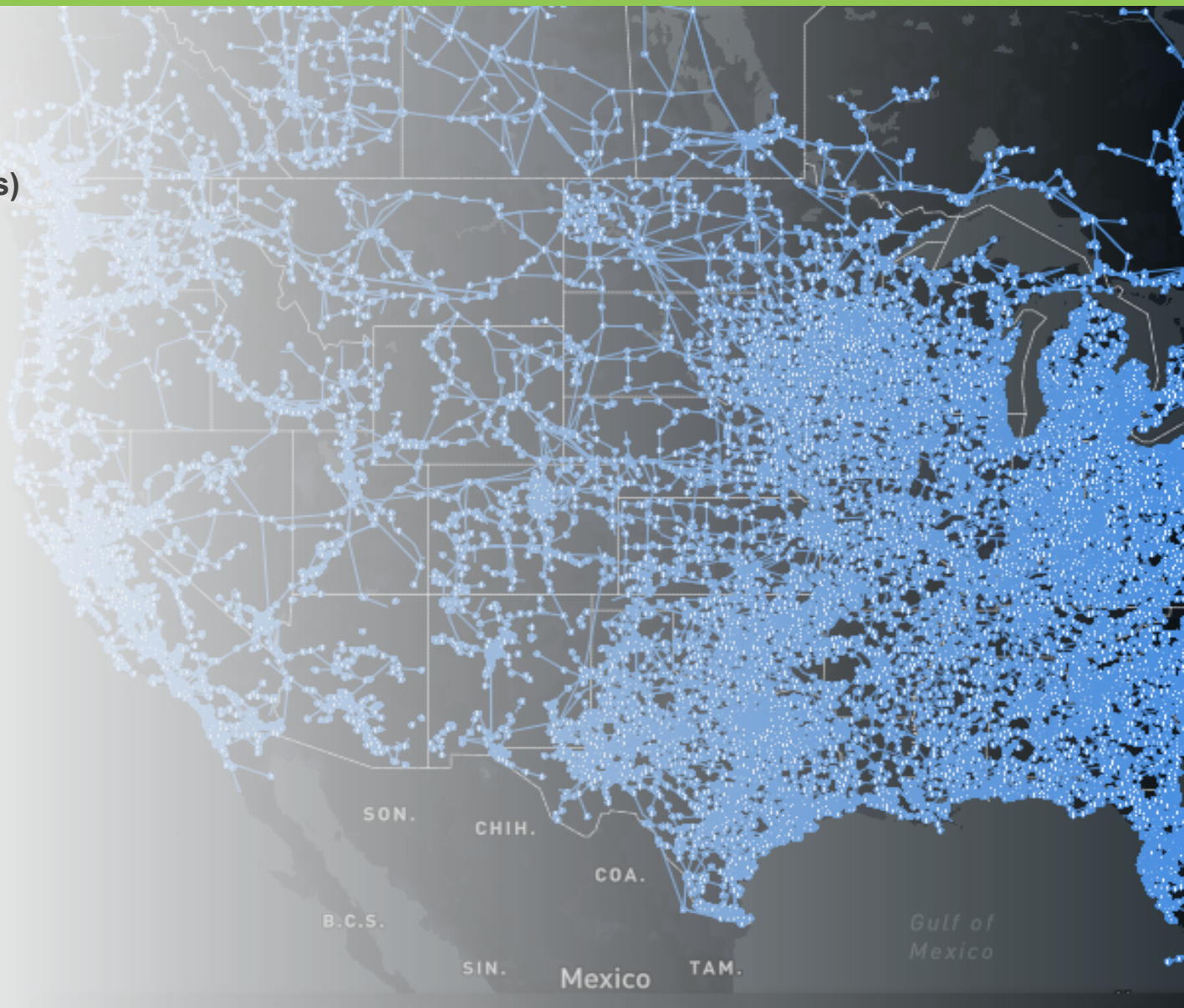
- PowerWorld, PSSE (Transmission)
- Dynamic Contingency Analysis Tool (Cascading Analysis)
- Prescient (PCM, UCED)
- OpenDSS, GridLAB-D/GridAPPS-D (FY23) (Distribution)

<u>Modeling capabilities:</u>

- Steady-state
- Transient
- Commitment and dispatch modeling *(FY23)*
- High-k N-k contingency analysis
- AGC *(prototype for Comms)*

<u>Example of Data Layers Used:</u>

- WECC, ERAG, and ERCOT planning models
- Real-time EMS and telemetry data *(under development)*



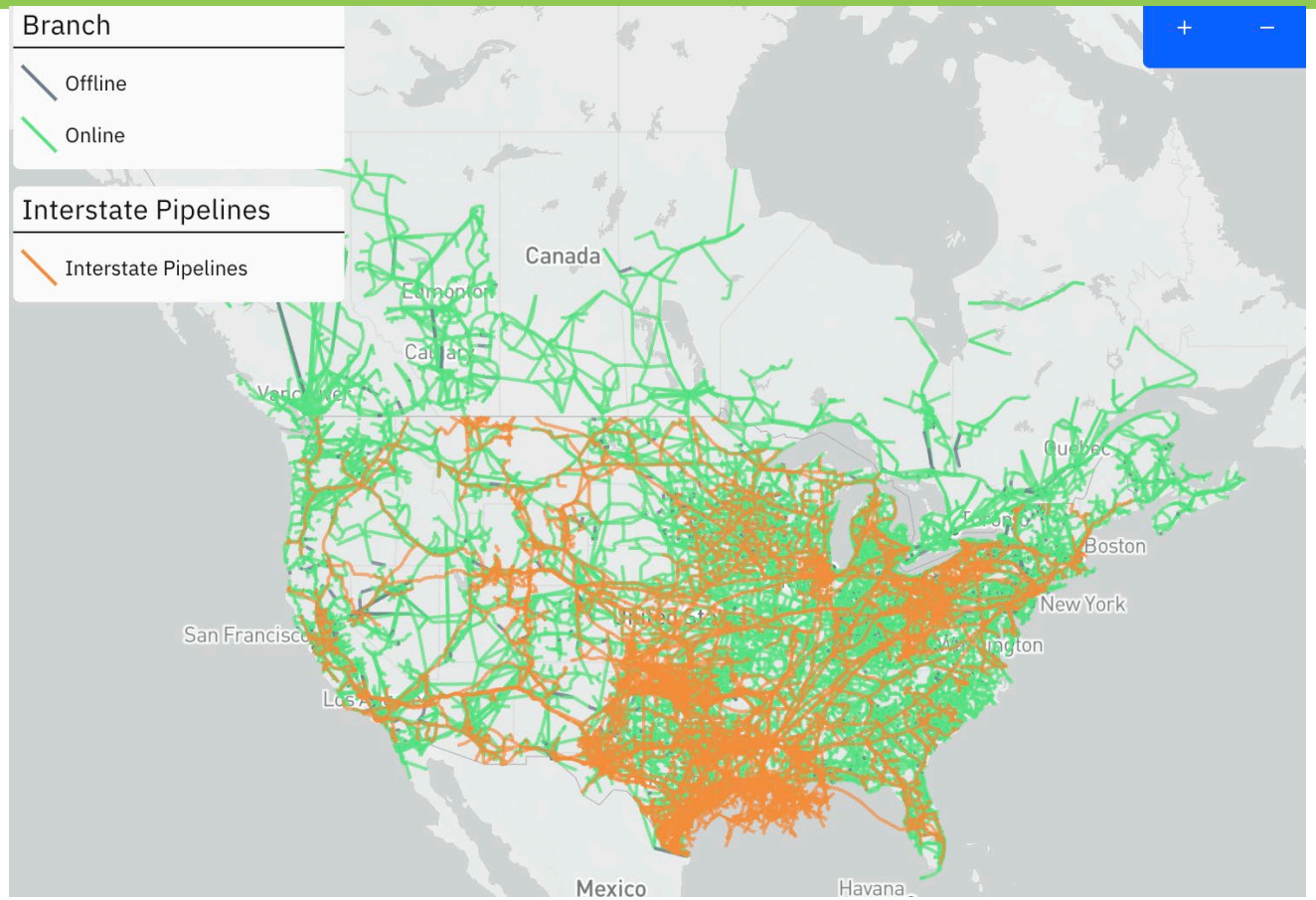
Natural gas modeling tools support two-way BES-NG contingency analysis

Lab-Developed Tool
- Ngfast

Modeling Capabilities
- Steady-State;
- Updated N-k capabilities allows to disrupt a mix of asset types

Data
- Almost 1,000 State Border Points with detailed NG pipeline info
- All LNG terminals and UGS storage facilities
- Nearly 1,400 compressor stations
- 2018 data deployed (2019 data being validated)

Under Development or Proposed
- Updates for 2019 and 2020 data
- Intrastate pipelines, Canada pipelines, Mexico pipelines
- Develop capability to predict time of loss of supply for gas-fired generators
- Add capability to ingest EBB data
- Further validation and verification
- Uncertainty analysis capabilities



Today 40% of U.S. electricity is generated using natural gas. NG-BES modeling will be critical for charting resilient pathways to carbon neutral and clean energy goals.

Transient pipeline modeling tools provide first-of-kind national modeling capability

Lab-Developed Tools and Capabilities

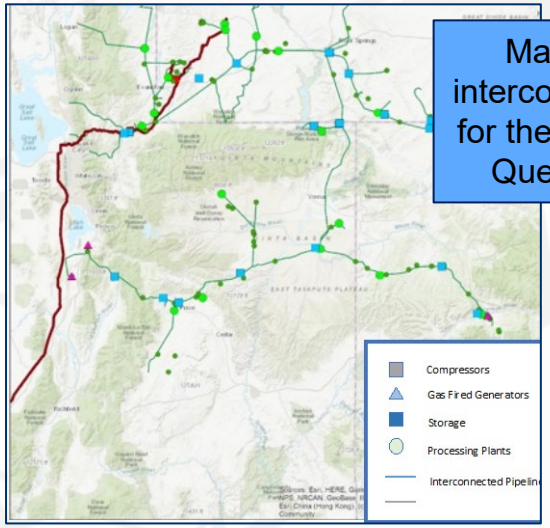
- GasModels: optimization and economic dispatch model for N-k contingency identification, network design, economic analysis
- NGTransient: control and simulation model for contingency failure analysis, optimal control formulation, operating cost minimization
- Regional coverage of pipelines serving major generators in the WECC and Northeast (~50% of national interstate pipeline mileage)

Data

- FERC Form 567 (CEII)
- National Pipeline Mapping System (NPMS)
- Pipeline nominations (EBB, Genscape)
- HIFLD Open, Secure, EIA

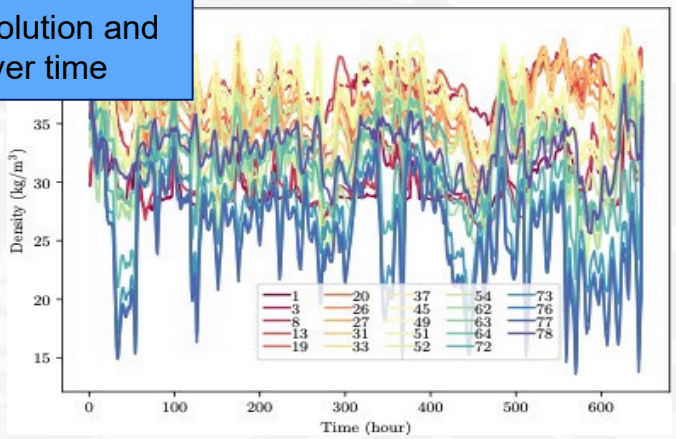
Under Development or Proposed

- Implementation of peer review recommended enhancements (e.g., modeling elevation change effects)
- Implementations to handle pipeline models for H2, CO2, blended gases
- Complete national pipeline coverage
- Enhancements to improve robustness, convergence, and scalability of BES-NG co-simulation
- Integration of extreme n-k identification capabilities

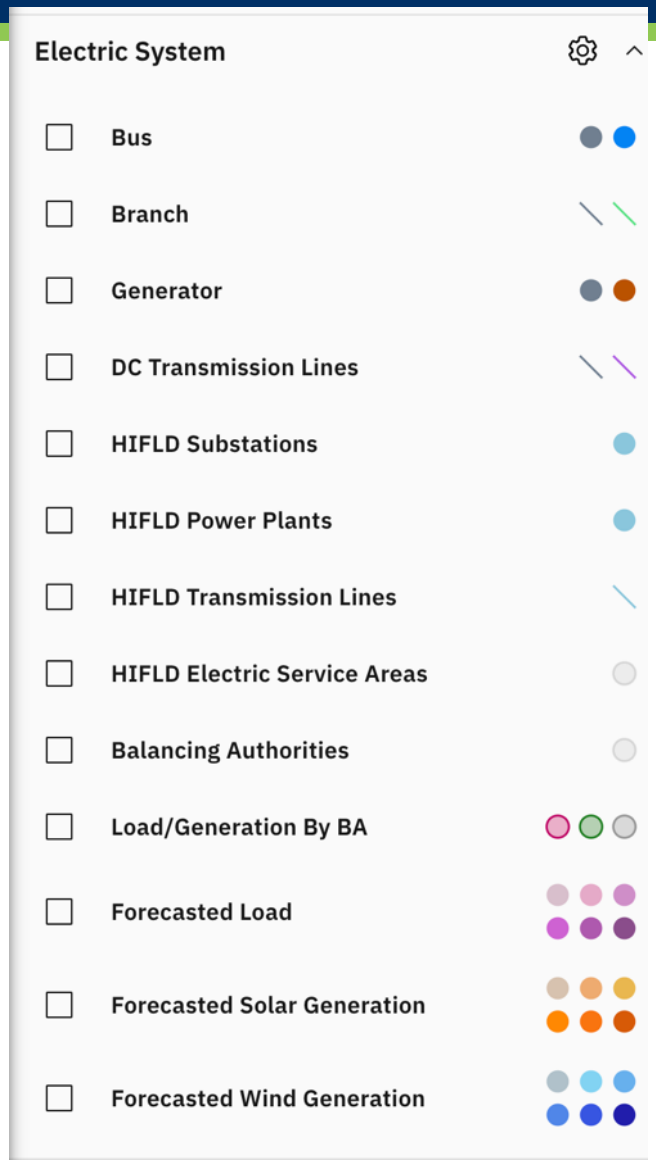


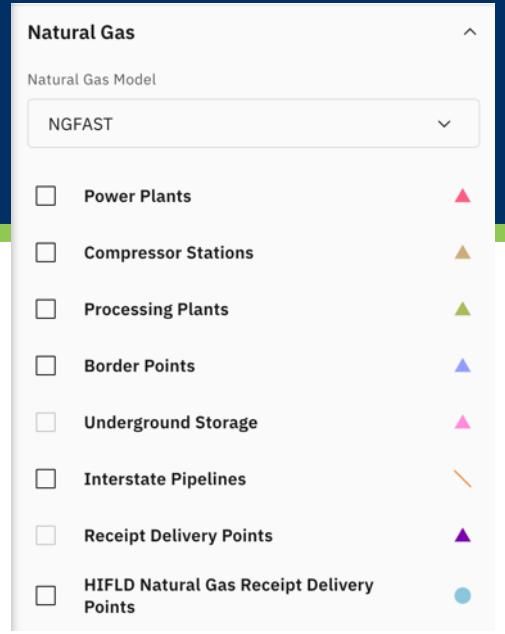
Map represents interconnected models for the Kern River and Questar pipelines

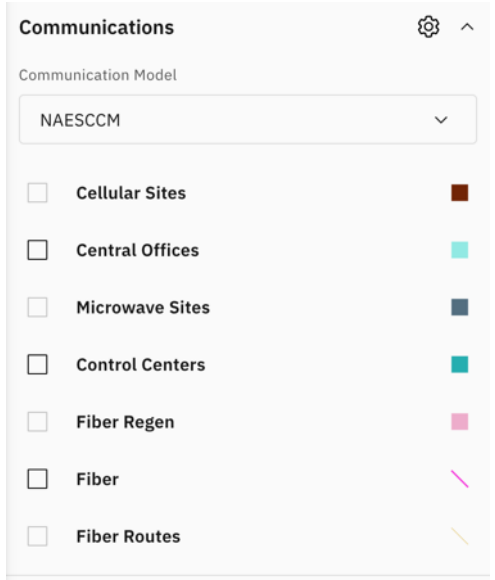
Pressure and flow profiles that track system evolution and impacts over time

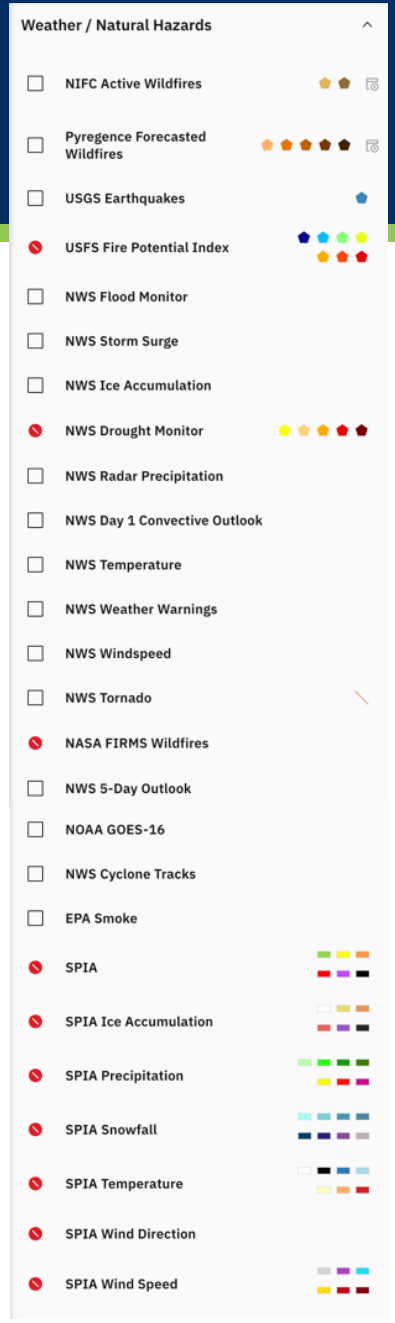


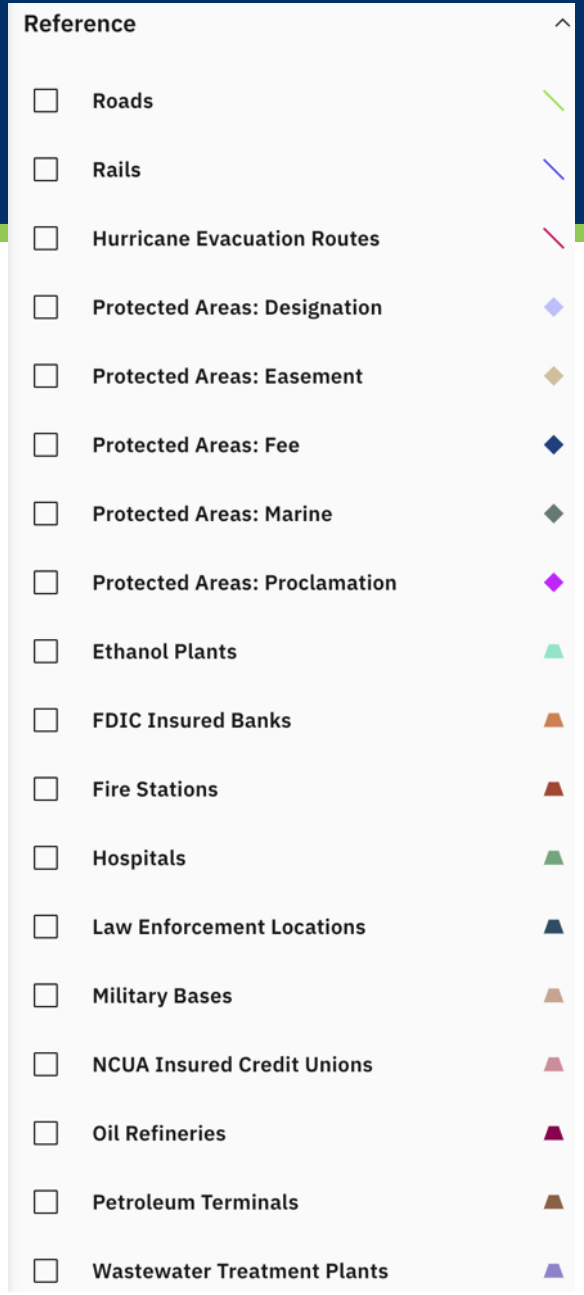
Datasets


Electric System
Bus
Branch
Generator
DC Transmission Lines
HIFLD Substations
HIFLD Power Plants
HIFLD Transmission Lines
HIFLD Electric Service Areas
Balancing Authorities
Load/Generation By BA
Forecasted Load
Forecasted Solar Generation
Forecasted Wind Generation

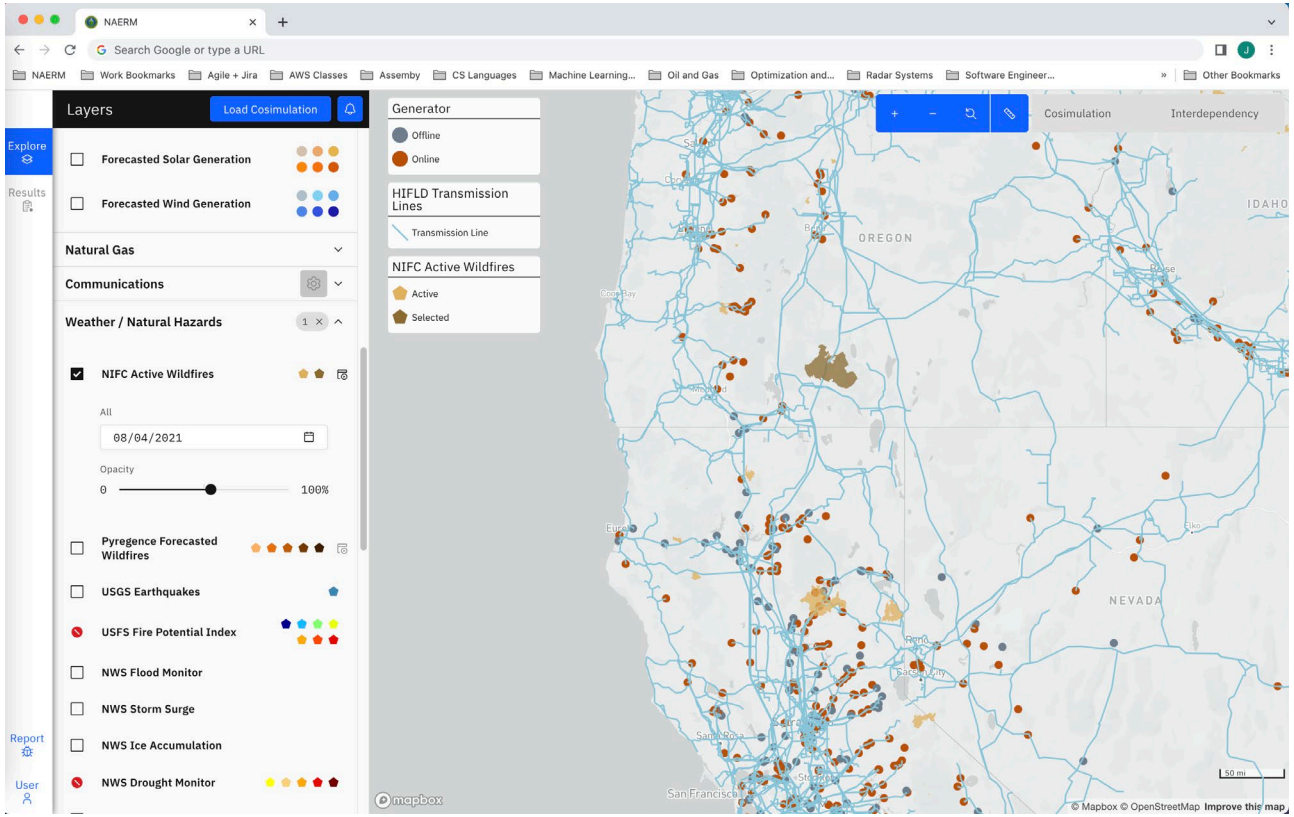

Natural Gas
Natural Gas Model
NGFAST
Power Plants
Compressor Stations
Processing Plants
Border Points
Underground Storage
Interstate Pipelines
Receipt Delivery Points
HIFLD Natural Gas Receipt Delivery Points


Communications
Communication Model
NAESCCM
Cellular Sites
Central Offices
Microwave Sites
Control Centers
Fiber Regen
Fiber
Fiber Routes

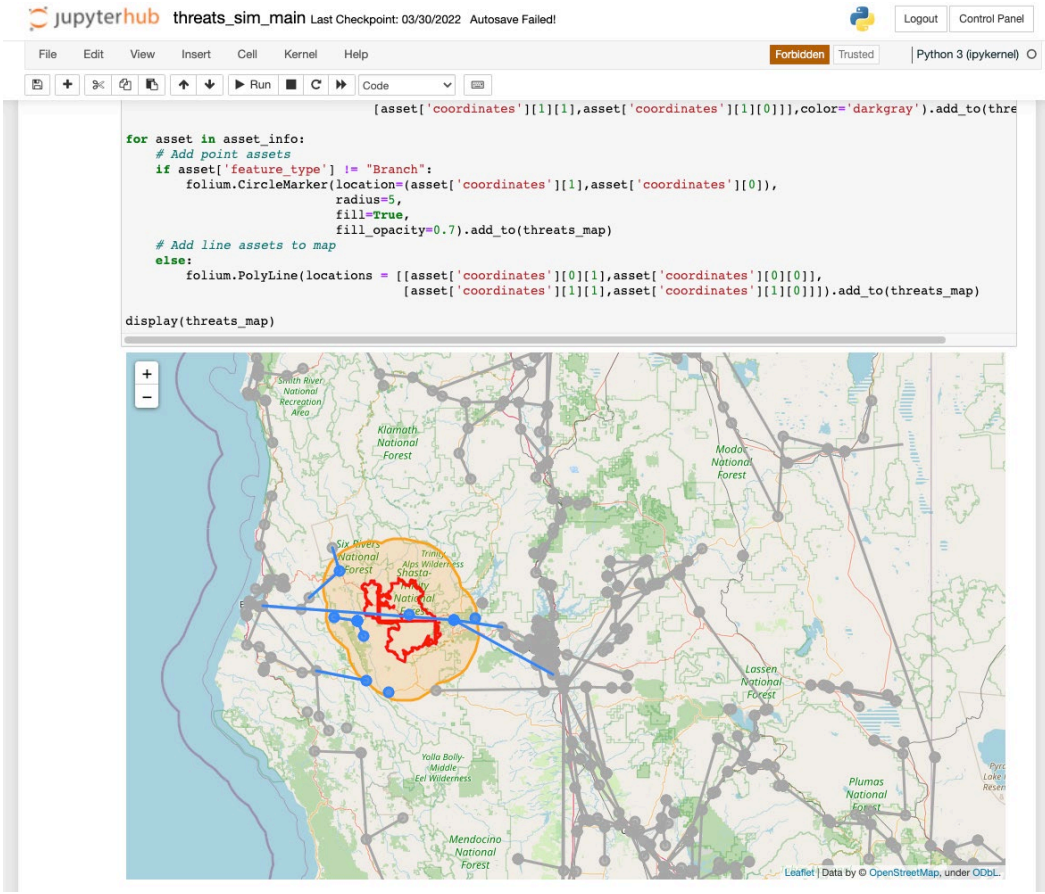

Weather / Natural Hazards
NIFC Active Wildfires
Pyregence Forecasted Wildfires
USGS Earthquakes
USFS Fire Potential Index
NWS Flood Monitor
NWS Storm Surge
NWS Ice Accumulation
NWS Drought Monitor
NWS Radar Precipitation
NWS Day 1 Convective Outlook
NWS Temperature
NWS Weather Warnings
NWS Windspeed
NWS Tornado
NASA FIRMS Wildfires
NWS 5-Day Outlook
NOAA GOES-16
NWS Cyclone Tracks
EPA Smoke
SPIA
SPIA Ice Accumulation
SPIA Precipitation
SPIA Snowfall
SPIA Temperature
SPIA Wind Direction
SPIA Wind Speed


Reference
Roads
Rails
Hurricane Evacuation Routes
Protected Areas: Designation
Protected Areas: Easement
Protected Areas: Fee
Protected Areas: Marine
Protected Areas: Proclamation
Ethanol Plants
FDIC Insured Banks
Fire Stations
Hospitals
Law Enforcement Locations
Military Bases
NCUA Insured Credit Unions
Oil Refineries
Petroleum Terminals
Wastewater Treatment Plants

DOE used NAERM to monitor and model the impact of wildfire in the Western U.S.



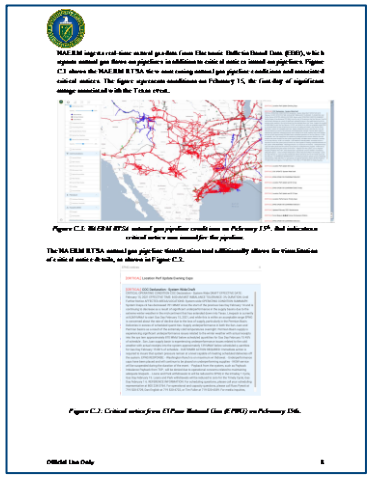
NAERM Graphics User Interface



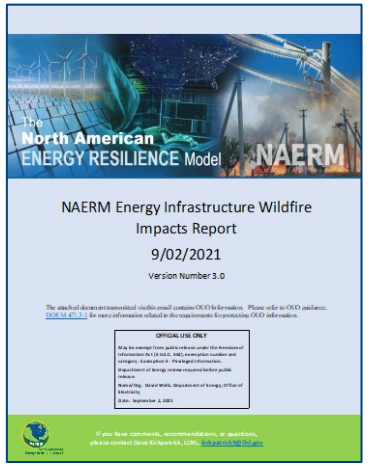
Jupyter Interface

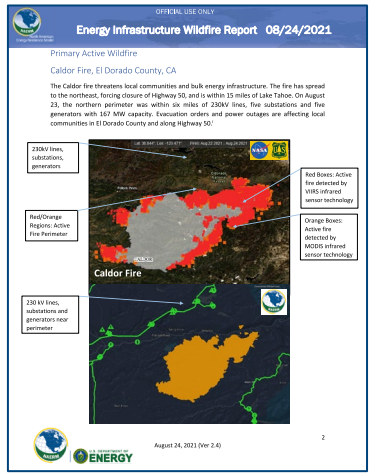
NAERM formed ‘strike teams’ to perform resilience analysis AND drive development of platform

- Wildfire and cold wave reports provided to DOE and DHS in 2020 and 2021
- Rapid-turn-around report to DOE on Feb 2021 Cold Weather Event
- Supported FERC and NERC on Feb 2021 Cold Weather Event Report

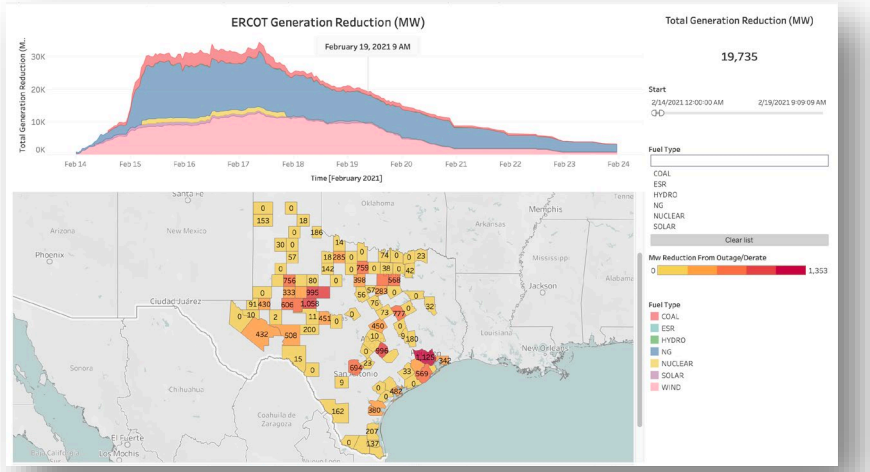


Winter Storm Uri Report





Wildfire Report



Outage analysis for FERC and NERC

Supporting Resilience Investments: Technical Assistance for IIJA/BIL

- Demonstrate how modeling and analytics can be used to support transformational resilience investments
- Rapidly demonstrate the type of studies, metrics, and threats that can be analyzed, then engage stakeholders to improve outcomes
- Focus on regional use cases that can be extended to other parts of the country
- Coordinate with other DOE TA investments to extend analysis capabilities (e.g., energy equity)

- Weatherization technologies and equipment,
- Fire-resistant technologies and fire prevention systems,
- Monitoring and control technologies,
- The undergrounding of electrical equipment,
- Utility pole management,
- The relocation of power lines or the reconductoring of power lines with low-sag, advanced conductors,
- Vegetation and fuel-load management,
- The use or construction of distributed energy resources for enhancing system adaptive capacity during disruptive events, including microgrids and battery-storage subcomponents,
- Adaptive protection technologies,
- Advanced modeling technologies,
- Hardening of power lines, facilities, substations, of other systems, and
- The replacement of old overhead conductors and underground cables

Developing Regional Use Cases to Demonstrate Tools

Use Case	Target Region for Demonstration	Season(s)	TA Case Topics	
Hurricane Threat Analysis	**Southeast**	**Summer**	**Climate Impact**	Demo in mid-January
New England Cold Wave BES + NG	**Northeast**	**Winter**	**Climate Impacts; BES-NG Interdependencies**	
Western Wildfire	**Western Interconnect**	**Summer**	**Climate Impacts**	
Western Heat Dome + Drought	Western Interconnect	Summer	Climate Impacts	To be determined
Critical Vulnerability Assessment	Midwest	All	High Consequence	
Electrification and Heat Wave	Midwest or Pacific Northwest	Summer	Climate Impacts + EV	
Adaptive Capacity Planning Using DER	Northeast or Midwest	All	Renewable Transition + DER	
Reserve Margins Under High Renewables	Western Interconnect	All	Renewable Transition	

Hurricane Threat Analysis

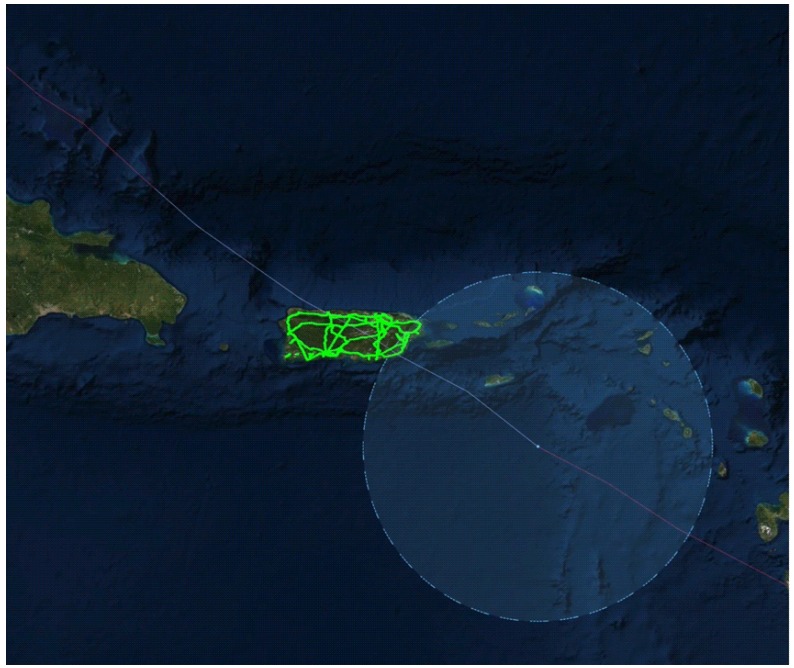
Alan Berscheid, PNNL
Nils Stenvig, ORNL

Approach:

- Evaluate energy system resilience to hurricane threats (N-k)
- Model hurricane threats mapped onto energy infrastructure fragility (wind at 3 months, flooding at 12 months)
- Support both existing and future system studies to look at lifecycle benefits of infrastructure investments
- Use Eastern Interconnect planning models and historical / forecasted hurricane weather data

Benefits:

Quantifiably assess how infrastructure investments improve resilience to hurricane threats, both in existing and future energy systems

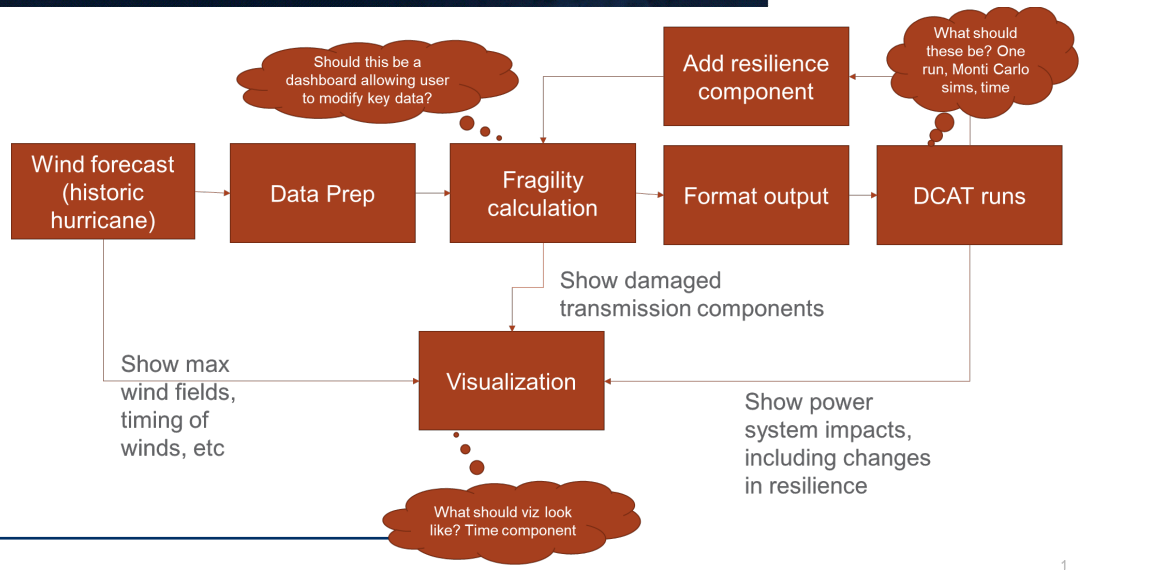


EGRASS

Electrical Grid Resilience and Assessment System

Simulation:
Hurricane Maria
Puerto Rico, 2017

PNNL



Cold Wave Threat Analysis

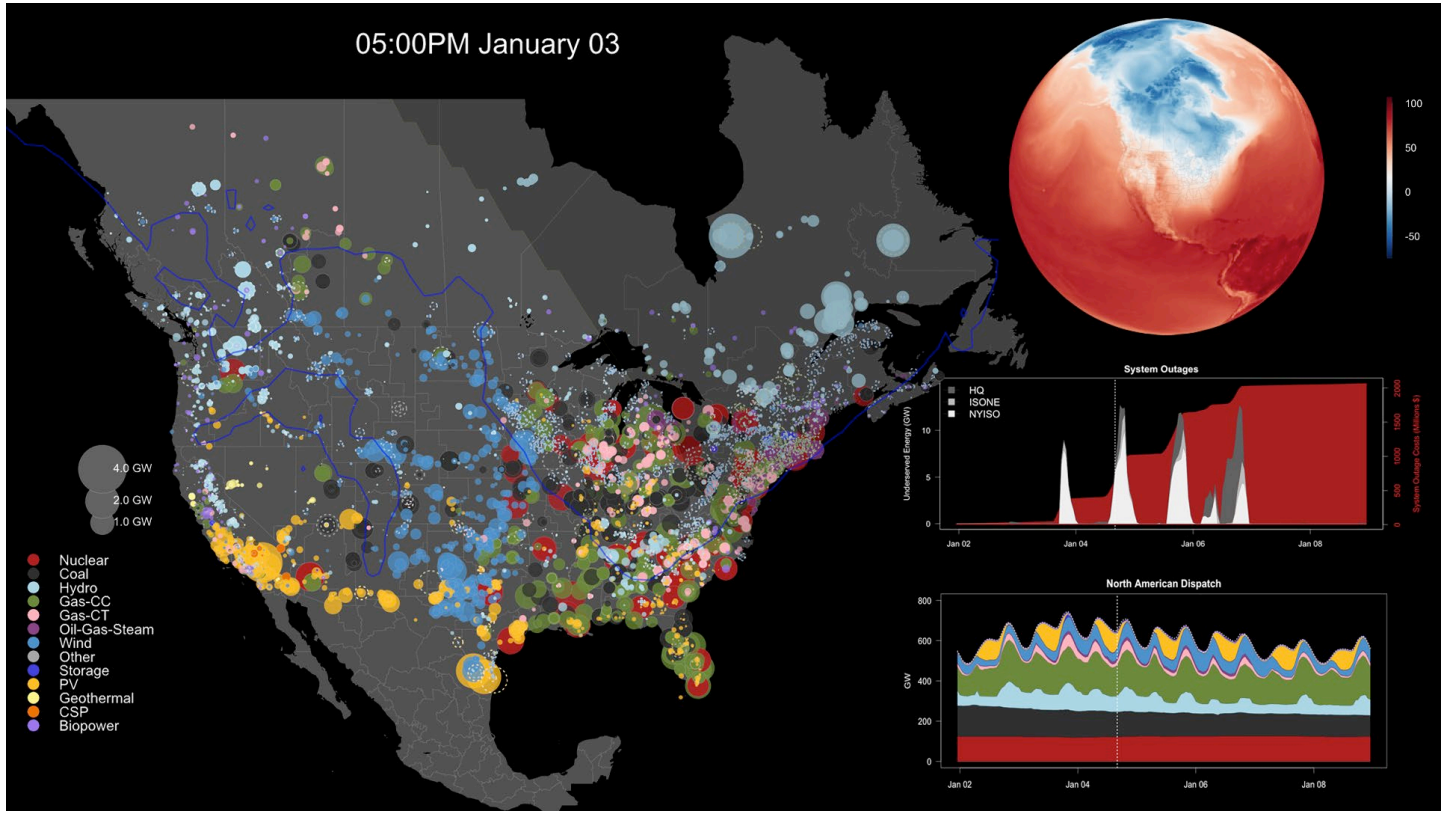
Josh Novacheck, NREL
Greg Brinkman, NREL
Russell Bent, LANL

Approach:

- New England has experienced several cold weather events that have caused tight generation and gas supplies in the region.
- Assess the resilience (N-k) of BES+NG during extreme cold weather, with reliability (N-1) as a secondary focus, using PCM and Powerflow Models.
- Assess proposed investments, such as dual fuel units, wind turbine winterization, increased LNG capacity, and electrification with demand flexibility.

Benefits:

Inform planners on compounding risk of cold weather impacts to generation infrastructure, increased demand, and tight gas supply and plan mitigation strategies for these scenarios



Example analysis of 2014 Polar Vortex which the NAERM team analyzed using Production Cost Modeling

Wildfire Threat Analysis

JP Watson, LLNL
Kaarthik Sundar, LANL

Approach:

- Climate change is predicted to amplify the intensity, frequency, and extent of wildfires in the western US
- Changes in the above metrics will impact the benefits associated with various proposed mitigation options
- Critical to focus on how wildfire threats are *going* to manifest, rather than how they manifest presently
- Climate-impacted fuel moisture and temperature data is required for high-fidelity modeling; risk maps for lower fidelity modeling

Benefits:

Analyze future wildfire impacts on Western Interconnect infrastructure and maximize resilience benefit of hardening investments and other mitigation options

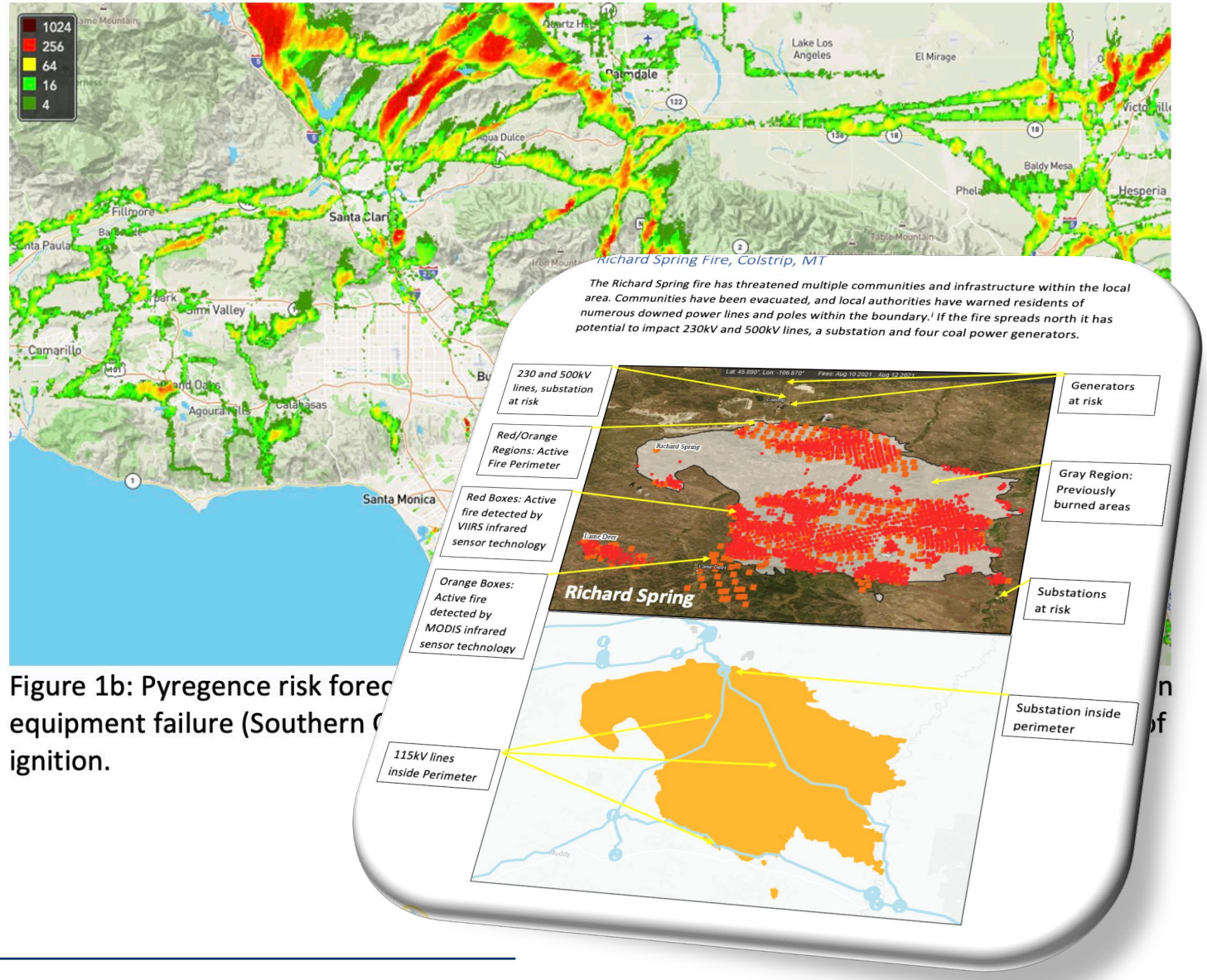


Figure 1b: Pyregence risk forec
equipment failure (Southern C
ignition.

NERC-Related Reliability Studies

- Demonstrate capabilities that could be used to improve our awareness (and mitigation) of seasonal reliability
  - NERC produces a bi-annual seasonal reliability assessment
  - What can we add to these assessments that inform beyond reliability requirements?
- Opportunity to demonstrate capabilities and provide tools to industry to support reliability assessments
- Impact industry over the next 12-18 months in their decision making by making the tool available

Use Case	Capability Developed
Inter-regional analysis	Evaluate adequacy and stability impacts due to inadequate inter-regional energy transfer availability.
Western Heat Dome + Wildfire	Analyze reliability impacts of combined Wildfire/Heat Wave events from project climate models.
High Fidelity Load and DER Models	Assess and mitigate the impacts of tripping events on both transmission and distribution inverter-based resources.
Water Resource Availability	Determine the combined effects of reduced hydro availability, thermo-electric deratings, and temperature-dependent loads on reliability.
Operational Reliability Modeling	Introduce high-performance computing and statistically-based ensembles of future weather and demand scenarios on system reliability.

Questions & Discussion

Additional Resilience Tools (Just the ones I'm aware of!)

Grid Deployment Office Technical Assistance Tools

- State Resilience Resources Interactive Map & Database
- Climate Risk-Informed Planning for the Grid
- Incorporating Equity in Grip Planning
- Resilience Objectives and Metrics Survey
- Baseline Utility Planning Workflows and Decision Processes

Office of Electricity Activities

- North American Energy Resilience Model (NAERM)
- Secure Communications Program
- Energy Storage Analysis
- North American SynchroPhasor Initiative (NASPI)
- Grid Architecture Program
- Advanced Grid Modeling Program

National Lab Tools

- Electrical Grid Resilience and Assessment System (EGRASS)
- Grid Operations, Decarbonization, Environmental and Energy Equity Platform (GODEEEP)
- Climate Risk and Resilience Portal (ClimRR)
- Risk-controlled Expansion Planning with Distributed Resources (REPAIR)
- Resilience Node Cluster Analysis Tool (ReNCAT)
- Technical Resilience Navigator (TRN)
- Customer Damage Function Calculator
- Probabilistic Resource Adequacy Suite (PRAS)
- Prescient Production Cost Modeling
- Hurricane Electric Assessment Damage Outage (HEADOUT)
- All Hazards Analysis Framework (AHA)
- Interruption Cost Estimate (ICE)
- Power Outage Economic Tool (POET)
- …

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy