Annual Report 2021

EVERSOURCE
ENERGY CENTER

A Utility-University
Partnership at UCONN

ENERGY CENTER

CONTENTS

WELCOME

Dear Friends,

2021 was a milestone year for the Eversource Energy Center. Our Center increased its annual expenditures, and Eversource announced it would be extending its support for us with an additional $14 million through 2028. Over the past six years, the Center has brought the formidable potential of university and industry collaboration and expertise to bear on the great resilience challenges confronting the energy industry at the intersection of weather extremes, climate change, and clean power infrastructure. Today, it is positioned better than ever to continue and expand that work.

Located at the UConn Tech Park's Innovation Partnership Building, the Center enables Eversource and other energy industries to tap into the university's exceptional resources—its internationally recognized faculty, its outstanding students, and its state-of-the-art facilities—to innovate, develop new technologies, and establish advanced science-based solutions, while providing needed data and analytical support for effective decision making in managing the risks of extreme weather and security events. By obtaining considerable ongoing funding from the electric utilities and regional system operators, private industry, and federal sources listed on our Sponsors and Partnerships page below, the Center is meeting its goal of becoming a hub for innovation in the economical and reliable distribution of power through interdisciplinary research, teaching, and workforce development.

Among the many research projects highlighted in this year's annual report are the expansion of our outage prediction model to account for storm damage in transmission lines, the development of a new model to predict the strongest kind of storms, and the advancement of a new approach for forecasting winter storm outages. Also presented are projects that apply high technology, such as satellite data, terrestrial laser scanning, and computer models, to the challenges associated with forest management. Center researchers are investigating as well the effects of climate change on the power distribution grid and the relative benefits of enhanced tree trimming and pole replacement. And our Center continues advancing into the energy future with analyses of the integration of distributed energy resources into the electric grid, the interactions of the atmosphere and the ocean with wind turbines, and the proliferation of electric vehicles in Connecticut.

That commitment to the future extends to people, too, as we report on the progress of the first cohort of students from our Power Grid Modernization Certificate Program and on our efforts to increase student diversity at the Center. To that latter end, the Eversource Energy Center has set aside funds for a new initiative to provide direct support to underrepresented and minority students so they can conduct research on Center projects. To date, we have funded thirteen URM students in total, and we are expanding to include an additional eight in 2022.

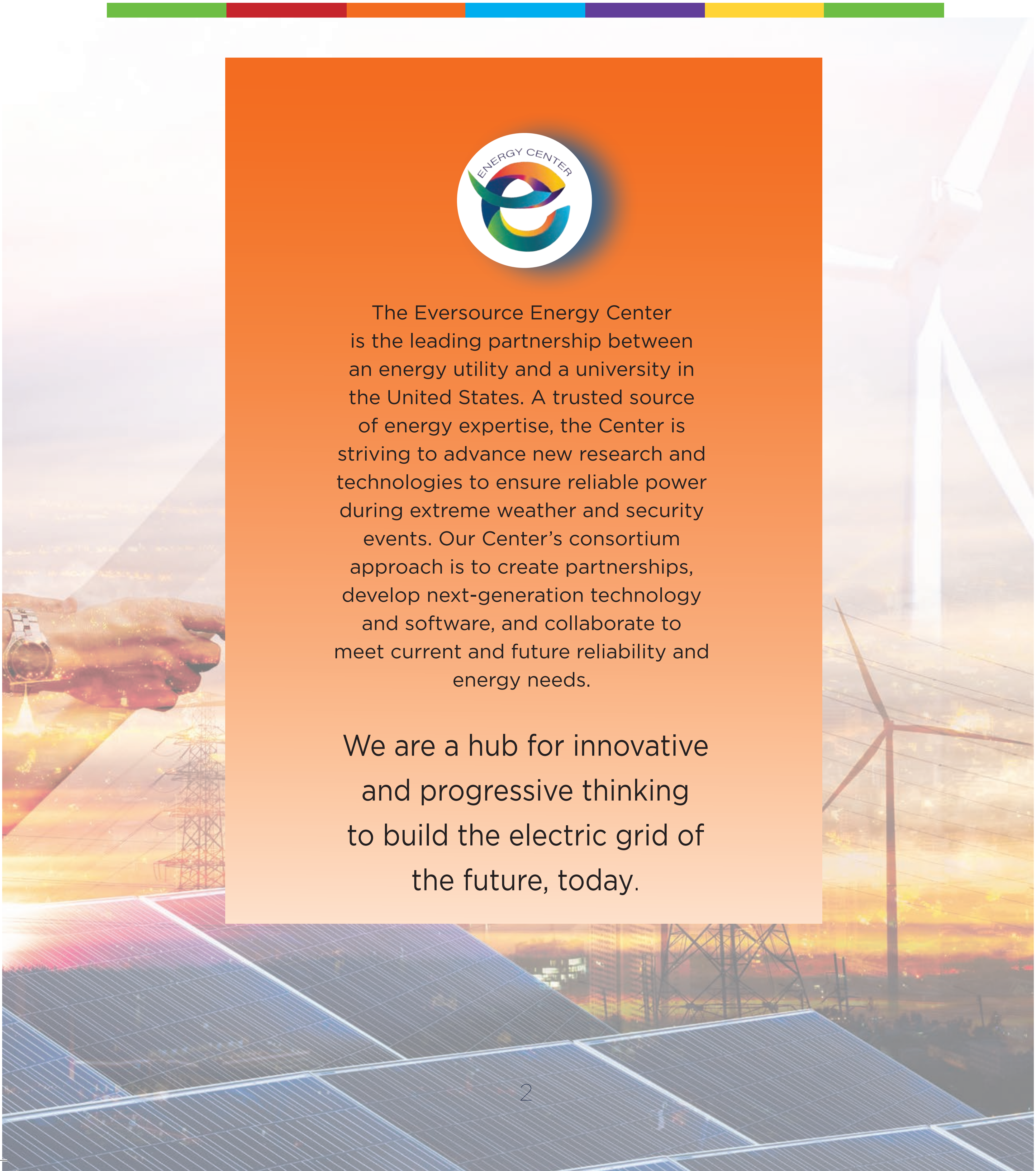
Finally, the Sponsors and Partnerships page also describes the exciting work the Center is both planning and doing in collaboration with the Electric Power Research Institute, the University of Albany, and a great many industry members to meet the challenges of climate change and to guide policymakers and the utility industry in ways to improve power grid performance.

We urge you to navigate the research summaries and other information in this report and hope you will find it both enlightening and useful. Our active collaborations with representatives of academia and industry will produce the next generation of technologies and software, leading to transformative commercial products and services and advances in storm preparedness, grid resilience, and grid modernization. These partnerships are driving innovation, and we invite you to join us in building the grid of the future, today. ■

Emmanouil Anagnostou
Director, Eversource Energy Center

September 1, 2022

WHO WE ARE



The Eversource Energy Center is the leading partnership between an energy utility and a university in the United States. A trusted source of energy expertise, the Center is striving to advance new research and technologies to ensure reliable power during extreme weather and security events. Our Center's consortium approach is to create partnerships, develop next-generation technology and software, and collaborate to meet current and future reliability and energy needs.

We are a hub for innovative and progressive thinking to build the electric grid of the future, today.

OUR TEAM

PRINCIPAL INVESTIGATORS

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Emmanouil N. Anagnostou, Board of Trustees Distinguished Professor, Eversource Energy Endowed Chair in Environmental Engineering, Director of the Eversource Energy Center

Diego Cerrai, Assistant Professor, Associate Director and Manager of the Eversource Energy Center

Marina Astitha, Assistant Professor, Weather Forecasting Team Lead

Amvrossios Bagtzoglou, Professor, Grid Resilience Team Lead

Malaquias Peña, Associate Professo, Grid Modernization Graduate Certificate and Diversity, Equity, and Inclusion Coordinator

Guiling Wang, Professor

Wei Zhang, Associate Professor

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Amir Herzberg, Professor

Fei Miao, Assistant Professor

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Yang Cao, Professor

Sung-Yeul Park, Associate Professor

Zonjie Wang, Assistant Professor

Junbo Zhao, Assistant Professor, Associate Director of the Eversource Energy Center, Grid Modernization Team Lead

DEPARTMENT OF FINANCE

Fred Carstensen, Professor, Director of the Connecticut Center for Economic Analysis

DEPARTMENT OF MECHANICAL ENGINEERING

Georgios "George" Matheou, Assistant Professor

DEPARTMENT OF NATURAL RESOURCES AND THE ENVIRONMENT

Robert Fahey, Assistant Professor, Associate Director of the Eversource Energy Center, Tree and Forest Management Team Lead

Thomas H. Meyer, Professor

Anita Morzillo, Assistant Professor

Jason Parent, Assistant Research Professor

Chandi Witharana, Assistant Professor in Residence

Thomas Worthley, Associatet Extension Professor, Forestry Specialist

Zhe Zhu, Assistant Professor

DEPARTMENT OF OPERATIONS AND INFORMATION MANAGEMENT

David Wanik, Assistant Professor in Residence

GRADUATE RESEARCH ASSISTANTS

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Armin Azad
Zhixia Ding
Brenden Edwards
Stergios Emmanouil
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William Hughes
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Mariam Khanam
Rehenuma Lazin
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Xiaolong Ma
Panagiotis Mitsopoulos
Mahjabeen Fatema Mitu
Kasra Motlaghzadeh
Sardorbek Musayev
Sita Nyame
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Francesco Rouhana
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Aaron Spaulding
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Department of Mechanical Engineering

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Department of Natural Resources and the Environment

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Nancy Marek
Kerste Milik
Kexin Song
Danielle Tanzer

Department of Statistics

Jieying Jiao

Department of Agricultural and Resource Economics

Donghoon Kim

Postdocs

Brian Maitner
Marika Koukoula
Quing Yang

CENTER RESEARCH STAFF

Fagni Lei, Assistant Research Professor

Cory Merow, Assistant Research Professor, jointly with Department of Ecology and Evolutionary Biology

Ha Nguyen, Assistant Research Professor, jointly with Department of Electrical and Computer Engineering

Xinyi Shen, Assistant Research Professor, jointly with Department of Civil and Environmental Engineering

Giulia Sofia, Assistant Research Professor, jointly with Department of Civil and Environmental Engineering

Xinxuan Zhang, Assistant Research Professor, jointly with Department of Civil and Environmental Engineering

CENTER STAFF

Ronny Heredia, Financial Assistant for Eversource Energy Center

Claudia Dijmarescu, Student Assistant

COLLABORATORS

Zoi Dokou, Assistant Professor, California State University, Sacramento

Baptiste François, Research Assistant Professor, University of Massachusetts Amherst

Marcello Graziano, Associate Professor, Southern Connecticut State University

Peter Gunther, Senior Research Fellow, Connecticut Center for Economic Analysis

George Kallos, Professor, University of Athens

Jordan Kern, Assistant Professor, North Carolina State University

Andreas Langousis, Assistant Professor, University of Patras

Efthymios Nikolopoulos, Assistant Professor, Florida Institute of Technology

Melkior Ornik, Assistant Professor, University of Illinois Urbana-Champaign

Raymond V. Petniunas, Member, Academy of Distinguished Engineers

Peng Zhang, Associate Professor, Stony Brook University

MILESTONES 2021

Our Center originated from a partnership between Eversource Energy and the University of Connecticut, with the purpose of enhancing electric utility preparedness, hardening infrastructure, and embracing the grid of the future: intelligent, interactive, automated, reliable, and safe!

The Center comprises experts at universities, state organizations, and the electric utility industry, collaborating within the framework of a Center of Excellence. Marshaling the expertise of these various stakeholders through an integrated analytical approach enables us to advance forecasting tools, proactively manage risk landscape, and embrace new technologies, yielding strategies and actions to manage severe weather hazards. Importantly, research at the Center features a dynamic vision: it accounts for climate evolution, as well as the changes in exposure and vulnerability to extreme weather events produced by different societal activities and demographics.

Key Initiatives

Among the Center's key initiatives in 2021 were the launching of numerous research projects, the continuation of the projects started in 2020, and the successful engagement of female and underrepresented minority undergraduate students in peer-reviewed research.

Research Projects

In 2021, there were 22 active projects in six thematic areas:

- Outage Prediction Modeling and Emergency Response
- Resilience System Modeling and Economic Effects
- Vegetation Management, Outreach, and Forest Science
- Renewable Energy and Grid Integration
- Cyber and Physical Security
- Offshore Wind Energy

Undergraduate Student Research

In 2021, the Center started an undergraduate research initiative focused exclusively on underrepresented minority students. It engaged eight undergraduate students in research aligned with the abovementioned six thematic areas. Their efforts met with great success, with all the projects producing papers submitted to and published or accepted for publication by high-profile peer-reviewed journals.

Our Sponsors

EVERSOURCE

AVANGRID

Electric Power Research Institute (EPRI)

Housatonic Valley Association

Independent System Operator of New England (ISO-NE)

National Aeronautics and Space Administration (NASA)

National Meteorological Center, Kingdom of Saudi Arabia

National Science Foundation (NSF)

New York State Energy Research and Development Authority (NYSERDA)

Strategic Partnerships

The Center is continuing its collaboration with Bay State Wind Energy, Aquarion Water Company of Connecticut, the Electric Power Research Institute, and the University of Albany Atmospheric Research Center, in the areas of offshore wind resource characterization, water conservation, grid vulnerability and the establishment of a new Industry-University Cooperative Research Center (IUCRC) focusing on Weather Innovation and Smart Energy and Resilience (WISER).

Aquarion

Aquarion Water Company of Connecticut, a subsidiary of Eversource, is the public water supply company for approximately 198,000 customer accounts, covering more than 625,000 people in 52 cities and towns throughout Connecticut's Fairfield, New Haven, Hartford, Litchfield, Middlesex, and New London Counties. It is the largest investor-owned water utility in New England and among the seven largest in the United States.

In September 2019, the Center and Aquarion began their partnership with a research project that aims to make available to water providers a mechanism for encouraging homeowners to reduce turf watering voluntarily.

Bay State Wind Energy
Bay State Wind Energy has brought together Eversource and Ørsted, builder of the first and largest offshore wind farms in the world. The new partnership combines Ørsted's preeminent offshore wind development capability with Eversource's predominant presence in the Northeast, its industry-leading financial strength, and its expertise in regional transmission development. In 2019, the Center signed a sponsor research agreement to expand its activities beyond Eversource CT. This agreement approved support for an integrated research project that aims to enhance environmental monitoring and modeling capabilities for offshore wind energy generation.

Electric Power Research Institute
The Electric Power Research Institute (EPRI) is an independent, nonprofit organization for public interest that conducts research on electricity generation, delivery, and use in collaboration with the electricity sector, its stakeholders, and others focusing on electric power safety, reliability, affordability, and the nexus between electric power and the environment. In 2020, the Center established a research collaboration with EPRI to provide complete and accurate information on the vulnerability of the electric grid to weather extremes and assess trends in power outages and efforts needed to maintain reliable energy delivery. In 2021, we demonstrated our methodology over the northeastern United States, where our team has many years of outage and electric infrastructure data from Eversource Energy and the United Illuminating Company. In 2022, we are working for extending this effort nationwide.

University of Albany Atmospheric Sciences Research Center
The Atmospheric Sciences Research Center (ASRC), of the State University of New York at Albany, was established on February 16, 1961, by the Board of Trustees of the State University of New York as a SUNY systemwide resource for developing and administering programs in basic and applied sciences related to the atmospheric environment. In 2020, ASRC and the Center submitted a planning grant proposal to the National Science Foundation for the formation of an Industry-University Cooperative Research Center (IUCRC) for Weather Innovation and Smart Energy and Resilience (WISER, https://wiser-iucrc.com/home.html) that will provide state-of-the-art weather and climate information, combined with leading-edge, industry-inspired research and development, to ensure reliable and resilient energy in the 21st century. The planning grant was awarded, and several planning activities focused on the engagement of industry partners took place in 2021, culminating in the submission of the Center full proposal in Spring 2022. ■

CENTER BY THE NUMBERS

Publications and Patents 2016-2021

Peer-reviewed 90
Patents 3

Expenditures

2016 $998,059
2017 $2,158,683
2018 $2,423,839
2019 $2,454,938
2020 $2,156,234
2021 $2,366,012

Awarded Amounts Total 2016-2021

$21,145,521

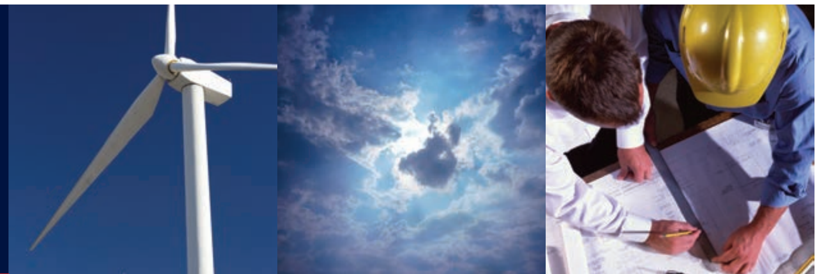
Pending

Proposals pending $15 million

Students

Undergraduates 10
Graduates 40
Postdocs 3
Alumni 51

UCONN



Preparing for the Grid of the Future

The Power Grid Modernization Certificate Program at the University of Connecticut

The modernization initiative to create the power grid of the future is one of the largest investments and most consequential infrastructure projects in the United States. It needs an engineering workforce with the interdisciplinary skills to do the job.

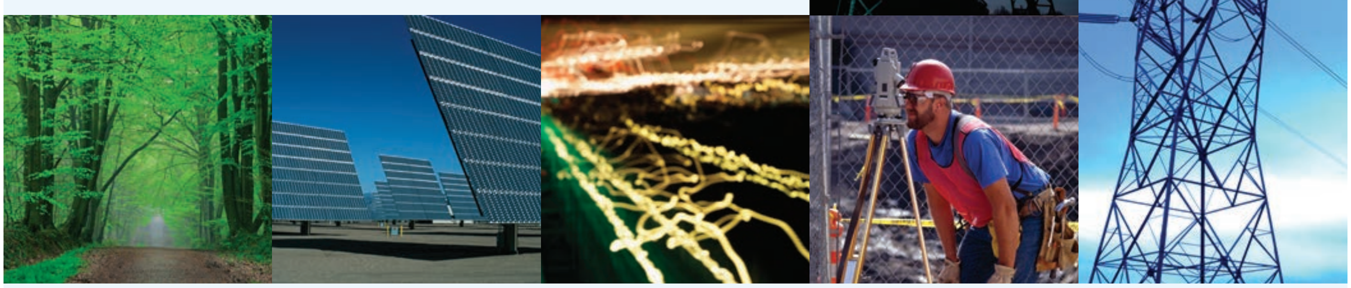
At UConn's Eversource Energy Center, utility engineers can gain these skills in a four-course, fully online program that will prepare them for the new technologies and the challenges of managing an increasingly complex electric grid. The graduate-level engineering certificate conferred upon completion is accredited by the University of Connecticut[WHO?] and can be applied toward a Master of Engineering degree.

EXPAND YOUR HORIZONS. ADVANCE YOUR CAREER.

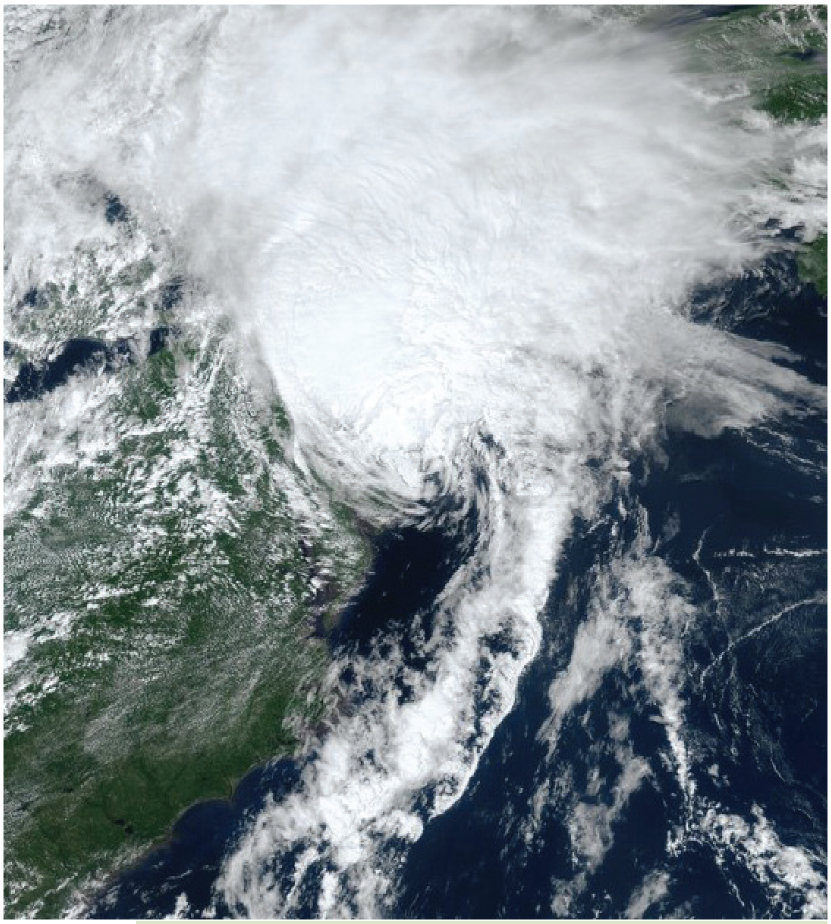
Join the modernization effort to bring about a more resilient, secure, sustainable, and reliable power grid by applying for UConn's Power Grid Modernization Certificate Program today.

FOR MORE INFORMATION, VISIT

https://engineeringcertificates.uconn.edu/power-grid-modernization/



In preparation for the more frequent and more severe power outages brought on by climate change, accurate prediction—of both weather events and their effects on utility infrastructure—is paramount. Researchers at the Eversource Energy Center are pursuing this goal from many angles.



Tropical storm Isaias over Connecticut.

PHOTO: Geostationary Operational Environmental Satellite (GOES), NOAA.

Advancing the OPM

Improved Prediction for Extreme Outage Events

Because they are so rare, the prediction of extreme events is especially difficult with data-driven methods like machine learning, and doing it with accuracy has always been a challenge for the UConn Outage Prediction Model (OPM). In 2021, we sought to address this challenge with the development and release of an OPM module specially designed to predict the impacts of the strongest storms: hurricanes, nor'easters, and bomb cyclones. The new module represents a significant advance in the Center's ability to support utility operations and help reduce the disruption these storms bring to people's daily lives.

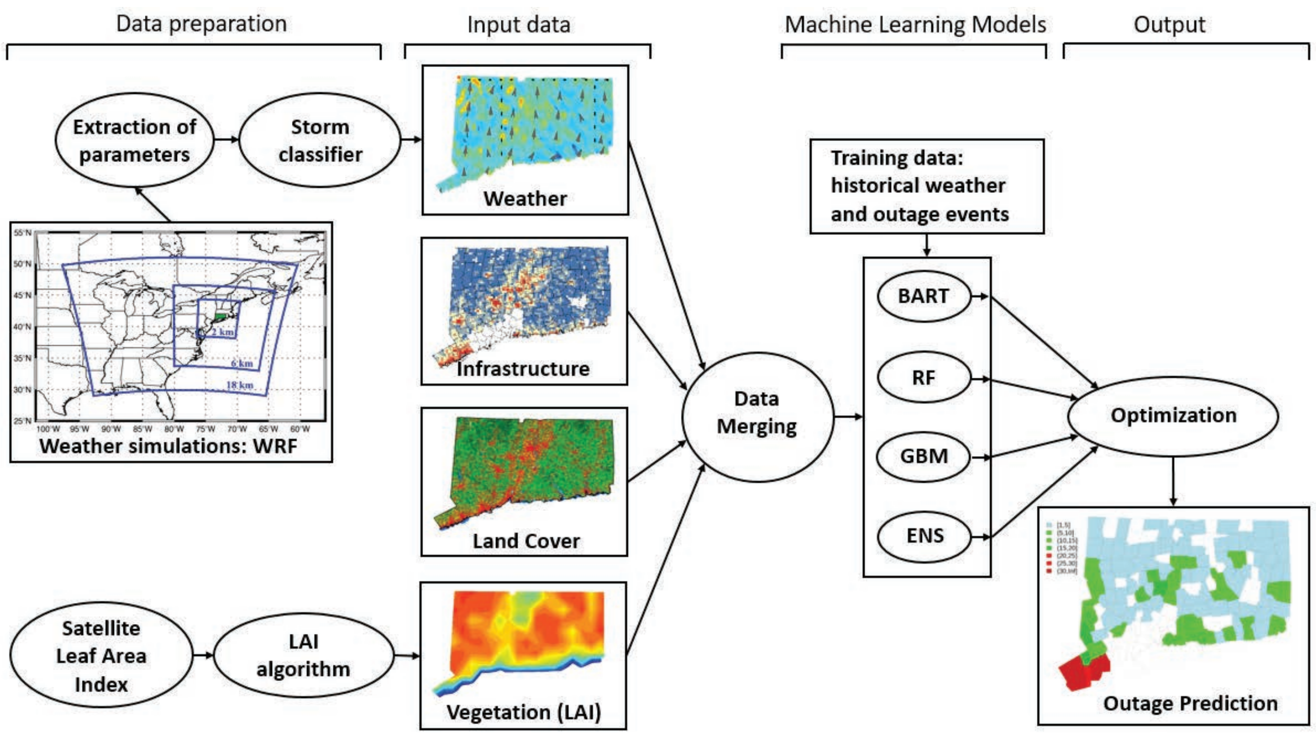
By using more data from weather simulations and applying statistical transformations, we have greatly improved how the machine-learning algorithms can learn the dynamics associated with high-impact storms. This has resulted in a system that is particularly good for operational predictions of extreme events—that is, weather forecasting that supports decision making related to preparing for or responding to such events—because it neither overestimates moderate events nor underestimates the extremes. In other words, our system accurately quantifies the impacts of events like Hurricane Sandy and tropical storm Isaias without overestimating weaker storms like Hurricane Henri. With this system now in service, we can have a great deal of confidence in the outage predictions we issue for the most important storms affecting New England. ■

Machine learning is a branch of artificial intelligence (AI). It involves developing algorithms that allow computers to identify and learn from patterns in sample (training) data, based on which they can make predictions whose accuracy increases as they learn.

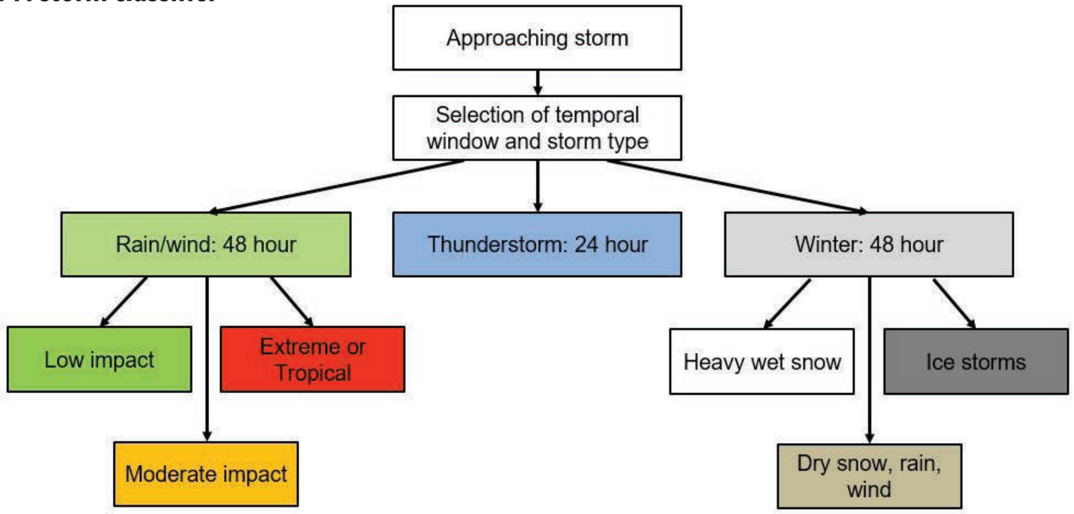
The University of Connecticut Outage Prediction Model

The OPM is a statistical framework developed by researchers at the Eversource Energy Center that integrates weather predictions with infrastructure, land cover and vegetation characteristics, and historical power outage data to predict, through the use of machine learning models, the number and locations of storm power outages across utility service territories in the northeastern United States. Predictive modules of the OPM—some of which are discussed in this report—are developed separately for different types of storms.

OPM architecture



OPM storm classifier



Failure Risk Prediction for Transmission Lines

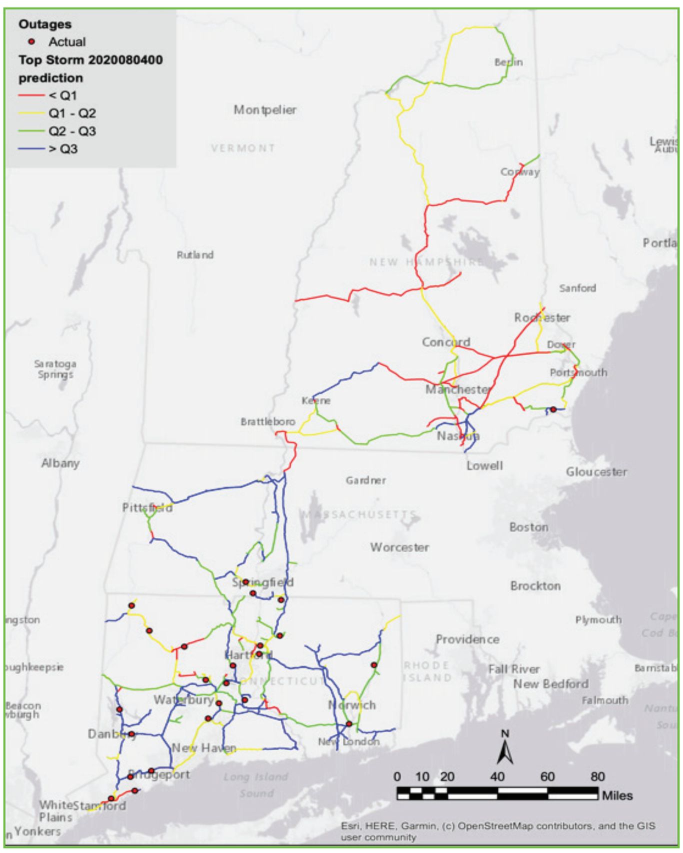
Researchers at the Eversource Energy Center made significant progress in 2021 in their development of a transmission system damage prediction model, or Transmission DPM. The model, inspired by the UConn Outage Prediction Model (OPM), determines the probability of transmission line failure in advance of storm events. Understanding the risk of outages in the transmission network is important because, although the vast majority of those caused by strong winds and heavy precipitation occur on the electric distribution system, those in transmission networks tend to have the greatest impact. Our project has so far unfolded along two parallel lines of research. In the first, we use machine learning to determine the probability for each transmission line to fail during a given storm. The second involves improving predictions in cases of extreme storms for which we have limited historical data by developing fragility curves that express the probability of structural damage as a function of the infrastructure and weather conditions.

The machine-learning model takes as inputs data on weather, climate, vegetation, physical environment (for example, elevation and land cover), and infrastructure (such as information on pole type and age) and outputs an outage probability for each transmission line. The current model, which covers the Eversource territory in Connecticut, New Hampshire, and western Massachusetts, has produced results that are 29.3 percent more accurate in ranking the lines most at risk than a baseline model that sorts the risk by the wind speed, precipitation, and vegetation around each line. Future work will include the creation of new variables and the use of more advanced machine-learning techniques to improve the accuracy of the Transmission DPM and will expand the model to eastern Massachusetts.

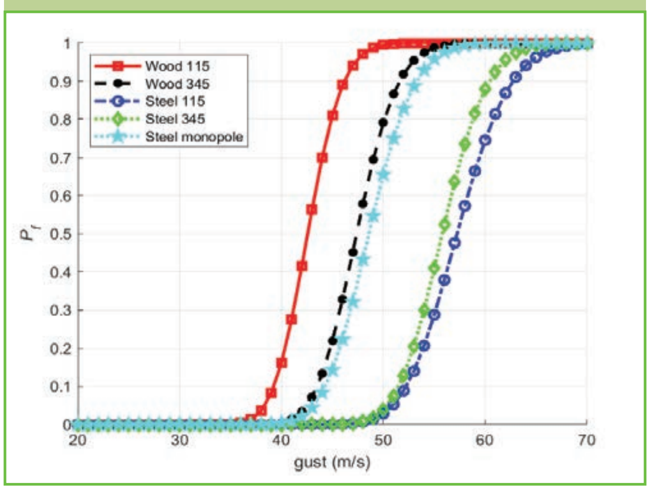
The fragility curves are developed from physics-based modeling of wind and ice loadings on structures and conductors. We consider various structure types, such as H-frame and monopole, and materials, such as wood and steel, alongside age-related strength degradation to predict the probability of structural damage, which for pole structures is defined when the groundline stress exceeds the material strength. To take into account the many different structural designs in the transmission system, we conduct sensitivity analyses to get fragility curves for various design parameters, span lengths, wind speeds and angles, and ages.

Ultimately, we will implement the fragility curves in the machine-learning model to improve further its accuracy in predicting risk scores for transmission lines. The outcomes from this research will help utilities take both preventive measures in terms of resilience hardening and reactive measures in terms of knowing where to station crews when large storm systems are forecast. By combining our work on transmission outage risk with existing modules of the OPM for the distribution network, we will also provide a better understanding of comprehensive power grid risk from storms—information useful to decision makers considering future improvements to storm resiliency.

A **fragility curve** is the statistical expression in graphic form of the probability that a given structure will fail under a given type and amount of stress.



Sample risk score predictions for one of the top storms.

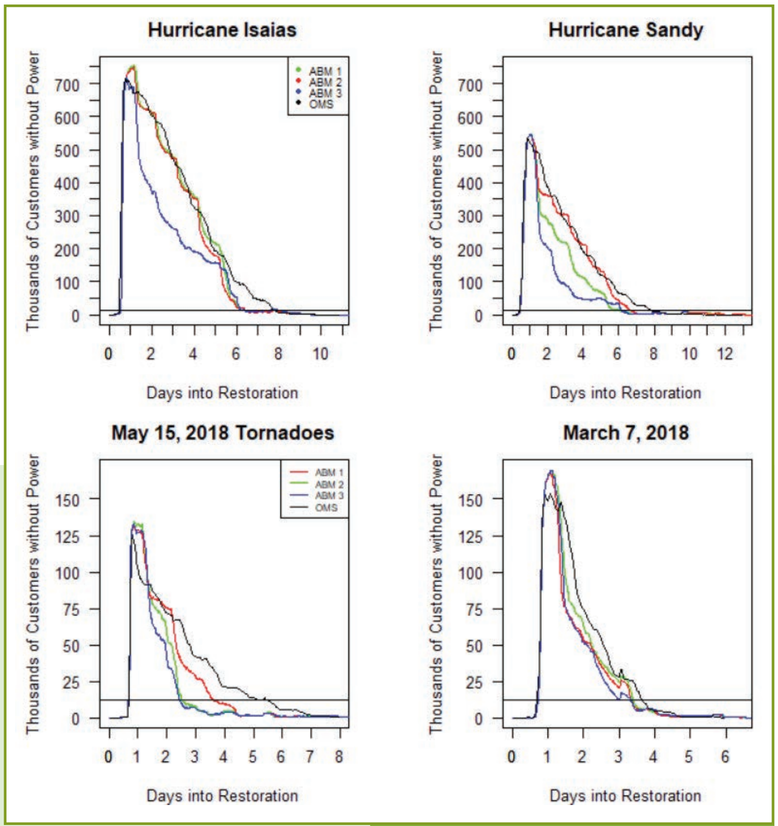


Sample fragility curves for various structure types.

Every Minute Counts

Advances in Agent-Based Modeling for Fast Restoration

Power restoration following a storm is a complex problem with many different variables that work together to affect the time needed to get the lights back on, including the severity of the storm, the number of outages, the extent of the damage for each individual outage, how long each repair takes, the number of crews working, their locations, and the speed with which they can move between outages. Researchers at the Eversource Energy Center have been developing a computer model using agent-based modeling techniques to describe the behavior of the utility crews and estimate the overall restoration time for high-impact storms. In the past year, this project has advanced from creating and validating an agent-based model (ABM) for power outage restoration to combining the ABM with results from the UConn Outage Prediction Model (OPM).



EEC researchers validated the current ABM and tested new applications using historical data from four high-impact storms. The colored lines in the graphs show the duration of restorations under various conditions tested with the ABM as compared to the actual duration of the past restorations, indicated by the black line (OMS). The green line shows the ABM validation result using historical resource crew counts and allocations (ABM1). The red line shows the results produced by the ABM based on keeping the resources the same as the historical counts but using the outage prediction model to redistribute crews to areas with more severe damage (ABM2). The blue line shows the results from using the crew redistributions from ABM2 but increasing the overall crew counts to try to achieve restoration in 96 hours (ABM3). Each step in the experiment highlighted a new layer the ABM can add to restoration preparation.

Recent updates include using the outage prediction results to inform the ABM and assigning crews to specific work centers to make the ABM better reflect actual restoration practices. This stage of the project has involved using historical restoration data to validate the ABM against past storms—that is, to confirm that the model would generate restoration times similar to what actually happened. We then changed the crew allocations based on the damage predicted by the OPM. Finally, we ran the model a third time with increasing crew counts, with the goal of achieving a restoration time of 96 hours.

Through this experiment, we showed how the ABM can be used to replicate the restoration outcomes of past storms based on known resources, estimate restoration times by reallocating those resources, and determine the number of resources needed to reach a desired outcome. As storms continue to become more intense and widespread, the ABM will provide emergency managers with a powerful tool whose range of applications can help them determine the resources necessary to prepare for and respond to the damage.

Agent-based modeling is a computational technique that simulates human decisions while also representing technical conditions. The ABM under development at the Eversource Energy Center provides a virtual environment where utility managers can test their restoration decisions before implementing them. The model can also be used in real time to provide an estimate of the time to restoration, given available resources.

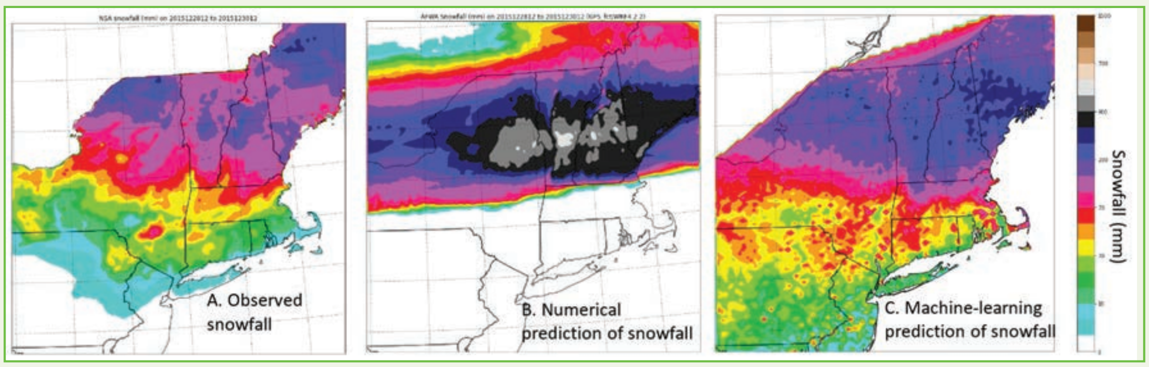
A New Approach to Forecasting Snowfall

The dense forested area that surrounds power lines and essential infrastructure in the northeastern United States, and the state of Connecticut in particular, makes the prediction of snowfall during winter storms very important for this region. In addition to enabling effective disaster preparedness and support, their forecasting is crucial to selecting the appropriate module of the UConn Outage Prediction Model (OPM) to use when a winter storm threatens.

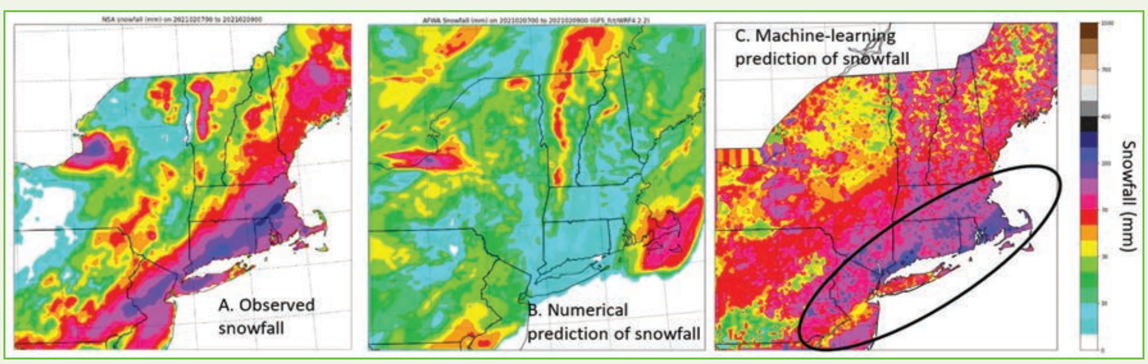
The traditional approach to predicting snowfall amounts is to use numerical weather prediction (NWP) models. These present challenges, as inadequacies in their microphysical schemes might cause them to under- or overestimate the severity of snowstorms. At the Eversource Energy Center, researchers are working to assess an alternative and innovative methodology for predicting snowfall by integrating simulations from an NWP model with snowfall observations and machine-learning algorithms, while continuing to enhance the capabilities of the OPM to forecast distribution network outages from winter storms.

During the first four months of the project, the researchers collected snowfall observations and weather prediction model outputs and developed the first version of the new modeling framework based on machine learning, with promising preliminary results. For a New England snowstorm in December 2015, the machine-learning model demonstrated its capability to capture the pattern shown in the observations, substantially improving on the prediction made by the numerical model. For the February 2021 Nor'easter, the numerical model underpredicted the snowfall, especially with respect to the band of snow shown in the observations. The machine-learning model was able to correct the snow band in Southern New England, and it has predicted snowfall with good granularity everywhere else.

The next steps of the project include adding more snowstorms to the training of the machine-learning model to enhance its capability to identify snowfall patterns across the domain; assessing and revising atmospheric variables that act as predictors for the machine-learning algorithm; and testing new machine-learning algorithms. Our continuing progress in building the accuracy and scope of the model will make it increasingly useful to electric utilities striving to prepare for and respond to the effects of winter storms.■



December 28–30, 2015, snowstorm in the Northeast. The map in (A) shows the actual observed accumulated snowfall. The map in (B) indicates that the NWP model missed snowfall in Connecticut, Rhode Island, and Massachusetts and overpredicted it in New Hampshire, Vermont, Maine, and northern New York. The map in (C) presents the substantially more accurate prediction produced by our new methodology, which uses machine learning to integrate observations with numerical prediction.



February 7–9, 2021, Nor'easter. The map in (B) shows the underprediction of snowfall by the numerical model, especially with regard to the band of snow shown in the observations in (A). As (C) indicates, the machine-learning model was able to capture the snow band.

Tree trimming helps prevent power outages by removing branches near power lines, but it doesn't reduce the risk from diseased or weakened trees. In the Eversource Energy Center's Stormwise program, researchers are developing strategies for vegetation management to improve the health of roadside forests.

PHOTO: Bryan Futom

Tropical storm Isaias leaves behind downed trees at Union Street in Manchester, Connecticut.

The NAFRI project

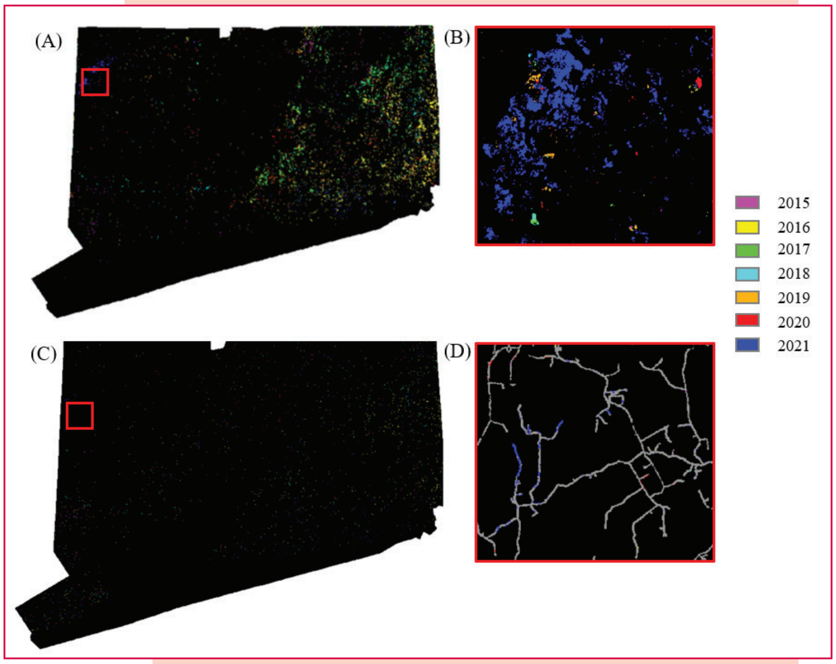
Near-Real-Time Assessment of Forest Risk to Infrastructure

Disturbances such as insects, drought, and disease greatly affect the health of forests. In 2016–18, for instance, gypsy moth outbreaks resulted in damage to more than 4,000 square kilometers of forest in New England. Unhealthy trees pose big risks to electric infrastructure, as they are more likely to fall during storms and cause widespread outages. The identification of stressed trees along roads could minimize costly damage from future storms and help maintain system reliability.

The goal of the Near-Real-Time Assessment of Forest Risk to Infrastructure (NAFRI) is to reduce weather-related power outages by helping Eversource manage roadside and right-of-way (ROW) forests to increase their storm resistance.

Using NASA's Harmonized Landsat and Sentinel-2 (HLS) satellite time series, NAFRI researchers are monitoring and assessing the health of trees in Connecticut and creating high-resolution forest disturbance maps of the state. By masking out non-roadside areas on the maps, we can enable the early identification of forest disturbances, such as gypsy moth infestations, near electric utilities, allowing utility companies to conduct preventive tree trimming at specific locations before the next storm season.

To date, the research team has produced statewide forest disturbance maps for the period 2015 to 2021 and has estimated the time, location, and intensity of disturbance events occurring during these years. Based on our preliminary findings, we will next classify the causes of roadside forest disturbances as a means for predicting vegetation risk in the future.■



The first high-resolution statewide forest disturbance map produced by NAFRI. In the map view in (A), black represents stable surface, and the other colors represent forest disturbances by year, as specified by the color key. A magnification of the area in the red box in (A) is shown in (B), with blue indicating the area of gypsy moth infestation in Litchfield, Connecticut, in summer 2021. In (C), non-roadside area is masked out to obtain a map of forest disturbances near electric utilities. The area in the red box in (C) is magnified in (D), which, again, shows the gypsy moth damage in Litchfield. Grey denotes stable roadside forest, black means the area is out of the region of interest, and blue and red represent forest disturbances in 2021 and 2020, respectively.

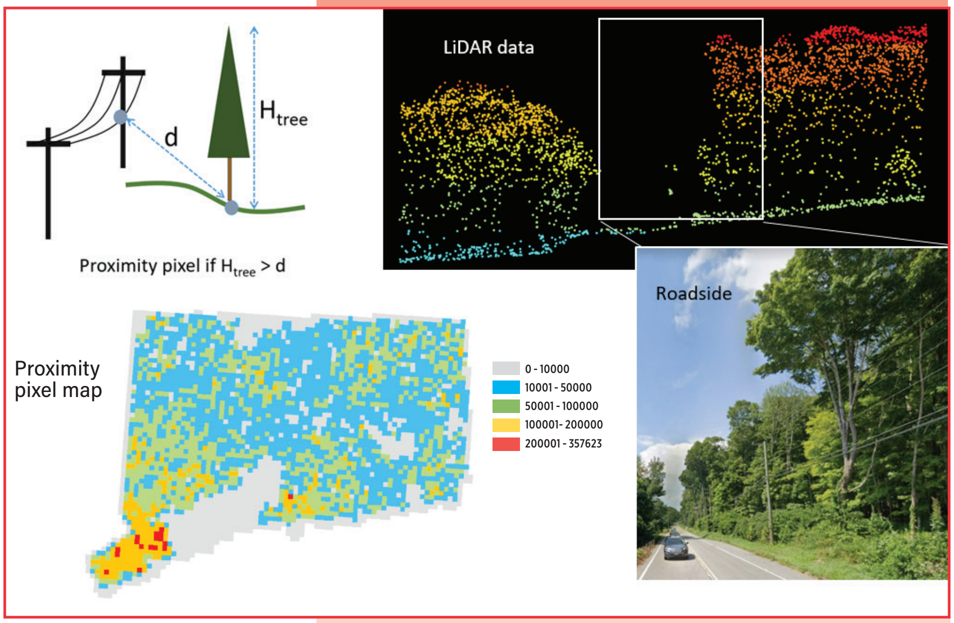
Geospatial Modeling of Roadside Vegetation Risk

Using Aircraft, Dashcams, and Algorithms to Monitor Forest Structure

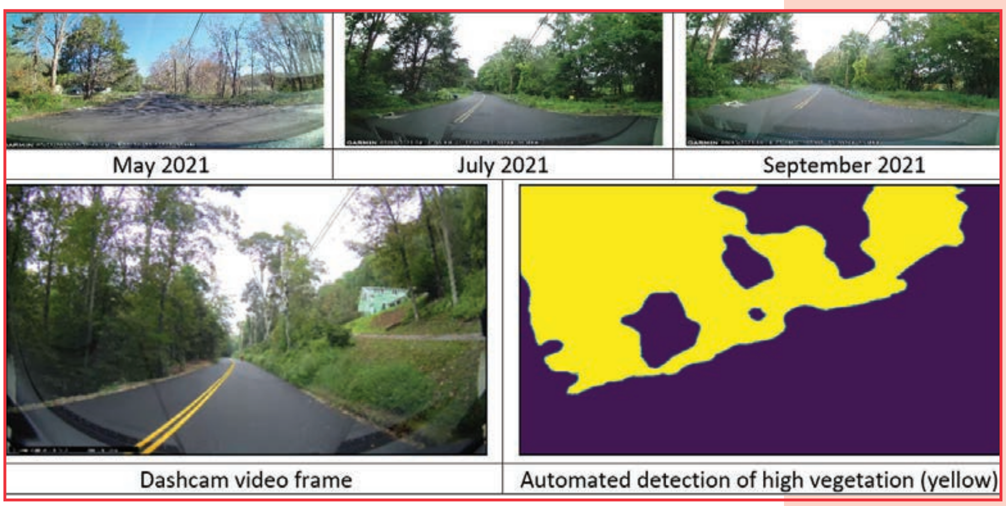
The two key determinants of the risk to powerlines from roadside forest are the physical structure of the trees and the state of their health. As the Neal-Real-Time Assessment of Forest Risk to Infrastructure (NAFRI) project develops disturbance maps to assess forest health based on time series satellite data, another team of researchers at the Eversource Energy Center is using a variety of remote-sensing technologies in the development of several key products that model, monitor, and assess forest structure:

- With publicly available data acquired by Light Detection and Ranging (LiDAR) sensors flown by manned aircraft, we have generated a 3D tree canopy height model (CHM) for the entire state of Connecticut. Proximity pixel maps based on CHM show the trees that are in striking distance of powerlines during storms.
- By combining LiDAR-based CHM with aerial optical imagery, we are delineating individual tree canopies, providing information on tree canopy diameter that is useful in modeling the physical structure of the roadside forest. We are also employing artificial intelligence (AI) algorithms to conduct an automated analysis of multiyear aerial imagery to identify defoliated and/or dead tree canopies along powerlines.
- Using dashcam video analysis, along with AI algorithms, we are identifying and localizing dead trees and modeling structural forest parameters, such as stem density.

LiDar (Light Detection and Ranging) is a remote-sensing technology that determines distances by targeting an object or a surface with a laser and measuring the time for the reflected light to return to the receiver.



"Proximity pixels" are identified where the height of trees is greater than their distance from powerlines and can be mapped along roads where powerlines are located using LiDAR. Modeling can be applied to the entire state to generate a proximity pixel map.



Seasonally acquired dashcam video is used in the identification of different tree types, as well as "leaf-off" conditions, and to enable the estimation of different forest variables, such as stem density. The videoframes in the top row are taken from a dashboard camera that was deployed in Connecticut across spring, summer, and fall. In the bottom row, video streams acquired by a dashboard camera are used for the automated detection of roadside vegetation.

- Through geospatial modeling, we are learning how roadside forest risk is affected by tree-related characteristics, like height and canopy cover, as well as environmental variables, including soil, nutrients, terrain, and slope, among others.

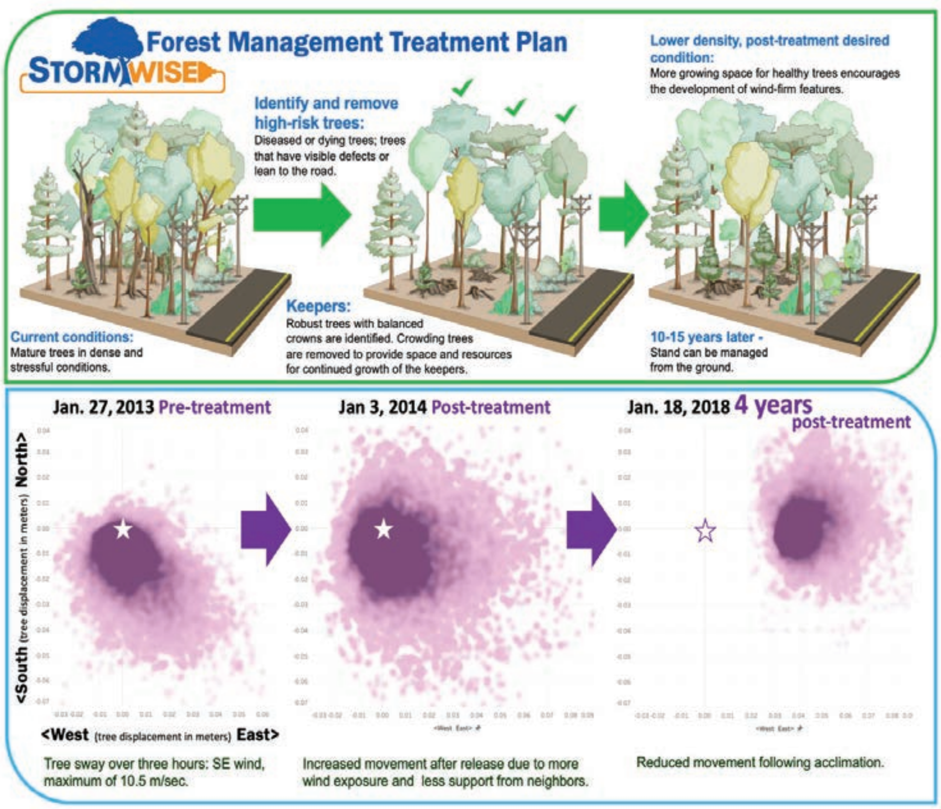
Taken together, our findings will help utility companies reduce the vulnerability of the electric grid to windstorm events by enabling them to target more effectively the locations in greatest need of vegetation management and other resilience programs, to implement the most effective resilience strategies for given locations, and to justify mitigation strategies to regulatory agencies and the public. ■

Protecting Both the Power Lines and the Trees

Power companies commonly trim trees to mitigate the risk to the electric grid posed by our valuable and beloved roadside forests. In events like Hurricane Irene and the Nor'easter in the fall of 2011, however, many trees that fell on powerlines were twenty feet or more off the road—well beyond the trimming zone. To develop management practices that protect both trees and power infrastructure by addressing the whole roadside forest, the Eversource Energy Center has formed a collaboration between its Stormwise researchers, who are tracking the biomechanical properties of roadside trees, and foresters and arborists, with their vast knowledge about growing and maintaining trees. Together, we are producing practical recommendations for roadside forest management that will improve the resiliency of our power grid in extreme weather.

Implementation of the forest management practices developed through this joint effort began in 2012. Trees in three roadside sites were outfitted with tilt sensors to track changes in their movement over time, as the trees were removed and the remnant ones acclimated to the new conditions. Nearby meteorological towers tracked wind conditions. The idea was that information gathered about the shapes of the trees—the most important factor determining how they sway in the wind—coupled with careful inventorying along roadsides would help improve predictions of severe power outages. Almost ten years after data collection began, this study is showing how we can affect forest resiliency through forestry practices.

A second study is now underway to learn more about the biomechanics of tree trimming by better characterizing the structure of roadside stands and looking at the impacts of common trimming practices on tree structure and movement. For this effort, we are modeling the trees by combining sway measurements with data gathered by unmanned aerial vehicles equipped with LiDAR sensors and by terrestrial laser scanning. Using readily accessible microcontrollers and open-source software, we are developing new tilt sensors we can deploy in many new roadside locations to examine the structural components of roadside trees, including crown area, crown density, and crown asymmetry. With this information, utilities will be better able to evaluate the need for trimming to protect powerlines from storms. ■



As climate change advances, power outages from weather-related events are both proliferating and getting worse. With the new importance of electricity for mobility and remote work, this growing vulnerability has made "hardening" the grid an especially urgent objective for Eversource Energy Center researchers.

Return period is a statistical measurement that represents the estimated interval between the recurrence of a particular type of event—such as storms or power outages—based on historical data. Although the return period may be expressed as once-in-so-many-years, such as a 100-year flood (or, in the case of power outages, as once-in-so-many-outages), the calculation is only an average; the event may actually occur at any time.

Grid Vulnerability to Climate Change

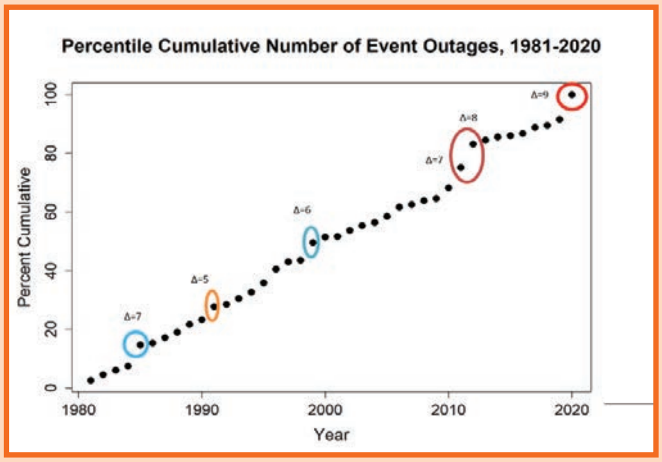
With the progression of climate change, power outages from severe weather-related events are continually increasing in number and regularity. Understanding the effects of weather extremes on the electric grid under current and future climate conditions is essential for quantifying trends of weather-related outages and justifying investment to maintain or improve the reliability of the power system. Using machine-learning algorithms to predict outages caused by severe weather events based on a global, 40-year atmospheric reanalysis dataset, researchers at the Eversource Energy Center have worked in the past year to show how climate change may be affecting the vulnerability of the power grid to storms.

To identify weather-related outage events and quantify the associated outages, we classified into two categories the severity of such events occurring between 1981 and 2020, based on wind speed and wind gust. High-impact events were those leading to system outages comprising more than 500 trouble spots, and extreme-severity events produced more than 2,000 trouble spots. We then developed a high-impact and extreme-severity module of the UConn Outage Prediction Model (OPM) to predict the number of outages for the classified events. Tests of the module for the Eversource-Connecticut power grid for the years covered demonstrated high accuracy in both classification and prediction. The results showed that hurricane years had the highest annual total outages.

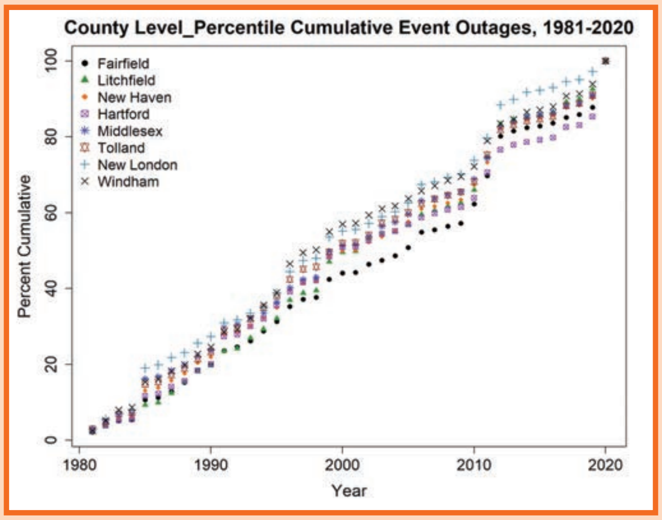
"Trouble spot" refers to a system outage, caused by physical damage to the electric network—for example, damage to a power line from a fallen tree branch. Each trouble spot can cause multiple customer outages, meaning that, for instance, fifty different customers may be affected by just one branch falling over a line.

We also examined the return levels of event outages (that is, how many outages on average occur once every certain period) and the return periods of outage events (how often the event occurs once every certain number of outages) for Eversource-Connecticut. The percentile cumulative numbers of event outages at both the state and county levels indicated an intensification of events with high return periods—that is, extreme events—in the past decade, possibly indicating an intensification of climate impacts on the vulnerability of the power grid. The return levels of event outages found for periods of 1, 2, 5, 10, 20, 50, and 100 years, respectively, were approximately 600, 2,500, 5,600, 8,700, 13,000, 21,000, and 30,000 outages; the return periods of six identified hurricanes (Gloria, Bob, Irene, Sandy, Floyd, and Isaias) were 12, 16, 30, 32, 41, and 52 years. In yet another investigation spanning up to 100 years of return periods for eight counties served by Eversource-Connecticut (Fairfield, Litchfield, New Haven, Hartford, Middlesex, Tolland, New London, and Windham), we found that Fairfield and New London showed higher return periods of event outages than the others.

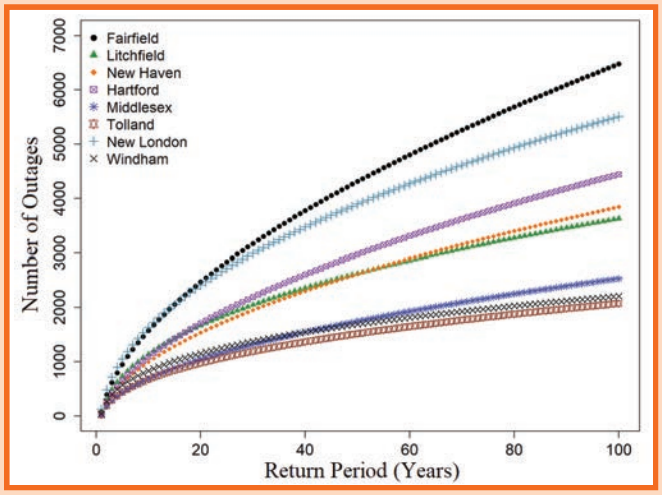
As the frequency and intensity of extreme weather and climate events are expected to rise, such an understanding of these impacts on power grid vulnerability is crucial to long-term planning.



Cumulative outages for Eversource-Connecticut at the state level from 1981 to 2020. The highlighted delta percentiles in the figure indicate high-return-period events: hurricanes Gloria, Bob, Floyd, Irene, Sandy, and Isaias.



Cumulative event outages by county, 1981 to 2020, for eight counties served by Eversource-Connecticut.



Return levels of event outages by county for eight counties served by Eversource-Connecticut.

It Works: Enhanced Tree Trimming prevents outages

Over the past year, the Eversource Energy Center has developed two mathematical models—one machine-learning and one statistical—to evaluate the effectiveness of enhanced tree trimming (ETT) in preventing power outages during storms. While billions are spent nationally on vegetation management every year, the damage from storms can be even more costly. Outages also exact a toll on society that is not captured in the dollar amounts. Finding cost-effective ways to reduce the number of outages and, where they do occur, the cost for repairs and the time to restoration is an important research focus.

The machine-learning model developed by researchers at the Center to predict how many outages will occur in a storm includes a new vegetation management variable that accounts for how much ETT has been performed on each electric circuit.

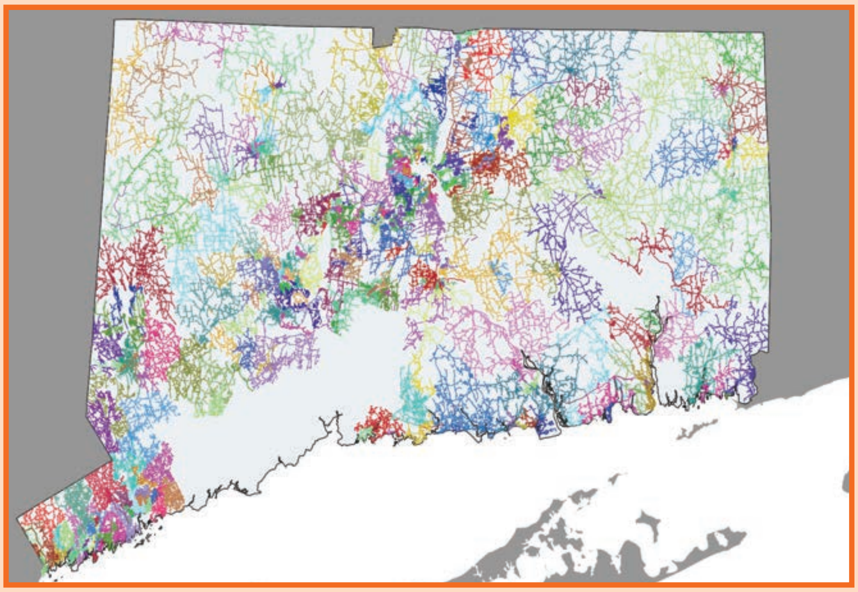
In a comparison of the output from the machine-learning model before and after inclusion of the vegetation management variable, the after model predicted outages with greater accuracy. This means that, incorporated into the UConn Outage Prediction Model, the vegetation management data will improve the OPM's accuracy, allowing for better storm preparedness responses from utilities. By changing the vegetation management variable, utilities will also be able to test the

In **enhanced tree trimming,** the chance of outages is reduced by removing all trees and branches that are within eight feet of power lines from ground to sky. This is a more aggressive approach than the standard maintenance program followed by most utilities, in which trees are trimmed every four to five years to remove branches within a certain distance above, below, and next to power lines.

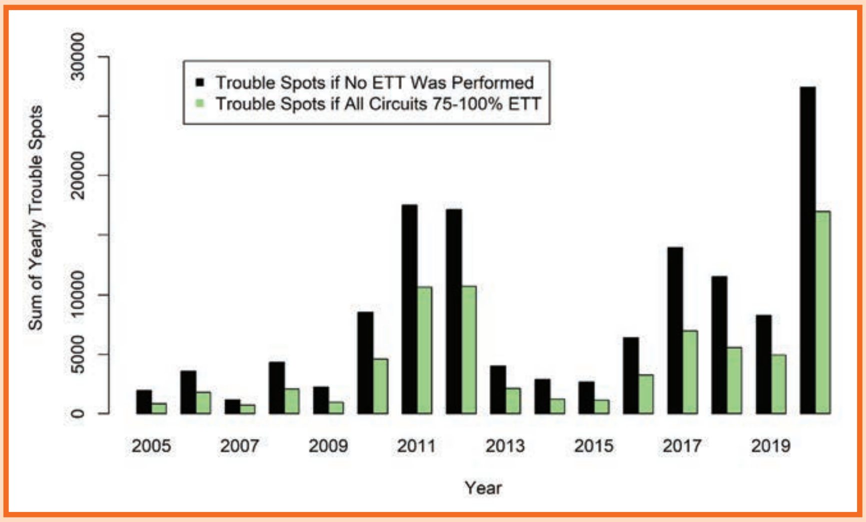
effectiveness of different ETT plans in reducing outages, which will support their decision making with respect to resilience plans.

While advantageous in many ways for forecasting outages, machine learning can struggle in making predictions at the extremes. To examine these cases, we also created a statistical framework to determine the effectiveness of ETT for high- and low-severity storms. The results showed tree trimming to be highly effective for lower-severity storms, with moderate to comprehensive ETT reducing outages by 46 to 64 percent. Vegetation management also produced a large increase in effectiveness for higher-severity events when comprehensive ETT was performed, with the results demonstrating a 37 percent reduction in outages. Finally, the results of the statistical modeling provided information on total annual outages useful to evaluating the reliability of the power grid.

Together, the new machine-learning and statistical frameworks developed by Eversource Energy Center researchers advance the next generation of storm damage modeling to reduce and shorten outages by including vegetation management data and providing information on the effectiveness of ETT that supports the strategic implementation of storm resiliency improvements to the electric grid.■



Map of Eversource overhead power lines in Connecticut, colored by circuit ID.



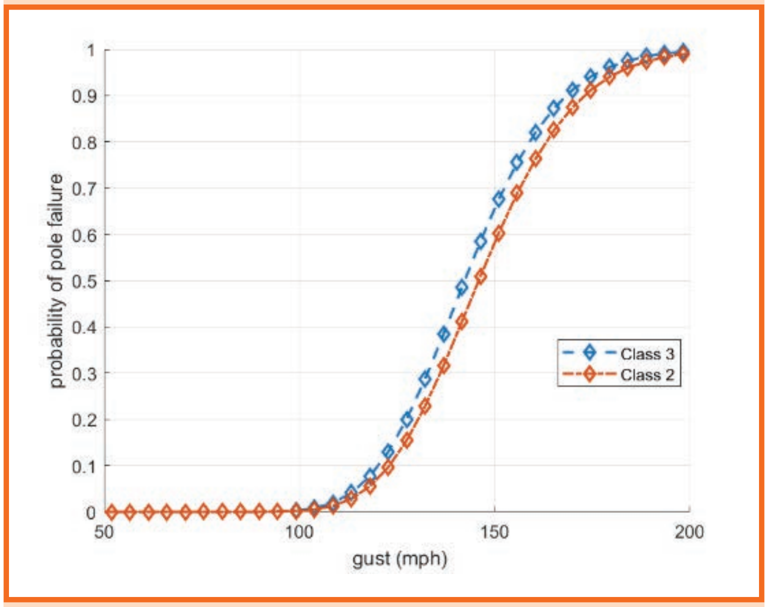
Total annual trouble spots, based on the statistical analysis of 173 storms for two scenarios: with no ETT performed on circuits and with comprehensive ETT performed on every circuit before the storms occurred.

A Closer Look at Pole Failures

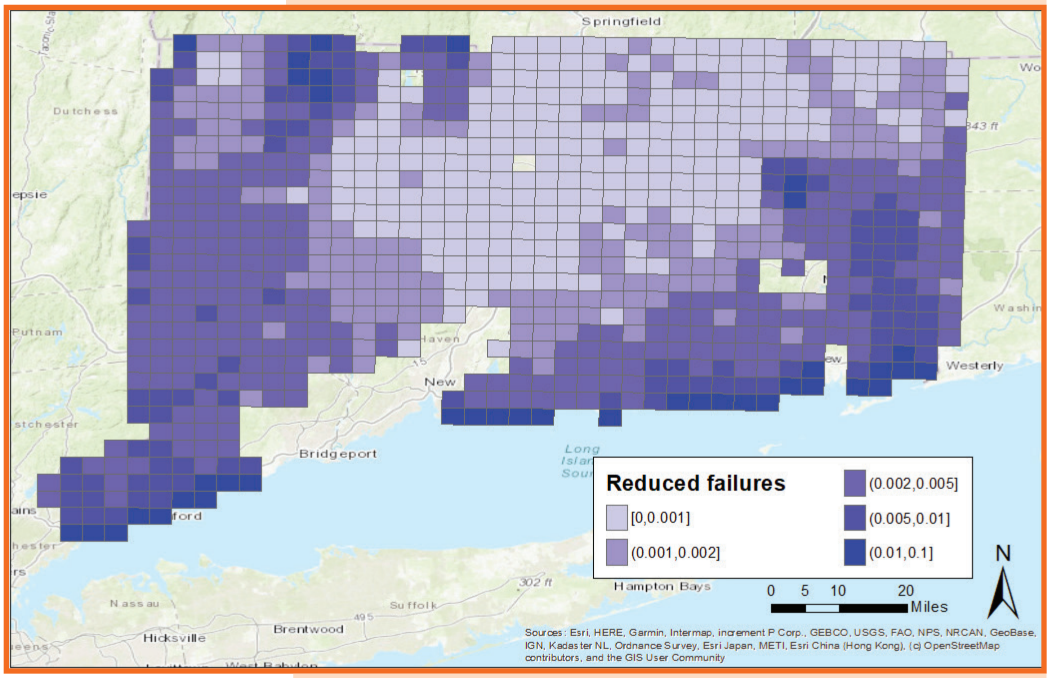
For several years, researchers at the Eversource Energy Center have been investigating the effectiveness of infrastructure strengthening in making the power distribution system more resilient to storms. The goal is to avoid the devastation wrought by severe storms like hurricanes Sandy and Irene, whose strong wind gusts brought down thousands of powerlines and poles, resulting in widespread and prolonged outages.

Using hybrid mathematical models that incorporate physics-based simulation into data-driven machine-learning approaches based on historical outage and weather data, we are developing fragility curves that express the probability of pole failure as a function of wind speed and the class and age of the poles, considering the deterioration in pole strength over time. By updating the fragility curves with curves representing the impacts of various grid resilience hardening strategies, we can assess the effectiveness of replacing aging poles with newer ones, upgrading the pole class to stronger poles, and other measures. Having quantified the impacts of the infrastructure upgrades through the fragility curves, we can then simulate what the impacts of the storms of the last 15 years would have been under the hardened scenarios.

In the future, the fragility curves will be expanded to include factors such as span length, ice thickness, and conductor properties. We will explore the effects of additional hardening scenarios, such as tree trimming, undergrounding, and steel poles, alongside the associated impacts on time to restoration and economic analysis of the benefits of grid resilience enhancement. Building on this, we can generate optimized hardening scenarios that will support decision making on grid management strategies in the coming years.



Comparison of fragility curves for class 3 and class 2 poles.



Sample projected impacts of replacing 5 percent of the oldest poles with new poles between 2005 and 2019.

Do the Benefits of Tree Trimming Outweigh the Costs?

The Answer Is "Yes."

One way in which utilities increase the hardening of the power grid is by limiting the overgrowth of bushes and tree branches around powerlines through tree-trimming operations (TTOs). These operations are expensive and time and labor consuming; in 2017 alone, they cost Eversource Energy $75 million.

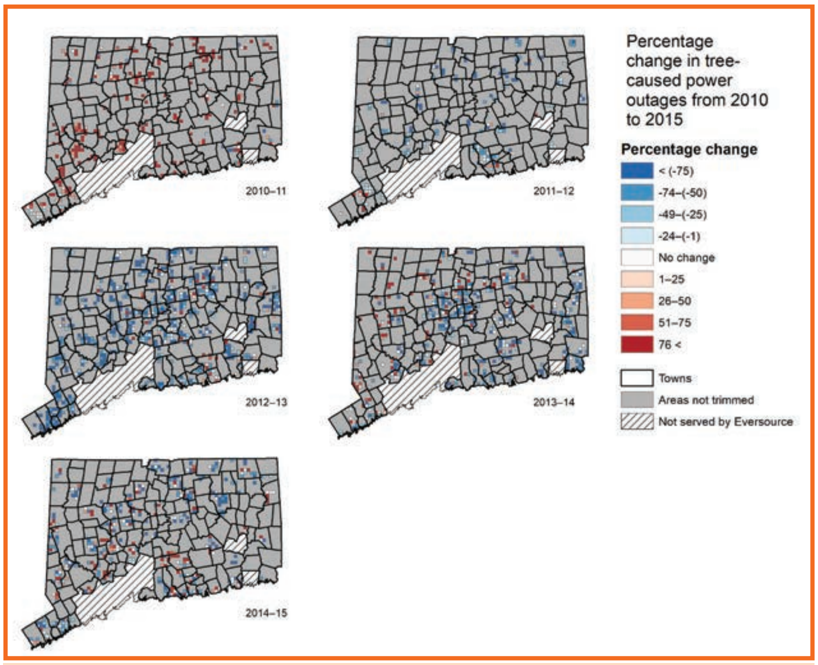
In a recent study, researchers at the Eversource Energy Center sought to quantify the benefits TTOs bring to grid resilience. If these operations were spread across the grid (taking into account diminishing effectiveness over time), would their benefits offset their costs? We focused on 2009–15, a period marked by extreme climate events like Hurricane Sandy, and found the answer to be a resounding "yes": the benefits from TTOs spread across the grid, and they lasted for at least four years.

To produce these results, we used a process called "fishnetting," which allows us to examine something that is in the form of a series of lines (like the power grid) by "cutting" the areas of the state serviced by Eversource into two-kilometer cells.

Our results showed a direct effect in each cell where TTOs were carried out, with 91 outages prevented in the four years after the trimming took place. In addition, the trimming had a spillover effect for the immediately surrounding cells, which had 737 fewer outages than would have occurred without TTOs. Even for those outages that took place, TTOs helped reduce their duration by a total of 364.81 minutes (direct effect) and 88,000 minutes (spillover), possibly by making it easier for crews to restore electricity. Finally, the severity of the outages, measured in numbers of customers affected, also declined, by 2,134 customers (direct effect) and 19,446 (spillover).

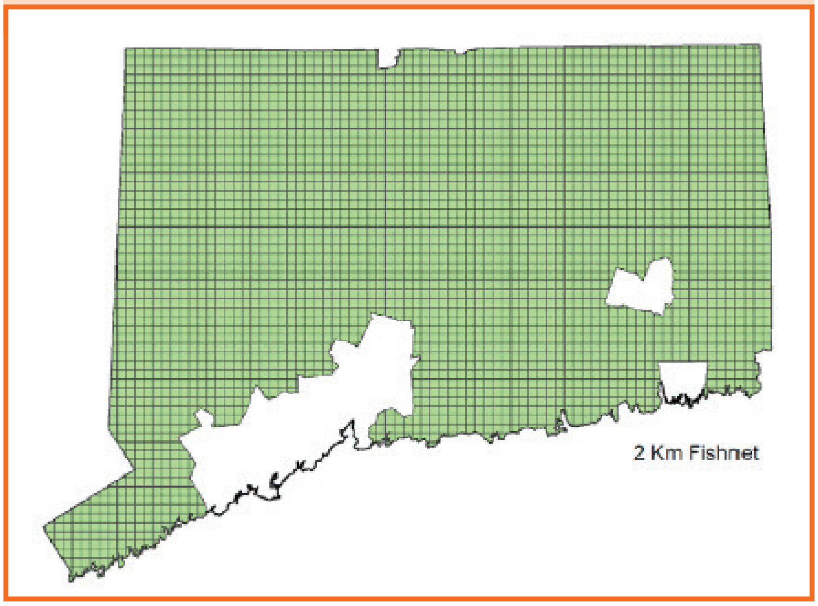
The spatial character of the TTOs revealed by our study is good news for utility companies and regulators: the operations will propagate the benefits of vegetation management throughout the grid, beyond the trimmed areas, and for at least four years. Our results also indicate that planning for TTOs should be thought of as a spatiotemporal process, with optimization of TTO practices aimed at maximizing these spillovers across the grid.

In a world marked by climate change, and with the value of working from home increasing as a result of the COVID-19 pandemic, a reliable and resilient power grid is pivotal to our well-being. Our work supports an expansion of the operations that support it. In the future, we will be incorporating into our analysis micro-outages (that is, outages of less than five minutes), which, although less felt by residential customers, affect high-end manufacturing and other industries key to Connecticut's economy.

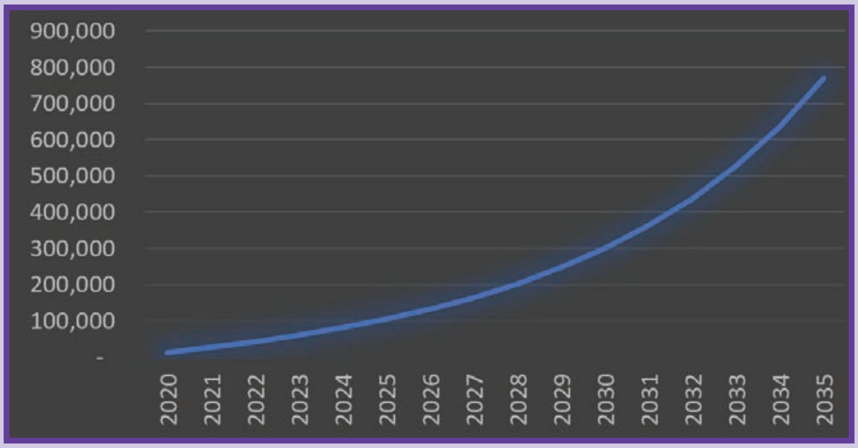


Change in 2009–15 (first year not displayed) in power outages reported to be caused by trees in the Eversource distribution network in Connecticut.

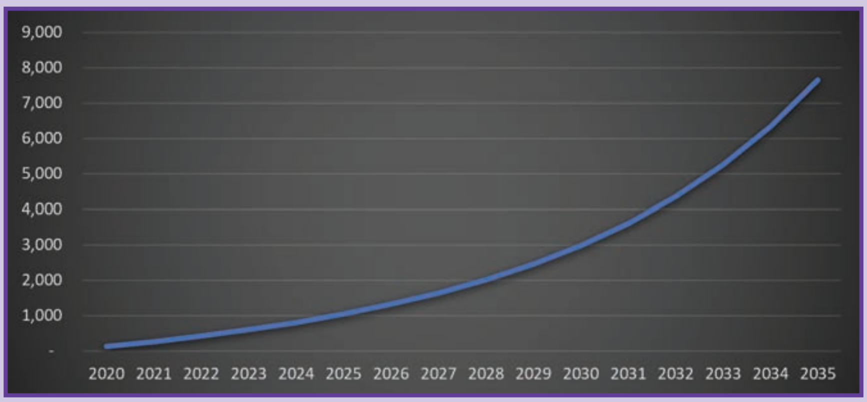
Two-kilometer fishnet, Eversource towns only.



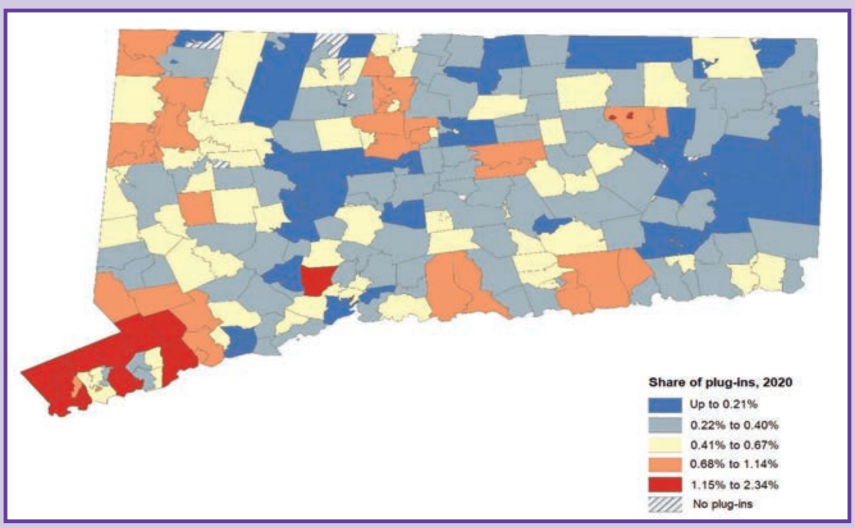
ELECTRIC CARS ARE COMING! Making Sure the Grid is Ready



Connecticut EVs on the road, 2020–35.



Electricity generation needed to meet Connecticut EV demand, 2020–35 (MWh/day).



Share of vehicles in Connecticut that are electric, by ZIP code.

Electric vehicles will transform the transportation sector in the next decades and represent a vital part of any strategy to mitigate the effects of climate change. But surging demand for EVs, driven by decarbonization commitments by both policymakers and manufacturers, will drive in turn the demand for electricity considerably above current supply in Connecticut. At the Eversource Energy Center, researchers are working to produce growth projections for the use of EVs throughout the state to identify areas on which the state's utilities will have to focus their efforts to strengthen the infrastructure of the electric grid.

According to our analysis, increased demand for electricity after 2028 will have to be met by generating 2,000 MWh per day, which will further increase to 9,000 MWh per day by 2035. Without significant improvements in batteries and additional policies for making recharging more efficient, the state will see an even larger increase in demand by 2060, when all vehicles on the road will be electric. By mapping the adoption of EVs in the state over the period 2013–21, our team found EVs concentrated in the wealthier areas along the southwestern corridor and the more affluent suburbs surrounding the larger cities. These are the locations where utilities will need to concentrate their grid modernization efforts.

Early rates of EV adoption were high but were declining, and, by 2035, EVs will still comprise less than a quarter of all Connecticut vehicles on the road. This is bad news in terms of addressing climate change, but, with this expansion coming largely after 2028, it does mean utilities still have some time to expand generation, transmission, and storage.■

“Hardware in the Loop” Validation for Effective DER Integration

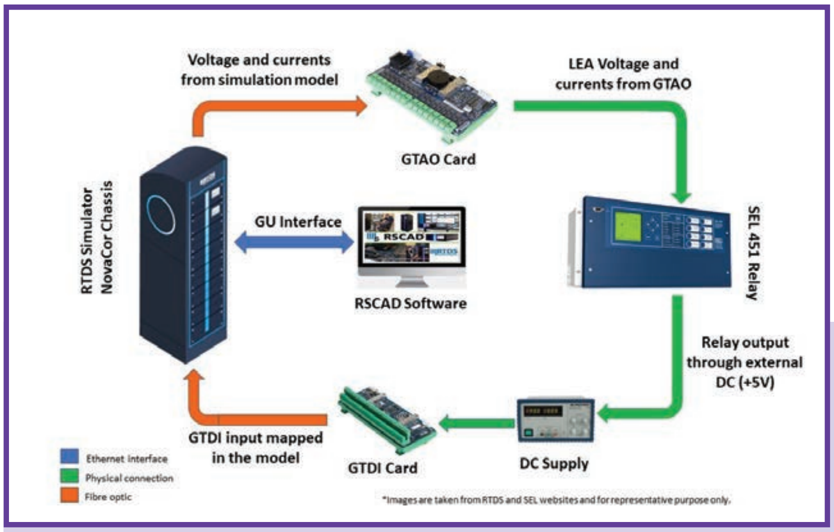
Distributed energy resources are small, often residential or commercially owned units of electricity generation, like solar panels or generators fueled by natural gas, that are connected to the utility distribution system (the power grid) at or near the end user.

The transition from the generation of electricity on a large scale to small distributed energy resources (DERs) like wind and solar power systems presents utility companies with many challenges in terms of coordinating the distribution networks and protecting the power grid. Researchers at the Eversource Energy Center are working to address these challenges using “hardware in the loop” (HiL) validation.

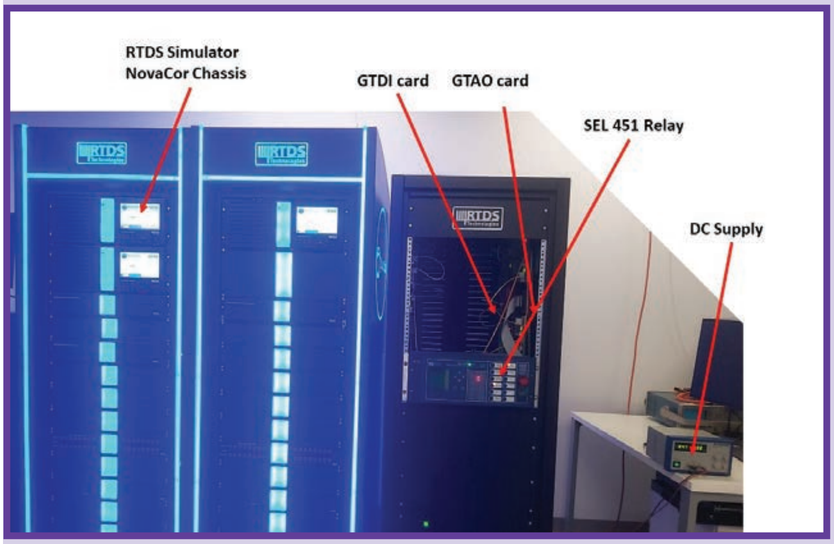
When DERs are integrated into the electric system, the two protection failures that most commonly occur are reverse power flow and sympathetic (or nuisance) tripping. Reverse power flow happens when the electricity generated by the DERs exceeds local demand and is sent back to the power grid. Whenever this reverse flow exceeds the allowed set value, it results in the unintentional opening—or sympathetic tripping—of circuit breakers at the distribution side, which causes outages for related customers.

Unintentional tripping has been considered more likely to happen when the bidirectional current contributes to a fault in the system that otherwise would not open the breakers, and the extent to which it contributes has been thought to depend on how far the fault is from the generation location. To explore this, we set out to develop a “hardware in the loop” setup, in which the hardware (an SEL 451 relay protection device) was connected to a simulated system in real time to evaluate the impacts of DER integration on distribution protection performance.

Contrary to the conventional wisdom, both the hardware test and simulation case studies showed that the DER contribution could create malfunctions in protection that would cause outages under healthy network conditions as well as during a fault. Knowing this, the next step is to formulate a new protection philosophy for renewable-based systems, such as adaptive protection schemes where the protection relay changes the setting based on the system topologies and operating conditions.■



First, the electricity distribution system was modeled in Powerfactory software to evaluate the impact of DERs on protection performance (a).



Then an HiL setup (b) was developed to validate the performance of real SEL 451 protection devices in a real-time digital simulator (RTDS).

The accelerating move toward harnessing the wind as a sustainable form of energy has increased exponentially the need for information about conditions above the ground and below the water. The Eversource Energy Center is engaging in exciting and innovative efforts to obtain it.

Offshore wind energy is generated by turbines that have fixed foundations in relatively shallow waters and float on platforms where the water is deeper. Several wind farms will be installed in the Atlantic Ocean to the South of Cape Cod in the next few years. They will provide electricity to cities in New England, using systems of cables buried in the seafloor to transmit electricity to the grid.

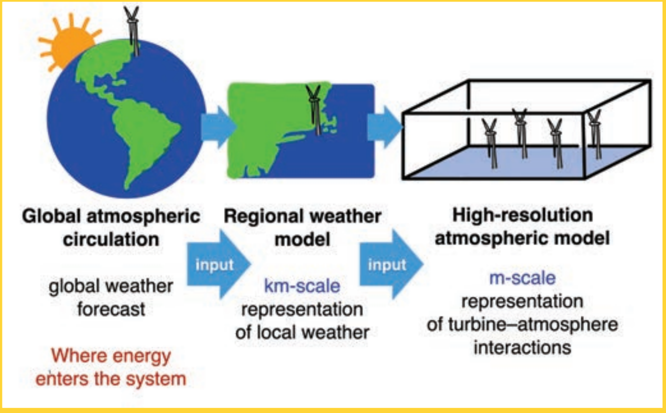
From Wind to Power

Offshore wind is an abundant energy resource with significant environmental and economic benefits, but as a natural resource, it is variable. At the Eversource Energy Center, researchers are continuing their work to develop a modeling system that better characterizes meteorological conditions at the wind-farm scale.

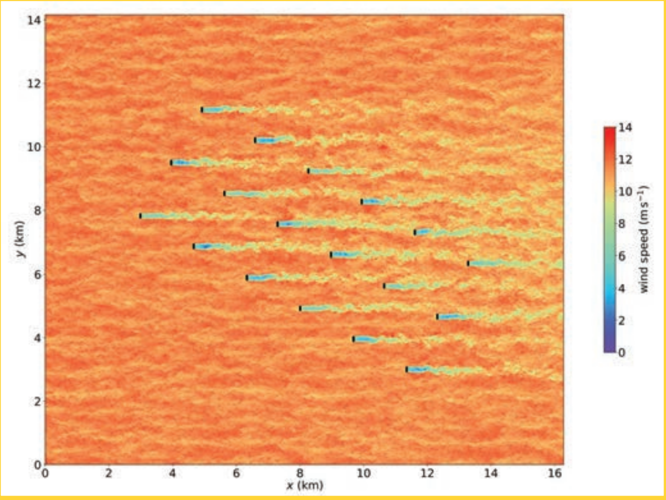
This comprehensive modeling system simulates the flow of energy through the atmosphere to the wind turbines that generate electricity. The heating of the Earth's surface by the sun is uneven, with regions near the equator receiving more radiant heat than those near the poles. This spatially variable heating drives global atmospheric circulation, weather patterns, and, eventually, the wind fields at the locations of wind farms. The optimal design and operation of a wind farm depends on discerning the details of the wind field near the surface and at scales of less than 100 meters.

Since modeling the entire atmosphere at such a fine scale is not feasible, a hierarchy of modeling methods is used to track the energy flow through the system, beginning with weather prediction modeling of the entire atmosphere that provides information about global weather patterns. The output of the global weather forecast model is then used as input to a regional model that captures wind patterns at smaller scales of about 250 meters. The output of the regional model is passed on in turn to a high-resolution model that captures the interaction of the wind field with the wind farm.

Finally, a representation of each wind turbine is included in the high-resolution atmospheric simulation, using an "actuator disk model" that accounts for the interaction of the turbine with the turbulent wind field. Much like an airplane on a bumpy flight, the turbine blades move through a constantly fluctuating wind field. The fluctuations affect the efficiency of the turbines in energy extraction, as well as causing structural fatigue that shortens their lifespan. The newly developed comprehensive modeling system will allow detailed simulations of entire wind farms using realistic meteorological conditions, enabling improvements to their design and operation.



A hierarchical modeling system tracks the flow of energy from the global atmospheric circulation to the wind turbines.



High-resolution simulation of a wind farm under development in the North Atlantic. The locations of the wind turbine disks are indicated with black lines, and the color contours correspond to wind speed. The wind speed downstream of the turbines decreases as a result of the reduction in kinetic energy as the atmosphere moves through them.

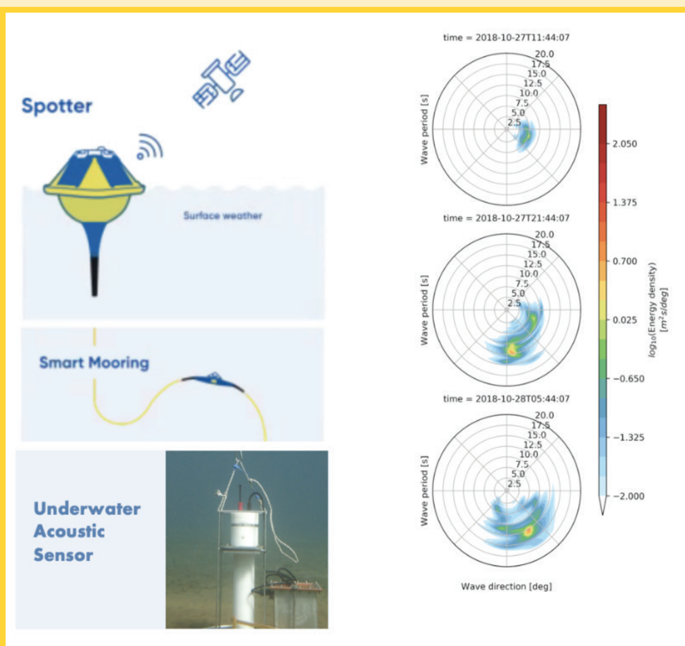
Listening Beneath the Sea

The ability to measure and monitor conditions in the marine environment is central to the success of offshore wind energy projects. Given the sparseness of in situ observations over the ocean, offshore energy projects rely on remote sensing technology, such as satellites and radar, to fill the extensive spatial gap. Offshore wind energy companies also install purpose-specific observing systems such as LiDARS. Below the surface water, the sparseness of observations is even worse.

Underwater acoustic sensors (UASs) offer a low-cost, robust alternative. Placed on the seabed or attached to mooring lines, they are capable of differentiating precipitation rates and wind speeds and quantifying intensities with great accuracy. These sensors have been used extensively for marine, fishery, and ecosystem monitoring, but whether they can provide information about weather and sea conditions at sufficiently high resolution for calibrating offshore wind models remains to be demonstrated.

The Eversource Energy Center's offshore wind energy team has been developing an underwater acoustic sensor called the Passive Acoustic Listener to monitor background noise and acoustic signals for marine engineering applications. One of the PAL's key characteristics is its ability to remain underwater for periods of at least six months, unlike other hydroacoustic sensors.

In November 2021, with the support of the University of Connecticut's Department of Marine Science, the team deployed the PAL, attaching it to UConn's buoy station located in central Long Island Sound. The sensor was retrieved in January 2022 for analysis. In this first trial, the amount of data collected by the system was limited, leading us to examine its acoustic sensor and electric system for possible flaws. Based on our findings, we completed a second version of the PAL system, which we expect to deploy in the same location this summer. To make it more resilient, we upgraded the system with the latest software and thoroughly tested its hardware. We are also developing a new design to allow real-time transmission of underwater data with simultaneous surface observation. This new design will couple the PAL with a compact-size autonomous buoy—the Sofar-Spotter—through a Sofar Smart Mooring.



Fabricated through a collaboration between the University of Connecticut and the National Technical University of Athens in Greece, the PAL-Spotter is an integrated surface and underwater acoustic and surface multisensor system. The Sofar-Spotter's buoy measures wind speed and direction, wave amplitude and direction, surface pressure, and precipitation amount.

https://www.sofarocean.com/

At present, the PAL must be deployed close to sensors at the surface, but with the new design and through the joint efforts of Eversource and Sofar, it will become an autonomous system, which will allow for more flexibility in location and real-time data transmission. Major deployments for the PAL-Spotter are scheduled for Fall 2022.

The Eversource Energy Center continues to make strides in preparing the expert, diverse workforce so essential to building the grid of the future.

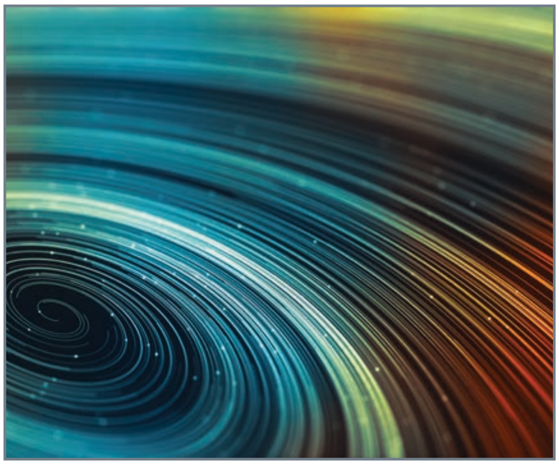
The First Class of Students Graduates

The UConn Commencement of 2022 marked the culmination of the Grid Modernization Certificate Program for its first ever cohort of students. Those who graduated that day included five professionals from AVANGRID, one from Eversource, and one from ENERCON, all of whom had completed a rigorous twelve-credit graduate program to earn their certificates. Among the courses were Predictive Analytics, which trains students in end-to-end processing, analytics, and interpretation of modern power grid data; Microgrids, which provides the fundamentals of the control techniques, design, and operations of microgrids; Energy Management Systems, which covers the operation, control, and management of energy resources in smart distribution grids; and Communication Systems, which introduces students to smart grid architectures and their applications, requirements, technical challenges, and enhancements in communication systems.

The achievement of completing the first Grid Modernization Certificate Program belongs not only to the students who graduated but also to the many other hardworking individuals who made the program possible. Many thanks are owed to the faculty who were involved in planning the online courses, the industry managers who provided feedback on the course materials, and the program's leaders, who met with various stakeholders to pull together the study plan, budgets, and commitments and implemented the program at unprecedented speed. The certificate program did not just meet the needs of the utility industry; in preparing students for the challenges of the future power grid, it exceeded them.■

The **Power Grid Modernization** Graduate Certificate was first offered by the Eversource Energy Center at the University of Connecticut in response to the specific need of the utility industry to prepare for its transition to the grid of the future by providing training each year to cohorts of early-career engineers on the technical aspects of grid modernization. Based on this need, the EEC designed a program that increases human expertise on predictive analytics, microgrids, communication systems, and distribution management systems to enable higher-level control functions and schemes to manage the increasing levels of distribution energy resources (DER) penetration. The four courses in the study plan cover the fundamentals required to address industry's new challenges: integrating renewable energy sources into the grid; predicting future electricity demands, capacity, smart grid designs, and operations; and confronting issues surrounding physical and cyber security.

Pioneering Diversity at the Eversource Energy Center



The Eversource Energy Center strives to give all its students an equal opportunity to achieve and to learn in their chosen fields. To complete this vision, the Center has started a Diversity and Inclusion Initiative, through which funds are set aside to support internships and plan strategic activities and partnerships within the School of Engineering and UConn that foster a positive, conducive, and inspiring environment for underrepresented and minority (URM) students to conduct research. The program also provides funding for mentors and covers the expenses of selected students who present their research at national conferences and publish their work. As of 2021, the Center had funded ten URM students and awarded funding to another eight. The goal is ultimately to have URM students comprise 25 percent of the Center's funded students.

The funding awarded to URM students through the Diversity and Inclusion Initiative provides them with several valuable benefits:

Mentorship. URM students are matched according to their interests with principal investigators who include them in ongoing research and engage them in research programs of regional and national priority.

Workforce preparation. Through certification opportunities and higher education programs, more URM students are prepared to conduct meaningful work in the future.

Professional promotion. Participation in national conferences and publications gives URM students more outlets to present their findings.

Leadership training. Communication, networking, and profile enhancements enable URM students to become leaders in their fields of choice.

UConn experts, including Michael Bradford, the Vice Provost for Faculty, Staff, and Student Development, have made possible the planning and tracking of the Diversity and Inclusion Initiative. Faculty members are responsible for conducting training and evaluations to assess the current performance of the Eversource Energy Center in its diversity and inclusion efforts. Additionally, the Center has requested feedback from students currently in the program through both interviews and anonymous surveys to better its understanding of their experiences and how the program can improve. To expand the initiative's reach, the Center plans to seek more resources from other groups throughout the university, such as the Institute for Student Success, the Diversity and Inclusion Office, and UConn's regional campuses. Eventually, the initiative will go beyond UConn to include students at other universities throughout Connecticut, as well as at local high schools.

In sum, through links to internships with the energy industry sector, engagement with faculty and graduate students in its funded projects, and participation in workshops and regional university collaborations, the Eversource Energy Center's Diversity and Inclusion Initiative provides essential learning experiences to a broader range of students than would otherwise have these opportunities. The Center's commitment to supporting them promises not only to increase the retention and graduation rates of URM students but also to prepare them for career success in today's global society.■

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