APPENDIX G

ENERGY SECURITY, STORM RESILIENCY, AND NEW TECHNOLOGY

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INTRODUCTION

This Appendix will review Connecticut's progress to evaluate, mitigate and respond to the risks facing the electric grid. The focus of the state's response includes energy security, storm resiliency, and new technology to meet today's challenges.

Specifically, the state has pursued a strategy to strengthen the electric grid generally, to better prepare for emergencies in targeted areas, against known and knowable threats. The state is also turning to new technologies in its approach to consider immediate and longer-term solutions to guard against climate change, and meet its environmental, energy diversity, and reliability goals. The Department, in partnership with the gas and electric distribution companies (EDCs), municipalities, and universities, is identifying and assessing various restoration process improvements and electric system resiliency. However, additional critical work to improve preparedness and training, restoration performance, management and communications, and infrastructure hardening needs to continue. In this Appendix, the following specific areas are assessed:

- *Energy Security:* ensuring a secure and reliable energy delivery system for customers, through improved cybersecurity and microgrids.
- *Storm Resiliency:* hardening the electricity delivery system against major weather events with improvements to vegetation management, structures, and substations; improving emergency responsiveness through geographic information systems.
- *New Technology:* creating a cleaner, more robust, more efficient grid through "Smart Grid" technologies, alternative fuel vehicles, and energy storage.

ENERGY SECURITY

Cybersecurity

While public awareness of national vulnerability to cyber-attacks is increasing, more focus and attention to this area is warranted. The growing complexity of power systems and networks, increased use of internet-based communication and rapid globalization are leading to serious vulnerabilities in our electric grid today. A cyber-attack could shut down major electric systems, disrupt gas supplies, interrupt telecommunications and water systems, and ultimately destabilize an entire region. All of these risks have cascading effects that could cause catastrophic events that disrupt people's lives, impact national security, and hurt our economy.

The complexity of the energy supply system requires sophisticated cyber infrastructure to operate reliably and efficiently. The use of emerging energy infrastructure technologies such as smart meters, electric vehicles, distributed generation, and microgrids is growing. While these applications enhance our energy supply system in many ways, they also increase the magnitude of a potential cyber disruption. These technologies are increasingly automating utility functions, incorporating two-way communications, and are often connected to the Internet or other computer networks. Systems requiring enhanced cybersecurity include information technology

(IT) systems, supervisory control and data acquisition (SCADA) systems, and smart grid systems. The ever-increasing use of complex technology creates more vulnerabilities and threats whether the threats are unintentional technology failures or intentional attacks on energy infrastructure.[1] Meanwhile, cyber-attacks on utility infrastructure are known to be trending upward. In 2012, reported cyber-attacks on utility sector control systems increased more than 50% over the previous year.[2] The Department of Homeland Security (DHS) reported in 2012 it saw an increase of 68% in cyber-incidents involving Federal agencies, critical infrastructure, and other select industrial entities.[3]

Federal and Regional Efforts in Cybersecurity

During the 2013 congressional session, 40 different cyber security bills were introduced, including the Grid Cyber Security Act, all of which failed due to conflicts over privacy issues and understanding of private/public networks. Many of these bills would have increased information sharing among federal agencies and industry to address cyber threats. There was success in establishing the Office of Energy Infrastructure Security within the Federal Energy Regulatory Commission (FERC) in 2012 to facilitate information sharing related to both physical and cyber threats to energy facilities. FERC Commissioner Philip Moeller recently discussed the need for swift action in the event of a cyber or physical attack on the power grid. According to Moeller, emphasis needs to be placed on a rapid recovery after an attack rather than on only attack prevention. This change in focus reflects the assumption that an entity will be successful in attacking the system and causing crippling damage.

Much of the focus of cybersecurity within the electricity industry focuses on developing security standards. On the federal level, the North American Electric Reliability Corporation (NERC), the electric reliability organization certified by FERC, has created standards and guidelines concerning cyber infrastructure that the electric distribution companies must comply with. On the regional level, the Northeast Power Coordinating Council (NPCC) develops regional reliability standards, including cybersecurity standards, and provides compliance assessment and enforcement of both NERC and regional reliability standards.

FERC and various electric industry groups have also issued recommendations to enhance physical security at critical facilities. Some of these security enhancements are under FERC authority and therefore their costs will be recovered in transmission rates. Others are under the scope of PURA and will be recovered in electric distribution company rates.

NERC issues Critical Infrastructure Protection Standards (CIP), which contain both cyber and physical security requirements for the bulk electric system. CIP Version 3 requirements are currently in effect. CIP Version 4 requirements became effective October 2014, and CIP Version 5 requirements are under FERC review and expected to be effective in early 2016.

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1 EPRI's December 2012 report, finding that the deployment of AMI technology significantly increases the attack surface that utilities have to protect, available at http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001026553.

2 Ahren Tryon, Cozen O'Connor, "Industry Wide Cybersecurity Standards Emerging Through Voluntary Framework," Electric Light and Power, June 12, 2012.

3 Edward Markey and Henry Waxman, "Electric Grid Vulnerability: Industry Responses Reveal Security Gaps," May 21, 2013.

The EDCs in Connecticut work closely with NERC and federal agencies to implement these standards and other cybersecurity enhancements across their infrastructure. This includes coordination with FERC, the Department of Homeland Security (DHS), and the Department of Energy (DOE), as well as assistance received from federal intelligence and law enforcement agencies.

In addition to the development of standards, federal agencies are leading collaborative projects targeting best practices. The National Electric Sector Cybersecurity Organization Resource (NESCOR), for example, serves as an important tools for utilities developing risk assessments, planning, procurement, training, tabletop exercises and security testing. These three cybersecurity failure scenarios and impact analyses documents list common mitigations used by utilities in order to give utilities a manageable set to use, in contrast to assessing hundreds of mitigations. Similarly, the DOE has lead an effort with the DHS that create an Electricity Subsector Cybersecurity Capability Maturity Model (ES-C2M2) designed to assist utilities in improving cybersecurity, benchmark their success against other utilities, and prioritize cybersecurity actions and investments.

NERC is also assisting in preparing the electric grid for such risks. NERC conducted its second grid security exercise on November 13-14, 2013. "GridEx II" is a scenario created as a learning event for the electricity industry and allows organizations to do real-world training so that existing communication paths that include regional entities can be used as they would be in a real event. The simulation exercise plays out a fictional cyber and physical attack on the electric grid and measure the response of various participating entities. GridEx II will foster and enhance relationship-building in the industry. It also allows organizations to stress-test their incident response plans. The ISO New England (ISO-NE) participated in this event. The exercise allows participants to follow and react to external cues and actions as they unfold and identify shortcomings or gaps in response activities.

Other Industry Efforts in Cybersecurity

In the natural gas industry, trade organizations offer local distribution companies (LDCs) guidance regarding cybersecurity. For example, the American Gas Association (AGA) produced its Report No. 12 "Crytographic Protection of SCADA Communications" to aid natural gas companies in protecting against cyber threats. The Edison Electric Institute (EEI) has also developed tools for utilities such as its Threat Scenario Project and Resiliency Self-Assessment Tool.[4] The National Association of Regulatory Utility Commissioners (NARUC) has developed a primer on cybersecurity so that regulators can better understand industry efforts.[5]

In addition to industry-specific cybersecurity measures, several groups help to enhance cybersecurity generally. The Information Systems Security Association, a global not-for-profit organization of IT security professionals, and InfraGard, an information sharing and analysis effort between the FBI and private sector, both have chapters in Connecticut to help protect our cyber systems and infrastructure.

[4] Lewis Hay II, "Meeting the Cyber Security Threat," Electric Perspectives, January/February 2013.

[5] Miles Keogh and Christina Cody, "Cybersecurity for State Regulators," The National Association of Regulatory Utility Commissioners, February 2013.

Connecticut's Efforts in Cybersecurity

Although much of the cyber infrastructure protection is left to the owners and operators of such infrastructure, Connecticut must continue to participate in cybersecurity improvements. The state is taking measures both to prevent a cyber-attack and to respond effectively should an attack occur. For example, the Connecticut Division of Emergency Management and Homeland Security (DEMHS) is in the process of enhancing its cyber disruption response team. Further, PURA has examined the cybersecurity policies of the public service companies serving Connecticut, as discussed below.

In 2010, the former DPUC (currently, PURA) opened Docket No. 10-11-08 to investigate the state's public service companies and licensed electric and telecommunications service providers' cybersecurity principles, policies and practices employed to protect their respective infrastructure and computer networks from cyber-attacks. In that docket, the EDCs and LDCs expressed confidence in their own preparedness and internal cybersecurity efforts, and the efforts of various organizations involved in cybersecurity.[6,7,8,9] In responses to interrogatories, Eversource and Yankee Gas Services Company (YGS) had no recommendations regarding how PURA could assist them with cybersecurity, nor did they see a benefit in PURA organizing a cybersecurity utility working group. With respect to the same issues, United Illuminating (UI), Southern Connecticut Gas Company (SCG), and Connecticut Natural Gas Corporation (CNG) suggested that PURA facilitate a semi-annual meeting between PURA staff, other utilities, and themselves to discuss best practices and longer-term evolving threats/concerns.

In accordance with the 2013 Comprehensive Energy Strategy (CES), PURA is working in conjunction with other relevant state agencies, to conduct a review of Connecticut's electricity, natural gas, and major water companies to assess the adequacy of their capabilities to deter interruption of service. A report including recommended actions to strengthen cybersecurity was submitted to the Governor and General Assembly in April, 2014. In the April 14, 2014 report, PURA identified a number of questions that need to be addressed. PURA' s Docket No. 14-05-12 is intended to address those questions and produce a set of compliance standards and oversight procedures to strengthen the State's cybersecurity defense capabilities. Overall, PURA is carefully examining the cybersecurity needs of the state's utilities to determine the best approach to energy assurance with respect to critical cyber systems. The continuing efforts of PURA will help to ensure the state's energy supply systems are well-protected.

Both UI and EVERSOURCEEVERSOURCE work hand-in-hand with various agencies as well as with industry organizations such as EEI and the American Gas Association (AGA). The collaboration among these organizations and various federal agencies provide the EDCs with a big-picture view of threats and risk facing the industry.

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6 CL&P and YGS submitted joint filings for the cyber security docket.

7 UI, SCG, and CNG submitted joint filings for the cyber security docket.

8 *See generally* CL&P/YGS and UI/SCG/CNG Responses to Interrogatories accessible in Docket No. 10-11-08, available at http://www.ct.gov/pura/docketsearch.

9 Various organizations referenced in the interrogatories include: Edison Electric Institute, Utilities Telecom Council, Electric Power Research Institute, Electricity Sector-Information Sharing and Analysis Center, among those previously mentioned (ISSA, US-CERT, InfraGard, NERC, NPCC, and AGA).

When factoring in these threats, UI utilizes state-of-the art security technology and services to provide defenses against the most current threats and vulnerabilities. Cybersecurity is a company-wide initiative that is supported from the CEO down. There will be a continued investment in intelligence gathering, technology and education through the company to keep UIL as secure as possible.

Northeast Utilities also has a well-developed cybersecurity program. In a recent audit performed by the Northeast Power Coordinating Council (NPCC), the audit team concluded NU "has a robust compliance culture," and was so satisfied they had no suggestions for improvement.[10] Northeast Utilities' NERC Reliability Compliance Officer Committee (NRCOC) has been established to ensure compliance with NERC and regional reliability standard requirements.

Challenges in Cybersecurity

Information-sharing is the biggest issue faced by the electricity industry with regards to cybersecurity. For example, information with security clearance requirements from federal agencies can make it challenging to compile "actionable" information. Cybersecurity data comes not only from federal agencies but also from all the organizations listed above: state agencies, trade associations, utilities or other industry stakeholders. There have been many calls for greater information-sharing and collaboration across these groups. Each group provides valuable insight into their perceptive and experience that is needed to create a top level view of the threats. Information-sharing needs to cover both data on the growing threat as well as sharing of best practices as they are established. More streamlined and effective information sharing channels and procedures would help cybersecurity efforts immensely.

Another barrier to improved data on threats utilities face is their reluctance to divulge the frequency of which their infrastructure is attacked. Recognizing this growing threat, Senators Edward J. Markey and Henry A. Waxman surveyed 150 investor-owned utilities (IOUs), municipally-owned utilities, rural electric cooperatives, and federal entities, allowing them to comment anonymously. Of the 60% that responded, more than a dozen utilities reported "daily," "constant," or "frequent" attempted cyber-attacks.[11] Developing new methods for collecting this data could help refine our understanding of true threat utilities face.

[10] "Reliability And Critical Infrastructure," Northeast Utilities Website, accessed November 11, 2013.

[11] Edward Markey and Henry Waxman, "Electric Grid Vulnerability: Industry Responses Reveal Security Gaps," May 21, 2013.

Recommendations on Cybersecurity

The Department acknowledges that there is still much to learn before the state can ensure it is well-prepared to respond to cyber threats, and believes it would be fitting that both policymakers and the utilities to take full advantage of lessons learned and strategies prepared by experts in this field. The Department also notes that there are several models and guides that utilities should take advantage of in addition to the NESCOR tools. Because of the changing threats and technologies, more study by stakeholders across the industry is needed to identify the best approaches, and these efforts should be continuous.

There is also a need for greater implementation of voluntary NERC recommendations. Many utilities only comply with mandatory cybersecurity standards, which may not always be enough to cover the threat they face. The Executive Order on Improving Critical Infrastructure Cybersecurity released in 2013 will lead to the development of further voluntary standards for cybersecurity that may provide the industry with additional guidance.

Finally, DEEP should continue to assess cybersecurity threats and defenses to better understand how vulnerable utilities are and what kinds of defenses are technically feasible. DEEP's Grid Modernization proceeding will enable DEEP to pursue this discussion and probe the commitment of the electric utilities as far as what the latest strategies and implementation plans are being utilized. Such an assessment is very important given the potential size of the threat, the incomplete state of knowledge of the threat, and the likelihood that sufficient defenses are not currently in place. PURA should also continue its own dialogue with the utilities and prepare to present its findings in the new year.

Microgrids

A microgrid is a distributed resource island system. A microgrid is able to disconnect and/or run parallel with the distribution system. In other words, the microgrid can perform instead of the utility grid or during emergency or outage situations. It is a mini-electric grid.

Public Act 12-148 provides a legislative framework for a state-wide microgrid program and outlines Connecticut's commitment to invest in grid reliability. In accordance with other provisions in the Act, DEEP launched a pilot program to support the development of some initial microgrids to protect critical facilities like hospitals, public shelters, police and fire stations, water treatment plants, and telecommunications towers[12]. The pilot is testing different distributed generation and microgrids to evaluate the technology for mitigating risks of outages during storms. Microgrids can be designed for standby configuration to operate continuously during outage events on the rest of the system, to provide electricity to critical facilities and town centers.

DEEP conducted its first round of the Microgrid Grant and Loan Pilot Program in 2013. In the first round, DEEP reviewed 36 proposals for potential microgrid projects. Nine microgrid projects, shown in Figure 1, in Bridgeport, Fairfield, Groton, Hartford, Middletown, Storrs, Windham, and Woodbridge were awarded a total of $18 million in funding primarily through the

[12] Connecticut Public Act 12-48, "An Act Enhancing Emergency Preparedness," (2012), available at http://www.cga.ct.gov.

DEEP Microgrid Pilot Program.[13] The total funding for the two-year pilot of $30 million was recommended by Governor Malloy and authorized by the General Assembly to provide critical services during emergencies or outages.

DEEP conducted the second round of Microgrid Program in 2014. The second round incorporates many of the lessons learned from the Pilot round. For the second round DEEP received five proposals. The projects were required to be cost-effective to implement; ensuring that only projects that offer the most benefit to municipalities receive financing as part of any future State microgrid program. In rounds going forward, DEEP's goal is to leverage as much of private funding as possible to build microgrid projects reducing the costs supported by ratepayers. In round two, only two proposals met all the Stage One Threshold Review Criteria and moved to the Stage Two review. Both projects were ultimately awarded grants for a total of $5.1 million. DEEP continues to address its lessons learned and is refining its program in response to outreach sessions it has conducted with stakeholders.

Figure 1
Microgrid Grant and Loan Pilot Program
First Round Results

Project	Facilities	Generation	Grant Value
UConn Depot Campus/Storrs	Campus Buildings	400 kW fuel cell, 6.6 kW PV	$2,144,234
City of Bridgeport-City Hall/Bridgeport	City hall, Police Station, Senior Center	(3) 600 kW natural gas microturbines	$2,975,000
Wesleyan/Middletown	Campus, Athletic Center (Public Shelter)	(1) 2.4 MW and (1) 676 kW Natural Gas Combined Heat and Power Reciprocating Engine	$693,819
University of Hartford-St. Francis/Hartford	Dorms, Campus Center, Operation Building	(2) 1.9 MW diesel (existing), 250 kW diesel, 150 kW diesel	$2,270,333
SUBASE/Groton	Various Buildings and Piers	5 MW cogen turbine, 1.5 MW diesel	$3,000,000
Town of Windham/Windham	2 Schools (Various Public Purposes)	(2) 130 kW natural gas, 250 kW solar, 200 kWh battery; (2) kW diesel,	$639,950
Town of Woodbridge/Woodbridge	Police Stations, Fire Station, Department of Public Works, Town Hall, High School, Library	1.6 MW natural gas, 400 kW fuel cell	$3,000,000
City of Hartford-Parkville Cluster/Hartford	School, Senior Center, Library, Supermarket, Gas station	600 kW natural gas	$2,063,000
Town of Fairfield-Public Safety/Fairfield	Police Station, Emergency Operations Center, Cell Tower, Fire Headquarters, Shelter	50 kw natural gas recip engine, 250 kW natural gas recip engine, 27 kW PV, 20 kW PV	$1,167,659

Microgrids can be configured to include emergency generation and should have the fuel supply needed to operate through a long outage. New backup standards, such as designing for longer operational independence during main grid outage or requiring regular testing or minimum fuel supplies for existing backup systems, can bolster resilience. Over the long-term, distribution-

[13] http://www.governor.ct.gov/malloy/cwp/view.asp?a=4010&Q=528770

level resiliency can be enhanced by smarter, more distributed, or otherwise novel grid architectures, including microgrids.[14]

Barriers to Microgrids

There are many technical, operational, and economic challenges with implementing microgrids. Regarding the technical and operational challenges, a "microgrid" requires "micro-operators" – persons responsible for ensuring overall power quality to customers while the microgrid is islanded from the rest of the distribution system. The island's power quality can only be ensured through a complex system of measurement and communications equipment and engineering applications to ensure system stability, voltage control, and frequency control. The microgrid also requires security systems and ongoing maintenance.

To achieve high reliability during an extreme weather event; the following must be taken into account in addition to the technical and operational considerations:

- Facilities serving the microgrid are most reliable if constructed underground.
- The microgrid must provide adequate and reliable generation.
- Generators should have access to an uninterruptable fuel sources.
- Generators must possess "black start"[15] capability.
- A microgrid system must be able to follow sub-hourly, hourly, and daily fluctuations in load.

Microgrids also have some economic challenges, many of which are not yet fully understood. As systems built to benefit specific locations, the cost and reliability impacts on microgrid versus non-microgrid customers need to be carefully considered. Also, there may be a significant diseconomies of scale tradeoff to enhancing energy security through microgrids. Thus, it is important to balance the costs versus benefits (including reliability benefits) of any microgrid system. Finally, there are uncertainties in the costs of ongoing microgrid maintenance and major capital requirements as the system ages. These costs could be significant, and should be carefully considered.

Utility Efforts and Role in Microgrid Development

The EDCs will work with municipal grant recipients to ensure that microgrids are built in a safe and reliable manner, and follow Connecticut Interconnection Procedures. The microgrid owner and utility will enter into an Operation Agreement that will define the roles and responsibilities for the installation, operation and maintenance of the microgrid during normal and abnormal system conditions. The EDCs will coordinate protection with grid distribution system infrastructure through this program.

[14] 2013 Comprehensive Energy Strategy for Connecticut, Connecticut Department of Energy and Environmental Protection. February, 19, 2013. Page 102, available at http://www.ct.gov/energystrategy.

[15] Generators capable of black-start can go from offline to online without an initial external power source.

The report, the fourth edition of Navigant Research's Microgrid Deployment Tracker, identifies at least 405 microgrid projects that are currently planned, proposed, under development, or fully operating. Pike Research has identified a total of 3.2 GW of total microgrid capacity throughout the world, up from 2.6 GW in the previous update in 2Q 2012. Total numbers of new project entries was 67, representing an increase of 571 MW or a 22% increase in identified capacity within a 6 month period. Several additional microgrids are in the planning stages.[16] Besides these existing projects, other states including Massachusetts, Maryland and New Jersey have actively begun to emulate Connecticut's program. Connecticut recently received a national award from the Clean Energy States Alliance as one of the outstanding clean energy programs of 2014.[17]

Recommendations on Microgrids

Microgrids are a rather new technology being implemented across the world. As the projects are being installed and operated, there will be challenges encountered and lessons learned. The Department thanks the EDCs for their willing support of the DEEP microgrid programs offered. DEEP understands the need to develop microgrid standards and guidelines with the help of the EDCs. DEEP's subsequent rounds will incorporate lessons learned internally as well as the feedback received from our outreach sessions.

STORM RESILIENCY

DEEP notes that the Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) jointly issued a report, titled, " U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather" (2013 DOE/NREL report). This comprehensive report states increasing temperatures, decreasing water availability, more intense storm events, and sea level rise will each independently, and in some cases in combination, affect the ability of the United States to produce and transmit electricity from fossil, nuclear, and existing and emerging renewable energy sources.

According to DOE, the key findings of the report include: establishing a more climate-resilient energy sector requires improved technologies, information to support decision-making, effective stakeholder engagement, and an enabling policy framework. Specifically, the report highlights the following action items:

- The pace, scale, and scope of combined public and private efforts to improve climate preparedness and resilience of the energy sector will need to increase given the magnitude of the challenge.

- Some practices and technologies are already improving resilience to climate change, including deployment of dry cooling technology for thermoelectric power plants, more energy-efficient building technologies, and storm-hardened energy infrastructure.

[16] Navigant Research. More information at http://www.navigantresearch.com/newsroom/more-than-400-microgrid-projects-are-under-development-worldwide.

[17] See "2014 Leadership in Clean Energy Awards: Outstanding Programs Found Here," available at http://www.cesa.org/resource-library/resource/cesa-state-leadership-in-clean-energy-awards-outstanding-programs-found-here.

- The federal government plays a key role in researching and developing technologies and providing information to promote climate resilience, but enhanced private sector, state and local government, and non-governmental engagement is also essential to these efforts. [18]

Shortly after the release of the 2013 DOE/NREL report, the Office of the President issued its own report concerning, "Economic Benefits of Increasing Electric Grid Resilience To Weather Outages." This report is limited in its scope to estimating the annual cost of power outages caused by severe weather between 2003 and 2012. The President's report: recognizes that severe weather is the leading cause of power outages; estimates the U.S.-wide cost of weather-related outages to be $18-33 billion annually; estimates the 2012 cost, driven by Superstorm Sandy, to be $27-52 billion; expects the number of outages due to severe weather to increase over time, driven by climate change.[19]

Both of these reports capture the heightened concern surrounding the vulnerabilities most states now face due to the increasing occurrences of extreme weather events including; "super storms", heat waves, droughts and floods. Given the physical and economic impact of these events, it is incumbent upon government leaders, policy makers, regulators, utilities, city/local planners, building inspectors, insurance and public health related organizations, to name a few, to form public and private partnerships to better address the strategies that need to be in place to mitigate and prevent the damage of such events.

Connecticut Storm Resiliency

Connecticut has been impacted by three storms in the past few years that have led to record numbers of residents without electricity, communication, heat or reliable supplies of water.

1. Tropical Storm Irene – 800,000 customers without power in 2011
2. October Nor'easter – 880,000 customers without power in 2011[20]
3. Hurricane Sandy –856,184 customers without power in 2012[21]

These storms have been more frequent and impacting compared to Hurricane Gloria in 1985 with 506,150 outages. The climate trends tend to suggest that Connecticut will be impacted more by storms. The two storms in 2011 were the first in a while to impact the state. This led to policy changes and recommendations by PURA, Legislature, Connecticut's Electric Distribution Companies, municipalities, and Connecticut residents. Below is a comprehensive list which includes many of the regulatory reviews that conducted in response to the storms.

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[18] U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather. U.S. Department of Energy's Office of Policy and International Affairs (DOE-PI) and the National Renewable Energy Laboratory (NREL) http://www.energy.gov/sites/prod/files/2013/07/f2/20130716-Energy%20Sector%20Vulnerabilities%20Report.pdf. July 2013.

[19] Executive Office of the President, Economic Benefits of Increasing Electric Grid Resilience to Weather Outages, August 2013. Available at http://www.energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf.

[20] Report of the Two Storm Panel, available at http://www.governor.ct.gov/malloy/lib/malloy/two_storm_panel_final_report.pdf.

[21] PURA Docket No. 12-11-09, available at http://www.ct.gov/pura/docketsearch.

The Governor's Two Storm Panel Commission Report: The report contained 82 recommendations on a wide variety of topics, with subjects ranging from utility infrastructure issues to changes that should be considered and implemented at the State level to improve the State's preparedness for the next emergency. [22] The two-storm panel concluded that 90% of the outages created during Tropical Storm Irene and Superstorm Sandy were related to trees. Tr. at 1861.[23]

Docket No. 11-09-09: *PURA Investigation of Public Service Companies' Response to 2011 Storms:* As part of PURA's review of the performance of the electric distribution companies following the 2011 storms in Docket No. 11-09-09, UI was required by the Authority to "track all recommendations from all reviews of the 2011 storms, including the Liberty Report." The Authority directed UI to either implement each recommendation or provide the Authority with a justification for not doing so.[24] In total, 127 recommendations applied to UI.40 Tr. at 2661.[25]

Docket No. 12-06-09: *PURA Establishment of Industry Performance Standards for Electric and Gas Companies*: Pursuant to Public Act 12-148, PURA reviewed (i) practices concerning service restoration after an emergency, (ii) restoration management after any emergency, (iii) planning for at-risk and vulnerable customers, (iv) policies concerning communication with state and local officials and customers, including individual customer restoration estimates and the timeliness and usefulness of such estimates, (v) adequacy of each such utility's infrastructure, facilities and equipment, (vi) coordination efforts between each EDC and any telecommunications company, and (vii) tree trimming policies of each EDC.[26]

Docket No. 12-11-07: *PURA Investigation into the Performance of Connecticut's Electric Distribution Companies and Gas Companies in Restoring Service Following Storm Sandy*: In its draft decision, PURA found that the companies performed in a generally acceptable manner in preparing for and responding to the storm and that improvements are necessary in certain areas. PURA ordered the companies to make such improvements to their policies, practices and procedures, and to provide the PURA with status reports on their implementation.[27]

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22 http://www.governor.ct.gov/malloy/lib/malloy/two_storm_panel_final_report.pdf.

23 Brief of the United Illuminating Company, Application of the United Illuminating Company to Increase its Rates and Charges, PURA Docket No. 13-01-19, June 4 2013, available at http://www.ct.gov/pura/docketsearch.

24 Docket No. 11-09-09 Decision, Order 15, available at http://www.ct.gov/pura/docketsearch.

25 Copied from: Brief of the United Illuminating Company, Application of the United Illuminating Company to Increase its Rates and Charges, PURA Docket No. 13-01-19, June 4 2013, available at http://www.ct.gov/pura/docketsearch.

26 Copied from: Brief of the United Illuminating Company, Application of the United Illuminating Company to Increase its Rates and Charges, PURA Docket No. 13-01-19, June 4 2013, available at http://www.ct.gov/pura/docketsearch.

27 PURA Docket No. 12-11-07, PURA Investigation into the Performance of Connecticut's Electric Distribution Companies and Gas Companies in Restoring Service Following Storm Sandy, August 21 2013, available at http://www.ct.gov/pura/docketsearch.

Energy Assurance Plan: The 2012 Energy Assurance Plan ("EAP")[28] for Connecticut presents a comprehensive overview of the ongoing efforts within Connecticut to enhance the State's energy system reliability and resiliency and energy emergency response. The EAP addresses the ongoing activities and efforts by the State and other stakeholders in place to prepare for, respond to, recover from, and mitigate the effects of a potential or actual energy supply disruption event that poses a threat to the health, safety, or welfare of Connecticut's citizens.

Challenges in Storm Resiliency

The recent three storms demonstrated Connecticut's need to continually improve critical energy infrastructure and enhance energy system resiliency to prevent or mitigate future energy supply disruptions. The above referenced decisions, recommendations and policy changes improved efforts and communication based on PURA's array of investigations and proceedings. While no energy system is 100% damage-proof, continually making improvements on storm response will better prepare the state for future storms and increase the systems reliability.

The EDCs are continually assessing their vegetation management, pole hardening, substation reinforcement, and GIS data collection systems to improve their reliability.

Vegetation Management

Connecticut is known for its trees along the scenic roads and highways. Connecticut has the distinction of being the 5th most forested state in the nation (72.6%), and leads the nation in the forest cover found in our urban areas (67.4%).[29] There are benefits to trees, but they are a threat to the electric infrastructure during a storm event. The two-storm panel concluded that 90% of the outages created during Tropical Storm Irene and Superstorm Sandy were related to trees. Tr. at 1861.[30] The past storms have shown that vegetation impacts system reliability and system resources for EDCs.

In the Final Report of the State Vegetation Management Task Force, Eversource and UI proposed jointly the Utility Line Clearance Standards. The EDCs propose vegetation management within the "utility protection which is the rectangular area extending horizontally for a distance of eight feet from any outermost electrical conductor or wire installed from pole to pole and vertically from the ground to the sky through a four year cycle." This standard is demonstrated in Figure 2. The existing specification of 12-15 feet above, 6 feet to the side, and 8 feet under would change to cutting, trimming and removal of tree limbs or trees within the utility

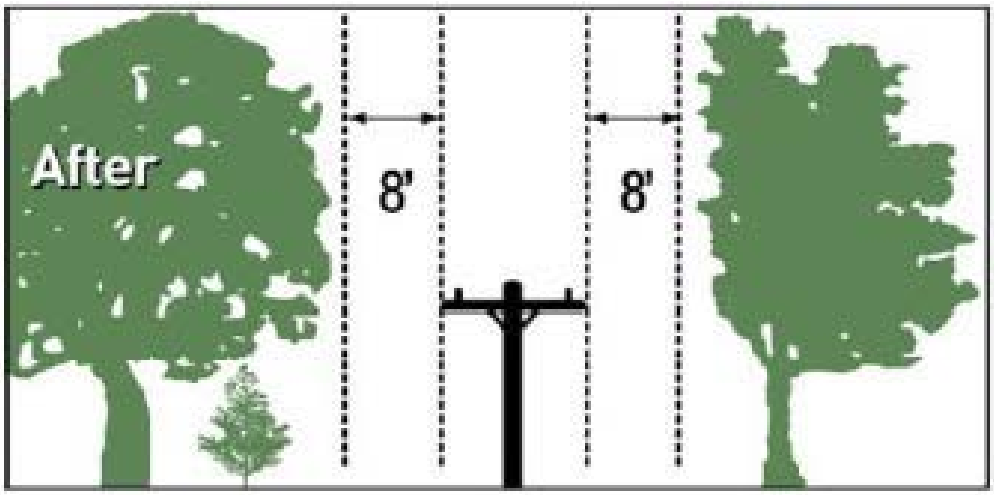
[28] 2012 Energy Assurance Plan (EAP) for Connecticut, available at http://www.ct.gov/deep/cwp/view.asp?a=4120&Q=481702.

[29] State Vegetation Management Task Force Final Report, April 28, 2012, available at http://www.ct.gov/deep/lib/deep/forestry/vmtf/final_report/svmtf_final_report.pdf.

[30] Brief of the United Illuminating Company, Application of the United Illuminating Company to Increase its Rates and Charges, PURA Docket No. 13-01-19, June 4 2013, available at http://www.ct.gov/pura/docketsearch.

protection zone and retaining desirable low height or ornamental trees that are already within the zone or those that are planted under a Right Tree – Right Place program.[31]

Figure 2
Proposed Tree Trim Specification



As part of this effort, UI designed an Enhanced Tree Trimming ("ETT") program that is estimated to reduce the total number of customers affected and total restoration by 25-50% for a Tropical Storm Irene and Superstorm Sandy event.[32]

Similarly, Eversource plans to address the tree-related outages from severe weather events through both its maintenance tree trimming program and its enhanced tree trimming/tree program. In its January 16, 2013 Decision in Docket 12-07-06, PURA allowed Eversource enhanced tree trimming costs of $25-$34 million annually for the annually for the years 2013-2017 to improve distribution system resiliency.

Challenges in Vegetation Management

Connecticut's dense urban vegetation present challenges in balancing resiliency with vegetation management. As a result of legislative and regulatory actions, renewed efforts have been undertaken to resolve issues where conflicts exists in neighborhoods and to improve communications among the utility, its customers and tree wardens in the affected municipalities where tree-trimming is occurring.

[31] State Vegetation Management Task Force Final Report, April 28, 2012, available at http://www.ct.gov/deep/lib/deep/forestry/vmtf/final_report/svmtf_final_report.pdf.

[32] Brief of the United Illuminating Company, Application of the United Illuminating Company to Increase its Rates and Charges, PURA Docket No. 13-01-19, June 4 2013, available at http://www.ct.gov/pura/docketsearch.

Structural Hardening

More frequent and severe wind and ice storms increase the risk of physical damage to electric transmission and distribution infrastructure and can decrease available transmission capacity and lead to power outages. Updating old and damaged poles and structures helps the cause of storm hardening and system resiliency.

During Superstorm Sandy, UI addressed 3,800 tree issues that knocked down wires or poles.[33] Replacement of poles during a storm can delay restoration, so the EDC's are looking at hardening their infrastructure. UI plans on spending $344 million for the years 2013-2018 to replace aging infrastructure including inspect and treat the approximately 87,000 poles for which UI is the custodian.[34]

Eversource has over 700,000 poles in its distribution system, many of which additionally carry appurtenances that support telecommunication and cable attachments. As part of the Company's System Resiliency Program, which was approved by PURA in Docket 12-07-06, the Company plans to spend approximately $100 million from 2014-2017 on structural, electrical hardening and automation of its distribution system. The purpose of the System Resiliency Program is to deliver measurable and sustainable customer service excellence, through significant improvement in infrastructure performance.

As part of the System Resiliency Program, Eversource will select circuits each year to perform hardening work, mainly on the backbone and large laterals, to improve the segments and overall circuit's resiliency to storms. The program will focus on upgrading poles, guy wires, and cross arms to achieve structural hardening. The program will also focus on upgrading conductors, insulators, and electrical connections for electrical hardening. Automation improvements will include smart grid sensors and remote operation devices at substations and remote circuit locations.

Substation Reinforcement

Substation assessment and reinforcement is vital for storm resiliency in "at risk" substations. "At risk" substations are located in flood zones or at low elevations.

In response to outages at five substations due to Superstorm Sandy in 2012, UI dedicated $11 million to make the Congress Street substation and six others like it in Bridgeport and New Haven much less vulnerable to rising waters. Reinforcements will include flood barriers, pumps and water sensors. In addition, the buildings are being sealed up to a certain height and new emergency generators are being installed to power the substations.[35, 36]

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[35] http://www.ctpost.com/local/article/UI-hardens-substations-against-high-water-4682439.php

[36] See description of Sandy disruptions on Page 26 of Draft Decision, PURA Investigation into the Performance of Connecticut's Electric Distribution Companies and Gas Companies in Restoring Service Following Storm Sandy, PURA Docket No. 12-11-07, July 30 2013, available at http://www.ct.gov/pura/docketsearch.

Eversource has developed a short-term mitigation plan that identifies and prioritizes its most critical assets along with reinforcement plan for each. In addition, Eversource is in the process of evaluating a long-term plan to reinforce all substations against storm surges and river flooding, including assessments of potential best-practice mitigation techniques and estimated costs.

Geographic Information Systems (GIS) Data Collection

A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS technology has been utilized in the electric industry to assist in the maintenance and protection of the power system. GIS is becoming essential to understanding what is happening—and what will happen – in geographic space. Once utilities get access to data, it can effectively communicate to its staff and prescribe action. This new approach to management—managing geographically – is transforming the way that organizations, including utilities operate. GIS is widely used to optimize maintenance schedules and daily fleet movements for utility linemen. Currently, both UI and Eversource maintain GIS infrastructure, and have plans to invest in expanded infrastructure.

UI has proposed a Transmission and Distribution Operational Excellence Initiative ("TDOEI") that, if approved, would provide stakeholders with the desired result – technology that will enable faster, more complete and better communication during storms (including estimated restoration times to allow customers, municipalities and all stakeholders to plan their lives during severe storms. Planned improvements include:

a. Customer specific estimated restoration times (ERTs);
b. Timely, accurate and close to real-time information that is updatable and provided to the customer in the medium of its choice;
c. Reasonable global ERT within 48 hours;
d. Improved transparency to municipal officials and Municipal Emergency Operations Centers for better visibility on crew locations and restoration plans and status;
e. Improved ability to predictively model storms to support lean-in decisions;
f. Better accommodation of influx of external resources; and
g. Enhanced efficiency.[37]

GIS technology has also been leveraged to support Eversource's Emergency Preparedness & Response initiatives, including the creation of the town liaison map. The town liaison map provides Eversource's liaison's a visual communication tool when discussing major outages with local town government. Recently, a significant effort has been given to the development and deployment of a mobile Damage Assessment Application (DAA). The DAA will provide close

[37] Brief of the United Illuminating Company, Application of the United Illuminating Company to Increase its Rates and Charges, PURA Docket No. 13-01-19, June 4 2013, available at http://www.ct.gov/pura/docketsearch.

to real time damage and electric device statuses. This data will be used to improve overall performance during major restoration events. Additionally, a desktop application was developed that converts GIS data which includes structures and devices into what is known as a POI, or Point of Interest File. The desktop application loads the POI into standard Vehicle GPS navigation devices. The device provides field employees turn by turn direction to specific utility pole or major electric device.

Recommendations for Storm Resiliency

Due to the progression and dynamic nature of storm-related threats described in the 2013 DOE/NREL report, and given the state's recent experiences with major storms, energy security and resiliency to extreme events in an ongoing concern. The Department is encouraged by the EDCs investment in tree-trimming, hardening of infrastructure, and use of GIS as tools effective in mitigating the effects of severe weather and power disruptions. DEEP supports the continued investment and development of such programs.

The Department recommends that regulators, policymakers and the utilities continually assess how adaptable their framework is to the changing nature of the risks Connecticut faces. It is easier to prepare for those natural disasters we have already experienced because those types of threats are known and often well understood. Innovative techniques, use of new technology, better training and preparation as well as recovery techniques need to be continually tested and assessed to ensure the reliability of the electric system and to protect the health and welfare of Connecticut's residents and businesses. Connecticut is doing its due diligence in this respect but should not rest on its laurels. DEEP will monitor through PURA the EDCs response to storms after every major event with significant power outages to review utility performance and ensure it continues to meet the standards established in Connecticut and best practices.

NEW TECHNOLOGY

Smart Grids

"Smart grid" is a blanket term that refers to the application of advances in technology and networking abilities to improve the reliability and efficiency of the electric transmission and distribution system. Major components of a smart grid include automation and two-way communication between components of an electric system. This includes the introduction of smart meters that can receive data from, and send information back to, utilities. A smart grid is able to respond more rapidly to outage occurrences and possible even "self-heal" in the event of a major disturbance. Smart grid systems can be very useful to EDCs with respect to their restoration efforts.

The Electric Power Research Institute has stated, that to gain the full advantage of smart grid-related systems such as advanced metering infrastructure (AMI), geographic information systems (GIS), outage management systems (OMS), data analytics and workforce management systems,

these systems must all be well-integrated.[38] This is a task that will require years and more large investments.

AMI represents an upgrade to the metering system that allows for digital two-way communication between the utility and the meter (and ultimately the customer). This enables the utility to remotely collect granular electricity consumption data from each meter measured in short time intervals (*e.g.*, every 15 minutes). This functionality has a number of operational benefits, including avoided manual meter reading costs, remote connect/disconnect capability, faster outage detection, and improved load research and forecasting. As technology for reliability and resiliency continues to improve, smart grid applications become an important tool in mitigating disturbances to the power system.

In addition to these operational benefits, AMI also allows a number of new services to be offered to the customer, which allows customers to better manage their energy use. By reducing or shifting their electricity consumption, customers have the opportunity to lower their bills and utilities will be able to defer or avoid resource investment costs.[39]

AMI Deployment in the United States

There has been an increase in the number of smart meters installed across the country, from 27.3 million in 2011 to 45.7 million in 2012, as shown in Figure 3. The figure shows the number of smart meters funded through the Smart Grid Investment Grant (SGIG) program that are installed and operational. [40]

[38] http://www.intelligentutility.com/article/12/11/epri-part-two-sandy-exposes-smart-grid-limits-and-maturity

[39] Ahmad Faruqui, Ryan Hledik, and John Tsoukalis, "The Power of Dynamic Pricing," *The Electricity Journal*, April 2009.

[40] http://www.smartgrid.gov/recovery_act/deployment_status/ami_and_customer_systems

Figure 3
Smart Meters Installed and Operational
Deployed as of September 30, 2013

Source: SmartGrid.gov, Recovery Act Smart Grid Programs. More information at http://www.smartgrid.gov/recovery_act/deployment_status/ami_and_customer_systems

Figure 4 shows smart meter penetration in 2013, and Figure 5 shows the extent of smart meter deployments by state by 2015 that are completed, underway, or planned. Figure 5 does not include automatic meter reading (AMR) installations.[41]

[41] http://www.edisonfoundation.net/iee/Documents/IEE_SmartMeterUpdate_0813.pdf

Figure 4
Smart Meter Penetration in 2013[42]

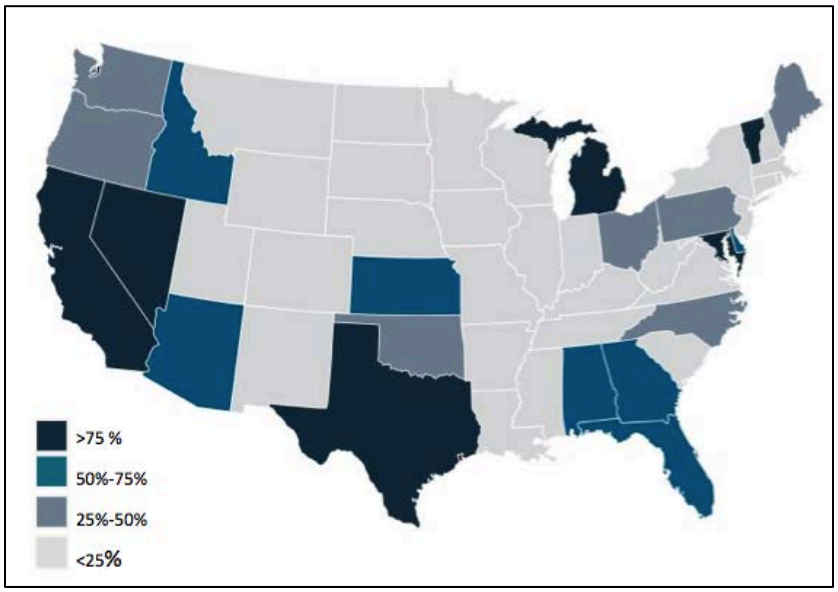
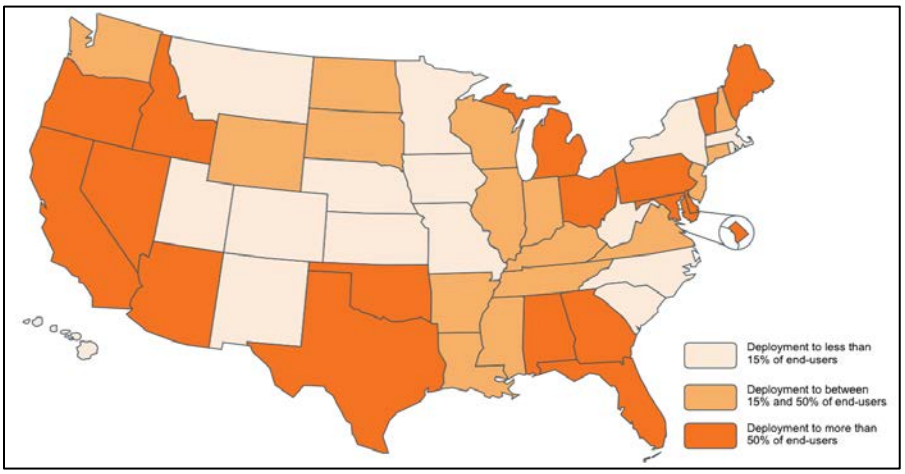


Figure 5
Expected Smart Meter Deployments by 2015[43]



AMI Deployment in Connecticut

Similar to more than half of the states, Connecticut has less than 25 percent of the smart meter or AMI meter penetration in the state.

[42] GTM Research report Utility AMI Analytics for the Smart Grid 2013-2020: Vendors, Markets and Opportunities, available at http://www.greentechmedia.com/articles/read/what-is-the-future-of-the-ami-analytics-market.

[43] Source: Institute of Edison Foundation.

As of January 2015, UI had 161,000 AMI meters deployed out of 340,000 customers. With the overlapping Southern Connecticut Gas Company (SCG) and UI territories, the parent company, UIL Holdings Company, is planning to install 210,000 AMI gas meters by 2015 to replace aging infrastructure. UI and SCG will continue in the future replacing aging meter infrastructure with AMI meters.

In an effort to reduce the peak demand, UI has a Time-of-Use (TOU) rate option for all customers.[44] As of December 2014, there were approximately 63,212residential customers on their TOU Rate RT and approximately 7376 commercial and industrial customers on a TOU Rates GST and LPT.

Eversource has utilized AMR technology in its service territory and will need to evaluate deployment of AMI technology as part of a move to a modernized electrical grid. Moving to a metering system with enhanced capabilities could bring operational and customer information benefits. The operational benefits of integrating AMI meters into a utility's outage management system can help to improve restoration performance, especially during extreme weather events. An informed customer will be better able to make decisions around energy use and will also lead to improved customer satisfaction. Such evaluation will focus in ensuring that a selected option is cost-effective to ratepayers over the life of the selected meter technology.

Challenges with Smart Grid Technologies

The vast majority of Eversource's electric customers still have traditional meters, which only measure gross monthly usage and provide no information to consumers on their time of use, demand, or other usage characteristics. Challenges to AMI deployment still exist for with respect to cost-effectiveness and acceptance rates by consumers. The Department is aware that stranded costs can adversely affect the economics of an AMI business case to the extent that the smart meters are replacing equipment with significant remaining useful life. The availability of more granular meter data represents a risk of loss of privacy to some consumer groups. Security risks associated with AMI database such as hacking or careless data management are also a concern.

Recommendations for Smart Grid Technologies

As evidenced in the above tables and graphs, AMI is growing in its acceptance and deployment. Moreover, the Department has previously stated in its Comprehensive Energy Strategy, without advanced meters, Connecticut will be unable to take advantage of the benefits that dynamic pricing and the enhanced demand management opportunities that emerging technologies provide.[45] Connecticut needs to start building for a more innovative and responsive electric system.

[44] In Time-of-Use rates, utility customers pay one of two (or more) electricity prices depending on the time of day. In most cases, the peak and off-peak prices differ widely (with peak prices being much higher than off-peak prices), heavily incentivizing the customer to shift use away from the peak hours and on to the off-peak times.

[45] 2013 Comprehensive Energy Strategy for Connecticut, Connecticut Department of Energy and Environmental Protection. February, 19, 2013. Page 84-85, available at http://www.ct.gov/energystrategy.

Although there are material challenges, the Department is confident that the risks associated with the deployment of smart grid technology can be adequately balanced. For example, stranded cost issues can be addressed by the appropriate cost recovery mechanisms that share risk between the utility and ratepayers. To lessen the substantial cost burden on ratepayers a gradual roll-out of smart grid meters can be planned in a meter by meter program during regular replacement of the useful life of equipment. Policies can be established to provide better consumer protections for specific customer sub-segments as the elderly which may be negatively impacted by dynamic pricing such as opt-in and opt-out tariff provisions. Lastly, education and outreach plans can enhance customer acceptance and increase participation in AMI-enabled programs and opt-out options can be made available for those customers who are still adverse to the technology.

The Department understands that every utility will accomplish the goals of improving communication on its systems and enhance reliability by providing more efficient technology for its customers in its own manner. Some will pursue comprehensive highly integrated suites of smart grid technology. Others will make targeted investments with a more narrow technology focus. The Department is also cognizant that a business case must exists for every utility which has its own regulatory pressures, legacy systems, geographic circumstances and reliability issues before investing in such technology.

As part of an ongoing and evolving process, the Department will require that Eversource enter into discussions with the Department concerning the phasing-out of its AMR meters based on attrition and on a meter-by meter basis with smart grid meters. The appropriate place for these discussions will be in DEEP's Grid Modernization proceeding. Along with considering how advanced metering functionality can be achieved, the EDCs will also need continue to monitor privacy guidelines and regulations established by federal agencies, such as the Department of Homeland Security, the Department of Energy, and the National Institute of Standards and Technology to adapt existing privacy and security standards of Connecticut's utilities to meet the new data requirements that accompany smart grid technology.[46]

Alternative Fuel Vehicles

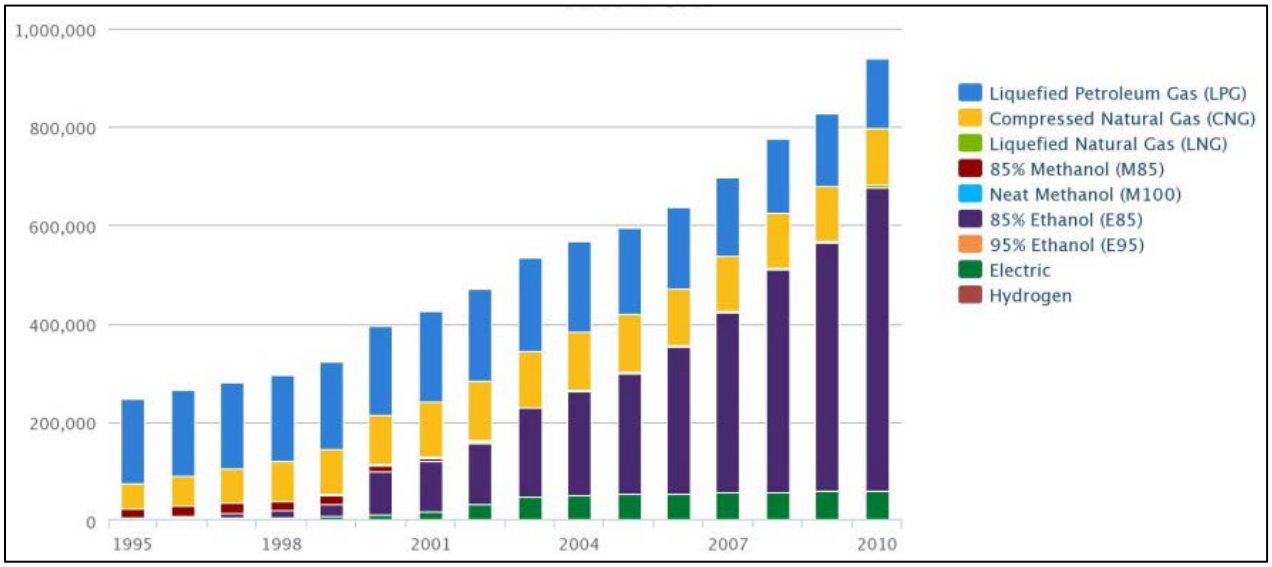
The country's increasing dependence on imported oil and the relative instability of the oil-producing countries prompted Congress to pass the Energy Policy Act (EPAct) of 1992. The Act called on the U.S. Department of Energy to expand research and development in the transportation sector, and to create programs for accelerating the introduction of alternative fueled vehicles (AFVs) to replace conventional models fueled by gasoline. [47] Fossil fuels burned to power cars, trucks, ships, trains and planes were responsible for 28 percent of U.S. greenhouse gas emissions in 2011, according to the Environmental Protection Agency.[48]

Figure 6 shows the number of alternative fuel vehicles (AFVs) in use in the United States between 1995 and 2009. The number of AFVs in use has been increasing steadily during the past 15 years, largely due to federal policies that encourage and incentivize the manufacture, sale, and

[46] 2013 Comprehensive Energy Strategy for Connecticut, Connecticut Department of Energy and Environmental Protection. February, 19, 2013. Page 84-85, available at http://www.ct.gov/energystrategy.
[47] http://www.fleet.wv.gov/SiteCollectionDocuments/Green/State%20EPAct%20Guide.pdf.
[48] http://www.epa.gov/climatechange/ghgemissions/sources.html.

use of vehicles that use non-petroleum fuels. AFVs in widest use today are those that run on E85, propane, electricity, and compressed natural gas. [49]

Figure 6
Number of Alternative Fuel Vehicles in Use[50]
1995-2010



Plug-in Electric Vehicles

Alternative fuel vehicles such as electric vehicles (EVs) or plug-in electric vehicles (PEVs)[51] continue to be a strategy for Connecticut to balance our state's energy and environmental goals. Replacing conventional models fueled by gasoline will create economic opportunities and put us on a path towards greater energy independence. These are goals that are shared by the Governor's Office, the legislature and by this Department. The Obama Administration has pledged its support of PEVs from the outset with stimulus money and other pilot programs administered by the DOE. On October 24, 2013, eight governors, (California, Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island and Vermont) have signed a memorandum of understanding (MOU) to help build a strong national market for zero-emission vehicles. Zero-emission vehicles include battery-electric vehicles, plug-in hybrid-electric vehicles, and hydrogen fuel-cell-electric vehicles. The MOU outlines joint cooperative actions as well as specific actions that individual states will take to ensure the successful implementation of their ZEV programs. The signatory states agree to a collective target of having 3.3 million zero emission vehicles on the road in the respective states by 2050 and to work together to establish a

[49] http://www.afdc.energy.gov/data/#10300.
[50] U.S. Energy Information Administration, Annual Energy Review, available at http://www.afdc.energy.gov/data/#10300.
[51] "PEVs" is used throughout this section to refer to electric vehicles in general, but also includes plug-in hybrid vehicles.

fueling infrastructure that will adequately support this number of vehicles.[52] Currently, the updated sales report of Hybrids and PEVs in September 2013, states there are 67,979 electric vehicles nationwide, as shown in Figure 7.

Figure 7
Hybrid and Plug-In Hybrid Electric Vehicle Sales in 2013[53]

2013				
Month	**Hybrids (HEVs)**	**Plug-In Hybrid (PHEVs) incl. Extended Range (EREVs)**	**Battery (BEVs)**	**Total**
January	34,611	2,354	2,022	38,987
February	40,173	2,789	2,616	45,578
March	46,327	3,079	4,553	53,959
April	42,804	2,735	4,403	49,942
May	48,796	3,209	4,545	56,550
June	44,924	4,169	4,573	53,666
July	45,494	3,499	3,943	52,936
August	53,020	6,407	4,956	64,383
September	33,576	4,477	3,650	41,703
October				
November				
December				
Total	**389,725**	**All plug-ins:**	**67,979**	**457,704**
		Total Vehicle Sales YTD 2013		11,742,211
		Electric Drive Market Share		**3.90%**

Challenges

Although it is important to highlight the advantages of PEVs, including reduced fueling costs and potentially zero emissions, PEVs do continue to face significant challenges. The U.S. Environmental Protection Agency (EPA) website, fueleconomy.gov, lists the following issues related to PEV batteries, while reminding its audience that improvement is occurring on all of these fronts:

- Driving range: Most PEVs can go only about 60–100 miles before recharging, while gasoline vehicles can travel more than 300 miles before refueling.
- Recharge time: Fully recharging the battery pack can take 4–8 hours or more. Even a "quick charge" to 80 percent capacity can take 30 minutes.

[52] See "Governors Announce Bold Initiative to Put 3.3 Million Zero-Emission Vehicles on the Road by 2025," available at http://www.ct.gov/deep/cwp/view.asp?Q=533888&A=4380.

[53] Sales figures sourced from HybridCars.com with additional input from EDTA member companies. http://electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952.

- Battery cost: Battery packs are expensive and may also need to be replaced at a later date.
- Bulk and weight: Battery packs weigh several hundred pounds and take up considerable vehicle space, with some states removing that weight for classification.

All of these factors represent tradeoffs for PEV buyers to consider. DEEP considers the potential benefits of PEVs as numerous and provide balance, to a large degree, to many of the challenges mentioned above. DEEP maintains its commitment to working to eliminate one of the key barriers to the widespread introduction of PEVs, the ability to keep the vehicles on the road, and avoid "range anxiety". Range anxiety is the fear of running out of battery power. DEEP is eager to work towards the transition to PEVs by providing PEV charging infrastructure in the state to better position Connecticut to contribute and to benefit from cleaner transportation opportunities.

The Department's Comprehensive Energy Strategy (CES) identified the development of EV charging infrastructure to support Connecticut's advanced technology vehicle market and to encourage consumer choice. Since the release of the CES, DEEP has created its own EV Connecticut website to provide information for PEV users such as: general information on PEV ownership, a map containing information on publically available charging stations, and information on workplace charging. In addition, DEEP established a grant program, EV Incentive Program in 2013 to issue rebates for charging station projects, covering up to half of the project cost, with a maximum award of $5,000 per unit or $10,000 per location. Applicants were required to have a publically accessible charging station that must be operational by January 1, 2014. Applicants also had to agree to make the stations available free of charge for at least the next three years.[54] On November 4, 2013, the Governor awarded 56 grants to publicly-available EV charging stations in 42 locations across the state. The grants are being awarded to 36 municipalities, businesses and organizations, some of whom will install charging stations at multiple locations as well as charging stations that can service multiple vehicles at one time.[55] The Department is also in discussions with Connecticut's Green bank on developing further funding opportunities to foster EV growth in our state.

The legislature also showed its support of expanding the use of PEVs in the state with the passage of Section 53 of P.A. 13-298, *An Act Concerning Implementation of Connecticut's Comprehensive Energy Strategy And Various Revisions To The Energy Statutes*. DEEP, from non-appropriated resources, is required to provide grants or rebates to municipalities, academic institutions, and other entities to buy or install alternative fuel vehicles, alternative vehicle fueling equipment, and energy efficient devices. Section 64 of the Act also requires PURA to consider Time-of-Use rates for electric vehicles.

As the legislature so clearly understood, PEVs are a great match for the adoption of TOU rates given the amount of electricity required to charge a PEV, coupled with how easy it would be to charge one during off-peak hours. Incentivizing PEV charging away from the peak also minimizes the load on the grid during the day and avoids some of the environmental problems

[54] More information on the EV Connecticut website at http://www.ct.gov/deep/evconnecticut.
[55] See http://www.governor.ct.gov/malloy/cwp/view.asp?a=4010&Q=534556

associated with the dirtier generating units that are only economical during peak hours, DEEP will monitor and participate in any PURA proceedings concerning TOU for PEVs.

In the New York State Energy Research & Development Authority's (NYSERDA's) *Compilation of Utility Commission Initiatives Related to Plug-in Electric Vehicles and Electric Vehicle Supply Equipment Report*, the topics involved utilities and commissions in addressing potential barriers to PEV technology deployment. This report contains an overview of states with specialized rates for PEV charging.[56] There have also been some further developments by the EDCs through infrastructure pilots, consumer outreach, research and other efforts to support the state's goals with alternative fuel vehicles.

Consumer Education and Outreach

On August 5, 2013 Eversource opened a new information center at its call center in Windsor to help customers understand electric vehicle technology and ask questions. The electric vehicle information hotline offers customers expert service, information and guidance about electric vehicles and vehicle charging options. Eversource also created a website where customers can access a variety of information, tools, and resources.[57]

Demand Charges for Direct Current (DC) Fast Chargers[58]

Due to their load characteristics, DC Fast Charging stations are placed on commercial electric rates which are comprised of the demand-based billing components. The demand charge component recovers the cost to utility of providing capacity to meet monthly peak demand. The electrical capacity (kW) of DC Fast Charging stations largely determines the demand level recorded by the utility meter which is ultimately used for billing purposes. Since these stations operate at their full capacity for only short periods of time, these stations need only be used by one EV customer to hit their peak demand. In other words, the demand component is expected to be largely independent the volume of kWh drawn by customers utilizing the charging stations. With low utilization rates in the early deployment stage, it is not inconceivable for the effective price per kWh (total electric bill divided by total kWh) to be well above $1/kWh. Therefore, an interim rate solution that more closely correlates with the volume of customer usage was adopted to facilitate the operation of these stations in the early years when utilization is expected to be relatively low.

The EV Rate Rider pilot is a critical bridge between this early stage momentum and long-term solutions to facilitate EV charging.[59]

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[56] Compilation of Utility Commission Initiatives Related to Plug-in Electric Vehicles and Electric Vehicle Supply Equipment, April 2013, available at https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Transportation/Compilation-Utility-Commission-Initiatives-Plug-acc.pdf.

[57] http://cl-p.plugmyride.org

[58] DC Fast Charging stations are designed to deliver an 80% state of charge to an electric vehicle's battery in less than thirty minutes. The electrical capacity of these charging stations can vary between 20 kW and 120 kW depending upon the size of the vehicle's battery. For example, 40-50 kW DC Fast Charging stations are used to serve vehicles with 20-25 kW batteries such as the Nissan Leaf. On the other hand, 90-120 kW DC Fast Charging stations are used to serve vehicles with 60-85 kW batteries like the Tesla Model S.

Time-of-Use Rates

TOU EV rates have been tested in jurisdictions outside of Connecticut to encourage customers to charge their vehicles at off-peak times, when demand for electricity is lower, thus putting less strain on the distribution system, and potentially improving load factors. Several utilities, including those in California and Michigan, have tested residential electric vehicle tariffs. Typically the goals of such tariffs were:

- To collect data on charging patterns for the assessment of grid impacts;
- To study consumer response to price incentives to modify their overnight charging patterns;
- To provide an incentive for consumers to purchase an EV, and/or
- To ensure current utility rate practices don't disadvantage EVs (inclining block rates).

These utilities have learned that consumers will modify their charging patterns based upon a utility rate program.

It appears that the metering and billing processes associated with TOU EV rate implementation presented the most significant challenges to the success of the programs. Some utilities required participating customers to install a separate electric service exclusively for electric vehicle charging. This minimized the need for the utility to modify their back-end billing system, but required customers to make modifications to their electric system (replacing the existing meter pan with a dual meter pan), which could cost customers $1,000. Since the realized rate savings average $50 - $150 per year, consumers would not recoup their investment for more than 6 years. Additionally, many utilities that implemented this approach sent out two separate bills to participating customers; one for the electricity usage for the house, and one for the usage for the EV, which may have been burdensome to participants.

Other utilities required customers to commit to a whole house TOU rate. While it appears that this minimized the back office modifications to the utility billing systems, customers did not respond well. Automakers have also argued that requiring a whole house TOU rate is a source of confusion for customers who already had to make many decisions in purchasing an electric vehicle.

Still other utilities deployed a submeter for EV charging. The submeter was used to apply the EV rate only to EV charging. The utilities that implemented this approach either have modern meter and billing IT systems or deployed an expensive manual billing process. Utilities that did not have meter and billing systems that can easily be modified to perform this role have claimed that it will cost millions to modify their billing system to enable this function. Cost recovery of such an expense would likely be challenging because the investment would only benefit several thousand customers.

[59] See PURA Docket 13-08-39, Filing submitted on October 10, 2013, available at http://www.ct.gov/pura/docketsearch.

In the PURA docket, 13-12-11Eversource requested approval of an Electric Vehicle Rate Rider Pilot (EVRRP) as a solution to mitigate the high demand charges. The Company stated that this will allow for a more rapid deployment of fast charging stations by the State of Connecticut and will allow Eversource to gather data more quickly regarding public charging stations, including their use levels, rates, and technology. In its June 4, 2014 Decision, PURA approved the EVRRP effective July 1, 2014. The Rider Pilot remains in effect until such time as new rates are developed and filed with the Authority. In its final decision, the Authority stated it expects the pilot to produce the necessary data to assess the issues surrounding public electric vehicle fast charging stations, including their utilization rates and patterns, electricity demand, consumption, and impact on electric distribution infrastructure.

UI is also investing in the technology to prepare for PEVs. PEVs are part of UI's solution for new and innovative ways to help lower costs to our customers and address growing energy demand through alternative energy strategies. UI considers PEVs as a solution to help reduce our dependence on foreign oil and lower greenhouse gas emissions. UI has been a member in industry groups such as Electric Power Research Institute (EPRI) and Electric Drive Transportation Association (EDTA). In 2010, UI participated in Governor Rell's Electric Vehicle Infrastructure Council to make recommendations for developing a course of action for the state to benefit from PEVs based on their positive environment, economic, and energy impact. [60] UI has also educated Connecticut Residents with their PEV at trade shows, events, schools, and other location about electric vehicles, charging stations, and the utility's involvement. UI has also piloted installations of at least 15 public and 2 residential charging stations to determine be aware of the usage impacts and the installation and operation costs of the technology. UI has conducted an impact study of charging station demand on our electrical distribution system. UI will continue to support DEEP and CT DOT on their goals and incentive programs for charging stations. UI will continue to educate residents about the technology and the impacts on the utility. UI will continue to assess and evaluate changes in the technology, the market, and the future for PEVs.

Natural Gas Vehicles

There are 250,000 natural gas vehicles ("NGVs") operating on U.S. roads, accounting for 0.14% of U.S. demand for natural gas[61]. The American Clean Skies Foundation estimates there may be as many as 1.5 million NGVs travelling U.S. roads within in the next decade[62], while the International Association of NGVs estimates there will be more than 65 million NGVs in use worldwide in the same timeframe[63].

There are two main barriers to NGV deployment in Connecticut and the U.S. The first is the initial up-front cost premium to purchase a NGV and the second is a lack of local, public fueling infrastructure. The initial up-front cost premium for cars and trucks can range from $10,000 to $25,000 depending on the type of vehicle being purchased. The price premium for vehicles such as garbage trucks or bucket trucks is even higher due to the high level of customization required

60 http://www.ct.gov/pura/lib/pura/ev/evfinal.pdf
61 www.eia.gov
62 www.cleanskies.org
63 www.iangv.org

in building and designing special use NGV vehicles. Lack of a comprehensive fueling infrastructure leads to "range anxiety", which is a problem that all alternative fuel vehicles will experience until a proper network of fueling stations can be constructed across our State and the Nation. These barriers to deployment may be addressed in several different ways.

There are both economic and technical challenges associated with NGV's and filling station deployments. From a technical perspective NGV equipment has come a long way and is generally accepted as an alternative to conventional gas or diesel driven engines. Filling stations have a much greater technical variability including siting, permitting, gas pressure and gas capacity. Early utility engagement with the owners/developers is imperative to ensure sufficient capacity and to plan for future expansion. Station owners often require higher pressures than are physically available at the proposed filling sites, which will require significant utility investment to rectify. This either makes the site financially not viable because of the cost of system upgrade requirements or places additional operational expenses on the station owner for gas compression further challenging the ROI.

UIL is actively engaged with NGV associations and developers to educate and promote NGV deployment throughout the SCG and CNG franchise service territories. In addition UIL will deploy 10 vehicles to validate and lead by example. UIL works closely with developers, fleet vehicle owners and station owners to assess technical feasibility and economic viability. UIL encourages the purchase and use of NGVs, with an emphasis on fleet vehicles, public transportation, government fleets, and other taxpayer-funded vehicles. Norwich Public Utility has a robust program, but they have access to Federal and State incentives because they are a municipal utility, not a publicly traded company. Yankee Gas has 2 or 3 Honda Civics as a pilot.

To increase the deployment of NGV's and filling stations the State should consider additional incentives for converting vehicles and building, owning and operation filling stations. Vehicle rebates, fuel tax credits and infrastructure tax credits appear to be a successful method in other States, such as California, in accelerating deployments.

Energy Storage – UConn Innovation Hub

The previous IRP discussed energy storage as an emerging technology. The cost of such technology was discussed as a major barrier to its success in Connecticut. The Department still considers the entrance of low cost energy storage as an important tool in the development of renewables in our state. Advances are needed to lower the cost of this technology for it to have an impact in Connecticut and to advance the goals of cleaner, cheaper, more reliable energy. The Department notes that progress has been made in our state to further the potential of energy storage with the establishment of the Fraunhofer Center for Energy Innovation at UConn.

On July 25, 2013, the Fraunhofer Center for Energy Innovation at UConn, a partnership between UConn, Fraunhofer USA[64], and DEEP, was officially launched by Governor Malloy at the University's Depot Campus. The center will focus on developing advanced technologies related to energy storage, fuel cells, in-stream hydro, power management, and distribution. There are 60

[64] Fraunhofer USA is a subsidiary of Fraunhofer-Gesellschaft, Europe's largest applied R&D organization, which has 66 institutes and research units and an annual research budget of $2.5 billion.

Fraunhofer centers in Germany and seven in the U.S., all affiliated with major universities, pursuing research on everything from lasers to molecular biology to renewable energy. At the ground breaking, Governor Malloy made the following comment:

"This partnership between the state, UConn, and Fraunhofer USA is a welcome and important collaboration when it comes to finding solutions to some of the most pressing energy challenges we face," said Malloy. "With the resources, talent, and expertise of UConn and Fraunhofer, we expect to see technological breakthroughs that will help deliver a cheaper, cleaner, and more reliable energy future for Connecticut, the nation, and the world."

The Fraunhofer Center for Energy Innovation will develop highly efficient and cost-effective energy conversion and storage systems. Working with industry, the center's research and development will concentrate on modern functional materials, such as metals, ceramics, micro- and nanostructures, as components for fuel cells and electrolyzers.

UConn, DEEP and Fraunhofer each are providing $2.4 million in seed money over the next four years for the center. The deal struck with Fraunhofer allows the state to share in the intellectual property rights of research that leads to commercial technologies.

Recommendations on Emerging Technologies

Optimization of new technologies will improve the State's energy future. It is vital that the State partner with its utilities, universities, and other organizations, and continues to invest in emerging technologies and that will help materialize the benefits of new technologies. DEEP is committed to developing policies to overcome barriers to the adoption of these emerging technologies. If we fully take advantage of these opportunities, the State will be much closer to its goals regarding climate change, assuring an adequate and diverse energy supply systems in the future and remaining competitive in a global economy.

CONCLUSION

Attacks on our power system whether due to severe weather or cyber threats require extensive and thoughtful planning, Today there is a growing realization that technology can be both a help and a hindrance, but utilities must continue this discussion and work towards finding solutions. By partnering and collaborating with private and public organizations to consider nontraditional responses in the form of distributed generation, emerging technologies and hardening our electric grid our communities will be better protected as these events become more frequent and the new norm. DEEP recommends that Connecticut utilities should strive to be as educated and aware of what the potential threats may be, implement standards that are flexible in their response and develop training protocols to prevent and mitigate power disruptions in a modern world.