North American Energy Resilience Model (NAERM)

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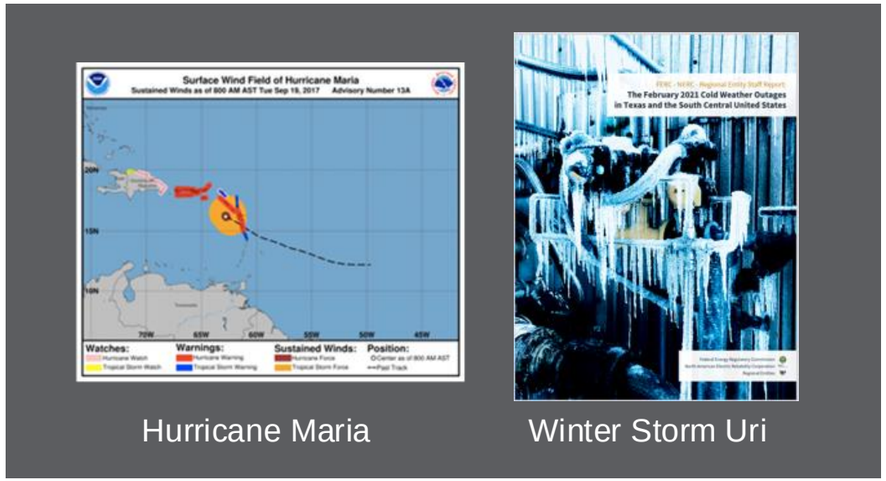
U.S. Department of ENERGY | Office of Electricity

PNNL is operated by Battelle for the U.S. Department of Energy

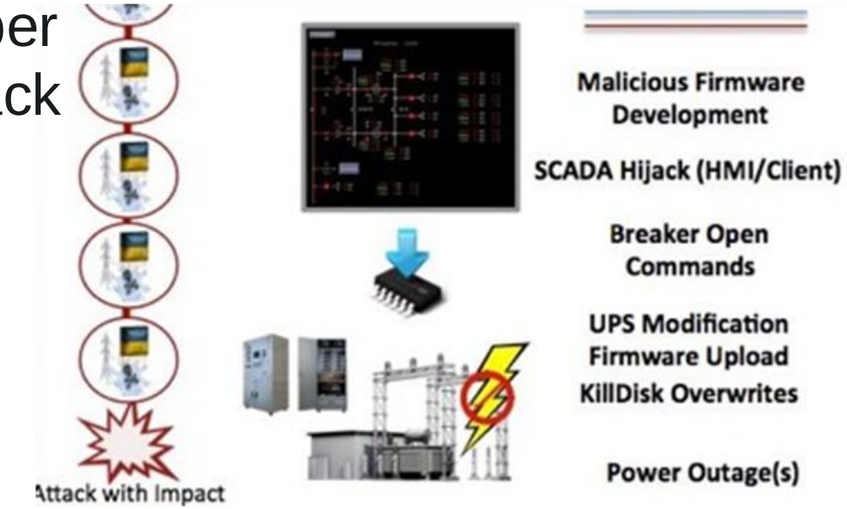
The U.S. energy infrastructure faces many threats



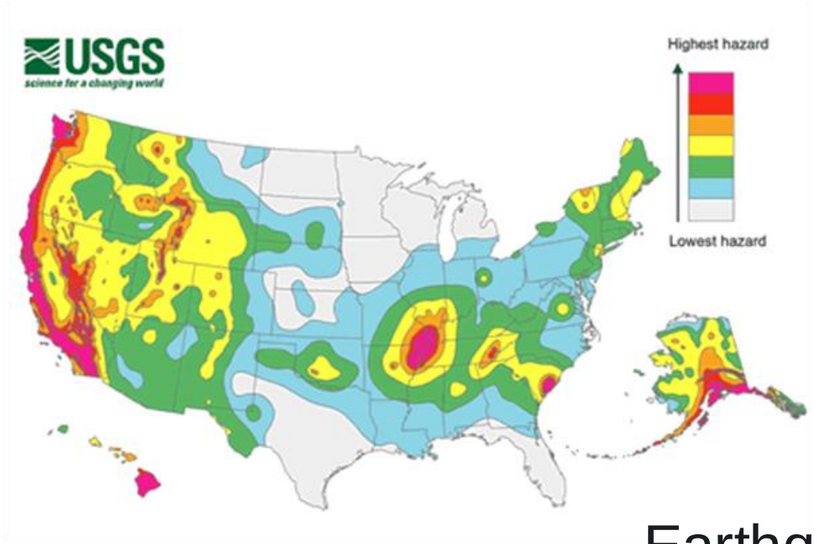
Hurricane Maria

Winter Storm Uri

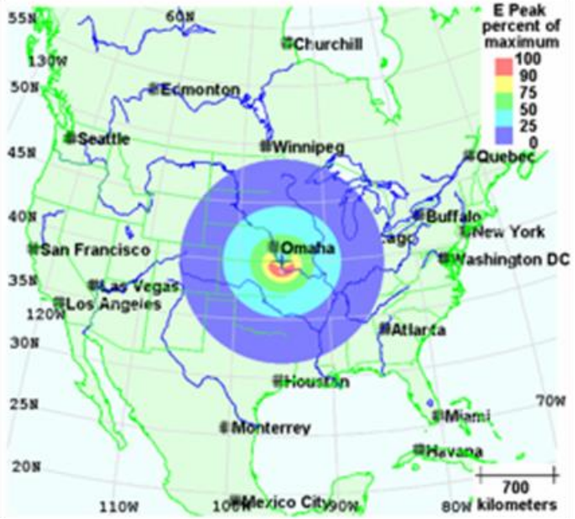
Cyber Attack



Extreme Weather



Earthquakes



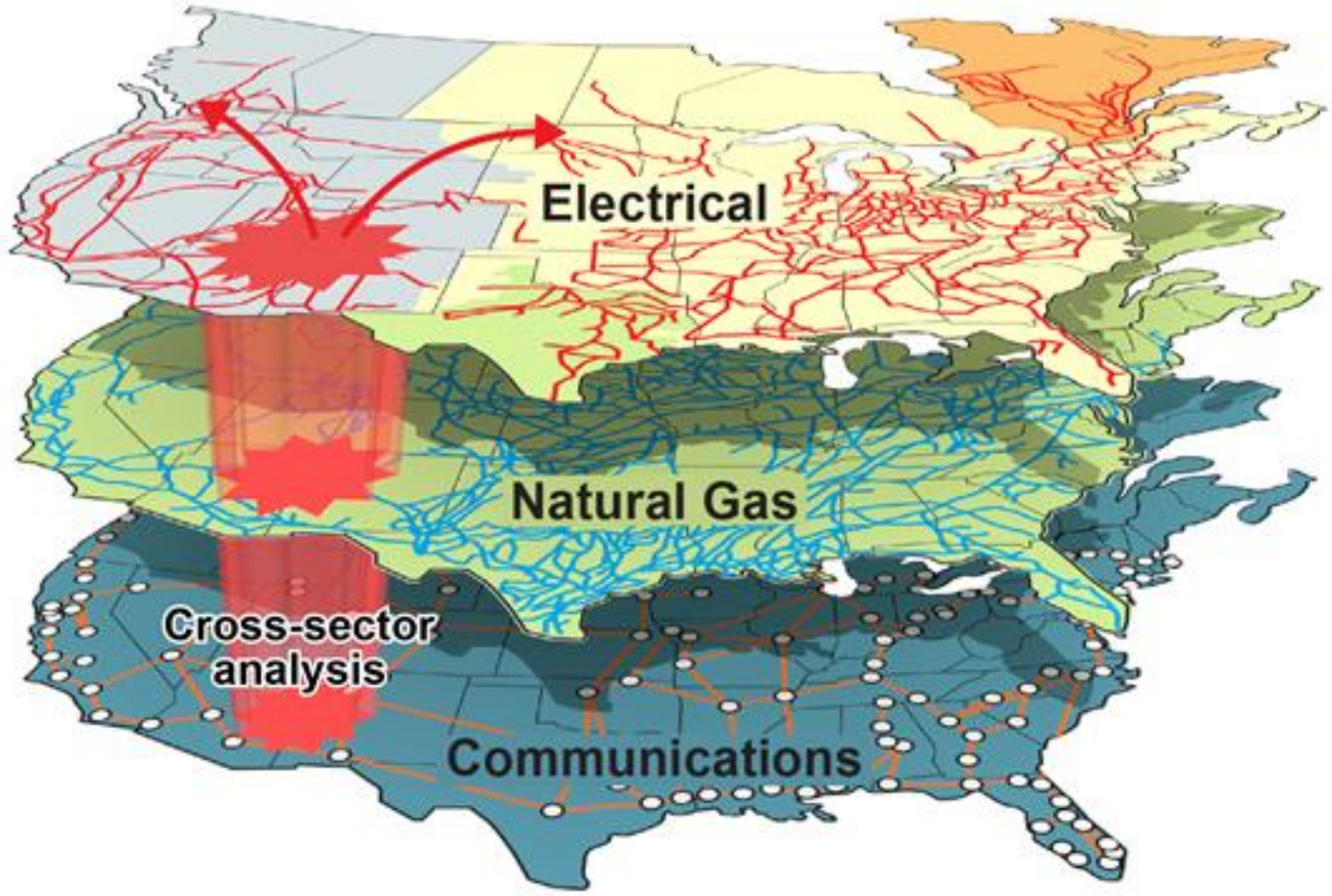
EMP

North American Energy Resilience Model (NAERM)

Vision: Rapidly predict energy system interdependencies, consequences, and responses to reduce risk of extreme events at a national scale

Mission: Develop and deploy engineering-class modeling system for planning and near real-time resilience analysis

Key Objective: Catalyze partnerships with industry, national labs, states/communities, and other federal agencies to enhance coordination to support energy resilience



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

Resilient and reliable grid decarbonization requires cross-cutting analysis - NAERM positions us to meet this need

Threat and Hazard Models and Data

- Extreme Events
- Intentional Threats
- New Technologies & Policies
- Climate Change

Integrated Multi-Sector Modeling Environment

- Bulk Electric System
- Natural Gas and Pipeline System
- Distribution System
- Communications System
- Transportation System
- Water System
- Cross-Domain Data Mapping
- Multitemporal Modeling and Simulation

HELCS

- Predicted Outages and Other Impacts
- Resilience Enhancement Assessments
- Operational Planning Options
- Metrics and Economics Assessments
- Resilient Investment Trade-offs
- Decarbonization Pathways

Multi-Sector Data

Critical Energy Infrastructure | Proprietary | Public

Best-in-Class Tools

Commercial/ Industry | Open-Source | Lab-Developed

= in progress or planned

Courtesy of PNNL

NAERM is organized around three major capabilities

- Multi-Infrastructure Planning Modeling

  Analyze options to affect energy resilience, improve rapid restoration and recovery, and enable risk-informed planning and coordination to mitigate large-scale energy disruptions (e.g. earthquakes, wildfires).

- Data and Analytics

  Store and analyze wide range of data to support resilience analysis. Data layers include modeling databases for bulk electric system, generation, natural gas pipelines; cell, fiber communications; weather forecasts, icing; hospitals, roads. Analytics include graph analysis and machine learning (ML).

- Software and Computing Architecture

  Enable a complex, multi-component software system focused on security, integration, scalability, and open architecture that leverages existing commercial and open-source software and commercial and government cloud services.

NAERM builds on 50+ projects / technologies from DOE, government agencies, and industry

Sponsors

DOE OE

DOE EERE

DOE GMI

DOE CESER

DOE FE

DOE NNSA

DOE LDRD

DOE GDO

DHS

ARPA-E

DARPA

DOS

Labs

- ANL
- INL
- LLNL
- LANL
- NREL
- ORNL
- PNNL
- Sandia
- Vendors

Partial List of Tech Contributions to NAERM

- HELICS co-simulation framework
- Extreme events modeling
- Solar, wind, and load forecasting
- Modeling distributed energy resources
- Communications modeling
- Natural gas pipeline modeling
- Dynamic and worst-case contingency analysis tools
- Situational awareness tools
- Validation, verification, and UQ
- Commercial power flow solvers

Tech Stack

Cloud Services


EC2


EKS


SageMaker


S3


IAM


Azure AD

JupyterHub

Apps


Apache Arrow


Flask


GeoPandas


HELICS


Mapbox


Apache Parquet

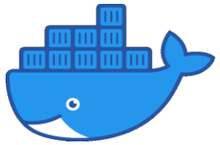

PyTest


React


PyPi


Python

DevOps


Docker


GitLab


Harbor

Helm


Kafka


Sonar Qube


Swagger


Grafana


Kubernetes

Data


MongoDB


PostgreSQL


Timescale

Business Tools


Confluence


Jira

Modelers & Solvers


PowerWorld


PSSE

NGFast
KNitro

NAERM team is developing capabilities at the National Level

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 R&D to extend analysis capabilities (e.g., energy equity)

Ensuring electricity system reliability

- Identifying key interdependencies between different parts of the nation’s energy system and their vulnerabilities.
- Understanding the impacts of natural disasters, such as wildfires and earthquakes, as well as man-made threats to the U.S. energy system.
- Reconstructing natural disasters and exploring additional mitigation options for future preparation.
- Utilizing modeling data, in light of increasingly intense and frequent weather patterns, to better guide investments in energy resiliency.
- Supporting national efforts to integrate renewable energy, distributed energy resources, and other elements of grid modernization.

Resilience & Reliability Evaluation: Vital to planning-based studies

Addressing resiliency & reliability through the lens of NAERM capabilities and:

- **Interregional** analysis
- **Water** resource availability
- **High-performance computing** to manage uncertainties
- High fidelity load and **distributed energy resources** modeling for reliability
- Grid reliability during extreme heat and **wildfire**

Other Use Cases:

- Studying the impact of wildfire (WI), Coldwave (NE), hurricane and flooding (FL) on the electric power system.
- Working with NERC to conduct a Gas-electric interdependency study for the entire country (Single Point of Failure).
- Advanced Conductoring study for the S1
- Working with NERC and Office of Policy to study the retirement of the EVERET station on the reliability of the Northwestern section of the country.
- Working with NRECA customers to study the impact of wildfire on their regions.

Thank you

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