A Pathway to Enhance Grid Resilience: Zero-Carbon Energy Communities with DER-based ELCC Quantification

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- **Research Interests:**
  - Power System Planning and Operation, Optimization,
  - Renewable Energy Integration, Grid Resilience.
- **Selected Awards (Lead-PI):**
  - **Eversource Energy**: Distribution system flexible load modeling;
  - **Eversource Energy:** Grid Resilience and ELCC Quantification;
  - **ISO-NE**: DER modeling and ISO-NE market dynamics;
  - **MISO:** Decomposition and coordination approach for Markov-based unit commitmer
  - **NSF:** Machine learning methods and microgrid control;
  - **BNL:** Grid dynamic behavior of solar integration at D levels;
  - **BNL:** Intra-day ahead unit commitment with wind and solar;
  - **DOE WPTO:** Hydropower Optimization Prize.

Project Period: 11/2023-11/2026

Industry Relevance & Need

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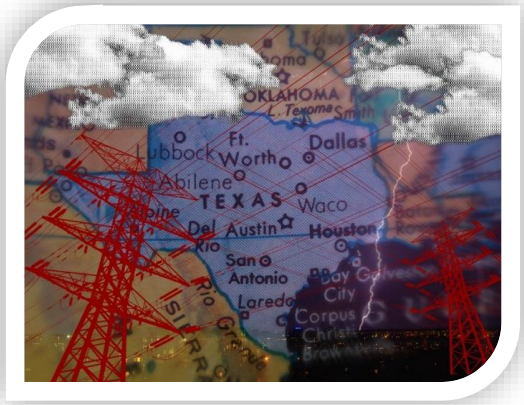

01 Extreme Weather events

- Low-probability;
- Extensive socioeconomic costs and impacts;
- Address Eversource's need for enhanced grid resilience against events.

02 Critical grid components

- Reduce the likelihood outages;
- Analyze different event behaviors;
- Resilience metrics quantification;
- Provide solutions for future system planning and upgrading schemes.

03 Economic-Resilience Framework

- Find a trade-off between resilience and costs (economic);
- More resilience;
- More cost effective.

04 Resilience & Zero-Carbon Transition

- Advanced tools and methodologies, reinforcing Eversource's leadership in sustainable energy transitions;
- Charts a progressive course towards the 2050 net-zero emission targets, catalyzing industry-wide adoption.

Project Goals and Objectives

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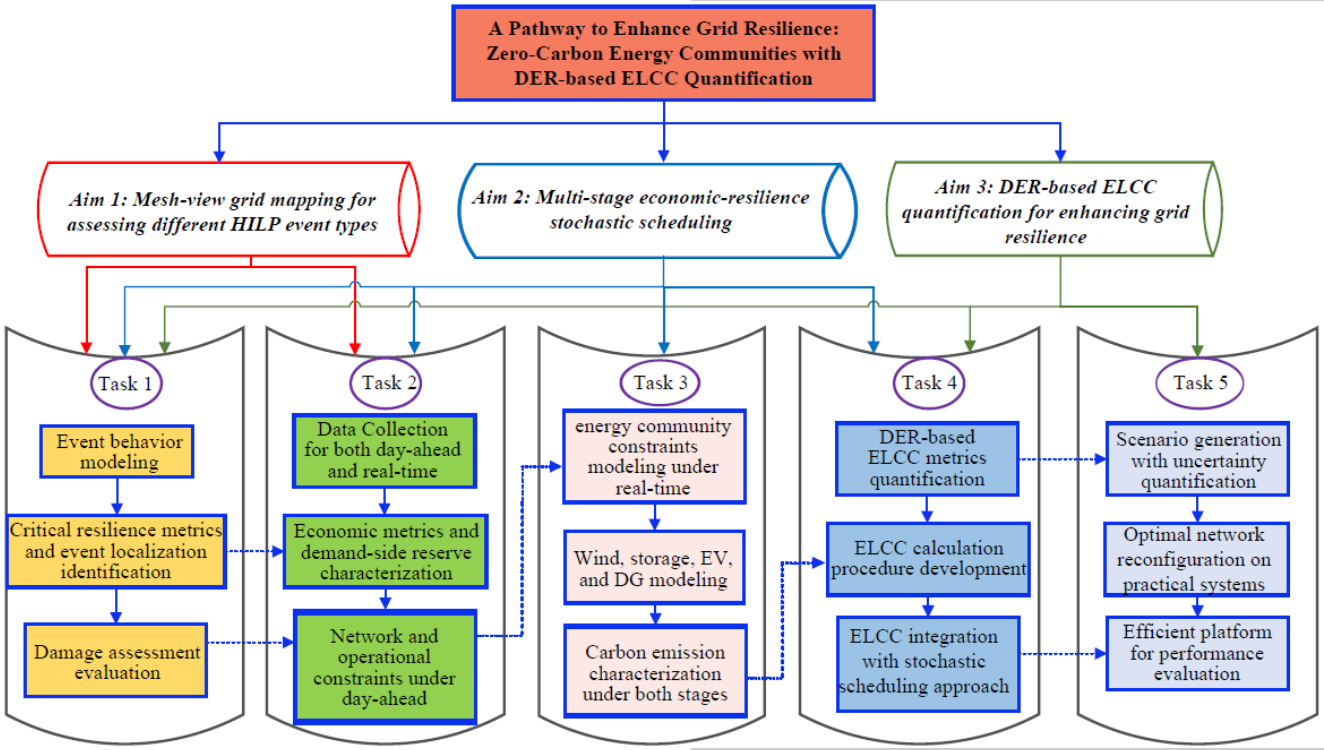
Primary Goal is to increase the resilience of energy communities by leveraging innovative grid mapping techniques, detailed resilience assessments, and integrating DERs into planning and operations, aligning with Eversource's strategic direction towards a reliable, resilient, and sustainable energy future.



Project Objectives

Mesh-view Grid Mapping for HILP Events

Develop a mesh-view grid mapping tool to identify critical grid components and vulnerability areas and optimal resource allocation, for different types of HILP events.

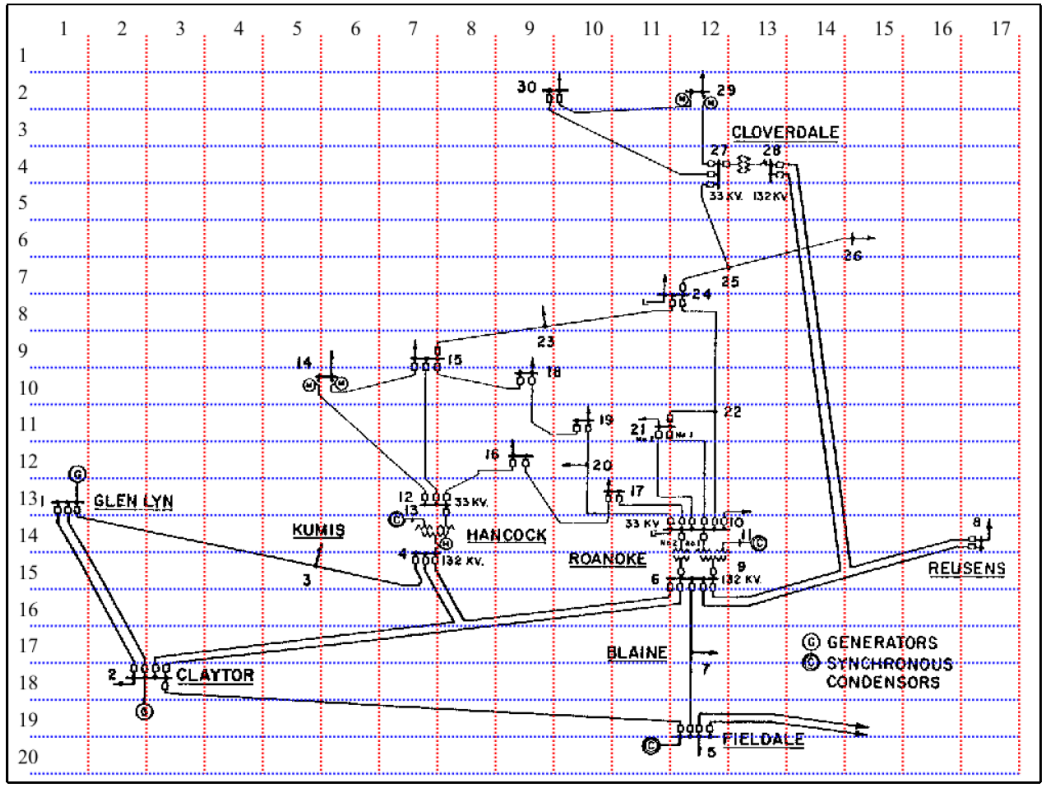
Quantitative Resilience Metrics

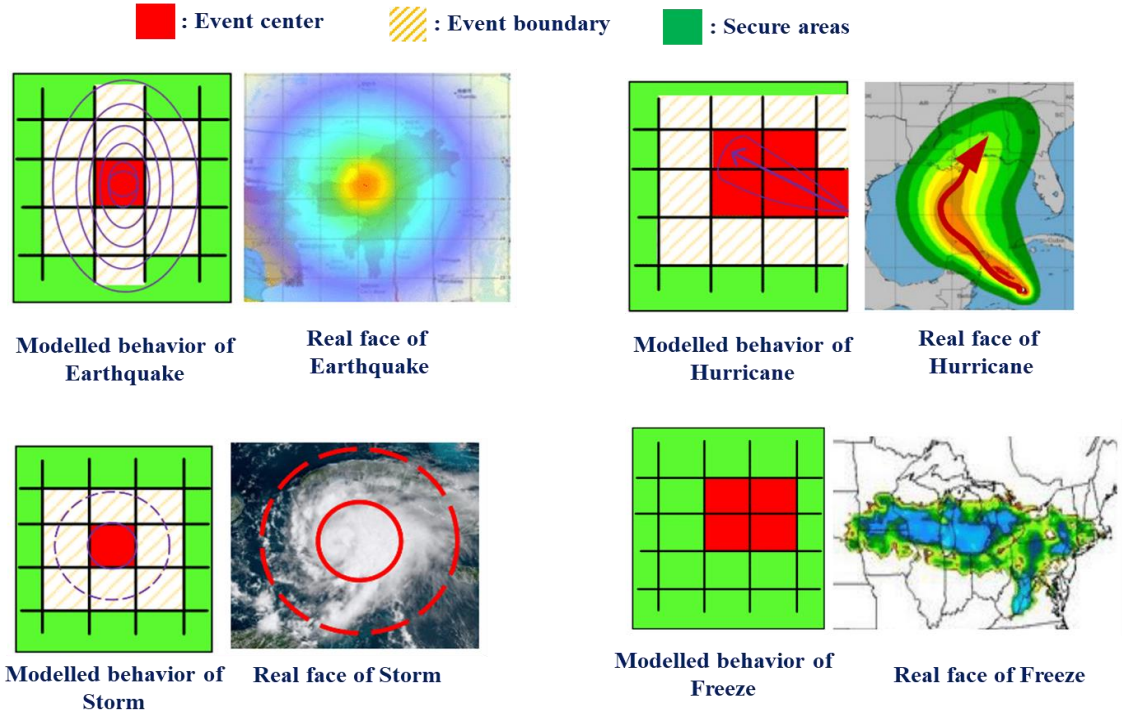
Establish innovative DER-based effective load carrying capability (ELCC) resilience metrics to expedite the restoration and ensure resilient operation of carbon-free energy communities.

DER-based ELCC for Resilient Energy Communities

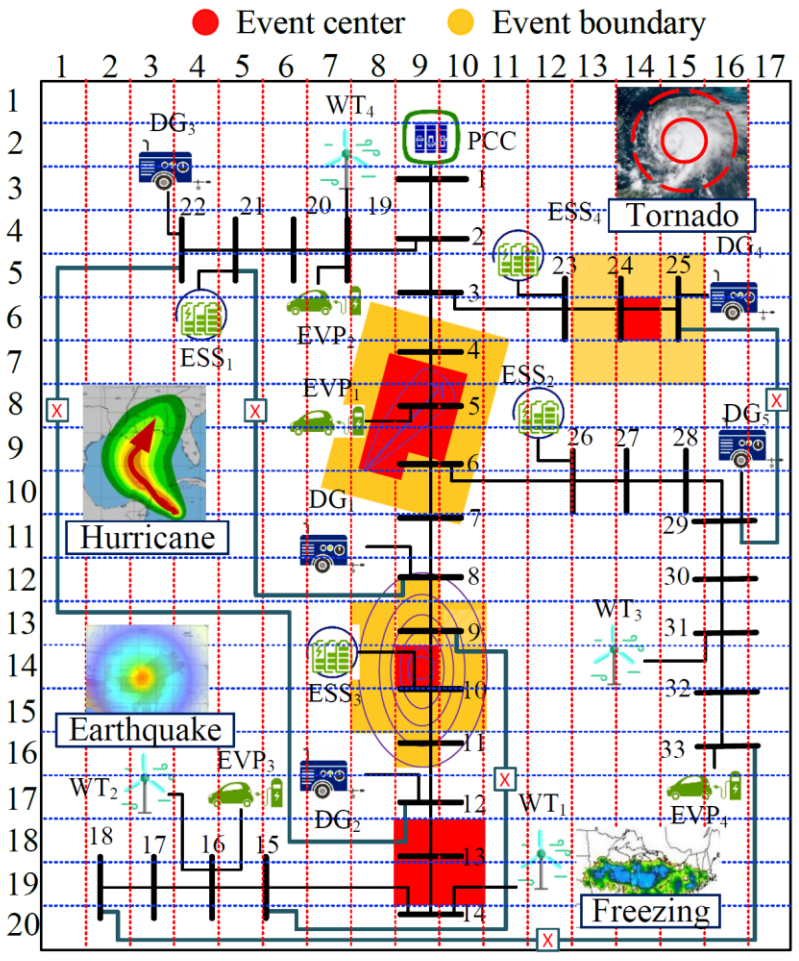
Incorporate a probabilistic vulnerability assessment strategy using ELCC metrics with the mesh-view mapping tool for precise event localization and grid components to enable effective resource deployment and improved decision-making for resilience enhancement.

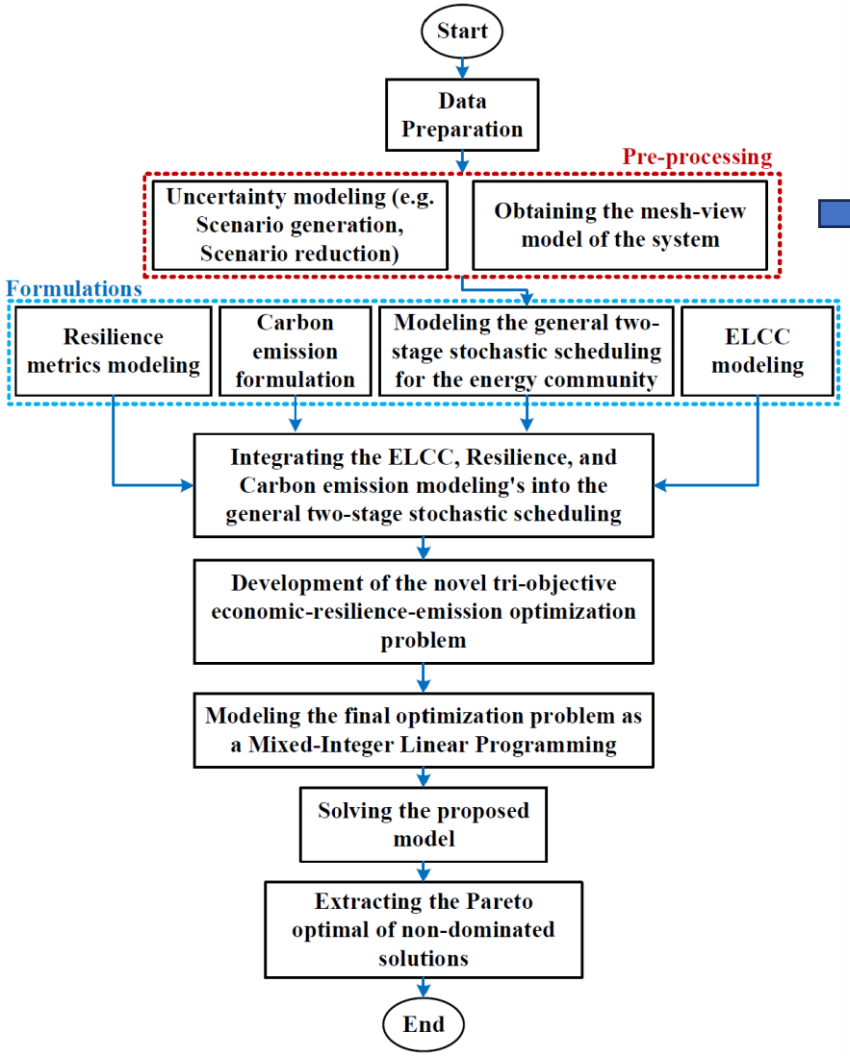
Research Approach

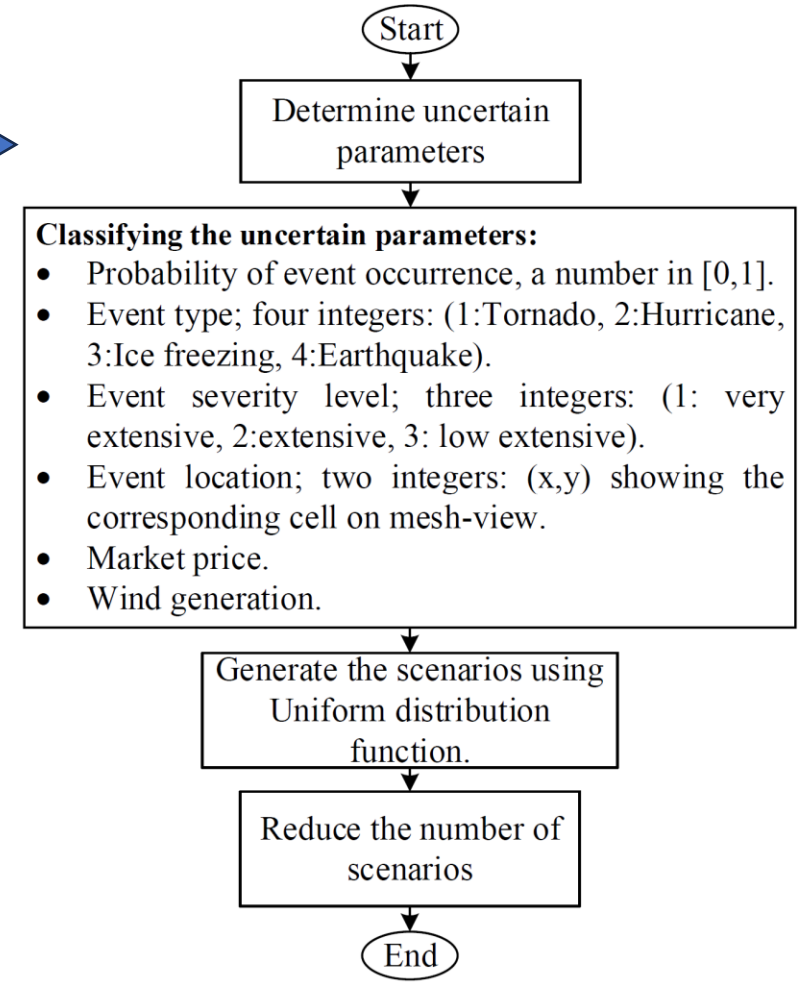




Research Approach







Outcomes and Research Impact

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01 Mesh-view Grid Mapping

DER-based ELCC quantification;

Critical grid component identification for various events;

Resilience-economic framework with Markov stochastic optimization with network topology configuration.

02 Practical Framework Validation

Analyze the grid resilience against different natural disasters with different specific resilience criteria;

Practical distribution system validation with DER integration;

Provide solutions for future system planning and upgrading schemes.

03 Resilience Enhancement Tool

Implement specific resilience assessment matrix for utility needs;

Real-time adaptability;

Effective tool for utilities to enhance decision-making and resource allocation for improved resilience.

Long-term goal: ***Implement the mesh-view grid mapping tool across multi-regional utilities to be flexibly designed and meet specific state-defined information needs for a zero-carbon, resilient, and reliable energy communities.***

Project Relevant Publications:

- A. Younesi, **ZJ Wang***, etc. Enhancing the Resilience of Zero-Carbon Energy Communities: Leveraging Network Reconfiguration and Effective Load Carrying Capability Quantification [J]. *Journal of Cleaner Production*, 2023. (Accepted) Impact Factor: **11.07**
- A. Younesi, H. Shayeghi, **ZJ Wang***, etc. Trends in Modern Power Systems Resilience: Smart Grids Challenges and Opportunities [J]. *Renewable and Sustainable Energy Reviews*, 2022, (162), 112397. Impact Factor: **16.8**

A. Younesi, **ZJ Wang***, etc. DER Analysis with Effective Load Carrying Capability for Enhanced Carbon-Aware Active Distribution System Resilience [C]. *IEEE PES GM*, 2024.
A. Younesi, **ZJ Wang***, etc. A Pathway to Mitigate Climate Change Impacts on Energy Communities: Decarbonization-Based Cost-Effective Grid Resilience Enhancement [C]. *IEEE PES GM*, 2023.
A. Younesi, **ZJ Wang***, etc. Quantification of DERs Penetration Level in Microgrids: A Quest for Enhancing Short-Term Power Grid Resilience [C]. *IEEE PES GM*, 2023.
A. Younesi, **ZJ Wang***, etc. Investigating the Impacts of Climate Change and Natural Disasters on the Feasibility of Power System Resilience [C]. pp. 1-5, *IEEE PES GM*, 2022.
A. Younesi, **ZJ Wang***, etc. A Pathway to Enhance the Modern Distribution Systems Resilience: Flexible Behavior Investigations on Electric Vehicles [C]. pp. 1-5, *IEEE PES GM*, 2022.