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

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 commitment;
- 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.

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Project Period: 11/2023-11/2026
Industry Relevance & Need

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.
**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
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Classifying the uncertain parameters:
- Probability of event occurrence, a number in [0,1].
- Event type; four integers: (1:Tornado, 2:Hurricane, 3:Ice freezing, 4:Earthquake).
- Event severity level; three integers: (1: very extensive, 2:extensive, 3: low extensive).
- Event location; two integers: (x,y) showing the corresponding cell on mesh-view.
- Market price.
- Wind generation.

End
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.

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.

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: