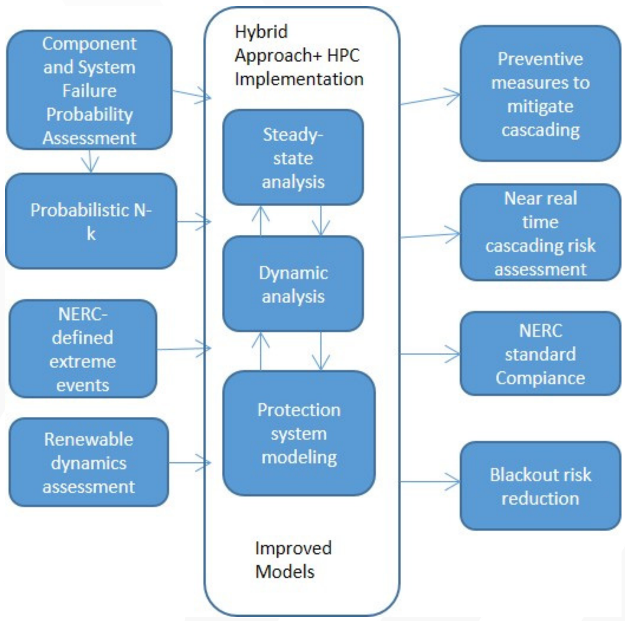
Extreme Event Modeling

CHALLENGE

Extreme weather events like Hurricanes Harvey and Irma, Superstorm Sandy, Hurricane Katrina, and the 2003 Northeast blackout, provide hard evidence of the enormous threats they pose to the nation's electric grid and the socio-economic systems that depend on reliable power delivery. Given the economic costs and social hardships of such events, better tools would significantly enhance the ability of the power industry to predict and prepare, but significant technological gaps and hurdles remain in forecasting and response.



Process flow for modeling extreme events.

Chief among these technical challenges are the modeling of cascading events and N-k analysis. Cascading events are sequences of failures of individual components that successively weaken a power system and can lead to a major system blackout. N-k contingency events are defined by nearly simultaneous failures of a finite number (k) of components in a power system with N components, that interact with each other in complex ways. Utilities can use these capabilities to assess the risk posed by cascades and identify problematic initiating events in order to address NERC Standard TPL-001-4.

APPROACH

Advised by numerous industry partners, a multi-laboratory team aims to bridge multiple gaps in cascading-outage and N-k analysis by creating a unique prototype tool capable of automatically simulating and analyzing cascading sequences, as well as identifying probable N-k events in real systems using multiprocessor computers. Their approach is divided into two key areas in extreme event modeling and simulation, with key gaps identified for current industry practices and tools:

At-A-Glance

PROJECT LEADS

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BUDGET

$3 million

DURATION

April 2016 – April 2019

TECHNICAL AREA

Design and Planning

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1. **Cascading event modeling and dynamic simulation.** Current tools in cascading event modeling and simulation suffer from two major limitations: inadequate modeling of the complicated cascading phenomenon and lack of computational efficiency. This project will develop novel approaches to introduce new models of cascades such as detailed models of protection schemes and slow dynamics of renewable energy sources. It will also explore novel approaches for leveraging high-performance computing resources, model reduction, and cascade path pruning to improve computational efficiency.
2. **Probabilistic N-k contingency analysis.** Current N-k contingency analysis lacks the ability to scale to large k (k is used to bound the number of power system components that can fail). In this project, the team will develop new models of probabilistic failures both at the system and component level, and more computationally efficient approaches for identifying sets of k components whose failure leads to undesirable outcomes.

EXPECTED OUTCOMES

This project will deliver a prototype set of tools for efficient cascade modeling and probabilistic N-k identification. These tools will be 500 times faster than existing industry cascade simulation packages, which are currently 10–100 times slower than real time. They will also identify the worst (probabilistic) k contingencies where k is twice as large as existing practices (k = 3 in existing tools).

Ultimately, these tools will support mitigation and prevention of economic and social costs due extreme events and help meet DOE's objective of "a 10% reduction in the economic costs of power outages by 2025."

LAB TEAM

Argonne National Laboratory | Brookhaven National Laboratory | Lawrence Livermore National Laboratory | Los Alamos National Laboratory | NREL National Renewable Energy Laboratory | Oak Ridge National Laboratory | Pacific Northwest National Laboratory | Sandia National Laboratories

Launched in November 2014 under the U.S. Department of Energy's Grid Modernization Initiative, the GMLC is a strategic partnership between DOE Headquarters and the national laboratories, bringing together leading experts and resources to collaborate on national grid modernization goals. The GMLC's work is focused in **six technical areas** viewed as essential to modernization efforts:

Devices and Testing | Sensing and Measurements | Systems Operations and Control
Design and Planning | Security and Resilience | Institutional Support