2019

Eversource Energy Center
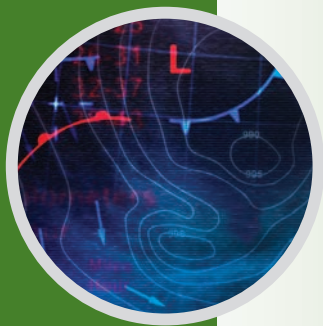
A utility-university partnership at UConn

Annual Report

Contents

Welcome

Dear Friends,

The Eversource Energy Center marked the year 2019 with a series of developments and acquisitions, the completion of several research projects, the securing of new funding, and the strategic alignment of our research activities into integrated projects. We maintained our strategic focus, stuck firmly to our development goals, and expanded our collaboration and mission to promote further cutting-edge research that fulfills our commitment to delivering new scientific knowledge and high-quality products to the electric utility sector and concomitant industries and stakeholders.

Among the several milestones highlighted in this report are the expansion of our operational outage prediction model to contain new variables, and the consolidation of two new research facilities: the Power Grid Simulation Testbed and the Unmanned Aerial Systems Laboratory. New funding in the amount of $6.2 million will support six new integrated projects: 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, and Offshore Wind Energy.

The Center made further progress in national and international activities. We organized the Second Annual Grid Modernization Workshop, attracting numerous participants from industry and among regulators to discuss the challenges and opportunities the new set of tools and technologies will bring into play in the grid of the future. We also collaborated with the organizers of the NECPUC (New England Conference of Public Utilities Commissioners) Annual Symposium. June 2–5, 2019, to establish the first academic poster and panel session on Making Research Relevant: Academic Research and Economic Regulation.

We invite you to take a look at the topics in this report and hope you find the information useful. We are open to partnering with universities and research centers, as well as utilities and other organizations that wish to participate in our research, activities, and initiatives. Our proven consortium method will produce the next generation of technologies and software, leading to transformative commercial products and services and advances in storm preparedness and grid resilience and grid modernization. Our exceptional 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

January 21, 2020

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

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Amvrossios Bagtzoglou, Professor, Grid Resilience Team Lead
Diego Cerrai, Assistant Research Professor
Jonathan Mellor, Assistant Professor
Malaquias Peña, Associate Professor, Manager of the Center
Giulia Sofia, Assistant Research Professor
Xinyi Shen, Assistant Research Professor
Guiling Wang, Professor
Wei Zhang, Assistant Professor

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Fei Miao, Assistant Professor

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Cory Merow, Assistant Research Professor

Department of Electrical and Computer Engineering
Yang Cao, Associate Professor

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

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Georgios "George" Matheou, Assistant Professor

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Robert Fahey, Assistant Professor, Associate Director of the Eversource Energy Center, Tree and Forest Management Team Lead
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Anita Morzillo, Assistant Professor
Jason Parent, Assistant Research Professor
John C. Volin, Professor, Vice Provost of Academic Affairs
Chandi Witharana, Visiting Assistant Professor
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Zhe Zhu, Assistant Professor

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David Wanik, Assistant Professor in Residence

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Andreas Langousis, Assistant Professor, University of Patras
Efthymios Nikolopoulos, Assistant Professor, Florida Institute of Technology
Peng Zhang, Associate Professor, Stony Brook University

Milestones

Our Center originated from a partnership between Eversource Energy and the University of Connecticut, with the purpose of enhancing electric utility preparedness and hardening infrastructure, improving accuracy in predicting the severity of localized storms, and enabling effective resource allocation for response to and recovery from extreme weather events. The Center now comprises experts at universities, state organizations, and major utilities collaborating within the framework of a Center of Excellence. Marshaling the expertise of these various stakeholders through an integrated analytical approach enables us to develop a comprehensive assessment of the region's most vulnerable "hot spots" for severe weather hazards, yielding strategies and actions to manage these threats. 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.

In 2019, the Center continued to carry out nine Phase II projects in the three thematic areas of storm preparedness, vegetation management, and electric grid reinforcement.

Key initiatives

The Center's key initiatives in 2019 included the consolidation of its research facilities and the introduction of integrated projects.

CONSOLIDATION OF RESEARCH FACILITIES

The Center has consolidated four facilities to carry out its research and development objectives:

The **High-Performance Computing Infrastructure** supports large-scale numerical prediction modeling, especially for high-resolution weather and outage prediction.

The **Biomechanics Laboratory** offers a set of sensors for monitoring tree sway and stability.

The Power Grid Simulation Testbed consists of a state-of-the-art real-time digital systems (RTDS) simulator for performing power grid simulations at various levels of refinement.

The **Unmanned Aerial Systems (UAS) Laboratory** has LiDAR, infrared, thermal, and radar capabilities for mapping and intrusion detection.
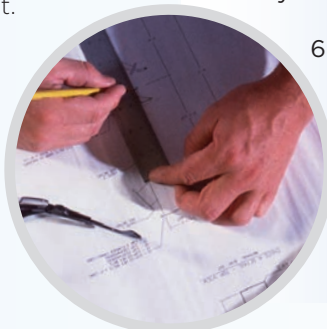
INTEGRATED PROJECTS

With its many endeavors continually increasing in number and diversity, the Center conceived and implemented a set of overarching projects to improve the management of and communication and internal cooperation among its research activities and more effectively address high-priority objectives. Six such integrated projects are now underway:

1. Outage Prediction Modeling and Emergency Response

2. Resilience System Modeling and Economic Effects

3. Vegetation Management, Outreach, and Forest Science

4. Renewable Energy and Grid Integration

5. Cyber and Physical Security

6. Offshore Wind Energy

Strategic Partnerships

The Center also established two new strategic partnerships.

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 new agreement approves support for an integrated research project that aims to enhance environmental monitoring and modeling capabilities for offshore wind energy generation.

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 partnerships with a research project that aims to make available to water providers a mechanism for encouraging homeowners to reduce turf watering voluntarily. ●

Center by the Numbers

Publications

Peer-reviewed 49

Our Sponsors

Eversource Energy

AVANGRID/CT (United Illuminating)

Connecticut Institute for Resilience &
Climate Adaptation (CIRCA)

DTN, LLC

Housatonic Valley Association

National Science Foundation (NSF)

Travelers

U.S. Department of Defense

U.S. Department of
Energy

Awarded Amounts

2016–present $12,627,018

2020 (new awards) $5,900,000

2020 (pending proposals) $1,897,415

Expenditures

2016 $998,059

2017 $2,158,683

2018 $2,423,839

2019 $2,454,938

Students

Undergraduates 25
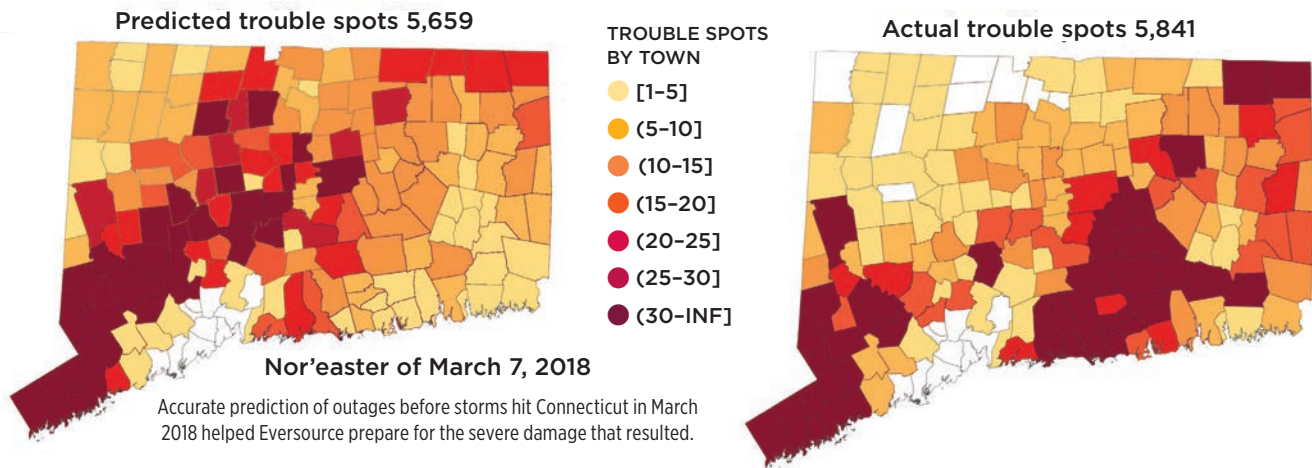
Graduates 34

Postdocs 2

Alumni 24

Outage Prediction Modeling

Model Advances for Snow and Ice Storms

The "Halloween nor'easter" that left 3.5 million electric utility customers in New England without power in 2011—some for more than ten days—prompted development by Eversource and UConn of an outage prediction model to help utilities make decisions that could improve restoration time after such extreme weather events. Seven years later, when three nor'easters less than a week apart severely affected the same area, the Eversource Energy Center's Ice and Snow Outage Prediction Model (ISNOPM) proved its worth. Despite the extensive damage caused by these storms, Eversource was better prepared for them, fully restoring power in less than three days.

Predicted trouble spots 5,659

TROUBLE SPOTS BY TOWN
- [1–5]
- (5–10]
- (10–15]
- (15–20]
- (20–25]
- (25–30]
- (30–INF]

Actual trouble spots 5,841

Nor'easter of March 7, 2018

Accurate prediction of outages before storms hit Connecticut in March 2018 helped Eversource prepare for the severe damage that resulted.

ISNOPM is a machine learning–based predictive model that matches data on power outages from snow and ice storms of the past fifteen years with high-resolution weather analysis, as well as land, vegetation, and infrastructure characteristics, to provide high-resolution outage predictions based on storm forecasts.
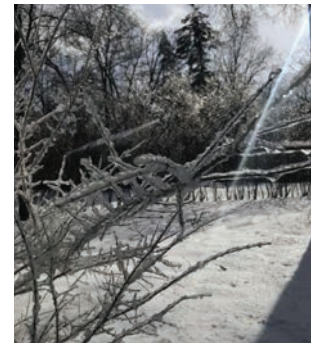
In 2019, the UConn researchers working on ISNOPM continued to advance its capabilities. Fundamental to this effort was the understanding that different types of snow have extremely different impacts on the electric grid. Wet snow sticking to power lines and trees, for instance, is responsible for catastrophic events when associated with strong winds, while dry, fluffy snow can accumulate on power lines only when winds are low.

Outages per 100 assets

Light snow   Average snow   Heavy snow

Mean outages
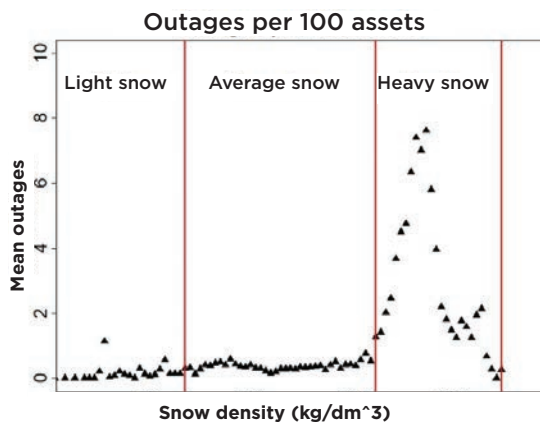
Snow density (kg/dm^3)

Different types of snow have different impacts: The chart (left) shows the mean number of outages for varying snow density with a clear peak for wet snow, such as that which appeared on trees along the Fenton River in Mansfield, Connecticut, after the March 7, 2018, nor'easter (right).
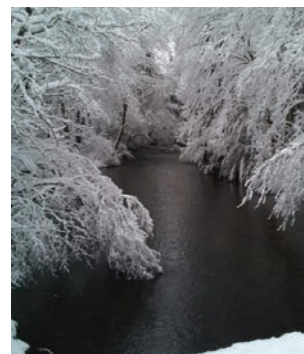
With the progress made in the past year, ISNOPM can now even be used to predict the impact of rare snowstorms over leafy vegetation. And while high-resolution weather models like ISNOPM are still somewhat limited in predicting power outages during ice storms, ongoing work will address this challenge, as well.

Photo credit: Eversource MA.

Ice accretion around power lines in Falmouth, Massachusetts, after the March 13, 2018, blizzard (left) and on trees in Willington, Connecticut, after the January 20, 2019, ice storm (right). Ongoing work on ISNOPM will improve the prediction of outages during such events.

ISNOPM represents a novel model for the power utility industry, capable of predicting outages over a large range of wintry conditions. As ISNOPM becomes even more reliable, the ability of Eversource managers to prepare for outages during severe blizzards and ice storms will continue to improve. The power will still go out, but restoration will be ever faster than in the past. ●

Extreme Weather Forecasting Developments

The importance of extreme weather events is underscored by the serious effects they have on human lives, infrastructure, and the environment. Severe storms disrupt the operations of electric power utilities by damaging infrastructure and causing blackouts. In the northeastern United States, the impacts of such storms have been well documented, including the effects of tornadoes in western Connecticut on May 15 and October 2, 2018, and the three consecutive nor'easters of March 2018.

The Eversource Energy Center's extreme weather forecasting project aims to assess the uncertainty and improve the accuracy of weather prediction so we can better predict the number, locations, and duration of power outages resulting from such events. The outage prediction models (OPMs) developed by the Center use geographical data, data on attributes of the electric system, and, especially, numerical weather prediction (NWP) information to predict the impact of storms many days before they happen. UConn researchers gather data for the project by running an operational version of the model to generate predictions every time a storm occurs in New England.

In the past, we successfully developed combined NWP products to reduce the error in weather prediction by up to 40 percent, thus improving the reliability of our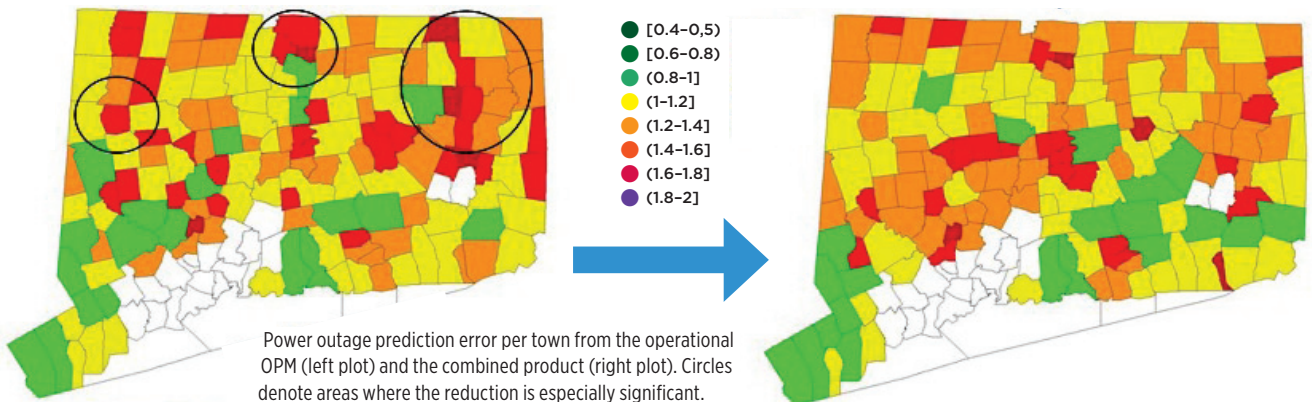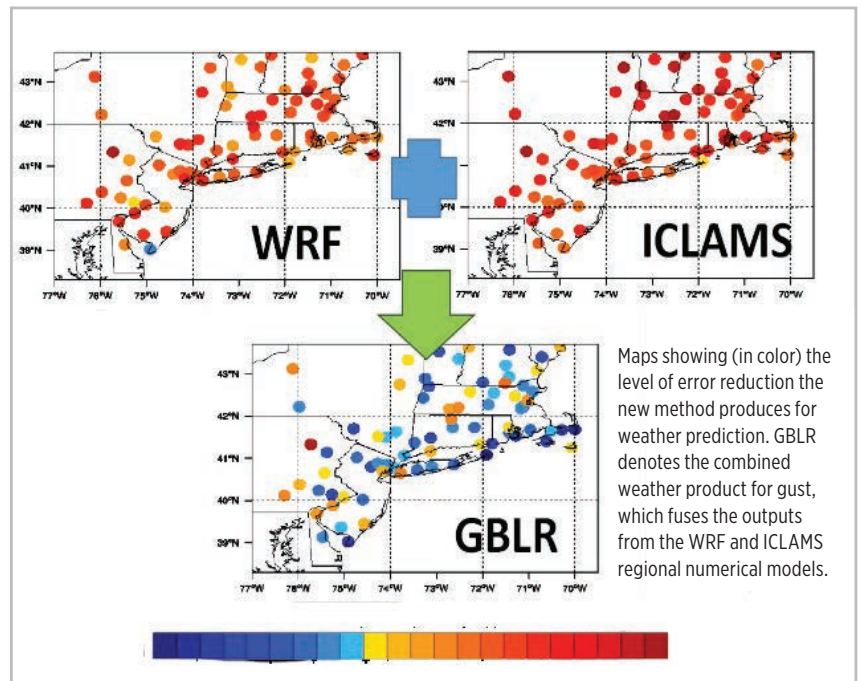 extreme weather predictions. During 2019 we concentrated these ongoing efforts in two areas. The first was evaluating the uncertainty in the OPMs as influenced by the uncertainty in weather forecasting. With a focus on extratropical storms exhibiting heavy rain and wind and lasting from hours to days, we developed a combined weather product that fuses the output from two regional numerical models. The combined product reduced random error in predicting wind speed by around 20 percent, with a reduction of around 40 percent in predicting gust.

As a result of the improvement in weather prediction produced by the combined model, the level of error is, in turn, reduced in predicting the number of power outages that result from storms.
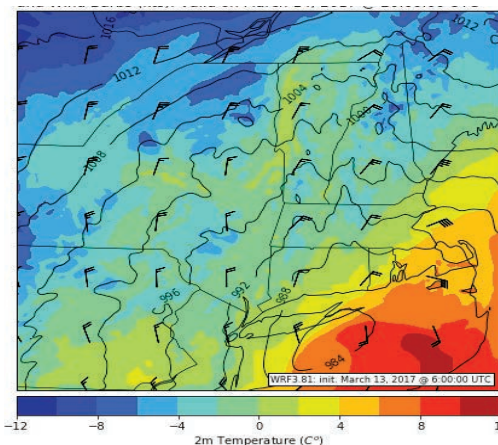
Second, we focused on assessing NWP models specifically during winter storms, with primary emphasis on mixed-phase precipitation (ice, snow, freezing rain, and

so on). This activity occurred in 34 winter storms that affected the northeastern United States during 2006–17; an example was the March 14, 2017, blizzard that brought heavy snow and strong winds to the northeastern United States, leading the governor of Connecticut to issue a travel ban for the entire state and causing thousands of power outages.
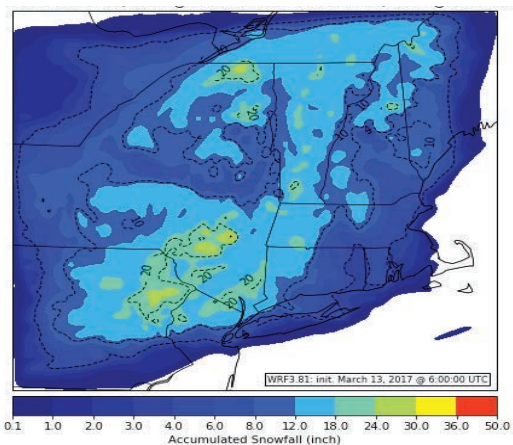
Our analysis of this storm and the others from the period provided insights into the specific NWP improvements needed to increase further the functionality and accuracy of the OPMs, primarily with regard to the over- and underprediction of extreme weather. ●

Maps showing (in color) the level of error reduction the new method produces for weather prediction. GBLR denotes the combined weather product for gust, which fuses the outputs from the WRF and ICLAMS regional numerical models.

● [0.4–0,5)
● [0.6–0.8)
● (0.8–1]
● (1–1.2)
● (1.2–1.4)
● (1.4–1.6)
● (1.6–1.8)
● (1.8–2)

Power outage prediction error per town from the operational OPM (left plot) and the combined product (right plot). Circles denote areas where the reduction is especially significant.

Snapshots of the March 14, 2017, storm prediction by UConn's team, typical of the products generated by the operational OPM.

Mean Sea Level Pressure (hPa), 2 m Temperature [C⁰], and Wind Barbs (kts): Valid on March 14, 2017 @ 20:00:00 UTC

Total Accumulated Snowfall (inch) from March 13, 2017 @ 18:00:00 UTC to March 15, 2017 @18:00

Using OPM to Assess the Impact of Tree Trimming

With the vast majority of power outages during storms caused by trees or tree branches falling on power lines, a constant dilemma for electric utilities is how to reconcile our need for reliable power with the careful preservation of the trees whose presence is so essential to the beauty of the landscape around us.

At the Eversource Energy Center, research has led to new ways of evaluating the effectiveness of vegetation management in preventing power outages while protecting our trees. Our goal is to find an optimal combination of grid hardening investments that maximizes the reliability of the electrical system while minimizing the impact on roadside vegetation. To meet this goal, we have developed a methodology based on outage modeling and weather patterns that allows us to predict how effective different tree-trimming scenarios will be in reducing weather-related power outages. We have used the methodology to compare the actual power outages that occurred during 2017 to the outages that would, hypothetically, have occurred had Eversource not performed enhanced tree trimming. From this evaluation we found that, although the enhanced tree trimming done by Eversource is focused primarily on only a very small percentage of the power lines, the number of outages during storms would have been 10 to 30 percent higher without it.

The map illustrates these reductions in power outages in 2017 for Connecticut towns as the result of tree trimming. The "Halloween nor'easter" in 2017 alone could have caused 30,000 additional customer outages and outages of up to five days' duration. Further analysis indicates that, without enhanced tree trimming, each of the three back-to-back nor'easters in March 2018 would have caused tens of thousands more outages than actually happened. This new vegetation management evaluation methodology, then, revealed the effectiveness of the localized enhanced tree trimming program carried out in Connecticut on the core of its distribution system.

Future work will focus on translating these storm outage reductions into economic benefits for the population and the utility itself. ●

Reduction of storm outages in Connecticut 2017 as a result of tree trimming

[0–5]%
(1–2]%
(2–5]%
(5–10]%
(10–15]%
(15–20]%
(20–30]%
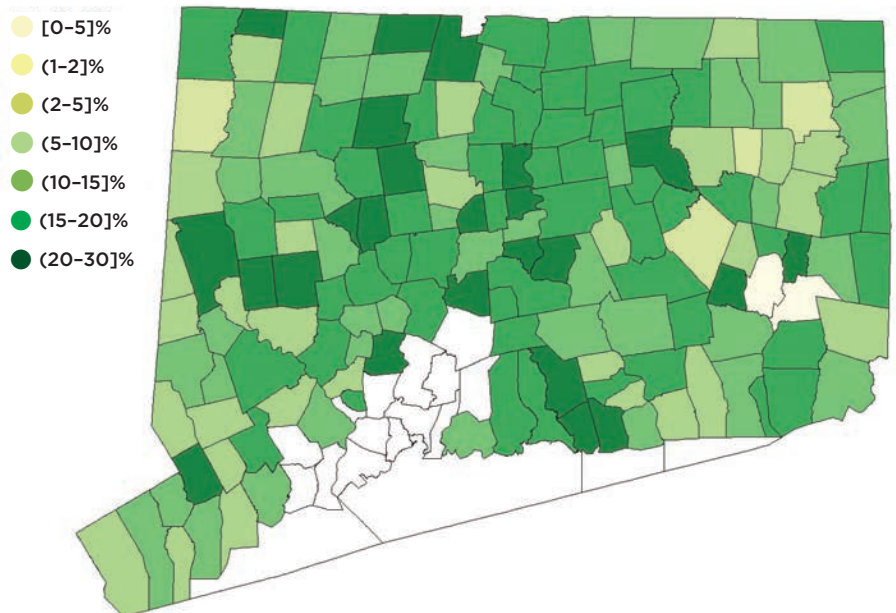
# Tree and Forest Management

Evaluation of Tree Trimming

I n the forested regions of the United States, falling trees and tree limbs are the single biggest cause of power outages during storms. It is hardly surprising, then, that tree trimming is the main tool electric utilities use to reduce the number of outages.

In the standard maintenance program followed by most utilities, trees are trimmed every four to five years to remove branches within a certain distance above, below, and next to power lines. Many utilities have also recently started using a more aggressive program called Enhanced Tree Trimming (ETT), which removes all trees and branches that are within eight feet of power lines from ground to sky.

Standard Maintenance Trimming (SMT)	Enhanced Tree Trimming (SMT)
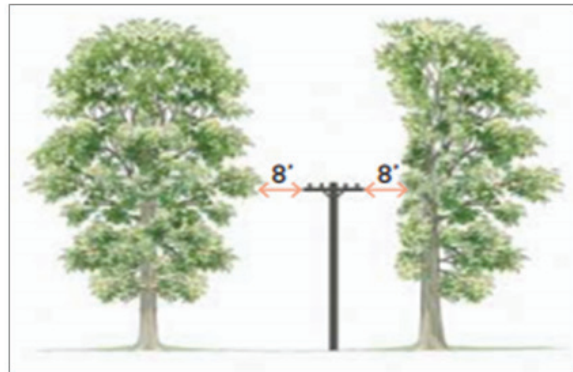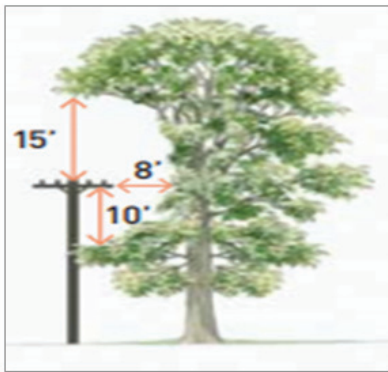
Vegetation management programs used by Eversource

Utilities expect the ETT program to be much more effective than their standard trimming programs; it is also, however, much more expensive. The goal of our evaluation of tree trimming was to measure the actual benefit of ETT in terms of reduced outages. This research would help Eversource decide if ETT is a cost-effective way to make the electric grid more resilient to storms.

To evaluate ETT, we needed to compare outage rates in a particular area before and after ETT had been applied. This sounds simple enough, but, in reality, it is complicated by the fact that the weather is not consistent over time. A location hit by a damaging storm in one year may experience no storms the next. So how can we tell if a change in outage rates is due to ETT or simply to normal variations in the weather? Our solution was to compare each area trimmed with ETT to a nearby location that was not trimmed. If outage

rates before and after trimming changed more for the ETT-treated locations than for the untreated ones, then we could say this change was due to ETT rather than the weather.

Our study results told us that ETT did reduce annual power outage rates by 130–310 outages per 1,000 kilometers in areas affected by storms—a reduction that was in addition to the outages prevented by the standard trimming program. We predict that using ETT to maintain all of Eversource's power lines in Connecticut would reduce outages by 16–38 percent in a typical year and by 6–14 percent in a year with major storms.

In other words, with its potential to prevent hundreds of storm-related power outages per year in Connecticut, implementing the ETT program more widely would be a big step toward making the state's power system more resilient. ●

Stormwise Update

"Stormwise" is a management concept that advocates for innovative approaches to fostering more storm-resistant roadside forest conditions. Stormwise aims to reduce the number of power outages caused by falling trees and tree limbs, shorten the power outages that do occur, make it possible to manage most roadside stands from the ground rather than the air, and—by growing the right trees in the right places—extend the time required between management visits.

Early efforts under the Stormwise Initiative involved establishing more than a dozen research and demonstration sites around the state, where various forest-stand thinning and regeneration treatments were applied based on local conditions. These sites continue to be monitored for various vegetative, tree, and storm-response effects. The initiative also set out to establish up to three pilot projects to explore solutions to the logistical challenges that might confront any roadside forest management endeavor, such as questions regarding property ownership, contractual arrangements, and wood material handling, and to draft associated promotional and training materials.

In 2018, however, roadside forest management priorities suddenly and dramatically changed. Drought conditions from 2015 to 2017 led to severe gypsy moth caterpillar defoliation during 2016 and 2017. This, in turn, led to heightened activity by native opportunistic insects and tree diseases, on top of continuing activity by the invasive emerald ash borer. The result was extensive tree mortality during 2018, particularly in the central and eastern parts of Connecticut.

While a major hurricane or other catastrophic storm resulting in the loss of eight to ten million trees all at once might have brought disaster aid from government sources, emergency declarations, and mobilizations, that has not happened with the "Slow Storm," as we have called it, because of the quiet and ongoing nature of this tree mortality event. Tens of thousands of roadside trees—often large legacy trees with massive crowns along country roads throughout the region—became public safety hazards and threats to power infrastructure in a matter of months, far surpassing the capacity of arboricultural contractors to address the problem and far exceeding town, state, and utility tree removal budgets.

The Stormwise Initiative is now helping to address "Slow Storm" issues by taking on a number of technical, communication, and outreach tasks:

● Convening an ad hoc committee of stakeholders to foster communication and collaboration

● Raising awareness about the "Slow Storm" at numerous conferences, meetings, and events

● Surveying random road segments throughout eastern Connecticut to quantify and describe the scope and scale of the problem

● Testifying before the Environment Committee of the state legislature and the Public Utilities Regulatory Authority

● Developing a Tree Mortality Survey tool that uses a free mobile app to describe, locate, and quantify further tree mortality along local roads

While the Stormwise management pilot projects as initially conceived are temporarily delayed, the tree mortality issues in many communities have raised awareness about the need for proactive roadside forest management. The Stormwise Initiative will continue to work closely with the Eversource vegetation management team to identify, prioritize, and focus on these and other vital roadside forest management needs.●


Photo credit T. Worthley
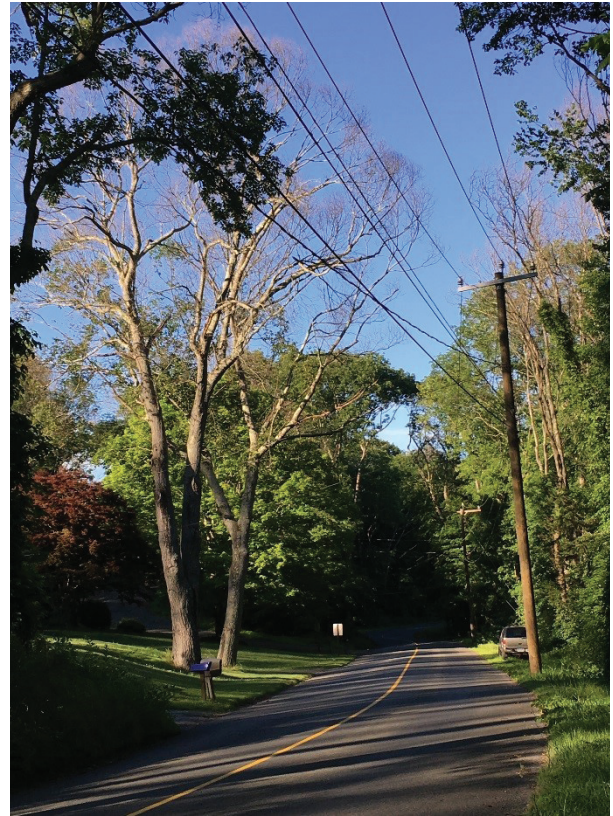
Roadside dead oak trees in Brooklyn (left) and Haddam (right) in July 2018.

Grid Vulnerability Assessment

Substation Vulnerability to Flooding

In the past decade, unprecedented rainfall events associated with tropical storms and projections of climate change have heralded more frequent, and possibly more damaging, flooding conditions in many places around the globe. Connecticut is no exception, and our Center has set out to respond to this threat. Our work involves implementing a modeling framework to assess the vulnerability of critical infrastructure to flooding and, eventually, to predict the risk of damage.

(a)

(b)
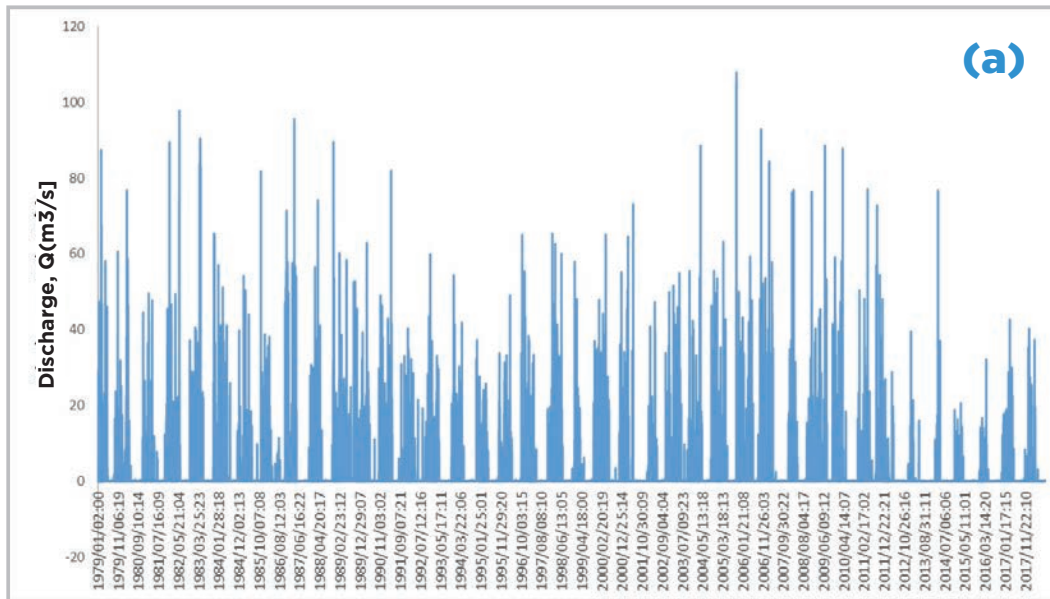
An example of hydrological inputs and output of the early warning system, showing the upstream and downstream boundary conditions for the inundation simulation. Water inflow is charted in panel (a), while panel (b) shows the actual coastal water level (WL), surge, and tide and the maximal water level if the peak of surge and tide coincide
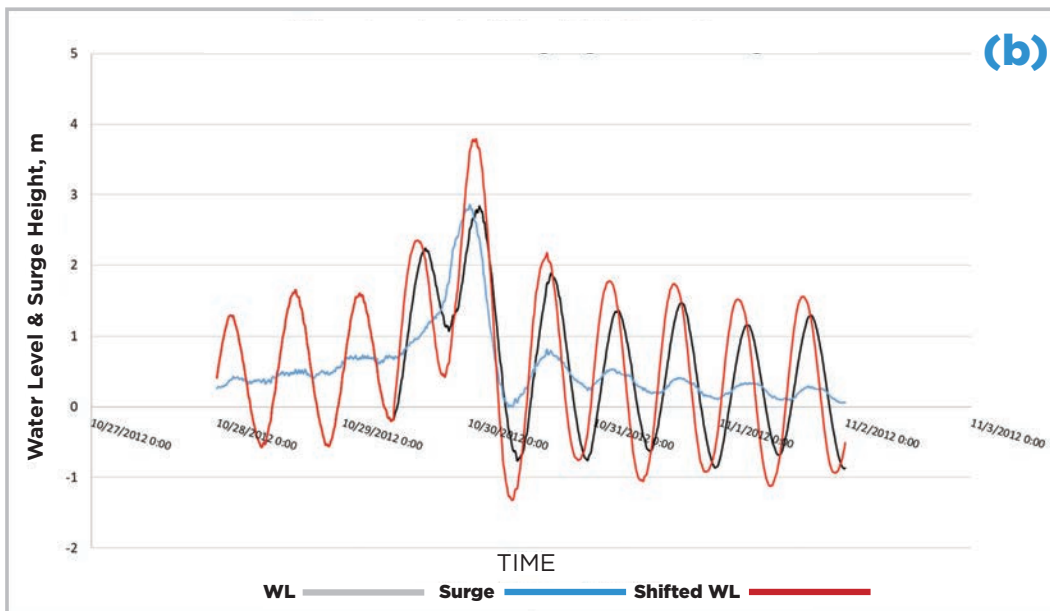
The specific objective of the flood vulnerability project is to forecast flood damage to Eversource substations from incoming storms by rendering in detail the potential extent of the predicted flooding. The substations are critical grid components, where power is transferred from the high-voltage system to the low-voltage lines for customers' use. Getting a flooded substation up and running again is not only costly but takes a long time to accomplish. The project aims to help decision makers find protective measures to take against flooding by combining existing meteorological, hydrological, and hydraulic models into visual georeferenced products.

Since its deployment, an early flood warning system developed by the project has been providing forecasts every 12 hours. In 2019, the focus was on substations across the state of Connecticut, and, in 2020, it will be extended to other New England states, with continuous testing underway for another two years. An additional next step is to enable the system to forecast the inundation situation up to 72 hours into the future. ●

(a)

(b)
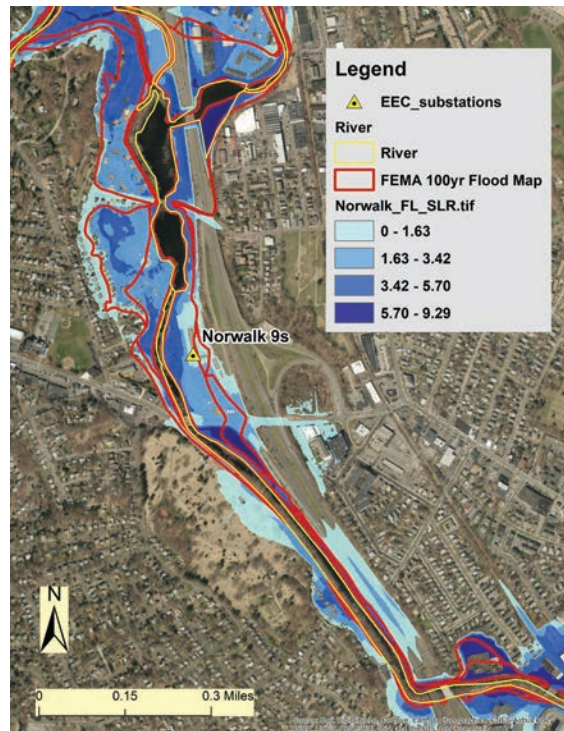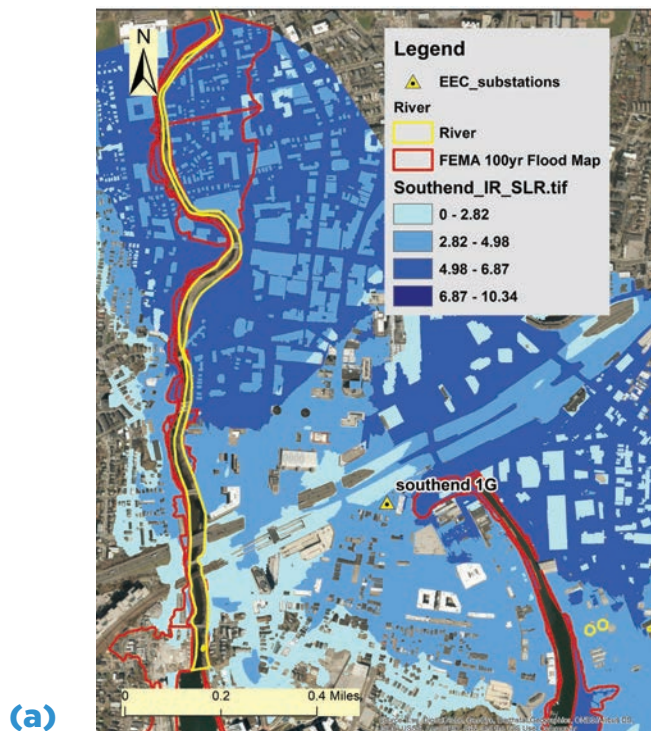
Demonstration of the final flood vulnerability of two example substations on the southwest coast of Connecticut. Panel (a) delineates the maximal inundation extent and depth around South 1G station during Hurricane Irene, which hit the east coast in August 2011 and brought devastating flooding to the community, with water about three feet deep at the substation. Panel (b) shows the same thing around Norwalk 9S station during hypothetical Hurricane Florence, which was supposed to hit the New England coast in September 2018 but, luckily, did not happen.

Grid Resilience

Total System Assessment Informed by Soil Vulnerability Maps

Many different options are available to increase the resilience of the overhead electrical distribution system in the wake or anticipation of severe weather or security events. These include trimming trees near power lines, installing stronger poles, and improving the design of electricity distribution systems, among others. The question is, which of these methods is most cost effective in reducing power outages? To provide answers, our UConn team is developing a physics-based total system assessment (TOSA) modeling framework, using a series of databases that include information on observed or predicted weather and the condition of the physical soil–pole–wire system.

The TOSA model is used to link power outages with extreme-weather variables. Weather uncertainties and topographical data are included in the calculation. The goal is to find the best ways to reduce power outages while taking into consideration the costs of pole hardening and vegetation management strategies. The TOSA model is also provided with information about the soil and the physical characteristics of the pole–wire system, as well as environmental data, such as the intensity of wind gusts. Sensitivity analysis is carried out to evaluate the key influences on soil conditions so detailed soil parameters based on geographic information system (GIS) mapping can be further integrated. These soil parameters enhance the TOSA model's assessment of the fragility of

the pole–wire system to improve outage prediction and determine the option providing the most resilience.

The results TOSA generates will support solutions to the problem of power outages that account for power demand, power supply, grid structure, climate, population growth, business value and economic impact, and soil behavior, while meeting the challenges of business and engineering constraints, such as limited availability of capital, utility crews, and equipment. With this support in the management of its power grid assets, Eversource will be able to make the best possible decisions for enhancing the resilience of its power systems, to the benefit of the people of Connecticut and other New England states. ●
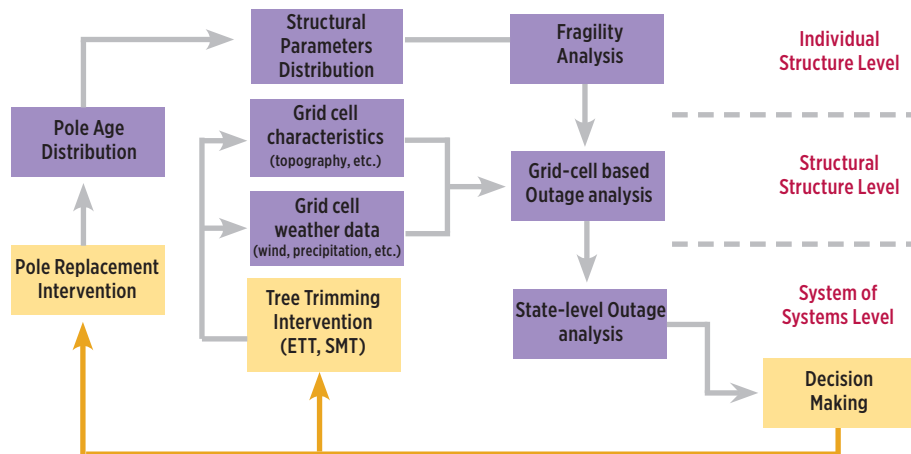

The TOSA model in schematic form. The diagram shows the interplay among different datasets and processes in the model.

Outage reduction prediction as a result of updating poles. The graph shows the effect on predicted outages due to severe weather of delaying the replacement of aging poles in the state, based on a synthetic Sandy storm event. Delaying pole replacement from 10 to 20 years, for example, is expected to require increasing the proportion of poles replaced from 14 to 30 percent (more than doubling it) to bring about the same level of outage reduction.
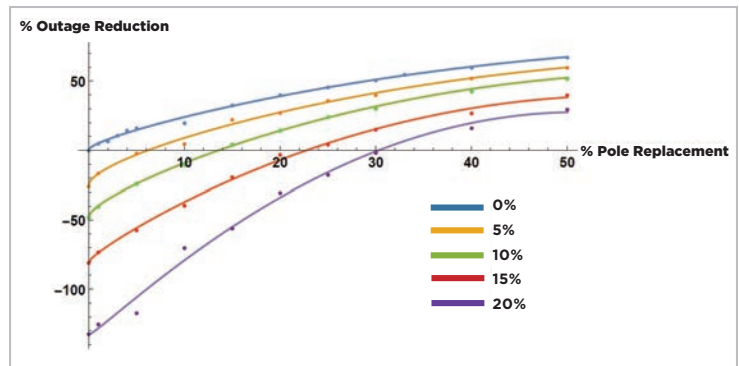
Outage reduction prediction as a result of percentage of ETT activities. The graph indicates the predicted effect on outage reduction of enhanced tree trimming (ETT) activities in the state. Increasing ETT to beyond 30 percent, for example (more than doubling it), produces a very modest increase in outage reduction, from 65 to 85 percent.
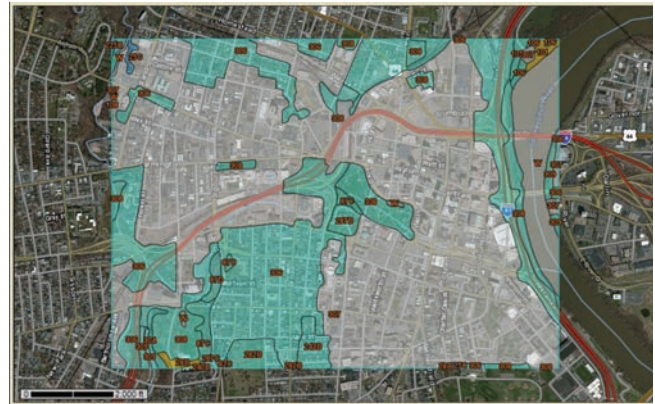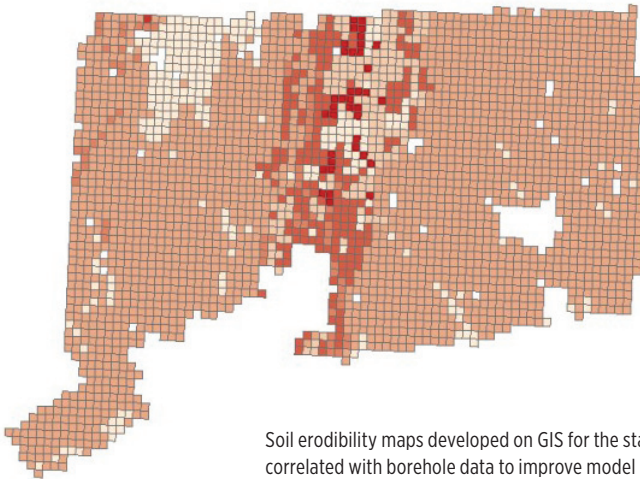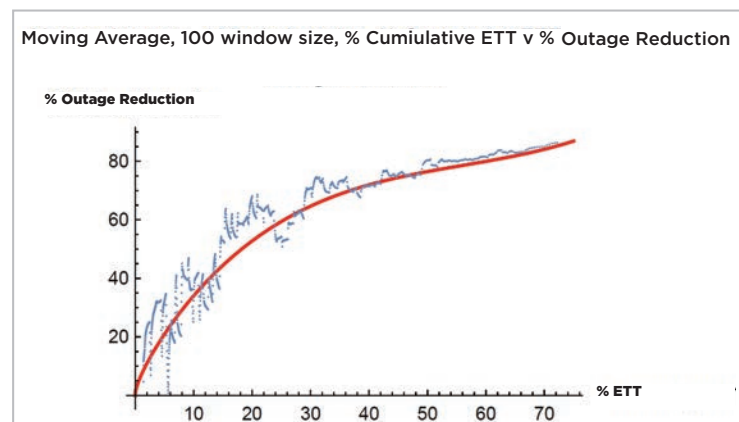
Soil erodibility maps developed on GIS for the state and the Hartford area. These maps are being correlated with borehole data to improve model parameters. This will allow analysis of soil–pole fragility based on a model of a two-span, typical pole-wire system, with pole height 12 meters above the ground, burial depth of 2 meters, and span of 61 meters.

Grid Modernization
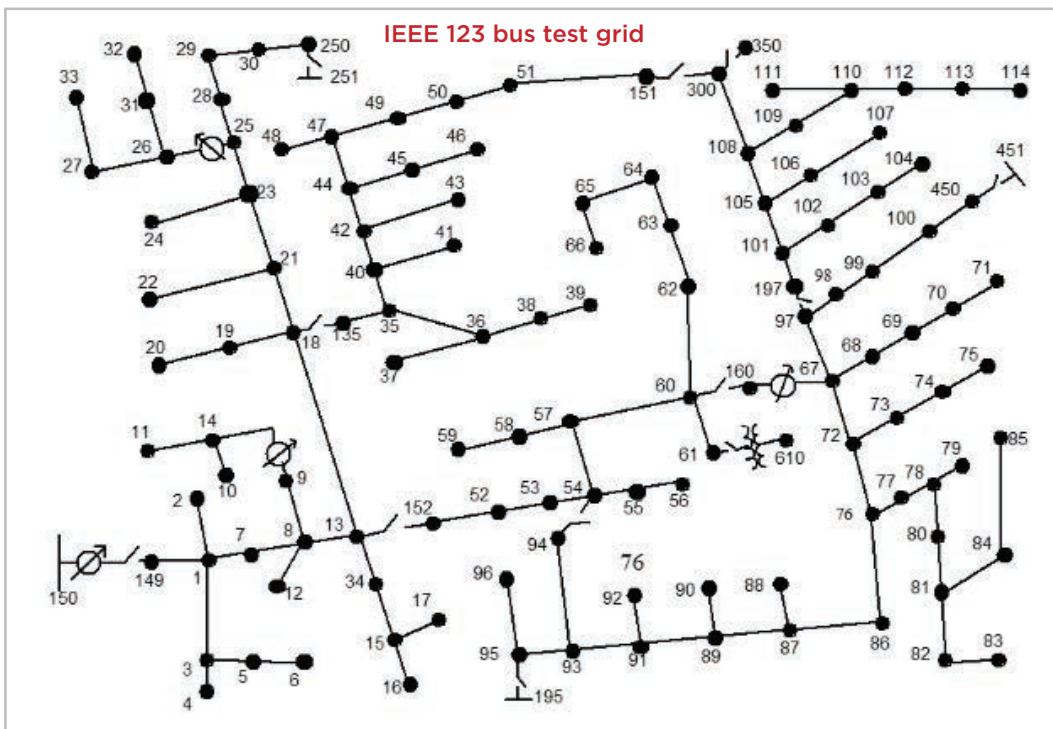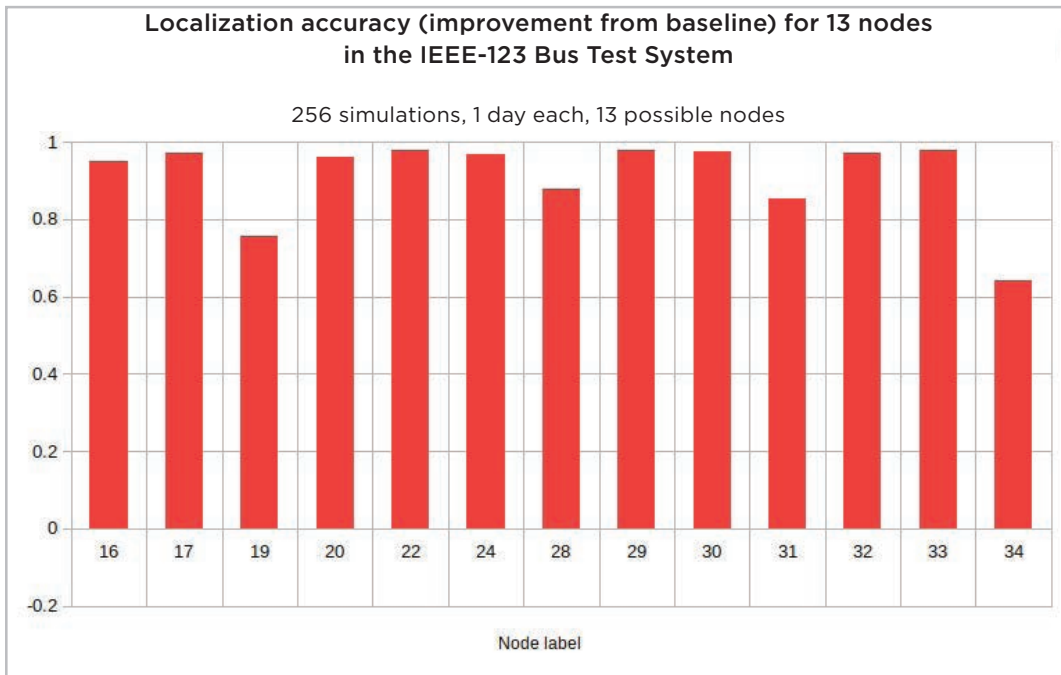
Meeting the Botnets Challenge

The Eversource Energy Center conducts research on many dimensions of grid modernization. In the past year, a new focus has emerged on cybersecurity research, with the goal of protecting our power grid against any cyber threats that may arise.

Smart "Internet of things" devices, such as smart phones, smart thermostats, and digital assistants like Siri and Alexa, have a long history of security vulnerabilities. Attackers hack devices en masse to build "botnets"—networks of computers infected with malware that allows them to be remotely controlled. No longer limited to the cyber domain, the growing market for high-wattage smart devices has allowed botnets to evolve so that an Internet-based adversary, controlling a network of such devices, can attack electric utility grids.

IEEE 123 bus test grid

The diagram shows the distribution of power flows through the grid to consumers. "Eavesdropping" on the power grid can provide data on power loads to the different nodes, which a would-be cyber intruder can then analyze to determine how and when to manipulate the power loads through the botnet.

Localization accuracy (improvement from baseline) for 13 nodes in the IEEE-123 Bus Test System

256 simulations, 1 day each, 13 possible nodes

Node label

Researchers challenge a machine-learning algorithm to identify which of thirteen nodes in the test grid (represented by the red bars in the chart) are vulnerable to manipulation by the intruder, making it possible to ward off the manipulation. The chart shows the percentage improvement produced by the new method over the baseline method for each of the thirteen nodes.

Through the use of these so-called "power botnets," an attacker can remotely control critical components in utility substations, wearing them down so they need to be replaced years earlier than normal. Such hardware damage is expensive for utilities and can lead to sustained outages for the customers supplied by the targeted substations. UConn cybersecurity researchers, in tandem with experts from Eversource, have been developing mechanisms that show promising ability to detect whether these attacks are occurring and locate which parts of the grid they are coming from, making it possible to defend against them.

In 2020, this research will continue, with a focus on Connecticut infrastructure. Using our high-fidelity Eversource Energy Testbed, equipped with real-time simulators and grid topology and data provided by Eversource, we plan to simulate and analyze the impact of attacks against the state's most vital infrastructure. Our findings will lead to the development of technologies that will ward off power botnets, potentially saving electric utilities from millions of dollars in damage and customers from the unnecessary disruption of power outages.●

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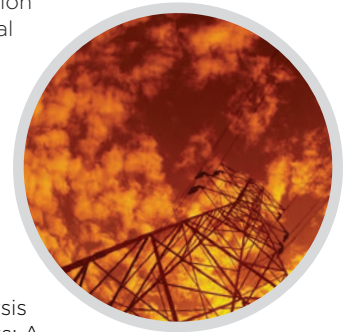
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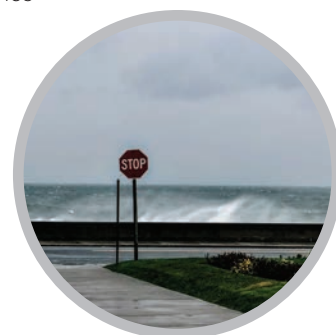
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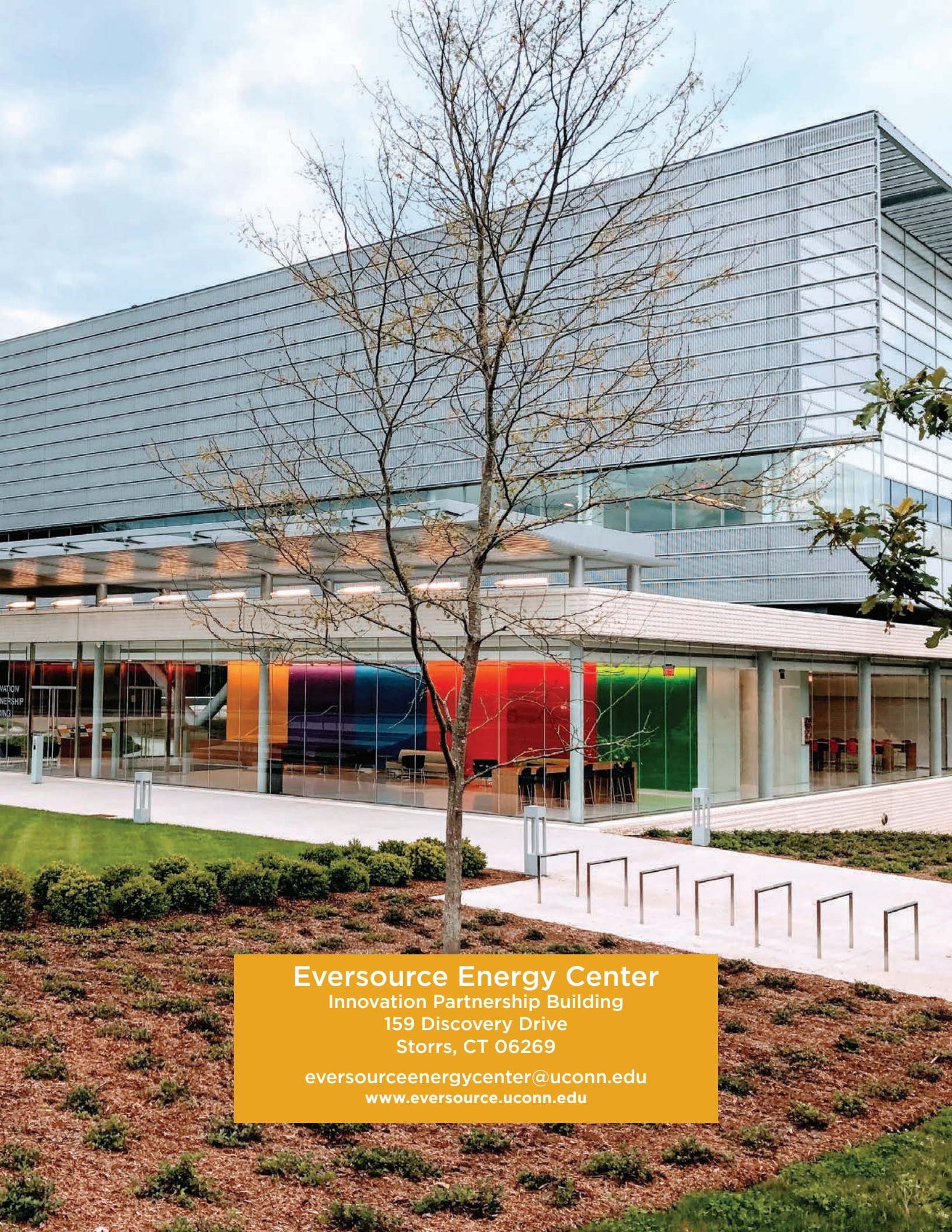
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