Eversource Energy Center

Securing Resilient Energy Infrastructure and Sustainable Green Energy

Advisory Board Meeting – February 9, 2024

Our Leadership Team

Faculty and Staff

Director, Prof. Emmanouil Anagnostou

Center Manager

Dr. Xinxuan Zhang

Associate Director, Vegetation Risk Management,

Prof. Robert Fahey

Associate Director, Storm Preparedness

Prof. Diego Cerrai

Associate Director, Grid Modernization

Prof. Junbo Zhao

Financial Analyst

Mr. Ronny Heredia

Team Leader, Weather Forecasting

Prof. Marina Astitha

Team Leader, Grid Resilience

Prof. Ross Bagtzoglou

Team Leader, Graduate Certificate and Diversity

Prof. Malaquias Pena

Financial Assistant

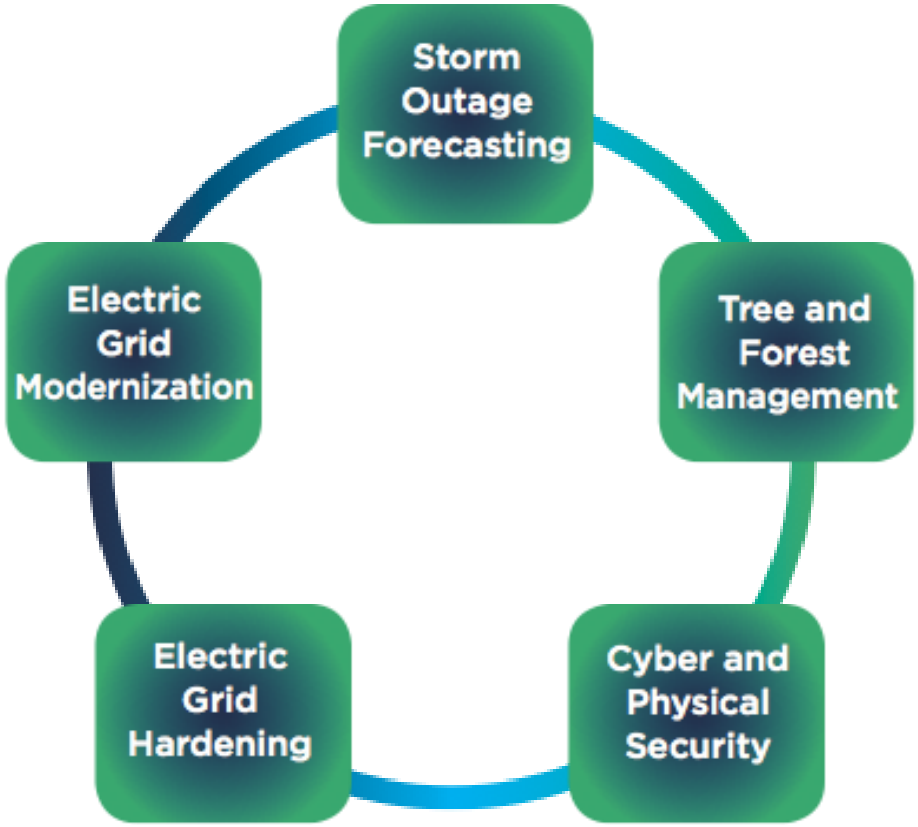
Ms. Natalka Tuczkewycz

13 Core faculty | 3 Postdocs | 27 PI faculty | 41 Graduate students | 8 Undergraduates

Our Mission and Goals

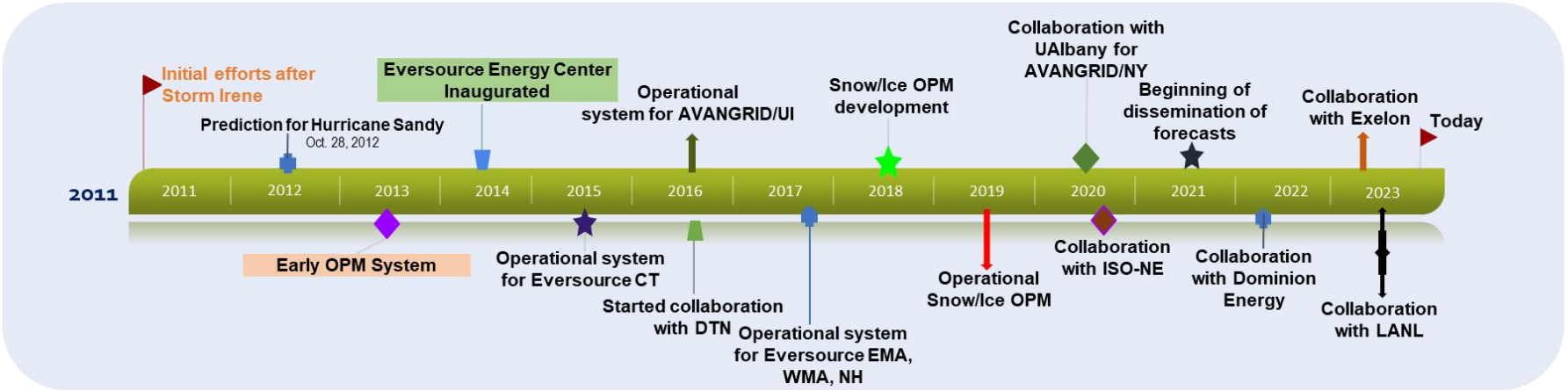
An industry-academia partnership of Eversource and UConn

"Advance leading-edge interdisciplinary and translational research to assure reliable power during extreme weather and security events"



Our History

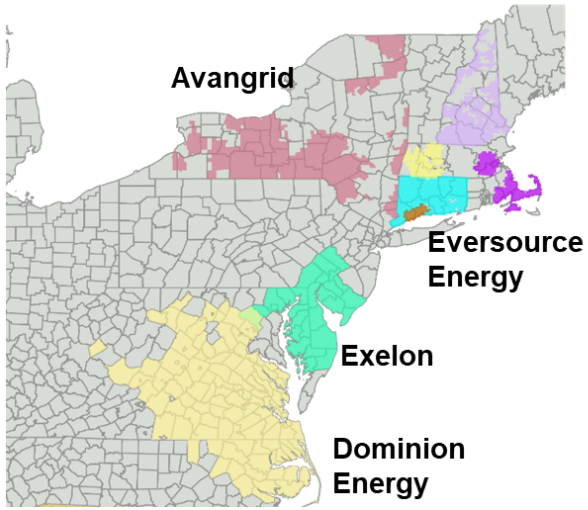
The history of the Eversource Energy Center is closely tied to the development of the UConn OPM



Collaborators

… but now, the Eversource Energy Center is much more than grid resilience and outage prediction

We have been developing OPM models for 4 major electric utilities across 11 states.



We are conducting applied projects for grid modernization, cyber and physical security and renewable energy.

Federal Agencies

U.S. Department of Energy, NREL, Argonne National Laboratory, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, NASA, Pacific Northwest National Laboratory, Office of Naval Research, NERC, Oak Ridge National Laboratory, NSF, ESTCP

Industries

GE, Siemens, Hitachi ABB, VR Energy, EPRI Electric Power Research Institute, ISO new england, Quanta Technology, Raytheon Technologies, EnerNex

Utilities

exelon, nationalgrid, Eversource, Avangrid, Entergy, Dominion Energy, TVA, Holy Cross Energy, ComEd, Southern Company

NREL Partnership

NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

UCONN
UNIVERSITY OF CONNECTICUT

UConn-NREL Partnership for Clean Energy Innovation and Grid Resilience

UConn-NREL partnership will leverage scientific knowledge and state-of-the-art facilities to solve complex, multidisciplinary challenges in energy efficiency and resiliency, renewable energy technologies, and smart grid innovation.

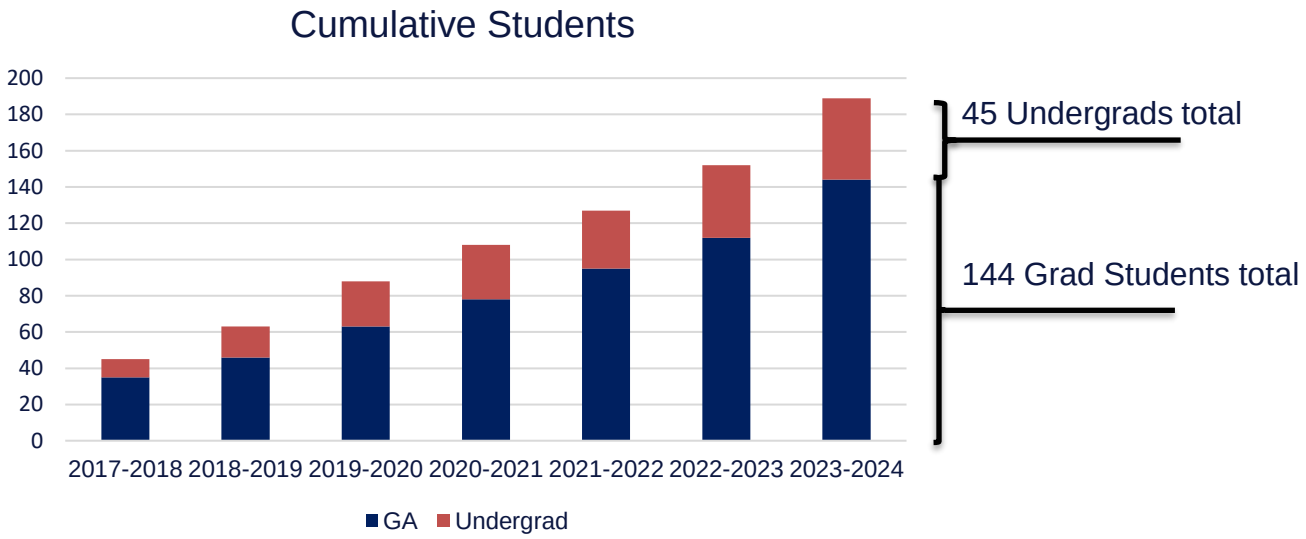
The missions of this partnership include

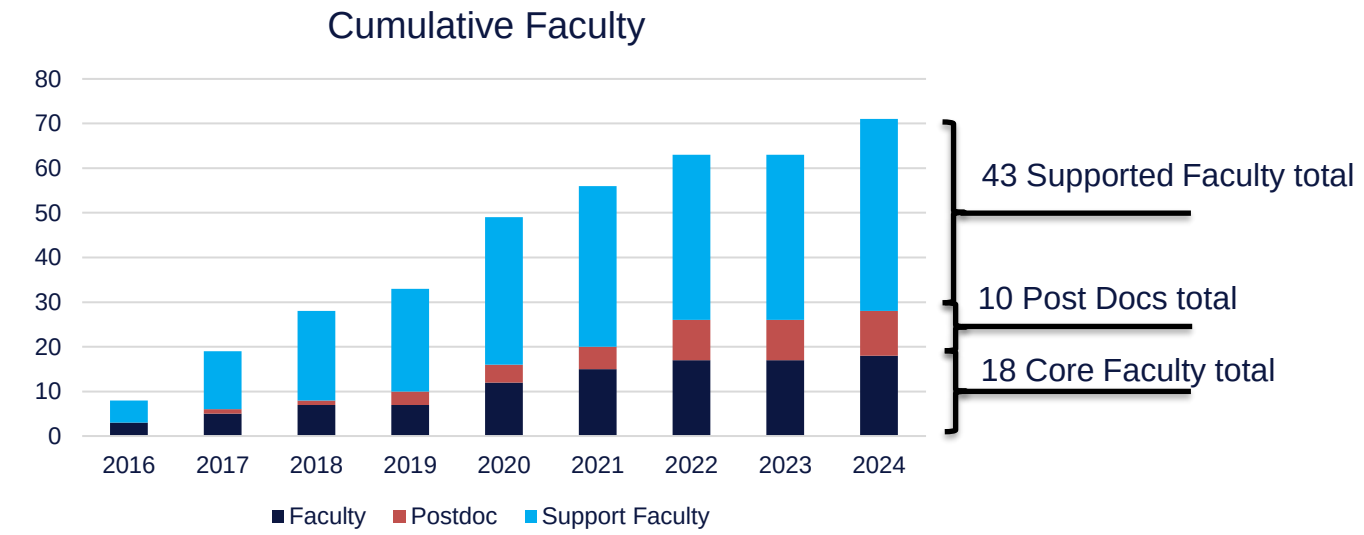
- Invest in the development of joint solutions to grand clean energy challenges.
- Foster the exchange of ideas to expand research capabilities that lead to scientific breakthroughs.
- Increase funding opportunities for joint research from sources not available to UConn or NREL individually.
- Joint appointment program to advance faculty's and NREL researcher's scholarship and increase the impacts of their works to community, the state and the nation.

NREL is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy operated by the Alliance for Sustainable Energy, LLC.
The University of Connecticut is a public land-grant and top-ranked research institution.

Center Facts

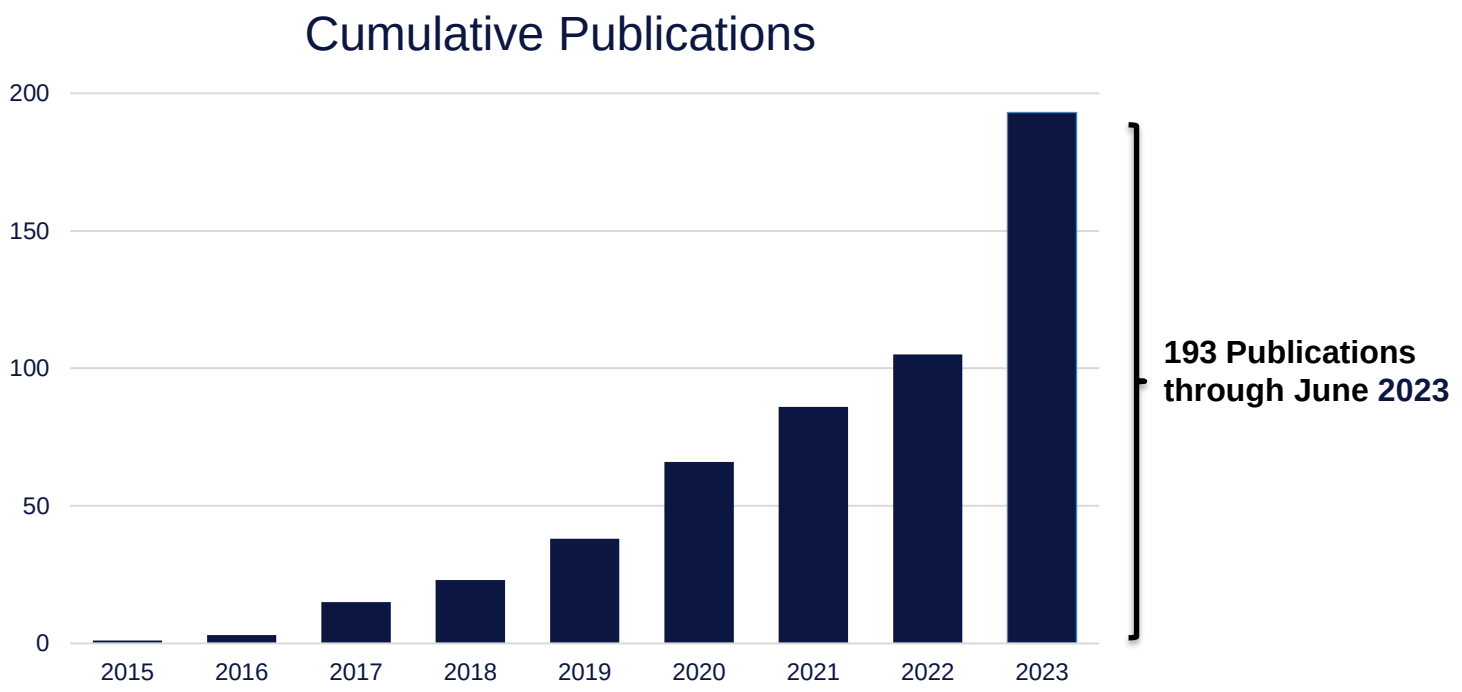
Growth in personnel





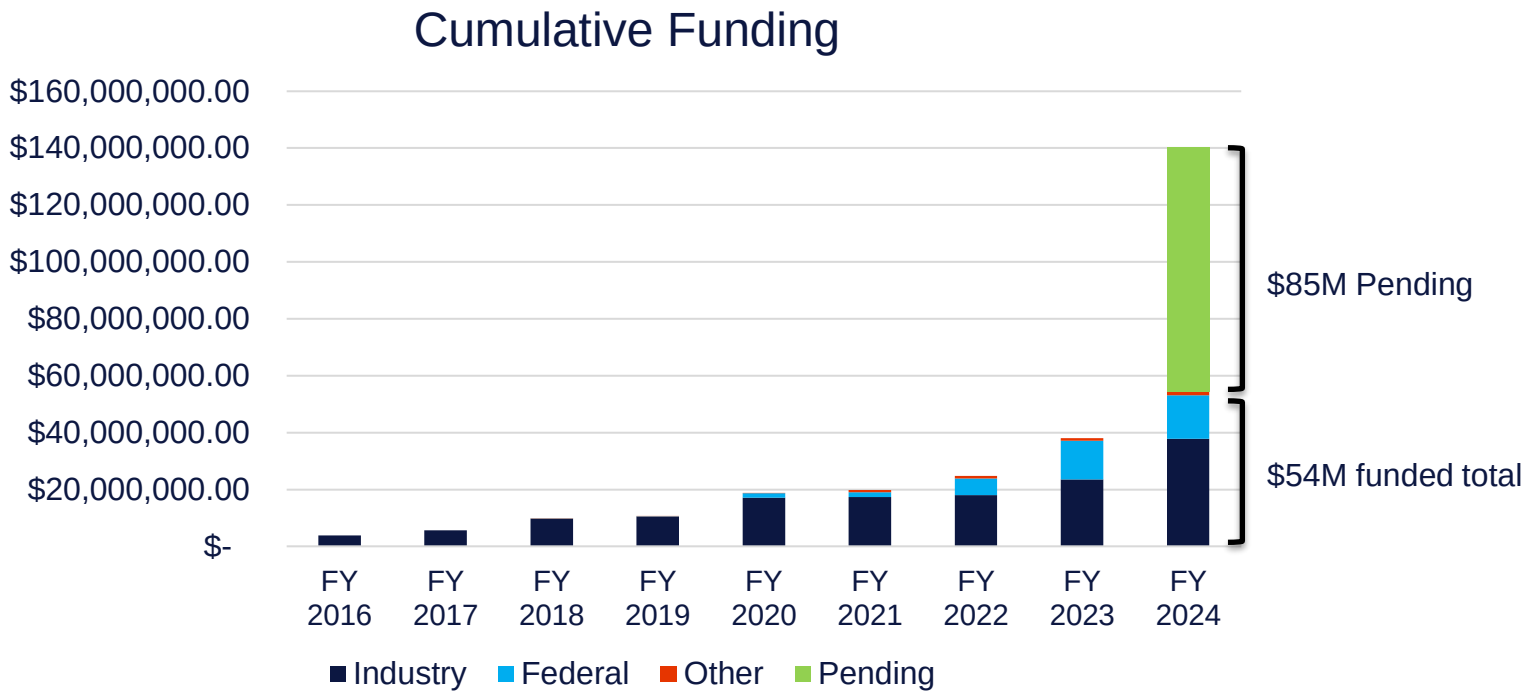
Center Facts

Accelerated growth in scholarship and invention



Center Facts

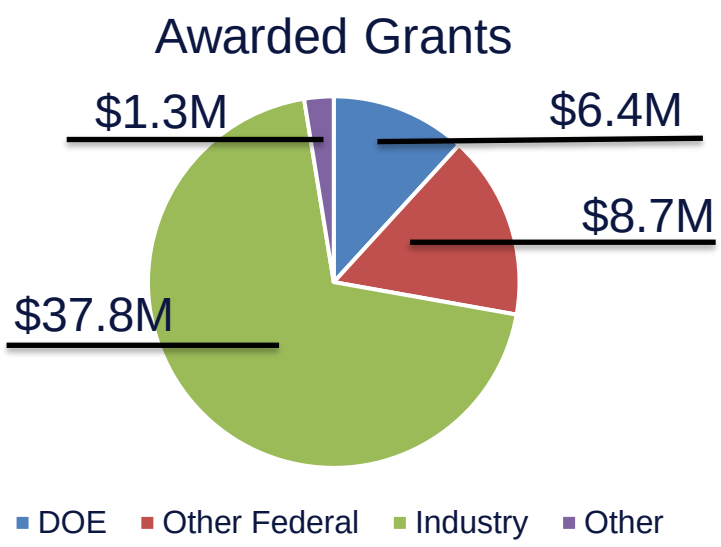
Accelerated growth in funding

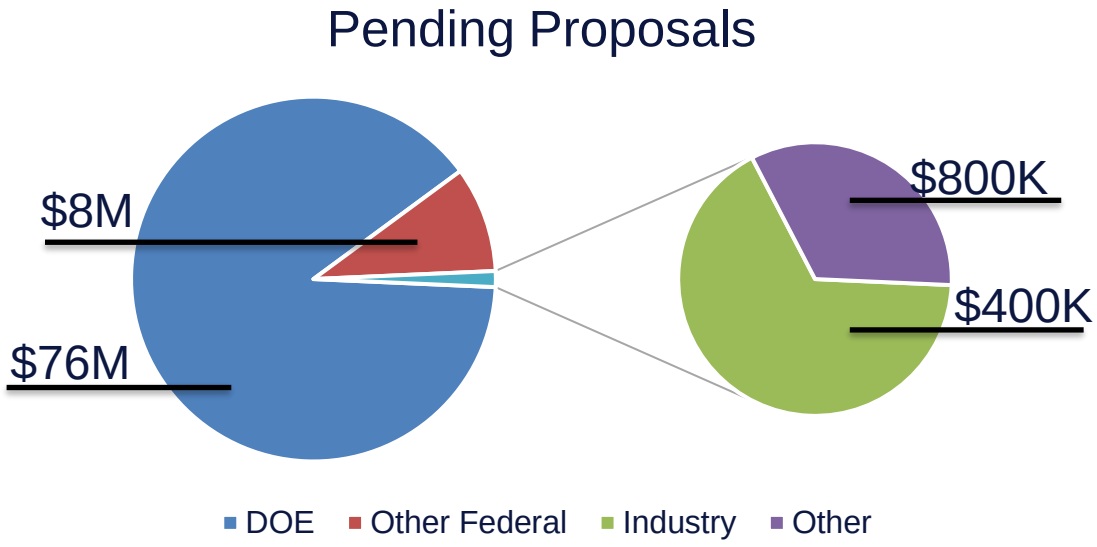


$736,000 in revenue from commercialized patents

Center Facts

Focus on DOE and other Federal funding sources





Expanded Goals

Climate, clean energy, sustainability

Develop and Demonstrate solutions aimed at increasing the reliability and resilience of the grid, modernizing the grid through new technologies, facilitating a safe and secure deployment of renewnable-based DERs, and ensuring a smooth transition from traditional to renewable energy resources.

- Grid Resilience in a Warming Climate
- Grid Reliability in a Changing Demand Environment
- Renewable Energy Integration
- Cyber-Physical System Security
- Workforce training, outreach, and policy

Funded Projects

Grid Resilience, Reliability in a Warming Climate (Pillars 1 & 2)

Improving wind gusts and snow forecasting
Develop two operational products for improved wind gust and temperature/ snowfall forecasts

Assessing risk for substation flooding
Addressing the technical, financial, and societal issues that may arise from potential susceptibility of Eversource substations to compound flood events across the State of Connecticut, under the influence of climate change.

Modeling tree risk on infrastructure
Combining remote sensing observations to monitor roadside tree structure and health condition and develop models to predict tree failure risk.

Outage Prediction Model
Continuous improvements to the UConn OPM

Power system vulnerability assessment
Quantifying assets vulnerabilities and estimation of weather and outage return periods under current and future climate conditions.

A model for estimating time to restoration
Complete the ABM for estimating time to restoration and use it to operationally predict ETR in advance of storms using OPM forecasts.

Integrating DERs in communities and development of resilience metrics
Development of a framework to integrate DERs and Effective Load Carrying Capability within energy communities, and development of resilience assessment metrics to evaluate system performance under extreme conditions.

Resilience assessment and climate change
Improving the resilience system performance model to estimate benefits and costs of grid hardening improvements under changing climate conditions.

Assessing roadside tree risk
Provide a forest disturbance and health monitoring framework for roadside utility risk assessment.

Funded Projects

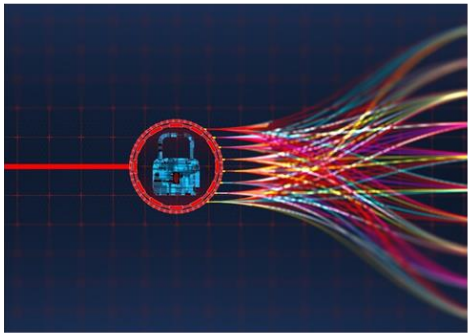
Renewable energy integration (Pillar 3)

- **Pillar Objectives**: This pillar aims at understanding the future impacts of very high levels of penetration of intermittent generations on power systems and developing enabling technologies to ensure reliable and resilient grid planning and operation
- **Projects Selected**: 3 funded projects

- ❑ Next-level Grid Resilience by Utilizing Sensors in Distributed Power Converters
- ❑ Connecticut's Low-carbon, Innovative, and Modernized electric grid for Better resilience.
- ❑ A Regional Weather-Power Forecasting System (WPFS) for Granular Energy Prediction and Resilience Analysis: System Design, Implementation, and Demonstration.

Funded Projects

Cyber-physical system security (Pillar 4)



- **Pillar Objectives**: This pillar aims at the deployment of technologies at Eversource distribution infrastructure and machine learning-based applications potentially for use within the control room to continuously monitor the state of the DERs at critical points on our grid, identify and isolate where the cyber intrusion is detected.
- **Projects Selected**: 2 funded projects

❑ Development of Reliable and Resilient Cyber Physical Distributed Energy Resources using the Smart inverter control and Reinforcement Learning Algorithms

❑ Distribution System Cyber-Physical Security RTDS Testbed with High Penetration of DERs.

Funded Projects

Workforce training, Outreach and Policy (Pillar 5)

- Five funded projects, with 11 PIs from across 7 Departments and 5 Colleges/Schools

- Assess strategies that integrate innovation for grid resilience among carbon and climate resiliency goals and public communication.
- Assess the progress in uptake of decarbonization technologies and what factors affect consumer decisions about energy consumption behavior.
- Evaluate the effect of electric vehicle charging stations and residential solar of real estate values and equity in benefits.
- Link the needs of the energy business community to the training and education institutions across the state through an informed, data-driven process
- Quantify benefits to customers from resiliency investment costs, as required for a full evaluation of the societal rate of return, net societal benefits of resiliency improvements, and their distribution.

Major Federal Awards

NSF IUCRC - WISER

Funded by NSF and industry ($3.5M) we are becoming WISER …

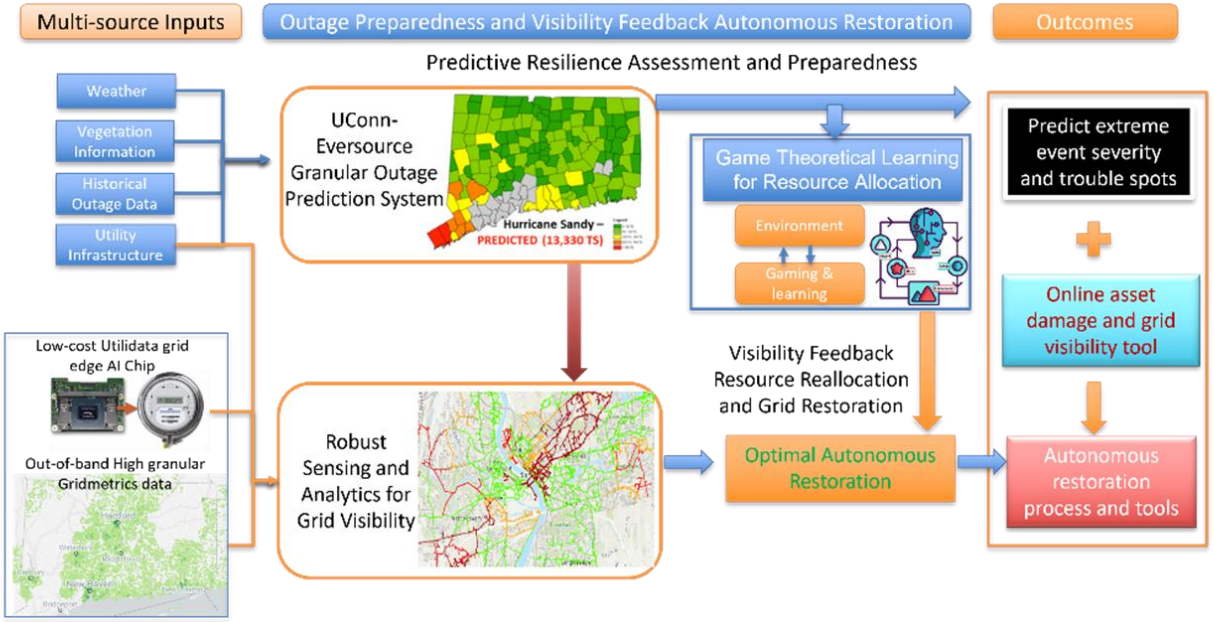
- The Center for Weather Innovation and Smart Energy and Resilience (WISER) is a partnership between UAlbany and UConn.
- WISER aims to provide state-of-the-art weather and climate information combined with leading edge industry-inspired research and development to empower and safeguard the energy industry of the future.
- With support from NSF, WISER will become a leading energy industry-academia partnership, advancing research and cutting-edge technologies to continually improve power grid efficiency and reliability in the face of a changing climate and transition to clean energy.

Major Federal Awards

DOE – PROACTIVE

Support local communities' resilience to outages with PV and DERs funded by DOE ($4.35M):

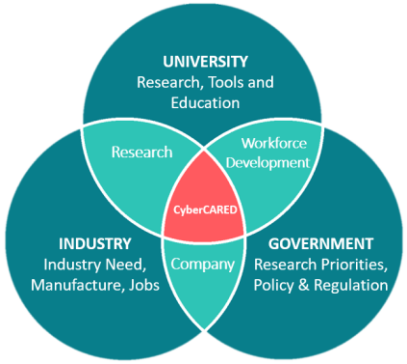
Develop and demonstrate a predictive community outage preparedness and active last mile visibility feedback autonomous restoration solution to achieve community resiliency with PVs and other distributed energy resources (DERs).



Major Federal Awards

DOE – CyberCARED: Northeast University Cybersecurity Center for Advanced and Resilient Energy Delivery

$3.6M DOE grant to develop **a network of university-based regional electric power cybersecurity center** to address **interrelated research and development challenges of cybersecurity and critical energy infrastructure.**



Education and Training

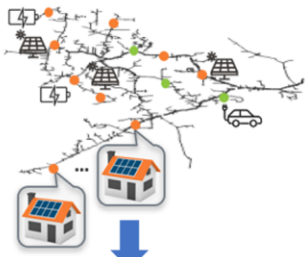
Workshop Co-Ops | Cyber Competition | New Courses

Inclusive Outreach

Gateway Community College | Quinebaug Valley Community College

Survalent. SIEMENS
etap | Connecticut Department of Energy & Environmental Protection Public Utilities Regulatory Authority
Gridmetrics | COMCAST | EVERSOURCE | AVANGRID
Hitachi Energy | IBM Research | EnerNex | GE

Emulate
Capture Real Cyber-Physical Distribution System Attack Range



RTDS

Industry Education
Educate university students and high school students, and train utility operators

Simulate
Hardware-in-the-Loop Cyber-Physical Security Co-simulator

CyberCARED

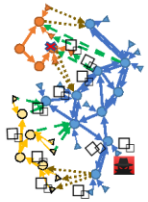
Defense Modeling
Machine Learning based, Distributed Attack Detection, Isolation and Service Restoration

Raytheon Technologies | Utilidata | The University of Vermont | HITACHI Inspire the Next | UMASS LOWELL | Argonne NATIONAL LABORATORY

Analyze
Attack Scenarios
Hygiene Scores

EnerNex | Survalent. | COMCAST | radiflow

System Graph & Attack Graphs



Cyber-Physical Hygiene Scoring

- **CCSU:** network signal authentication-based detection
- **UConn, UML**: hybrid physical-cyber information fusion for detection
- **Gridmetrics**: Edge analytics-based detection and verification
- **URI**: SDN for attack isolation
- **UVM** : Grid aware control and optimization for restoration
- **NREL and UConn**: Learning-based decentralized control

Major Federal Awards

DOE – CyberCARED: Northeast University Cybersecurity Center for Advanced and Resilient Energy Delivery

UCONN
UNIVERSITY OF CONNECTICUT

Partners

- University of Rhode Island
- University of Massachusetts, Lowell
- University of Vermont
- Central Connecticut State University
- New York University
- National Renewable Energy Lab
- RTRC
- Eversource Energy
- Gridmetrics™

CyberCARED
NORTHEAST UNIVERSITY CYBERSECURITY CENTER FOR ADVANCED AND RESILIENT ENERGY DELIVERY

Advisors

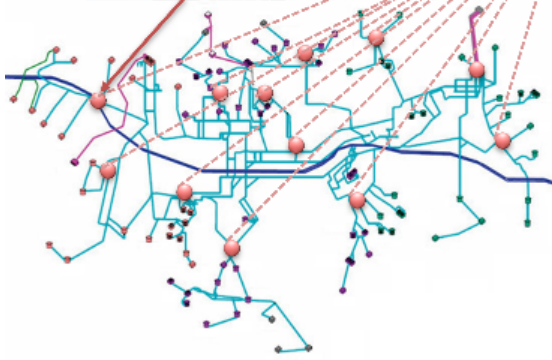
- Avangrid and PASCOAG
- Connecticut PURA
- CCAT, Inc. and IBM Research
- GE
- ETAP
- Siemens
- ANL and YASKWA
- EnerNex and Borrego
- Survalent Technology Inc
- Hitachi Energy
- V&R Energy
- radiflow and COMCAST

UCONN Eversource Energy Center EVERSOURCE

Major Federal Awards

DOE – Offshore wind power grid integration project

$3.6M DOE grant for field demonstration project to provide detailed analysis and validation for using DLR in benefiting offshore wind integration. The successful story can be shared with other utilities for national impacts given ambitious offshore wind integration plan in U.S.



System Probabilistic Risk Assessment for DLR Sensor Placement and Evaluation

- ✓ Probabilistic power flow and contingency analysis considering uncertain future load/renewable
- ✓ Extreme weather event impact analysis

DLR Data Validation and Uncertainty Quantification

- ✓ Multi-data fusion for DLR data validation and correction
- ✓ Granular wind characterization model
- ✓ Uncertainty quantification of DLR

VINEYARD WIND

800MW Vineyard offshore wind

Eversource Transmission System Field Demonstration

V&R Energy Advanced PFC

- Optimal control combination
- Line congestion mitigation
- Operational planning
- Resilience enhancement
- Protection system setting coordination

Strategizing our next steps

- **Industry**
  - Developing storm resilience assessment and outage prediction systems for regulated utilities
  - Extending climate resilience collaboration with EPRI and DoE
- **State**
  - Offshore Wind Energy R&D and workforce training – collaboration with DEEP, DECD and CWC
  - Community resilience needs (e.g. formulae grants) – support DEEP and State regulators
- **Federal**
  - DOE GRIP program: multiple demonstration and community benefit projects
  - DOE SETO, WETO, OE, CESER and clean energy demonstration programs
  - DOE ARPA-e
  - NSF Engines
  - NSF TIP program
  - ERC, and other Center or regional collaboration programs
- **Innovation**
  - Support innovation projects with start-ups
  - Commercialization of our patented technology
  - Workforce training program(s)