Northeastern University
George J. Kostas Research Institute for Homeland Security

INTERCEP
NEW YORK UNIVERSITY

"AFTER HURRICANE SANDY: LESSONS LEARNED FOR BOLSTERING ENERGY RESILIENCE"

Hosted by Kostas Research Institute for Homeland Security, Northeastern University & New York University's International Center for Enterprise Preparedness

Read Ahead Materials

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Report Summaries

"Hurricane Sandy Rebuilding Strategy: Ensuring a Regionally Coordinated, Resilient Approach to Infrastructure Investment." Hurricane Sandy Rebuilding Task Force. (Aug19, 2013): 61-66

Commissioned by President Obama, this report details strategies created by the Hurricane Sandy Rebuilding Task Force for rebuilding communities impacted by Hurricane Sandy in a way that makes them stronger and more resilient. The report includes a section on energy infrastructure that highlights the importance, as well as informs efforts that improve regionally coordinated, resilience approaches to infrastructure investment such as a smarter, more flexible electric grid and better-protected liquid fuel supply chains. The Task force recommends that the federal government ensure that recovery investments in the energy sector are focused on resilience, and that states, in partnership with private utility companies, explore concepts such as microgrids, distributed generation, smart-grid technology, energy storage, and combined heat and power systems. This report also suggests that states review safety rules for backup generators and fuel storage in order to improve energy resilience.

"A Stronger, More Resilient New York," Plan NYC (June 2013): Ch. 6 – Utilities, Ch. 7-Liquid Fuels

This report is part of New York City's Special Initiative for Rebuilding and Resiliency. It (1) analyzes Sandy's impacts on city buildings, infrastructure, and people, (2) assesses the risks that climate change poses to the city, and (3) provides strategies for increasing resiliency. Chapter 6 provides background information on the layout and regulation of New York's power grid and details the impacts of Superstorm Sandy on power generation, transmission, and distribution. Among the strategies it proposes to help better protect the city in the face of climate change and future major storms are (a) redesigning the regulatory framework to support resiliency, (b) hardening existing infrastructure to withstand climate events, (c) reconfiguring utility networks to be redundant and resilient, (d) reducing energy demand, and (e) diversifying customer options in case of utility outage. Chapter 7 supplies similar background and impact assessment for the liquid fuel system in the area, and recommends that the city work to (a) harden liquid fuels supply infrastructure, (b) enhance the ability of the supply chain to respond to disruptions, and (c) improve the ability to provide fuel to emergency responders and private critical fleets in order to lessen the negative impacts of future storms.

"Hurricane Sandy After Action: Report and Recommendations to Mayor Michael R. Bloomberg," Deputy Mayors Gibbs and Holloway (May 2013). Sections on "Power Outages, Generators, and Boilers" (pp. 14-15) and "Fuel and Transportation (pp. 21-22).

This after action report released by Mayor Bloomberg in May 2013 provides a high-level summary of recommended improvements to the City's operations that are drawn from lesson learned before, during, and immediately following Hurricane Sandy. After-action working sessions and discussions with partners generated 59 recommendations in six core areas: (i) communications; (ii) general and healthcare evacuations; (iii) public safety; (iv) general and special medical needs sheltering; (v) response and recovery logistics; and (vi) community recovery services. The recommendations made in this report that are specific to energy infrastructure include:

- *Develop a comprehensive plan to expedite power restoration to multi-family public and private housing;*
- *Improve and expand off-season site generator assessments for public facilities;*
- *Establish a Dewatering and Generator Task Force and Action Plan to activate in advance of the approaching storm that will collect and use detailed information about buildings in flood-prone areas to expedite recovery.*
- *Create a Fuel Task Force to ensure adequate fuel for rescue and recovery operations;*
- *Develop a Citywide Transportation Plan to ensure the liquidity of the transportation system, including the timing and triggering conditions of implementing the plan;*
- *Upgrade City-owned fuel infrastructure, including mobile fuel trucks and real-time reporting from the City's 414 in-house fueling locations.*

"New York/New Jersey Intra Harbor Petroleum Supplies Following Hurricane Sandy: Summary of Impacts Through November 13, 2012," U.S. Energy Information Administration (Nov 12): 1-3.

This report, sponsored by the US Energy Information Administration, details the damage done by Superstorm Sandy to the petroleum supply infrastructure in the New York and New Jersey area. Damage to the two refineries in northern New Jersey and many of the terminals in the area resulted in a significant disruption of fuel supply not only to the NY/NJ area, but also to New England and upstate New York. The report contains tables which quantify the reduction of product flow by amount and by method of transportation.

"Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure," NYS 2100 Commission (Jan 2013). Chapter on Energy (pp. 80-108)

The State of New York's energy infrastructure was built to withstand 100-year weather events. Yet Superstorm Sandy, Hurricane Irene, and Tropical Storm Lee demonstrated that the system was significantly compromised by the intensity of recent extreme weather events. In order to help New York achieve its goal of a more resilient and future-ready energy system, the NYS 2100 commission makes five broad recommendations:

- *Strengthen critical energy infrastructure*
- *Accelerate the modernization of the electrical system and improve flexibility*
- *Design rate structures and create incentives to encourage distributed generation and smart grid investments*
- *Diversity fuel supply, reduce demand for energy, and create redundancies*
- *Develop long-term career training and a skilled energy workforce*

Under each of these recommendations, the report outlines a series of more concrete, specific recommendations, drawing on detailed maps and figures that illustrate various components of the energy infrastructure.

"Overview of Response to Hurricane Sandy-Nor'Easter and Recommendations for Improvement," U.S. Dept. of Energy, Office of Electricity Delivery and Energy Reliability (Feb 26, 2013): 1-14.

This report, published in February 2013, identifies the major findings from the Department of Energy's (DOE) after-action assessment process. The report provides possible "best practices" from *the Department of Energy's response to Hurricane Sandy. These include (a) dedicated senior leadership involvement, (b) expanded mutual aid assistance, and (c) expedited waivers. It also identifies key areas for improvement including (a) information and communication to address inadequate situational awareness of fuel supplies and to support speedier restoration timeframes, (c) enhancing access and resources for crews and first responders, fuel, electric power, and equipment, and (c) better assignment of resources through developing a mutual assistance network in the oil and gas sector similar to electrical utilities). The report concludes with a series of recommendations in these three identified areas, as well as additional recommendations developed from the findings of a series of "Hotwash" meetings with industry, Federal, and State and local government in December 2102. The DOE plans to implement the recommendations outlined in this report.*

"Moreland Commission on Utility Storm Preparation and Response," The Moreland Act Commission. (Jun 22, 2013) Section 5, Section 7.2.3, 7.5.1 (pp. 35-40; 47-53)

Commissioned by Governor Andrew M. Cuomo, this report studies the responses of New York's power utility companies to recent major storms including Sandy. Chapter 5 of this report highlights the need for increased energy infrastructure resilience, and tasks utility companies to develop a strategy for outlying the value proposition of rate increases to cover the costs associated with making necessary infrastructural improvements and ensuring the rapid restoration of service to critical infrastructure in the aftermath of major emergencies. The section includes several options for forming these strategies. Chapter 7 recommends (a) reforming the mutual assistance system, (b) training the National Guard to assist utilities in storm preparation and restoration, and (c) better coordination between utilities and government to facilitate the automation of emergency waivers, among other things. This chapter also evaluates specific preparation and response practices of regional utility companies.

"Comparing the Impacts of Northeast Hurricanes on Energy Infrastructure," U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability (Apr 2013): 1-40.

This report provides a side-by-side comparison of how Hurricanes Irene and Sandy impacted the energy infrastructure in the northeastern United States. Despite the fact that Sandy was weaker at landfall than Irene, Sandy had a larger and longer-lasting impact on the region's energy infrastructure and supply, which required a great response from all levels of government. For instance, following Irene, utilities had restored power to 95% of affected customers within 5 days after Irena. After Sandy, it took 10 days to restore power to 95% of affected customers. Sandy's damage to petroleum infrastructure was also more extensive than Irene's, and restoration of petroleum supply systems took longer following the storm. Neither storm, however, had a major impact on the natural gas infrastructure or supplies in the Northeast.

"Loglines: Fueling East Coast Relief," Defense Logistics Agency (Jan-Feb 2013): 8-13.

This report relates the experience of the Defense Logistics Agency during their relief efforts during and after Hurricane Sandy. DLA Energy Americas commander established operations at Joint Base McGuire-Dix-Lakehurst and worked with DLA fuel contractor Foster Fuels to help answer fuel needs in New York and New Jersey. Anticipating fuel requirements from FEMA, DLA Energy had the contractor dispatch 60 trucks containing 175,000 gallons of diesel fuel and 25,000 galls of motor gasoline from Foster Fuels' Brookneal, VA facility. The estimated account of DLA Energy's assistance *includes 6.9 million gallons of unleaded fuel and 4.1 million gallons of diesel fuel dispatched to New Jersey; 2.6 million gallons of unleaded fuel and 387,000 gallons of diesel fuel dispatched to New York; more than 5 million gallons of ultra-low sulfur diesel fuel to Connecticut; and fuel to 272 civilian gas stations in New York and New Jersey. Some significant challenges that DLA faced was a lack of a standard tasking system and managing the demand by government officials for information.*

"Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities," ICF International: Prepared for Oak Ridge National Laboratory (Mar 2013): 4-12, 32-35.

This report, advances the case for combined heat and power (CHP) to improve the resiliency of critical infrastructure by keep critical facilities running without interruption in electric or thermal service. A specially configured CHP system can continue to supply power and heating/cooling even when an emergency disrupts the electric grid. A CHP system that runs consistently throughout the year is more reliable in an emergency than a backup generator system that only runs during an emergency. Because of CHP, some commercial and industrial facilities in the areas affected by Superstorm Sandy were able to maintain power throughout the storm. Among the sites that lost grid power, and where the CHP unit was designed to operate during a grid outage, all of the CHP systems performed as expected and there was not a single site that lost grid power where the CHP unit failed to perform as expected.

"Weathering the Storm: Report of the Grid Resiliency Task Force," The Grid Resiliency Task Force. (Sep 24, 2012): Section II.B (pp. 17-20), Section IV.A.2 (pp. 23-33), Section V (pp. 44-56)

This report, commissioned by Governor Martin O'Malley of Maryland, evaluates the effectiveness and feasibility of (a) underground power supply and distribution lines, (b) options for improving the resiliency of the Maryland power grid, and (c) strategies for financing and recovering the cost of these types of investments. This report provides background information on the structure and function of the electric supply and distribution grid, as well as current practices and regulations. It makes the following recommendations: (a) increase accountability of utility companies for reliability standards in major storm outages; (b) accelerate investments to effective infrastructure improvements to include selective undergrounding to harden the grid; (c) perform joint exercises between the state and utility companies; (d) increase information sharing between utilities, state agencies, and emergency management agencies, and (e) re-evaluate state-wide vegetation management regulations for utility companies.

Hurricane Sandy
Rebuilding Task Force

HURRICANE SANDY **REBUILDING STRATEGY**

Stronger Communities, A Resilient Region

August 2013

~~the fund may present one possible model for other jurisdictions that are seeking effective strategies for aligning and leveraging Federal funding to support disaster recovery.~~

- ~~The Task Force has also worked with HUD, DOE, and the States of New York and New Jersey to ensure that $30 million CDBG-DR funding is available to support financing targeted at improving the resilience of energy infrastructure in Sandy-affected areas. More specifically, New York is pursing the establishment of a "Green Bank" Resilience Retrofit program, and New Jersey is considering an energy finance program. The programs in New York and New Jersey are exploring the financing of energy resilience-oriented activities that target important infrastructure facilities, including, but not limited to, smart grid technologies as well as distributed and resilient energy generation assets, such as Combined Heat and Power (CHP), microgrids, solar, fuel cells, and energy storage. These efforts would allow both States to evaluate a loan loss reserve in stimulating private investment in necessary energy infrastructure improvements and repair in Sandy-affected areas.~~

~~Owner~~

~~***Leads:*** *HUD, DOT, DOE, EPA*~~

~~Status~~

~~Recommendation adopted: Currently available for projects funded by the Sandy Supplemental and will be applicable to future disaster recovery efforts in the region.~~

Energy Infrastructure

Challenge and Goal

Extensive power outages during Sandy affected millions of residents and resulted in substantial economic loss to communities.[100] Despite the size and power of Hurricane Sandy, this was not inevitable: resilient energy solutions could have helped limit power outages. In addition, improvements in and hardening of, the liquid fuel supply chain would have prevented some of the most visible impacts of the storm.

One of the biggest problems with the liquid petroleum (i.e., gasoline and diesel fuel), supply chain after Hurricane Sandy was flooding damage to major terminals and docks in the Arthur Kill area of New Jersey, as described earlier.
As shortages accumulated, consumers struggled to find gas stations that were functional. The lack of

100 National Hurricane Center, "Tropical Cyclone Report: Hurricane Sandy," 02/12/2013, http://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf.

shared priorities among different groups of critical officials and service providers led to shortages and a general lack of information and coordination. Immediately after the storm, the White House Office of Science and Technology Policy (OSTP), FEMA, and DOE worked together to use technology to help inform the public which gas stations were open and had fuel and power from a backup generator. In spite of these efforts, many people struggled to get accurate and timely information about available fuel sources.

To prevent shortages in future disasters, the Task Force worked to ensure that critical infrastructure such as hospitals, transportation systems, drinking water and wastewater treatment plants, and public facilities, as well as industrial economic engines such as refineries, office buildings, data centers, and manufacturing facilities, become more energy resilient as a result of investments made by the Federal government during the Sandy recovery. Additionally, the Task Force encourages the alignment of investments in the Nation's energy infrastructure with the goal of improved resilience and the national policy initiatives regarding climate change, transparency, and innovative technology deployment. Most energy infrastructure is privately owned and operated, which means that resilience investment will come about only through close cooperation between the Federal and State governments and the private sector.

12. RECOMMENDATION: Ensure that Sandy recovery energy investments are resilient.

The Task Force and DOE provided technical assistance to New York and New Jersey to help them evaluate and develop pilot projects, financial mechanisms, and policy and market development tools and to generally promote cost effective investments in resilient energy generation and storage using Sandy recovery funds. The Task Force and DOE are also helping the states explore ways to use fees paid by utility customers and other revenue streams to help finance energy resilience for infrastructure. The region, assisted by the Federal Government, will launch programs later this year using public-private partnerships to lower project costs and increase the value of energy resilient infrastructure. Through these and other measures, New York and New Jersey have embraced the opportunity to provide national leadership in energy resilience.

Specifically, in New Jersey, DOE and the Task Force worked in partnership with the State to review critical facilities and energy infrastructure and to develop a State-wide solution for resilient energy infrastructure. The State is considering an energy finance program and exploring how facilities funded by the program could serve as primary hubs for microgrids, distributed generation, smart grid technologies, and energy storage. The analysis began with a mapping of all relevant systems and needs in the State for a qualitative and quantitative analysis of requirements for a resilient state-wide system. This effort will complement previous efforts performed under DOE grants for energy assurance plans. DOE and the State also reviewed various deployment models designed to lower the cost of capital financing and leverage private sector expertise and capital through public-private partnership. This review also included exploration of financing structures such as loan loss reserves, revolving loan funds, and other credit enhancement mechanisms that are designed to magnify the impact of scarce public dollars. With assistance from DOE, the State is also exploring ways to create markets that value energy reliability. These innovative structures have the potential to unlock value from resilience beyond what is reaped in the event of a disaster.

In Bergen County, N.J., the public utility authority used a biogas-powered CHP system to keep its sewage treatment facilities working during and after the storm.[101]

In New York, the Task Force, HUD, and DOE are providing funding and technical assistance to support the planning and implementation of resilient energy communities using microgrid and other distributed generation and storage technologies through the Green Bank Resilience Retrofit program. Connecticut is also pursuing projects with microgrids and CHP systems through a solicitation process that was started in the State prior to Sandy. In response to requests from stakeholders and Members of Congress, the Task Force worked with HUD, DOE, and EPA to develop guidance relating to the use of disaster funding in the Sandy Supplemental to support CHP technologies. Lessons learned from Hurricane Sandy will be considered to ensure that our power systems across the country are more resilient to disaster.

This summer, the Task Force along with DOE, New York Governor's Office, New Jersey Governor's Office of Recovery and Rebuilding, and Connecticut Governor's Office, are participating in a discussion of innovative finance, policy, and market development approaches to energy resilience. All of these issues are aligned with the goal of "building stronger and safer communities and infrastructure" as set forth in the President's Climate Action Plan.

Successful Implementation of CHP Systems during and after Hurricane Sandy

CHP is an efficient and clean approach to generating electric power and useful thermal energy from a single fuel source -- eliminating the need for a separate on-site boiler or furnace and purchased electricity. College campuses such as Princeton University, Stony Brook University, New York University, and the College of New Jersey, used CHP to keep the lights (and the heat) on both during the storm and in the days and weeks that followed.[101] South Oaks Hospital on Long Island and Connecticut's Danbury Hospital used CHP to keep medical facilities online when the local electrical grids failed.[102 103] Commercial buildings and even residential communities like Co-op City in Bronx County, N.Y. showed the enormous resilience of CHP during Sandy.[104]

101 Ibid.

102 Stony Brook University, "In the Aftermath of Superstorm Sandy: A Message from President Stanley," http://www.stonybrook.edu/sb/sandy/index.shtml; ICF International, "Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities," 03/2013,

103 DOE Office of Energy Efficiency and Renewable Energy, "CHP: Enabling Resilient Energy Infrastructure," 04/03/2013, http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_enabling_resilient_energy_infrastructure.pdf.

104 American Council for an Energy-Efficient Economy, "How CHP Stepped Up When the Power Went Out During Hurricane Sandy," 12/06/2012, http://www.aceee.org/blog/2012/12/how-chp-stepped-when-power-went-out-d.

105 ICF International, "Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities," 03/2013, http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_critical_facilities.pdf.

Owner

Leads: *DOE, HUD, FEMA, EPA*

Status

Recommendation adopted: Currently available for projects funded by the Sandy Supplemental and will, to the extent allowable by law and regulation, be applicable to future disaster recovery efforts in the region as well as future disaster recovery efforts nationwide.

13. RECOMMENDATION: Mitigate future impacts to the liquid fuels supply chain like those experienced during the Sandy recovery.

The Task Force, in partnership with DOE, worked with State and local officials in New York and New Jersey as well as with other Federal agencies and industry partners to find ways to improve the resilience of the fuel supply chain during and following disasters in the region. All aspects of the supply chain were considered and the outcome of those discussions was a consensus that disruptions to the supply chain are caused by a number of separate, but often related issues. The issues raised in these discussions included:

- Physical impacts to key distribution facilities and infrastructure (e.g., marine terminals, refinery, pipelines, storage facilities).
- Electric power outages at retail filling stations and important transportation-related infrastructure (e.g., pipelines, refineries, marine terminals, storage facilities).
- Public awareness of which retail locations were open and had fuel available.

Additionally, local safety rules for backup generators, including limiting the amount of fuel storage (e.g., a 72-hour supply), and requiring larger volumes of fuel for backup generators to be stored in basement locations, impaired energy resilience or created additional unsafe situations following Sandy.[106] For example, Bellevue Hospital Center moved their generators from the first floor to a safer location on the 13th floor prior to Sandy; but because the fuel was still stored at ground level and the pumps which supplied the fuel to the generators were submerged, hospital staff created a human chain to move the fuel by hand up 13 floors to keep life-safety power operating and their patients safe for another two days. New York City and other jurisdictions are reviewing these requirements to determine if new rules can be developed to maintain safety while increasing resilience. Lessons learned from Hurricane Sandy will be considered to ensure that our fuel delivery systems across the country are more resilient to disaster.

106 2008 New York City Mechanical Code, with January 1-December 31, 2011 Supplement, Section MC 1305.11.1.3.

Owner

Leads: *DOE, FEMA, HUD*

Status

Recommendation adopted: Currently available for projects funded by the Sandy Supplemental and will, to the extent allowable by law and regulation, be applicable to future disaster recovery efforts in the region as well as future disaster recovery efforts nationwide.

14. RECOMMENDATION: Encourage Federal and State cooperation to improve electric grid policies and standards.

States should work with DOE and the Institute of Electrical and Electronic Engineers to develop a new approach for electric grid operations. The new approach would define policies and technical requirements for how to incorporate smart grid technology, microgrids, building controls, and distributed generation, including CHP, with two-way flow networks into the grid. This approach would ensure that problems can be isolated, surviving generation can be optimally dispatched (with priority to essential services), and that degradation can be graceful and not catastrophic. This approach would allow building controls to provide a minimal level of service such as basic lights and refrigeration during emergencies. States should also review DOE's new report, "U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather,"[107] which assesses vulnerabilities that would be helpful in developing a new approach for electric grid operations. Improvements need to include addressing damage to power generation and medium to long-term alternatives to power sources if critical power generation facilities are damaged or destroyed.

Owner

Lead: *DOE*

Status

Recommendation adopted: To be implemented for future projects funded by the Sandy Supplemental and could be applicable to future disaster recovery efforts nationwide.

15. RECOMMENDATION: Mobilize the private sector and non-profit community to develop innovative solutions that support and integrate whole community efforts for disaster relief.

OSTP and FEMA, with the support of DOE and other Federal agencies, will convene an all-day brainstorm with whole community partners, such as technologists, entrepreneurs, designers,

107 DOE, "U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather," 07/2013, http://energy.gov/sites/prod/files/2013/07/f2/20130716-Energy%20Sector%20Vulnerabilities%20Report.pdf.

philanthropists and local and state officials at the White House to develop innovative solutions to support how disaster survivors respond to and recover from disasters. These solutions will empower disaster survivors and enhance the ability of first responders as well as Federal, State, and local officials to conduct response and recovery activities. All efforts will support and integrate whole community efforts to better prevent, protect, mitigate, respond to, and recover from disasters.

Owner

Lead: *OSTP and FEMA, in coordination with DOE, and other Federal agencies*

Status

Recommendation adopted: Brainstorm currently scheduled for the end of August.

16. RECOMMENDATION: Develop a resilient power strategy for wireless and data communications infrastructure and consumer equipment.

DOE and the National Telecommunications Information Administration (NTIA, part of DOC), should work with FCC to promote a programmatic approach to ensure that cellular towers (antennas), data centers, and other critical communications infrastructure are able to function regardless of the status of the electrical grid. In addition, encouraging stored power (i.e., batteries) for consumer level broadband equipment, through funding or other means, will improve impacted individuals' ability to seek information, help with recovery needs, communicate with family members, and even work from home when transportation or business facilities are significantly compromised.

Owner

Leads: *DOE and NTIA*

Status

Recommendation in process: Under consideration for implementation for future recovery efforts.

~~Transportation Infrastructure~~

~~Challenge and Goal~~

~~Sandy caused damages directly (from the wind and water) and indirectly (loss of power) to the region's~~

planYC

A STRONGER, MORE RESILIENT NEW YORK

The City of New York
Mayor Michael R. Bloomberg

Utilities

A steam vent in Midtown

Credit: Jorge Royan

At night, the city is aglow: Times Square dazzles visitors with all shades of neon; lights trace the spans of bridges from the Verrazano to the Whitestone; and street lights illuminate the clouds of steam that rise from the streets of Manhattan. Energy—electricity, natural gas, and steam—makes so much that is iconic about New York City possible. Utility networks not only bring the city's famous skyline to life, they also run the subways, keep the city cool in summer and warm in winter, and support every aspect of the economy.

Under the surface of the streets and out of sight, layers of critical energy infrastructure power the city. Pipelines bring natural gas from across the country. Power lines link the city to the larger regional grid. Generators burn gas to produce electricity. Steam travels from large boiler and cogeneration facilities to buildings through miles of underground conduits. These systems are complex and, in many cases, old—yet most New Yorkers do not think about them until they fail. However, these critical systems deserve careful consideration because they are vulnerable to extreme weather events—and likely will become more vulnerable as the climate changes.

Extreme weather has always been an issue for utility networks, including in the last decade. In 2006, an extended blackout affected approximately 250,000 Queens residents. In 2011, Hurricane Irene's floodwaters came close to leaving parts of Lower Manhattan in the dark. And in the summer of the same year, another heat wave led to an all-time record for city electricity demand.

But Sandy was different. Never before had the city experienced a weather event on this scale (the citywide blackout in the summer of 2003 was a result of a software error several states away). During and after the storm, one-third of the city's electric generating capacity was temporarily lost. Five major electric transmission substations in the city flooded and shut down. Parts of the natural gas distribution network were inundated. And four of six steam plants in the city were knocked out of service.

By the time the storm passed, more than 800,000 customers (representing over 2 million New Yorkers) were without power and 80,000 customers were without natural gas service. A third of the buildings served by the city's steam system—including several major hospitals—were without heat and hot water.

Within a few days of Sandy's departure from New York, much of the city had regained service. In some neighborhoods, however, including large parts of the Rockaways and Staten Island, outages lasted for weeks, as crews of electricians and plumbers went door-to-door to repair flooded equipment.

As serious as the damage to the city's energy infrastructure was, in many ways, the impact that this damage had on people and businesses was even worse. Hospitals had to be evacuated under emergency conditions when primary power was lost and backup generators failed. In high-rise buildings, elevators did not run and most taps above the seventh floor went dry because water pumps had no power. Many offices were left in the dark and without heat. The power outage caused transit shutdowns that prevented employees from going to work, even if their offices were unaffected. The real cost of the hurricane was measured less in repairs to energy infrastructure than in the profound disruption to the existing patterns of city life and commerce.

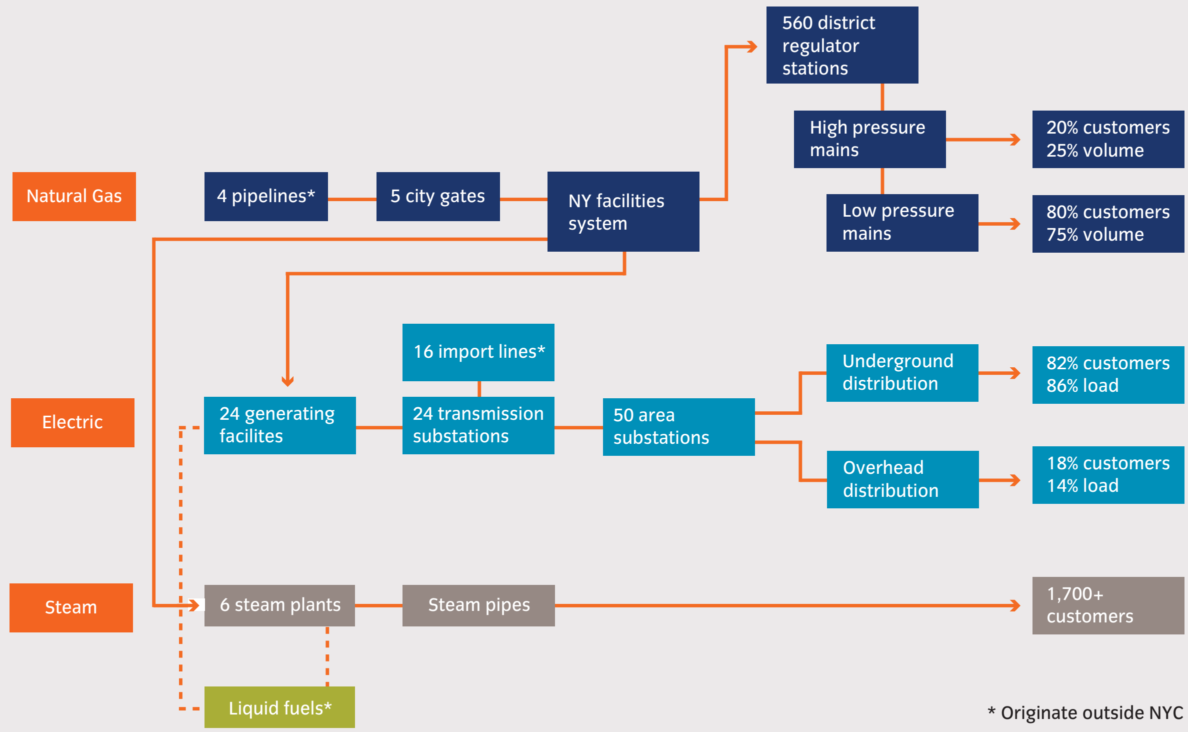
In the future, stronger storms and longer and more intense heat waves will likely pose new challenges to energy infrastructure. The city's energy systems—although reliable during ordinary weather events—need to be upgraded.

In keeping with the overarching goals of this report—which are to limit the impacts of climate change while enabling New York to bounce back quickly when impacts cannot be avoided—the City will work with utility companies and regulatory bodies to improve the current approach to utility regulation and investment. The City will advocate for incorporating risk-based preparation for low-probability but high-impact events, spending capital dollars to harden energy infrastructure and make utility systems more flexible, and diversifying energy sources. Collectively these strategies will reduce the frequency and severity of service disruptions, while allowing for more rapid restoration of service when these disruptions do occur.

How the System Works

New Yorkers spend roughly $19 billion per year on the energy to power, heat, and cool their city. The city's highly interdependent electricity, natural gas, and steam networks are among the oldest and most concentrated in the nation. Yet they are also still among its most reliable. These systems bring energy in bulk into the region and then transport it through layers of infrastructure, reducing levels of voltage (for power) or pressure (for gas) along the way and ultimately delivering energy to consumers. To understand how this system works as a whole, it is first necessary to understand its constituent parts. (*See graphic: Diagram of the Utility Systems*)

Diagram of the Utility Systems



Source: OLTPS

Electric System

The world's first centralized electric generation and distribution system was developed in New York City in the 1880s, by Thomas Edison. As of the writing of this report, New York's electricity system has since grown to serve 3 million customers—including 8.3 million people and 250,000 businesses—who consume roughly 1.4 percent of all electricity produced in the United States. In summer, the grid handles peak loads of over 11,000 megawatts (MW)—almost twice as much as the next largest city, Los Angeles.

The electric system consists of three major elements: generation, which produces electricity; the transmission system, which transports electricity at high voltages to large substations; and the distribution system, which carries electricity from large substations to smaller ones and ultimately to homes, businesses, and other customers. This system is owned, operated, and regulated by a wide array of private and public entities. *(See graphic: Overview of Electric Industry Participants)*

Generation

Multiple private companies and a public authority own and operate 24 plants within or directly connected to New York City (the "in-city fleet"). These plants can generate up to 9,600 MW of power, which is more than 80 percent of New York City's peak demand (defined as the peak level of electricity demand required on the most power-intensive days each year). Usually, only a subset of the in-city fleet will be running at any given time, with roughly 50 percent of the city's needs met with cheaper electricity imported from Upstate New York and New Jersey. The entire in-city fleet operates only during periods of peak electricity usage, such as during summer heat waves, when the use of air conditioning soars. New York City reached an historic peak of over 11,500 MW during a heat wave in July 2011, when temperatures reached over 100 degrees Fahrenheit for three consecutive days.

The in-city generation fleet is fueled predominantly by natural gas, with many plants also able to burn fuel oil. All of the in-city plants are located along the waterfront, with more than half concentrated in Astoria and Long Island City in Queens. Almost two-thirds of the fleet is more than 40 years old, equipped with technology that has lower efficiency and higher air emissions than modern plants.

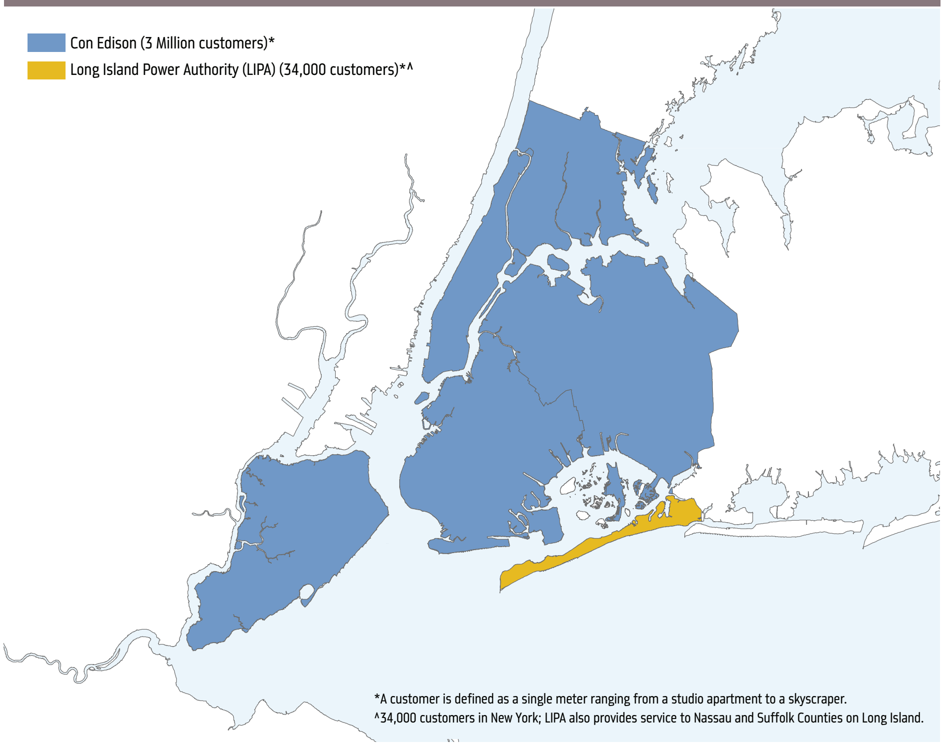
In addition to the in-city generating fleet, another small but growing source of energy in the New York market is customer-sited distributed generation (DG). Much of the 160 MW of DG capacity in New York consists of combined heat and power (CHP) installations, with smaller installations of renewable generation, including solar photovoltaic panels and fuel cells. CHP installations typically are found at large residential complexes, hospitals, and universities. These systems are usually in operation most of the time, replacing or supplementing electric power received from the grid. Some of these installations also are configured so they can operate independently of the grid during blackouts.

Transmission

Long-distance transmission lines connect the city with up to 6,000 MW of supply from areas as near as Northern New Jersey, Long Island, and the Hudson Valley, and as far as Northern and Western New York State. Both in-city-generated and imported electricity feed into Con Edison's electric grid at 24 high-voltage facilities housing switching and transformer equipment—known as transmission substations. Each of these substations routes the electricity that powers a large number of customers or clusters of critical infrastructure. In fact, a single substation in New York may support hundreds of thousands of customers—numbers that make New York's transmission system rare among other US systems.

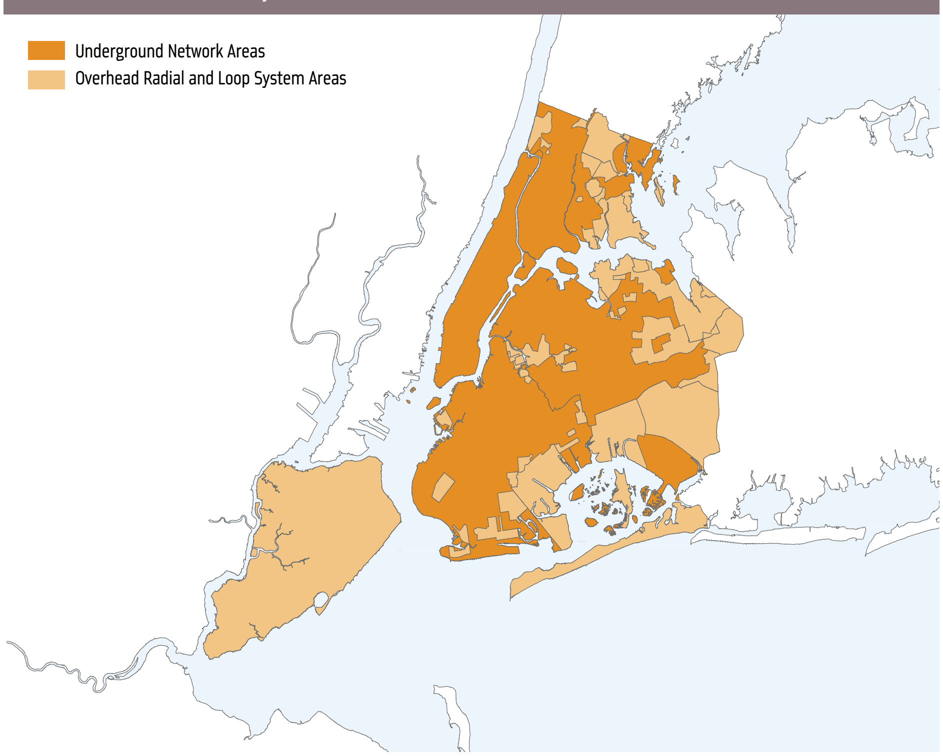
At the city's transmission substations, transformer equipment decreases electrical voltages. Electricity is then sent at these lower voltages through sub-transmission lines to area substations. There, smaller transformers decrease voltage once again and feed the

Electric Service Territories



Source: Con Edison, LIPA

Electric Distribution Systems



Source: Con Edison, LIPA

distribution system. The New York Independent System Operator (NYISO) coordinates the flow of electricity on the transmission system across the State, while Con Edison operates the transmission facilities it owns in the city.

Distribution

Con Edison is the primary electric utility in the city, providing electric distribution services to all five boroughs. The one exception is the Rockaways, which are served by the Long Island Power Authority (LIPA), a public authority controlled by New York State. LIPA does not operate and maintain its distribution system directly. Rather, it contracts for the operation and maintenance of this system to National Grid. This arrangement is set to expire at the end of 2013, when a subsidiary of Public Service Enterprise Group (PSEG) is scheduled to take over for National Grid for a 10-year period thereafter. (*See map: Electric Service Territories*)

The utilities' distribution systems consist of feeder lines that originate from "area substations," which are smaller than the transmission substations described above, but are nonetheless critical. Area substations typically serve one or two neighborhood-level "networks" or "load areas" of customer demand, each of which includes tens of thousands of customers.

In densely populated areas, such as Manhattan and certain portions of the other boroughs, the distribution system that carries power from area substations to end users consists of underground network systems—that is, systems that operate as a grid that can serve customers via multiple paths. In the rest of the city, the distribution system consists of a combination of underground and overhead loop systems and radial lines—that is, systems with simpler architecture, though also with fewer redundancies. These loop systems and radial lines account for about 14 percent of load on Con Edison's distribution system. LIPA's system in the Rockaways is made up exclusively of loop and radial systems. (*See map: Electric Distribution Systems*)

Customers ultimately receive electric power through service lines that are connected to their buildings' electrical equipment. In many cases, high-rise buildings or campus-style complexes have dedicated transformer equipment that serves these individual customers. This equipment is typically located in vaults beneath area sidewalks.

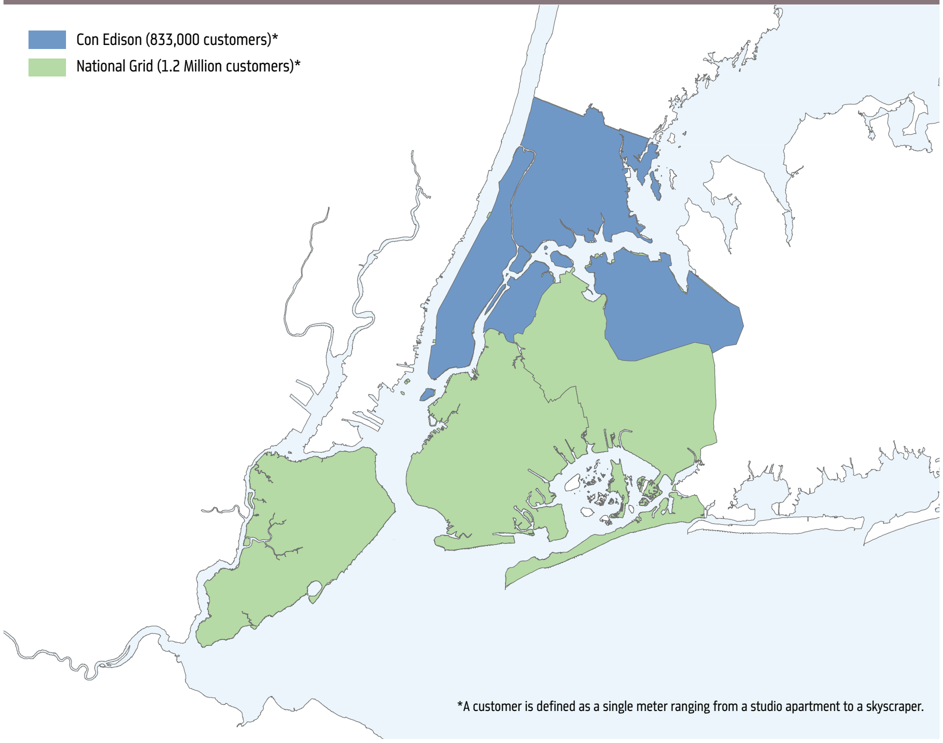
Natural Gas System

Natural gas fuels approximately 65 percent of heating and a significant percentage of cooking needs in buildings throughout New York. It also fuels more than 98 percent of in-city electricity production by power plants. A system of four privately-owned interstate pipelines transports natural gas from the Gulf Coast, Western Canada, and other production areas into the city at interconnection points called "city gates."

From the various city gates, high-pressure gas flows through an intra-city transmission system known as the New York Facilities. Gas that is destined for New York's power plants generally is drawn at high pressure directly from the New York Facilities. To reach most other customers, gas is delivered through a set of regulator stations that reduce the pressure of the gas and send it into a vast network of underground distribution mains. In New York, these distribution mains come in two varieties: high-pressure and low-pressure. The low-pressure system is composed of cast iron and bare steel mains—outdated infrastructure that gradually is being replaced by the system's operators. This system is located mostly in the oldest parts of the city. Newer, high-pressure mains tend to be made of coated steel and plastic.

In New York, Con Edison owns and operates the gas distribution system in Manhattan, the Bronx, and parts of Northern Queens. National Grid owns and operates the system in the rest of the city. (*See map: Natural Gas Service Territories*)

Natural Gas Service Territories



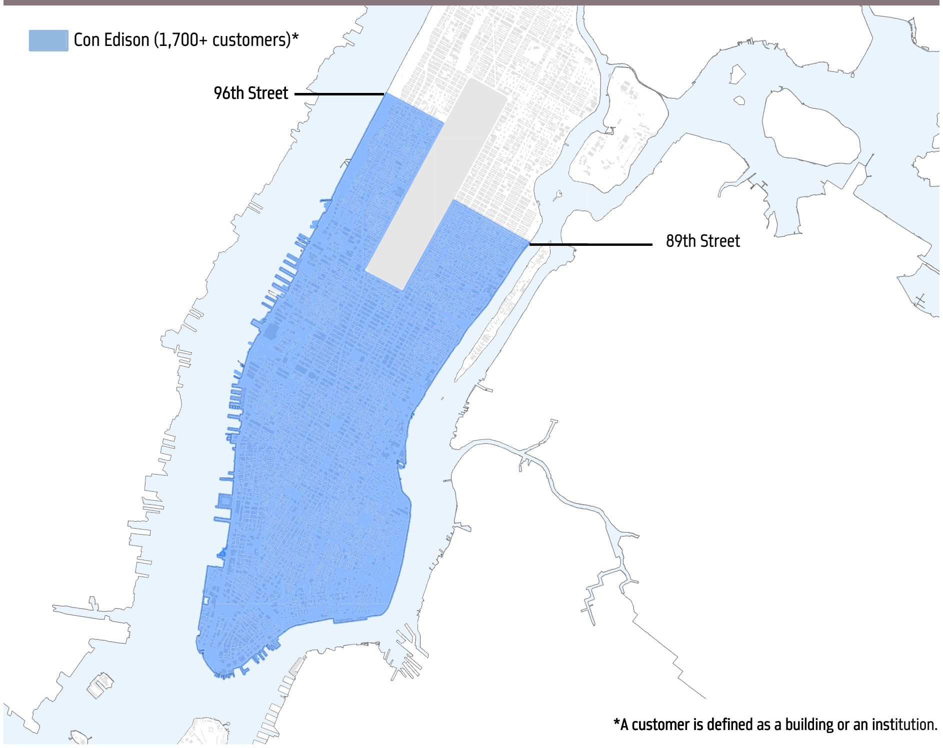
Source: Con Edison, National Grid

New York City's natural gas demand usually peaks on cold winter days, when it can exceed the capacity of the four interstate pipeline connections. On those days, utilities ask electric generating plants and other large users to switch to liquid fuels. In the next three years, pipeline capacity will expand as private companies complete two new pipeline connections to serve the city, a significant advance in the City's cleaner burning fuels initiatives.

Steam System

The Con Edison steam system, one of the largest district steam systems in the world, provides over 1,700 buildings in Manhattan—including 10 hospitals and many of the city's largest institutions—with energy for heat, hot water, and, in some cases, air conditioning. The advantage of the steam system to customers is that it allows them to avoid owning and maintaining their own boiler systems. Instead, these customers are responsible for the easier task of maintaining on-site steam traps and condensate pumps. (*See map: Steam Service Territory*)

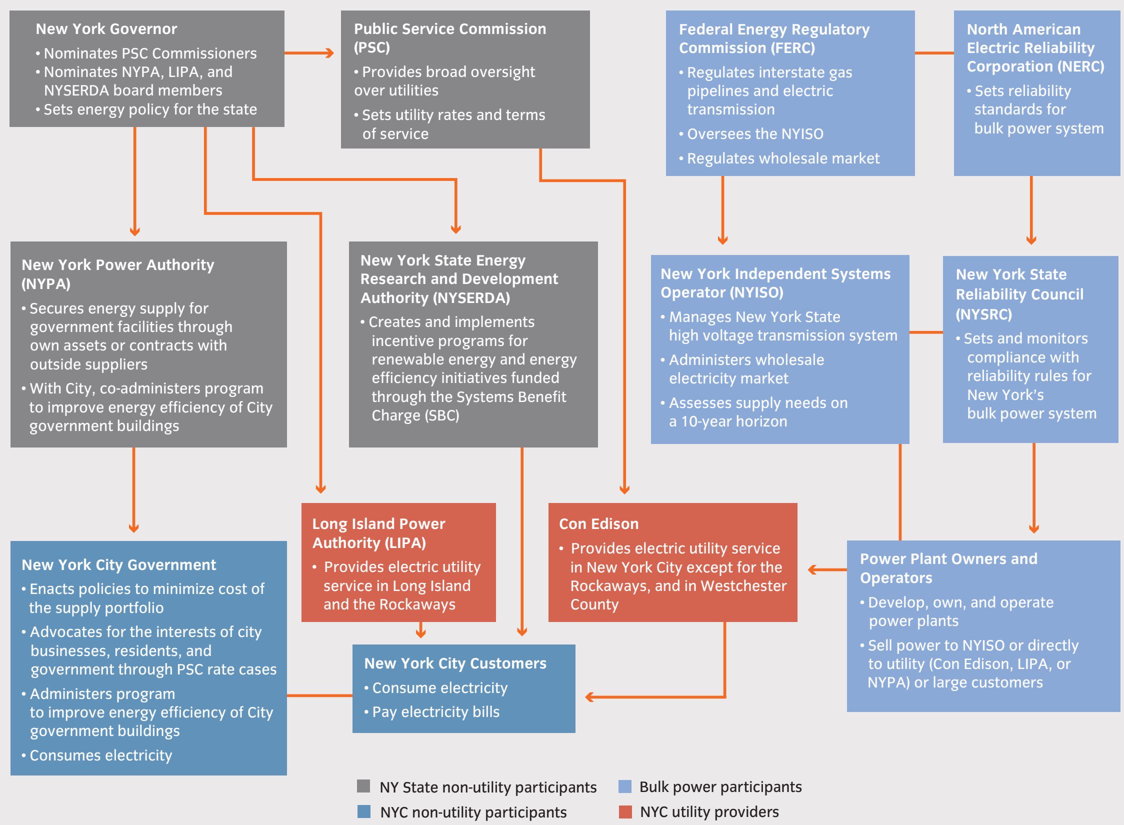
Steam Service Territory



Source: Con Edison

Six natural gas- and fuel oil-fired steam generating facilities in Manhattan, Brooklyn, and Queens can collectively produce over 10 million pounds of steam per hour, either cogenerating this steam along with electricity, or producing steam alone in massive boilers. A network of 105 miles of underground pipes transports this steam to customers.

Overview of Electric Industry Participants



Source: OLTPS

Utility Regulation

A combination of private companies and public authorities own and operate New York's energy system, which is subject to a complex system of Federal and State oversight. Within this regulatory system, different entities are responsible for setting reliability expectations and standards, providing regulatory oversight, and for monitoring compliance with performance standards. The overall goal is to ensure safe, reliable, and affordable delivery of electricity, natural gas, and steam. (*See graphic: Utility Regulation*)

In the electric sector, the Federal Energy Regulatory Commission (FERC) oversees interstate transmission rates and wholesale electricity sales, while the New York State Reliability Council (NYSRC) establishes the State's electric reliability standards for the bulk power and bulk transmission systems. Subject to these standards, the NYISO operates the state's wholesale electricity market and high-voltage transmission system, and monitors the reliability of the state-wide transmission system. The New York State Public Service Commission (PSC) oversees all aspects of retail electric service, including the utilities' rates, terms, and conditions of service, as well as the safety, adequacy, and reliability of the service they provide.

Reliability expectations set by regulators govern the design and operation of the electric system. In the generation and transmission system, the reliability standards are set by the NYSRC, which requires that the bulk power and transmission system be designed so as to have an unplanned outage no more than once in 10 years.

Con Edison, in turn, designs and operates its electric system so that its network system, the portion of its system that serves the city's more densely-populated areas, is able to withstand the loss of two components within a distribution network and still maintain service. In less densely-populated areas, the system is designed to withstand the loss of one component.

Oversight of the rates, terms, and conditions of electric service is the domain of the PSC. One mechanism used by the PSC towards this end is the "rate case" process, in which the PSC determines the conditions for utility rate increases. During this process, a utility submits a filing that contains a justification for a rate increase, including details on capital investments that it proposes to make. The City and a variety of other stakeholders offer comments, testimony, and recommendations on the rate request and other related issues. The PSC then makes a decision about the proposed increase based on factors including whether the rates adopted will maintain safe and adequate service for customers. The same process applies to gas and steam utilities

To measure how well the electric utilities are performing, the PSC uses quantitative metrics. The two main metrics are the System Average Interruption Frequency Index (SAIFI) and the Customer Average Interruption Duration Index (CAIDI). SAIFI measures the average number of interruptions per customer per year, while CAIDI measures the average length of each interruption. Con Edison's SAIFI is the lowest in the nation among large investor-owned utilities; its CAIDI, however, is above the national average. This generally reflects the fact that Con Edison's underground network systems are quite robust, suffering outages less frequently than typical above-ground systems – but when outages do occur, they can take longer to address and repair than overhead disruptions. (*See chart: Reliability Performance Comparison Among Selected US Utilities*)

For the natural gas and steam utilities, regulation of system design and operations is focused on safety. Oversight on rates and conditions of services is regulated similarly to the electric sector. In the case of the natural gas system, the FERC regulates interstate pipelines and the PSC

Utility Regulation

UTILITY SERVICE	RELIABILITY EXPECTATIONS	REGULATORY OVERSIGHT	PERFORMANCE MONITORING
Electric generation and transmission	• NYSRC requires that the probability of the loss of firm load due to system wide resource deficienciesbe no more than 1 day per ten years in accordance with Federal standards set by NERC	• FERC oversees NERC and NYISO, which manages bulk electricity generation and transmission in New York • NYSRC sets reliability standards (with FERC and PSC oversight)	• Compliance with NERC and NYSRC standards is monitored by the NYSRC and NYISO through reporting, audits, and investigations
Electric distribution	• Con Edison designs network system to withstand the loss of two components; parts of the overhead system are designed to withstand the loss of one component (depending on location and population density)	• PSC regulates rates, terms, and conditions of service	• PSC measures performance using SAIFI, CAIDI, and major outage events • PSC also tracks use of remote monitoring systems and restoration times following outages
Natural Gas transmission	• N/A, focus is on safety	• FERC regulates rates, terms, and conditions of service • USDOT regulates pipeline safety	• N/A
Natural Gas transmission	• N/A, focus is on safety	• PSC regulates rates, terms, and conditions of service • PSC regulates pipeline safety as USDOT's delegate	• PSC measures emergency response time to leaks, leak repair backlog, damages to gas facilities, and replacement of leak-prone gas mains
Steam	• N/A, focus is on safety	• PSC regulates rates, terms, and conditions of service	• PSC measures response time to leaks and leak repair backlog

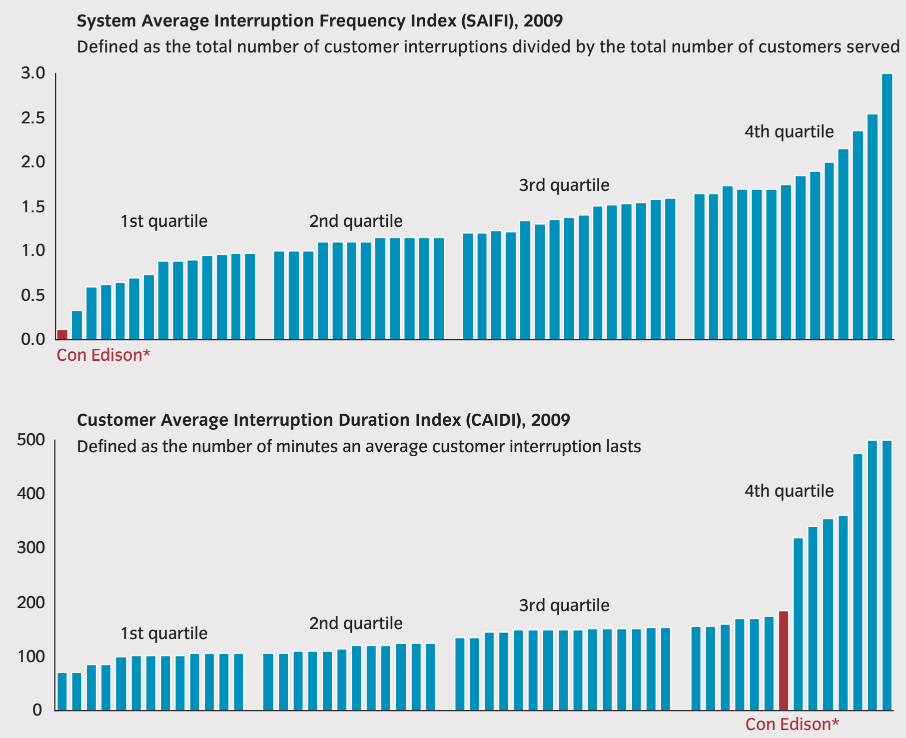
Source: OLTPS

regulates local distribution companies and the provision of retail gas service. Gas pipeline safety is regulated by the United States Department of Transportation (US DOT), though in New York State, the PSC is the US DOT's designee for this purpose. The steam system, on the other hand, is regulated solely by the PSC. For both systems, performance metrics used by the PSC measure how well utilities manage leaks and how quickly they respond to reports of them (and, in the case of the natural gas utilities, odors).

Across all of the city's energy systems, the PSC also establishes financial incentives for each utility. These incentives impose revenue adjustments for failure to achieve specified thresholds or target levels of performance.

Climate change and its associated risks are not considered with respect to virtually any aspect of the regulatory framework applicable to New York's energy system. For example, the models that the NYISO runs to test whether the electric system will be able to meet future standards factor in the possibility of future heat waves, but do not yet consider the fact that in the future, heat waves are likely to be more frequent, more intense, and longer lasting than today, impacting electric demand. Similarly, when the utilities design their equipment, they tend to do so with a certain level of storm surge in mind. The regula-

Reliability Performance Comparison Among Selected US Utilities



* Con Edison numbers include the underground network system, which is unique among compared utilities

Source: Edison Electric Institute, NYS PSC, Team analysis

The Arverne Substation in the Rockaways was severely damaged by Sandy. Credit: LIPA

tors, however, do not yet require these utilities to consider a full range of present and future storm surge risks. When it comes to measuring performance, the SAIDI and CAIFI metrics that are used for the electric system actually exclude outages that are caused by major weather events.

What Happened During Sandy

Sandy caused unprecedented damage to New York's electricity and steam systems. The city's gas system experienced damage that was smaller in scale and impact. In all three systems, however, damage occurred to infrastructure and customer equipment alike, leaving hundreds of thousands of customers without electricity, tens of thousands of customers without natural gas, and hundreds of the city's largest buildings without steam for heat and hot water.

Most of the city's energy systems ultimately recovered within a week of Sandy's departure. However, in parts of the city where floodwaters inundated basements and sub-basements, it took additional weeks to make the extensive repairs to homes and businesses that were necessary for utility service to be restored.

Electric System

The total number of New York customers left without power as a result of Sandy ultimately came to 800,000, which, given that utilities define a customer as a single electric meter, is equal to more than 2 million people. This is five times as high as the number that lost power during Hurricane Irene, the second most-disruptive storm in recent history. Despite actions by the utilities to protect their assets, the storm caused serious damage to generation, transmission, and distribution systems, as well as to customer-owned equipment. While utilities sought to restore services as quickly as possible, the extent of the damage led to a complex and lengthy restoration process. Service to most Con Edison customers was restored within four days. However, some customers' service was not restored for almost two weeks, making this event the longest-duration outage in Con Edison's history. LIPA's electric service restoration in the Rockaways took an average of almost 14 days—with some customers enduring outages over a much longer period.

In the days leading up to Sandy, the utilities took preemptive actions to minimize potential downtime by protecting and preserving their infrastructure. For example, to mitigate the impact of a surge (which, based on the best available forecasts, would top 11 feet at the Battery in Manhattan), the utilities protected critical facilities with sandbags, plywood and other temporary barriers. Then, as the storm arrived on the night of Oct. 29, Con Edison shut down three entire networks preemptively—its Bowling Green and Fulton networks in Lower Manhattan, and its Brighton Beach network in Brooklyn—to prevent catastrophic flood damage to several clusters of underground distribution equipment as well as to customer equipment. Elsewhere, Con Edison prepared to de-energize feeders when flooding appeared imminent at key underground transformer vaults. Because of the configuration of the network distribution system, many of these preemptive moves caused the loss of electricity not only to customers in areas that were anticipated to be in Sandy's inundation zones but also to many customers that were expected to be outside of those zones.

When the storm arrived, the surge exceeded projections, topping out not at 11 feet but at 14 feet (MLLW) at the Battery and overwhelming many pre-storm preparations. Flooding forced several power plants and several transmission lines that import electricity from New Jersey to shut down, leaving New York City more dependent on a subset of its in-city generation capacity and on the electricity supply from Upstate New York. Some facilities also were damaged severely by Sandy's surge. This was true, for example, at the Brooklyn Navy Yard Cogeneration plant and the Linden Cogeneration plant. Other facilities, meanwhile, were disconnected temporarily because of impacts to the transmission system. While the impacts to electricity supply were significant, Sandy, ultimately, did not have the impact it might have had, had the storm arrived during the summer. (*See sidebar: Summer Demand Scenario*)

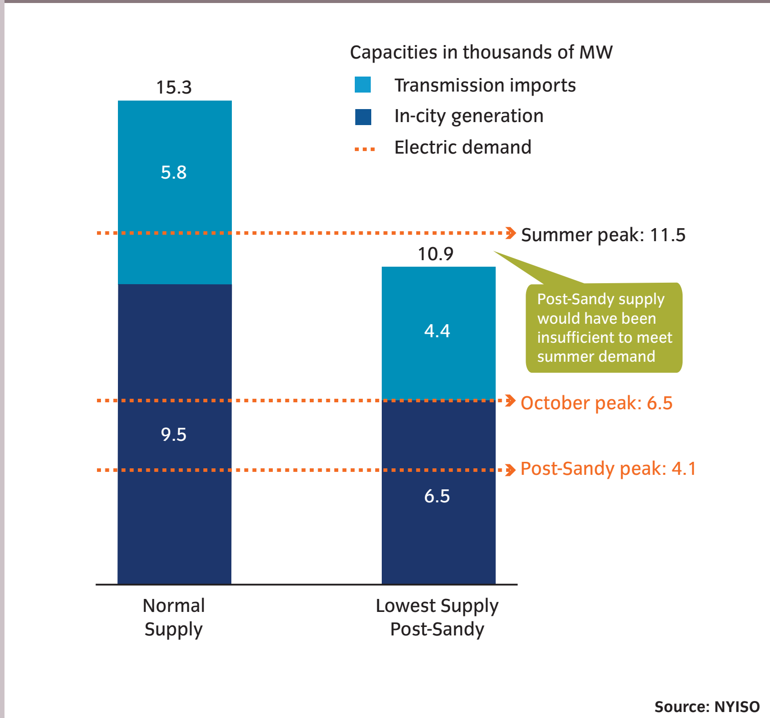
Perhaps the most significant (and dramatic) impact that Sandy had on the operation of the transmission and distribution systems occurred when the storm's surge came into contact with several key substations—including substations that, based on earlier surge forecasts, were not

Summer Demand Scenario

After Sandy, New Yorkers generally focused on the impact of the storm on the city's electricity consumers. By damaging distribution systems and customer equipment and disrupting activity across New York, the storm temporarily reduced demand for electricity in the city by some 40 percent. What has received less attention, however, is the fact that Sandy also disrupted a large number of in-city generators (directly and indirectly), leaving the city short of 3,000 MW of capacity upon which it normally could depend (almost one-third of normal in-city capacity). In addition, due to impacts to low-lying sections of the transmission infrastructure between New York and New Jersey, Sandy also left the city temporarily unable to access more than 1,400 MW of import capacity from New Jersey.

Because of the timing of Sandy's arrival in late October, when electricity usage tends to be relatively low, the remaining supply available to the city after Sandy ended up being sufficient to support the city's demand at the time. However, if Sandy had come during the peak summer demand period, it is possible that—once the storm had passed and peak load had recovered—the remaining in-city generation capacity would have been inadequate to meet the city's demand. This, in turn, could have resulted in severe outages on a much wider scale than those actually caused by Sandy. This disruptive outcome is one that the city may not avoid during future extreme weather events, particularly if hardening measures are implemented to protect distribution infrastructure and customer equipment without also protecting generating assets.

Electricity Supply and Demand Balance

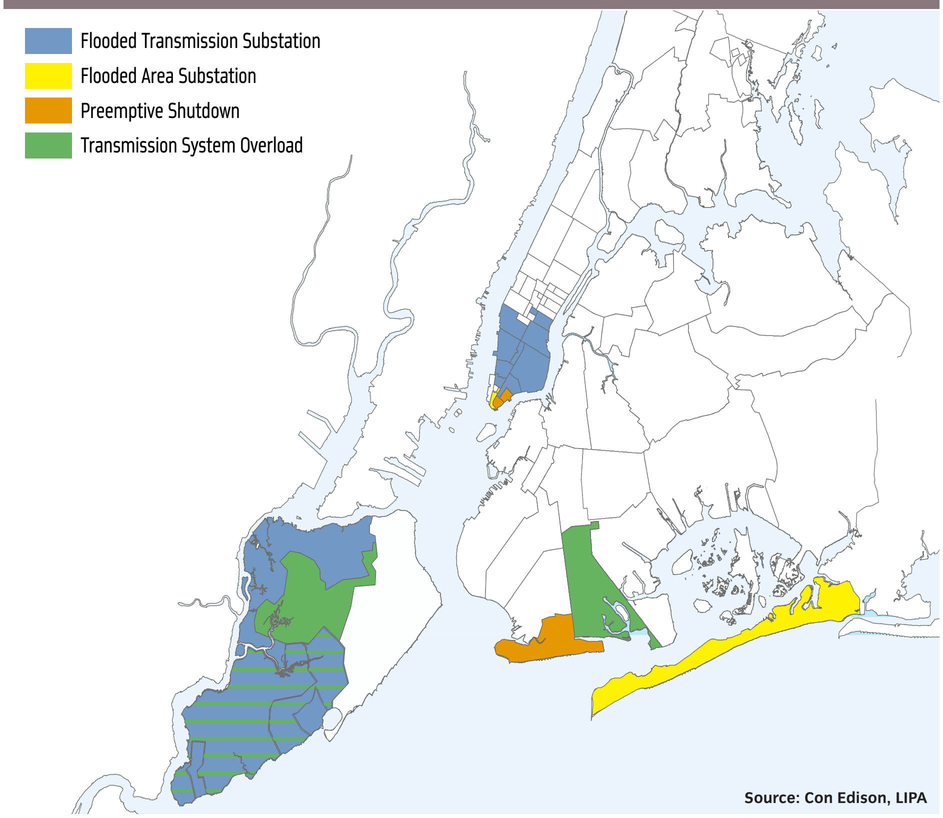


Source: NYISO

expected to be impacted. For example, in the Rockaways, all four LIPA substations were knocked out by floodwaters, resulting in widespread power failures throughout the peninsula. In Manhattan, Sandy's surge overtopped temporary protective barriers at Con Edison's East 13th Street complex, flooding two transmission substations and leading to an intense electric arc that could be seen from across the East River. Storm surge also impacted a Con Edison area substation in Lower Manhattan. Across these facilities, critical control equipment was submerged in saltwater. The damaged systems made the substations inoperable, knocking out power to most of Manhattan south of 34th Street (with one notable exception being Battery Park City, which is supplied with electricity from a transmission substation in Brooklyn). Finally, flooding of a transmission substation in Staten Island caused a grid-level shutdown in the western part of the borough.

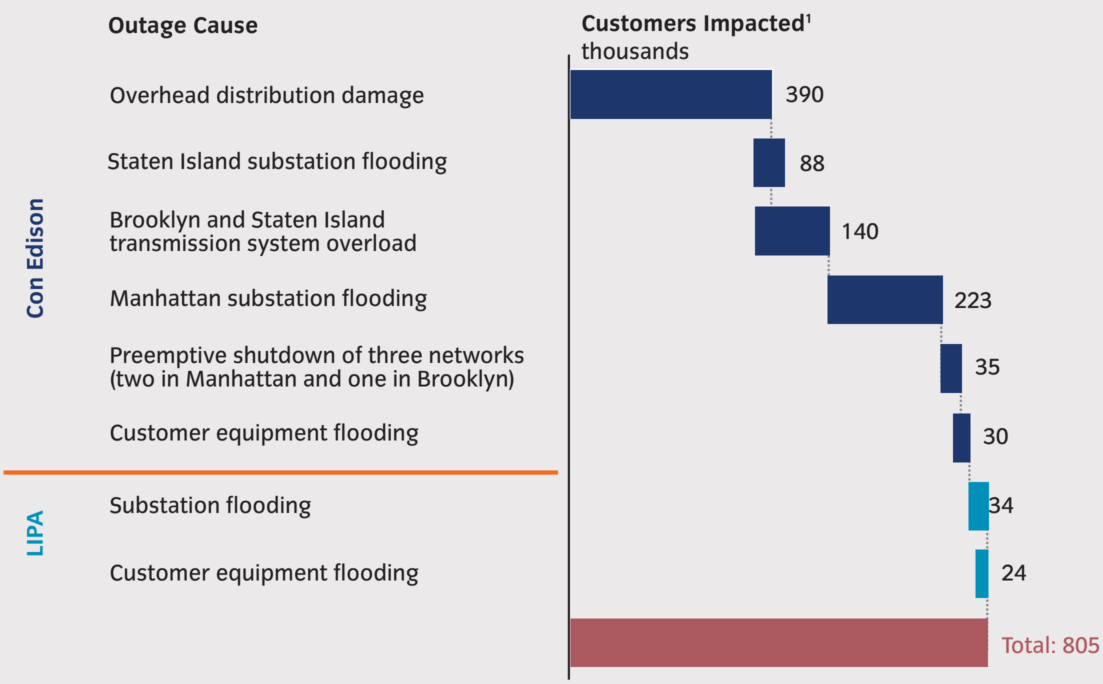
Each of these substation losses impacted tens or hundreds of thousands of customers. In all, approximately 370,000 electric customers in New York City lost power due to network shutdowns and substation flooding in Manhattan, Brooklyn, Queens, and Staten Island. (*See map: Electric Network Shutdowns During Sandy by Cause*)

Electric Network Shutdowns During Sandy by Cause



Source: Con Edison, LIPA

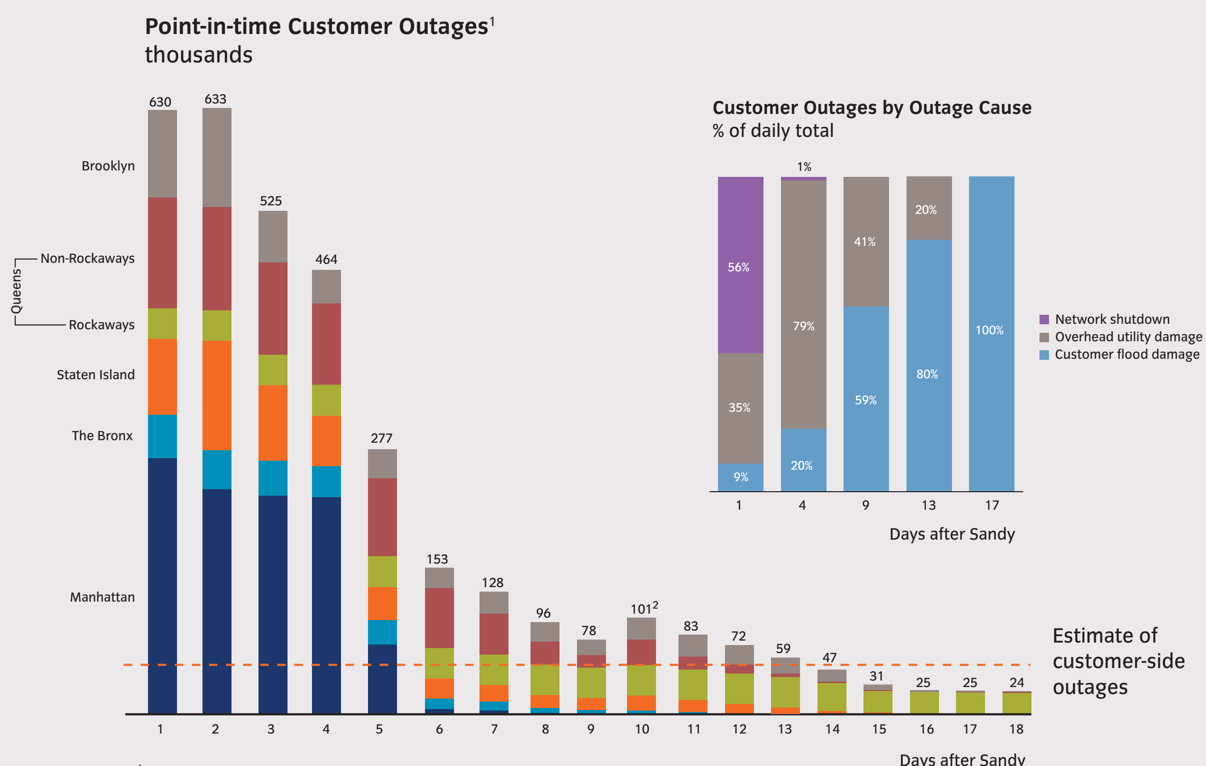
Causes of Electric System Outages and Customer Impacts



[1] Overlaps of customer counts exist between categories

Source: Con Edison, LIPA

Electrical Outage Restoration

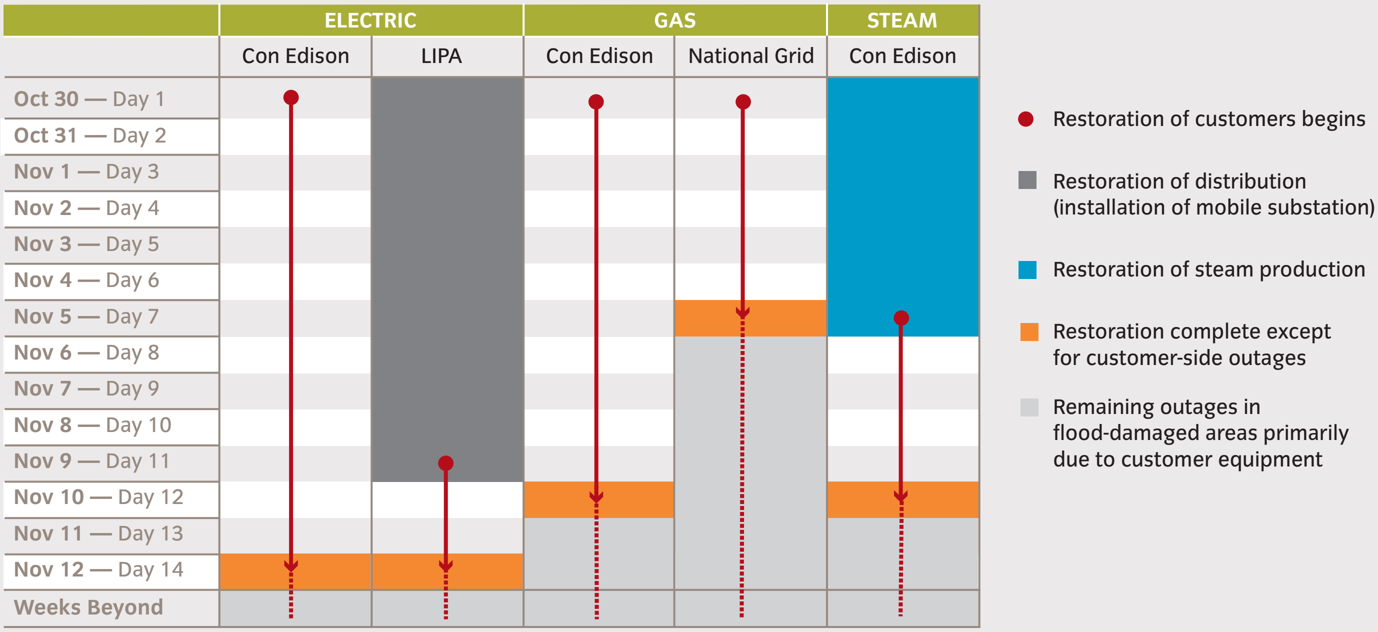


[1] A total of 805,000 customers lost power after the storm, but point-in-time daily estimates are lower because accounts went on and offline at different times

[2] Increase in customer outages due to the impact of nor'easter on Nov. 7

Source: Con Edison, LIPA

Electric, Gas, and Steam System Restoration Milestones



Source: Con Edison, LIPA, National Grid

Substation disruptions also led to stresses within the city's bulk transmission system, which became another cause of power outages. For example, a day after Sandy's departure, a transmission system overload resulted from equipment damage at two flooded transmission substations in Brooklyn and Staten Island, as well as the disconnection of the Arthur Kill generating facility. The combination of these factors and the loss of all import capacity from New Jersey meant that the remaining transmission line capacity from northern parts of the city to parts of Brooklyn and Staten Island was inadequate. As a result, Con Edison was forced to terminate service to 140,000 customers, including some customers who had lost and regained power just the day before. This situation persisted for two and half hours, until the Arthur Kill generating units could be brought back online.

In addition to the outages caused by substation disruptions, Sandy caused localized outages in the city's overhead distribution system. Intense periods of sustained winds as well as wind gusts reaching 90 miles per hour toppled trees and pushed branches into power lines. Ultimately, 140 miles of overhead lines, 1,000 poles, and 900 transformers were damaged in Con Edison's system and had to be replaced or repaired. As a result approximately two-thirds of the city's customers served by the overhead system, or 390,000 customers, lost power at some point.

Within heavily flooded areas, approximately 55,000 customers primarily lost power not because of damage to the utility system serving them but because of damage to electrical equipment in their buildings. In many cases, these customers suffered much longer outages due to the extensive repairs needed on their own equipment. Customers that were impacted by flooding in their basements included three hospitals. These hospitals eventually were forced to evacuate patients because they were unable to rely on their backup power systems. (*See chart: Causes of Electric System Outages and Customer Impacts*)

As Sandy's floodwaters receded, the utilities were faced with the massive task of restoring electricity to those who had lost it. The efforts to restore electric service were centered around repairs to damaged transmission infrastructure and local distribution system equipment. Of course, before restoration could occur, it was necessary for the utilities to determine where the need for restoration existed. The identification of system outages generally relies on a combination of grid monitoring technology, customer complaints, and, in areas of heavy damage, special assessment teams sent out by the utilities. Following Sandy, once the utilities assessed the location and extent of damage, restoration of service was prioritized to the extent possible for facilities necessary for critical care and public safety, City infrastructure, and individual customers. *(See charts: Electric Outage Restoration* and *Electric, Gas and Steam System Restoration Milestones*)

Electric service restoration to customers connected to the underground distribution system depended on the utilities' ability to reenergize inundated substations. In most cases, during Sandy, the major electricity-carrying equipment in these substations escaped catastrophic damage. In fact, most of the portions of the system that were damaged were restored in a matter of days. Once each substation was restored, service to the tens of thousands of customers could be turned on almost instantaneously.

Much work remained even after the restoration of substations. While Con Edison's decision to deenergize portions of the underground distribution system in Lower Manhattan and low-lying areas in Brooklyn and Queens preemptively reduced the extent of damage, localized areas of flooding required hundreds of underground vaults to be pumped dry. The combination of dewatering, the replacement of the many components that were damaged by inundation, and the inspections that were required prior to reenergizing turned out to be a significant undertaking for Con Edison.

Utilities from around the country sent "mutual assistance crews" to assist in this restoration effort. For example, Con Edison brought in nearly 3,400 overhead line workers (as well as over 400 underground workers) from as far away as California. As a result of these efforts, service to the majority of overhead and underground system customers was restored within a week. Due to the sheer volume of damage across the system, it took another week to restore power to all of Con Edison's customers who could accept it.

Utility workers pumping water out of underground electric vaults post-Sandy

Credit: Con Edison

The situation in LIPA's territory in the Rockaways was worse. There, several substations were so badly damaged that a mobile substation unit had to be put in place while longer-term repairs were conducted. As a result, it took 11 days after Sandy passed before LIPA could begin to reenergize its grid. Three days later, LIPA was able to restore power to 10,000 customers, predominantly in portions of Far Rockaway, whose homes were built on higher ground. The majority of customers in Rockaway neighborhoods such as Belle Harbor, Rockaway Beach, and Arverne, had significant flood damage to electrical equipment in their homes and businesses, which further delayed service restorations.

As indicated, even when power was restored to different parts of the city's electrical grid, customers were not able necessarily to use that power in their homes and businesses; this was due, in many cases, to significant damage to customer-side equipment caused by the flooding. In these cases, the City worked with Con Edison, LIPA, and National Grid to create an innovative program for impacted homeowners called Rapid Repairs. This program, funded by FEMA, made licensed electricians available to repair customer-side electrical damage. By the time it ended, five months after Sandy, the Rapid Repairs program had helped restore service to some 20,000 homes.

It is worth noting that, amidst the widespread electric outages, there were some cases where facilities performed well on either backup generators or CHP systems. For example, at least five hospitals relied on backup generator systems in order to stay in operation during the storm and its aftermath. Meanwhile, New York University had success keeping key buildings on its Washington Square campus lit and heated thanks to a newly installed gas-fired CHP system, which it was able to operate seamlessly in isolation from the grid when the grid failed.

Natural Gas System

Overall, the city's natural gas system fared better than its electric grid. However, even this generally resilient system did not escape damage, with approximately 80,000 National Grid and 4,000 Con Edison customers ultimately losing service.

As was the case for the electric grid, Sandy's impact on the city's natural gas system began with a series of preemptive steps that were taken by Con Edison and National Grid. For example, as Sandy approached, the two utilities isolated some low-lying parts of their networks to ensure that any intrusion of water would be limited, rather than spreading system-wide. Both Con Edison and National Grid also shut down several regulator stations in anticipation of the storm.

As Sandy's surge peaked, Con Edison and National Grid needed to take immediate action, resulting in the shutdown of still more sections of their respective distribution systems. In some parts of the low-pressure distribution system, the pressure of floodwaters quickly exceeded the pressure inside the gas mains, resulting in water intrusion through cracks, holes and other weak points. Meanwhile, in the high-pressure distribution system, floodwaters entered some customer service lines. The net effect of the preemptive actions and the inundation damage was loss of gas service in a number of city neighborhoods, including Coney Island, Howard Beach, the Rockaways, Edgewater Park, Locust Point, City Island, and portions of the East Village and South Street Seaport. Additionally, some of Con Edison's gas control and monitoring equipment stopped functioning, due to the loss of power and telecommunications services.

As Sandy's floodwaters receded, restoration primarily depended on the removal of water from distribution mains, equipment and pipe inspections, and the re-lighting of customers' appliances. Though this work began almost immediately, damage to some system components was extensive. For example, in the weeks following the storm, National Grid had to rebuild 13 miles of gas mains serving Breezy Point (which had also been damaged by fire) and New Dorp.

Similar to the electric grid, restoration of the gas distribution system was still, in some cases, insufficient to re-light appliances in homes and businesses that were damaged by floodwaters. Here again, the City's Rapid Repairs program was instrumental in assisting homeowners with making repairs to damaged boilers and heating systems.

Steam System

During Sandy, one-third of the city's steam customers, including five acute care hospitals, experienced outages. As was the case for the electric grid and gas distribution system, Sandy's impact on the city's steam distribution system began with a series of preemptive steps that were taken by Con Edison. These included the closing of low-lying segments of the system, in order to avoid a damaging and potentially explosive effect called "water hammer" that occurs when cold floodwaters meet hot steam pipes. Con Edison also shut down two generating stations that were potentially vulnerable to inundation: East River and Brooklyn Navy Yard.

The storm surge from Sandy forced Con Edison to shutdown two more generating stations, one at 59th Street and one at 74th Street in Manhattan. In total, during Sandy, the city's steam system lost nearly 90 percent of its generating capacity, resulting in a complete shutdown of the system below 14th Street. Other customers lost steam service when parts of the First Avenue distribution tunnel, which steam mains, gas mains, and electric lines traverse, were flooded with 500,000 gallons of water. Moreover, some customers' steam services were shut down when the electric grid failed in Southern Manhattan, and they were unable to power their buildings' systems.

Following Sandy, restoration of the steam system took approximately 12 days. This was not only because of the significant damage that had occurred but also because of the careful timing and sequencing required for restoration, including the repair of production capacity and dewatering of pipes, which are both necessary preconditions for the warming and pressurization of mains.

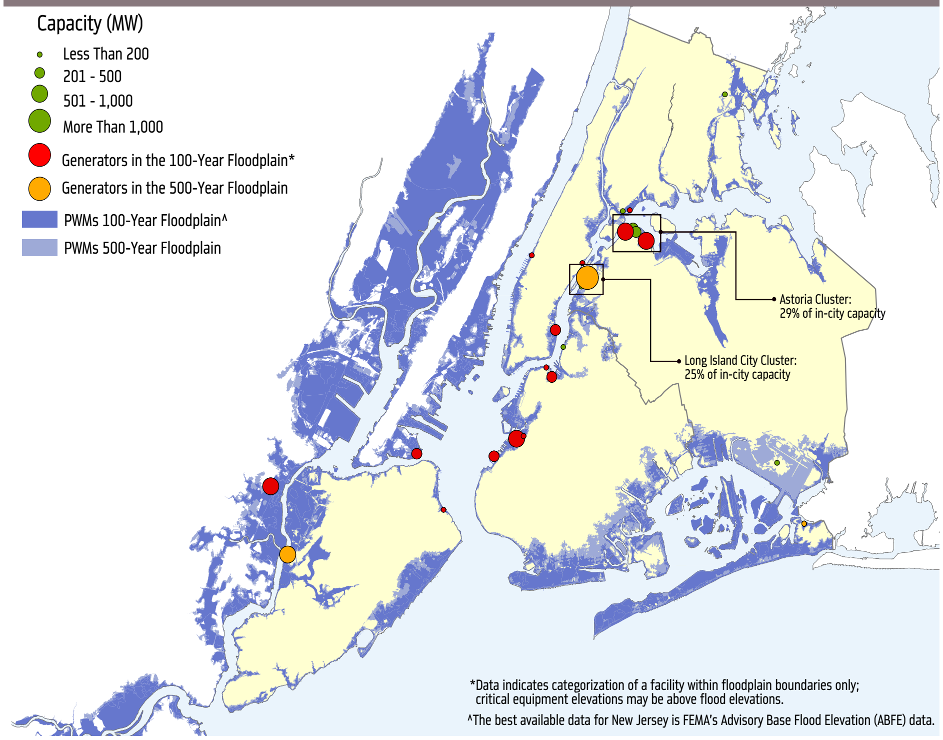
What Could Happen in the Future

Going forward, impacts from several types of extreme weather events could cause major failures in the city's utility systems, which could take multiple days to weeks to repair. The electric and steam systems face the greatest risks, with storm surge, paired with sea level rise, representing the most significant challenge. The electric system also could be impacted seriously by more frequent, longer, and intense heat waves. The natural gas system is fairly resilient overall, but storm surge could still pose a localized risk.

Major Risks

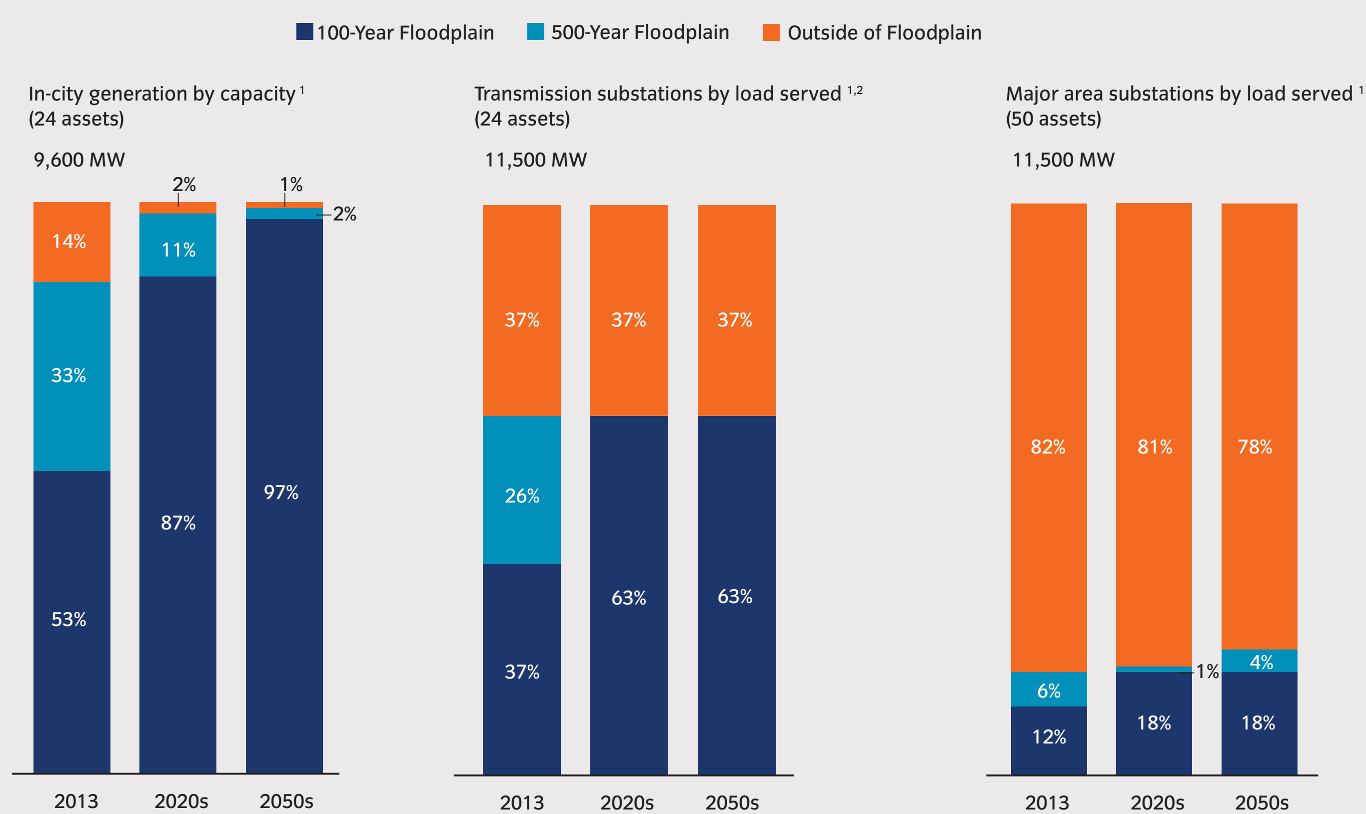
As demonstrated by Sandy, storm surge could cause major loss of electric and steam service. The city's underground electric and steam distribution systems are vulnerable to floodwaters, as are electric and steam generating facilities. Today, 88 percent of the city's steam generating capacity already lies within the 100-year floodplain. In the electric system, 53 percent of in-city electric generation capacity, 37 percent of transmission substation capacity, and 12 percent of large distribution substation capacity lie

In-City Electric Generating Facilities in the Floodplain



Source: FEMA, OLTPS

Electric Assets in Current and Future Floodplains



[1] Data indicates categorization of a facility within floodplain boundaries only; critical equipment elevations may be above flood elevations

[2] Does not include transmission substations that do not serve load directly

Source: FEMA, CUNY Institute for Sustainable Cities, OLTPS

Risk Assessment: Impact of Climate Change on Utilities—Electric System

Major Risk | Moderate Risk | Minor Risk

	Scale of Impact			
Hazard	**Today**	**2020s**	**2050s**	**Comments**
Gradual				
Sea level rise	Minor Risk	Minor Risk	Minor Risk	Minimal impact
Increased precipitation	Minor Risk	Minor Risk	Minor Risk	Minimal impact
Higher average temperature	Minor Risk	Minor Risk	Minor Risk	Minimal impact
Extreme Events				
Storm surge	Major Risk	Major Risk	Major Risk	Much of the critical infrastructure is in floodplains; flood risks will become worse over time
Heavy downpour	Minor Risk	Minor Risk	Minor Risk	Minimal impact
Heat wave	Moderate Risk	Major Risk	Major Risk	Increased risk of outages due to the impact of heat waves on peak demand and on electric infrastructure
High winds	Moderate Risk	Moderate Risk	Moderate Risk	Risk of damage to overhead power lines

Risk Assessment: Impact of Climate Change on Utilities—Natural Gas System

Major Risk | Moderate Risk | Minor Risk

	Scale of Impact			
Hazard	**Today**	**2020s**	**2050s**	**Comments**
Gradual				
Sea level rise	Minor Risk	Minor Risk	Minor Risk	Minimal impact
Increased precipitation	Minor Risk	Minor Risk	Minor Risk	Minimal impact
Higher average temperature	Minor Risk	Minor Risk	Minor Risk	Minimal impact
Extreme Events				
Storm surge	Moderate Risk	Moderate Risk	Moderate Risk	City gates could lose monitoring/control systems; low-pressure distribution pipes could experience water infiltration
Heavy downpour	Minor Risk	Minor Risk	Minor Risk	Minimal impact
Heat wave	Minor Risk	Minor Risk	Minor Risk	Minimal impact
High winds	Minor Risk	Minor Risk	Minor Risk	Minimal impact

Risk Assessment: Impact of Climate Change on Utilities—Steam System

Major Risk | Moderate Risk | Minor Risk

	Scale of Impact			
Hazard	Today	2020s	2050s	Comments
Gradual				
Sea level rise	Minor	Minor	Minor	Minimal impact
Increased precipitation	Minor	Minor	Minor	Minimal impact
Higher average temperature	Minor	Minor	Minor	Minimal impact
Extreme Events				
Storm surge	Major	Major	Major	Most steam generation assets and parts of the distribution system are in floodplains; flood risks will become worse over time
Heavy downpour	Moderate	Moderate	Moderate	Localized outages are possible
Heat wave	Minor	Minor	Minor	Minimal impact
High winds	Minor	Minor	Minor	Minimal impact

within the 100-year floodplain. Based on the best available sea level rise projections, these figures are forecast to grow by the 2050s to 97 percent, 63 percent, and 18 percent, respectively. *(See map: In-City Electric Generating Facilities in the Floodplain; see chart: Electric Assets in Current and Future Floodplains)*

For the natural gas system, the biggest risk that storm surge poses (both today and in the future) is to the distribution infrastructure. Although flooding in and of itself usually will not stop the flow of gas, if water enters pipes, service can be compromised. The low pressure system is particularly vulnerable to this type of infiltration. Further upstream, the risks are lower, since gas can continue to flow if water inundates a city gate or regulator station (though controls and metering equipment are not always impervious to flooding).

Another significant risk to the city's energy systems—primarily its electric grid—comes from heat waves. Historically, heat waves impacted the city's electric grid more frequently and more significantly than any other type of weather event. For example, in 2006 a heat wave-related electrical outage in Long Island City, Queens resulted in the loss of power to approximately 115,000 customers—some for more than a week. In the future, New York is likely to face longer, more frequent, and more intense heat waves.

Heat waves generally create issues for the electric grid in two ways. First, they typically lead to a significant increase in demand as the use of air conditioning soars. This risks an imbalance between demand and supply, which can lead to outages. Second, the very temperatures that cause increases in demand simultaneously strain the electric generating and distribution equipment itself. For example, a prolonged heat wave makes it difficult for electricity-carrying equipment (such as transformers) to dissipate heat, while urban heat island effects (where heat absorbed during the day is retained near asphalt surfaces) put particular strain on distribution equipment located underground. These factors can lead to equipment failures and cascading disturbances in the electric system.

These two risks caused by heat waves can be mitigated, to an extent, if the NYISO or utilities ask certain customers to reduce electricity usage (and pay them for doing so) as part of demand response programs. Additionally, utilities can implement network-wide voltage reductions (between 5 and 8 percent) to relieve stress on equipment in strained networks. Con Edison employed this strategy in the summer of 2012, reducing voltage in 28 networks for a half day to 3 days at a time. However, if these measures do not sufficiently reduce demand and equipment stress, more significant impacts could occur, including the disconnection of entire neighborhoods or—when all strategies fail—cascading blackouts. *(See map: Heat Wave Impact: Voltage Reduction in Con Edison Networks)*

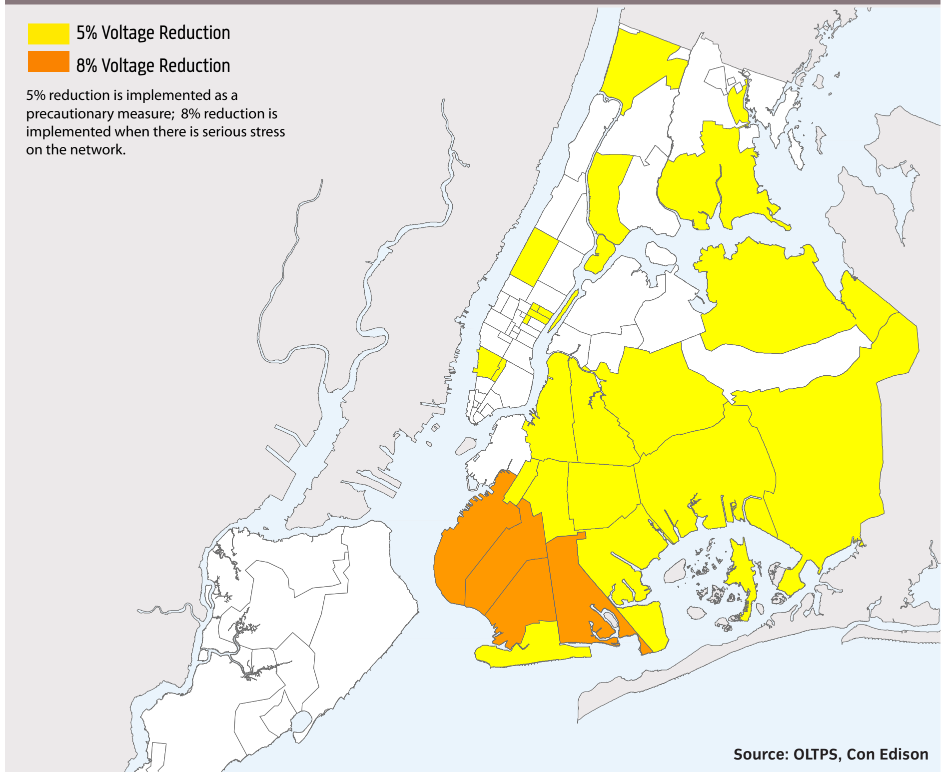
Finally, in addition to storm surge and heat waves, the vulnerabilities of the various energy systems present a significant risk to their sister systems, due to their interconnectivity. For example, natural gas and liquid fuels are necessary for the generation of much of the city's electricity and steam. Thus, disruptions to the fuel supply chains in turn disrupt power and steam production. The steam system is also vulnerable to large-scale power outages: All of the city's steam generating plants rely on electric equipment, and although backup generation is often available, switching to it requires time, meaning that the steam system is vulnerable to depressurization during the downtime. This is what happened during the citywide power outage of 2003, when the entire steam system was shut down for more than five days.

Other Risks

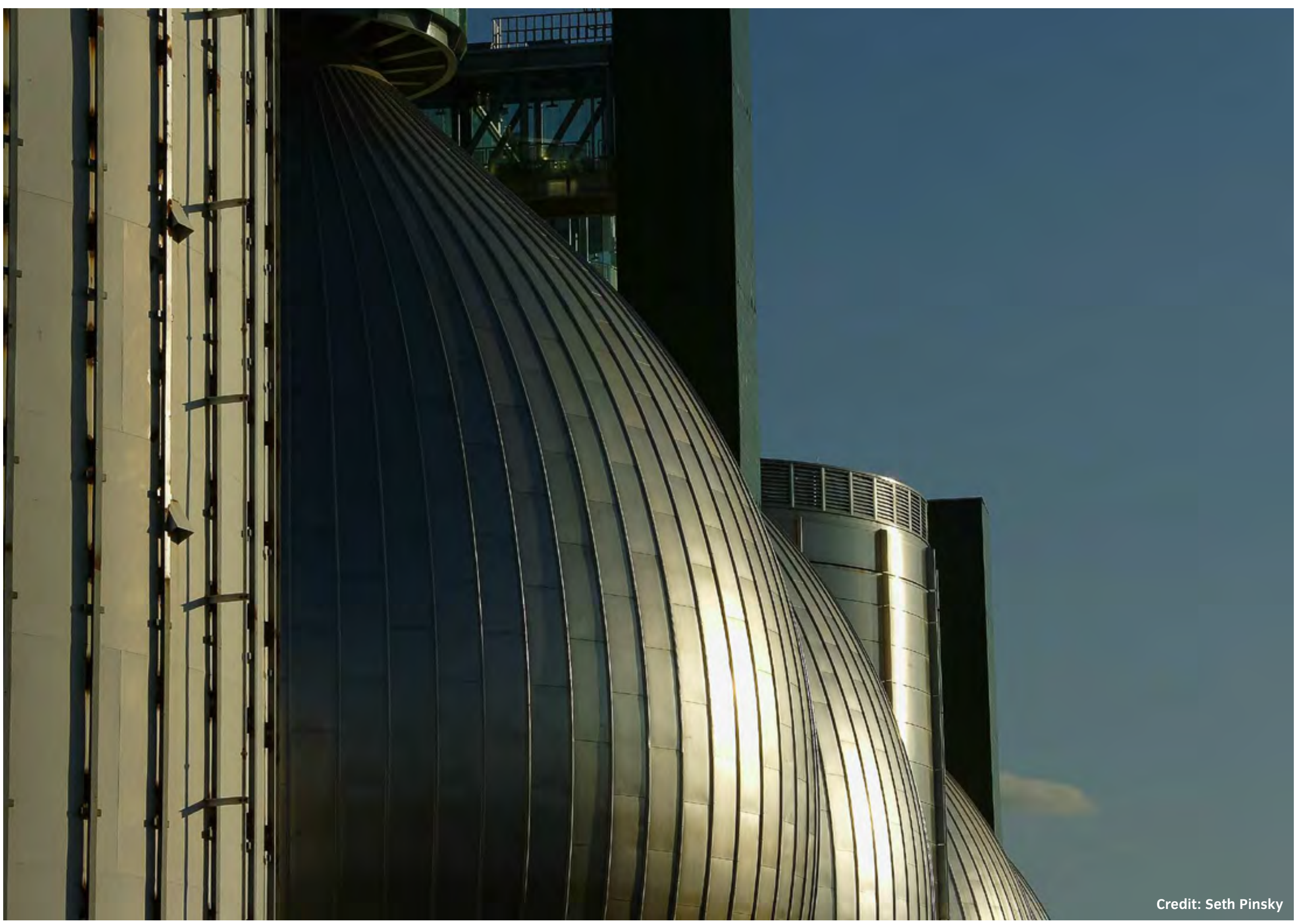
High winds will continue to pose a serious risk to the electric system looking forward. Since most wind-related damage occurs when winds topple trees and branches into power lines, the damage tends to cause more localized outages, rather than system-wide issues. That said, hurricanes and other large storms with significant wind can lead to damage that is more widespread.

Meanwhile, for the steam system, tropical storms or hurricanes that bring heavy downpours may present some of the same challenges that surge does, though likely on a much more localized basis. Large volumes of water around steam mains prevent condensate traps from functioning properly, potentially leaving piping vulnerable to water hammer effects that can shut down steam mains.

Heat Wave Impact: Voltage Reduction in Con Edison Networks



Source: OLTPS, Con Edison



Credit: Seth Pinsky

This chapter contains a series of initiatives that are designed to mitigate the impacts of climate change on New York's utility systems. In many cases, these initiatives are ready to proceed and have identified funding sources assigned to cover their costs. With respect to these initiatives, the City intends to proceed with them as quickly as practicable.

Certain other initiatives described in this chapter may be ready to proceed, but still do not have specific sources of funding assigned to them. In Chapter 19 (*Funding*), the City describes additional funding sources, which, if secured, would be sufficient to fund the full first phase of projects and programs described in this document over a 10-year period. The City will work aggressively on securing this funding and any necessary third-party approvals required in connection therewith (i.e., from the Federal or State governments). However, until such time as these sources are secured, the City will proceed only with those initiatives for which it has adequate funding.

From the 19th century to today, New York's energy systems have evolved along with the city that they serve. However, emerging climate threats will necessitate a rethinking of important aspects of the systems' architectures. At the same time, new technologies present an opportunity to modernize these systems in ways that could increase their resiliency significantly.

To this end, the City will advance a series of proposals designed to enable electricity, gas, and steam to be delivered reliably to New Yorkers, even during the extreme weather events that are expected in the coming decades. These proposals will address gaps in the regulatory framework applicable to these systems, as well as the infrastructure that supports them. Collectively, even as the climate changes, these proposals will reduce the frequency and severity of service disruptions, while allowing for more rapid restoration of service when disruptions do occur.

Strategy: Redesign the regulatory framework to support resiliency

The first set of proposals is designed to address gaps in the regulatory framework that governs the city's energy systems. This will assist utilities and regulators with identifying and appropriately funding long-term capital projects that will make the electric, gas, and steam systems more resilient.

Initiative 1
Work with utilities and regulators to develop a cost-effective system upgrade plan to address climate risks

Utilities and regulators long have employed analytical techniques to ensure adequate energy supply in the event of heat waves or failure of individual pieces of equipment. However, regulators generally do not require utilities to prepare for the possibility of losing entire facilities to weather events such as storm surge, nor do they consider the indirect economic and societal impact of such events. This is primarily because current guidelines instruct utilities, in designing their systems, to consider what is known and measurable—an approach that does not address low-probability but high-impact events such as Sandy.

The City, through Long-Term Planning and Sustainability (OLTPS), will work with utilities, regulators, and climate scientists to adjust the existing regulatory framework to address these shortcomings. These changes will seek to require utilities to analyze costs, benefits, and risks, and to upgrade their systems as appropriate to withstand the sorts of high-impact risks that they face not only today, but also are likely to face with increasing frequency in the future. At the same time, the City will seek modifications in the ratemaking process to ensure that resiliency-related investments are given due consideration and that the utilities have a reasonable opportunity to recover those investments, just as they now recover their investments related to reliability.

Underlying all decisions on infrastructure upgrades that address extreme weather and climate change resiliency (including the type of investments that the City will seek to encourage utilities to make through the aforementioned regulatory changes) is an accurate assessment of risks. This is because not all assets need to be protected to the same standard, given that some are more vulnerable or important than others. To avoid unnecessary rigidity, the City will advocate for the use of probabilistic risk assessments by regulators and utilities to help guide the most efficient use of the utilities' capital budgets.

OLTPS has taken the first steps towards developing a risk assessment model that takes into account storm probabilities and future surge heights, quantifying possible customer outages and economic losses, and thereby beginning to identify the system assets that should be prioritized for protection. OLTPS will work with the utilities and climate scientists to continue to refine this model, with the goal of building a cost-benefit tool upon which to base storm hardening investment decisions that the PSC will incorporate into its utility regulation framework. (*See sidebar: Climate Risk Model for the Electric Sector*)

Initiative 2
Work with utilities and regulators to reflect climate risks in system design and equipment standards

To date, the system planning approaches and design standards used by New York's utilities and regulators have ensured highly reliable systems in New York. However, they have not been established with the goal of optimizing system resiliency. Ultimately, the city's systems should be capable not only of reliable day-to-day operation, but also of remaining operational during extreme weather events (such as hurricanes, tropical storms, and heat waves), and recovering quickly when parts of the system fail.

This can be achieved in part by considering climate change impacts in system planning decisions. With regard to heat waves, for

Climate Risk Model for the Electric Sector

Extreme climate events may be difficult to predict more than a few days in advance—but their general patterns of occurrence are measurable. In the electric sector, these measurements can support analytical techniques that reveal the extent of existing and future risks and support better decision-making as utilities and regulators decide how much and how quickly to invest to prepare for heat waves, storm surges, and high wind events.

OLTPS, with support from the Analytics Division of the Mayor's Office of Policy and Strategic Planning, has taken the first steps towards a more quantitative approach to addressing the climate-related risks to New York City's electric systems. The Electric Sector Storm Surge Risk Model (ESRM), which the City is developing, contains three main modules:

1. The storm surge module, which builds on third-party storm models and climate change projections from the NPCC to generate hundreds of inundation scenarios and associated probabilities of occurrence for critical electric infrastructure locations, looking at 2013, the 2020s, and the 2050s;
2. The network structure module, which maps out the dependencies between individual substations and the networks they serve and compares the design elevation of each substation with the surge height in each individual storm to determine whether or not it would remain functional; and
3. The customer module, which uses the wealth of data available to the City to move past the simple number of customers that a network serves towards a more nuanced understanding of the network's importance—including the critical customers that depend on it, the amount of economic activity it supports, and, for example, the number of high-rise housing units that it serves that contain vulnerable populations.

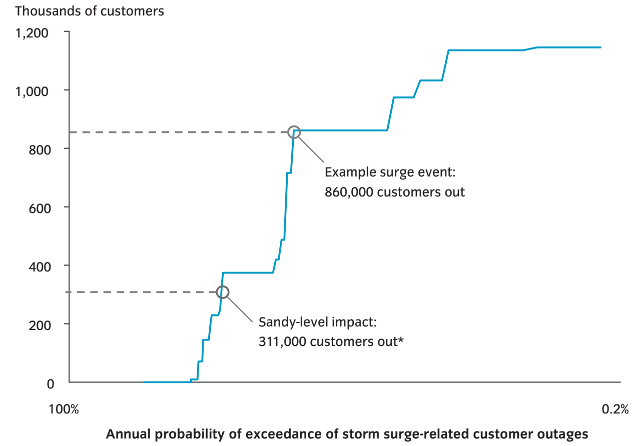
The model is still in the early phases of development; the examples shown here illustrate how the three modules, taken together, make it possible to develop a preliminary quantitative baseline of risks that the electric system faces. For example, Chart A demonstrates the relationship between a given level of customer losses and the probability that this level will be met or exceeded in any one year. This analysis shows that, from this perspective, Sandy is not the "worst storm" that could hit the city. In fact, storms at the tail-end of the distribution, though unlikely, could result in customer losses almost four times as high as those suffered during Sandy. The model can also guide investment decisions. Again, by way of example, Chart B demonstrates that only five substations are likely to be responsible for 80 percent of annual expected customer losses. This would suggest that resiliency investments in these substations should be prioritized. If the outcomes are measured in terms of Gross City Product (GCP) losses resulting from outages, the order of priority among the five substation changes but the overall list remains the same.

The next step in the development of the model is to move beyond estimating baseline losses and testing the impact of protection strategies towards calculating the various strategies' cost-effectiveness and also guiding the standards to which critical assets should be protected. Further on, strategies to address heat and wind risks could be included as well, though the proper development of these elements would require a significant commitment of engineering resources. As an example, an early estimate developed as a proof of concept, shown in Chart C, suggests that hardening substations against surge may be a more effective use of funds than burying overhead power lines to protect them against wind.

The City has already been working closely with utilities and regulators to discuss these new quantitative approaches and to explore ways to incorporate them into utility decision-making and regulation – but much more work remains to be done. OLTPS will continue to refine the ESRM, and will work with utilities and regulators to expand the approach to include costs of protection strategies and to incorporate heat and wind risks within a common framework.

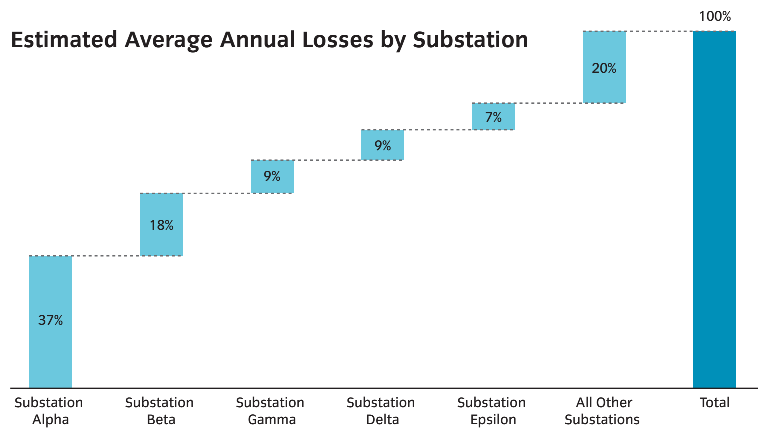
Customer Losses Due to Storm Surge-Related Substation Outages

A. Estimated Total Losses by Event Probability



*Outages associated with direct substation outage
Note: Preliminary analysis

B. Estimated Average Annual Losses by Substation

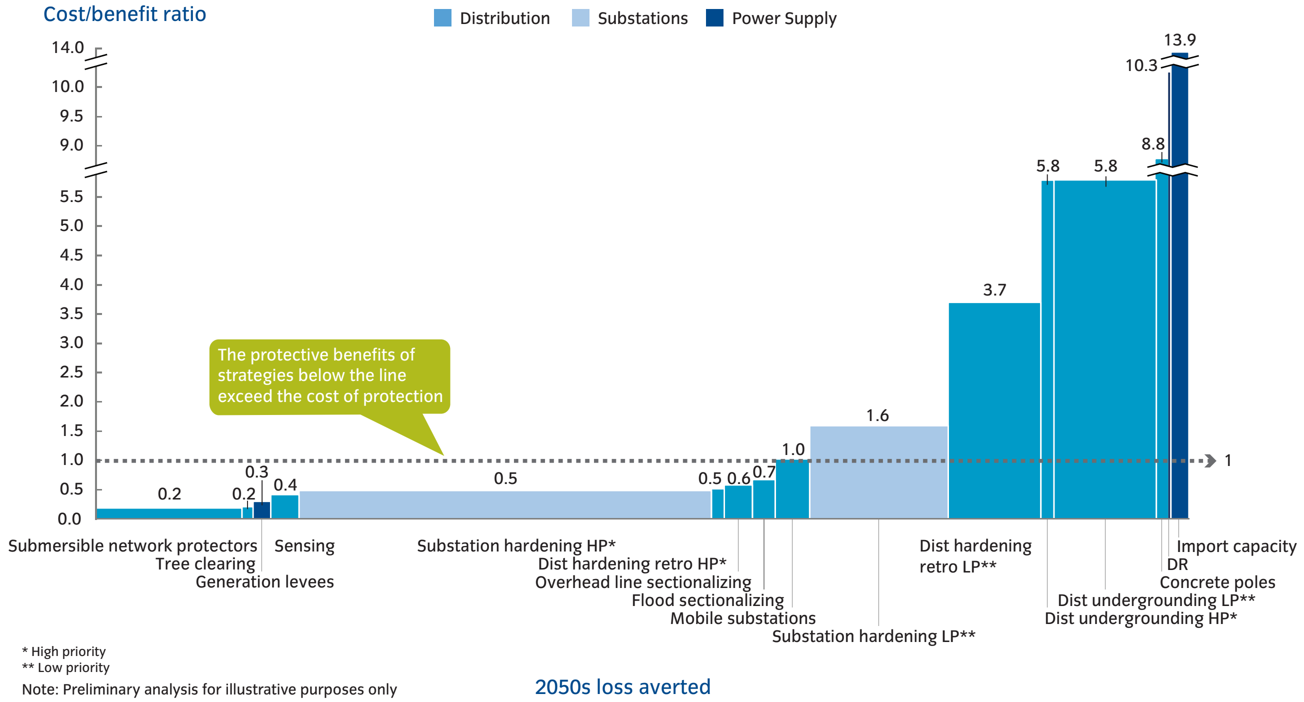


2013 climate risk
Note: Preliminary analysis

Source: OLTPS

Estimated Risk Reduction Potential of Protection Strategies

C.



* High priority
** Low priority
Note: Preliminary analysis for illustrative purposes only

Source: Team Analysis

The city's night-time skyline depends on the successful operation of electrical infrastructure

Credit: Stefan Klaas

example, the City has worked with the New York City Panel on Climate Change (NPCC) and Con Edison to establish that an increase in average temperatures of just 1 degree Fahrenheit in New York in the years ahead could increase peak demand in the city by as much as 175 MW—a likely underestimate given that it does not include the impact of changes in average humidity (which could increase air conditioner use and therefore peak demand even further). The City's goal is for the NYISO to incorporate temperature and humidity forecasts into the Reliability Needs Assessment used in bulk power system planning. This would allow system planners to make adjustments to long-term plans for resource adequacy and transmission reliability to ensure supply will be adequate even as the climate changes.

Design of a more resilient system will also be accomplished in parallel by updating system and equipment design standards. The City, therefore, will call on utilities to work with it and the PSC to examine system designs and consider changes to design standards in light of the likelihood of higher ambient peak temperatures, longer heat waves, extended exposure to flooding and saltwater, and stronger and more sustained winds.

With regard to heat waves, a specific focus must be on Con Edison's underground networks. As part of this evaluation, the City will ask Con Edison and the PSC to reexamine and evaluate the strategy employed in recent years by which peak system demand during heat waves has been met by reducing voltage. In particular, the City will ask the utility and the regulator to assess the propriety of the use of voltage reductions in lieu of system reinforcements and upgrades, as well as the potential implications of relying on voltage reductions during more frequent and longer duration heat waves.

Initiative 3
Work with utilities and regulators to establish performance metrics for climate risk response

Regulators exclude performance during extreme weather events when evaluating utility performance and structuring the financial incentives associated with such evaluations. However, given the likely increases in frequency of these weather events, the time has come for utilities to be held accountable for their performance before, during and after such events.

The City will work with the utilities and the PSC to develop updated resiliency metrics and realistic performance standards, including appropriate incentives. Examples of performance metrics could include, among other things, minimum times to reach a 90 percent restoration threshold for customers following different classes of weather events. The City's expectation is that these metrics and standards would evolve over time as climate-related threats increase.

In connection with the metrics and standards above, the City also will call upon the PSC to require utilities to publish annual progress reports describing their preparedness for climate risks. Among the indicators described in the annual reports could be recent and projected climate-related capital investments, including replacements of unprotected conductors in overhead networks with extensive tree coverage, replacement of cast iron and bare steel gas mains in flood-prone areas, and installation of submersible underground equipment.

Strategy: Harden existing infrastructure to withstand climate events

Sandy demonstrated how the failure of key nodes in the energy distribution system can have widespread impacts on the city's energy systems, with significant repercussions for people, businesses, and communities. To address this, the City will call upon the utilities to identify high-priority infrastructure that is vulnerable to increasingly common climate risks, such as floods and heat waves, and to make the investments necessary to harden that infrastructure.

Initiative 4
Work with power suppliers and regulators to harden key power generators against flooding

As described above, 53 percent of New York City's power plants are in the 100-year floodplain. By the 2050s, 97 percent will be. Despite this, regulators do not yet require the owners of these plants to invest in flood-protection measures.

The City, working through OLTPS, will convene plant owners, utilities, and regulators to work together to prioritize, plan, and budget for the hardening of key in-city assets. For existing plants, the City will call upon the NYSRC to develop reliability rules that would be administered and enforced by the NYISO and that would require select plant owners to upgrade their facilities to withstand at least a so-called "100-year flood" (a flood level that has a 1 percent chance of being met or exceeded in any given year). The City will work with the facility owners, the NYSRC, NYISO, PSC, and Con Edison to identify the selected plants based on a cost-benefit analysis developed by all of the parties, and to determine the measures that should be undertaken, the timeframe for completing the measures, and a method by which the owners could recover the costs of such projects.

For new generating facilities and those undergoing substantial upgrades (such as repowering) that will be sited in the city's 500-year floodplain, the City further will call upon the PSC to require hardening to a 500-year flood elevation, or demonstration of other measures to be able to remain operational during, or recover quickly from, a 500-year flood event.

Initiative 5
Work with utilities and the PSC to harden key electric transmission and distribution infrastructure against flooding

Transmission substations, distribution substations, utility tunnels, and underground equipment are all at risk of flooding. For example, 37 percent of transmission substations are in the 100-year floodplain today and 63 percent are likely to be in the 100-year floodplain by the 2050s.

The City will work with utilities and regulators to protect these assets from future flood events. In the case of substations, the City, working with Con Edison, LIPA, and the PSC, will prioritize investments by evaluating the role that each such substation plays in system reliability, the number and criticality of customers that it serves (e.g., giving priority to hospitals), and the projected economic impact of its failure. The City's initial modeling suggests that 20 percent of transmission-level substations are responsible for 80 percent of annual expected customer losses.

Storm hardening measures to be implemented at the selected substations will be site-specific. In some cases, depending on the substation's configuration, selected assets within a substation could be elevated; in other cases, a combination of strategies, including protecting the perimeter of the facility, could be implemented.

In the case of utility tunnels, the City will support Con Edison's proposed plans to protect each from flooding. Finally, in the case of underground transformers and switches in the floodplains—of which 52 percent are currently submersible or water-resistant—the City will work with utilities and regulators to advance the goal of replacing, over time, all underground equipment in the 100-year floodplain with equipment that is submersible and unaffected by saltwater.

Initiative 6

Work with utilities and the PSC to harden vulnerable overhead lines against winds

During storms, high winds and downed trees threaten overhead electric poles, transformers, and cables. The City will work with Con Edison and LIPA to manage these risks through tree maintenance, line strengthening, and a line relocation program.

In some cases, rerouting lines underground may also be warranted, depending on the number of customers impacted and cost involved. In most cases, however, this option will be complicated and very expensive. On February 25, 2013, the City passed Local Law 13, directing OLTPS to conduct a study examining the "undergrounding" of overhead power lines in the city. Findings are to be submitted to the Mayor and City Council. The study is being conducted in partnership with Con Edison and will include an analysis of both projected costs and the expected effects on grid reliability of more extensive "undergrounding." It also will lay the foundations for including wind risks in the overall regulatory framework governing system reliability. If appropriate, the study will further identify the areas of the city, if any, where "undergrounding" could be of particular benefit, as well as those areas where it is viewed to be impracticable or subject to greater reliability risk.

Initiative 7

Work with utilities, regulators, and gas pipeline operators to harden the natural gas system against flooding

Although the city's gas system performed relatively well during Sandy, there were instances where remote operation of parts of the system failed. Additionally, the distribution system had localized outages due to water infiltration.

To ensure that future floods do not extensively compromise the gas system or reduce the ability of Con Edison or National Grid to control and monitor their systems, the City will work with the PSC, pipeline companies, and utilities to develop plans to harden all city-gates, interface regulator stations, and control equipment against flooding. To protect the distribution system, the City will work with the PSC, Con Edison, and National Grid to take steps to prevent water from infiltrating into gas pipes. In the low pressure system this will be achieved by expanding existing programs to replace the bare steel and cast iron pipes that are prone to corrosion, leaks, and cracks. In the high pressure system this will be achieved by installing backflow prevention devices on vent lines.

Initiative 8

Work with steam plant operators and the PSC to harden steam plants against flooding

Five out of six of the city's steam plants are in the floodplain today. Relocating these plants is neither practical nor cost-effective. The City, therefore, will call upon Con Edison and the PSC to increase the resiliency of these plants by taking flood-protection measures, including adding floodwalls, sealing building perimeters, raising equipment, and installing flood-protected, natural gas-fired back-up generators as appropriate (allowing Con Edison to deliver steam even during widespread power outages).

Strategy: Reconfigure utility networks to be redundant and resilient

Hardening existing infrastructure is only the first step in making the city's energy networks stronger. In the coming years, regulated utilities and private companies alike should rethink the entire architecture of their systems to help the City meet its twin goals of reducing the likelihood of failure and ensuring that service restoration can happen more quickly when failures do occur.

Initiative 9

Work with industry partners, New York State, and regulators to strengthen New York City's power supply

New York City's 9,600 MW of power generation can satisfy over 80 percent of peak demand, but the majority of these in-city power plants are located in the 100-year floodplain, all depend on natural gas and liquid fuel supplies (which themselves are subject to supply interruptions during extreme weather events), and almost two-thirds are more than 40 years old. The City will take steps to diversify and improve the sources of the city's power supply, and to do so in a way that will connect the city directly to new, low-carbon generation sources (which address some of the causes of climate change).

First, the City will continue to work with the NYISO to change wholesale energy rules to encourage generation owners to repower their older, less efficient, and higher polluting in-city power plants. The City already has facilitated the repowering of a 500 MW power plant operated by NYPA in Astoria.

Second, the City will encourage the development of new transmission lines connecting the city to other markets and sources of supply. The Hudson Transmission Project, which recently commenced operation, provides a new 660 MW connection between the city and the transmission system in the Mid-Atlantic and Midwestern regions. Additionally, the City actively supported the issuance of a State permit to construct and operate a 343-mile transmission line from Quebec that would allow for the importation of 1,000 MW of clean, low carbon Canadian hydropower directly to New York City.

Third, the City will continue to explore opportunities to expand low-carbon electricity generation sources in the area—working, for example, with NYPA and Con Edison on the potential development of up to 700 MW of offshore wind turbines in the waters south of the Rockaway peninsula. The Federal government currently is reviewing a NYPA lease application for use of underwater lands for such purposes.

Initiative 10

Require more in-city plants to be able to restart quickly in the event of blackout

Many New York City power plants, including some of the newest ones, cannot be restarted without external power sources (i.e., they cannot "black-start") after grid-scale outages. This slows the grid's ability to recover. State regulators only recently adopted a requirement that all new plants proposed to be built in New York either be able to provide for "black-start" capacity or to justify why such capacity is not included. This requirement did not exist when the city's newest plants received siting approval, while older in-city plants that do have such capacity are approaching the end of their useful lives. The City, through OLTPS, therefore, will work with generators, the PSC, the NYISO, FERC, and Con Edison to expand "black-start" capabilities within the existing generation fleet.

Initiative 11

Work with Con Edison and the PSC to develop a long-term resiliency plan for the electric distribution system

While hardening existing power assets is an important strategy, utilities also need to incorporate resilience into their long-term expansion plans, factoring in changing patterns of load growth. The City will call on Con Edison and the PSC to develop a long-term system resiliency strategy for the in-city electric system that will seek to divest load from coastal, "too-big-to-fail" nodes, with a strong bias towards building inland, so as to diversify geographic exposure. The strategy will also seek to relieve transmission limitations to large load pockets in Brooklyn and Manhattan.

Additionally, the strategy will provide for the system to evolve to contend with heavy blows from extreme weather events, such as storms and heat waves. Examples of potential projects that could emerge from the development of such a strategy could include: the creation of a new 345 kV link between Queens and the Bronx to strengthen the connection to Upstate electrical supplies and reduce reliance on the Astoria generation cluster; load divestment from substations to reduce congestion in the Brooklyn load pocket; and a new transmission corridor running inland between Staten Island and Queens. OLTPS will work with Con Edison, the NYISO, and the PSC to develop this strategy, outlining potential options, analyzing costs, and developing a roadmap for implementation.

Initiative 12

Work with utilities and regulators to minimize electric outages in areas not directly affected by climate impacts

Coastal flooding typically requires the shutdown of electrical feeders that could be exposed to floodwaters. In extremely dense areas of Lower Manhattan and Brooklyn, this can mean preemptive shutdowns of entire networks, with large swaths of customers losing service even if they are not directly affected by flooding.

To reduce the incidence of these so-called "sympathetic outages", the City will work with the utilities to design and implement new network boundaries. In the Fulton network, for example, a reconfiguration of the network would allow New York Downtown Hospital, which lies outside the 100-year floodplain, to continue to receive electricity during a coastal flood (rather than losing power as occurred during Sandy). Elsewhere in coastal areas served by the underground system, utilities should take measures like installing sectionalizing switches to allow more precise control over feeder shutdowns and isolations, reducing the number of customers impacted by a shutdown. Similar principles should be applied to the overhead system. For example, estimates by Con Edison indicate that 650 or more automatic reclosers or switches could be installed on overhead loop and radial systems citywide, each of which could locally have the effect of reducing by 50 percent the number of customers affected by a problem like tree branch damage to an overhead line. The City will work with Con Edison and LIPA to identify areas for priority attention.

Initiative 13

Work with utilities and regulators to implement smart grid technology to assess system conditions in real time

After an extreme weather event, the first task of any utility is to identify the location and extent of damage. Utilities usually rely on customer reports of power outages, together with on-site inspections by crews. Gathering information in this way, though, takes time and can be delayed by problems on the ground, such as impassable roads.

The City, will call on Con Edison and LIPA to work with the New York State Smart Grid Consortium and stakeholders such as the USDOE to develop, demonstrate, and deploy low-cost sensor technologies, along with system integration, automated control, and decision-aided tools, that would allow the two utilities to assess system conditions in real time and facilitate timely dispatch of crews and equipment to the highest priority problem locations. To minimize costs, utilities could prioritize coverage of a statistically significant number of customers with smart meters, focusing, for example, on the 34,000 residential high-rise buildings in the city, or could prioritize coverage of key grid locations, such as at distribution sectionalizing switches, which could be monitored with advanced voltage sensors.

Initiative 14

Work with utilities and regulators to speed up service restoration for critical customers via system configuration

After extreme weather events, electric utilities may not be able to restore electric service to individual customers until damaged customer equipment is repaired or replaced.

The City, will work with Con Edison and LIPA to identify cost-effective ways to isolate critical customers, including through installing switches and other equipment along feeders that supply them. In some cases, this could allow utilities to restore service to these customers more quickly than they are able to restore service to others on the same circuit—or even to avoid service interruption in the first place. The City also will evaluate whether other options, such as on-site backup power for these critical customers would be more cost-effective.

Initiative 15

Work with utilities and regulators to speed up service restoration via pre-connections for mobile substations

Mobile substation units can restore partial functionality of electrical distribution circuits, while utilities undertake permanent repairs to damaged substations. This technology could potentially be effective at substations that support Con Edison's 4kV distribution grids or at LIPA's substations in the Rockaways. However, for these units to be effective, the utilities must pre-install the necessary connections in the system and have a way to source the mobile substations quickly.

The City will work with Con Edison, LIPA, and the PSC to complete technical evaluations of the use of mobile units as a strategy for high-priority substations, and, where this strategy is believed to be cost-effective, will advocate for its implementation. As part of this analysis, the City will work with the utilities to explore strategies for reducing the cost of these mobile units by, for example, sharing mobile units with neighboring regions.

Initiative 16

Work with pipeline operators to expand and diversify natural gas supply

The natural gas connections to New York City generally have sufficient capacity to provide the city's customers with gas, but on days when demand is high, all five city-gate connections are needed to prevent forced shutdowns.

The City will continue to support ongoing projects by gas pipeline operators to install additional city-gate capacity linking New York City to new natural gas pipelines. These projects include the Spectra pipeline, which will connect to Con Edison's gas system. The City supported the Federal approval of the Spectra pipeline and has continued to support its completion; it is now under construction. The City also has supported and will continue to support the issuance of a FERC permit for the Williams Rockaways Lateral, which will serve National Grid's gas network and is now seeking approval from regulators.

Initiative 17

Work with utilities and regulators to strengthen the in-city gas transmission and distribution system

Even when adequately supplied from the outside, New York's natural gas system has limited capacity to move gas within the city. If one city gate were to shut down on a high demand day, the

New York Facilities may be unable to supply the area that the city gate serves from elsewhere, which could cause significant outages. The City, working through OLTPS will collaborate with pipeline companies, Con Edison, and National Grid to assess this risk and develop plans to strengthen the in-city transmission system.

Initiative 18
Launch energy infrastructure resiliency competition

Many resiliency solutions for the city's energy systems are available today, including building floodwalls or elevating equipment. However, new approaches—especially more cost-effective ones—could play a critical role in protecting these systems in the future.

To this end, the City will launch a Resiliency Technologies Competition that will allocate competitive grants to projects that use innovative technologies to further (1) building resiliency and (2) infrastructure resiliency. New York City Economic Development Corporation (NYCEDC) and the Mayor's Office will launch the competition in the summer of 2013 and expect to select winners in 2014. The City allocated $45 million in Federal CDBG funding to the competition.

Cost Impact and Recovery

Most of the initiatives described in this chapter carry a cost. Utility infrastructure costs of this type are typically included in the rates charged by utilities, subject to PSC authorization. Non-utility transmission providers and owners of electric generation facilities recover their infrastructure costs from the revenues they receive in the wholesale electric markets, and sometimes through rate surcharges authorized by the FERC.

Increases in infrastructure investments do not necessarily lead to higher rates because the utilities may be able to net the incremental costs against credits or savings produced from other program and project changes. Here, the City anticipates that most, if not all, of the infrastructure improvements related to the initiatives can be undertaken as part of the utilities' ongoing capital programs, thereby avoiding any rate increases. To the extent the resiliency investments are additive to rates, the increases are expected to be relatively small, perhaps no more than a fraction of one percent each year. While any increase in rates could have an impact on customers, businesses and residents expect and depend on reliable utility service, and the economic costs of utility outages can be enormous – a single day without electricity can mean more than $1 billion in lost economic output for New York City.

Worker repairing electrical infrastructure after Sandy

Credit: Con Edison

Strategy: Reduce energy demand

In the years to come, rising temperatures will lead to higher peak demand. One strategy to accommodate it involves increasing the supply of energy available to the city. However, an equally (or more) effective—and far less expensive—strategy is to manage demand itself, both during peak periods, and more broadly. Programs are already in place to encourage both kinds of demand reduction. The City will continue to advance them, as well as develop new ones.

Initiative 19
Work with utilities and regulators to expand citywide demand response programs

In recent years, Con Edison and the NYISO have built up approximately 500 MW of demand response (DR) capacity to manage the brief periods of peak electrical demand that would otherwise require costly system expansions. The City will call on Con Edison, LIPA, PSC and the NYISO to increase this capacity and will support two strategies to accomplish this goal.

First, to create additional incentives for DR participation, the City will continue to support full implementation of a recent FERC ruling that brings DR pricing closer to the pricing of traditional generation. Second, to expand DR beyond its existing base of large customers, the City will work with the NYISO, Con Edison and LIPA to update participation standards and increase the role of private companies that aggregate DR potential across multiple small users.

City government also will play a role in decreasing in-city peak demand. It will do this directly, acting through the Department of Citywide Administrative Services (DCAS) to scale up its DR capacity with the goal of reaching 50 MW by 2018—including through expanding DR capacity at City facilities like wastewater treatment plants and City University of New York campuses.

Initiative 20
Work with government and private sector partners to expand the energy efficiency of buildings

Energy efficiency programs save owners money and reduce carbon emissions. These programs also have resiliency benefits, both because they reduce the chance of peak season outages by lowering demand and because they allow buildings themselves to remain habitable longer if outages do occur.

Expanding on the ambitious building energy efficiency programs put in place in PlaNYC in 2007, the City will scale up its energy efficiency efforts by focusing on energy use benchmarking, audit and retro-commissioning requirements, upgrades to lighting, and new financing approaches that would be available to a wider segment of New York City's one million buildings. In one example, the City will launch Green Light New York, a new energy efficiency and lighting center to educate designers, engineers, and the real estate community on effective technologies and best practices for lighting and building systems integration. In another example, the New York City Energy Efficiency Corporation (NYCEEC) will work with government partners including the New York State Energy Research and Development Authority (NYSERDA) and private lenders to identify and finance energy efficiency projects in the City.

Strategy: Diversify customer options in case of utility outage

Even the most reliable utility networks occasionally will fail, and when they do, alternatives become important. Distributed generation can provide a source of light and power for individual customers and their local communities. Pre-installed connections to mobile boilers can expedite emergency provision of heat and hot water. CHP installations can supply all three. The City will explore both customer-level and district-wide options for power redundancy.

Initiative 21
Work with public and private partners to scale up distributed generation (DG) and micro-grids

There exists the potential for significant expansion of DG systems in New York. However, regulatory structures, financing challenges, and lack of information constrain further growth. The City, acting through OLTPS and the New York City Distributed Generation Collaborative (DG Collaborative)—a stakeholder group convened by the City in 2012, and consisting of utilities, regulators, the USDOE Northeast Clean Energy Application Center at Pace University, developers, and other industry representatives has been working to address barriers to DG and micro-grid penetration, with a goal of bringing citywide capacity to the original PlaNYC goal of 800 MW by 2030.

To promote DG, the City will work with the DG Collaborative to employ four main strategies. First, to address regulatory barriers, the City will call on the PSC to reevaluate the existing tariff structures and interconnection standards relating to DG in New York. Second, to address the financing barriers to DG, the City will work with NYCEEC and New York State to increase access to low-cost financing for DG systems, and with NYSERDA to revise DG incentives, especially at critical facilities such as hospitals. Third, to address information barriers, the City will work with the DG Collaborative to provide technical assistance to property owners and developers, sharing best practices on DG projects and applying lessons learned from municipal buildings to privately-owned facilities. For example, the City has screened over 340 municipal buildings for technical compatibility with cogeneration, resulting in a 15 MW project under construction at Rikers Island and a 12 MW project at North River Waste Water Treatment Plant. The City will expand its screening analysis to include other DG technologies, such as fuel cells and renewables, working to expand DG in City buildings to 55 MW by 2017. Fourth, the DG Collaborative will work with City agencies to streamline administrative processes to promote prompt one-stop regulatory review of potential DG projects.

For solar photovoltaic systems (PV), in particular, the City will call on the Smart DG Hub—a stakeholder group convened by CUNY—to examine the applications of solar PV during outages and the technical and regulatory solutions for enabling cost effective and safe deployment of PV during outages.

Meanwhile, micro-grids, or neighborhood-scale networks of DG installations, have the potential to provide resiliency benefits, but require study. To encourage micro-grid adoption, the City will focus on four actions. First, the City will call on the PSC to clarify the rules governing the export of energy to multiple property owners and across roadways, so as to reduce uncertainty for private investors. Second, the City will evaluate the potential for a micro-grid pilot in clusters of City-owned buildings. Third, the City will work with USDOE, NYS Smart Grid Consortium, the DG Collaborative, and NYSERDA to examine the feasibility of micro-grid pilots throughout the city, including in areas like the Rockaways. Fourth, the City will work with NYSERDA and academic institutions to study the technical and economic effects of higher penetration of micro-grid systems on New York City's energy networks. Finally, utilities should incorporate micro-grid expansion into their planning.

Initiative 22
Incorporate resiliency into the design of City electric vehicle initiatives and pilot storage technologies

Electric vehicles (EVs) can emit 70 percent less carbon than average cars, one reason the City has one of the largest public sector EV fleets in the nation. With future enhancements, they also could have resiliency benefits. For example, during a power outage, an EV potentially could be used as an energy source to power a small home for a day.

The City, acting through OLTPS, will build on its work to accelerate EV adoption in the city, incorporating resiliency features into electric vehicle infrastructure. The biggest barrier to doing this is that the standards for two-way power flow between vehicles and chargers do not exist yet; even though the technologies have been tested in the US, national standards organizations have not yet codified the necessary protocols. The standards may not arrive for several years, but the City will work to ensure that the EV infrastructure being built today is sufficiently robust to accommodate two-way power flow in the future. In addition, the City will pilot new battery storage applications and streamline regulation to enable private sector adoption. For example, NYCEDC is piloting a large battery storage system at the Brooklyn Army Terminal that will pave the way for adoption of distributed storage applications that could improve grid reliability, provide emergency power to critical systems, and manage peak loads. The City will continue to work with technology developers to determine how batteries can be safely and efficiently added to buildings.

Initiative 23
Improve backup generation for critical customers

During a power outage, it would be advantageous for the city if critical customers had backup generation in-place. It would also be advantageous for less critical users to be able to connect to backup generation.

The City, acting through the Office of Emergency Management (OEM), will expand its capacity to supplement the backup generation needs of critical and public interest customers, focusing separately on two tiers of need. The first tier—hospitals, nursing homes, police and fire stations, and wastewater treatment plants—already tend to have backup generation installed. Sometimes, though, this generation fails. OEM, therefore, maintains a fleet of mobile generators that it can deploy on short notice.

With respect to facilities in the second tier—gas stations, pharmacies, food supply stores and other private customers that provide critical services that can be interrupted by extreme weather events—they generally do not have backup generation, but may need it in the event of a widespread power outage. OEM, therefore, will coordinate with NYSERDA and Federal partners to develop a generator plan that uses a combination of incentives and regulations to pre-wire a subset of these facilities to accept generators and encourages these customers to rely on a combination of purchases of generators and generator supply contracts to enable availability in case of need.

In a separate but related effort, in the city's public housing developments, the City, acting through NYCHA, will install more than 100 natural gas-fired generators in buildings in the 100-year floodplain that have the greatest share of vulnerable residents.

Liquid Fuels

Lines form outside of a gas station in Sunnyside, Queens after Sandy.

Credit: Brian Kingsley

Liquid fuels keep New York City on the move. Every day, approximately 3.4 million gallons of gasoline and diesel fuel course through engines as vehicles move through the streets of the city, logging over 22 million miles and transporting passengers, consumer goods, supplies, equipment, and personnel to their various destinations. This potent energy source powers the 57,000 taxis, limos, liveries, and other "for-hire" vehicles that provide up to 650,000 rides per day. It fuels most of the 5,600 MTA busses serving over 2.1 million riders daily, along with the 26,000 vehicles of the Police, Fire, Sanitation, and other departments. And it ensures that the private cars among the 2 million vehicles registered in New York City stand at the ready to get New Yorkers across the five boroughs to where they need to go.

Liquid fuels do more, though, than just power vehicles. Over 10,000 buildings in the city use heating oil to keep homes warm and showers hot, consuming up to 6.6 million gallons on the coldest days. The three major airports serving New York fill planes with 6 million gallons of jet fuel daily. Moreover, although natural gas fires most of the city's power and steam generators, almost all of these facilities are also capable of switching to liquid fuels during shortages of natural gas supplies. Because liquid fuels are both energy dense (meaning they produce a large amount of energy from a relatively small amount of volume) and easily portable on ships, through pipelines, in trucks, and even in hand canisters, they provide the flexibility needed during disruptions to other energy sources.

And yet, for all of the flexibility of liquid fuels, during Sandy, failures occurred across the supply chain that brings this precious resource to New York and the larger metropolitan region. Refineries and terminals lost power and were damaged, and pipelines shut down—all of which led to the widespread gas station closures that, for many New York drivers, have become among the most vivid memories of the post-storm period. Despite the early conclusion many reached that these closures were due primarily to power outages that prevented stations from pumping gas, the larger problem turned out to be that stations simply had no gas to pump. The station closures, and the long lines at the stations that did have gas, not only frustrated drivers, limited mobility, and slowed economic activity, they also hampered recovery efforts. Lack of fuel made it more challenging for ambulances to respond to emergencies. It made it harder for utility workers to restore electricity. It delayed doctors and nurses who were trying to treat patients. It interfered with the ability of relief workers to reach the hardest hit areas of the city. In short, the storm and its aftermath highlighted just how dependent New York City is on gasoline, diesel fuel and heating oil—and underscored the vulnerabilities in the fuel supply infrastructure.

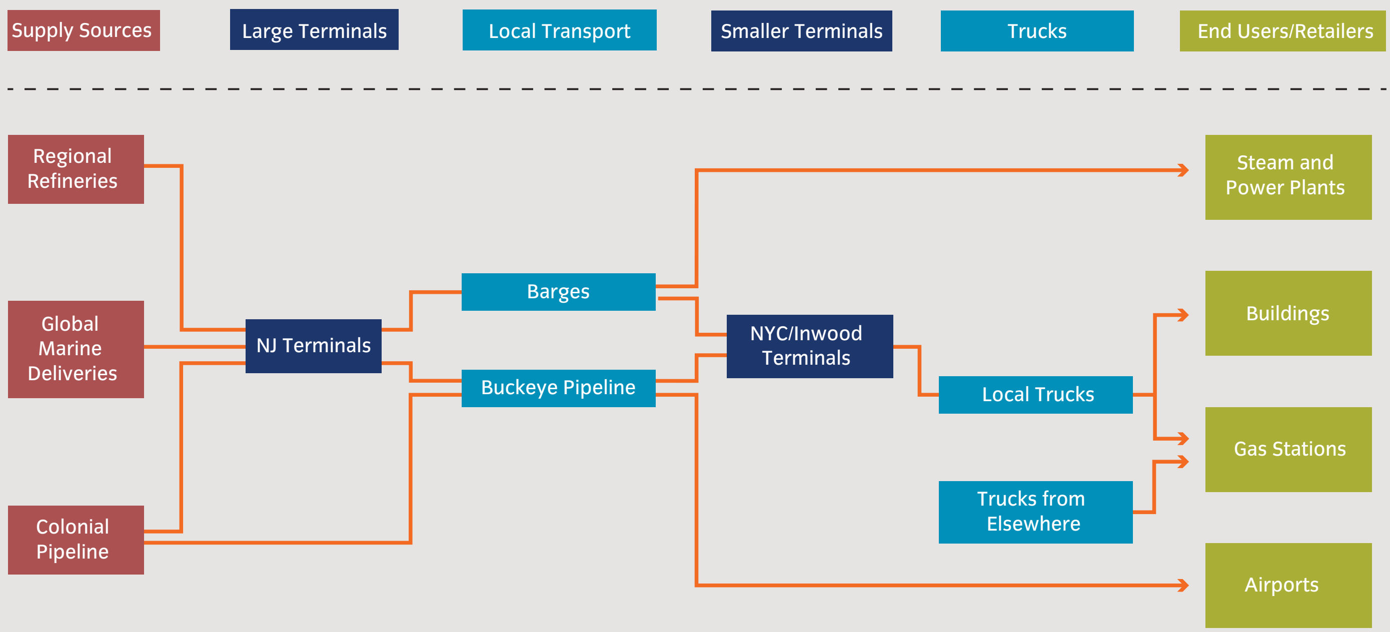
In keeping with the overarching goals of this report, which are to limit the impacts of climate change and enable New York to bounce back after extreme weather events, the City will seek to strengthen the liquid fuels supply chain so that fuel networks can quickly recover after disruption. To do so, the City is proposing ways to harden infrastructure along this supply chain, to increase redundancy and fuel supply flexibility, and to ensure that supply is always available for vehicles critical to the city's infrastructure, safety, and recovery after extreme weather events.

How the System Works

The New York metropolitan area is the largest liquid fuels hub on the East Coast and one of the largest in the country. Liquid fuels reach New York City after traveling through a supply chain via assets spread across many owners. There is little regulatory oversight with respect to infrastructure climate resilience, and almost no operational information is shared by owners, either with each other or third parties.

Liquid fuels generally enter the New York City market from three major sources: regional refineries, pipelines that originate at refineries in

Liquid Fuels Supply Chain



Credit: OLTPS

the Gulf Coast region, and marine fuel tankers that arrive from refineries all over the world. Regional refineries and pipelines each provide 35 to 40 percent of New York City's supply. Marine tankers supply the balance.

Refineries separate crude petroleum into finished liquid fuels for consumer use. Currently one refinery in northern New Jersey and four refineries in the Philadelphia area provide over 42 million gallons per day of regional refining capacity serving the Northeast market. These refineries require large amounts of electricity to operate, mostly relying on power delivered by utilities.

The Colonial pipeline is a major conduit for New York City and the Northeast with a maximum capacity of 37 million gallons per day. This pipeline transports fuels from refineries as far away as the Gulf Coast region to a major hub in Linden, New Jersey. The Buckeye pipeline then brings fuels from the Colonial line, refineries, and terminals in the Linden area to New York City and Long Island terminals, as well as directly to JFK and LaGuardia airports. Fuel is propelled through these pipelines by pumping stations, which are powered by electricity delivered by utilities.

As for the marine tanker network, these vessels deliver fuels to and ship fuels via New York Harbor. In 2010, 8.7 billion gallons were imported from other countries, while over 12.6 billion gallons were exported abroad. In the New York area, the movement of these marine tankers occurs mainly along the waterways between Staten Island and New Jersey.

Once liquid fuels arrive in the New York area via pipeline, regional refineries, or marine tankers, they are stored and sold from terminals mainly concentrated in a few waterfront areas in New Jersey and around the city. Large terminals, which receive shipments from pipelines and tanker ships, supply small- and medium-sized terminals via barge or pipeline. The small- and medium-sized terminals blend in mandated additives, such as ethanol, or performance- and brand-based additives. Truck racks then are used to load liquid fuels from terminal storage tanks onto trucks, which then supply gas stations and buildings.

Approximately 800 gas stations are located throughout New York City. These stations have an estimated 14.6 million gallons of storage capacity in underground storage tanks—enough capacity to satisfy approximately four days' worth of demand. However, since not all stations' storage tanks are full at all times, the city generally has much less than four days' worth of fuel supply on hand.

Over 500 of the gas stations in New York City are associated with seven major brands. Most of these stations are franchised. Under traditional retail fuel franchise agreements, these stations are obligated to source fuel from designated suppliers and to sell only specific formulations of gasoline and diesel. By contrast, the retail fueling stations selling fuel under the Hess brand are corporate-owned. However, as of the writing of this report, Hess has announced that it intends to sell its retail network to focus on other aspects of its business. Regardless of ownership structure, gas stations traditionally operate on thin profit margins from their core business of selling gasoline and diesel fuel.

The City has its own transportation fueling sites for government use. Of its 414 total sites, 16 are located Upstate and serve the Department of Environmental Protection (DEP) vehicles in the City's watershed areas. The majority (240) of the City's sites are at Fire Department of New York (FDNY) facilities. Overall, the City has storage capacity for 1.2 million gallons of fuel—a two weeks' supply for City vehicles—though, again, not all tanks are always full.

Given the Northeast's dependence on heating fuels, the US Department of Energy (DOE) maintains a home heating fuel reserve in case of major supply disruptions. This reserve is stored in fuel terminals in Connecticut, Massachusetts, and New Jersey, and contains over 42 million gallons of ultra-low sulfur diesel meant to be used in buildings, but able to be used in diesel-fueled vehicles.

With respect to other sectors in New York, each of these acquires and stores fuel in a different way. For example, as mentioned above, airports generally receive jet fuel directly via pipelines that feed large on-site tanks. Buildings accept truck deliveries of heating oil, pumped directly into their fuel storage tanks. For the most part, power and steam generators receive liquid fuel shipments via barges, which replenish large tanks used for on-site storage.

Regulation of the Liquid Fuel Supply
Responsibility for the regulation of the fuel supply infrastructure, and the transportation and consumption of fuel, is divided among Federal, State, and City agencies. These agencies have promulgated a variety of rules affecting supply in New York City. For example, regulations from the US, New York State, and New York City Departments of Transportation determine how fuel is transported into and around the city. Meanwhile, the US Environmental Protection Agency (EPA), NYS Department of Environmental Conservation (NYSDEC), and DEP all regulate

Transportation and Consumption Regulations Affecting Liquid Fuels

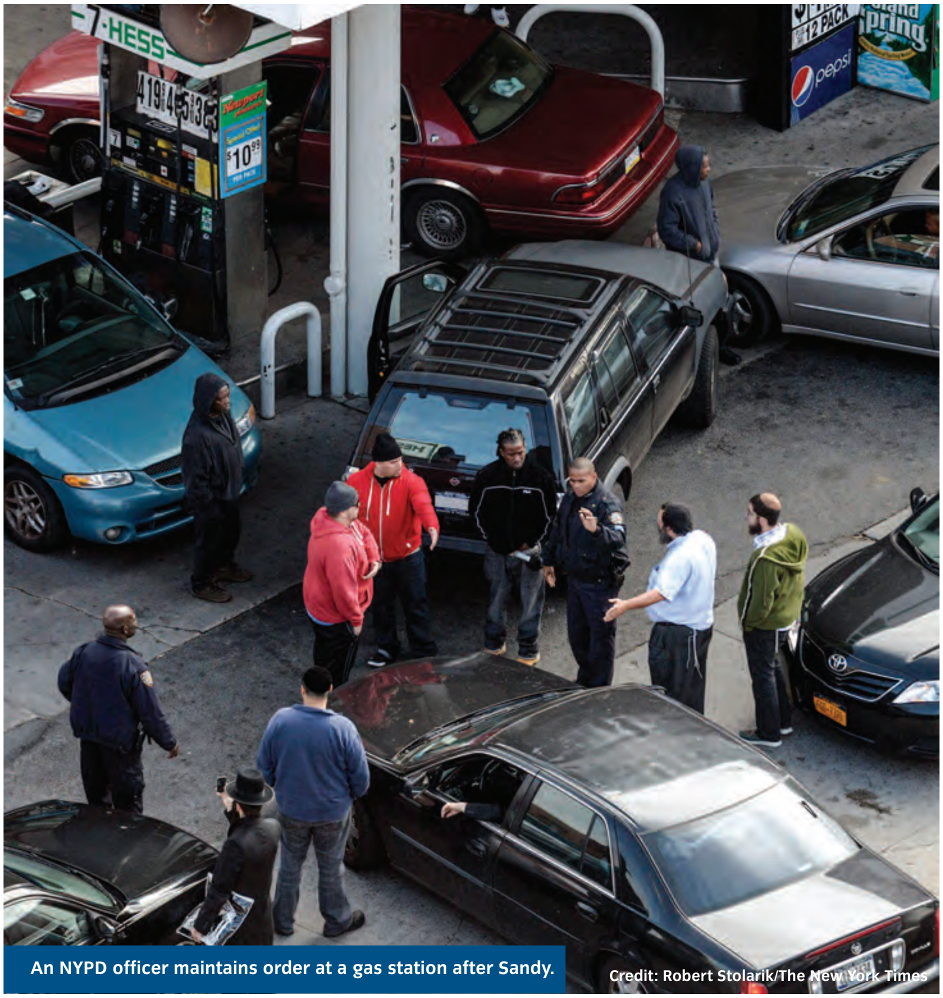
Law or Regulation	Administered by	Description
NYC biodiesel requirement	DEP	Requires a minimum of 2% biodiesel in all heating fuels used in buildings.
NYC heating oil sulfur regulation	DEP	Requires #4 and #6 heating oils in buildings to have lower sulfur content.
Transportation height and weight restrictions	NYSDOT, NYCDOT	Restricts vehicles above certain heights, weights, and lengths on designated roadways and bridges.
Truck route regulations	NYCDOT	Restricts freight truck vehicle traffic through certain roadways.
Transportation of flammables through tunnels	Port Authority, the MTA, FDNY	Restricts transportation of flammable liquids through tunnels.
On-road vs. off-road diesel requirement	NYSDOT	Treats fuels that are used for on-road (transportation) use and off-road (heating) use differently for tax purposes, even if they are chemically the same. Off-road fuel is tinted red and is prohibited for on-road use.
NYS heating oil sulfur regulation for NYC	NYSDEC	Requires #2 heating oil to have no more than 15 ppm sulfur content in New York City.
Local formulation requirements	EPA	Requires the use of reformulated gasoline blendstock for oxygenate blending (RBOB) in NYC, LI, Westchester, Orange, Putnam, and Rockland Counties to improve air quality by reducing ground level ozone.
Vapor pressure requirement	EPA	Requires the reduction of the vapor pressure of gasoline in summer months, thus reducing volatile organic compounds (VOCs) that lead to ground level ozone.
Federal sulfur requirement	EPA	Requires ultra low sulfur diesel (ULSD), with less than 15 parts per million (ppm) sulfur specification, for highway diesel fuel. Requires low sulfur (500 ppm) and ULSD fuel to be phased in for non-road, locomotive, and marine engines from 2007–2014.
Vapor recovery systems requirement for fuel loading/unloading	EPA	Requires bulk gasoline and marine loading terminals and associated truck racks to use vapor recovery or vapor combustion devices during fuel loading and unloading for both emissions and safety.
Jones Act (Merchant Marine Act of 1920)	US DHS	Requires that all goods transported by water (including fuels) between US ports be carried in US-flagged ships, constructed in the United States, owned by US citizens, and crewed by US citizens and US permanent residents.
Driver hours-of-service (HOS) regulations	US DOT	Allows delivery truck drivers to drive a maximum of 11 hours after 10 consecutive hours off duty.

the chemical composition of fuels sold and consumed within the city. In addition, the Jones Act, originally passed in 1920, restricts foreign-flagged vessels from delivering fuel supply from domestic sources. Of note, none of these entities set regulations that are expressly designed to address the threats to the fuel supply chain by climate-related risks, such as storm surge. *(See chart: Transportation and Consumption Regulations Affecting Liquid Fuels)*

What Happened During Sandy

Disruptions occurred at nearly every level of the fuel supply chain, reducing all fuel flow into and within the New York metropolitan area. Most of the infrastructure affected was located in New Jersey, where a combination of extended power outages and direct damage from storm surge, for a time, nearly dried up New York City's fuel supply.

Despite widespread failures throughout the supply chain during and after Sandy, a lack of available information on the operational status of terminals, pipelines, refineries, and other key infrastructure delayed situational awareness for several days. Duplicative efforts among different governmental entities to secure information further delayed diagnosis of the cause of the supply disruptions and resulted in conflicting reports and, at least initially, responses that did not properly address the underlying issues.



An NYPD officer maintains order at a gas station after Sandy. Credit: Robert Stolarik/The New York Times

Regional Refineries, Operational Status After Hurricane Sandy

Refinery	Location	Operating Capacity (thousand bbl/day)	Operational Status, Days After Sandy									
			0	+1	+2	+3	+4	+5	+6	+7	+8	+9
Hess	Port Reading, NJ	70	Shut	Shut	Shut	Shut	Shut	Shut	Shut	Shut	Shut	Shut
Phillips 66	Linden, NJ	238	Shut	Shut	Shut	Shut	Shut	Shut	Shut	Shut	Shut	Shut
Sunoco	Philadelphia, PA	335	Reduced operations	Reduced operations	Reduced operations	Reduced operations	Reduced operations	Reduced operations	Reduced operations	Reduced operations	Reduced operations	Operational
PBF	Delaware City, DE	182	Reduced operations	Reduced operations	Reduced operations	Operational	Operational	Operational	Operational	Operational	Operational	Operational
PBF	Paulsboro, NJ	160	Reduced operations	Reduced operations	Reduced operations	Operational	Operational	Operational	Operational	Operational	Operational	Operational
Monroe Energy	Trainer, PA	185	Reduced operations	Reduced operations	Operational	Operational	Operational	Operational	Operational	Operational	Operational	Operational

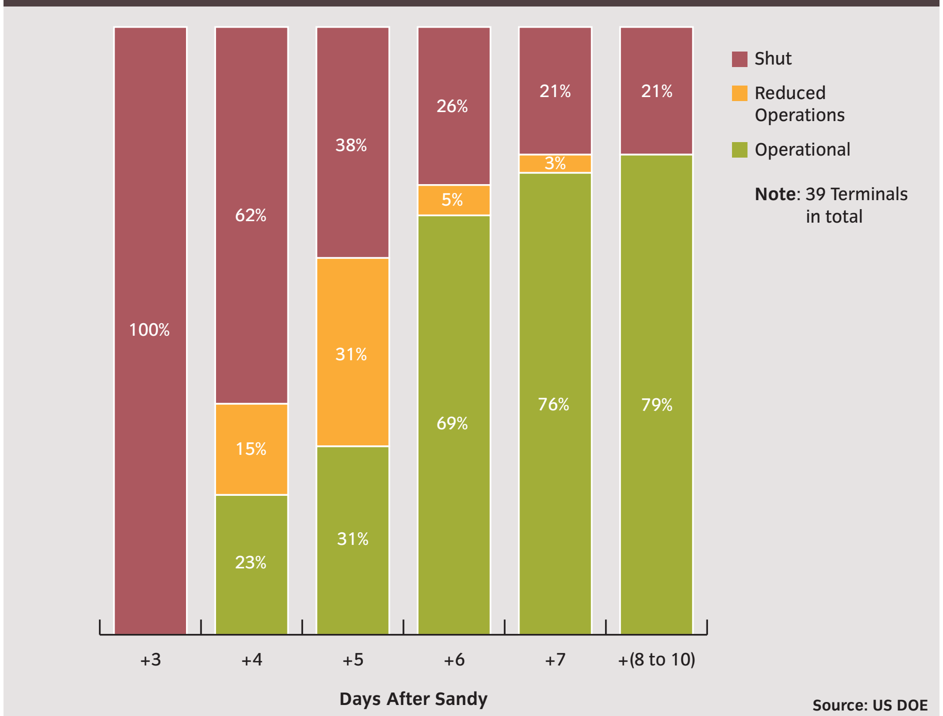
Pipelines, Operational Status After Hurricane Sandy

Pipeline	Operational Status, Days After Sandy									
	0	+1	+2	+3	+4	+5	+6	+7	+8	+9
Colonial	Shut	Shut	Shut	Shut	Shut	Reduced operations	Operational	Operational	Operational	Operational
Buckeye	Shut	Shut	Shut	Shut	Shut	Reduced operations	Operational	Operational	Operational	Operational

Shut | Reduced operations | Operational

Source: US DOE

New York Metropolitan Area Fuel Terminals, Operational Status After Sandy



Hurricane Sandy dramatically reduced output at refineries that supply New York City. While Philadelphia refineries were not greatly affected by the storm and reopened fairly quickly, two northern New Jersey refineries were closed for extended periods. The owners of these regional refineries partially shut down their facilities before the storm to minimize damage to equipment, eliminating 35 to 40 percent of the region's total supply capacity preemptively. Despite this prudent preparation, storm surge damage to electrical equipment at two of the six refineries delayed their restarting, reducing regional refining capacity by 26 percent. Although both refineries eventually reopened several weeks later, one of the two subsequently was permanently closed, due to market conditions. *(See chart: Regional Refineries, Operational Status After Sandy)*

The Colonial and Buckeye pipelines also were impacted by Sandy, shutting down for four days due to extensive power outages in New Jersey. This reduced total supply in the region by another 35 to 40 percent. Even after backup power generators were deployed and utility power was restored, it is likely that the flow of fuel through these pipelines still did not reach pre-storm levels for several days because of bottlenecks at the terminals that they supplied. *(See chart: Pipelines, Operational Status After Sandy)*

Of all of the ways in which Sandy interfered with the liquid fuel supply chain in the New York region, perhaps the most significant was the damage to the area's terminals. This damage took multiple forms. For example, docks at some terminals were destroyed, making it impossible for those terminals to ship or receive fuel. In many cases, damage to electrical equipment reduced the capacity of impacted terminals to dispense fuel to delivery trucks that service gas stations. Additionally, damage to storage tanks at several terminals resulted in spills into area waterways totaling some 460,000 gallons of fuel around the city. And, as a result of the large amount of storm-related debris in the harbor immediately following Sandy, the US Coast Guard placed restrictions on port traffic for days until the waterways were deemed safe for use. As a result, even if a terminal were otherwise able to operate, many were still, for a period, unable to dispense or receive tanker and barge shipments, reducing supply capacity by an additional 20 to 25 percent. Overall, for three days after Sandy, all fuel terminals in the New York metropolitan region were completely out of service. Even 10 days after the storm, only 79 percent were operational. *(See chart: New York Metropolitan Area Fuel Terminals, Operational Status after Sandy)*

The closures of terminals meant that many gas stations had no supply. However, supply agreements required franchised gas stations to source their fuel only from those facilities. Accordingly, even where alternative sources of fuel may have been available, these stations could not take advantage of them. One significant exception to this during Sandy was gas stations owned by Hess, which had the ability to source fuel from corporate-owned terminals outside of the region. As a result, Hess stations received more frequent fuel shipments and remained open on average twice as long daily as other gas stations.

Another barrier to the restoration of fuel availability was local, State, and Federal regulations relating to the transportation and consumption of liquid fuels, which restricted supply from entering the city. For example, New York State's price-gouging law, which was meant to prevent predatory price increases during emergencies, may actually have had the perverse effect of constraining fuel supply due to its lack of clarity. This is because this law, prohibiting an "unconscionably excessive" price increase, made it unclear to retailers how much of a price increase would be considered price gouging, preventing them from temporarily raising prices at the pump. This would have allowed retailers, in turn, to pay the additional transportation costs associated with sourcing fuel from other regions.

With little or no fuel to sell to customers, stations all across New York City were forced to close—even though, unlike in New Jersey and on Long Island, 90 percent of the stations in the city were outside of the areas that experienced widespread power outages. In fact, most drivers in New York City were able to find a station that had access to adequate power within a five mile radius after the storm, except those in the Rockaways. *(See map: Retail Gas Stations, Electrical Network Shutdowns, and Sandy Inundation Area)*

Because of the post-Sandy fuel shortage, however, within one week of Sandy's landfall, less than 20 percent of stations were able to sell fuel at any given time. During that time, even after receiving fuel shipments, in many cases, stations would end up selling out in short order. For many drivers, this meant spending hours searching around the region for stations with gas, often waiting in long lines at the few that remained open—only, in some cases, to have those stations run out before every customer had a chance at the pump. Because demand was concentrated at fewer stations, the presence of New York City police officers was required at gas stations to maintain order and direct traffic. *(See chart: New York City Gas Stations by Point-in-Time Operational Status)*

As significant as the impact of the fuel shortage was on the general population, even more seriously, personnel and entire fleets that were critical to storm response had difficulties refueling. This was true of utility technicians essential to power-restoration efforts, hospital staff, nonprofit relief workers, and other critical personnel. In each case, these important individuals were also forced to spend hours either searching for open gas stations or waiting in line, delaying emergency response and restoration efforts citywide.

The fuel supply disruption also affected power and steam plants in and around the city. As the storm approached, Con Edison called upon power plants within the city to switch to liquid fuels preemptively in case of a natural gas disruption. Eventually, as the area's fuel supply issues emerged, some power and steam plants actually had difficulty obtaining adequate fuel shipments, in some cases, coming close to depleting their fuel supplies.

In response to the fuel shortage, the City worked with the State and Federal governments and with private industry to put in place a variety of measures to restore supply, with a goal of prioritizing fuel for emergency responders, then for private fleets critical for infrastructure restoration and relief, and finally for the general public.

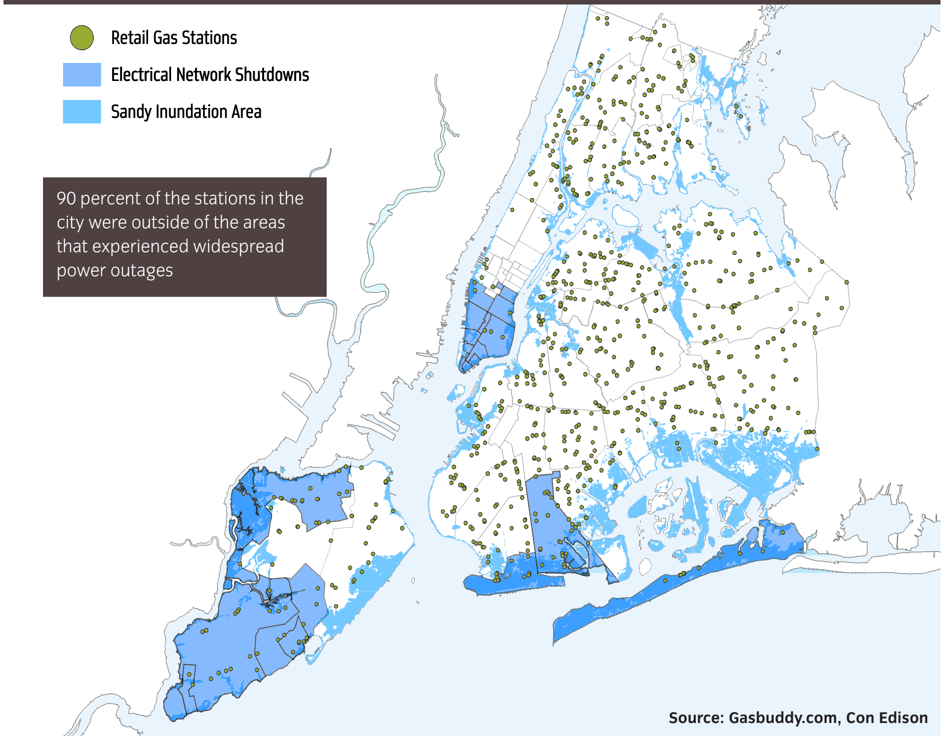
One example of the steps that the City took to bring supply and demand back into balance was a waiver of regulations on the transportation and consumption of fuels within New York City. The City, State, and Federal governments also worked together to secure a waiver of a series of relevant restrictions, including the Jones Act, local gasoline formulation requirements, gasoline vapor pressure requirements, on-road diesel requirements, diesel sulfur requirements, biodiesel requirements, and certain transportation restrictions. While these actions all took place within a few days of the storm and led to additional supply entering the system, the depletion of service station inventories continued to occur too quickly for the supply chain to "catch up," resulting in continued shortages.

Therefore, 11 days after the storm and consistent with steps taken in New Jersey and Long Island, Mayor Bloomberg issued an Executive Order for the rationing of gasoline—the first in New York City since the 1970s. Pursuant to the Executive Order, drivers of vehicles with license plates ending in odd numbers were permitted only to fuel on odd-numbered days, while those with plates ending with even numbers or letters were permitted to fuel only on even-numbered days.

The US Department of Energy also began releasing supply from the Northeast Home Heating Oil Reserve. The ultra-low sulfur diesel contained in the reserve, which was meant to be used in buildings for heating, was made available for use in vehicles, helping to reduce the area's diesel shortage.

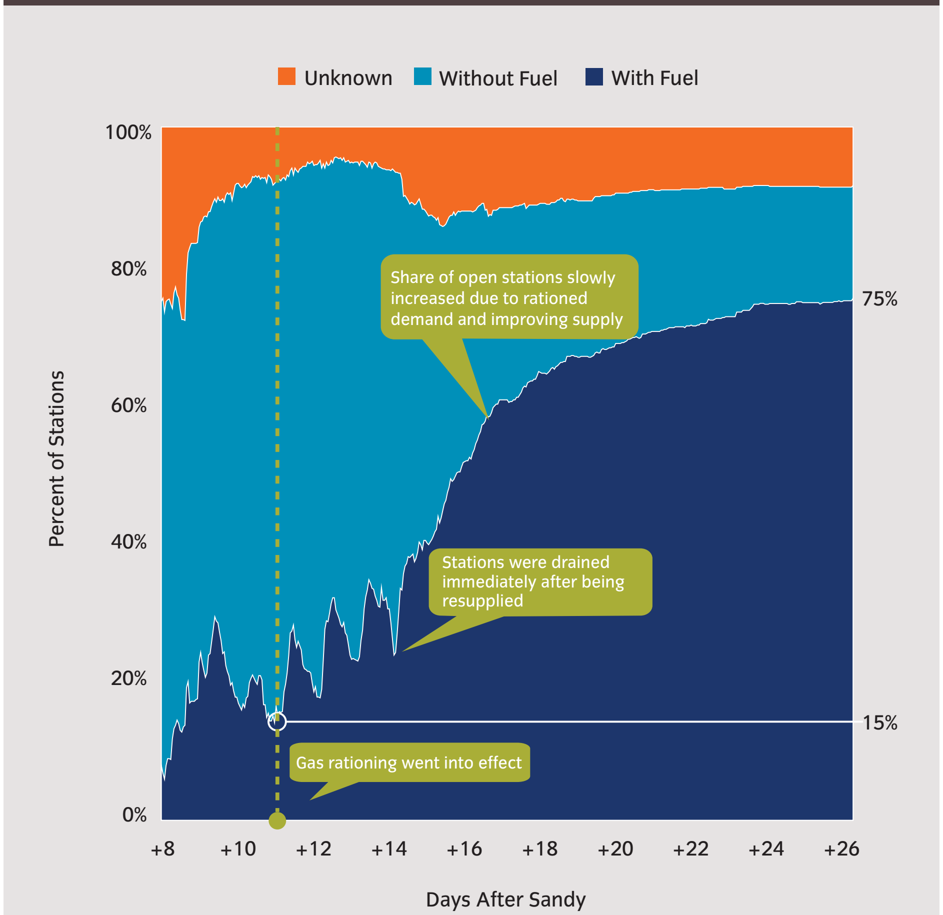
The City also identified groups deemed critical to storm response and in need of fueling assistance. These groups included City staff from uniformed

Retail Gas Stations, Electrical Network Shutdowns, and Sandy Inundation Area



Source: Gasbuddy.com, Con Edison

New York City Gas Stations by Point-in-Time Operational Status



Source: Gasbuddy.com

Risk Assessment: Impact of Climate Change on Liquid Fuels

Major Risk Moderate Risk Minor Risk

	Scale of Impact			
Hazard	Today	2020s	2050s	Comments
Gradual				
Sea level rise	Minor Risk	Minor Risk	Moderate Risk	Low-lying infrastructure could be vulnerable to minor damage with significant sea level rise
Increased precipitation	Minor Risk	Minor Risk	Minor Risk	Minimal impact
Higher average temperature	Minor Risk	Minor Risk	Minor Risk	Minimal impact
Extreme Events				
Storm surge	Major Risk	Major Risk	Major Risk	Most terminals and refineries are already in the floodplain
Heavy downpour	Minor Risk	Minor Risk	Minor Risk	Minimal impact
Heat wave	Moderate Risk	Major Risk	Major Risk	INDIRECT: Increased likelihood of power outages could disrupt operations of supply infrastructure
High winds	Moderate Risk	Moderate Risk	Moderate Risk	INDIRECT: Increased likelihood of power outages could disrupt operations of supply infrastructure served by above-ground lines

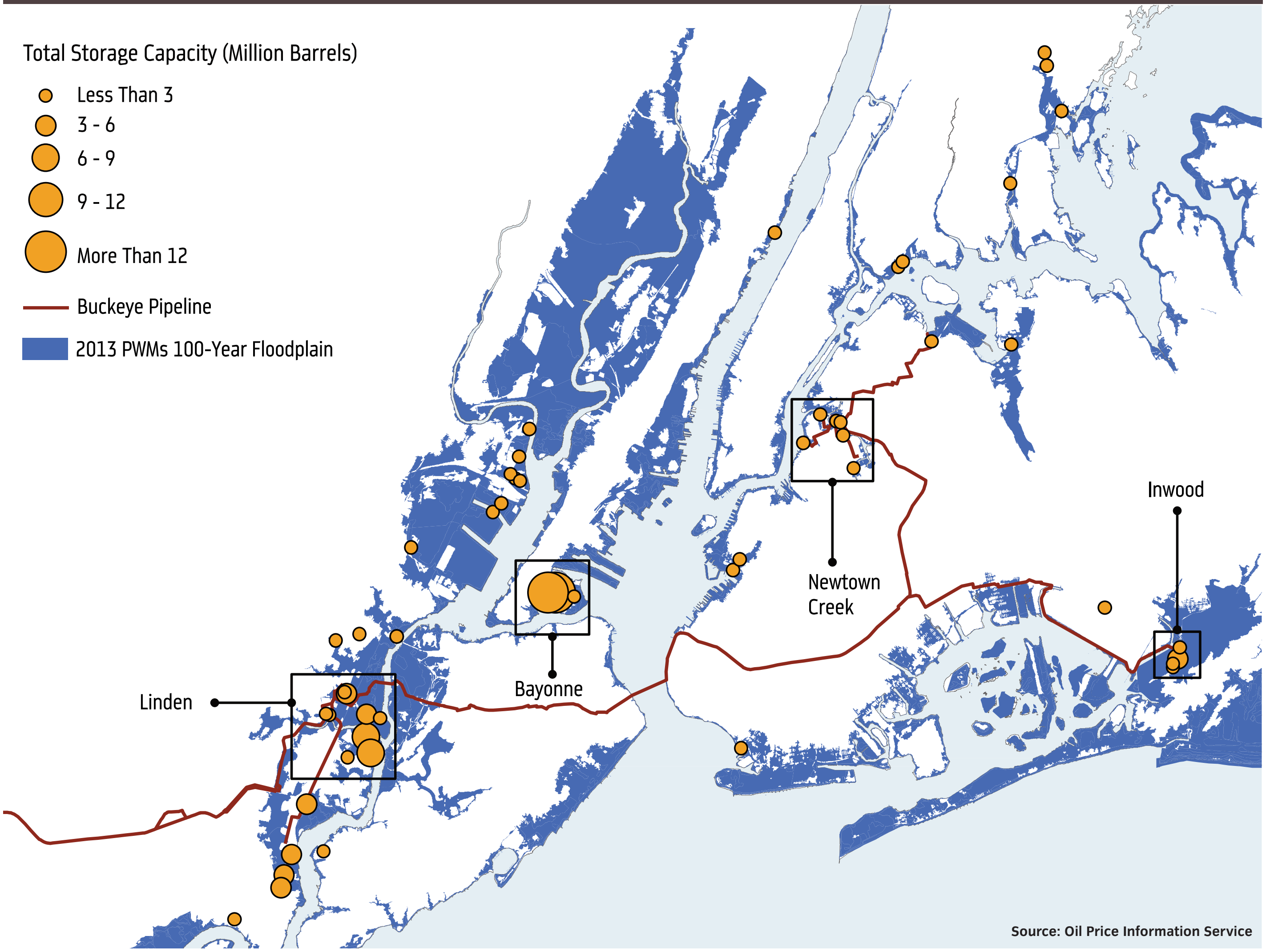
Fuel terminals between Newark Liberty International Airport and Port Elizabeth in northern New Jersey

Credit: Keith Meyers/The New York Times

agencies, doctors and nurses, and electricians and other skilled tradespeople. To fuel their vehicles and the vehicles of others, the City worked with the New York National Guard, the US Defense Logistics Agency, the US Department of Energy, the National Park Service, and the City's fuel vendors to set up an emergency fueling station at Floyd Bennett Field in Brooklyn. A total of 450,000 gallons of fuel were supplied to over 25,000 vehicles from this station. The assisted vehicles included private ambulances, Access-a-Ride vehicles, food trucks supporting storm response efforts, and utility trucks. In a complementary effort, the New York National Guard and the Department of Citywide Administrative Services (DCAS) also conducted fuel missions to fill gas cans to supply emergency electrical generators.

Another fuel-related effort in the aftermath of Sandy was one undertaken by the City, which involved working with the fuel vendors to increase fuel deliveries for City fleets. As a result of these efforts, the City's two primary vendors ended up delivering supplies that exceeded normal fuel deliveries by 65 percent. The City also made arrangements to fuel emergency and critical storm response vehicles at 10 Hess retail stations across the city. The NYPD monitored the Hess sites, ensuring that critical vehicles were able to access fuel without having to wait in line.

Regional Liquid Fuel Terminals



What Could Happen in the Future

The risks that extreme weather events pose to the liquid fuels supply chain are, as Sandy showed, serious if not addressed. The systematic failure that occurred as a result of Sandy's storm surge revealed that there are already significant challenges today. These challenges will only be exacerbated by climate change in the future.

Major Risks

Given the existing locations of key terminals, pipelines, and refineries, and the importance of waterfront access for the movement of fuels into New York City, the greatest risk to the liquid fuel supply is storm surge. Of the 39 fuel terminals in the New York metropolitan area, nearly all lie within FEMA's 100-year floodplain as mapped on the 1983 FIRMs. The same is also true of the refinery in northern New Jersey as of the writing of this report. As the climate changes, the frequency of the most intense hurricanes is likely to increase, potentially increasing the risk to these facilities. *(See map: Regional Liquid Fuel Terminals.)*

Not only do extreme weather events cause direct damage to key liquid fuel assets in the region, they also disrupt the power infrastructure critical to the functioning of terminals, refineries, and pipelines. Although utilities must meet current reliability standards, the increased frequency and severity of heat waves, storm surges, and potentially high winds associated with the most intense coastal storms are likely to increase the frequency of power disruptions throughout the region that would, in turn, render key refineries, pipelines, and terminals inoperable (see Chapter 6, *Utilities*). Given the high energy requirements of pipelines and refineries, backup generation may only provide limited operability during utility power outages. Additionally, if power were out for more than a few hours, refineries would quickly shut down, after which it would take weeks to restart them. Gas stations and terminals, which generally do not have on-site backup generation, also are fully reliant on utility power.

Other Risks

High winds present moderate risks to the liquid fuels supply chain. Wind events could result in direct damage to refineries, which have tall distillation columns that are critical to the processing of crude oil. In addition, if wind events affect the availability of utility-supplied electric power, they will also impact terminals, refineries, pipelines, and gas stations.

This chapter contains a series of initiatives that are designed to mitigate the impacts of climate change on New York's liquid fuel supply. In many cases, these initiatives are both ready to proceed and have identified funding sources assigned to cover their costs. With respect to these initiatives, the City intends to proceed with them as quickly as practicable, upon the receipt of identified funding.

Meanwhile, in the case of certain other initiatives described in this chapter, though these initiatives may be ready to proceed, they still do not have specific sources of funding assigned to them. In Chapter 19 (*Funding*), the City describes additional funding sources, which, if secured, would be sufficient to fund the full first phase of projects and programs described in this document over a 10-year period. The City will work aggressively on securing this funding and any necessary third-party approvals required in connection therewith (i.e., from the Federal or State governments). However, until such time as these sources are secured, the City will proceed only with those initiatives for which it has adequate funding.

Storm surge, storm- or heat wave-driven power outages, and other natural or manmade disasters can cause disruptions in the supply of liquid fuels. The City will seek to minimize the frequency and severity of disruptions by increasing the resiliency of key infrastructure. However, in recognition of the fact that it is not possible to prevent all disruptions, the City also will seek to minimize the impacts of such disruptions by improving restoration times. Finally, in the event of a significant, lengthy and widespread fuel supply disruption, the City will prepare for a work-around of the normal supply chain to maintain operations that are necessary to restoration and relief while the normal chain is being restored.

Strategy: Seek to harden the liquid fuels supply infrastructure

The fuel supply infrastructure is vulnerable to extreme weather events, which are likely to become more frequent and more severe in the future. Hardening of key assets would decrease disruptions and allow for faster restoration of operations.

Initiative 1

Call on the Federal government to convene a regional working group to develop a fuel infrastructure hardening strategy

The fuel supply shortage after Sandy was caused mainly by damage to infrastructure in New Jersey, where the City and State of New York have no regulatory or legislative authority. Owners are not required by any existing regulations to harden infrastructure against climate change impacts. In fact, due to the highly dynamic and competitive nature of the fuel industry, suppliers often do not have the resources and long-term outlook necessary to make their waterfront assets more resilient against threats such as storm surge and power loss.

The City, therefore, will call on the Federal Hurricane Sandy Rebuilding Task Force and the US Department of Energy to convene the necessary stakeholders to ensure that key infrastructure is hardened. The City also will call on the Columbia University Center on Global Energy Policy to join this effort. In addition to the City, participants in this effort should include the State of New York, the State of New Jersey, and private owners of key assets. The Office of Long-Term Planning and Sustainability (OLTPS) will begin working with these parties immediately to develop a strategy that will achieve the goal of hardening pipelines, refineries, and terminals critical to maintaining fuel supplies in the region.

Initiative 2

Develop a reporting framework for fuel infrastructure operators to support post-emergency restoration

There currently are no requirements to report information on the operational status of terminals, pipelines, refineries and gas stations. In an emergency, not being able to access the information needed to gain a comprehensive understanding of the regional challenges will hamper recovery and restoration. The City will call on and work with the Federal government and private industry to develop streamlined reporting protocols for operators, as well as automated sensors and other information technology (IT) systems that will monitor the operational status of these facilities. OLTPS and the New York City Economic Development Corporation will begin working immediately with the US DOE to develop these systems and an information-reporting framework for these facilities, in a manner that is sensitive to the industry's need for security and confidentiality.

Initiative 3

Work with Buckeye and New York State to safely build pipeline booster stations in New York City to increase supply and withstand extreme weather events

Many existing pumping stations along pipelines are not hardened against extreme weather. Before Sandy, Buckeye had proposed the installation of a booster station to increase flow into New York City for economic reasons. This booster station also would help bring additional supply to New York City in emergency situations. New York State has advocated for the building of a booster station to increase supply during shortages. The City also will advocate for the building of a new booster station if design specifications meet the necessary legal, safety, and resiliency standards, and all necessary commercial terms could be secured. OLTPS will begin working immediately with Buckeye and New York State to ensure that a booster station, once installed, will be designed to withstand climate change impacts to the greatest extent possible.

Initiative 4

Work with New York State to provide incentives for the hardening of gas stations to withstand extreme weather events

Although lack of power supply at gas stations was not the primary cause of fuel shortages after Sandy, a widespread power outage in the city would cripple gas station operations, making gasoline and diesel unavailable. New York State's 2013–2014 budget requires retail fuel stations within a half-mile of controlled access roads and designated evacuation routes to invest in equipment that would allow them to connect generators quickly in the event of a power loss, and to enter into supply contracts for emergency generators.

The City will support the State in the design and implementation of the generator connection program, an effort that will include working with the New York State Energy Research and Development Authority (NYSERDA), which was directed to develop an incentive program to minimize the financial impact of the budget requirements. In addition the City will work with the State to assess the vulnerability of gas stations on the Rockaway Peninsula, an area of the City in which gas stations are not required to comply with the State budget requirements, but should, due to its geographic isolation.

Because the aforementioned program does not require any other hardening measures against flooding or other climate-related risks, OLTPS will work with NYSERDA, retail gas stations, and the State legislature to seek to develop effective hardening incentive programs for key retail fueling stations in vulnerable areas, including the Rockaways, by 2014.

Initiative 5
Ensure that a subset of gas stations and terminals have access to backup generators in case of widespread power outages

As previously mentioned, gas stations are vulnerable to widespread power outages, which could prevent them from operating. In New York State's 2013–2014 budget, NYSERDA was directed to develop a generator pool program for gas stations. The Office of Emergency Management (OEM) will assist NYSERDA, the Federal Emergency Management Agency, and the US Army Corps of Engineers (the USACE) in developing such a pool and in creating a pre-event positioning plan to enable the ready deployment of generators to impacted areas immediately in the wake of a disaster.

Strategy: Enhance the ability of the supply chain to respond to disruptions

One reason restoration of fuel supply was so slow after Sandy was the lack of redundancies and market flexibility needed to respond to such disruptions. As Sandy also showed, the impacts of a supply disruption can be blunted through market and regulatory changes.

Initiative 6
Explore the creation of a transportation fuel reserve to temporarily supply the private market during disruptions

Even if the fuel supply chain is hardened, the possibility of widespread disruption to supply still exists. In the event of such a disruption for an extended period of time in and around the city, a transportation fuel reserve for the City, State, or region would assist in restoration and relief efforts. The City will work with Federal and State governments, and the Columbia University Center on Global Energy Policy to evaluate the feasibility and cost of such a program. Such a program would complement the already existing Northeast Home Heating Oil Reserve, managed by the US DOE in Connecticut. In 2013 and 2014, OLTPS will work with the US DOE, New York State, and surrounding state governments on this effort.

Initiative 7
Call on New York State to modify price-gouging laws and allow flexibility of gas station supply contracts to increase fuel availability during disruptions

There is lack of clarity in New York State's price-gouging laws during the very limited circumstances of a widespread disruption of fuel supplies in the New York region. This uncertainty results in retail fuel station owners' unwillingness to raise prices after such a disruption to pay for supply from outside of the region. The City estimates that a $0.33 increase in fuel prices after Sandy (a premium of approximately 10 percent) would have allowed stations to cover the additional transportation costs to bring fuel into the city from as far as Charlotte, North Carolina. Another challenge during Sandy was that many retail fuel stations were bound by franchise agreements to source fuel only from certain suppliers, which were either not operational or had insufficient supplies after the storm. These contractual obligations prevented station owners from temporarily sourcing fuel from different suppliers.

A solution to the problem posed by the State's price-gouging laws would be to allow a controlled increase in prices during fuel supply emergencies, while still ensuring fair pricing. A solution to the problem posed by retailers' franchise agreements, meanwhile, would be the inclusion of a "force majeure" clause in fuel supply contracts that would allow franchised stations to source fuel on a temporary basis from any wholesaler if a retailer's usual suppliers are unable to deliver.

OLTPS will, therefore, work with New York State to seek legislation in 2013 and 2014 that would permit controlled increases in fuel prices during and after extraordinary weather events, and that would mandate a "force majeure" clause in all fuel supply contracts and franchise agreements, in each case, to be exercised only during a liquid fuels shortage, as declared by the Governor.

Initiative 8
Develop a package of City, State, and Federal regulatory actions to address liquid fuel shortages during emergencies

Various regulations relating to the transportation and consumption of fuels in New York City limit the flexibility of the market to respond to disruptions. The City will work with the State and Federal governments to prepare an "off-the-shelf" package of regulatory measures for use in the event of a liquid fuels shortage. A list of such waivers that would be issued rapidly across different levels of government would allow supply-demand imbalances in the fuel supply to be mitigated more quickly. The waiver of the Jones Act, for example, would allow foreign-flagged ships to deliver fuel into the region. Waivers of the City's fuel sulfur requirements and the local formulation requirements would allow fuel that is normally consumed upstate and elsewhere to be shipped into and sold within New York City. A waiver of the on-road diesel fuel requirement would allow heating fuel to be used in vehicles. The imposition of fuel rationing would further allow the retail fuel supply to stabilize, allowing more stations to dispense fuel.

OEM and DCAS will, therefore, develop and regularly maintain a fuel-rationing plan and package of regulatory waivers and modifications that would be put in-place immediately after the declaration of a liquid fuels shortage, as declared by the Mayor. OEM will further work with the State and Federal governments to develop complementary measures. OEM will update the City's plan and package on an annual basis.

Strategy: Improve the City's ability to fuel first responders and private critical fleets

The City must be able to respond quickly to a fuel supply disruption, providing continuous fueling to vehicles that are critical for emergency response, infrastructure rebuilding, and disaster relief. These vehicles include emergency responders, utility restoration fleets, medical personnel vehicles, electricians and other skilled trades workers, construction vendors, private ambulances, wheelchair accessible transportation vehicles, food supply trucks supporting relief efforts, and City government staff from uniformed agencies.

Initiative 9
Harden municipal fueling stations and enhance mobile fueling capability to support both City government and critical fleets

During a widespread disruption to the retail liquid fuels market, the City must be able to bypass the supply chain by using its own network of gas stations and mobile fueling trucks. This will ensure continued service at City-owned fueling sites and mobile fueling operations for City-owned fleets, as well as select critical fleets that are privately owned. The City, through DCAS, will procure additional mobile fueling trucks, generators, light towers, forklifts, and water pumps to permit the City to harden its own fuel supply infrastructure and put in place emergency fueling operations immediately following a disruption in the supply chain.

In the event of a prolonged disruption, the City must ensure that it does not deplete its own fuel supply for first responders and critical fleets. Currently, the City owns almost two weeks of fuel storage capacity for its own normal usage, and much less when fueling privately-owned vehicles. Therefore, DCAS also will also issue a request for expressions of interest in 2014 in order to evaluate the different options for sourcing fuel during emergencies.

Hurricane Sandy After Action

Report and Recommendations to Mayor Michael R. Bloomberg

May 2013

Deputy Mayor Linda I. Gibbs, Co-Chair
Deputy Mayor Caswell F. Holloway, Co-Chair

Power Outages, Generators, and Boilers

As noted above, storm surge and high winds left millions of New Yorkers without power; the inundation of critical infrastructure including the 13th Street Con Edison substation and four LIPA substations, led to an outage greater in extent and longer in duration than what could have been predicted based on the National Weather Service's forecast and surge modeling and experiences in previous severe weather events.[13]

After large portions of the city lost power at approximately 8:00 PM on Monday, October 29, the City deployed as many generators as it could source to meet a demand that exceeded the number of requests from any other incident.[14] In addition to City facilities, including hospitals and public housing, private facilities that did not have generators or where generators failed turned to the City for assistance. The City established an intergovernmental generator and boiler task force comprised of the Mayor's Office of Long-Term Planning and Sustainability, OEM, FEMA, and the Army Corps of Engineers to prioritize placement to locations that needed power for immediate life-safety needs. In total, the City deployed approximately 230 generators to hospitals, nursing homes, large multi-family buildings, and NYCHA developments in the days following the storm. The City worked closely with Con Edison and LIPA to monitor and prioritize power restoration throughout the inundation zone.

Although all evacuation shelters are located outside of Zone A, they remain susceptible to systems outages-including power outages-that extend beyond the borders of the evacuation zone. Seward Park High School in the Lower East Side lost power for several hours on October 29 for this reason. In anticipation of this possibility, schools that are selected as emergency shelters are assessed for generators so that temporary power can be restored as quickly as possible.

After the generator and boiler task force met the demand for generators to protect life and safety, the next highest priority for building systems restoration was NYCHA: approximately 80,000 residents in 423 buildings were affected by lost power, heat, and/or hot water. NYCHA staff worked to restore at least temporary services as quickly as possible, though many buildings subjected to saltwater and sand required a significant amount of work to bring them even to this standard.

To expedite power restoration in public housing facilities, NYCHA entered into emergency contracts with electrical contractors to build temporary switch boxes and restore connections to the Con Edison and LIPA power grids. In the 15 days immediately following the storm more than 150 electricians and other skilled trades restored power to approximately 400 NYCHA buildings housing more than 79,000 residents. As a result of these efforts, heat, power, and hot water were completely restored to all NYCHA buildings impacted by the storm by November 18.

Although essential services were ultimately restored, this review concluded that significant steps can be taken to strengthen the City's capacity to more quickly respond to the massive power outages that residents and businesses faced following the storm. As part of its internal post-storm review, NYCHA will research the best practices and work with residents to clearly outline its responsibilities to residents who remain in their homes during a mandatory evacuation and in the event of prolonged power outages in areas that are not evacuated. The City also used contact information from tax records and water accounts to reach out to owners of buildings in the Department of Housing Preservation and Development (HPD) portfolio to hold them accountable to restore buildings to habitability, and where possible, assist them in doing so.[15]

13 Prior to Sandy, Con Edison made preparations for the 11 to 12 foot surge at the Battery forecast by the NWS by erecting temporary barriers around installations, including those in the East 13th Street complex. The actual storm surge came into the Battery at 14 feet, exceeding all official forecasts and overwhelming the barriers erected at the East 13th Street complex. The unpredicted surge level flooded five Con Edison substations and four LIPA substations. The network outages caused by the unprecedented substation flooding numbered almost 350,000 customers.

The most common cause of weather-related power outages is damage to overhead lines outside Manhattan (up to approximately 600,000 customer accounts). During Sandy, Con Edison made preparations for power outages in certain areas by de-energizing certain networks, particularly in Lower Manhattan, and portions of the steam system in response to rising storm surge. Sandy's storm surge exceeded the areas where Con Edison took preemptive action, causing additional outages in Manhattan and Staten Island; the LIPA network experienced massive inundation in the Rockaways, which was essentially completely without power following the storm.

14 The City works with the U.S. Army Corps of Engineers outside of hurricane season to survey building-specific needs for backup generation at critical facilities based on the type and use of the building; the Army Corps keeps detailed specifications for each assessment, including information about generator sizing, placement, and connections, on record in case of an event that requires a generator to be deployed to that location. Following Sandy the need for generators far exceeded the available supply, and in a number of cases, the generator specifications on record for a particular facility were incorrect based on building use or were out of date. The Army Corps' mission limits its generator assessments to buildings that house services essential to victim survival or public health, public safety and disaster recovery operations, shelters, and infrastructure operations.

15 The NYC Department of Housing Preservation and Development (HPD) is responsible for enforcing the New York State Multiple Dwelling Law and the New York City Housing Maintenance Code. These laws outline the rights and responsibilities of renters and property owners regarding the maintenance of property, including heat and hot water, lead-based paint, window guards, carbon monoxide detectors, bedbugs, basements and cellars, and Certificates of No Harassment for certain types of housing. See NYC HPD, Residential Building Owners, http://www.nyc.gov/html/hpd/html/owners/owners.shtml (last visited April 8, 2013).

Recommendations

14. **Develop a comprehensive plan to expedite power restoration to multi-family public and private housing.**

    Work with building owners to conduct a power needs assessment of mid- and high-rise residential buildings in low-lying areas in the event of a sustained power outage.

    Set standards for power and essential service restoration and require plans from building owners to meet those needs as part of their obligation to provide habitable dwellings.

    Develop power needs assessments for NYCHA developments and set standards for essential service restoration in the event of a sustained power outage and develop a pian to meet those standards.

15. **Improve and expand off-season site generator assessments for public facilities.**

    Work with the Army Corps to develop criteria and assessment processes appropriate to New York City.

    Expand the list of facilities that receive power assessments to private buildings with City agency tenants.

    Develop a process for facilities, including private residential buildings, to conduct self-assessments following Army Corps methodology.

16. **Establish a Dewatering and Generator Task Force and Action Plan to activate in advance of an approaching storm that will collect and use detailed information about buildings in flood-prone areas to expedite recovery.**

    Develop a plan to address environmental contamination in dewatering and debris removal.[16]

    Develop street siting and permitting criteria for large temporary generators and boilers.

    Identify goods for a strategic stockpile and/or establish emergency contracts for additional critical resources such as generators, boilers, and electrical switchgear.

    To the extent necessary, contract for emergency on-call electricians for generator installation and post-disaster assessments, and for on-call plumbers to install boilers.

    Add generator operations and maintenance and GPS locators to the standard scope of work for generator contracting to help track location and placement in areas with poor communications connectivity.

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16 The New York State Department of Environmental Contamination regulates a hazardous waste management program on behalf of the federal Environmental Protection Agency (EPA), including the State Pollutant Discharge Elimination System (SPDES) that controls point source discharges to publi c wastewater and stormwater systems. Inundation of building basements may damage building fuel tanks or cause them to leak, introducing the possibility of environmental contamination if the building discharges to the City's sewer system during dewatering.

Fuel and Transportation

Sandy triggered one of the most severe fuel shortages in the City's history by damaging energy infrastructure along the regional supply chain, including terminals, pipelines, refineries, and the electricity infrastructure that serves these assets. Although some gas stations were damaged by storm surge, the majority of the City's retail gas stations were not, and with the exception of the Rockaways, did not experience extended power outages; retail gas shortages were a result of not receiving fuel shipments due to disruptions to the regional supply chain.

City agencies had prepared for potential fuel disruptions by fueling vehicles and generators several days before the storm, and the NYPD's ability to maintain an independent fuel supply allowed other City agencies to fuel vehicles in the days following the storm. However, other types of critical vehicles were unable to obtain fuel. Beginning Sunday November 4, the City worked with the National Guard, the federal Defense Logistics Agency, the federal Department of Energy, and the National Park Service to set up a fueling operation at Floyd Bennett Field for City vehicles and other critical recovery personnel. Along with two satellite locations at Fort Wadsworth in Staten Island and Orchard Beach in the Bronx, more than 25,000 emergency and essential vehicles obtained fuel through this partnership. First responders, including private ambulances, also had the option to fuel at 10 Hess stations throughout the City through a partnership managed by the DCAS Chief Fleet Officer with assistance of the NYPD.

For the general public, the City worked with the State to temporarily waive sulfur content requirements for fuel consumption and to ease fuel transportation restrictions into and within the five boroughs. The City also worked with the federal government to suspend the Jones Act to allow tankers originating from foreign countries to supply fuel from refineries along the Gulf of Mexico, and to temporarily waive federal Environmental Protection Agency requirements that are specific to dense, urban environments, allowing fuel consumed outside of New York to be consumed within the city.[30]

The lack of subway and bus service caused standstill traffic on the City's major roads and highways, leading to gridlock for the general public and interfering with emergency services and the City's recovery operations. To alleviate these conditions, the Mayor issued high-occupancy vehicle (HOV) restrictions on the river crossings into Manhattan on November 1 and November 2. To alleviate persistent fuel lines, on November 9 Mayor Bloomberg issued an odd/even license plate fuel rationing system that remained in place until November 24, when the City's fuel supply infrastructure had been largely restored. Yellow taxicabs and other vehicles licensed by the Taxi and Limousine Commission were exempt from fuel rationing and HOV restrictions during certain hours, and were encouraged to allow ride-sharing while the subway system was shutdown. Liveries and black car services were also allowed to accept street-hail passengers between October 30 and November 5.

Damage to transportation infrastructure continued to limit mobility even after roads were clear and tunnels dry. The New York City Economic Development Corporation (NYCEDC) launched a temporary ferry service from the Rockaways to Lower Manhattan on November 9; DOT did the same from Staten Island on November 25. At $2 per ride, these services allowed residents of affected areas with relatively few public transit connections to affordably travel to work and access the rest of the City.

This review made clear that while the City adapted well to the severe challenges posed by the damage Sandy caused to the regional fuel supply, a fuel plan needs to be developed to take the steps necessary to more quickly alleviate the shortages that a storm or other emergency could cause in the future. In particular, the large number of industry participants and stakeholders, the competitive nature of the fuels industry, and relatively lax regulations limited the City's situational awareness of what caused long lines at the gas pumps and how to find a solution for City operations and private citizens. The Mayor's Office of Long-Term Planning and Sustainability (OLTPS) and DCAS relied on professional contacts, crowd-sourced data, and phone interviews to slowly piece together an accurate picture.

30 Waivers were issued of 40 C.F.R. 80 subparts D & E (EPA rule requiring the use of reformulated gasoline blendstock for oxygenate blending, known as RBOB, in New York City and surrounding counties); 40 C.F.R. § 80.27 (EPA rule establishing controls and prohibitions on gasoline volatility); N.Y. Tax Law Art. 12-A (requiring different tax treatment of fuel that is used for transport use versus heating and other off-road uses); N.Y. Envtl. Conserv. Law § 19-0323 (requiring the use of only ultra-low sulfur #2 oil for heating in buildings in New York City); New York City Administrative Code § 24-168.1(b) (two percent biodiesel requirement for heating oil); and regulations of the Port Authority of New York and New Jersey restr1ctmg transportation of flammable liquids through tunnels at tunnel and bridge facilities. Along with fuel-related requirements, waivers were also issued for 49 CFR Parts 385, 386, 390, and 395 (federal DOT restrictions on commercial-driver hours of service); N.Y. Veh. & Traf. Law § 385 (restricting vehicles of certain heights, weights, and lengths on designated roadways and bridges); and 34 R.C.N.Y. § 4-13 (NYC DOT Rule restricting freight truck vehicle traffic through certain roadways). See also generally, U.S. DOT, Federal Motor Carrier Safety Administration, Hurricane Sandy Relief Efforts - Declarations, Waivers, Exemptions & Permits, http://www.fmcsa.dot.gov/about/alerts/hurricane-sandy-2012.aspx (last visited April 25, 2013).

Recommendations

28. **Create a Fuel Task Force, modeled after the Downed Tree Task Force (the inter-agency tree removal group), to ensure adequate fuel for rescue and recovery operations.**
    - Add a fuels desk to OEM's Emergency Operations Center.
    - Formalize and expand DCAS/NYPD partnerships with retail gas stations.
    - Build federal and state support and create a "playbook" for regulatory relief during fuel shortages.
    - Protect and standardize eligibility for use of City fueling sites.
    - Research options and viability of creating local emergency fuel reserves.
29. **Develop a Citywide Transportation Plan to ensure the liquidity of the transportation system, including the timing and triggering conditions of implementing the plan.[31]**
    - Outline the conditions to institute fuel rationing.
    - Institute HOV restrictions with clear, industry-specific public messaging.
    - Ensure that critical responders/critical health and safety staff have an emergency transportation plan, including fueling options where practicable and contingency arrangements in the event of a significant disruption to the fuel supply.
30. **Upgrade City-owned fuel infrastructure, including mobile fuel trucks and real-time reporting from the City's 414 in-house fueling locations.**

Debris removal

Debris

Sandy generated an estimated 700,000 tons of storm debris, including construction and demolition debris, sand, concrete, and more than 27,000 tons of woody debris from nearly 20,000 downed trees and limbsY Clearing this debris from the public right-of-way and from homes was critical to maintaining public safety and facilitating recovery operations. On October 30, immediately after the storm ended, DSNY commenced debris removal operations, working fully-staffed 12-hour shifts around the clock as part of the Debris Removal Task Force (DRTF), which coordinated the collection and removal of debris from the City's rights-of-way to seven New York State Department of Environmental Conservation (DEC)-licensed Temporary Storage Sites (TSSs), including Floyd Bennett Field and Jacob Riis Park, both part of the National Park Service's Gateway National Recreation Area in Jamaica Bay.[33] More than 6,000 sanitation workers collected nearly 110,000 tons of debris in the eight days after the storm and worked at the TSSs to sort large appliances for recycling. From the Temporary Storage Sites, DSNY and contractors hired through the Army Corps of Engineers transported the debris out of the City for permanent disposal.[34] DEP monitored debris piles in the Rockaways and Staten Island for asbestos and all samples met the clearance criteria established for asbestos abatements conducted indoors. The Mayor's Fund also sponsored local cleanup teams from the Doe Fund and the Center for Employment Opportunities, two local nonprofit organizations that provide training and employment to unemployed and underemployed New Yorkers.

Five of the temporary storage sites closed by November 19 and two remained open longer to receive remaining debris, including from Rapid Repairs, the City's tern porary shelter program to restore power, heat, and hot water to private homes. DSNY continued to work full shifts through November 11 and had up to 2,000 sanitation workers collecting debris daily through March 18.

31 Elements of the transportation plan may include the MTA subway and bus systems, yellow taxi and black car services, and other public and private fleets.

32 See Recovery: Post-Storm Cleanup and the Effects on the City's Health and Infrastructure: Oversight Hearing Before the New York City Council Comms. on Environmental Protection. Health, Sanitation & Solid Waste Management, and Parks & Recreation (Feb. 28, 2013) (testimony of John Doherty, Commissioner, New York City Department of Sanitation).

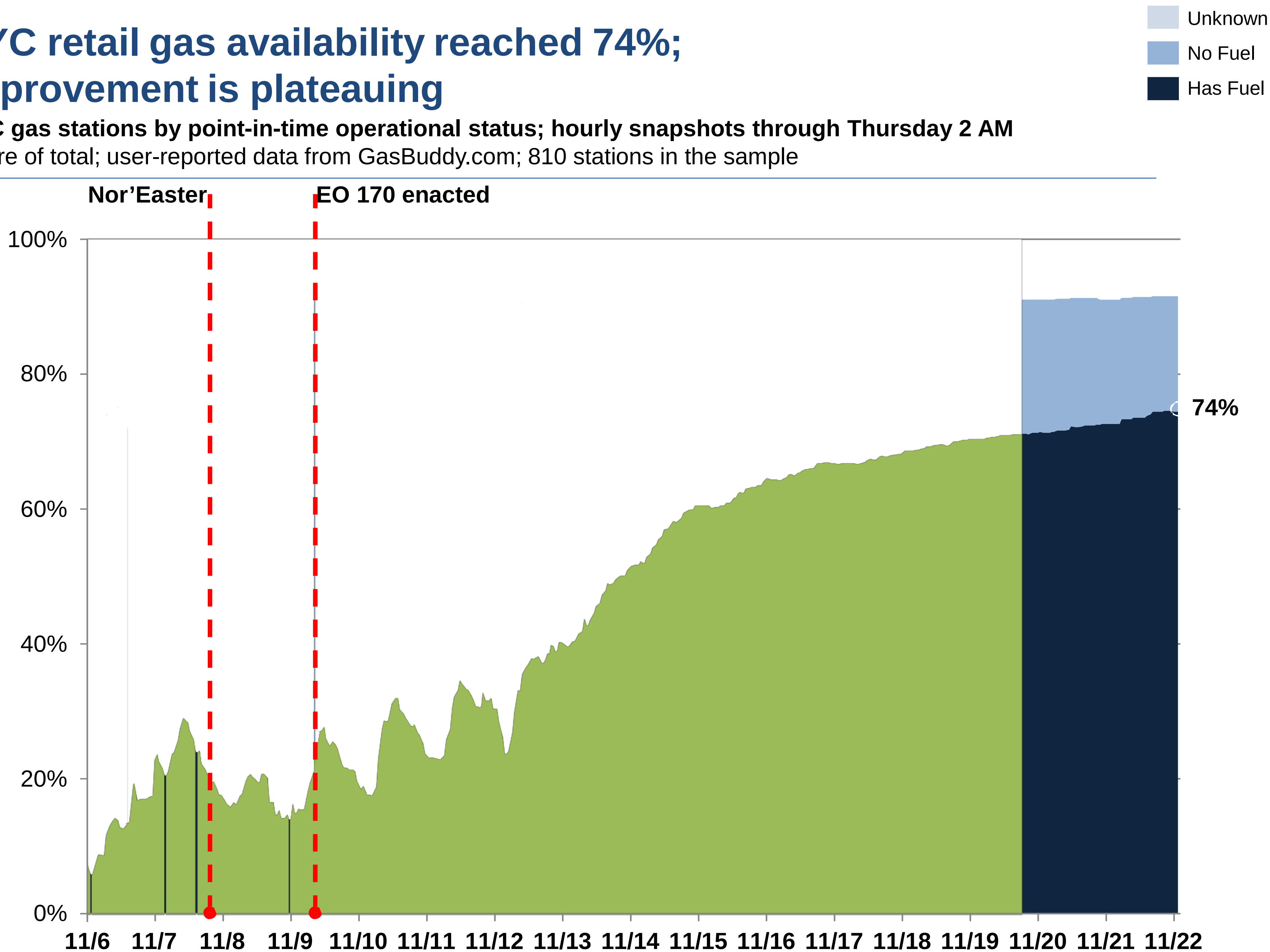
33 The debris temporary storage sites were selected from a pre-surveyed list compiled in 2006 by a multi-agency team comprised of OEM, DPR, NYCED(.and DEC. Although the selected storage sites had the capacity to manage the debris from Sandy, the number of approved storage sites has decreased over time as undeveloped properties and large parking lots are redeveloped into housing, parks, commercial buildings, or are designated for other uses that are not compatible with temporary debris storage.

34 Aithough Army Corps contractors provided significant assistance throughout the debris removal operation, it may be more efficient in future disasters for the City to contract directly for these resources.

NYC retail gas availability reached 74%; improvement is plateauing

NYC gas stations by point-in-time operational status; hourly snapshots through Thursday 2 AM

Share of total; user-reported data from GasBuddy.com; 810 stations in the sample

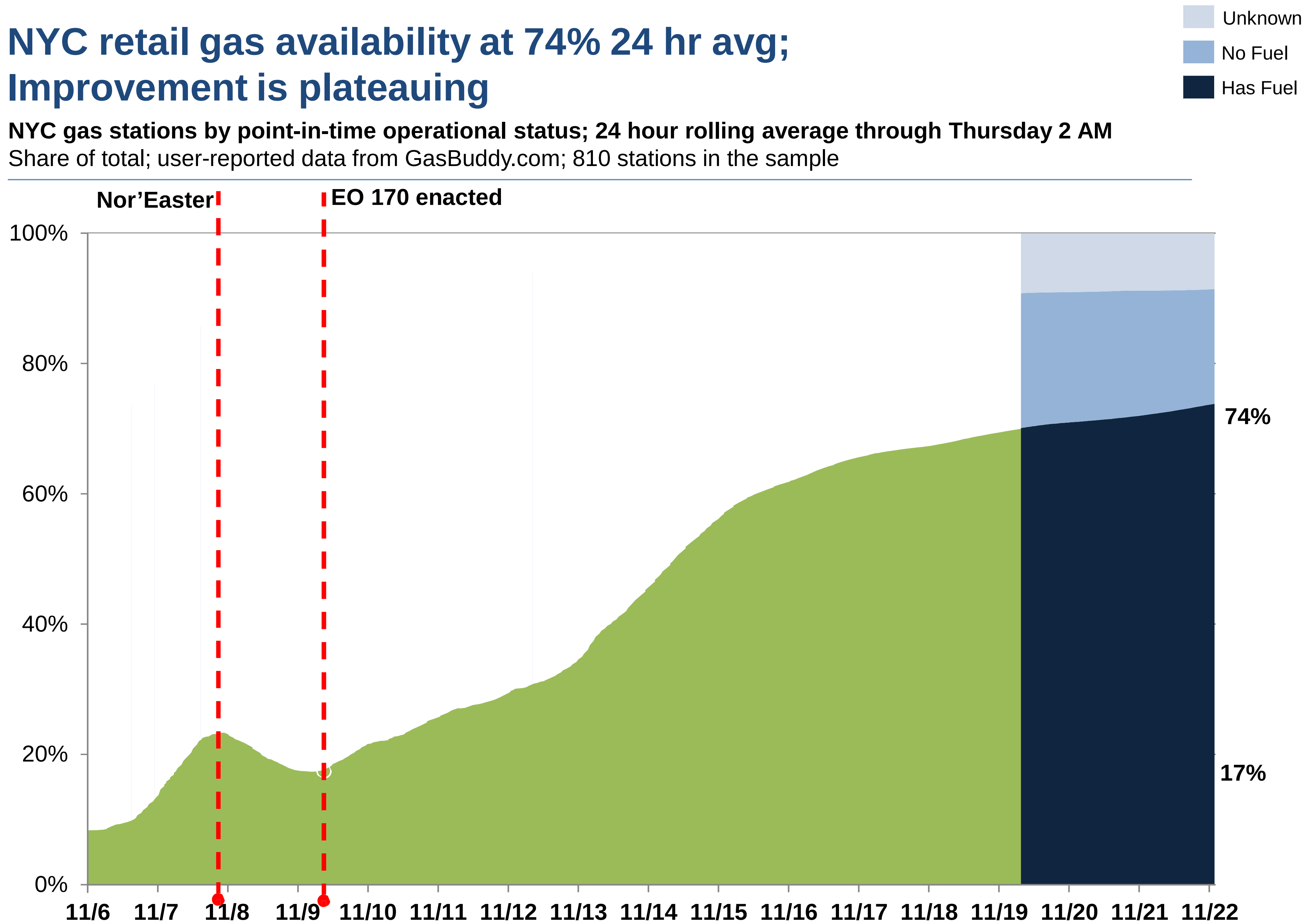


SOURCE GasBuddy.com

NYC retail gas availability at 74% 24 hr avg; Improvement is plateauing

NYC gas stations by point-in-time operational status; 24 hour rolling average through Thursday 2 AM

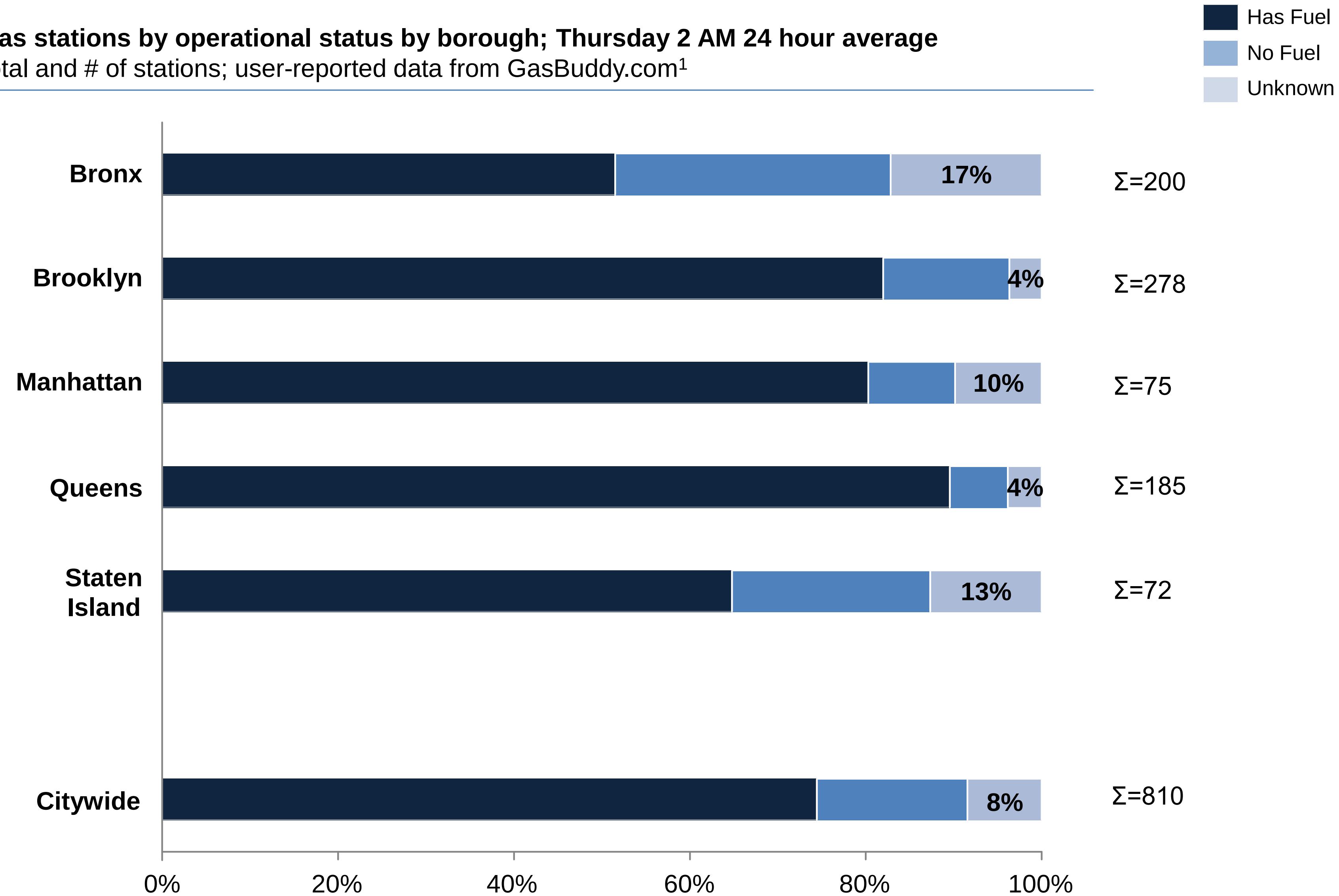
Share of total; user-reported data from GasBuddy.com; 810 stations in the sample



SOURCE GasBuddy.com

Retail situation appears more constrained in Bronx and Staten Island

NYC gas stations by operational status by borough; Thursday 2 AM 24 hour average
% of total and # of stations; user-reported data from GasBuddy.com[1]

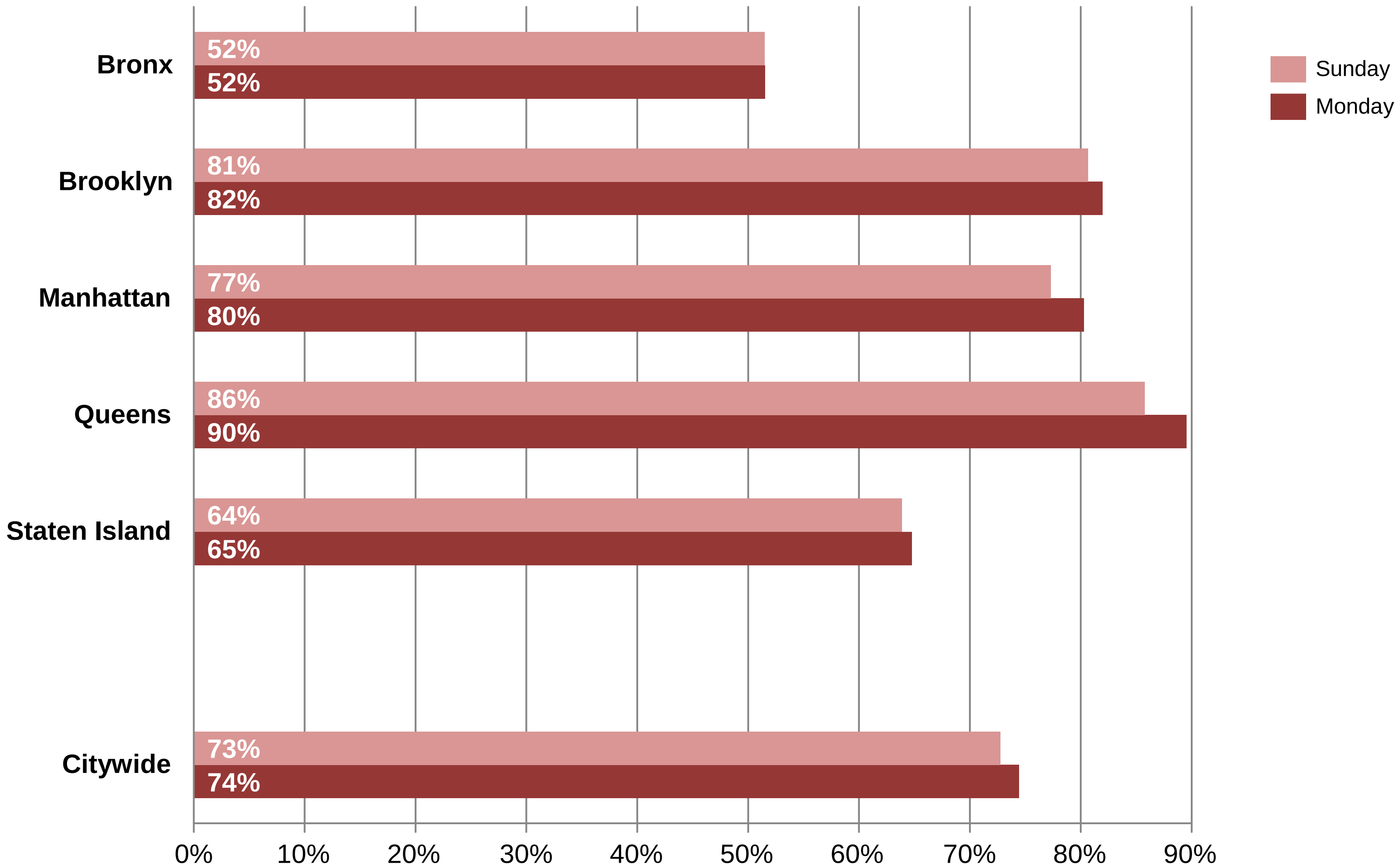


1 Stations not updated in last 24 hours revert to "unknown"

SOURCE GasBuddy.com

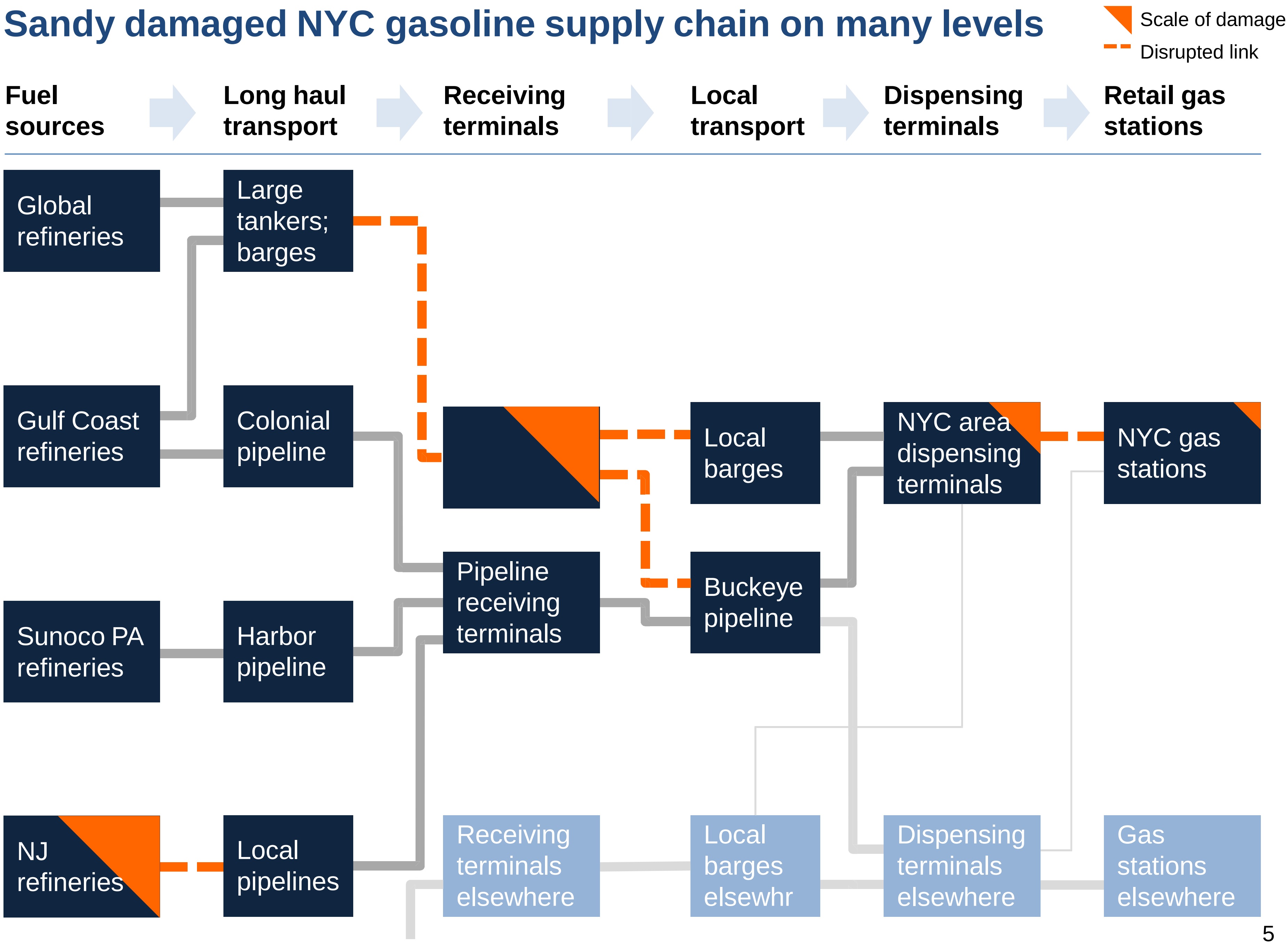
Situation in at borough level marginally improved from Monday to Tuesday

NYC stations by operational status by borough; Wednesday vs Thursday 24 hour average
% of total and # of stations; user-reported data from GasBuddy.com



SOURCE GasBuddy.com

Sandy damaged NYC gasoline supply chain on many levels



Independent Statistics & Analysis
U.S. Energy Information Administration

New York/New Jersey Intra Harbor Petroleum Supplies Following Hurricane Sandy: Summary of Impacts Through November 13, 2012

With the help of the National Petroleum Council and with the voluntary participation of the industry, the U.S. Energy Information Administration (EIA) conducted a survey to evaluate product flows in the New York Harbor (NYH) area both prior to Hurricane Sandy and as of Tuesday, November 13. Terminals representing 98% of storage capacity in the NYH area participated in this effort. EIA and Department of Energy staff have remained abreast of the evolving situation since that time. However, this paper reports on the situation as of November 13, the last date for which data covering virtually all of the NYH petroleum terminal infrastructure are available.

Background

At 8:00 p.m. EDT October 29, 2012, the National Hurricane Center reported that Sandy made landfall near Atlantic City, New Jersey, as a post-tropical cyclone. The accompanying winds and flooding were devastating to many areas in the Northeast and damaged much of the energy infrastructure, including petroleum product supply and delivery systems around the NYH area.

The NYH area is a major distribution hub for petroleum delivery to consumer markets in New England, New York, and New Jersey. The terminals in this area, with combined storage capacity of about 70 million barrels, receive product via pipeline from refineries on the U.S. Gulf Coast , the Philadelphia area, and the two refineries located in northern New Jersey – the Phillips 66 Bayway (238,000 barrels per day) and the Hess Port Reading (70,000 barrels per day). The terminals also receive product via tanker and barge, much of it imported from outside the United States. Products from the terminals are then redistributed by barge and pipeline mainly to distribution terminals in New England, throughout the NYH area, up the Hudson River as far as Albany, and via pipeline to upstate New York. These distribution terminals also supply gasoline, heating oil, and diesel fuel to trucks for delivery to retail outlets and local distributors.

Impacts of Hurricane Sandy

The hurricane damaged much of the petroleum supply infrastructure in the NYH area, including both of the refineries in northern New Jersey and many of the terminals. The damage to the refineries and the terminals significantly disrupted the supply chain. Immediately following the storm, the lack of commercial or generator power kept many terminals from operating. With terminals nonoperational, product supply into the region stopped. Colonial Pipeline, which moves substantial volumes of petroleum products from the Gulf Coast to the New York Harbor area, was forced to stop delivering products to the NYH terminals. Colonial also had to slow product movement throughout the entire pipeline, which serves areas from the Gulf Coast, up the East Coast into New Jersey and New York.

Some NYH terminals were badly damaged, but others were able to return to full or partial operation using generator power after dock inspections, underwater surveys, and electrical equipment replacement was completed. As terminals began operating, the Colonial Pipeline was able to normalize product flows into the NYH terminals, although the recovery has not been smooth. For example, after commercial power had been restored to terminals and pipelines in the area, Colonial Pipeline and several terminals lost power a second time as utilities struggled to repair the commercial power infrastructure.

As of November 13, neither the Phillips 66 Bayway Refinery nor the Hess Port Reading refinery was operating, although the Hess refinery has more recently begun to operate, and Phillips has reported plans to be partially operational late this month. As of November 13, most of the terminals in the NYH area had returned to at least partial operations, but some are still impaired. Damage to electrical and other infrastructure inside several terminals was significant and repairs continue. In addition, damage to barge and tanker dock facilities has been limiting waterborne receipts and shipments. Terminals representing 98% of storage capacity in the NYH area voluntarily reported information provided in Tables 1 and 2.

Table 1. Summary of product flows

(thousand barrels per day except as noted)

	Receipts (Inflows)			Deliveries (Outflows)		
	Pre-Storm	**Post-Storm Nov 7-13 Average**	**Post-Storm Percent of Pre-Storm**	**Pre-Storm**	**Post-Storm Nov 7-13 Average**	**Post-Storm Percent of Pre-Storm**
Gasoline	941	597	63%	838	605	72%
Distillate	281	184	65%	317	176	56%
Other (Jet, Ethanol)	197	136	69%	192	38	20%
Total	1,419	917	65%	1347	819	61%

Table 2. Summary of flows by transportation mode

(thousand barrels per day except as noted)

	Receipts (Inflows)			Deliveries (Outflows)		
	Pre-Storm	**Post-Storm Nov 7-13 Average**	**Post-Storm Percent of Pre-Storm**	**Pre-Storm**	**Post-Storm Nov 7-13 Average**	**Post-Storm Percent of Pre-Storm**
Tanker/Barge	523	307	59%	563	253	45%
Pipeline	753	573	76%	346	179	52%
Truck	12	7	58%	438	387	88%
Other	131	31	24%	0	0	0%
Total	1,419	918	65%	1,347	819	61%

The tables show about 1.4 million barrels of product movement through these terminals, but that number may include double counting of movements between some of the terminals. The data are very preliminary, and represent terminal operators' best information at the time. However, both the pre-storm and post-storm data were collected using the same methodology and, as a result, the data sets should be comparable and indicative of the change in product flows.

It is important to point out areas normally served by the NYH terminals were also receiving some supplies through more distant terminals as the industry pursued workarounds to meet consumer needs to the best of their ability. For this reason, the difference between the pre-storm and post-storm outflows from the NYH terminals is likely to overstate the impact on total product supplies available to consumers usually supplied through those terminals.

The data in Table 1 indicate some significant declines in ability to move product through the NYH hub. Gasoline is the major product moving through these terminals. After the storm, the terminals were receiving only 63% of the gasoline that they had been receiving before the storm, but were sending out 72% of the pre-storm volumes. Note that pre-storm gasoline outflows were less than inflows, implying inventory building of that product. But after the storm, outflows and inflows were fairly close.

Barge shipments have been most impacted by the storm. As shown on Table 2, as of November 13, barge shipments of all products were running at 45% of pre-storm levels. Barge shipments of gasoline were running at 54% of pre-storm levels and distillate shipments were even lower, only 46% of pre-storm barge shipments. These data are indicative of the storm damage to dock facilities and time required to repair the facilities and return them to normal service.

EIA also collected data from tanker truck loading facilities (truck racks) at the terminals in the New York Harbor area. These truck racks supply gasoline and distillate that is delivered to retail outlets and distributors in the New York metropolitan area. By November 13, truck rack loadings of gasoline at these terminals had reached 90% of pre-storm levels and distillate loadings were 104% of pre-storm levels.

Some companies also reported inventories both before the hurricane and as of November 13. By November 13, inventory levels at the reporting terminals had returned to normal levels.

NYS 2100 COMMISSION

Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure

Overview

Unlike many of the capital assets that sustain civic life, energy infrastructure is not one that most people notice. Catastrophes like Superstorm Sandy confront citizens with the importance of these assets by way of their absence. New Yorkers witnessed the result of operational assets strained past their breaking point. New York State must enhance and protect its energy infrastructure to prevent such devastating effects in the future.

New York's electric system is primarily composed of central power generation, transmission, and distribution facilities (Figures E-01 and E-02). Energy is delivered from generators to customers through transmission lines running overhead, underground, and underwater to electric substations. From the substations, distribution lines run to pad- and pole-mounted transformers, and to distribution substations where electricity is finally converted to usable lower voltages. There are also large industrial and commercial building users, and some residential customers who generate electricity on-site.

New York's natural gas is delivered to customers (residential, commercial, industrial, and municipal) utilizing an extensive pipeline network that extends beyond New York through the United States and Canada. Gas that is brought in

The following recommendations will help the State achieve its goal of a more resilient and future-ready energy system:

1. **Strengthen critical energy infrastructure.** Securing critical infrastructure should be a primary focus. Strategies of protection, include among other things, selective undergrounding of electric lines, elevation of susceptible infrastructure such as substations, secure locations of future power plants, hardening key fuel distribution terminals, and reexamination of critical component locations to identify those most prone to damage by shocks or stresses. Creating a long-term capital stock of critical equipment throughout the region provides an efficient system of distribution to streamline the delivery and recovery processes.

2. **Accelerate the modernization of the electrical system and improve flexibility.** As utilities replace aging parts of the power system, the State should ensure new technologies are deployed. It is important to immediately invest in new construction, replacement, and upgrades to transition the grid to a flexible system that can respond to future technologies, support clean energy integration, and minimize outages during major storms and events. The grid for the 21st century should seamlessly incorporate distributed generation, microgrids, and plug-in electric vehicles (PEVs).

3. **Design rate structures and create incentives to encourage distributed generation and smart grid investments.** The State should implement new technologies and system improvements to provide effective backup power, flexibility, distributed generation, and solutions for "islanding" vulnerable parts of the system. In addition to improving the resilience and stability of energy, electricity, and fuel supply systems, these solutions promote energy conservation, efficiency, and consumer demand response.

4. **Diversify fuel supply, reduce demand for energy, and create redundancies.** Lowering GHG emissions in the power sector through the Regional Greenhouse Gas Initiative (RGGI) will contribute to reducing the impacts of climate change over the very long term. To build on the success of RGGI, the State should encourage alternative fuel sources such as biogas, liquefied natural gas (LNG), and solar heating in transportation and other sectors. PEVs, energy storage systems, and on-site fuel storage where feasible, should also be used to provide new energy storage mechanisms. Incentive programs to promote energy efficiency and renewable energy deployment should be strengthened to increase the level of private sector investment in this space.

5. **Develop long-term career training and a skilled energy workforce.** The utility workforce is aging and tremendous expertise will be lost in the next several years. Workforce development strategies should ensure the availability of skilled professionals to maintain a state of good repair, effectively prepare for and respond to emergencies, and deploy and maintain advanced technologies.

Superstorm Sandy

The destructive forces of Superstorm Sandy exposed vulnerabilities in New York's energy infrastructure, including the electric, natural gas, steam, and fuel distribution systems. Sandy severely affected the electric system in New York, leaving 2.1 million residents and businesses without power statewide. In some regions of the state, power was not restored for two weeks or more. Long Island's electrical system experienced widespread devastation and outages of record number and duration — 90% of Long Island's electric customers experienced outages.[2] Superstorm Sandy led to the loss of power for over 1 million of Con Edison's 3.3 million customers. The storm was five times more destructive than any storm Con Edison has endured in recent history (including Hurricane Irene in 2011).[3] Many of the power plants, substations, and other electric system infrastructure in the downstate region of New York are clustered in or near coastal areas, making them vulnerable to the type of flooding encountered during this most recent disaster. The steam distribution system also experienced outages and damage from flooding, as the underground pipes and tunnels were not equipped to manage the large volume of water associated with major storm events.

In Manhattan, a power outage lasting five days below 39th Street caused some to proclaim an entirely new neighborhood: "SoPo," or "South of Power." There was tremendous frustration as the power restorations did not come quickly. This lag created an added danger as the temperatures dropped. Many businesses were unable to resume operations for weeks. Backup diesel generators rolled in as reports indicated that power restoration would take weeks for some of the most affected buildings in downtown Manhattan. The loss of heat and electricity in this area caused many commercial and residential tenants to break leases in their buildings and relocate permanently.[4]

The impacts of Sandy also exposed the fact that the natural gas and fuel distribution systems require improvement in order to better survive natural disasters. Though the natural gas system is considered to be more resilient to disasters because it tends to continue to function during outages in the electric grid, the system is still vulnerable to uprooted trees damaging underground pipes and flooding compressor stations. Sandy significantly affected the fuel distribution network in New York, which includes fuel for transportation, power generation, and heating. The fuel distribution supply chain comprises an interconnected collection of pipelines, hubs, terminals, refineries, marine supply, and service stations. As a result of the storm, a breakdown in this supply chain created gasoline shortages across the region and resulted in widespread impacts both on those responding to the emergency and residents attempting to recover from it.

For the first time since the 1970s, gasoline rationing took place in New York City and Long Island. New Yorkers were left waiting for hours to fill up their cars and gas cans. New York was ill-prepared for such massive destruction to energy and infrastructure, and the State has much work to do to prepare for the next major event.

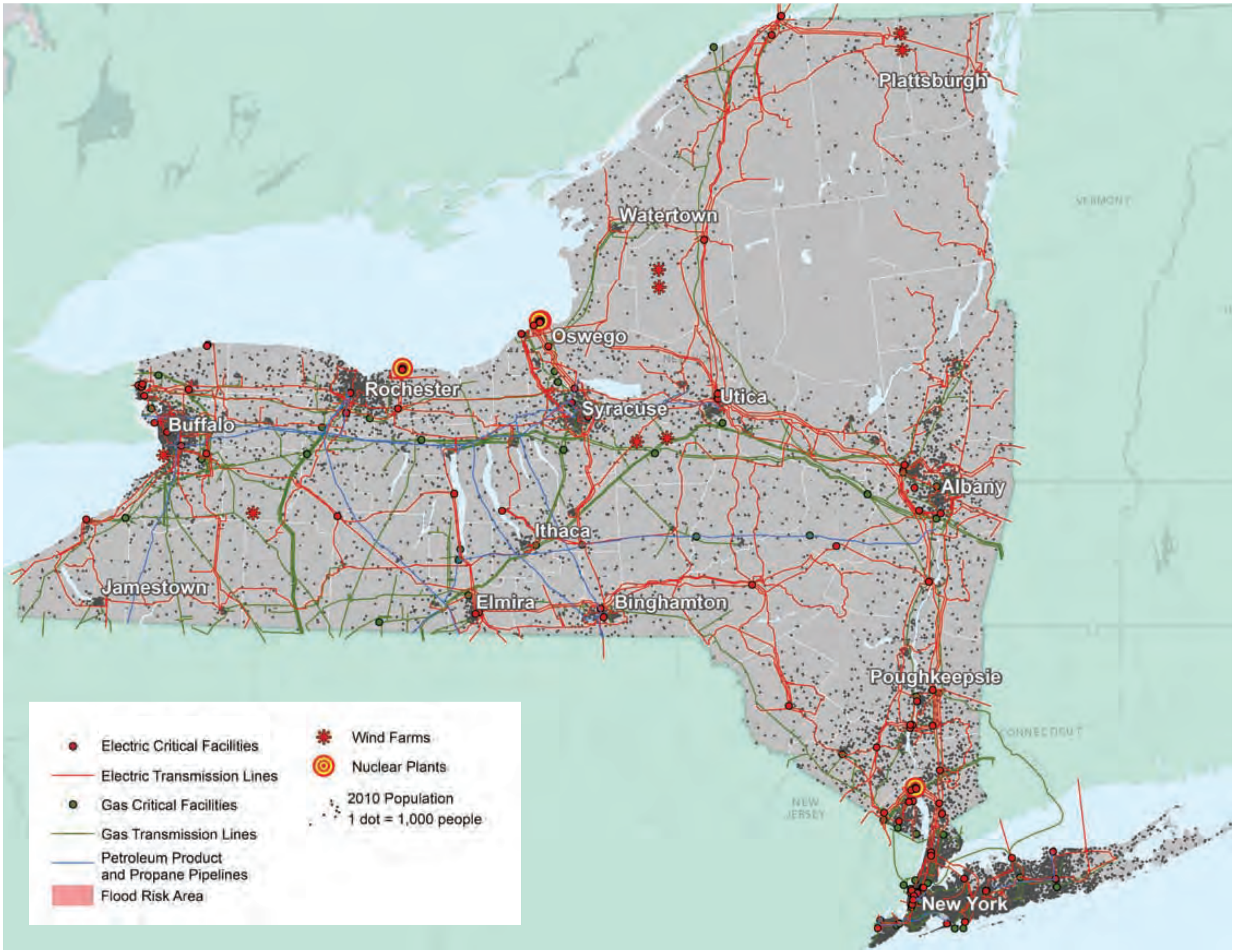


Figure E-01: New York Energy Network (State of New York, 2012)

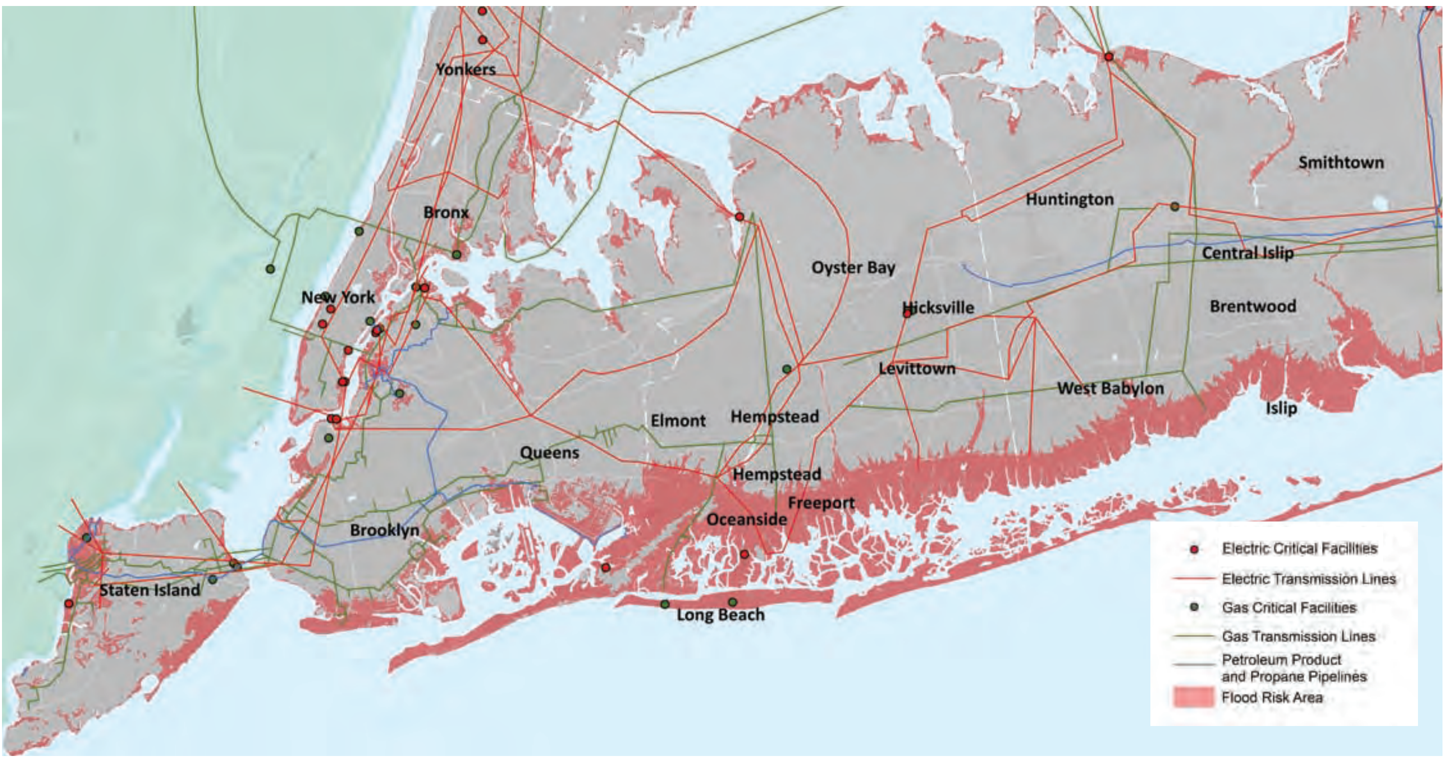


Figure E-02: New York Energy Network (State of New York, 2012) from out of state is delivered directly from the interstate pipeline to large industrial and electric power generation stations, or routed to local distribution companies serving residential, commercial, and midsize industrial customers. Fuels like gasoline, diesel, and heating oil are delivered via interstate pipelines, ship, rail, and truck to be stored in terminals, typically located along the coast. Refineries in New Jersey receive crude oil by ocean tanker, barge, and railcar. The manufactured petroleum fuel products then make their way into the region's supply distribution.

New York City relies on steam that comes from a distributed system managed by Consolidated Edison Company of New York (Con Edison) in Manhattan. The steam is generated in central plants and distributed through portions of Manhattan in insulated underground pipes. Campuses and research facilities across the state also rely on local steam infrastructure.

While the state's energy infrastructure was built to withstand 100-year weather events, Superstorm Sandy, Hurricane Irene (2011), and Tropical Storm Lee (2011) demonstrated that the system was improperly prepared for the increasing number and degree of extreme weather events.

In order to make today's energy infrastructure more resilient, New York State must rebuild and plan for the demands of the coming century. There is an emerging scientific consensus that storms like Superstorm Sandy will become more frequent in the near future. A more resilient energy infrastructure is more critical than ever. The Commission envisions a profound transition for New York State over the next century to an energy system that is at once affordable, efficient, resilient to natural and man-made disasters, responsive to the needs of its stakeholders, and largely decarbonized. Our technologically advanced society is ever more dependent on a reliable and resilient energy system to ensure public safety and to power our economy.

The energy system in place today, which is heavily dependent on fossil fuels, contributes to worldwide emissions of carbon dioxide and methane, two major greenhouse gases (GHGs) in our atmosphere that are contributing to climate change. According to the United Nations Intergovernmental Panel on Climate Change, substantial reductions in GHG emissions by midcentury have the potential to minimize the most severe climate change impacts currently predicted. The strategies we employ to reduce GHG emissions will also provide an opportunity to strengthen infrastructure against future storms.

New York State set a goal to reduce GHG emissions to 80% below the 1990 baseline by the year 2050.[1] Since energy use (in the form of fossil power and gasoline/diesel vehicles) accounts for a majority of GHG emissions in the state, a drastic system transition must take place. As the state shifts away from fossil fuel usage, it should focus on the goals of improving reliability, availability, and resilience.

New York's transition to a new energy system will not happen overnight. Major changes to the energy system can be expensive and disruptive to the economy. Because of this, changes will require a firm commitment to continuous improvement through sustained planning, informed by changing conditions, available technology and data, and robust public engagement and education. Over the short-term, the State should make public investments and induce private-sector support for a stronger, smarter, and more efficient electric grid and more resilient natural gas, steam, and fuel distribution systems. These investments will reduce the negative impacts of extreme weather events like Superstorm Sandy, while laying the foundation for an energy system that in the long-term will mitigate, rather than exacerbate, the threat of climate change.

The Commission has identified a number of recommendations that build on the Governor's Energy Highway Blueprint that will enable New York to develop a resilient energy ecosystem, strengthening critical energy infrastructure; creating alternatives, backups, and redundancies in vulnerable parts of the system; and setting the foundation upon which the energy infrastructure of the future will be built.[a]

Within each of the areas, recommendations include short-term steps based on lessons learned from recent events; medium-term projects that require more extensive planning and development; and long-term solutions that require systemic planning, process refinement, capital budgeting, and large-scale project implementation.

[a] In October 2012, Governor Cuomo's Energy Highway Task Force released the Energy Highway Blueprint with 13 specific recommendations to transform New York's aging, congested energy infrastructure. The recommendations shape a new energy infrastructure that is equipped to support economic growth and to supply reliable, lower cost, and clean power for New York's residents and businesses into the future, including expanding the transmission system to reduce congestion, accelerating investment in the electric and natural gas distribution infrastructure, and investing in new technologies and smart grid programs.

Strengthen critical energy infrastructure

The physical location of critical energy infrastructure should be reexamined to identify installations that are most prone to stress damage. Repairs, upgrades, replacement, and new infrastructure should mitigate the risks associated with climate change. New York State is seeking federal funding assistance for a portfolio of hardening, or strengthening projects. These investments are recommended to prevent future damage that would otherwise be incurred.

For example, New York has identified specific storm hardening projects for which it is seeking federal funding, including the following:

- strengthen substations against flood damage
- reconfigure network boundaries to separate flood areas from non-flood areas
- elevate critical distribution transformer installations
- replace critical distribution wood poles with steel poles or upgrade and harden existing poles (e.g., by installing guy wires)
- install excess flow control valves on the natural gas system
- install remotely operated natural gas control valves
- protect natural gas regulators from floods
- strengthen electric and steam production facilities
- strengthen steam tunnels

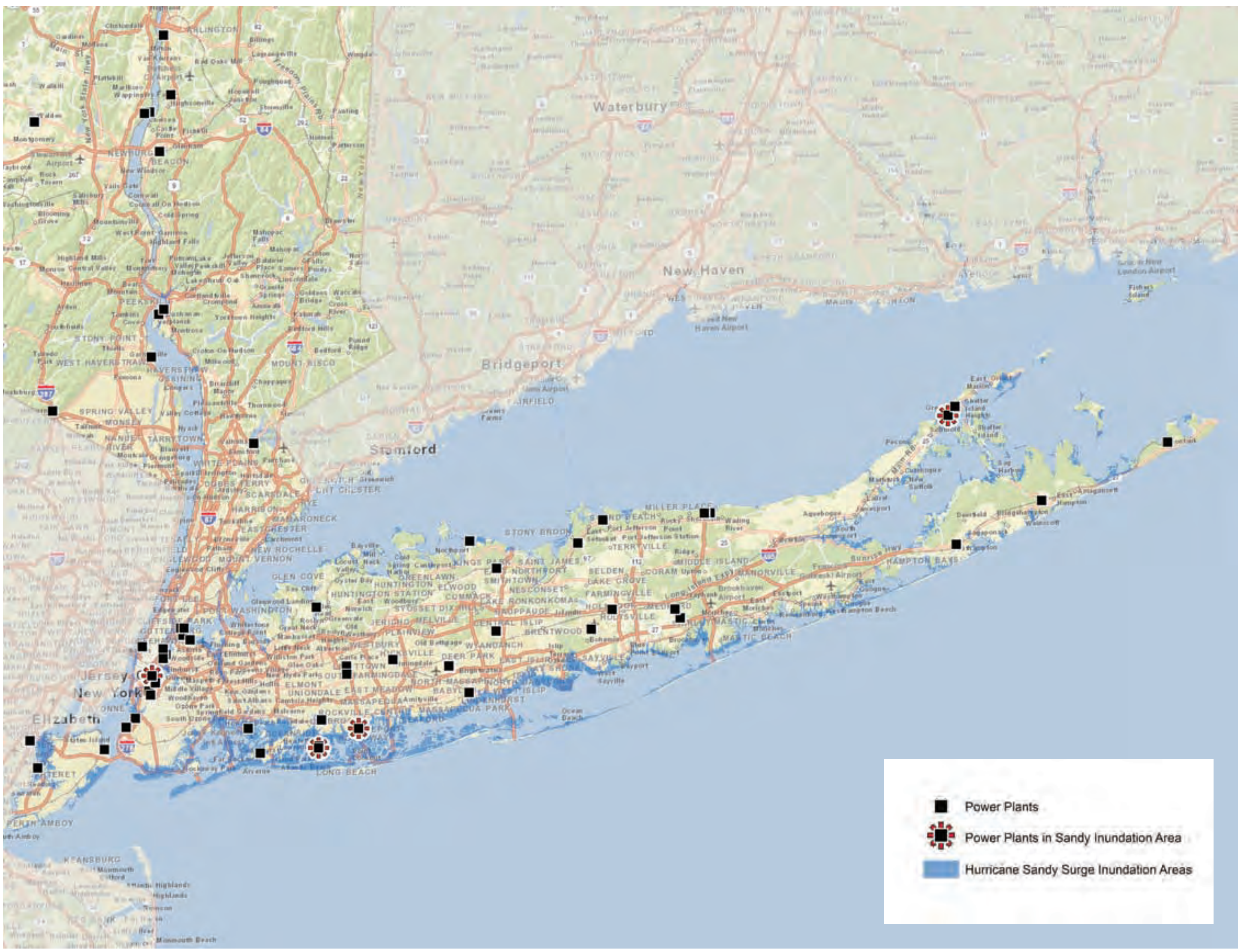


Figure E-03: Downstate power plants in and not in Superstorm Sandy inundation zone (NYSDPS, 2011; FEMA, 2012)

Strengthening these systems will reduce outages and fuel shortages and preserve the everyday quality of life for New Yorkers. While this will come at a considerable cost, and appropriate financing (including federal funding as available) will be needed to make these changes, not acting may be even more expensive due to the potential damage and extensive outages caused by recurring natural disasters. The Public Service Commission (PSC) should continue to work with utilities to coordinate the assessment and cost estimates of, and plans to address, these critical infrastructure improvements. In addition, the State should work with owners of the fuel supply and distribution system to identify opportunities for fuel system infrastructure improvements.

Require Plans to strengthen critical infrastructure

In 2013, the State should require public- and investor-owned utilities to provide detailed plans for strengthening existing infrastructure over the next one to three years and longer-term capital plans to continue building a strengthened system. Those plans should include the elements discussed below for the specific service areas covered.

Protect underground equipment and substations

Underground structures that house electric equipment and utility vaults are susceptible to sea water flooding. Saltwater can be more damaging than fresh water because of its corrosive effects. Many substations are located in flood zones (Figure E-05) including those flooded by Superstorm Sandy. Disruption of service to even one substation can affect thousands of customers. Expanced use of submersible switches and transformers should be considered in flood-prone areas and relocation of transformers considered in areas at risk for saltwater intrusion.

Figure E-04: Flooded substation (Flickr, FirstEnergy Corp, 2012)

Identify best underground locations for electrical transmission and distribution lines

Installing electric distribution lines and equipment underground can reduce the potential for damage caused by high winds, debris, impact, and lightning strikes. Placing equipment underground can also improve land use aesthetics and free up land for additional use. Because undergrounding can be cost-prohibitive, it may be more effective to employ it only for portions of a circuit that are difficult to access or particularly vulnerable. The PSC should require utilities to identify the best locations for undergrounding within the next six to twelve months, and work with utilities to devise workable plans to implement undergrounding in such areas.

Critical distribution lines that service areas affected by natural disasters should be considered a top priority for selective undergrounding.

Experience and best practices from other countries should be used as a reference when developing the policy and regulatory measures necessary to implement these recommendations. For example, Germany, Denmark, and France have each passed legislation or regulations to increase the proportion of undergrounded power lines on their systems. Western Australia has been implementing a comprehensive undergrounding program over the past 15 years. A recent review by the Economic Regulation Authority of Western Australia demonstrates the benefits achieved have outweighed the costs in that country.[5]

Protect transmission and distribution lines

To mitigate against damage to transmission and distribution power lines from snow and ice, hydrophobic coatings should be applied to appropriate components of the electric system as lines are replaced, installed new, or upgraded. By helping components shed precipitation these coatings mitigate water damage on non-ceramic insulators and can facilitate ice removal, thereby preventing outages from occurring.

Reconfigure electric system for critical infrastructure customers

Following Superstorm Sandy, the interconnectedness of our electric, telecom, natural gas, transportation, health care, and fuel delivery systems was made apparent. Marine terminals, telecom services, hospitals, and mass transit were all affected by the power outages. Loss of power to these critical assets disrupts other critical services to society. For example, following Superstorm Sandy, fuel terminals in the New York metro region were without grid power for days and in some cases more than one week. Delays in interconnecting back-up power at these sites, and in some cases technical problems with the back-up generators, significantly disrupted gasoline and other fuel deliveries. This led to a temporary fuel shortage and the imposition of fuel rationing for the first time since the 1970s. Damage to transformers and substations can cause power outages to thousands of customers, and take significant time to repair. In these instances, mobile

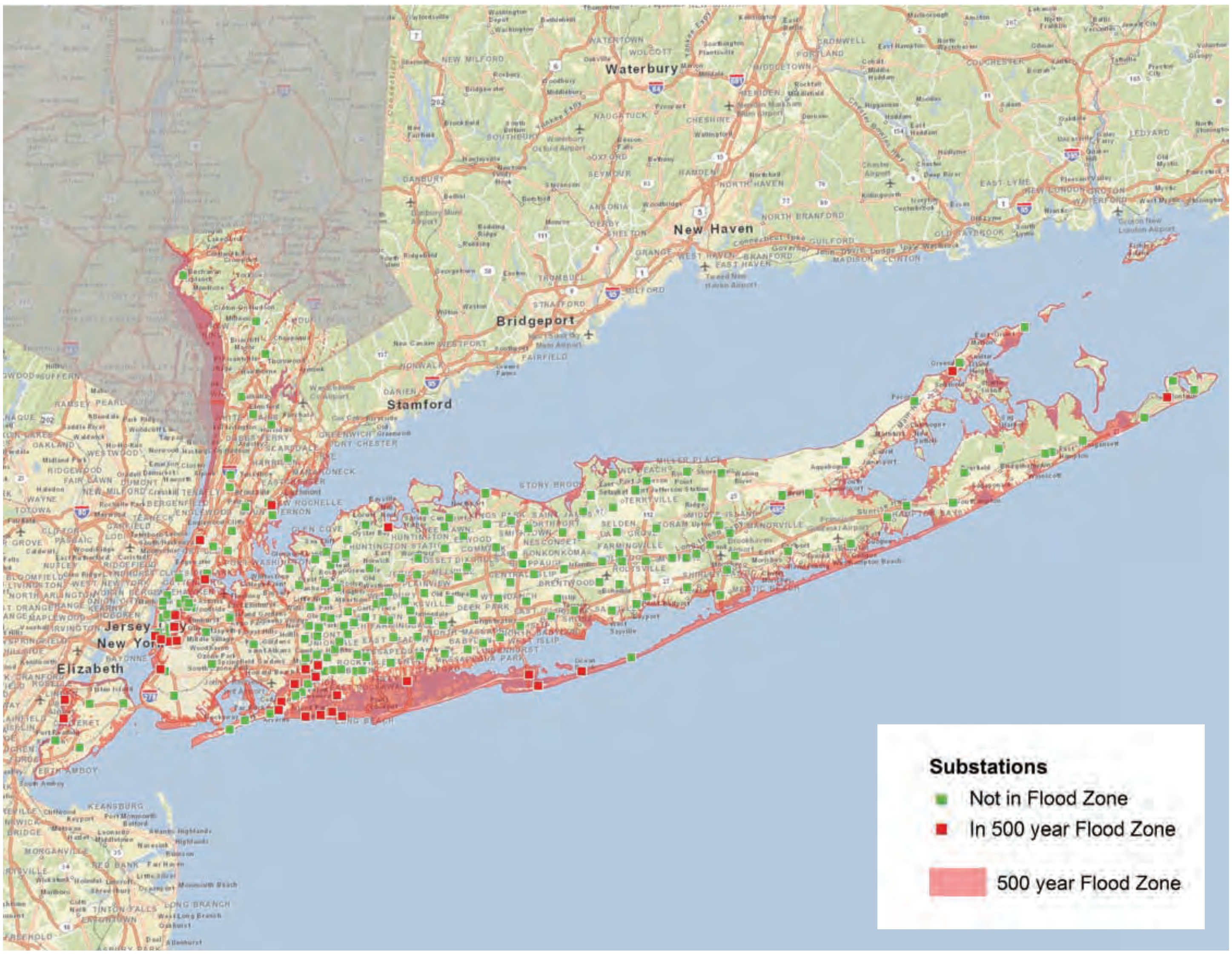


Figure E-05: Downstate substations in 500 year flood zone (NYSDPS, 2012; NYSDEC, 2012)

Figure E-06: A hard-to-reach distribution circuit that could be a candidate for selective undergrounding (NYPA, 2012)

Figure E-07: A Seattle City Light project as an example of selective undergrounding of a power line with frequent outages (City of Seattle, 2012)

transformers and substations could be rapidly deployed to replace the damaged equipment and provide temporary power to the affected customers. In many cases, however, such mobile solutions cannot be used because the grid has not been configured to allow it. Utilities should work to reconfigure their distribution systems to the extent feasible to maximize their ability to isolate and provide redundant (and mobile) power sources to critical infrastructure customers to minimize the impact of such outages.

Strengthen marine terminals and relocate key fuel-related infrastructure to higher elevations

In many areas of the State including New York Harbor, the Hudson River, and the Great Lakes, fuels are transported by barge to marine terminals (Figure E-09) and then distributed by truck to customers. Marine terminals are particularly vulnerable because of their location to storm surges and flooding. Dock supports and structures, moorings, loading and off-loading equipment, and leak containment equipment all require flood protection. In 2013, New York State Energy Research and Development Authority (NYSERDA) should lead an assessment of these structures in collaboration with asset owners, government authorities (e.g., port authorities, Coast Guard), and other experts to document existing risks and help prioritize mitigation strategies.

Refineries and distribution/delivery terminals also must be hardened or otherwise protected. Installing, upgrading, or raising existing floodwalls could help protect such facilities from corrosive saltwater. Control stations, crucial electronic equipment and instruments, and communication equipment may need to be elevated or relocated in these facilities to reduce the risk of service interruption. In certain cases, elevating or relocating key facilities serving critical loads for petroleum assets may be necessary

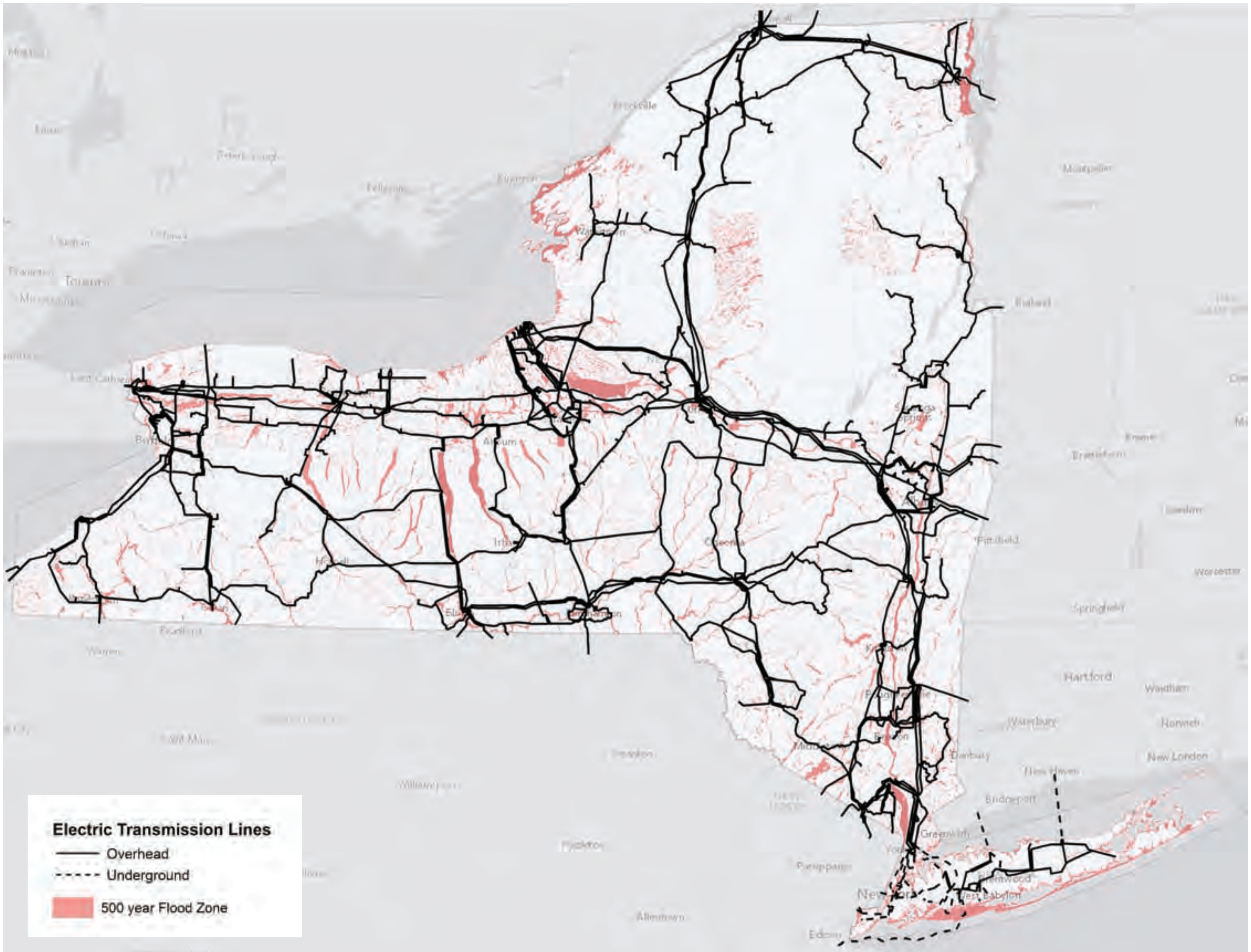


Figure E-08: New York State transmission lines and 500 year flood zone (NYISO, NYSDPS 2010; NYSDEC, 2012)

to minimize disaster impacts and accelerate restoration of fuel asset operations.

Reinforce natural gas distribution infrastructure

Many parts of New York's natural gas infrastructure (Figure E-08) have been in use for nearly two centuries. Miles of aging pipeline are prone to leakage and vulnerable to storm damage (and ground movement). Natural gas utilities have established programs to replace older, cast-iron portions of their systems that are prone to leakage (Figure E-09), but the programs cannot keep pace with the need. The State should accelerate pipeline replacement programs in flood prone areas. Further, the installation of remotely operated valves would enhance network resilience by allowing the rapid isolation of leaks and, consequently, service restoration. This is consistent with recent actions recommended in the Energy Highway Blueprint to accelerate improvements to the natural gas distribution system.

Natural gas compressor stations are another vulnerable asset. Compressor stations require gas turbines, reciprocating engines or electric motors to compress natural gas and move it through the pipeline. Importantly, these components of the natural gas distribution infrastructure enable the system to continue functioning during electric power outages, but all of these components can fail if inundated by flood waters. Reinforcing natural gas driven compressors can help to ensure continued natural gas delivery during power outages

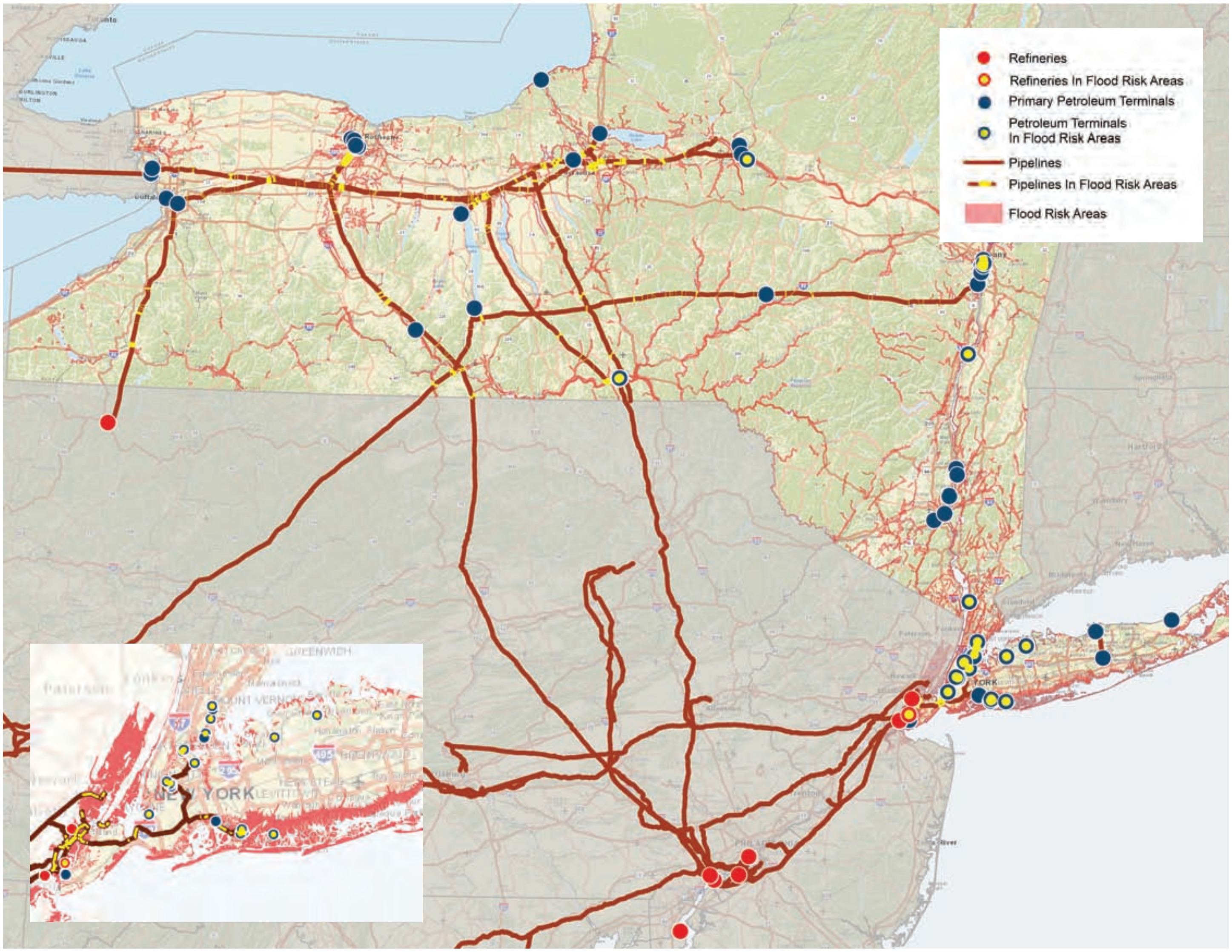


Figure E-09: Map of regional liquid fuel terminals and refineries and 500 year flood zones (NYSERDA, DOS, NYSDEC & FEMA, 2012)

and reduce fugitive methane leaks during normal operations. The PSC should require natural gas utilities to evaluate their infrastructure and prepare plans for strengthening these critical systems. This should involve annual review and development of design criteria for the natural gas network, including analysis of incidents, progress and priorities of gas supply providers.

Reinforce electrical supply to fuel infrastructure and pursue additional booster stations for the Buckeye pipeline

Petroleum products arrive into New York City and Long Island by barge, truck, and pipeline. The Buckeye Pipeline is the primary petroleum pipeline directly serving New York City and Long Island. Sustained delivery of power to key fuel supply and delivery assets is imperative to operation of the Buckeye Linden Hub (Figure E-10) and other critical assets that serve New York State with petroleum products. Because these critical assets are located across the New York Harbor, the Commission recommends that utilities such as Public Service Electric and Gas (PSE&G), Long Island Power Authority (LIPA), Con Edison, and other providers collaborate with petroleum supply chain asset owners, and New York and New Jersey agencies (e.g. New York Power Authority (NYPA), New York State Department of Transportation (NYSDOT), the New York

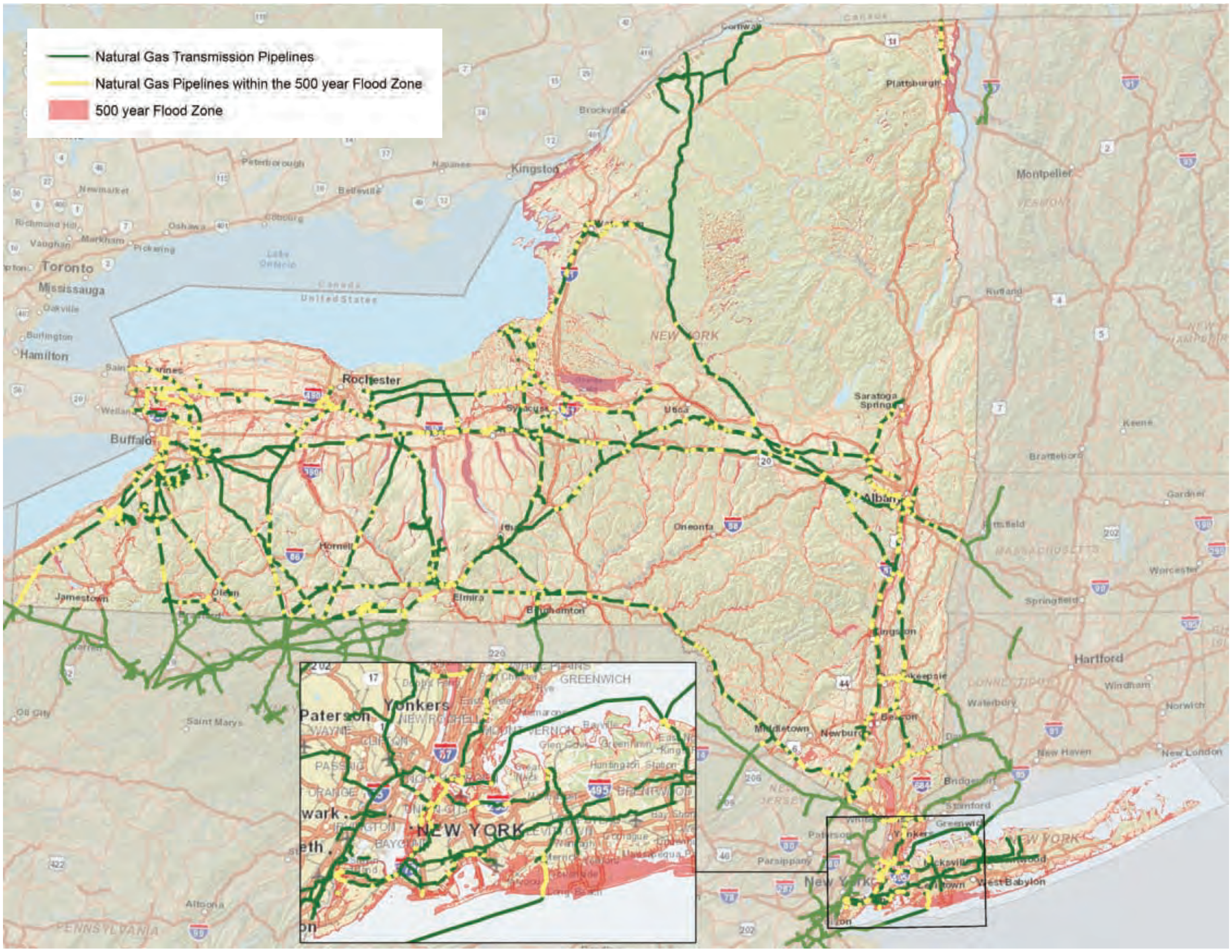


Figure E-10: New York State natural gas transmission pipelines and 500 year flood zone (National Pipeline Mapping System, 2010; NYSDEC, 2012)

Department of Homeland Security, and NYSERDA to assess vulnerable substations and transmission lines supporting New York State fuel infrastructure by the end of 2013. The Buckeye Linden Hub (and other fuel hubs) could be potential locations for distributed generation which could be used to maintain supply. Any assessment should focus on identification of potential locations for distributed generation and/or micro-grid opportunities to keep the power systems operating and maintaining fuel flows through the system.

Fuel supplies following a major event are critical, especially for emergency operations and first responders. As discussed in the NYS Ready Commission Report, New York should pursue procurement of additional fuel supplies into congested areas, and install the necessary infrastructure to ensure fuel shortages can be alleviated. While pipeline capacity is typically the most efficient method to deliver fuel following a major storm – Buckeye's pipelines are utilized at near full capacity to serve New York City and Long Island demand. When delivery of fuel over this pipeline network is disrupted as was the case following Superstorm Sandy, there is no additional capacity on the pipeline to help replenish supplies while keeping up with continuing demand. Buckeye has proposed to install a booster station that would increase the capacity of the lines servicing New York City and Long Island.

New York should support the addition of booster stations in New York City on the Buckeye pipeline, which would significantly increase capacity during emergency events and reduce impacts of fuel delivery disruptions.

Waterproof and improve pump-out ability of steam tunnels

Steam systems provide energy to campuses and buildings that is used for heat, hot water, air conditioning (running steam-driven compressors), and other industrial processes. Steam systems are typically installed in underground pipes that are especially vulnerable to flooding, which can cause the steam to condense to water and create a dangerous condition known as water hammer. Major steam systems such as the Con Edison steam system, must be protected from disaster events to provide necessary heating and cooling. Flood protection measures could include water-proofing tunnels, improving pump-out ability, building higher flood walls around steam generating stations, relocating critical equipment to higher elevations, installing flood pumps, and installing or improving protective barriers around facilities. The

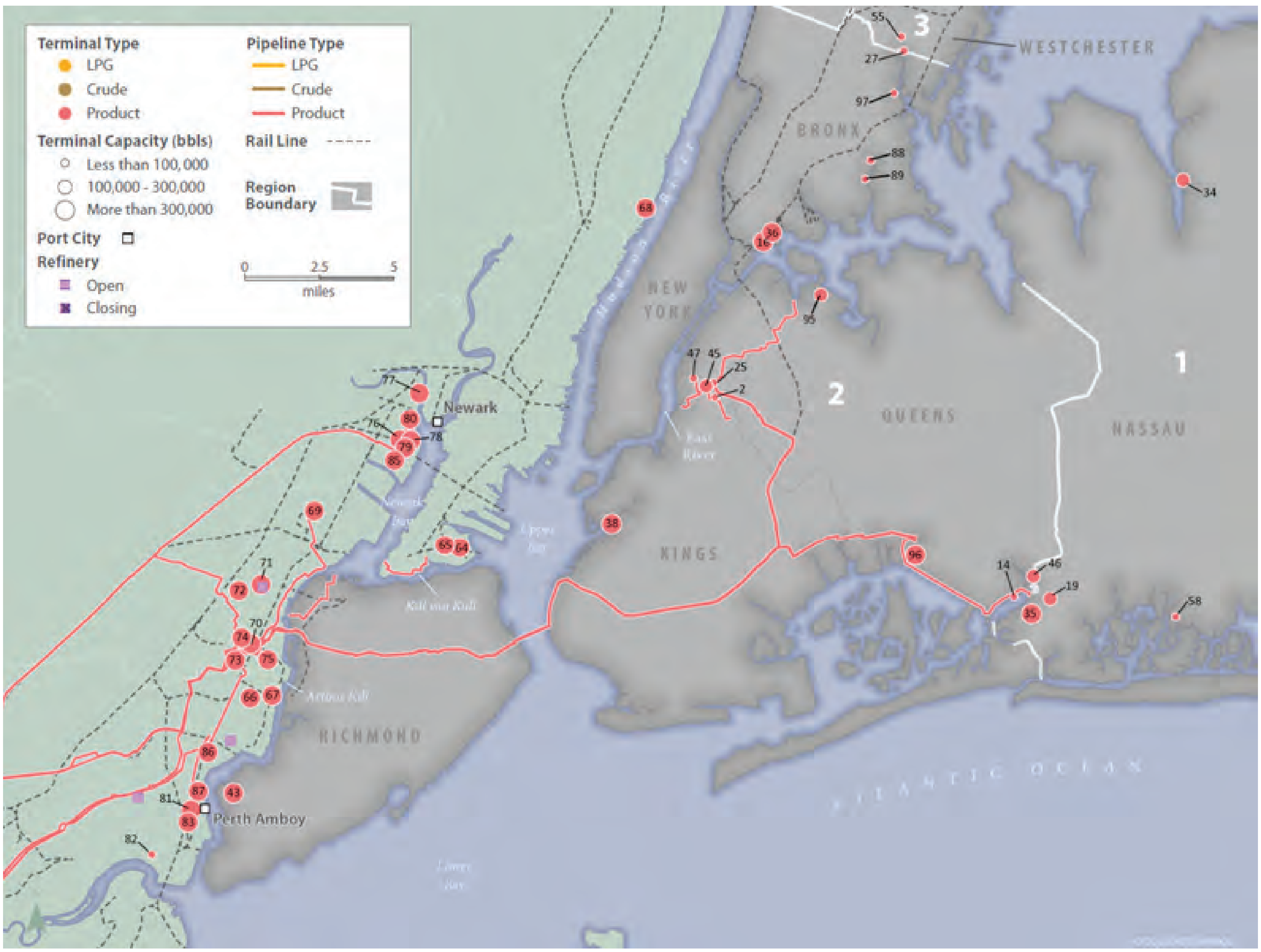
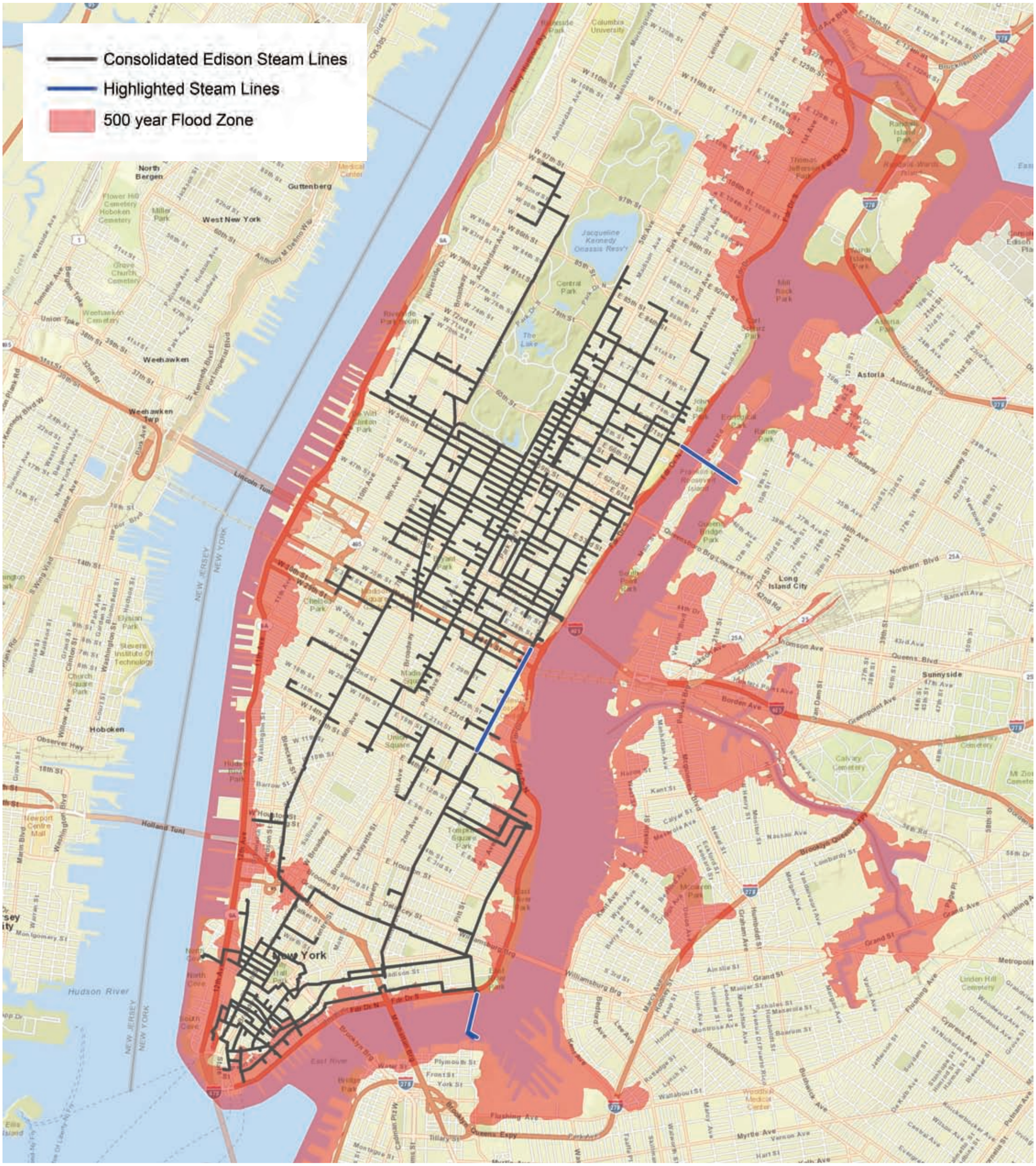


Figure E-11: Buckeye pipeline and fuel terminal which serves New York State with petroleum products (NYSERDA/ICF International, 2012; OPIS/Stalsby Petroleum Terminal Encyclopedia 2012, U.S. IRS xStars Database, 2012)

Figure E-12 (following page): Map of New York City Con Edison steam lines and 500 year flood zones (critical tunnels highlighted in blue) (Consolidated Edison, 2009)


Consolidated Edison Steam Lines
Highlighted Steam Lines
500 year Flood Zone

PSC should require Con Edison to submit a detailed plan to improve flood protection in critical steam tunnels (Figure E-11).

Create a long-term capital stock of critical equipment among utilities

Many utilities rely on a relatively small number of equipment suppliers for critical parts. Individual utilities are capable of managing equipment inventories and supply chains, but highly specialized equipment, such as extra-high-voltage transformers, require months to manufacture and are difficult to transport. This limits the ability of utilities to maintain spares which, if purchased, are often located in vulnerable areas.[6] A large event may introduce outages across multiple regions, causing supply chain or transportation interruptions. These interdependencies can lead to cascading failures that indefinitely extend recovery efforts.[7]

Following a disaster, the need for rapid response may result in regional or local shortages of critical equipment.[8] In addition, a robust stock of critical equipment will also reduce the potential for misalignment of available equipment among utilities and streamline the delivery process.

The PSC, New York Independent System Operator (NYISO), and utilities should establish this inventory and coordinated distribution plan by the end of 2013, as well as set-up periodic training sessions for employees for its use.

Surplus inventory maintained by individual utilities depends on capital budgets and available storage space. A shared stock of spare equipment, managed by a universally accessible database, spreads investment across the Region's utility providers, and creates access that would otherwise be unavailable or vulnerable to damage.

As improvements are made to local systems, spare components can be used to upgrade outdated equipment in vulnerable areas. These inventories should be protected in place, and never be located in proximity to the components they are intended to replace to avoid extending exposure during an event.

Accelerate the modernization of the electric system and improve flexibility

Today's power system relies heavily on central power generation plants, primarily powered by fossil fuels, nuclear, and hydroelectric sources based in New York (Figure E-12). Power flows almost exclusively in one direction, from power plant to customer. Beyond this, small distributed generators are used in limited applications, primarily for emergency power during grid outages. Much of the distribution grid today employs a system design developed decades ago, and does not incorporate recent technological advances. The system is largely static and not designed to allow for quick reconfiguration to redirect power along alternate routes when damage occurs to the primary sources of power supply in the distribution system.

New York's grid is aging — 59% of the state's generating capacity and 84% of transmission facilities were put into operation before 1980, and over 40% of the state's transmission lines will require replacement within the next 30 years, at an estimated cost of $25 billion.[9] This need represents an opportunity to upgrade the transmission system to a more distributed smart grid network.

Investments should be made to transition the electric grid to a dynamic and flexible system that allows for future technologies, additional clean energy integration, and minimal outages during major storms and events. New designs should not be dependent on specific technologies and should instead be flexible to be able to incorporate new devices as products are developed.

The PSC has previously ordered the electric utilities in New York to make smart grid investments starting at the transmission system level, pursuing investments with an incremental approach. The rationale for this relatively conservative approach is to minimize ratepayer costs and to ensure large investments are not made in technologies that may become obsolete. However, in light of recent extreme weather events, the PSC should review whether readily available smart grid technology could have reduced outages or improved power restoration and communications with customers, and reevaluate and prioritize utility investments in smart grid technology accordingly. The State should build on the existing PSC order and accelerate investments that offer the dual benefit of storm-strengthening and improved outage management while also implementing a smarter, more flexible system that better integrates distributed generation and improves communication flow between the utility and their customers.

Vision of the electric system operation

The modern electric power system must be a dynamic and flexible network that draws from constantly changing sources of electric energy. A smart grid is a dynamic electrical grid consisting of generation and consumption equipment interacting together to meet the loads on the grid efficiently. Enhanced sensors and controls give grid operators more visibility into the behaviors of electricity consumers, provide consumers a level of understanding of their energy usage, and enable the deployment of distributed generation, energy storage, and demand response. For instance, during times of peak load, a smart grid can automatically shut-down or temper high energy use appliances in homes and businesses. If utilities charge prices that vary by time-of-use, reflecting the actual cost of energy production in real-time, coupled with advanced metering, the system efficiency will increase by reducing peak demand (thereby reducing the need to build costly infrastructure to meet peak demand). Under such a rate design, consumers can shift loads to periods of low demand and pay a lower price for electricity which, in turn, will have a system-wide effect of leveling total demand on the system over time. To increase customer acceptance of these options, the choice of several alternative tariff structures can be offered.

Numerous jobs will also be created through the implementation, operation, and maintenance of smart grid technologies. In addition, the technologies involved in building a smart grid are the focus of extensive research in laboratories such as the Energy Power Research Institute (EPRI).

Operation and control of this increasingly complex and interconnected grid, along with the associated financial transactions of a competitive energy marketplace, will require significant changes to the static nature of today's power system. Smart grids will minimize the impacts of future natural disasters on consumers, by helping to enable individual premises and microgrid "islanding" to provide power to pockets of consumers when central power plants or portions of the transmission and distribution system are inoperable. Robust and highly integrated communications and distributed computing infrastructures utilizing a network of sensors will give utilities greater control over grid operations and customers greater control over their own electricity use. The central power plant's role will be diminished and clean microgrids[b] will become more prevalent, allowing small distributed plants to supply homes, buildings, and neighborhoods with power.

Enhanced sensors and controls also enable utilization of distributed generation networks.[c] Utilizing distributed generation resources, or on-site power generation, reduces dependence on the electric distribution system that is susceptible to damage during a natural disaster. To maximize the storm-resiliency benefits of on-site generation, it must be located appropriately and protected against damage during major weather events. Distributed generation resources, such as solar and wind, can also contribute to a cleaner electricity supply. Central power plants should still play a role in meeting energy demand, but proliferation of microgrids

[b] "Microgrids" refers to clusters of homes and buildings that share a local electric power generation and/or energy storage device while disconnected from the utility grid.

[c] "Distributed generation" refers to small electrical power generators installed in homes, businesses, and office buildings that can supply power to a location when grid power is not available.

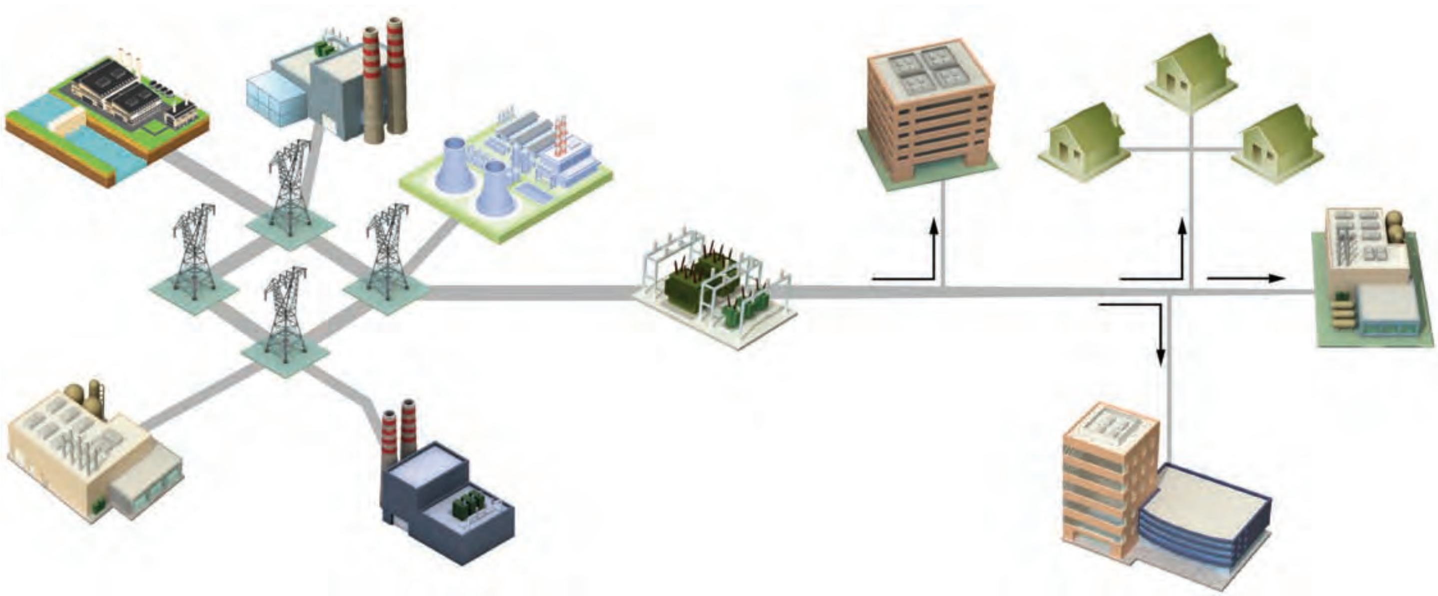


Figure E-13: Today's power system comprised of large central station power generation connected by a high-voltage network or grid to local distributions systems which serve homes, businesses and industry. Electricity flows predominantly in one direction using mechanical controls (EPRI, 2012)[10]

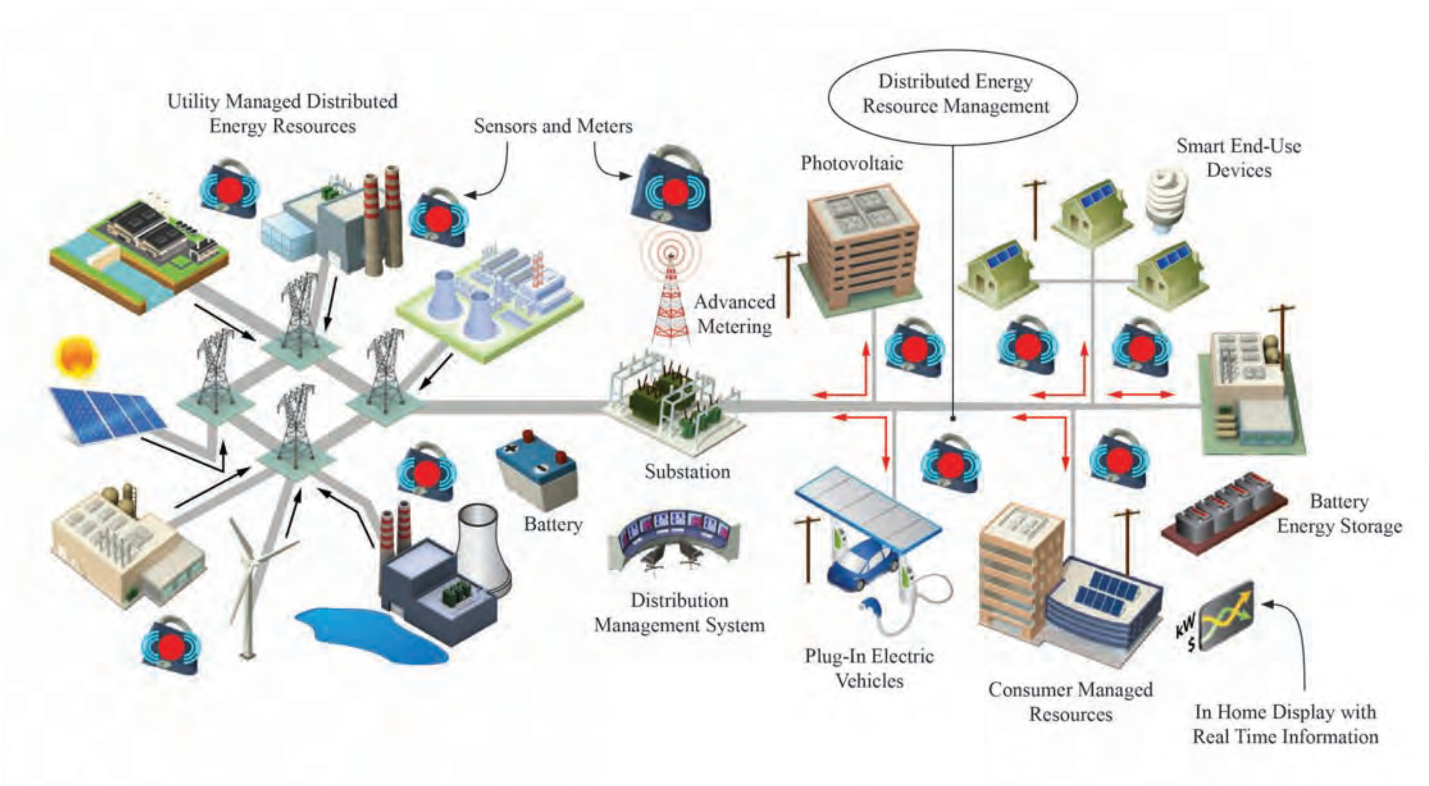


Figure E-14: Tomorrow's power system — the grid of tomorrow enables additional customer-sited clean energy generation and storage, and also provides for two-way communication between customer locations and the utility (EPRI, 2012)[10] can provide resilience through redundancy within the power supply system.

Design a more flexible electric grid to be dynamic and responsive during normal operations and emergencies

The smart grid makes the power system more flexible by employing automatic switching and sectionalizing equipment to reduce the extent and duration of power outages. Such equipment has the capability to automatically redirect power over in-service lines and isolate faulted areas. During Superstorm Sandy, entire neighborhoods were without power. A smart grid with sectionalizing switches and connections to multiple substation supplies would make it possible to restore portions of the neighborhood by using the switches to change power sources. The PSC and utilities should work to incorporate additional automatic switching and sectionalizing of equipment across the grid.

Smart grid technologies should also be used to enable better intelligence regarding the status and availability of electric system equipment, which would improve utility response to equipment and customer outages.

The smart grid includes the following major components:

1. **Distribution Management System (DMS)** – a decision support system for utilities to assist control room and field operating personnel to monitor, control, and optimize the electric distribution system without compromising safety and assets. For example, a modern DMS would enable the utility to identify the precise location of a faulted piece of equipment and mobilize a repair team more quickly to restore service. With many of the DMSs in place today the utility is unable to determine if individual customers are without service unless the outages are caused by a large-scale failure. A modern DMS can be used to provide the utility improved awareness of customer outages, facilitating faster response and restoration.

2. **Distribution Supervisory Control and Data Acquisition (D-SCADA)** – collects and reports voltage levels, current demand, equipment state, operational state, and event logging allowing operators to remotely control capacitor banks, breakers and voltage regulation. For example, the utility can control power flow over its system to prevent overloads before occurring, and in some case remotely correct issues to maintain service.

3. **Automated Metering Infrastructure (AMI) and Meter Data Management** – allows two way communication with smart meters, customer and operational data-bases, and provides customers with the ability to reduce electricity bills by using electricity more efficiently and at selected times when it is cheaper by participating in Demand Response Programs. This will facilitate customers who choose appliances, heating systems, and other technologies that can be programmed to operate based on electricity prices. Additionally, coupled with a Distribution Management System, the increased deployment of smart meters will assist utilities in determining which customers have lost service and inform restoration strategies.

4. **Distributed Energy Resource Management (DERM)** – coordinates with the dispatch of central power stations and the distribution management system to schedule more efficiently demand response and distributed energy resources (distribution-side generation, energy storage, and demand response technologies). Coordinating the timing and need for distributed generation and demand response resources (e.g., during peak demand periods or system outages) increases the value of these resources for end users.

Certain New York utilities are already implementing variations of these systems in their service territories. For example, utilities have been and continue to incorporate distribution automation devices (reclosers, sectionalizers, looping schemes, etc.) on their electrical system to help make the system smarter and responsive to issues and failures, but barriers including cost and customer acceptance of new technologies have been barriers to woider deployment. Each utility will have unique needs and opportunities to deploy smart grid technologies. To encourage greater deployment of these technologies, the PSC should factor in resiliency benefits in cost justifications.

In addition, the PSC, NYPA, NYSERDA, and others should continue to support investments in smart grid technologies such as those called for in the Energy Highway Blueprint. These include the following:

- advancing the Smart Grid in New York by funding demonstration projects, developing an Advanced Energy Management System Control Center and pursuing federal energy research grants;
- ensuring electric utility capital expenditure plans that include cost-effective smart grid technologies; and
- evaluating polices to encourage technological and commercial innovation in New York State to accelerate deployment of new technologies and capitalize on economic development opportunities.

Increase the deployment of distributed generation and microgrids throughout New York

As noted, distributed generation is customer or neighborhood-scale energy generation, which provides power locally to an individual customer or region in a distributed manner. Distributed generation can defer the need for additional utility transmission and distribution system upgrades while improving owner quality

Con Edison CoolNYC Program (New York City, United States)

This project involves working with building owners and tenants in large apartment buildings throughout New York City to install smart air conditioning controls. The goal of the program is to help residential customers use less energy for air conditioning and provide Con Edison a resource to help maintain high reliability during peak load periods. Con Edison plans to install controls through "modlets" on 10,000 air conditioners. This will result in a 5-MW demand reduction, which is enough to power 5,000 homes. Partnering with ThinkEco, a New York City company, Con Edison installed the modlets in the summer of 2012 on window air conditioning units. There are over six million air conditioning units of this type in New York City, and some of them run unnecessarily when residents are not at home. The modlet is a plug-in smart outlet that a smart air conditioning thermostat can control. Customers are able to remotely turn on or off their air conditioning, set its temperature, and set the schedule, from a smart phone or browser. When needed during peak load periods, Con Edison will alert these customers and adjust the unit's temperature to reduce usage.

National Deployment of Smart Meters (United Kingdom)

The United Kingdom has a two-stage national plan for smart meter deployment.[11] The first stage, which is currently in progress, involves collaboration between the government, the energy industry and the public to determine the best method of installing a smart meter in every home by 2020. This first stage allows all relevant stakeholders to be a part of the decision making process before smart meters are deployed across the entire country. The second stage of the plan encompasses the actual roll-out of the meters after all necessary customer engagement has been completed. The UK's two-stage approach is expected to help improve customer acceptance of smart meters while promoting a better understanding of the technology's benefits.

and reliability. Distributed generation can be based on several technologies, including: solar photovoltaic (PV), small wind, small-scale biomass generation, fuel cell, small hydro or small- to medium-sized gas generation providing both electricity and steam or hot water [referred to as combined heat and power (CHP)]. Energy storage (e.g., batteries) can supplement distributed generation networks to ensure continuous delivery of electricity.

Estimates indicate that developing new power generation facilities closer to high-demand areas can save New York in costs associated with constructing new transmission infrastructure as well as transmission congestion costs. Low-end estimates represent avoided fuel, operation and maintenance costs while high-end estimates also include avoided costs from constructing new power plants and upgrading transmission and distribution systems. Switching from central generation to distributed generation lowers operating costs (and potentially eliminates fuel costs) by providing more efficient energy generation. Generally, there is a trade-off between higher capital expenditures with reduced operating expenditures over time compared to paying for energy over time from a centralized grid.

Although distributed generation systems provide a wide range of benefits, all of these benefits are not captured by existing financial models.[12] Therefore, the avoided costs and added value of these systems are likely to be much higher than current estimates.

Expanding use of natural gas for distributed generation and combined heat and power applications will also improve storm resiliency since the natural gas system often continues to operate during major weather events. Notably, such applications will increase demand on the natural gas system, so the interdependency of these systems needs to be considered and system investments should be planned accordingly.

Microgrids are small-scale distribution systems that link and coordinate multiple distributed energy resources (DERs) into a network serving some or all of the energy needs of users located in close proximity. DERs include distributed generation resources, energy storage technologies, and power system control devices. In a microgrid, such DERs are linked together with multiple local energy users by separate distribution facilities (i.e., wires and pipes) and managed with advanced metering infrastructure, communications, and automated control systems.[13] Microgrids can be configured to operate in tandem with the bulk supply system during normal conditions, but also disconnect and operate as an independent island (i.e., "islanding") in the event of a bulk supply failure or emergency.[14] The microgrid is the natural evolution of distributed resources for areas where conventional power systems do not reliably serve customers or where critical customers need uninterrupted power supply during emergencies. Microgrids can also provide support to conventional power systems that are constrained in meeting demand.

To adopt and integrate microgrids and increase deployment of distributed generation into the current electric system, New York needs to create regulatory and statutory clarity and appropriate incentives. Current regulatory frameworks, laws, and compensation systems do not encourage the widespread deployment of such components (and limit them almost exclusively to campus settings). For example, regulations currently require electricity marketer or public utility status in order to be able to sell electricity to others. Appropriate policy and regulatory mechanisms should be developed by the State and the PSC to incentivize the microgrid investments that will allow expedited development and integration of microgrids. Incentives, such as rate-based cost recovery, should be explored to aid microgrid development. The PSC should create straight-forward protocols for interconnection and cost allocation for microgrids and their components.

Determination of responsible parties for microgrid maintenance and upkeep is also necessary to aid adoption and success of microgrid implementation. Accordingly, the PSC should work with utilities to develop protocols for establishing microgrid ownership to ensure the installations are well maintained.[15]

NYSERDA issued a report in 2010 ("Microgrids: An Assessment of the Value, Opportunities, and Barriers to Deployment in New York State"), which included a roadmap for facilitating microgrids in New York State. The recommendations found in that roadmap should be considered when developing statutory and regulatory changes necessary to integrate microgrids into the State's electric system. The PSC should identify and work to reform local utility policies and practices that hinder the development of clean distributed resources, such as requirements that shut down interconnected distributed resources during outages to prevent back-feeding into the grid. Such requirements are meant to protect utility workers when restoring power, but technology exists to allow the system to continue powering the customer during outages without back-feeding to the grid.

NYSERDA should expand its incentive programs for distributed generation resources, including solar and Combined Heat and Power programs. These programs should give preference to critical facilities

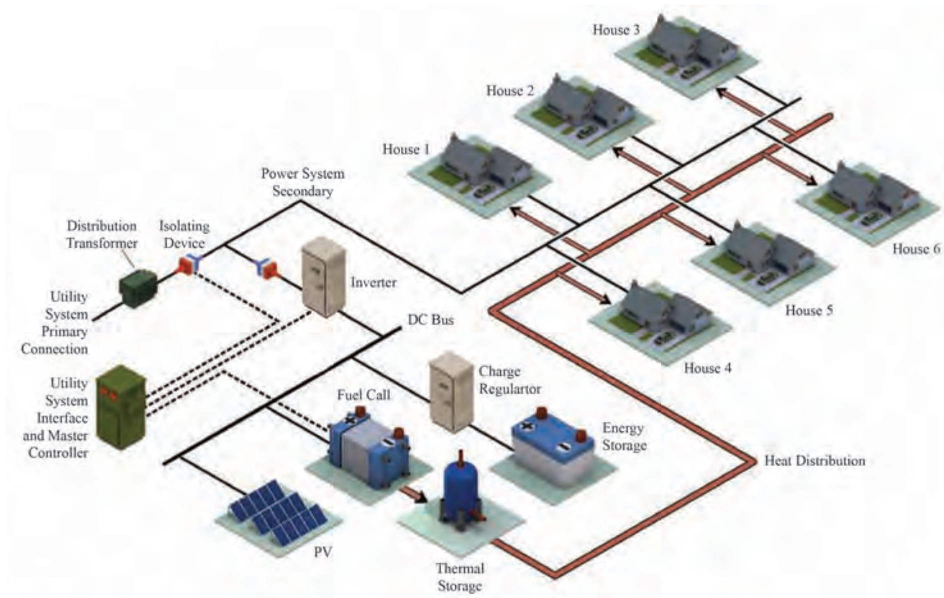


Figure E-15: Community-level microgrid with distributed energy resources (EPRI, 2010)[16]

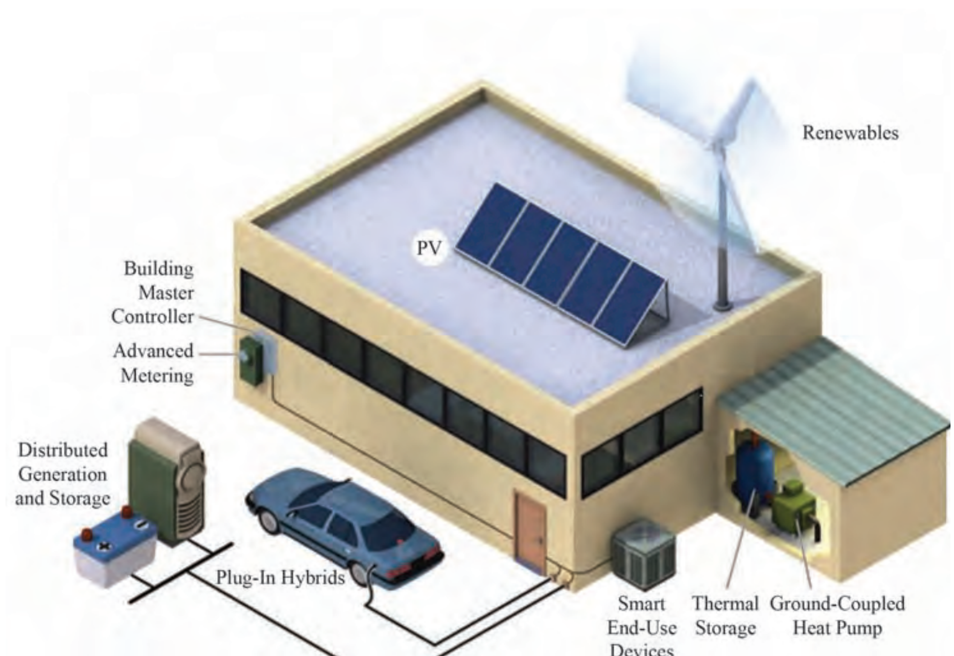


Figure E-16: Building-level microgrid with distributed energy resources (EPRI, 2010)[16]

Drake Landing Solar Community – Solar Hot Water District Energy (Okotoks, Canada)

A new housing development in Okotoks, Alberta, Canada, which started operation in 2007, incorporated a localized district energy system to provide heat to 52 single family homes almost entirely from solar energy. The innovative system stores heat energy captured during the summer in tanks and boreholes underground for use during the winter. A network of underground tubes transfers the captured heat into the surrounding rock and soil, which act as a natural heat storage reservoir. The underground boreholes and tubes are covered with sand, a waterproof membrane and high-density insulation to prevent heat from escaping. The stored heat is then transferred back to the tubes when heat is needed during the cold winter months. Over 90% of the energy used throughout the year comes from solar panels on the houses and garages of the development, decreasing dependence on fossil fuels.[17] Since the system is distributed, with the many components contributing to energy generation, and most of the pipework and tanks underground, it is resilient against weather-related disasters. Although the Drake Landing system is the first in the world to achieve a solar fraction of heating of over 90%, similar community-scale solar energy systems exist in Northern Europe.[18]

Figure E-17: Aerial view of the 52-home Drake Landing Solar Community, 2007 (Natural Resources Canada, 2007. Reproduced with the permission of the Minister of Natural Resources of Canada, 2012)

such as schools, hospitals and municipal buildings that are designated as safe havens during storms. Such facilities should have clean on-site generation designed to operate when the grid goes down. Private facilities, such as big box stores and shopping malls, willing to serve as such sanctuaries, should receive expedited permitting for installing distributed generation systems.

Make the grid electric vehicle ready

Plug-in electric vehicles (PEVs) are battery-powered vehicles that are charged via the electricity grid. According to a recent study by the Rocky Mountain Institute and a number of other partners including the International Energy Agency and C40 cities, New York City is one of the leading cities pursuing electric vehicle integration.[22]

The State (via agencies including the DOT, PSC, NYPA and NYSERDA) and local governments should continue to aid PEV deployment through the promotion of PEV charging installations, consumer incentives and education, and regulatory reform. Electric vehicles provide a benefit to the utility grid when they charge during off-peak times, providing a balancing service. Studies suggest that the integration of smart grid management and electric vehicle energy storage can limit increases in peak electricity loads.[23]

Electric vehicle readiness involves supporting PEV purchases, use, and education through a wide variety of channels. New York State, through NYSERDA, the DOT, and the private sector, should increase its electric vehicle readiness by installing more public and workplace charging stations statewide in areas where PEV users drive. This includes municipal and private parking lots, transit stations and park-and-ride lots, retail and tourist destinations, major travel corridors,

New York University Natural Gas Combined Heat and Power Plant (New York City, United States)

Distributed generation can function well even in the heart of bustling Manhattan. During Superstorm Sandy, when the electricity from Con Edison's distribution network failed, the cogeneration plant installed at New York University (NYU) in 2010 began running full-throttle in "island-mode". Although normally connected to the grid to export and import electricity when needed, the plant switched to microgrid operation. The plant burns natural gas in combined cycle gas turbines to produce both electricity (13.4 MW) and heat. The entire process operates at almost 90% efficiency, compared to 30% to 60% for traditional centralized fossil fuel power plants. Steam is even used to drive a chiller to produce cold air in the summer. Although the system does not cover the entire campus, it was able to keep the larger buildings and core of the Washington Square campus heated and powered throughout the storm and in the weeks that followed, while surrounding buildings were cold and dark. Since the natural gas infrastructure was well-protected during the storm, this system didn't suffer the same fate as Con Edison's steam and electricity distribution networks. As an additional benefit, the carbon dioxide output of the system is 23% smaller than that of NYU's previous system. The cost of the system was $125 million, with utility savings of $5-8 million per year. The cost-benefit analysis favored this system compared with decommissioning the existing district energy plant and using electricity and steam from Con Edison.[19,20,21]

Other cogeneration facilities were also able to keep the lights on during the hurricane using microgrids, such as Co-Op City (the largest cooperative housing development in the world), Princeton University, and One Penn Plaza.

and workplaces of all sizes, including state government lots.

Operational costs can be stabilized by transitioning drivers and fleet owners away from the volatile and escalating price of gasoline and diesel toward the relatively more stable costs of grid electricity. With time-of-use rates, PEVs can charge using lower cost off-peak electricity. In addition, if power is lost, distributed generation (recommended above) could help fuel PEVs. Fleet owners, who put many miles on their vehicles and can afford higher upfront costs in exchange for lower operating costs, will find the technology attractive today. This is especially true for state government agencies and local municipalities with long-term outlooks on operational costs

Electric vehicle deployment could be accelerated with expanded public charging stations, including fast charging capabilities (current technology can provide an 80% charge within 30 minutes). In addition, some fleets of government or commercial vehicles could benefit from technologies such as battery "swapping", which is a business model to replace the battery rather than recharging it, which can significantly reduce "recharging" time (such a model has been embraced by Renault in some European markets).

The Commission recommends prompting electric vehicle readiness by:

- Promoting PEV deployment by conducting a PSC proceeding to address PEV barriers to more rapid consumer and government agency adoption. Electricity distribution investments needed to support increased use of vehicles should also be addressed.
- Promoting State-sponsored investments (NYPA, NYSDOT, NYSERDA, etc.) in public charging stations. Deployment of charging stations powered by distributed generation with pricing that incentivizes the use of clean and off-peak energy should also be considered.[d]
- Requiring NYSDOT, utilities and vendors to collaborate and map PEV charging stations, and centrally track perational status in 2013.
- At the local level, streamlining permitting for charging stations and introducing updates to zoning and parking ordinances and building codes that encourage charging station installations and use in 2013.
- Developing State-led general public education campaign, supported by utilities and auto manufacturers, to increase consumer understanding of PEVs and the benefits they provide.
- Investing in vehicle-to-grid technology R&D to accelerate deployment.[e]
- Leveraging Public Private Partnerships (PPP) that expand state incentives for charging stations.

[d] Solar array covered parking lots could provide the electricity for the vehicles and provide shading to the vehicles during summer months, increasing vehicle efficiency from reduced cooling loads

[e] PEV applications can also provide a reverse flow power capability such as vehicle-to-grid (dis), however there are elements of these systems such as battery durability, utility/automotive/consumer acceptance, and economics that have yet to be demonstrated. V2G, therefore, remains an R&D and pilot project agenda.

FedEx Delivery Vehicle Pilot (New York City, United States)

A FedEx package distribution center in lower Manhattan started operating a pilot using ten electric delivery vehicles in Spring of 2012.[24] The pilot is a collaboration between Columbia University, General Electric and FedEx to explore convenient and cost-effective mechanisms to charge the vehicles. Putting a large amount of electric vehicles on the grid at once generates a fundamental shift in transport energy from liquid fuels to electricity. FedEx has a 500-vehicle fleet in New York City, and shifting one-third of its fleet to electric trucks would require a megawatt of generating capacity.[25] The pilot project is developing software to prevent the peak load draw during charging from spiking by providing each vehicle with the appropriate amount of energy in the evening to run the delivery route the next morning.

Electric vehicles are good workhorses for the urban delivery industry since they make frequent stops allowing for recapturing braking energy, cover short, predictable routes within the range of the batteries, and can be recharged overnight at distribution facilities. There is a potential for air pollution reductions in cities by removing a large source of diesel emissions from vehicles. The shift to much quieter electric vehicles also reduces noise pollution.

Figure E-18: FedEx electric delivery vehicle (FedEx, 2012)

Smith Electric Vehicles (Bronx, New York)

Smith Electric Vehicles, a leader in zero-emission, all-electric commercial vehicles, is establishing an electric truck assembly plant in the South Bronx, adding 100 jobs to the region. Working with bus fabricator Trans Tech of Warwick, NY, Smith will also be producing electric school buses. Smith was recruited to New York State based on an incentive package including an industry-wide electric truck incentive program announced by Governor Cuomo that provides up to $20,000 per vehicle to partially defray the incremental costs of an EV over an internal combustion engine. By replacing the average diesel truck of this size with a zero emission alternative, more than 26 tons of GHGs are offset each year per vehicle, along with 2,228 gallons of fuel saved annually. The Smith plant is currently in the later stages of refurbishment expected to begin assembling trucks in 2013.

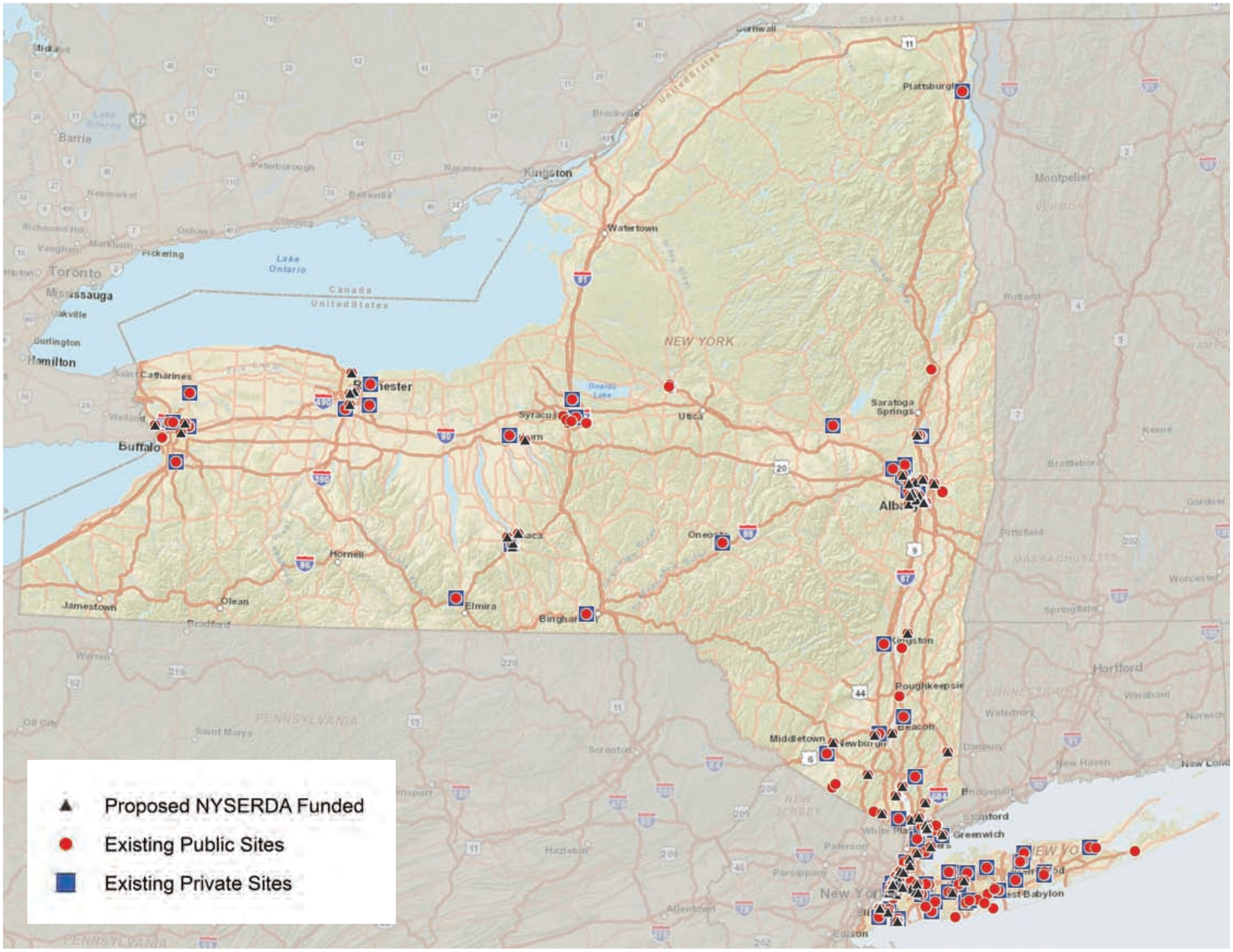


Figure E-19: Existing and proposed electric vehicle charging locations in New York State (NYSERDA, 2012)

Electric Vehicle and the Smart Grid in Denmark (Bornholm, Denmark)

Since 2009, a consortium of research institutions, energy companies and private technology developers has been testing the integration of electric vehicles and smart grid infrastructure in a small city in Denmark.[26] The project aspires to assess the viability of an integrated charging and grid system that uses information and communication technology to control stored energy in vehicle batteries. The system allows stored energy in vehicle batteries to power the grid during times of high demand or when intermittent power generation sources, such as wind, are not actively producing power. Denmark's high proportion of wind power makes it the perfect location to test the feasibility of a vehicle-to-grid system. Furthermore, the project will help support Denmark's long-term objective of having 200,000 electric vehicles on the road.

Design rate structures and create incentives to encourage distributed generation and smart grid investments

The existing energy regulatory framework was designed for large, centrally coordinated systems of generation, transmission and delivery of energy to consumers. There are a number of initiatives that could help support a shift to distributed energy that improve the efficiency of the power system and resilience for the State and benefit both providers and customers.

Price energy markets to all customers in real-time to maximize grid efficiency and enhance resilience

The electricity system is built to meet peak demand. This means that some of the infrastructure is only utilized for a relatively small number of hours each year. To meet higher demand for electricity at peak periods, higher-cost power generation units come online causing the wholesale price of electricity to vary with demand in real time. The vast majority of residential and small commercial electricity customers are informed of the price of electricity only upon receipt of a monthly bill.

Employing a utility rate plan based on prices that vary by time-of-use, and reflects the actual cost of energy in near real-time, coupled with advanced metering could improve electric system efficiency by reducing peak demand. Under this rate design, consumers can shift loads to periods of low demand and pay a lower price for electricity — this could provide system-wide leveling of demand and reduce the need for additional infrastructure to meet what would otherwise be higher peak demand. The PSC should work with utilities to develop these market mechanisms to help make the grid more efficient by allocating/distributing resources to where they are needed most.

Real-time pricing and the advanced metering necessary to support it need to be demonstrated (perhaps with several demonstration projects) and carefully explained to the rate payer, as well as made user friendly, so that they understand how and where these savings are generated and are thus motivated to support their use. Due consideration should be given to the practical hardships and difficulties related to implementing time-of-use rates for certain residential customers (e.g., elderly or disabled customers unable to shift load), and all possible means taken to mitigate any such hardship, such as including tiered rate structures for residential customers that do not penalize lower income citizens and those who use less electricity. Real-time pricing and the advanced metering to create it need to be explained to rate payers so that they understand how these savings are generated.

The Commission recommends the State consider requiring electricity to be priced to reflect the real-time cost, including exploring tiered pricing structures for residential and smaller commercial customers.[f] This will require a statutory change to eliminate the current prohibition of mandated real-time rates to residential customers.

Such pricing mechanisms will help make the grid more efficient by sending the economic signals that result in allocating and distributing resources to where they are needed most.

[f] This will also require digital metering equipment

Energy Storage Innovation (New York, United States)

The US Advanced Battery Consortium (USABC) is a research and development partnership of the major US automakers, EPRI and electric utilities to develop electrochemical energy storage technologies that support commercialization of fuel cell, hybrid, and electric vehicles. The Consortium's long-term goal to enable electric vehicles with energy storage systems costing $100/kWh, which is approximately 20 to 25% of current cost. At this level, electric vehicles would be less expensive to purchase and operate than internal combustion vehicles enabling large-scale deployment. Electric vehicles would also produce fewer emissions than internal combustion vehicles, even based on the nation's current power generation mix which includes significant amounts of coal. New battery chemistries continue to be developed for electrified transportation including advanced lithium-ion and sodium-metal halide batteries. Further improvements in energy density, power, cycle life, and cost will continue for existing technologies while new chemistries such as metal-air batteries will continue to be developed.

Similar benefits can be provided to the electric grid through medium and heavy-duty transportation storage, such as electrified delivery trucks and electrified rail. Energy storage options for distributed energy storage at customer locations and at the transmission and distribution level also include electrochemical systems, fuel cells with hydrogen storage, thermal storage, kinetic storage such as flywheels, and hydroelectric storage. New York academia, industry and government are seeking to capitalize on these benefits through the work of the New York Battery and Energy Storage Technology (NY BEST) Consortium.

Diversify fuel supply, reduce demand for energy, and create redundancies

Fuels such as coal, natural gas, heating oil, gasoline, and diesel, most of which are imported into New York State, contribute to climate change and make the State's system dependent on various delivery systems that themselves are vulnerable to climate change and other disasters. By diversifying our energy supply to include renewable energy sources (e.g., solar panels on rooftops, onshore and offshore wind farms, energy crops or waste and wastewater-to-energy), the State will be more energy secure and reduce its contribution to climate change. These resources have the added benefit of keeping New Yorkers' dollars spent on energy inside the State, supporting the local economy. In addition to a cleaner supply, an increase in energy efficiency and conservation will reduce the demand for imported fuels.

Facilitate greater investments in energy efficiency and renewable energy

Energy efficiency and renewable energy will continue to be priority resources for managing the growing demand for electricity and fuels within a resource-constrained environment. New York is recognized as a leader in the areas of energy efficiency and clean energy deployment, spending close to $1 billion annually through utility and state-sponsored programs. The Commission recognizes the importance of these areas and encourages New York to continue its leadership. Building energy efficiency measures (doors, windows, structural systems and insulation) could also strengthen a residential or commercial building's resilience to violent storms, and in the event, will reduce the need for fewer or smaller generators.

The state has a long history of supporting energy efficiency and renewable energy deployment through the Renewable Portfolio Standard and the Energy Efficiency Portfolio Standard, both currently approved by the PSC through 2015. These programs provide rebates and other incentives to overcome barriers to individuals making investments in energy efficiency and renewable energy investments.

The PSC should review these programs in light of the 2015 program expiration date and extend them to provide longer-term market certainty. In addition, the next step in New York's energy efficiency program should be to leverage additional private sector investment through public-private financing mechanisms. In 2012 New York launched a state-wide on-bill financing program that is still in its infancy. This program, administered by NYSERDA, allows electricity and natural gas customers to make energy efficiency improvements in residential, small commercial, not-for-profit, and multifamily structures through a loan from NYSERDA that is paid back through energy savings and a surcharge on utility bills. The program requires that the energy savings each month are greater than the loan repayment surcharge. To grow this program, the State should encourage the private sector to participate in the financing of these loans.

Diversify fuels in the transportation sector

New York's transportation sector is 97% dependent on petroleum fuels to power passenger and commercial freight movement. Such single fuel dependency reduces system resiliency. The impacts to disruptions in the fuels distribution system may have profound effects on the ability to move people and maintain commerce. This danger is compounded by the fact that petroleum is not produced or refined in New York, leaving New York vulnerable to disruptions caused by storm events or other incidents outside of New York. To reduce that vulnerability, New York should continue to pursue opportunities to increase diversity in the fuels used to power its transportation sector, and target programmatic opportunities that foster new technologies and alternate fuels. Some of these alternate fuel opportunities can be found in turning to electricity, natural gas and low-carbon sustainable biofuels that can be produced using materials such as switchgrass. Near-term opportunities exist for government and commercial fleet vehicles, including expanding use of E-85 (ethanol 85%, gasoline 15%), LNG, compressed natural gas (CNG), hybrid, and electric vehicles.

New York is building on the success of the regional approach created through Regional Greenhouse Gas Initiative (RGGI) to foster new transportation policies, programs and projects through the Transportation and Climate Initiative (TCI), an 11-state plus District of Columbia initiative to advance alternate transportation fuels, in the integrated Northeastern fuels markets. The TCI has adopted a comprehensive approach to transportation alternatives, and is looking at a suite of policies to reduce the use of petroleum, including alternate fuels opportunities provided by electric and natural gas vehicles.

Alternative fuels can be expanded in the transportation sector. The State should explore mechanisms to develop higher biodiesel usage in diesel fuels, supporting development of E-85 (ethanol 85%, gasoline 15%) usage by consumers, and use of LNG, CNG, hybrid, and electric vehicles (particularly in government and commercial fleets).[g]

New York should continue to examine whether regulatory policies can help to foster increased use of alternative fuels. States in the Northeast and Mid-Atlantic region have engaged in analytical work to determine whether a clean fuels standard, if adopted across all the Northeastern states, provides environmental benefits as well as economic opportunity to increase the use of alternate fuels. While California has implemented a clean fuel standard, New York should continue to track whether this approach, or a modified variation targeted to increased use of electric and natural

[g] Provided that fugitive methane emissions associated with the use of LNG/CNG vehicles are minimized.

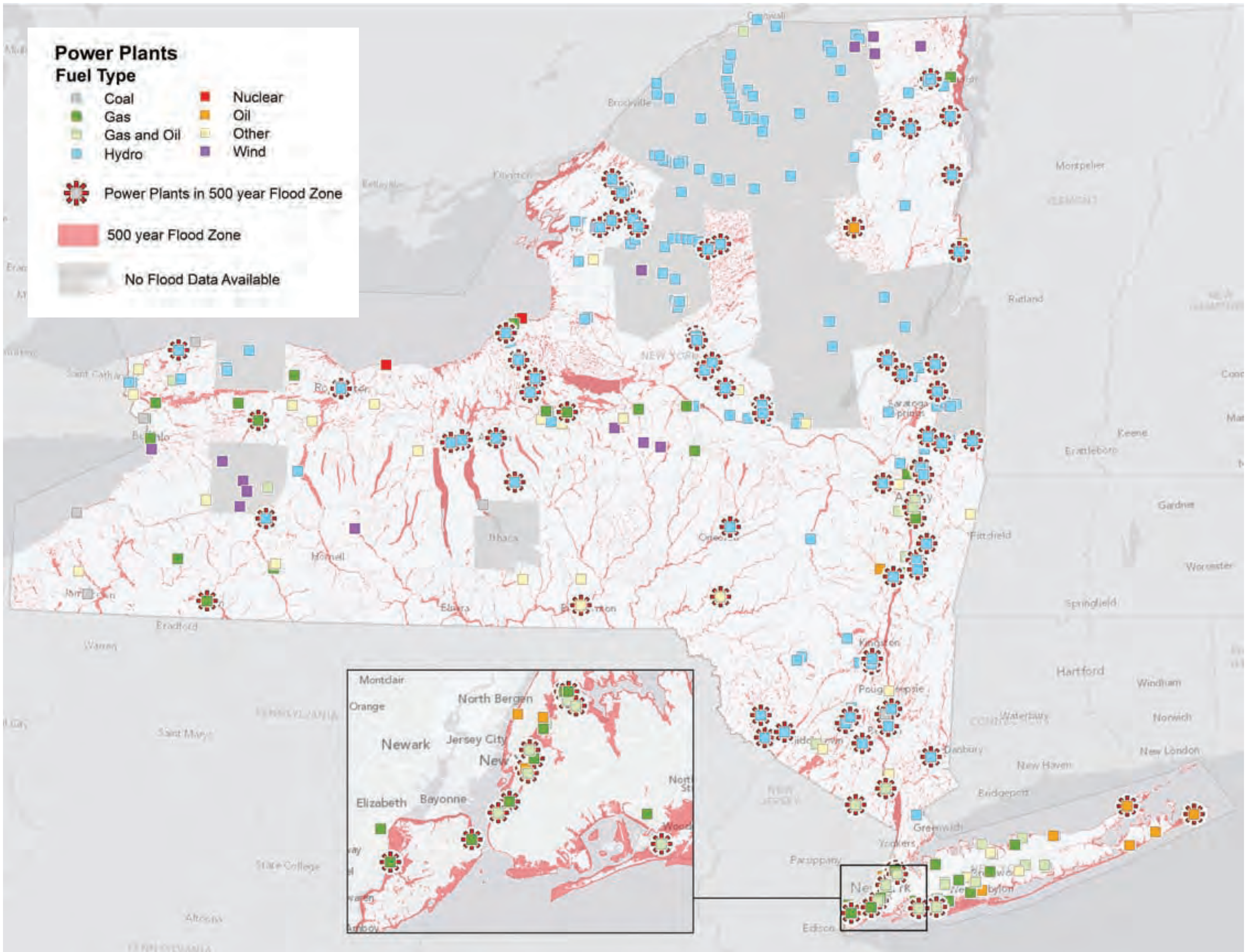


Figure E-20: Power plants in New York State by fuel source in and out of the 500 year flood zone (NYSDPS, 2011; NYSDEC, 2012)

gas-fueled vehicles, could provide a viable program platform for adoption across the region.

Support alternative fuels across all sectors

In the transportation sector, implementing a clean fuels program could promote fuel diversity, cut local air pollution and help prevent transportation fuel types from getting more carbon intensive. New York should begin to track the carbon intensity of the existing fuel mix it uses, including gasoline, diesel, ethanol and other alternative fuel supply and should adopt 'no-backsliding' measures on carbon intensity. These measures keep the fuel mix from getting dirtier (e.g., fuel providers should have a disincentive for increasing the carbon intensity of the fuel they sell). The State, including NYSERDA and the Department of Environmental Conservation (DEC), should explore ways to create incentives that cut, or at a minimum, maintain the carbon intensity of the fuel mix. This could lead to fuel diversification that increases domestic energy security and reduces overall fuel costs and price fluctuations.

There are diversification opportunities across all energy consuming sectors in New York. In the power sector, diversification that supports more distributed power resources helps to build resiliency for power supplies that are not dependent on central station power plants. Such diversification should be explored for high-efficiency, alternate power generation opportunities that continue to use conventional fuels, including applications for microgrids and/or cogeneration technologies that support industrial use complexes. Distributed configurations that can look to combinations of renewable generation with energy storage backup capability should also be explored.

In the waste and agriculture sector, New York should continue to pursue energy production options that provide both energy and waste minimization benefits. For example, there is potential to introduce biogas produced from sewage treatment infrastructure, landfills and waste-to-energy infrastructure into the natural gas pipeline. This biogas (after treatment) could provide a local, renewable energy source, or could be processed into CNG and used for transportation fleets (bus or vehicle) or backup fuel power. Enabling alternative fuels and energy such as biogas and wind and solar electrification provides benefits to local air quality and GHG reduction. For the agriculture and food processing sectors, expanded use of anaerobic digesters can continue to provide the dual benefits of on-site energy resources coupled with effective waste management practices. New York should also support new economic opportunities for the agriculture sector in the form of dedicated energy crops, such as switchgrass and willow, on underutilized land.

In the buildings sector, for home heating oil, greater efficiencies or energy conversion to lower-carbon fuels can be combined with weatherization efforts so that smaller amounts of heating fuels provide higher levels of heating capacity. When combined with on-site renewable options such as solar thermal, these combined renewable energy and energy efficiency opportunities can initiate more holistic approaches to home and commercial buildings energy use, and provide opportunities for GHG reductions.

Lastly, increased research, development, and deployment of micro-combined heat and power (CHP) options and other solutions should be pursued to capture potential improvements for on-site heating systems.

Lower the greenhouse gas cap through RGGI

One primary strategy to promote a cleaner energy supply is to further lower the GHG emission cap through the existing RGGI. This will, in turn, increase funding for cleaner supply projects.

RGGI is a groundbreaking nine-state program designed to cap, and reduce, power sector carbon pollution which contributes to climate change. RGGI has been in place for three years, with emissions from the power sector dropping well below the existing cap. This is due to a variety of factors including reduced economic activity, the low price of natural gas and energy efficiency measures. Lower emissions have reduced the demand for allowances. Allowances are selling at the minimum price and nearly half remain unsold. The current system is no longer driving emission reductions and investments in climate action have dwindled.

RGGI states are now evaluating options for increasing its effectiveness. Reducing the cap can restore RGGI's ability to reduce carbon pollution, and proceeds from the sale of allowances can be used for clean energy programs and transitioning communities to a lower-carbon future.

State legislation proposed by Governor Cuomo in 2012 would help to accomplish this recommendation. The Clean Energy and Economic Revitalization Act of 2012 would have authorized the use of RGGI proceeds generated as a result of a lower RGGI cap, for emission reduction projects in the power sector (e.g., renewable energy deployment or re-powering). The bill would have also provided municipal assistance and created additional revenue for other uses. By implementing measures to reduce GHG emissions through the RGGI auction, revenue will be generated for New York State that can be used to fund investments in modernizing the grid and expanding renewable energy, in addition to lowering emissions. The Commission recommends that the State work with other states in the Northeast to lower the RGGI cap.

Develop long-term career training and a skilled energy workforce

There is a lack of young members of the workforce with skills in the energy sector. Several utilities have identified and addressed a major risk affecting their long-term planning, namely the high percentage of employees that are nearing retirement age, and who have a great amount of experience that is hard to transfer to younger employees. A recent study showed that more than 20% of New York's utility employees are over the age of 55.[27] Exacerbating this problem is that while there are many skilled employees with one to five years of experience, there are not nearly enough with ten to fifteen years — the managerial and skilled tradespeople who would normally have the plant experience and skills to move into more senior positions vacated by retirees. This problem has arisen in part due to the difficulty in retaining young employees.

Without a skilled pool of workers to draw from, New York State will be unable to meet the demands of the energy system. The problem is exacerbated when considering the upgrades, repairs and new construction that are required to protect our energy infrastructure. Further complications due to labor shortages will arise when the energy system experiences stresses that cause disruption to services.

The State needs to be able to provide enough skilled energy workers from within its own borders to repair damage to equipment and reestablish service. Growing the pool of available skilled workers will put the State in a position to handle the current and future needs of its energy system during normal conditions and when extreme weather events disable the system. A concerted effort should be made by the State Department of Education, the State University of New York (SUNY) and the City University of New York (CUNY) programs, Regional Planning Boards, the New York State Department of Labor, NYSERDA, and industry groups to develop the energy workforce within New York State which will make the State's energy infrastructure system more self-reliant and robust by addressing impending and long-term labor shortages.

Create a workforce development center with utilities

The State should facilitate the development of a regional workforce development center to train the next generation of technical and operations workers for the utilities industry, and more broadly, the clean energy industry, by working with NYPA, NYSERDA, and Investor Owned Utilities. Envisioned as a training center for utilities, and other non-utility energy companies, with modified curricula and equipment tailored to each, this center would be designed to reach out and serve the regional business community, especially manufacturing companies that could share training on the advanced manufacturing equipment and techniques that are critical to global competitiveness with other countries and states. NYPA should take the lead to identify potential locations and develop a business plan for this center in 2013.

Expand energy career training and placement programs

New York State career training and placement programs should be expanded to meet the demands of the energy sector during both normal and emergency operations. Energy jobs require highly skilled workers with years of training, so the investment in training programs should begin immediately to account for future needs. NYSERDA has funded a statewide network of clean energy training providers that offer courses and certifications for energy efficiency and renewable energy jobs.

Creating a larger network of training programs and centers will help form a foundation for the continued development of the energy workforce for years to come. SUNY and CUNY, New York State Department of Labor, NYSERDA, and industry groups should aim to put these programs in place by the end of 2015. These programs should be continually reviewed, updated and revised to remain relevant in the changing technological environment.

Promote awareness of the need for skilled energy workers

Coinciding with the development of these educational programs, the State should promote awareness of our need for skilled energy workers. This can be done through the ongoing work of NYSERDA in different regions of the State. Students, educators, parents and non-energy laborers should be informed of the opportunities for employment in the State's energy sector starting in 2014.

Coordinate workforce development among all stakeholders within the energy sector

Coordination among State agencies, education institutions and businesses will play a vital role in the success of developing the State's long-term energy workforce. Energy and labor organizations should collaborate to establish a comprehensive plan that will be updated to reflect sector trends every one to five years. This plan should project trend development over a 20-year period, and be submitted to NYSERDA for distribution throughout the State.

OVERVIEW OF RESPONSE TO HURRICANE SANDY-NOR'EASTER AND RECOMMENDATIONS FOR IMPROVEMENT

U.S. Department of Energy
Office of Electricity Delivery and Energy Reliability

February 26, 2013

I. Introduction

Following the severe and widespread impact of Hurricane Sandy, the U.S. Department of Energy (DOE) reviewed the preparation, response, recovery, and restoration activities performed within its organization and by the Energy Sector. Understanding the wide range of challenges encountered by owners and operators of the energy infrastructure, States and localities, utility customers, and the Federal government will establish the basis for continuous improvement in preparedness and response activities.

Hurricane Sandy was the second-largest Atlantic tropical cyclone on record. Making landfall on October 29, 2012, Sandy's impact stretched across 21 States[1]—from North Carolina to Maine and as far west as Illinois – bringing extreme winds, heavy rains, and flooding. At its peak, hurricane-force winds extended 175 miles from the center of the storm and tropical storm-force winds extended 500 miles. Sandy caused significant damage to the energy infrastructure. During the recovery process, a Nor'easter hit the Mid-Atlantic and northeast causing additional electrical outages and damage to the region's energy infrastructure and prolonging recovery. For Sandy and the Nor'easter combined, the peak in each of the 21 States impacted totaled 8.6 million customers without power. To date, the estimated cost of property damage due to Sandy is in the tens of billions of dollars.

This document provides an initial review of DOE's Sandy-Nor'easter preparation and response activities, highlights some of the observations made during the response, and recommends specific activities to help DOE move forward with its government colleagues and industry partners to increase the resilience of the nation's energy infrastructure.

[1] There were 21 States who had 1,000 or more customers who lost power due to Sandy. The weather impacts from Sandy were felt across 24 States.

After Action Process

In December 2012, DOE held a series of “Hotwash” meetings to discuss and review challenges, lessons learned, and examples of what worked well in response to Sandy. The focus of these meetings was to identify how to improve preparation and response for future events. The first meeting was the ESF-12 Internal Hotwash, which was organized by the Office of Electricity Delivery and Energy Reliability (OE) Infrastructure Security and Energy Restoration (ISER) Division, which has the DOE lead for Emergency Support Function 12 – Energy (ESF-12). Its purpose was to identify opportunities for improving situational awareness, reporting, and the operations of ESF-12 responders at headquarters and in the field.

The second internal DOE Hotwash was held with the DOE elements contributing to the response: Power Marketing Administrations, the Energy Information Administration, Office of Fossil Energy, Chief Information Officer, National Nuclear Security Administration, Chief Financial Officer, Office of Policy and International Affairs, and others. A series of meetings were held with State and local government officials in New York and New Jersey to elicit their views regarding response and restoration of energy services. Additional Hotwash meetings were held with energy infrastructure owners, operators and their representative associations—one with the electricity sector and another with the oil and natural gas sector.

Initial Sandy Hotwashes

December 4- ESF-12 Internal Hotwash
DOE Staff, Responders, and supporting staff

December 10- DOE Internal Hotwash -
Representatives from DOE Departments: CIO, EIA, FE, GC, NNSA, OE, PMAs and PI

December 11-12 – State and Local meetings - *DOE meetings with individual State and Local officials in NY and NJ*

December 13- Electricity Hotwash -
DOE Deputy Secretary, OE Senior Staff, and Electricity Owners, Operators and Associations

December 14- Oil & Natural Gas Hotwash -
DOE Deputy Secretary, OE Senior Staff, and Oil & Natural Gas Owners, Operators and Associations

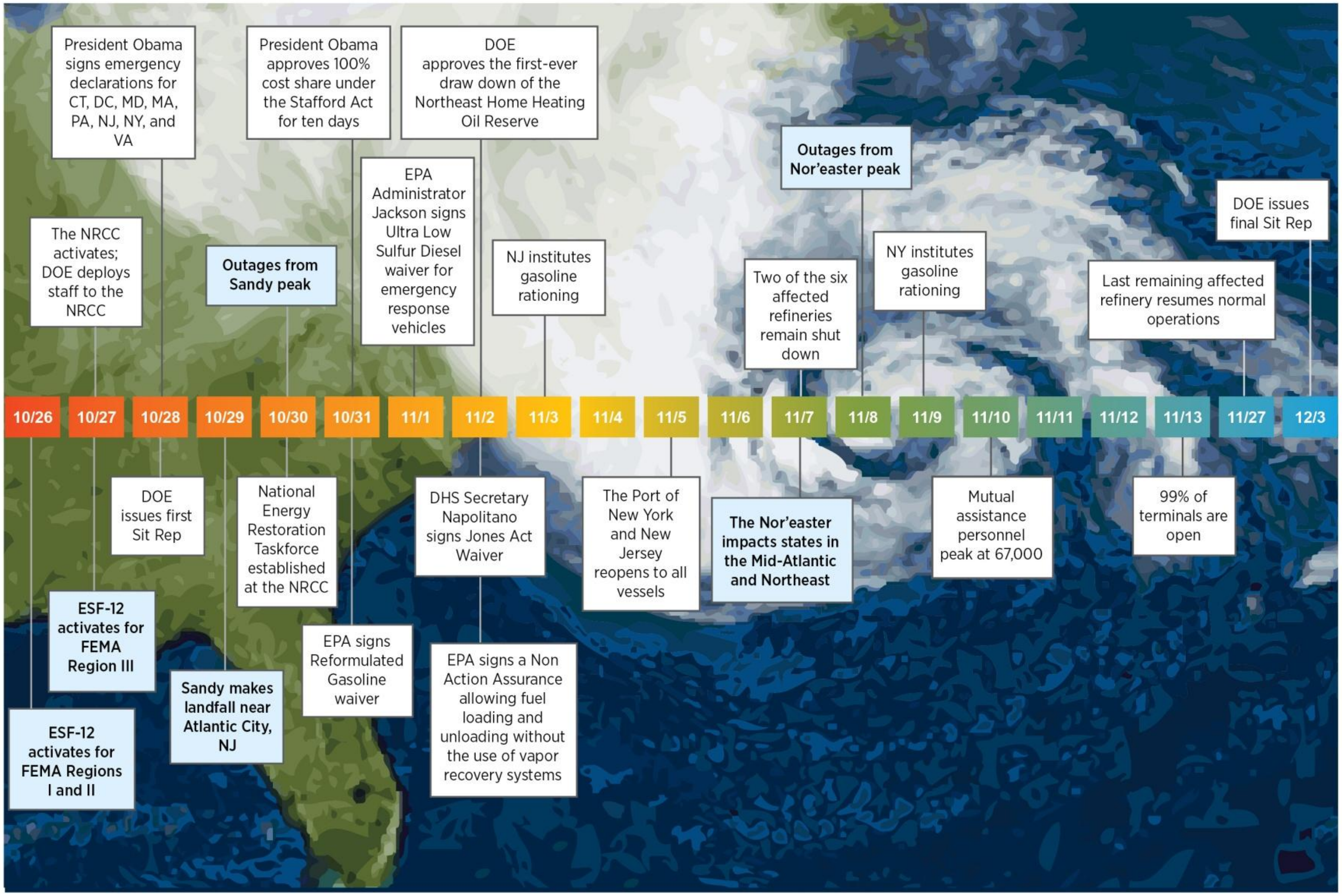
January 30 – Multi-State Fleet Response Initiative Working Group – *DOE, DHS, FEMA, State officials in PA, NJ, NY, electricity and fuel owners and operators*

These discussions identified preparation and response measures that worked well and initial thoughts on areas where improvements could be made. Specific recommendations have been developed to lead to better preparedness, response and restoration. The outcomes from ongoing After-Action activities will provide DOE and the Energy Sector a framework to enhance the resilience of the Nation’s energy infrastructure.

II. Background of Event

On the night of October 29, 2012, Sandy made landfall near Atlantic City, NJ, as a post-tropical cyclone. Over the next three days, the impacts of Sandy could be felt from North Carolina to Maine, and as far west as Illinois. With an unprecedented storm surge in the affected areas, there was especially severe damage to the energy infrastructure. Peak outages to electric power customers occurred on October 30 and 31 as the storm proceeded inland from the coast, with peak outages in all States totaling over 8.5 million, as reported in the DOE Situation Reports. Much of the damage was concentrated in New York and New Jersey, with some customer outages and fuel disruptions lasting weeks.

HURRICANE SANDY Response Timeline



Beginning November 7, 2012, a Nor'easter impacted the Mid-Atlantic and Northeast with strong winds, rain and snow, and coastal flooding. The second storm caused more than 150,000 additional customer outages and prolonged recovery.

According to the Edison Electric Institute, 67,000 mutual assistance personnel from 80 electric utilities, primarily private sector but including some government, from across the U.S. assisted with electric power restoration. Within two weeks of Sandy's landfall, workers had restored power to 99 percent of customers who could receive power.

The Administration assisted in the preparations, response, and recovery from the storm by coordinating the Federal response effort. This effort included the following:

- On October 31, the President sent a "Senior-Assessment Team," consisting of the Deputy FEMA Administrator, a DOE Deputy Assistant Secretary, a flag officer from NORTHCOM, and White House personnel, into the field. The team was tasked to directly address problems on the ground as they surfaced.
- President Obama approved a 10-day Federal funding waiver effective October 31, bypassing the need for State cost-share under the Stafford Act, in order to accelerate the government components of the response.
- Under ESF-12, DOE deployed 35 responders to Regional Response Coordinating Centers (RRCCs) in three FEMA regions (I, II, and III), the New York and New Jersey Emergency Operations Centers (EOCs), the National Response Coordination Center (NRCC) at FEMA's headquarters, and the Energy Response Center (ERC) at DOE's headquarters. These responders served as the energy advisors at their respective sites, handling issues and policy decisions relating to response and restoration efforts.
- OE began issuing its publically available DOE Situation Reports on October 28. Between October 28 and December 3, 2012, thirty-three DOE Situation Reports were issued, providing situational assessment of the impacts to and restoration activities of the electricity, oil, and natural gas sectors following Sandy and the Nor'easter.
- Three DOE Power Marketing Administrations (PMAs)—Bonneville Power Administration (BPA), Western Area Power Administration (WAPA), and Southwestern Power Administration (SWPA)—brought in 235 staff and roughly 200 pieces of equipment to help restore downed lines and repower substations. This was the first time WAPA or SWPA had engaged in mutual aid with investor-owned utilities as part of DOE's ESF-12 response. The U.S. Department of Defense (DOD) supported this effort by airlifting equipment from the PMA facilities in Washington and California.
- Starting the day before the storm struck the East Coast, senior DOE leadership began to participate in daily coordination calls with the electric sector CEOs and the Edison Electric Institute. DOE worked with utilities to assess their needs and ensured prioritization of repairs and power restoration to critical infrastructure. These efforts focused primarily on restoring power to affected terminals and refineries.

HURRICANE SANDY: Energy Response Actions

STORM IMPACTS

- 8.6 million customer outages— largest number ever reported from a single storm
- 21 states impacted
- Damage stretches from North Carolina to Maine, from New York to Illinois

DOE AND ESF-12 RESPONSE

- Daily conference calls between utility CEOs and Secretary Chu
- Energy Restoration Task Force created at the request of the President, addressing both power and fuel issues
- 33 ESF-12 Situation Reports published
- 34 infrastructure maps created
- 35 responders deployed to:
    - *FEMA National Response Coordinating Center*
    - *DOE Energy Response Center*
    - *FEMA Region I RRCC (Boston, MA)*
    - *FEMA Region II RRCC (Colts Neck, NJ)*
    - *FEMA Region III RRCC (Philadelphia, PA)*
    - *NY State Emergency Operations Center (Albany, NY)*
    - *NJ State Emergency Operations Center*

MUTUAL ASSISTANCE

- 67,000 mutual assistance personnel and worked to restore power
- DOE brought in 235 people and around 200 pieces of equipment from the Power Marketing Administrations, including Bonneville Power Administration (BPA), Western Area Power Administration (WAPA), and Southwestern Power Administration (SWAPA). They helped restore downed lines and power substations.
    - *This was the first time WAPA or SWAPA engaged in mutual aid with an investor-owned utility.*

FUEL WAIVERS AND RELEASES

- Jones Act Waiver
- Fuel Flexibility Waivers
    - *Reformulated Gasoline (RFG) waiver.*
    - *Ultra Low Sulfur Diesel (ULSD) waiver for emergency response vehicles and equipment in NY, NJ, and PA.*
    - *Non Action Assurance allowing fuel loading and unloading without the use of vapor recovery systems.*
- Released Northeast Home Heating Oil Reserve for the first time

- The U.S. Department of Transportation (DOT), other Federal agencies, and elements of the private sector worked with State and local authorities to ensure utility crews were able to reach the impacted areas. This included plowing snow and clearing fallen trees or other debris from the roads ahead of utility teams. For the first time, utility trucks were classified as emergency responders, allowing them to go to the head of fuel lines.
- DOE staffed the Energy Restoration Task Force at the NRCC. This group concentrated on power restoration and fuel availability. The Task Force focused on eliminating roadblocks and identifying choke points in power and fuel distribution systems. This was the first task force of its kind and its successes and failures will be evaluated for potential future implementation and standardization.
- On November 2, President Obama declared that Hurricane Sandy created a severe energy supply interruption and directed the Energy Department to loan the Department of Defense ultra-low sulfur diesel from the Northeast Home Heating Oil Reserve.

III. Recognized Practices

Well before Sandy made landfall, its scale and intensity made it clear that an unprecedented effort would be required to respond to its impacts. Some of these activities undertaken during the response are worth noting for consideration as possible "best practices" for future large scale disturbances to the energy infrastructure. Several are noted below:

Dedicated senior leadership involvement. The scale of Sandy's impacts required direct CEO involvement in hurricane response, as well as direct and regular communication between CEOs and Federal leadership. For example, the Secretary of Energy participated in daily conference calls with CEOs of major utility companies to assess electricity restoration and conditions. These communications aided both the restoration process and provided situational awareness to the government, enabling increased coordination between the public and private sectors. Additionally, the high-level interactions led to the placement of a private sector staff at the FEMA NRCC. This facilitated greater access to services and resources to support restoration. Senior leadership in the field also provided senior management at DOE headquarters with high-level situational awareness.

Expanded mutual aid assistance. Prior to the storm but ramping up once weather conditions stabilized, the electric and natural gas utilities mobilized the largest-ever dispatch of mutual aid workers across the country (totaling approximately 70,000) This total included DOE PMA crews from BPA, WAPA and SWPA. The effort to move these additional resources throughout the country required coordination at all levels of government. This included the expedited movement of personnel and equipment by DOD, waivers at the State and Federal levels to facilitate movement across State lines, and the commitment by companies to offer their own assets to assist the utilities and customers in affected areas.

Expedited waivers. The President's guidance that he would have "zero tolerance for red tape" had an immediate beneficial effect, as Federal and State governments quickly processed a variety of waivers to remove barriers to response and restoration. Both public and private sector partners utilized the waivers to aid the movement of crews across the country with limited interruptions and to provide flexibility in fuel systems. These waivers allowed workers to cross State lines, bring heavy equipment into the disaster areas, and quickly restore (at least) partial service—whether oil, gasoline, natural gas, or electricity—while addressing more long term restoration requirements. Agencies, including DOE, DOT, and the Environmental Protection Agency (EPA), among others, worked directly with owners and operators, industry trade organizations, and other Federal agencies to perform the due diligence needed to quickly approve waivers to facilitate restoration.

IV. Areas for Improvement

Though individuals throughout the public and private sectors dedicated tireless efforts to respond to Sandy, the tremendous scale of the storm and its destruction stripped bare a number of areas where our institutional mechanisms fell far short of what was needed to respond, mitigate, and restore the damaged energy infrastructure. It is essential that we take full advantage of these lessons and take the steps needed to ensure more effective responses to future events. Some of the major areas where improvement is needed are in availability of information of energy supplies and communication of restoration schedules. Access to impacted areas for restoration crews was a difficulty, as well as access to fuel and equipment needed in the restoration were both significant challenges that need to be addressed. While mutual assistance in the electricity sector was critical to the restoration of the infrastructure, improving efficiencies in scheduling and resource tracking is needed.

Information and Communications

Inadequate situational awareness of fuel supplies. Efforts to assist were impeded by a lack of information and understanding of where fuel was located and where it was needed. Data related to retail gas station levels is not available in real time. This lack of information significantly impeded governments' abilities to provide fuel or prioritize restoration to those areas that could have received it. A lack of data related to the ability of terminals to deliver fuel and their potential restoration estimates also created challenges for distribution of resources.

Better situational awareness, both pre- and post- event, would have allowed DOE to respond more quickly. Understanding the types of products and storage volumes in the petroleum fuels systems, how the storm surge could impact the energy infrastructure, and what resources were available in the affected regions, all would have contributed to a more effective response. Limited personnel resources, in addition to limited data resources and tools, negatively affected DOE's capacity to respond quickly. More resources in the field, integrated with energy sector partners as well as State and local responders, would have provided channels of communication back to DOE headquarters staff and leadership. These channels would allow faster communication of challenges, needs, and resources specific to the needs of critical energy sector partners. The Department is examining how much more could have been done, with greater dispatch, had additional resources been available to the Department.

Better communication of restoration timeframes needed. Examples of inaccurate and/or inadequate communication were exhibited within and between government, industry, and the public. Difficulty in communicating the availability of resources, restoration times and priorities, and community needs were recognized as key problems in all Hotwash discussions. In particular, the ability and willingness of utilities to share restoration information with stakeholders was uneven across companies. An example is a utility providing an estimated restoration timeline for a particular substation and the feeds from that substation but not communicating the area serviced by those feeds. Without an accurate sense of when power would be restored, communities were unable to plan effectively. Citizens were sometimes unable to decide when and if they could return to their homes; governments could not adequately identify needs and match them with resources. While it is clear that restoration is a challenging and complicated process, utilities need to do a better job of continually updating customers or, at least, explaining why they cannot produce the requested information.

Access and Resources

Crews and other first responders. The level of devastation in New Jersey and New York created many complications for both public and private sector responders. It was vital to assess damage while simultaneously ensuring protection of life and safety. One major impediment to both of these tasks was access to critical sites that needed to be restored. The storm conditions affected the ability of State, local and Federal governments to assist with staging, prepositioning, and other services which could have accelerated restoration once the storms had passed. A significant storm surge in some areas and high winds and rain in others inhibited the activities and movement of utility workers in the hardest hit States, particularly New Jersey and New York. Debris from by the storm was another major challenge. Although the National Guard was on-hand to assist with debris removal, safety hazards throughout impacted electric and natural gas infrastructure impeded progress, slowing the pace of restoration. The considerable challenge of removing debris, while also working to restore power to those able to receive it was especially difficult in areas that had experienced significant flooding. Communities are still working to remove debris, including downed trees, destroyed buildings, and displaced sand. The task of determining what can be done with the collected refuse remains an issue throughout the affected region. In New Jersey alone, 116,000 trees were downed as a result of the storms.

Fuel. Liquid fuels were essential for responders across all sectors. Wind and flooding caused damage to critical fuel facilities such as terminals, pipelines, storage facilities and truck racks, as well as to the electric power infrastructure that energizes those facilities. This led to significant shortages of fuels in the affected regions. Docks, control systems, vapor recovery units, and electric switching gear within facilities sustained serious damage. Replacement of parts and components and the complexity of the systems required time and technical expertise to safely restore services. Simultaneously, retail gasoline stations were without commercial power and/or fuel supplies in many instances, and those with power quickly ran out of fuel. The combined effects of damage to terminals, loss of electric power, and high demand for fuel led to shortages and long lines for fuel across the region. Gasoline rationing policies were eventually implemented, first in New Jersey and later in New York.

Electric Power. Due to the unprecedented damage to the electricity infrastructure, a massive restoration effort was required. While PMA crews have participated in mutual aid efforts in the past, the implementation of 100 percent Federal cost share during Sandy marked the first time

PMAs provided assistance under the Stafford Act. Although the PMA response was successful, PMAs were not considered in advance for the restoration effort and were not pre-positioned to respond. In addition, restoration efforts among the electric utilities and the Oil and Gas sector did not appear to be done in parallel but rather sequentially. This oversight extended restoration activities and complicated the prioritization of the response.

Equipment. In terms of long term restoration, access to equipment can be a major challenge for many of the operators attempting to repair or replace damaged and destroyed equipment. Much of the equipment used by electric and natural gas utilities, as well as oil and gas operators, is not quickly found, procured, and delivered. In some cases, infrastructure is outdated and replacement components are not readily available. Whether an issue of size, weight, technology, or cost, this equipment can take time to source, deliver, and install. As restoration proceeds, this challenge will continue to affect progress and the long-term reliability of systems. Additionally, the prolonged use of temporary patches can produce complications when waivers expire and regulatory enforcement resumes. Potentially, conditions may arise that require owners to operate at decreased capacity, which may affect primary and secondary services and processes.

Mutual Assistance Arrangements

Assignment of resources. Although the mutual assistance response in the electric sector was unprecedented in size and scope, there were problems that need to be considered before another event. Due to the size of Sandy and the uncertainty in where severe impacts would occur, utilities throughout the region retained crews in their own service territories as a necessary precaution. As the storm progressed northward, utilities had to assess, repair, and certify their own systems before releasing crews to areas where the storm continued to impact the electric infrastructure. Limited movement of crews within the region, as well as into the region due to weather conditions, limited fuel supplies, and local restrictions further delayed response. Additionally, the movement of crews and equipment within the region and within States was not adequately communicated and coordinated with State and local governments. In many cases States were not aware of the processes and protocols of the existing mutual aid framework which led to confusion at the local level as crews transited impacted areas.

Oil and gas sector lacks commensurate mutual assistance network. Whereas the electrical utilities have decades of experience in mutual assistance arrangements and rallying to one another’s support in response to natural disasters, no such arrangements exist in the oil and gas sector. The problem is aggravated by the competitive nature of the oil and gas industry, anti-trust legislation, and uncertainty of if and how mutual assistance can be adapted to the oil and gas industry.

V. Recommended Actions

This section describes the actions that industry and State, local, and Federal governments need to implement to enhance preparedness, response, restoration and resilience to events impacting the Nation’s critical energy infrastructure. These recommendations were developed through a series of Hotwash meetings with industry, Federal, and State and local governments.

Information and Communications

Educate stakeholders on the process for requesting and attaining necessary waivers. The government's efforts to efficiently process needed waivers were noted by both the public and private sectors, but there were instances when owners and operators were not aware of the process to request waivers or when waivers had already been granted. To avoid these potential impediments to restoration, agencies should take steps to ensure their processes are clear, well documented, and regularly communicated to stakeholders within the sector.

Share recommended practices with all energy sector stakeholders. The Federal government should collect and disseminate lessons learned generated from the After Action Hotwashes and discussions to improve long-term planning and response preparations. The Federal government can review stakeholder emergency response plans on an as requested basis to identify where improvements are needed. These improvements can include lessons learned from prior events.

Develop real-time monitoring of fuel availability and storage levels at all points of the pipeline from well to wheel. This information must be communicated in real time to customers and decision makers. The Federal government can work with the private sector to design technologies that measure and report accurate, real-time information. DOE should work with partners across the oil and natural gas sector to identify existing technologies to deliver this capability, and to identify if Federal investment is required for technology research, development and deployment.

Embed fuels industry representatives in operations centers. States can integrate fuel industry representatives in operations centers, and similarly the Federal government can integrate them in JFOs or RRCCs. This will provide a critical communications link for both government officials and the participating company. For example, industry representatives can help coordinate efforts with the available resources at the State, local, and Federal levels, such as with the National Guard or U.S. Army Corps of Engineers.

Identify interdependencies between the electricity and oil and gas sectors to educate stakeholders and decision makers. The Federal government should establish communication between critical energy infrastructure owners and operators to create a better understanding of interdependencies. This will include identifying energy requirements, communicating restoration processes, and identifying restoration priorities. Matching needs with resources and expertise will allow fuel industry owners and operators to plan restoration efforts in line with power restoration, thereby improving prioritization of critical facilities. Exercises to understand and identify interdependencies will be designed and implemented to disseminate information to all partners. This process will be a continual effort as interdependencies and priorities can be dynamic and situational,

State and local government should coordinate energy assurance planning efforts prior to a catastrophic event. State and local governments need to ensure they are utilizing existing intergovernmental relationships and structures for communicating during an event. Establishing and affirming these relationships will limit the creation of stove pipes, reduce duplication of efforts, and enhance the ability of governments to coordinate policies (such as fuel distribution) and programs when necessary.

Communicate restoration processes and schedules to public officials and customers. Government officials need to understand restoration processes and timelines in order to assist citizens during prolonged outages. Utilities should develop and exercise Communications Plans which inform government officials, as well as customers, as to their restoration timelines and priorities. If information is incomplete or unavailable, explanation should be provided.

Exercise Continuity of Operations Plans (COOPs) with suppliers and customers. Providers of critical energy services should exercise their COOP and their Emergency Response Plans with suppliers and customers to identify gaps and critical interdependencies that could impact response and restoration to a major event. Lessons learned from these exercises can inform their planning for preparedness, response, and restoration, as well as those of their partners.

Conduct regional exercises with State and local governments, and energy sector owners and operators. Exercising response plans, including communications, prioritization, and mobilization at a regional level helps educate all stakeholders as to restoration processes and requirements, the relationships necessary to facilitate response, and the challenges that can be expected. DOE will design and implement exercises focused on events that specifically impact critical energy assets and interdependencies. These exercises should also be designed to educate policy and decision makers about the energy infrastructure, fuel markets and to improve their ability to make informed decisions during a response.

Leverage technology to improve response and communications. Federal government should work with public and private sector responders to identify effective communication and response technologies, as well as processes and opportunities for technology solutions to improve information sharing.

Access and Resources

Use the Defense Production Act (DPA) to obtain critical supplies. In an event affecting a large geographic region, the demand for critical components is high, and access to those components can become constrained as demand grows. The DPA is a tool that can help acquire supplies in a timely manner to assist restoration in extreme events. DOE can develop a better understanding of how and when the DPA can be used, as well as the pros and cons for sector partners.

Designate energy sector restoration crews as first responders, eligible to be granted priority for fuel distribution. During events, when fuel is a scarce commodity, restoration crews (electric, oil, and natural gas) require fuel for vehicles and equipment in order to perform restoration efforts. Without adequate access to fuels, response can be seriously hindered. During the hurricane response, electrical workers were given "first responder" status which enabled them to be more effective. Other repair crews did not have this status. The Federal government should coordinate with State and local governments to ensure that refinery and terminal repair crews are given first responder status and appropriate credentials to enter damaged work zones quickly.

Create a corps of certified electricians and other ancillary services required during restoration activities. DOE can coordinate with States and critical infrastructure owners and operators to understand what types of ancillary services, such as electricians, are needed to facilitate restoration activities. Identifying skills and individuals in advance to create a corps of qualified professionals will help shorten restoration times.

Work with State and local governments to develop guidelines for law enforcement to follow which allow access for utility restoration crews. A recurring problem following natural disasters is the difficulty crews involved in restoration, such as utility crews have in accessing affected areas to begin restoration. DOE should work with State and local governments and industry to develop guidelines for law enforcement to use following future events which will allow access for restoration crews without compromising public safety.

Revise policies on how to deal with short-term and prolonged fuel shortages. States should identify key gasoline retail stations to provide fuel for first responders and consumers along evacuation routes. Those stations should be required to have electric power generator hook-up capability.

Assess the value of a refined product reserve. DOE should work with sector partners to perform cost-benefit analysis of a regional refined product reserve versus stockpile requirements for private sector entities (such as those in Europe). The analysis will consider, among other factors, existing legislation and authorities, siting issues, fuel types and dependent supplies, and market forces.

Create a dedicated DOE/ESF-12 response corps. Permanently deployed DOE responders can provide on-the-ground situational awareness, established relationships with State and local energy sector partners, and first-hand system knowledge at the State and local level. These responders can facilitate energy-sector specific response and restoration at the local level, affording DOE leadership first-hand reporting during an event.

Establish, in cooperation with States, the technical and financial conditions needed for retail gasoline stations to receive generator power. The fuel needs of emergency responders, as well as the public, necessitate more timely restoration for gasoline service stations. One option to promote restoration would be generator power, supplied either commercially or by governments. However, site-specific electric systems need to be configured to receive power and financial incentives need to be in place to encourage these adaptations. Governments should investigate what could be done at the State level to create favorable conditions to make these changes.

Mutual Assistance Arrangement

Clarify Anti-Trust Laws. DOE General Counsel and other relevant Federal agencies should perform a review of Federal anti-trust laws governing the oil and gas industries. Acceptable practices and policies will be documented, in regard to mutual assistance and other coordination that is allowable in response to energy emergencies.

Establish mutual-assistance relationships with the owners and operators of critical energy infrastructure before an event occurs. These relationships and networks should be established during steady-state operations to facilitate communication when an event occurs.

Review mutual aid agreements and the processes to receive and manage those agreements. All electric companies should have mutual aid agreements in place. Those agreements need to be current, reviewed, and ready to be executed so that companies can receive mutual assistance workers if and when they are needed. Companies need to understand the requirements for staging areas, coordination of restoration activities across their systems with mutual assistance crews, and the processes to manage workers and workloads.

Additional Recommendations

Establish standards and guidelines for fuels facilities. The fuels industry can establish industry standards and technical guidelines for all oil terminals, pipelines, and service stations based on industry-determined criteria to install transfer switches or other systems needed for facilities to accept generator power. When commercial power to a site is lost, generator power can be provided to those critical facilities that are configured to receive it. Industry standards for generator and other types of alternative power can decrease the time it takes to match available resources to needs in an event. Conclusions may also lead to changes at facilities that are not currently configured for generator power.

Strengthen resiliency and hardening of the system. Industry owners and operators have a responsibility to assess their system vulnerabilities to natural disasters in areas that are historically prone to these events. As the restoration process continues in New Jersey and New York, owners and operators should explore opportunities that could enhance resilience. These include such options as elevating substations, building berms, raising switching gear, and other measures which have proven effective in other areas of the country. Owners and operators should also have on-site backup electric power generation to operate facilities.

Consider alternative system configurations for critical facilities. For those facilities with critical needs, such as hospitals, fuel supply terminals or other critical sites, owners and operators should coordinate with energy providers to consider potential alternative system configurations to enhance the reliability of power. Potential solutions could include dedicated circuits, distributed generation, or combined heat and power units.

Revise current building and rehabilitation codes. Building planners and government officials will assess current codes to determine if they can be updated to enhance reliability and resilience.

VI. Next Steps

The response to Hurricane Sandy and the following Nor'easter is ongoing, both in the affected communities and within the Federal government. As part of this response, DOE will begin implementing the actions recommended in this report. Specific next steps are detailed below.

- Hold an After-Action meeting with all stakeholders to examine the overarching lessons learned and areas for improvement.
- Coordinate with energy sector stakeholders to identify what information is needed before, during, and after an event, and, ascertain which communication mediums should ideally be used to deliver that information.
- Identify what can be done, under existing laws, to facilitate access to critical supplies for restoration of critical services (such as electric power). Identify any existing laws that need to be amended or new laws promulgated, to facilitate such access.
- Facilitate communication of policies and practices which support preparedness and resilience between energy sector owners and operators through the Sector Coordinating Councils and trade associations.

While this list is not comprehensive, it does provide an initial set of activities in which DOE can engage, given current resources. The results of these activities should be shared with partners. They should inform future activities and decisions which can inform policy options to enhance preparedness, response, and recovery for future events.

MORELAND COMMISSION

ON UTILITY STORM PREPARATION AND RESPONSE

FINAL REPORT

June 22, 2013

Co-Chairs
Robert Abrams
Benjamin Lawsky

Appointed by
Governor Andrew M. Cuomo

resources are insufficient for the current level of oversight, which can be evidenced by some petitions for EEPS program changes languishing unaddressed for months and in some cases over a year. Many interviewees expressed the level of DPS oversight is too focused on the details of the programs at the expense of other important policy issues, such as tracking overall program progress and establishing guidance as how to apply evaluation results. As mentioned in the previous section, despite the volumes of data required of program administrators, there is an apparent failure of DPS to analyze that data, send timely signals to the program administrators for program adjustments based on the performance to date, or identify best practices and areas for efficiencies and collaboration among program administrators.

An example of this misdirected attention to detail that came up frequently in the stakeholder interviews is related to the Total Resource Cost (TRC) test. The TRC is a cost effectiveness test that measures the benefit of energy efficiency compared to the total cost (of the program administrator plus consumer) of the energy efficiency measures. DPS has chosen to apply the TRC at the measure level, meaning that in order for a measure to be incentivized in an EEPS program, the benefits of reduced energy consumption must outweigh the installed cost of the individual measure. The logic is that by making sure every measure in a given project is cost effective, the entire project and program as a whole will also be cost effective. There was general consensus among the stakeholders interviewed that the current application of the TRC at the measure level, while ensuring the EEPS portfolio of programs is cost effective, is too conservative and leaves some potential savings on the table. One program administrator gave an example of this in practice, saying that after installing insulation in a home, they sometimes have not been able to air seal the home because air sealing did not pass the TRC on its own. Generally, interviewees suggested a move towards application of the TRC at the program level would be more appropriate, allowing some measures that may not individually pass the TRC to be incentivized as long as the program passes the TRC. Another potential option is to switch to an alternative cost effectiveness test altogether, such as the Program Administrator Cost Test.

Recommendation:

- **Redirect the level of PSC/DPS oversight to allow programs to be more nimble and have the flexibility to adjust and respond to the market. Specifically, the PSC should:**
    - **Set clear savings targets and budgets in consultation with NYSERDA, the IOUs and other entities based on market studies or other relevant information;**
    - **Delegate authority to DPS staff to develop, maintain and revise program guidance with the assistance of NYSERDA, in consultation with the IOUs; and**
    - **Collect only pertinent information and appropriately use that information to guide the program administrators and increase transparency.**

5 Utility Infrastructure Investment

5.1 Need for Better Resiliency

The Recent Storms impacting New York State, most notably Hurricane Sandy, made it evident that utility infrastructure and the customers served by it are vulnerable during extreme weather events. In fact, a recent storm surge report suggested that in the residential sector alone, New York State has approximately 270,000 properties potentially at risk of hurricane-driven storm surge damage with a total potential financial exposure of nearly $135 billion.[71] As a result, the Commission believes it is necessary that utilities harden their systems by investing in infrastructure specifically designed to be more resilient. While this will be a costly endeavor amounting to billions of investment dollars statewide, it is nonetheless prudent in light of the concomitant human and economic losses experienced during the recent storm events.[72] Just as a guardrail at the top of a mountain can prevent the need for ambulances below, investments made to reduce storm damage will also reduce utilities' restoration costs and times in future storms.

Utilities continuously replace and upgrade their infrastructure in order to adequately serve existing and projected customer loads and to maintain or improve system reliability and service quality. While these activities generally improve the overall quality of the system (provided the remainder of the system is not aging at a faster rate), they fall short of what is needed to advance the system to a new level that would be capable of resisting the impacts of severe weather events. To obtain a more resilient infrastructure the utilities need to rethink and revise their design standards, particularly with respect to flood level potentials, critical equipment location, and material type and size. For example, when existing circuits are rebuilt and equipment replaced, rather than simply replacing in kind and at code minimums, utilities should assess the benefits of using stronger and more storm resilient components and equipment. The utilities should interact with other out-of-state industry members to identify alternative design criteria being used, their effectiveness, and their applicability to New York. The Commission also believes that utilities should determine areas where selective undergrounding of infrastructure would be appropriate.[73] As these hardening efforts are planned, it is vital that the utilities and the municipalities they serve work in a cooperative manner to minimize permitting delays, enable right-of-way acquisitions and support vegetation management programs.

Because of the need to balance the incremental costs and rate impact associated with a more resilient design, the utilities should also develop a strategy that targets maintaining service to critical infrastructure in their respective communities.[74] In addition to design changes, the utilities will need to modify cost/benefit analyses used to evaluate if funding a project is worthwhile in their future capital programs. The Recent Storms indicate that current risk assessment processes need to be redefined to account for the potential increase in the number of storms occurring, their size, and their destructive power. The risk assessments should not only account for impacts to the utilities' own infrastructure, but the overall impact to the affected region.

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[71] Matt Chaban, *NY faces greatest storm surge threat, report says,* Crain's New York Business, May 31, 2013, *available at* http://www.crainsnewyork.com/article/20130531/REAL_ESTATE/130539982 (*last accessed* 6/19/2013) (citing the Core Logic, Storm Surge Report from 2013).

[72] Estimating the total cost of hardening efforts statewide requires defining what would be an acceptable level of interruptions during various storms, followed by an engineering analysis by each of the utilities. However, the Commission is aware that post-Sandy, Con Edison has filed a hardening plan to invest $1 billion over four years, with over $700M allocated to improving its electric system (excluding generation) and in 2006 LIPA indicated a $500 million hardening plan that would be completed over 20 years.

[73] Following any serious interruption of electric service, there is customarily an acute public interest in undergrounding all power lines. The significant cost to underground the infrastructure (estimated to be as high as $4 million per mile) may not be a viable option in certain utility service areas given the initial costs to be borne by customers and the potential ongoing impact to ratepayers' bills.

[74] In March 2009, Quanta Technology prepared a report for the Public Utility Commission of Texas that contains, among other things, a list of considerations for analyzing targeted storm hardening projects that could prove useful to New York utilities. Quanta Technology, *Cost-Benefit Analysis of the Deployment of Utility Infrastructure Upgrades and Storm Hardening Programs* (Mar. 4, 2009), *available at* http://www.puc.texas.gov/industry/electric/reports/infra/Utlity_Infrastructure_Upgrades_rpt.pdf (*last accessed* 6/19/2013).

Following Hurricane Sandy, several projects have been proposed or are currently underway to harden the system. Many of these projects focus on reinforcing substations and other components located along the coast to be capable of withstanding sizable storm surges or improving the utilities' ability to restore customers. Such project investments include one-time efforts to modify existing infrastructure by relocating critical equipment to higher locations, constructing larger flood barriers, and adding better waterproofing materials. While coastal flooding risks are readily known from Sea, Lake and Overland Surges from Hurricanes (SLOSH) model maps, similar easy-to-use information regarding the effects of various floodwater heights does not exist.[75] The Commission believes that such information should be developed, under the guidance of NYS Division of Homeland Security and Emergency Services, for the major waterways within New York. By doing so, utilities and emergency preparedness groups will be able to work off of a common platform to design appropriate mitigation and response plans. An example that could provide some guidance is the Florida Division of Emergency Management's interactive mapping tool that provides a plethora of relevant information for residents and emergency responders.[76] One useful feature of this tool is that residents can input their addresses and view flood zone, storm surge zone and evacuation zone information for their homes.

Given the large number of assets comprising a utility system, many other improvement efforts consist of multiple projects under a long-term program. The Commission believes that as a starting point, the utilities should perform a health assessment for each of its asset classes (poles, transformers, etc.). This information could then be used to define and prioritize hardening programs and maximize the effectiveness of initial capital investments. The Commission believes this approach combined with new design criteria for hardening key components will better position New York during future storm events.

Recommendations:

- **The NYS Division of Homeland Security and Emergency Services should coordinate the development of flood maps for the major waterways within New York State.**

- **The PSC should direct the six investor-owned utilities to file an Asset Health Report for all of its major asset classes to be used in prioritizing and maximizing the effectiveness of the utilities' capital expenditure filings. LIPA should also be required to conduct a comparable asset health assessment.**

5.2 Improving Infrastructure Under A Cost Constraint

Average New York utility rates are among the five highest in the country.[77] The precise rank varies by type of customer and by utility, but the State's competitive position is not an enviable one. This situation complicates the task of improving utility infrastructure in the areas the Commission has highlighted. However, the State is not confined to a choice between making vital improvements on the one hand and preventing cost increases that would erode its competitive position on the other.

[75] While FEMA flood maps are available, the maps only identify the risk of an area being flooded and the coverage of different water heights.
[76] FloridaDisaster.org, http://map.floridadisaster.org/gator/map.html?config=config_evac_zone.xml *(last accessed* 6/19/2013).
[77] Average Price by State by Provider (EIA-861), U.S. Energy Information Administration (Oct. 1, 2012), *available at* http://www.eia.gov/electricity/data/eia861/ (*last accessed* 6/19/2013).

The total bill paid by all New York customers to all New York utilities at the end of 2010 was $23.7 billion.[78] Five years earlier, it was $20.9 billion. Five years before that, it was $16.2 billion. The Commission strongly recommends review and reduction of utility costs in any area in which they seem out of line with national averages in order to make revenues available for necessary infrastructure improvements. While some costs are on the table for serious scrutiny in individual rate cases, some are not. Inefficient configuration of utility service territories may be one area of potential savings. Tradeoffs between bill stability, infrastructure enhancement and renewable energy goals should also be reviewed.

Sound comprehensive policymaking in the electric utility sector is frustrated by the difficulty in getting all of these issues on the same table at the same time. Instead, separate debates take place in separate forums concerning rate levels, climate goals, taxation, economic development and demand side management. When these issues are addressed separately, the "solution" to any one problem tends to exacerbate others. Parties cannot make concessions in one proceeding because the concessions that they need in return are controlled by other parties in other proceedings before other decision makers.

5.2.1 *Options for Funding Infrastructure Improvements*

Under the constraint of not directly raising rates to provide for funding of storm hardening infrastructure investments, the Commission identified potential options, including redirecting existing utility assessment funds, redirecting clean energy funds, and development of a new "feebate" type program where fees and rebates are used simultaneously to encourage a specific behavior. Such funding mechanisms could be designed similar to that used under the American Recovery and Reinvestment Act of 2009, where specific projects could be proposed by the utilities for funding and they would be evaluated based on their potential benefits and other predefined criteria (such as geographic and utility service territory equity). Each of these approaches is discussed in more detail below.

Option 1: Redirection of Existing Electric Assessment Funds

Section 18-a of New York Public Service Law authorizes the State to impose an assessment on public utilities to fund costs and expenses of DPS and PSC, limited to one percent of the utilities' gross operating revenues. In 2009, a "temporary state energy and utility service conservation assessment" was added to this section of law, amounting to two percent of the utilities' gross operating revenues minus the traditionally funded costs and expenses of DPS and PSC; this new assessment is credited to the State General Fund. In 2010, the amount credited to the State General Fund was $519 million, as compared to the $69 million that went to DPS/PSC to support their regulatory responsibilities. Similar amounts went to the State General Fund and DPS/PSC in subsequent years as shown in Figure 4 below.

Figure 4: 18-a Collections for PSC/DPS Funding vs. State General Fund

18-a Collections	2010-11	2011-12	2012-13
PSC/DPS Funding	$69,205,806	$62,333,038	$72,353,000[79]
State General Fund	$519,018,900	$527,094,371	$508,670,498

[78] State Electricity Profiles, U.S. Energy Information Administration, Table 8, Line 21 (Jan. 30, 2012), http://www.eia.gov/electricity/state/NewYork/ (*last accessed* 6/19/2013).
[79] This figure reflects the August 2012 revised billings and the 18-a Enacted Budget numbers. The final numbers for FY2012 will not be available until October 2013.

If, rather than going to the State General Fund, the funding collected as part of the temporary state energy and utility service conservation assessment were used to support infrastructure hardening investments, it could go a long way to preparing for future weather events without requiring collections from ratepayers beyond what they currently provide. The potential downside to such an approach is that redirecting these funds would then presumably leave a hole in the State General Fund of the same size that would need to be addressed. Also, as indicated by its name, the assessment is temporary and set to expire in 2017; if this funding were redirected until then, there would again be the issue of how to pay for such infrastructure investments beyond that time.

Option 2: Redirection of Clean Energy Funds

The State has collected hundreds of millions of dollars from ratepayers over the last decade to fund its clean energy programs, including EEPS, RPS, and SBC. Some of this funding that has been collected remains unspent and uncommitted, specifically $108.5 million of EEPS and $39.5 million of SBC.[80] Furthermore, the second phase of the EEPS program (EEPS II) is authorized to collect $2.1 billion via a ratepayer surcharge for energy efficiency programs offered from 2012 through 2016.

The clean energy programs support a variety of State policy objectives identified in the State Energy Plan, including maintaining reliability, reducing greenhouse gas emissions, stabilizing energy costs and improving economic competitiveness, reducing public health and environmental risks associated with energy production and use, and improving the State's energy independence. However, as natural gas has become ever more prevalent in electric generation, and particularly as its cost is low, it makes the relative cost for energy efficiency and renewable investments greater.

While the Commission believes these clean energy program investments are important, it also recognizes the importance of electric infrastructure hardening investments at a time when ratepayers' wallets are stretched thin. Given this situation, the Commission sees the diversion of a *portion* of these clean energy program collections, in particular, the funding that remains unspent and uncommitted, to infrastructure hardening investments as an option to consider; however, this unspent and uncommitted amount falls significantly short of the level of investment needed for infrastructure hardening. Similar to Option 1, funding for the clean energy programs going forward is currently set through only 2018, so if a portion of these funds were redirected for infrastructure investments, there would again be the issue of how to pay for such infrastructure investments beyond that time. Also, and perhaps more importantly, redirecting clean energy funds for alternative uses sets a bad precedent. There will always be competing needs for ratepayer funding to support State policies and the energy market fluctuates, thereby changing the relative costs of energy sources. However, these clean energy programs are long-term investments in support of policies that are meant to move the State toward all of its energy-related objectives stated above. If clean energy programs were instead pursued only when they provided the greatest economic benefit over more traditional energy sources, they would likely be limited in success due to the sporadic signals being sent to the market.

Option 3: Development of an Anti-Hurricane Feebate Program

While not necessarily without ratepayer impact, the third option the Commission considered was an Anti-Hurricane "feebate" program. A feebate program is designed to use both imposition of fees and distribution

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[80] With respect to the second phase of EEPS (2012-2015) and RPS, there are currently no funds that have been collected and encumbered but remain unspent due to discontinued programs or abandoned projects. Any funds that were encumbered for projects and subsequently discontinued/disencumbered were rolled back into the program in an effort to achieve program goals.

of rebates to incent particular behavior through penalties and rewards. An Anti-Hurricane feebate program could include a fee on ratepayers' bills to collect funding for infrastructure hardening investments and to provide rebates to any ratepayer who cuts their energy use by a certain percentage over a number of years, thereby incentivizing energy efficient behavior while simultaneously raising funding for hardening investments. While this would entail a new charge to ratepayers, it would also give them control over the amount of such fee or rebate and ultimately prevent potentially even greater cost repairs to the system following a storm event.

The Commission believes the State must assume that the types of storm events seen in recent years will continue to happen on a frequent basis. Therefore, storm hardening is necessary and must happen quickly to protect the ratepayers from economic and health impacts of future events. Furthermore, the Commission believes that to be financially responsible and contain costs for the ratepayers, the State must first explore any and all funding alternatives that do not increase rates. Where possible, it should re-direct excess ratepayer dollars to infrastructure investments, particularly before instituting cuts in energy efficiency spending.

Recommendations:

- **The State should at a minimum redirect the Public Service Law § 18-a funding that is currently collected from ratepayers as the temporary state energy and utility service conservation assessment and provided to the State General Fund to support electric infrastructure hardening investments.**
- **The State should consider the other options identified herein as well as any other funding mechanisms and efficiencies available to support electric infrastructure hardening investments.**

~~6 Improving Regulatory Deficiencies~~

~~Throughout our work the Commission has been struck by one overarching shortfall. The people of New York have not been well served by aspects of the diminution and reorientation of utility regulation over the past 20 years. The Commission believes that the PSC of the 1970s, chaired by Joseph Swidler and then by Alfred Kahn and then again under the leadership of Peter Bradford from 1987 to 1995, was a national model. Its decisions were widely emulated and cited and it was staffed by recognized leaders in most of its fields. Top staff positions were filled on a nonpartisan basis and rarely if ever changed for political reasons.~~

~~The decline of New York utility regulation has been as much a product of national trends as of any particular ideology. Telecommunications is no longer dominated by monopoly companies. Neither is electric generation. Neither is the supply (as distinguished from the delivery) of natural gas. Each of these steps substituted competition for regulation and led to downsizing of the PSC.~~

~~The last two decades have also seen a trend toward so-called "performance based regulation," pursuant to which utilities and the PSC agree not to undertake rate cases for extended periods. The intention, in part, is to provide incentives to cut costs in order to increase profits (or avoid losses) in the absence of rate changes.~~ Various performance indexes replace close regulatory oversight in assuring that service doesn't decline.

INVESTIGATIVE FINDINGS AND RECOMMENDATIONS

7 THE COMMISSION'S INVESTIGATION

7.1 INVESTIGATIVE SUMMARY

The Moreland Commission's investigation into New York's IOUs has uncovered systemic problems within the industry, including inefficiencies, disorganization and lack of planning. The Commission has also found that, despite repeated recommendations from the PSC, the IOUs have consistently failed to improve certain areas of their electric operations. This unwillingness to reform is especially concerning given that these utility companies are conferred natural monopolies. The devastation suffered during the Recent Storms and the Commission's investigative findings have affirmed the need for industry reform. As the Commission proceeded in its investigation, it remained mindful that not all the utilities were affected by the same storms and some faced unique challenges based upon the location and topography of its service area.

7.1.1 LACK OF PREPARATION FOR RISK OF FLOODING.

The Commission found that a number of utilities were not adequately prepared for the effects of damage caused by widespread flooding during Hurricane Irene, Tropical Storm Lee and Hurricane Sandy. While these utilities took some actions to protect their own infrastructure, it was often not enough to prevent sizable interruptions to service. In addition, these utilities did not have a plan in place to isolate and restore customers who experienced damage to their own equipment. This was most notable with Con Edison's need to develop an expedited inspection process following Hurricane Sandy, which took over a week to develop and publicize. In addition, the Commission's investigation found that the utilities' emergency plans lacked formalized processes for dealing with the restoration of homes and businesses that were shut off due to severe flooding. In short, the lack of flood restoration planning was a significant problem experienced during Hurricane Irene, Tropical Storm Lee and Hurricane Sandy, causing customer confusion and unnecessary delays in restoration.

7.1.2 LACK OF LOCALIZED ESTIMATED RESTORATION TIMES (ETRS)

The Commission found that the IOUs continue to struggle to provide timely, accurate estimates for when power will be restored to their service areas. Such estimates are essential for allowing customers to plan for the outage period. Based on Grid New York's slow issuance of ETRs following the 2008 Ice Storm, the DPS developed guidelines to help ensure ETRs are made public in a timely manner.[107] For example, for events predicted to last more than five days (as applied to both Hurricanes Irene and Sandy), utilities are expected to develop global ETRs within 48 hours of the start of the restoration period. Additionally, because—to varying degrees—utilities do not have complete field information to come up with an informed estimate within that time period, the initial ETR should indicate that a comprehensive damage assessment has not been completed, and that the ETR may change once additional field information is gathered.

Certain utilities repeatedly failed to develop timely, accurate local ETRs. O&R is one notable example. Its failures during Hurricane Sandy are of concern given its problems with ETRs in prior storms, which the DPS

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[107] New York State Department of Public Service, *Report on Utility Performance for October and December 2008 Winter Storms*, at 22 (June 2009) [hereinafter DPS 2008 October & December Winter Storms Report]. (stating that by delaying the release of an ETR, National Grid did not provide the information needed by customers and emergency management personnel to allow them to make informed decisions).

has repeatedly criticized in past storm investigations. The Commission also notes that while NYSEG was ultimately able to issue ETRs for its divisions, it failed to provide more granular ETR information to customers. NYSEG's philosophy, like some of the utilities investigated, is to "under promise and over deliver."[108] The Commission notes that the PSC is currently soliciting comments on a utility performance scorecard that contains proposed metrics regarding the accuracy and publication of ETRs to better measure ETR performances.[109]

It is clear from the Commission's investigation that New York's electric utilities need to improve their development and timely issuance of ETRs. Customers deserve to have accurate estimates of when their lives will return to normal.

7.1.3 Unreliable Technology in Major Storms

A number of the utilities' website outage maps suffered glitches and malfunctioned during Hurricane Sandy. Customers increasingly rely on website outage maps for outage information. O&R's outage map was at times inaccurate and suffered a number of glitches. Con Edison's outage map was also problematic, which confused customers during the restoration period. National Grid also suffered problems with its outage map during both Hurricanes Sandy and Irene. National Grid's outage map suffered delays and was sluggish and unusable at times. The outage map and technology failures were in part tied to failures in the utilities' computerized outage management systems, which in many cases failed to keep up with increased user volume during emergency conditions.

7.1.4 Coordination with Local Governments

Coordination and communication with local governments and public officials was another problem area for the utilities during the Recent Storms. Con Edison, NYSEG and O&R municipal liaisons were largely ineffective and incapable of providing any more information than that contained on the utilities' public websites. In addition, O&R and Central Hudson did not adequately staff their municipal liaison departments for Hurricane Sandy. This caused local governments undue confusion and impeded coordination efforts between the utilities and local government officials. The lack of coordination between local governments and the utilities was especially obvious in O&R's ineffective coordination of road clearing of its down wires with local governments' tree removal efforts during Hurricane Sandy.

7.2 Industry Reforms and Recommendations

7.2.1 Mutual Assistance System Needs Reform

Utility staffing levels are based on daily and annual forecasted workloads. As a result, the utilities do not have the required field personnel at hand to effectively respond to large storms, and therefore need to supplement their workforce by obtaining crews from other neighboring utilities. This mutual assistance process follows the Edison Electric Institute's (EEI) governing principles, in which nine established Regional Mutual Assistance Groups (RMAGs) coordinate the sharing of resources within their respective states.[110] Utilities serving New York are part of the New York Mutual Assistance Group (NYMAG). Therefore, for a New York

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[108] NYSEG "Estimated Restoration Time (ERT) Philosophy" (NYSEG-RGE 00014856).
[109] New York State Public Service Commission, Case 13-M-0140 Proceeding on Motion of the Commission to Consider Utility Emergency Performance Metrics (Apr. 18, 2013).
[110] RMAGs are as follows: Northeast Mutual Assistance Group, New York Mutual Assistance Group, Mid-Atlantic Mutual Assistance Group, Great Lakes Mutual Assistance Group, Southeastern Electric Exchange, Wisconsin Utilities Association Mutual Assistance Group, Midwest Mutual Assistance Group, Texas Mutual Assistance Group, Western Region Mutual Assistance Group.

utility to obtain assistance, it would request crews via NYMAG conference calls.[111] The request would be fulfilled by other utility crews in New York, if available, or NYMAG would reach out to other RMAGs for assistance. The utility requesting the crews is responsible for reimbursing the utility(s) providing the crews for the days that they are away, even if a storm does not impact the area.

The Commission has identified numerous problems with the industry's current mutual assistance systems. While the Commission acknowledges the benefits of mutual assistance in general, it has concerns with the effectiveness of the current system during large-scale storm events. First, the number of people of who are routed through the system prior to storms is limited to utility workers and not contractors or other skilled personnel. Because of the limited pool, there is little movement within the process early on, since utilities are reluctant to offer their workforce until a storm's impact on their system is known. Con Edison's efforts to obtain resources from the mutual assistance process in advance of Sandy are illustrative in this regard. Prior to Sandy's arrival, Con Edison requested field staff through the mutual assistance process to supplement the limited crews it had obtained. On October 25, 2012, Con Edison requested 1,800 lineworkers, but was only allocated 32 people on October 27, 2012, (from San Diego Gas and Electric Company). On October 28th, Con Edison raised its request to 2,500 line workers and was allocated 171 additional crews from Pacific Gas and Electric.[112] Despite airlifting personnel and vehicles, the support did not arrive until the evenings of October 31, and November 2, 2012.

Second, the system restrains movement between RMAGs, so worse hit areas must wait for crews until lesser affected areas are close to full restoration. While this provides security for the individual RMAGs, it hampers appropriate responses on a national level.

Third, attempts to obtain assistance outside of the RMAG system—such as by petitioning other utilities directly for additional crews without engaging the appropriate mutual assistance group—weaken the mutual assistance function by further reducing the number of crews that are available to them through the mutual assistance process.

Each of the three areas identified above interact with each other, undermining the efficiency of the system and creating a highly competitive process for utilities to obtain outside resources on their own. Because of the uncertainty of the mutual assistance process, Grid New York told the Commission that it uses the NYMAG and RMAG processes as a last resort for obtaining crews to assist in its restoration efforts. As an alternative to the mutual assistance process, Grid New York tends to "crew up" for storm events several days prior to activation of the NYMAG and RMAG processes.[113] Grid New York's securing of contractor resources prior to other utilities has also led to concerns and criticisms relating to the Company incurring costs for crews well in

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[111] Mutual assistance conference calls are held in advance of a storm and throughout the restoration period until there are no outstanding requests.

[112] Consolidated Edison Company of New York, Inc. Report on Preparation and System Restoration Performance, Sandy October 29 through Nov. 12, 2012, at 58 (Jan. 11, 2013) [hereinafter Con Edison Sandy Part 105 Report]; Oct. 26, 2012 Email re: Mutual Assistance Summary (CE_00013356) (where Tony Torphy, Director, Electric Operations for Emergency Management, Con Ed, reports that Con Edison received no mutual aid crews even though it requested 1,800 FTEs. He notes "the only available resources east of the Rockies were 139 FTEs in the Mid-West Mutual Assistance Group. These 139 workers were distributed to the MAMA and NYMAG companies.").

[113] May 15, 2013 Interview of Allen Chieco (Director of Network Strategy for Electric, National Grid New York) [hereinafter Chieco Interview]; May 28, 2012 Kenneth Daly (President of National Grid New York) Hearing Transcript, at 22-23 [hereinafter Daly Transcript] (recalling that Grid New York began looking for outside resources nearly a week before Hurricane Sandy made landfall); May 28, 2013 Interview of Bill Akley (Senior Vice President of Maintenance and Construction, National Grid) [hereinafter Akley Interview].

advance of a storm when the need for crews is still uncertain.[114] It was noted that in the event that Grid New York has excess crews for its restoration efforts during major storm events, it will release these crews to New York State utilities.[115]

Overall, the mutual assistance process appears to function better during smaller and more localized events. In addition, the deficiencies discussed above have been amplified as the mutual assistance process is expanded to include resources for damage assessment, public safety, and logistics. In order to ensure that the mutual assistance process plays a more significant role in providing resources at the outset of large storm responses, the Commission believes that national reforms are needed to address these deficiencies. One possible step would be to include contractor crew allocations prior to a major storm event.

Train National Guard to Assist in Storm Preparation and Restoration

During Sandy, Con Edison, O&R and NYSEG received help from the National Guard (Guard).[116] The Commission believes that consideration should be given to expanding the Guard's role in supporting restoration efforts for all utilities in major storm events. This would require significant planning and coordination between State officials, the Guard and utilities to reach consensus on the circumstances under which the Guard would become involved, the functions its members would play, and the effective integration of Guard members into the utility restoration efforts. In discussions with the utilities, the Commission has identified a potential role for Guard members in pre- and post-storm functions, some of which would require training, including assessments of electrical equipment and damaged homes, the coordination with utilities for removal of downed wires and trees, and set-up and operation of staging areas and base camps.

The use of the Guard should be able to be integrated seamlessly going forward since the utilities currently use their non-operational personnel for specific storm operations (i.e. storm role)[117]. Because the assignments may be different than an employee's normal "blue-sky" role, each utility has defined training programs to instruct employees on how to perform their assigned tasks. Additionally, many utilities hold "refreshers" in the days prior to predicted storms to help mitigate inaccuracies during an event. For example, damage assessors within Con Edison undergo a four-hour course. To better understand the overhead electric system, the course is divided between two hours of classroom study and two hours at Con Edison's Learning Center where there are physical examples of equipment, poles and other electrical equipment. In addition to classes, companies, such as Central Hudson, have pre-printed cards on a ring to assist damage assessors correctly identify equipment when in the field.

The Commission believes that the utilities should identify the best practices used to train and instruct Guard personnel in the areas previously identified. In order for the Guard to be most effective and be able for deployment across the state, the training should be developed using a common platform and methods to

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[114] Daly Transcript, at 23-24; May 17, 2013 Interview of Dave Ethier (National Grid Eastern Division Director of Overhead Lines) [hereinafter Ethier Interview] (noting that, under the industry procedures for obtaining foreign crews, the company that solicits the crews begins paying for the crews' time as soon as the crews begin traveling to that utility's territory).

[115] Ethier Interview; May 23, 2013 Interview of Ellen Smith (former National Grid Chief Operating Officer) [hereinafter Smith Interview]; Daly Transcript at 47 (describing how Grid releases crews to Con Ed, LIPA, and Central Hudson as applicable).

[116] To deal with the shortage in site safety personnel, some companies eventually engaged resources from the National Guard. This could be a long-term solution for obtaining additional site safety resources in future storms.

[117] For example, Con Edison has indicated that the majority of its employees have a System Emergency Assignment.

identify and report electric components or other deficiencies in a consistent manner. The program should identify how often training should occur as well as when refresher training prior to the National Guard field deployment is appropriate.

Recommendations for utilities:

- **Engage in an industry-wide effort to address deficiencies in the current mutual assistance process.[118]**
- **Re-examine internal and external emergency staffing plans to address any perceived shortages in site safety or damage assessment personnel.**
- **Consideration should be given to expanding the National Guard's role in supporting utility restoration efforts in major storm events.**

7.2.2 Coordination With Telecommunication and Cable Providers

Utility Coordination with Telecommunication Providers

A large segment of New York's population rely upon their phone service, including that provided by voice over internet protocol, and the internet for communicating during weather emergencies. Therefore, it is essential that these industries coordinate a means to share customer information in order to create a more efficient restoration process to better serve New Yorkers. The extent of the Recent Storms and resulting outages highlighted the dependency of telecommunications equipment on commercial power. While many major telecommunications facilities have permanent generators as a backup, certain locations (e.g., a cellular tower) may only be equipped with batteries that have limited backup capacity. With some exceptions, the communication between the electric utilities and telecommunications providers to address these issues was inadequate.

Improvements could include having the electric utilities provide telecommunication providers with senior management level contacts or providing power restoration information to telecommunication providers through State Office of Emergency Management (OEM) reports. Whatever mechanisms are adopted, it is clear that effective communication between these two industries is essential, as it ensures that emergency responders and customers have a means to effectively communicate during a long-term event. As such, the Commission believes that government entities, including the Federal Communications Commission, should examine and make recommendations with respect to, among other things, the extent to which a telecommunications provider should be self-sufficient and the best means for communicating between the telecommunication and electric utility industries.

Utility and Cable Provider Coordination

An electric utility only needs a limited number of monitoring devices to manage its operation. As a result, however, a utility's ability to measure outages in localized areas is extremely limited during storms. Utilities must therefore rely on customers to inform the company, typically via telephone calls, that the power is out at a particular location. Outage information gathered from all sources is entered into a utility's Outage Management System (OMS), which models its electric system and the components on a scale such that the

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[118] The Commission interviewed representatives from the Edison Electrical Institute, which is currently leading a taskforce to examine mutual assistance and material resources. The Institute plans on making specific recommendations on these issues to its Board of Directors, made up of representatives from the electric utility industry, in June 2013.

utility can tell which transformer serves an individual account. While more devices with monitoring capabilities are being installed, the reactive nature of having to wait for outage reports is prevalent.

Unlike the electric system, today's cable systems employ two-way communications, enabling the cable providers to offer services such as video on demand and facilitating the transmission of system status information back to the cable provider. One such piece of information provided back to the service provider is whether particular network devices (cable boxes or nodes, for example) have power. This proactive method of collecting outage location information would be advantageous to electric utilities because it can rapidly identify the extent of outages in neighborhoods or on streets. Additionally, as the restoration progresses, the technology would allow for the identification of single homes still without power, a more onerous task currently performed by using outbound calls or waiting for customers to re-report an outage.

The Commission recommends that all New York investor-owned utilities and Long Island's next utility provider coordinate with their local cable company (or companies) to obtain cable network information related to loss of power during a storm.[119] One way to accomplish this is through increased communication between the utilities and their cable providers, and/or placement of utility and cable personnel within each other's emergency command centers.

Recommendations for all utilities:

- **Formalize coordination with telecommunication and cable providers before and during major events, including the placement of utility and cable personnel within each other's emergency command centers.**
- **Cable providers and utilities should devise a means to share relevant system information during emergency periods.**
- **Re-evaluate utility emergency plans in light of the Recent Storms and ensure that critical infrastructure lists include critical telecommunication and cable facilities.**

7.2.3 Coordination Between Utilities and Government to Create Automated Emergency Waiver Protocols

During the restoration process, utility crews and their equipment must be able to travel freely and safely between service areas, and sometimes across state and national borders. However, their travel during Hurricanes Irene and Sandy was at times delayed by unnecessary logistical hang-ups at toll roads, bridges and customs entry points.[120] Utilities had to scramble to obtain emergency waivers and permits in the midst of the restoration effort: for example, as mutual assistance crews were traveling to Con Edison's service territory, Con Edison was in the process of obtaining certain waivers and permits, such as high-occupancy

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119 During Hurricane Sandy, through Cablevision's encouragement, Cablevision and LIPA began to work together to exchange such information as part of the storm response effort by using Cablevision's proprietary mapping software. The Moreland Commission requested to review Cablevision's software to understand the full potential of the two-way communication process.

120 Akley Interview; Observation Tracker (NG-E-00533119) ("Need mechanism to provide emergency declaration letter to ops . . . Should coordinate river crossings, bridges with local law enforcement – if possible – in advance of event"); Dec. 12, 2012 Email re: No toll charges for Mutual Aid vehicles (NG-E-00228142) (email chain discussing the need for toll waivers, EZ Passes disseminated, and other advanced planning by municipalities for crews to seamlessly access New York regions).

vehicle lane exceptions and toll waivers.[121] Likewise, NYSEG reached out to the New York State Department of Transportation (DOT) during the restoration period to ensure that heavy equipment being moved into the area had waivers to use certain bridges and roadways.[122] Procedures and processes need to be developed to avoid these emergency responders being unnecessarily delayed in assisting with storm restoration. To that end, utilities should work with government agencies to identify, to the extent practical, protocols to automatically enact emergency waivers based on predicted storm conditions to allow for more streamlined response processes.

Recommendation:

- **Work with governing entities to explore the possibility of developing a process to enact waivers or other simplifications of permits and tolls to assist crews traveling to aid in restoration efforts.**

~~*7.2.4 Communications with life Support Equipment Customers*~~

~~Under 16 NYCRR Section 105.4(b)(9), the New York electric utilities are required to include in their Emergency Plans specific procedures for contacting life support equipment (LSE) customers within the first 24 hours of a pending emergency.[123] Incorporation of best practices over time has resulted in utility emergency plans that provide for notification prior to an event as well as daily contacts throughout the restoration period. To help assist with customers that were not reachable by phone, many utilities have developed policies that refers these unreachable customers to first responders or emergency management offices who physically go to the customer premises to establish contact.~~

~~As part of DPS's review of Hurricane Irene and Tropical Storm Lee performance, it noted that the electric utilities should work with referral entities to strengthen follow-up processes and to ensure that feedback regarding LSE customers that have been referred for contact assistance is obtained and recorded. Con Edison, for example, has established a separate telephone number for use between it and local police departments to discuss LSE customers who were not contacted. Additionally, there are proactive measures taken by utilities to contact the referral entities if they do not receive any information. By "closing the loop" with the referral entity, the utility maintains appropriate awareness of the status of these customer to know if they are safe or in need emergency assistance. The Commission sees value in coordination between the utilities and county or municipal agencies, i.e., Departments of Social Services or Aging, who may be in a position to offer staff resources to assist with LSE customer outreach during emergency events when utilities' staff resources are stressed.~~

~~**Recommendation for all utilities:**~~

- ~~**The PSC should direct the investor owned utilities to codify in their Emergency Plans the modified LSE outreach processes as described above, including coordinating with**~~ **county and municipal agencies. This recommendation should also be applicable to LIPA.**

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[121] Apr. 4, 2013 John Miksad (Senior Vice President of Electric Operations, Con Edison) Hearing Transcript at 50:2-11 [hereinafter Miksad Transcript].
[122] Apr. 4, 2013 Mark Lynch (President, NYSEG & RG&E) Hearing Transcript at 124 [hereinafter Lynch Transcript].
[123] LSE customers is defined in 16 NYCRR Part 105 as those who require electrically operated machinery to sustain basic life functions.

Comparing the Impacts of Northeast Hurricanes on Energy Infrastructure

Office of Electricity Delivery and Energy Reliability

U.S. Department of Energy

April 2013

Storm Comparison

This report compares two major hurricanes that hit the Northeastern United States in 2011 and 2012 and their impacts on energy infrastructure. Hurricanes Irene and Sandy were large, powerful storms that caused extensive damage across much of the Mid-Atlantic and Northeast. The National Oceanic Atmospheric Administration (NOAA) ranks both storms among the costliest and deadliest weather events in U.S. history.[1] Although Sandy was weaker than Irene when it first made landfall in the United States, Sandy was much larger, with tropical storm-force winds reaching as far as 500 miles from the center of the storm. Table 1 compares aspects of each storm. Figure 1 and Figure 2 on page 3 present satellite photographs of Irene and Sandy as they approached the U.S. mainland.

Table 1. Irene vs. Sandy Storm Comparisons

	Irene	Sandy
Landfall Date	August 27, 2011	October 29, 2012
Strength at First U.S. Landfall	Category 1 Hurricane	Post-Tropical Cyclone
Landfall Location (sustained winds)	8/27 – Cape Lookout, NC (90 mph) 8/28 – Little Egg Inlet, NJ (80 mph) 8/28 – Coney Island, NY (75 mph)	10/29 – Atlantic City, NJ (80 mph)
Distance of Tropical Storm-Force Winds from Center	300 miles	500 miles
Peak Flooding	New York City* – 9.5 feet Philadelphia – 9.9 feet	New York City* – 14.1 feet Philadelphia – 10.6 feet
Property Damage	$10 billion	Est. $20+ billion
Deaths	45	131

*The Battery

Sources: NOAA, EQUECAT, Property Claim Services, press

Irene

Irene made landfall as a category 1 hurricane in the Outer Banks region of North Carolina on the morning of August 27, 2011. In the days that followed, Irene tracked towards the Northeast, making its second U.S. landfall in New Jersey and its third and final U.S. landfall in Brooklyn, New York. Torrential rain and storm surges of 3–4 feet caused significant river flooding across eight States, including New York, Vermont, and New Jersey. The flood waters brought by Irene constituted one of the worst flood disasters ever recorded in the Northeast.[2] According to the National Weather Service, total water level peaked near 9.5 feet above the mean lower low water level at Battery Park in New York City, and at 9.9 feet along the Delaware River in Philadelphia.

Irene was unusually large, with tropical storm-force winds extending nearly 300 miles from its center. Irene was also a slow-moving storm, traveling at a top speed of 20 miles per hour (mph), compared to speeds of 30–40 mph for similarly sized storms. According to NOAA, Irene caused

[1] "Billion-Dollar Weather/Climate Disasters." NOAA. NCDC. http://www.ncdc.noaa.gov/billions/events
[2] State of the Climate Hurricanes & Tropical Storms August 2011. NOAA. NCDC. http://www.ncdc.noaa.gov/sotc/tropical-cyclones/2011/8.

45 deaths and $10 billion in property damage, making it one of the deadliest and costliest storms in U.S. history. In late October 2011—2 months after Irene made landfall—a historic and unprecedented early season winter storm (known as a Nor'easter) deposited more than one foot of heavy wet snow on interior portions of northeastern New Jersey, the Lower Hudson Valley, and southern Connecticut.[3]

Sandy

Sandy made landfall near Atlantic City, New Jersey on October 29, 2012 after transitioning from a tropical cyclone to a post-tropical cyclone. The storm had maximum sustained winds of 80 mph. Although weaker than Irene when it made landfall, Sandy was a larger storm, with tropical storm-force winds extending nearly 500 miles from the storm's center.[4] The storm's impact was recorded across 24 States, although not all of these States had measurable energy impacts. Sandy brought a large storm surge and high water levels to the coastal Northeast, where New Jersey, New York, and Connecticut experienced the greatest impact. Record water levels were observed at Battery Park in New York City (14.1 feet) and along the Delaware River in Philadelphia (10.6 feet). In addition to wind, rain, and storm surge impacts in coastal areas, Sandy also brought blizzard conditions to the Central and Southern Appalachians, where over a foot of snow fell in six States from North Carolina to Pennsylvania.

Sandy caused large-scale flooding and wind damage across the Mid-Atlantic and Northeast. Preliminary estimates indicate that Sandy led to at least 131 fatalities, and more than $20 billion in property damage, making it another one of the deadliest and costliest weather events in U.S. history.

More than a week after Sandy made landfall, an early-season Nor'easter brought wind, snow, rain, and storm surge to parts of the Northeast still recovering from Sandy. Locations in New Jersey, New York, and Connecticut reported record November snowfall figures as a result of the storm.[5]

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[3] "October 29th Historic Early Season Snowstorm." National Weather Service New York, NY. http://www.erh.noaa.gov/okx/StormEvents/10292011/index.html and "Transmission and Facility Outages during the Northeast Snowstorm of October 29-30, 2011" Federal Energy Regulator Commission and North American Electric Reliability Corporation. http://www.ferc.gov/legal/staff-reports/05-31-2012-ne-outage-report.pdf

[4] "National Summary Information - October 2012." NOAA National Climatic Data Center. http://www.ncdc.noaa.gov/sotc/summary-info/national/2012/10

[5] "Significant Events from November and Autumn 2012." NOAA National Climatic Data Center. http://www1.ncdc.noaa.gov/pub/data/cmb/images/us/2012/nov/monthlysigeventmap-112012.gif

Figure 1. Hurricane Irene Day before First U.S. Landfall (August 26, 2011)

Figure 2. Hurricane Sandy Day before First U.S. Landfall (October 28, 2012)

Source: NOAA

Storm Surge and Tides

Flooding resulting from storm surge and storm tides was a major problem affecting energy assets during Hurricanes Irene and Sandy. *Storm surge* is an abnormal rise in water levels generated by a storm, over and above the predicted astronomical tides. *Storm tides* are the abnormal rise in water levels due to a combination of storm surge and the astronomical tide. This rise in water level can cause extreme flooding in coastal areas, particularly when storm surge coincides with the normal high tide.[6] Table 2 shows storm tides as recorded at select locations along the East Coast following Irene and Sandy. In many cases, storm tides caused by the hurricanes exceeded previous maximum water level records.

Table 2. Maximum Recorded Storm Tides (Feet)* by Select Location and Storm

Location	Irene	Sandy
Wilmington, NC	5.24	5.91
Washington, DC	3.87	6.11
Baltimore, MD	2.98	4.66
Philadelphia, PA	9.93	**10.62
Atlantic City, NJ	6.96	8.90
Bergen Point West Reach, NY	**10.22	**14.58
The Battery, NY	9.50	**14.06
New Haven, CT	**11.57	**12.25
Providence, RI	8.25	9.37
Boston, MA	11.95	12.92
Portland, ME	11.96	11.90

*Referenced to Mean Lower Low Water (MLLW)
** Maximum recorded water level value exceeded historical maximum value.
Source: NOAA Center for Operational Oceanographic Products and Services

The storm tide during Sandy was more severe and had a greater impact on energy assets than the storm tide during Irene. Table 3 provides an analysis of spatial inundation data provided by the Federal Emergency Management Agency (FEMA) following Hurricanes Irene and Sandy, geo-located against energy assets. FEMA inundation data for Irene was available for all the States listed in Table 3. Data for Sandy was available only for New Jersey, New York, Connecticut, and Rhode Island. Data for Pennsylvania was not available for either storm. Energy assets identified in Table 3 are located in areas that were fully or partially flooded but the assets may or may not have experienced water damage depending on the level of inundation, whether key equipment was protected or elevated, and other site-specific factors.

[6] "Storm Surge Overview" National Hurricane Center. National Weather Service. http://www.nhc.noaa.gov/surge/

Table 3. Number of Energy Assets Located in Flooded Areas by Storm and State

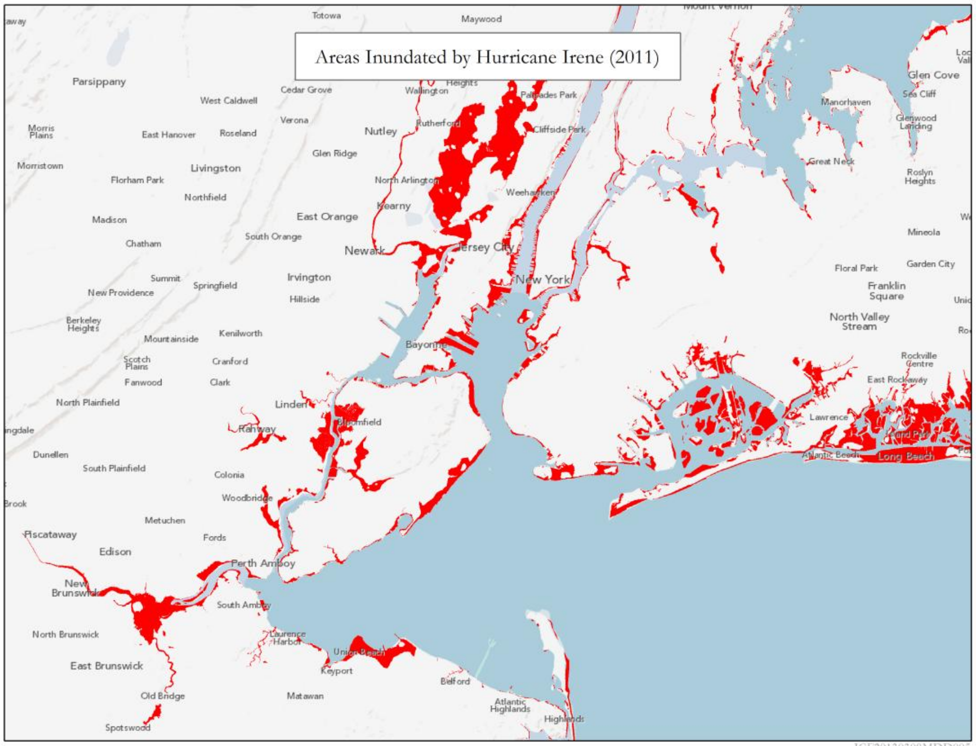
Storm	Asset Type	CT	DE	MD	MA	NC	NH	NJ	NY	RI	VA	Total
Irene	Electric Power Plant	7			1	5		19	12			**44**
	Electric Substations	9	1	3	1	8		21	12		9	**64**
	NG Compressors							1				**1**
	Oil Refineries											**0**
	Petroleum Terminals	4	2					9	7		5	**27**
	Irene Total	**20**	**3**	**3**	**2**	**13**	**0**	**50**	**31**	**0**	**14**	**136**
Sandy	Electric Power Plant	7	n/a	n/a	n/a	n/a	n/a	36	24	2	n/a	**69**
	Electric Substations	13	n/a	n/a	n/a	n/a	n/a	58	28	3	n/a	**102**
	NG Compressors		n/a	n/a	n/a	n/a	n/a	1			n/a	**1**
	Oil Refineries		n/a	n/a	n/a	n/a	n/a	1			n/a	**1**
	Petroleum Terminals	16	n/a	n/a	n/a	n/a	n/a	33	13		n/a	**62**
	Sandy Total	**36**	n/a	n/a	n/a	n/a	n/a	**129**	**65**	**5**	n/a	**235**

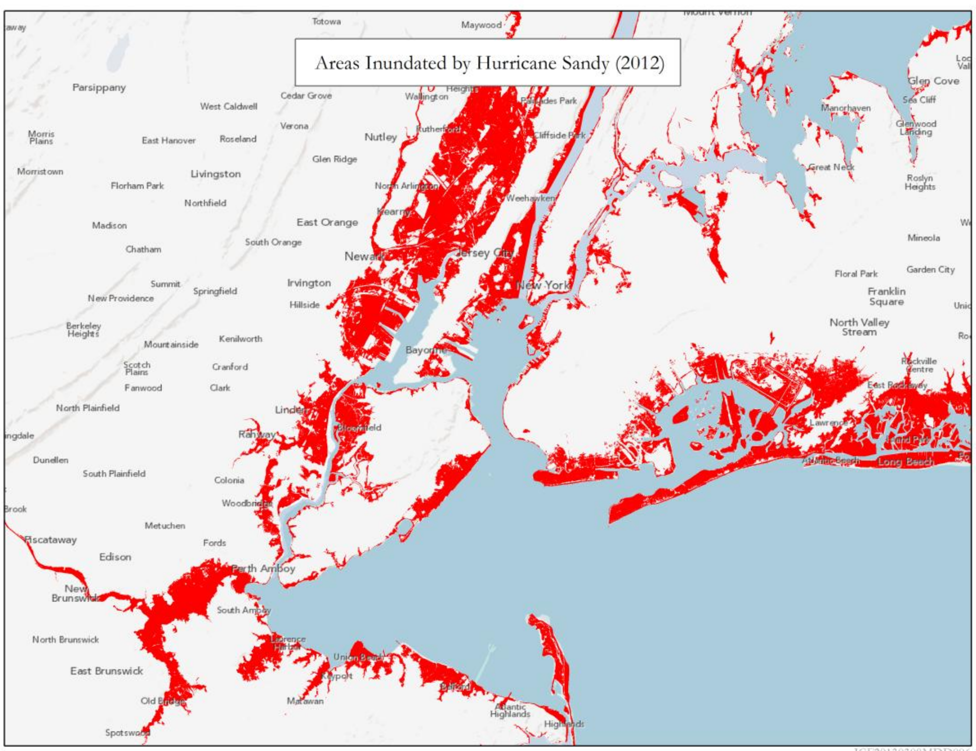
n/a = FEMA flood data are not available. PA flood data are not available for either storm.
Sources: FEMA, HSIP 2012, Ventyx, DOE

Table 3 indicates more energy assets were located in flooded areas during Sandy than during Irene, including power plants, substations, refineries, and petroleum terminals. The number of petroleum terminals in flooded areas during Sandy was more than double the number of terminals in flooded areas during Irene. During both storms, assets in New Jersey, New York, and Connecticut were the most severely affected, a factor that contributed to greater disruptions and longer restoration times for electric power service and petroleum supply chains in those States. These impacts are discussed in detail later in this report.

Flooding was a particular problem for petroleum assets located in the New York Harbor area during Irene and Sandy. Figure 3 shows a wider area of inundation in New York Harbor during Sandy than Irene, and NOAA's tidal gauge on Staten Island (See Bergen Point West Reach, NY in Table 2) measured a higher storm tide on the Kill Van Kull in New York Harbor during Sandy (14.58 feet) than during Irene (10.22 feet). Phillips 66's 238,000 barrel per day (b/d) Linden, New Jersey refinery reported that it sustained flooding in low-lying areas of its facility during Sandy. Petroleum terminals were also hit hard. Forty, or 76 percent, of the 53 petroleum terminals located in the New York Harbor were in flooded areas during Sandy, compared with 16 terminals, or 31 percent, during Irene.

Figure 3. New York Harbor Areas Flooded by Irene and Sandy





Source: FEMA

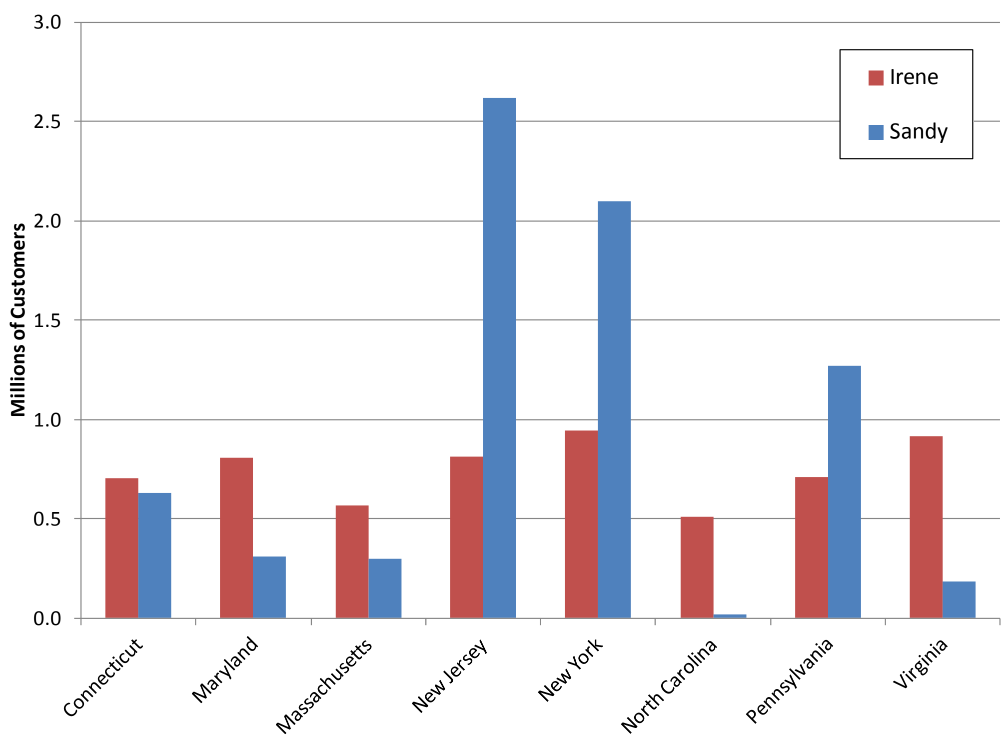
Electricity Impacts

Both Hurricanes Irene and Sandy caused widespread damage to electric power transmission and distribution networks and left millions of customers without power across the Eastern Seaboard. Hurricane Sandy caused more overall customer power outages and affected more States than Irene. Power restoration following Sandy was complicated by the November 2012 Nor'easter, and it took utilities more than twice as long to reach full restoration following Sandy than it did following Irene.

Power Outages

During Hurricane Irene, 6.69 million customer outages were reported across 14 States and the District of Columbia as the storm moved up the East Coast from South Carolina to Maine. By comparison, Hurricane Sandy and the November 2012 Nor'easter caused 8.66 million customer outages across 20 States and the District of Columbia from North Carolina to Maine and as far west as Illinois.[7] Figure 4 compares peak outages for States that experienced 500,000 or more peak customer outages during either storm. Figure 4 shows that Hurricane Irene caused more outages in Connecticut, Maryland, Massachusetts, North Carolina, and Virginia, while Hurricane Sandy caused more outages in New Jersey, New York, and Pennsylvania. For a full list of peak outages by State, see Appendix 1.

Figure 4. Peak Power Outages by Select State and Storm



Source: OE/ISER Emergency Situation Reports

[7] Outage totals for Irene and Sandy are the sum of peak outages reported for each State in Emergency Situation Reports published by DOE's Office of Electricity Delivery and Energy Reliability, Infrastructure Security and Energy Restoration division (OE/ISER). Outages for Sandy include 150,000 additional outages caused by the November 2012 Nor'easter. http://www.oe.netl.doe.gov/emergency_sit_rpt.aspx

Infrastructure Damage

Hurricanes Irene and Sandy brought devastating wind and flooding to the Northeast and Mid-Atlantic States, damaging electric power transmission and distribution infrastructure, including substations, power lines, and utility poles. Table 4 provides details of the damage, based primarily on information compiled from OE/ISER Emergency Situation Reports, company press releases, and utility filings with State public utility commissions. However, not all utilities in the affected areas provided detailed information on such impacts, and those that did report impacts did not often provide details in a uniform way. Consequently, it is not possible to directly compare the damage to power infrastructure between the two storms or even between utilities or States within the same storm. The data in the table is presented to provide perspective on the magnitude of damage caused by Hurricanes Irene and Sandy.

Although specific conclusions cannot be drawn from the available data, generally, utilities that experienced more customer outages experienced higher levels of infrastructure damage. In particular, available data indicates infrastructure damage was more severe for utilities serving customers in coastal New York and New Jersey during Sandy than Irene. The Long Island Power Authority's (LIPA) service territory, which serves customers on Long Island, New York, experienced high winds and flooding during both Irene and Sandy (See Figure 3). LIPA experienced damage to 50 substations, 2,100 transformers, and 4,500 utility poles following Sandy, as compared with damage to 22 substations, 1,000 transformers, and 900 utility poles following Irene.

Table 4. Electric Infrastructure Damage by Storm and Utility

State/Utility	Damage Locations		Substations		Transformers		Transmission Lines		Sections of Wire		Poles	
	Irene	Sandy	Irene	Sandy	Irene	Sandy	Irene	Sandy	Irene	Sandy	Irene	Sandy
VIRGINIA												
Dominion Virginia Power	35,000				27				57 mi		1,619	
MARYLAND												
Baltimore Gas & Electric			0		247				4,861	2,500	348	
Delmarva Power			1		40				308		53	
Pepco (MD)			2		92		131		1,166		36	
Potomac Edison			0		7					95 mi	14	700
SMECO			0		195		1				313	
PENNSYLVANIA												
Met Ed	6,889	9,500			130	304	25	41	18 mi	53 mi	143	731
PECO		13,000			278	390			90 mi	141 mi	316	750
Penelec	1,483	1,800			10	88		42	3 mi	11 mi	30	80
PPL						601	18 mi			~100 mi	900	619
UGI Utilities	617	382							1,043		39	
West Penn Power		1,500				120		31		19 mi		65
NEW JERSEY												
Atlantic City Electric				7	107			20	1,070		59	
Jersey Central Power & Light			7		465	400			47 mi	3,400	466	800
Public Service Electric & Gas			8	31	383	1,000			1,384		599	2,500
Rockland Electric					58				974			27
NEW YORK												
Central Hudson Gas & Electric		1,500		1	450		13	5	2,071	1,100	351	200
Consolidated Edison		30,000			163		4		2,598	900	91	
Long Island Power Authority	18,926		22	50	1,000	2,100	61		5,953	400 mi	900	4,500

State/Utility	Damage Locations		Substations		Transformers		Transmission Lines		Sections of Wire		Poles	
	Irene	Sandy	Irene	Sandy	Irene	Sandy	Irene	Sandy	Irene	Sandy	Irene	Sandy
National Grid (NY)					196		7		672		399	
N.Y. State Electric &Gas				22	64		7	38	4,985	5,000	224	1,023
Orange and Rockland	5,400			17	336		2	27	3,612		151	500
NEW ENGLAND												
Connecticut Light & Power (CT)	4,968				623	2,000		105 mi	3,404	2,400	941	2,700
Central Maine Power (ME)											259	95
National Grid (RI)				37			8				1,140	
National Grid (MA)					135		23		983		267	
NSTAR (MA)	10,000		6		194		4		2,000		194	
United Illuminating Co. (CT)	2								450		103	

Sources: OE/ISER Emergency Situation Reports, utility websites, State public utility commission filings (listed below)

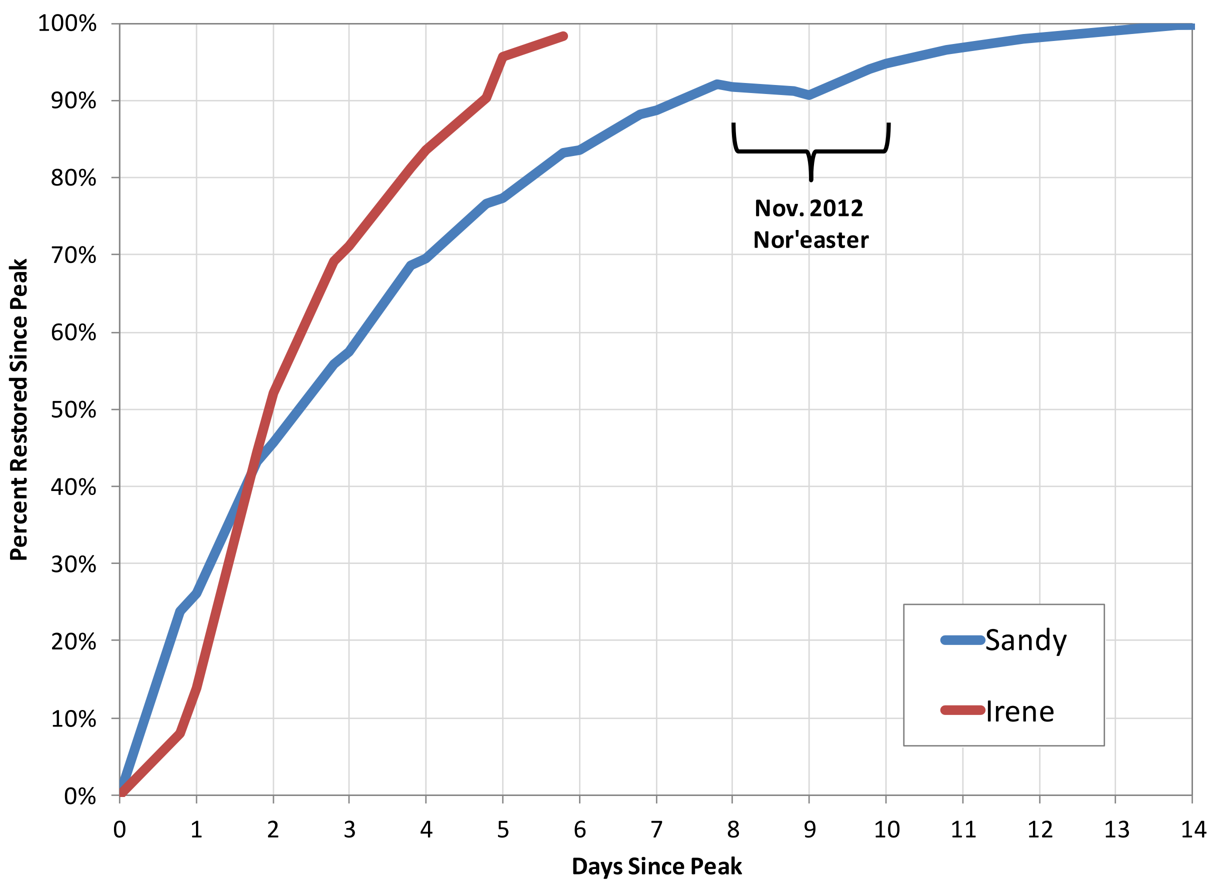
State Public Utility Commission Filings:
Maryland: http://webapp.psc.state.md.us/Intranet/casenum/CaseAction_new.cfm?CaseNumber=9279
Massachusetts: http://www.mass.gov/eea/grants-and-tech-assistance/guidance-technical-assistance/agencies-and-divisions/dpu/storm-orders.html
New Jersey: http://www.nj.gov/bpu/pdf/announcements/2012/stormreport2011.pdf
New York: http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=11-M-0481 and LIPA: http://moreland.ny.gov/sites/default/files/DPS%20Irene%20Report%20-%20LIPA.pdf
Pennsylvania: http://www.puc.state.pa.us/consumer_info/electricity/reliability.aspx
Rhode Island: http://www.ripuc.org/eventsactions/docket/D_11_94_Booth.pdf
Virginia: http://www.scc.virginia.gov/comm/reports/irene_pue.pdf
Connecticut: http://www.ct.gov/pura/lib/pura/pressreleases/2012/110909finaldecision.pdf

Power Restoration

Full power restoration took more than twice as long following Hurricane Sandy than it did following Hurricane Irene. Outages from Irene peaked on August 28, 2011. Three days later utilities had restored power to 71 percent of the peak reported outages, and 5 days later power had been restored to 95 percent of the peak.

Outages from Hurricane Sandy peaked on October 30, 2012. Three days later utilities had restored power to 57 percent of the peak, and 6 days later power had been restored to 84 percent. Power restoration had reached more than 90 percent when the November 2012 Nor'easter slowed the progress of utility crews and added additional outages. Restoration of 95 percent was not achieved until 10 days after the peak. Figure 5 compares the progress of power outage restoration following Hurricanes Irene and Sandy.

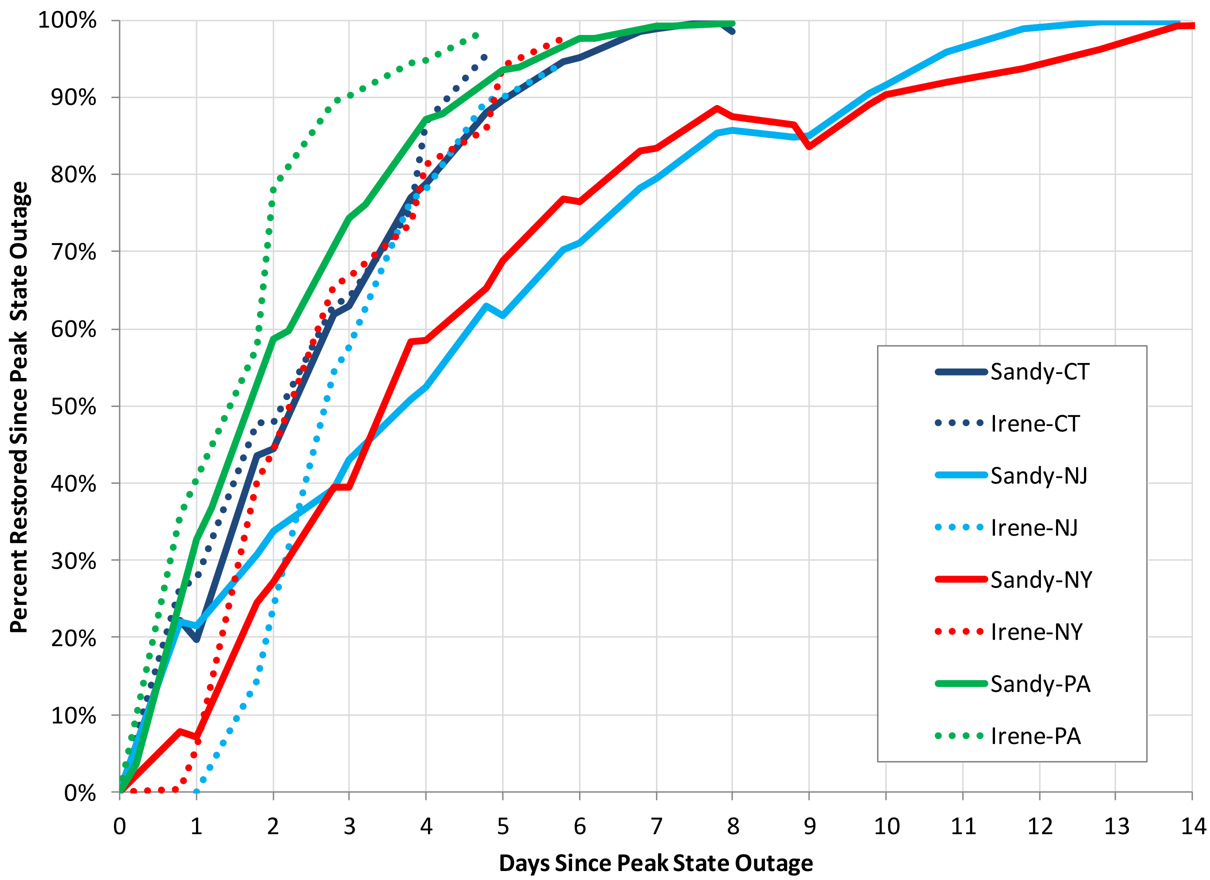
Figure 5. Comparison of Power Outage Restoration Percentages by Storm



Source: OE/ISER Emergency Situation Reports

Power restoration took longer for individual States following Sandy than after Irene. Figure 6 compares power outage restoration by storm for the four States that experienced 500,000 or more customer outages during both Sandy and Irene: Connecticut, New Jersey, New York, and Pennsylvania. Figure 6 shows that full restoration came 8 days or more after peak outages for each State following Hurricane Sandy, whereas outages were fully restored or nearly restored within 7 days for each State following Irene. Note that Hurricane Sandy caused more outages than Irene in three of the four States observed (See Figure 4). In New York and New Jersey, Hurricane Sandy caused more than twice the number of outages incurred during Irene.

Figure 6. Comparison of Power Outage Restoration Percentages by Storm



Source: OE/ISER Emergency Situation Reports

Utility Personnel

Utilities deployed internal and external resources to restore power outages caused by Hurricanes Irene and Sandy. During major outage events, utilities often turn to the power industry's mutual assistance network—a voluntary partnership of electric utilities from across the country. These mutual assistance partnerships utilize resources, skills, personnel, and equipment to help restore power during an emergency situation. According to the Edison Electric Institute[8], 50,000 mutual assistance workers were involved in the clean-up and power

[8] The Edison Electric Institute represents shareholder-owned electric companies in the United States.

restoration effort following Hurricane Irene.[9] By comparison, 67,000 mutual assistance workers were involved in the restoration effort following Hurricane Sandy.[10]

Nuclear Power Plants

Reactors at nuclear power plants in the Northeast were affected by Hurricanes Irene and Sandy. Some reactors were shut as a precaution to protect equipment from the storm; others were forced to shut down or reduce power output due to damage to plant facilities or transmission infrastructure serving the plant; and still others were forced to reduce power output due to reduced power demand caused by widespread utility customer outages. According to data from the Nuclear Regulatory Commission, two nuclear reactors (totaling 1,470 MWs of capacity) were shut and six others were operated at reduced capacity due to Hurricane Irene. Due to Sandy, three nuclear reactors (totaling 2,845 MWs of capacity) were shut and five were operated at reduced rates.

Table 5 lists the nuclear power reactors affected by Irene and Sandy. Of the nuclear reactors on the East Coast, three were affected by both storms: Dominion's Millstone Unit 3 in Connecticut and Exelon's Limerick Units 1 and 2 in Pennsylvania, which operated at reduced capacity during both Irene and Sandy.

Table 5. Nuclear Power Plants Units Affected by Hurricanes Irene and Sandy

Storm	Unit	State	Company	Capacity (MW)	Impact	Impact Start Date	Restoration Date
Irene	Calvert Cliffs 2	MD	Constellation	855	Shut	8/27/11	9/3/11
	Oyster Creek	NJ	Exelon	615	Shut	8/27/11	8/31/11
	Millstone 2	CT	Dominion	869	Reduced	8/28/11	8/30/11
	Millstone 3	CT	Dominion	1,233	Reduced	8/28/11	8/31/11
	Brunswick 1	NC	Progress Energy	938	Reduced	8/27/11	8/29/11
	Brunswick 2	NC	Progress Energy	920	Reduced	8/27/11	8/30/11
	Limerick 1	PA	Exelon	1,130	Reduced	8/28/11	8/30/11
	Limerick 2	PA	Exelon	1,134	Reduced	8/28/11	8/30/11
Sandy	Salem 1	NJ	PSEG	1,175	Shut	10/30/12	11/5/12
	Indian Point 3	NY	Entergy	1,040	Shut	10/30/12	11/3/12
	Nine Mile 1	NY	Constellation	630	Shut	10/29/12	11/10/12
	Millstone 3	CT	Dominion	1,233	Reduced	10/29/12	11/2/12
	Limerick 1	PA	Exelon	1,130	Reduced	10/30/12	10/31/12
	Limerick 2	PA	Exelon	1,134	Reduced	10/30/12	11/2/12
	Susquehanna 2	PA	PPL	1,190	Reduced	10/30/12	11/5/12
	Vermont Yankee	VT	Entergy	620	Reduced	10/30/12	10/31/12

Source: Nuclear Regulatory Commission

[9] "Understanding the Electric Power Industry's Mutual Assistance Network." Edison Electric Institute.
[10] "Multimedia Gallery Of Restoration Efforts - Superstorm Sandy." Edison Electric Institute. http://www.eei.org/ourissues/ElectricityTransmission/Reliability/Pages/MultimediaGallery-Sandy.aspx

Petroleum Impacts

Hurricanes Irene and Sandy disrupted petroleum supply networks in the Northeast due to direct effects from the storms (flooding, wind, etc.) as well as power interruptions caused by the storms. In particular, the hurricanes disrupted activity in the New York Harbor area—a major distribution hub for petroleum delivery to consumer markets in New York, New Jersey, Pennsylvania, and New England. The terminals in the New York Harbor area, which have a combined storage capacity of about 70 million barrels, receive product via pipeline from refineries on the U.S. Gulf Coast, the Philadelphia area, and the two refineries located in northern New Jersey − Phillips 66 Bayway (238,000 barrels per day) and Hess Port Reading (70,000 barrels per day). The terminals also receive product via tanker and barge, much of it imported from outside the United States. In addition, products from the terminals are redistributed by barge mainly to distribution terminals throughout the New York Harbor area, up the Hudson River as far as Albany, and into New England. Product moves via the Buckeye pipeline to Brooklyn/Queens terminals, all regional airports, and upstate New York and Pennsylvania. These distribution terminals supply gasoline, heating oil, and diesel fuel to trucks for delivery to retail outlets and local distributors.[11]

Refineries

Several Northeast refineries were affected by flooding, wind, and other impacts brought by Hurricanes Irene and Sandy. Area refineries were also affected by power outages and logistical issues caused by the closure of crude oil and petroleum product transportation and distribution systems in the wake of the storms. Hurricane Irene shut one refinery and caused reductions at five others in the Northeast, while Hurricane Sandy shut two refineries and caused reductions at four others. The Phillips 66 Bayway refinery in Linden, New Jersey, which is the second largest refinery in the Northeast, was shut as a precaution prior to both storms. Following Hurricane Sandy, the Bayway refinery lost power, sustained flooding in low-lying areas of the plant, and remained offline for several weeks as operators conducted repairs and maintenance.[12] Table 6 lists the refineries impacted by Hurricanes Irene and Sandy.

[11] "New York/New Jersey Intra Harbor Petroleum Supplies Following Hurricane Sandy: Summary of Impacts Through November 13, 2012." November 2012. Energy Information Administration. http://www.eia.gov/special/disruptions/hurricane/sandy/pdf/petroleum_terminal_survey.pdf

[12] Hurricane Sandy Situation Report # 5. October 30, 2012 (3:00 PM EDT). DOE/OE ISER. http://energy.gov/sites/prod/files/2012_SitRep5_Sandy_10302012_300PM.pdf

Table 6. Refineries Affected by Hurricanes Irene and Sandy

Storm	Refinery	State	Company	Capacity (b/d)[A]	Impact	Impact Start Date	Restoration Date
Irene	Linden	NJ	ConocoPhillips[B]	238,000	Reduced Shut	8/27/11 8/28/11	9/1/11
	Paulsboro	NJ	PBF	160,000	Reduced	8/27/11	8/29/11
	Trainer	PA	ConocoPhillips[C]	185,000	Reduced	8/27/11	8/31/11
	Philadelphia	PA	Sunoco[D]	335,000	Reduced	8/29/11	9/2/11
	Marcus Hook[E]	PA	Sunoco	178,000	Reduced	8/29/11	8/29/11
	Delaware City	DE	PBF	182,000	Reduced	8/29/11	8/29/11
Sandy	Linden	NJ	Phillips 66	238,000	Shut	10/29/12	11/27/12
	Port Reading	NJ	Hess	70,000	Shut	10/29/12	11/21/12
	Paulsboro	NJ	PBF	160,000	Reduced	10/29/12	11/1/12
	Trainer	PA	Monroe Energy	185,000	Reduced	10/29/12	10/31/12
	Philadelphia	PA	Philadelphia Energy Solutions	335,000	Reduced	10/29/12	11/7/12
	Delaware City	DE	PBF	182,000	Reduced	10/29/12	11/1/12

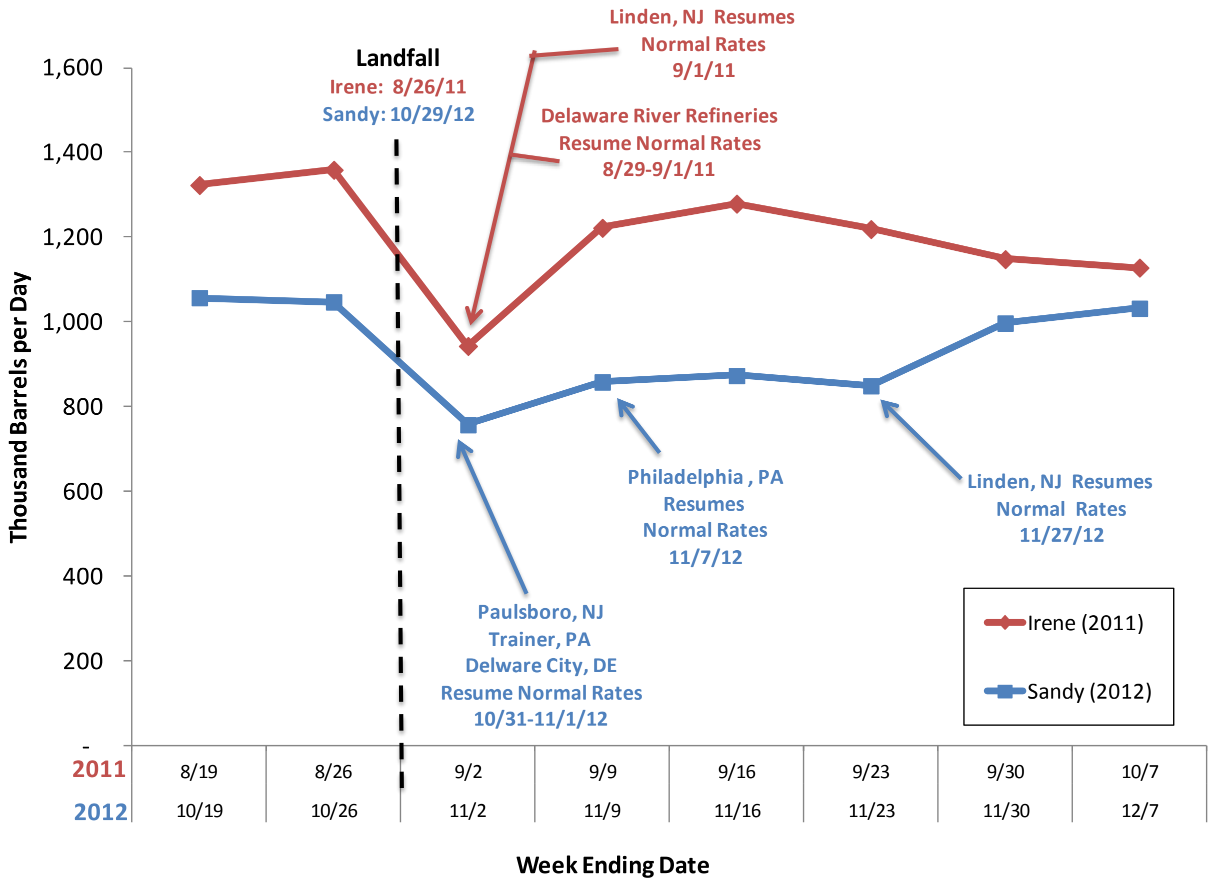
[A] Barrels per day – [B] Now Phillips 66 – [C] Now Monroe Energy – [D] Now Philadelphia Energy Solutions – [E] Idled December 2011
Sources: OE/ISER Emergency Situation Reports, Energy Assurance Daily

Refining activity is tracked by EIA at the regional level. Figure 7 compares weekly gross inputs of crude oil, unfinished oils, and natural gas plant liquids into atmospheric crude distillation units at East Coast refineries (in Petroleum Administration for Defense District 1, or PADD 1) in the weeks leading up to and following Hurricanes Irene and Sandy.[13] In the week after Hurricane Irene made landfall, gross inputs into East Coast refineries fell by 416,000 b/d, or 31 percent, from the week prior to landfall. In the second and third weeks after landfall, refining activity largely recovered, although not to pre-storm levels.

Hurricane Sandy disrupted East Coast refining activity for a longer period of time than Irene. In the week after Hurricane Sandy made landfall, gross inputs into East Coast refineries fell 290,000 b/d, or 28 percent, from the week prior to the storm.[14] Refineries that had reduced rates due to Sandy ramped inputs back up to normal rates in the following weeks but refining activity on the East Coast remained depressed due to the extended outage at Phillips 66's 238,000 b/d refinery in Linden, New Jersey. Refining activity did not return to pre-storm levels until a month after Sandy's landfall, when the Phillips refinery restarted and returned to normal rates.

[13] The gross inputs presented in Figure 7 do not include inputs into Hess's 70,000 b/d Port Reading, NJ refinery as this facility does not have a crude distillation unit.
[14] The overall lower crude runs in 2012 versus 2011 during this period is largely the result of the closure of the Sunoco refinery in Marcus Hook, PA and pre-storm reduced rates at Monroe Energy's refinery in Trainer, PA, which started up in September 2012. These closures were somewhat offset by the restart of the PBF Delaware City, DE refinery following PBF's purchase from Valero.

Figure 7. Weekly Gross Inputs* into East Coast (PADD 1) Refineries



*Gross Inputs: The crude oil, unfinished oils, and natural gas plant liquids put into atmospheric crude oil distillation units. (This does not include inputs into Hess's Port Reading, NJ refinery.)
Sources: EIA, OE/ISER Emergency Situation Reports

Transportation & Supply

In addition to affecting refinery production, Hurricanes Irene and Sandy also disrupted petroleum transportation and distribution assets—terminals, pipelines, and ports—that serve the Northeast.

Terminals

Hurricanes Irene and Sandy impacted many East Coast petroleum terminals. No comprehensive survey tracks the operational status of petroleum terminals and many companies do not publically report operations. Information compiled from company statements, trade press, and other media sources and published by OE/ISER in Emergency Situation Reports indicate that at least 25 terminals were partially or completely closed following Hurricane Irene, as compared with at least 57 terminals that partially or completely closed following Hurricane Sandy.

A survey of New York Harbor terminal operators conducted by EIA in the aftermath of Hurricane Sandy found that petroleum product flows remained significantly disrupted more than 9 days after the storm made landfall. The survey found that product receipts (inflows) of petroleum products (gasoline, diesel, jet fuel, and ethanol) at petroleum terminals had been reduced to 65 percent of pre-storm levels during the week of November 7–13, 2012. The survey found that product deliveries (outflows) from petroleum terminals had been reduced to 61 percent of pre-storm levels over the same time period. By product type, outflows of gasoline had recovered the most, with deliveries returning to 72 percent of pre-storm levels; diesel deliveries had recovered to 55 percent; and other (jet fuel, ethanol) deliveries had recovered to just 20 percent.[15] No comparable data were collected in the aftermath of Hurricane Irene.

Pipelines

Power outages and flooding at pipeline facilities and petroleum product terminals along the East Coast—particularly in the New York Harbor area—forced pipelines supplying the Northeast to shut segments or operate at reduced capacity in the wake of Hurricanes Irene and Sandy. Table 7 lists the pipelines affected by each storm. Irene shut segments of three petroleum product pipelines and one crude oil pipeline.

Sandy shut segments of three product pipelines. Both storms affected portions of the Buckeye Pipeline—a major interstate product pipeline that originates in New York Harbor and is the major supplier of fuel products to both the New York City metropolitan area as well as upstate New York and portions of Pennsylvania. Colonial Pipeline—a major interstate pipeline that supplies the East Coast with petroleum products from refineries on the U.S. Gulf Coast—experienced flooding and the loss of power at its facility in Linden, New Jersey during Hurricane Sandy. The Linden facility is the terminus of the Colonial Pipeline and the outage of this facility caused Colonial to shut down the segment of its mainline system serving markets in Philadelphia, New Jersey, and the New York Harbor.[16] Colonial Pipeline brought in portable generators to power the Linden facility and restored normal flows on the line following an outage of roughly 5 days.

Table 7. Petroleum Pipelines Affected by Hurricanes Irene and Sandy

Storm	Pipeline	Type	Capacity (b/d)[A]	Impact	Impact Start Date	Restoration Date
Irene	Buckeye	Product	900,000	Segments Shut	8/26/11	8/30/11
	Plantation	Product	600,000	Segments Shut	8/27/11	8/29/11
	Portland	Crude	410,000	Segments Shut	8/28/11	9/1/11
	TEPPCO (Enterprise)	Product	330,000	Segments Shut	8/27/11	8/30/11
Sandy	Buckeye	Product	900,000	Segments Shut	10/29/12	11/3/12
	Colonial	Product	2,400,000	Segments Shut	10/29/12	11/2/12
	Plantation	Product	600,000	Segments Shut	10/30/12	10/31/12

[A] Barrels per day, total system capacity
Source: OE/ISER Emergency Situation Reports

[15] "New York/New Jersey Intra Harbor Petroleum Supplies Following Hurricane Sandy: Summary of Impacts Through November 13, 2012." November 2012. Energy Information Administration. http://www.eia.gov/special/disruptions/hurricane/sandy/pdf/petroleum_terminal_survey.pdf
[16] Hurricane Sandy Emergency Situation Report #4. October 30, 2012 (10:00 AM EDT). DOE/OE ISER. http://www.oe.netl.doe.gov/docs/2012_SitRep4_Sandy_10302012_1000AM.pdf

Ports

The U.S. Coast Guard shut ports along the Eastern Seaboard from the Mid-Atlantic to New England in advance of both Hurricanes Irene and Sandy. Most of these ports re-opened 1 to 3 days later, after inspections and clean-up operations had been conducted. Following Sandy, a diesel spill from a damaged tank at a Motiva Enterprises' terminal in Sewaren, New Jersey, along with substantial storm debris in the waterway, kept the vessel traffic closed or heavily restricted on the Arthur Kill and surrounding waterways in New York Harbor for more than a week after the storm had passed. This closure affected barge and vessel traffic at several petroleum terminals in New Jersey and New York.

Table 8 lists the East Coast port sectors from North Carolina to Maine, the approximate petroleum imports registered at ports in each sector in 2011, and the shut-down and re-start dates for each sector in 2011 and 2012.[17] For a map of U.S. Coast Guard port sectors, see Appendix 2.

Table 8. East Coast Port Sectors Affected by Hurricanes Irene and Sandy

Port Sector	2011 Imports (b/d)*			Irene		Sandy	
	Crude Oil	Products	Total	Shut	Opened	Shut	Opened
North Carolina	-	19,973	19,973	8/26/11	8/29/11	N/A	N/A
Hampton Roads	-	17,008	17,008	8/26/11	8/29/11	10/29/12	10/30/12
Baltimore	-	19,425	19,425	8/27/11	8/29/11	10/29/12	10/30/12
Delaware Bay	737,534	81,715	819,249	8/27/11	8/29/11	10/29/12	10/31/12
New York	248,233	505,145	753,378	8/27/11	8/28/11	10/29/12	11/1/12**
Long Island Sound	-	47,707	47,707	8/27/11	8/31/11	10/29/12	10/31/12
S.E. New England	-	57,082	57,082	8/27/11	8/31/11	10/29/12	10/31/12
Boston	-	154,216	154,216	8/27/11	8/31/11	10/29/12	10/30/12
N. New England	-	119,764	119,764	N/A	N/A	N/A	N/A
Grand Total	**985,767**	**1,022,035**	**2,007,802**				

*Barrels per day. The volumes include only international imports.
**On November 1, 2012 the Port of New York reopened to all vessels. Due to an oil spill, traffic on the Arthur Kill and Kill Van Kull remained closed or restricted until November 7.
Sources: OE/ISER Emergency Situation Reports, EIA

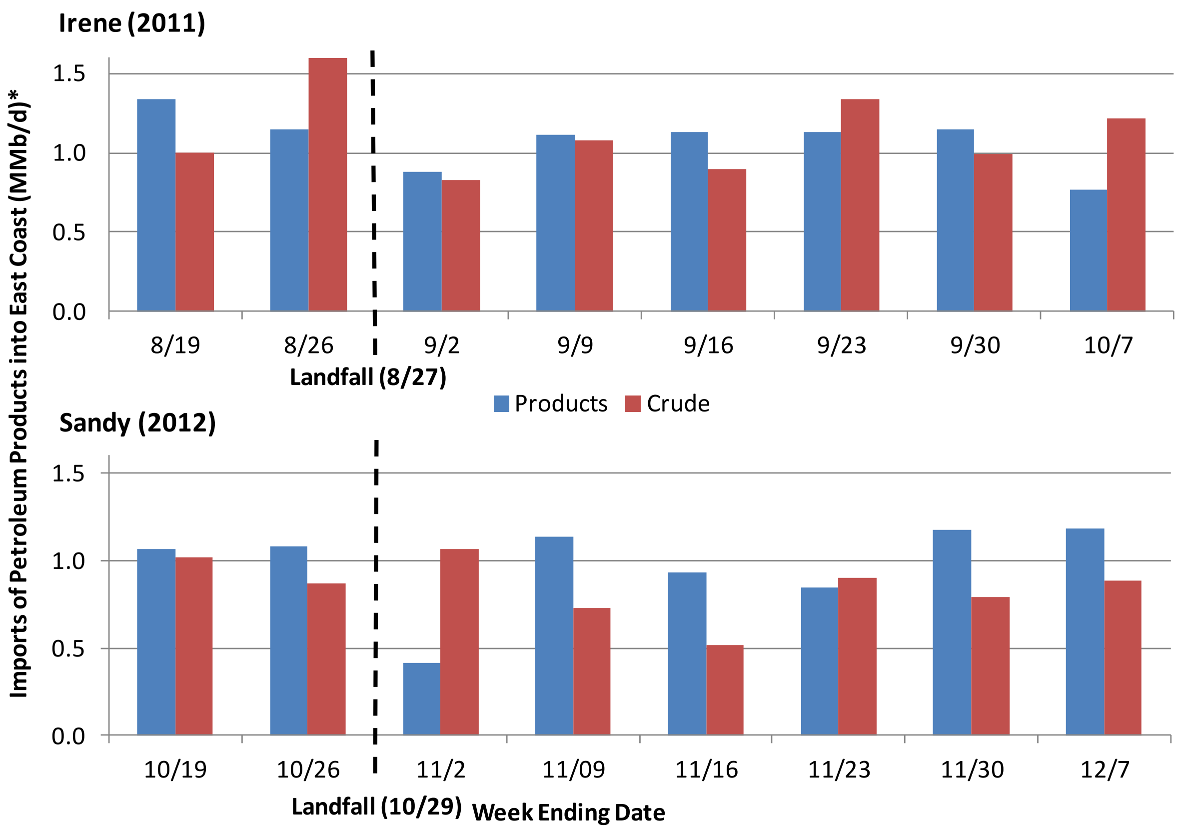
Imports

Hurricanes Irene and Sandy disrupted imports of petroleum products and crude oil into the Northeast due to the closure of port infrastructure was forced shut by from water and wind impacts, the inability of many terminals to receive cargoes, and outages and reductions at crude oil refineries. Figure 8 shows petroleum product and crude oil imports into the East Coast (PADD 1) in the weeks before and after Hurricanes Irene and Sandy made landfall. The data in Figure 8 show product imports into the East Coast following Irene fell by 264,000 b/d, or 23 percent, from the week before the storm. Following Sandy, East Coast product imports fell by roughly 668,000 b/d, or 62 percent, from the prior week. Figure 8 indicates that petroleum

[17] Drawn from the latest annual data available from EIA at the time of this report.

product imports began to return to pre-storm levels in the second week after the storms made landfall.[18]

Figure 8. Weekly Petroleum Imports to the East Coast (PADD 1)



*MMb/d = million barrels per day
Source: EIA

Crude imports were also affected in weeks following Irene and Sandy. In the week Irene made landfall, crude oil imports into the East Coast fell by 769,000 b/d, or 48 percent, from the previous week. By contrast, crude oil imports increased by 198,000 b/d, or 19 percent, in the week that Sandy made landfall. This increase may have been due to shipments that were en route to the East Coast in the week prior to landfall having to wait to come into port until Sandy had passed. In the next 2 weeks after Sandy's landfall, imports fell to as low as 500,000 b/d, or about half of their pre-storm levels, in part due to the extended shutdown of the Phillips 66 refinery in Linden, New Jersey.

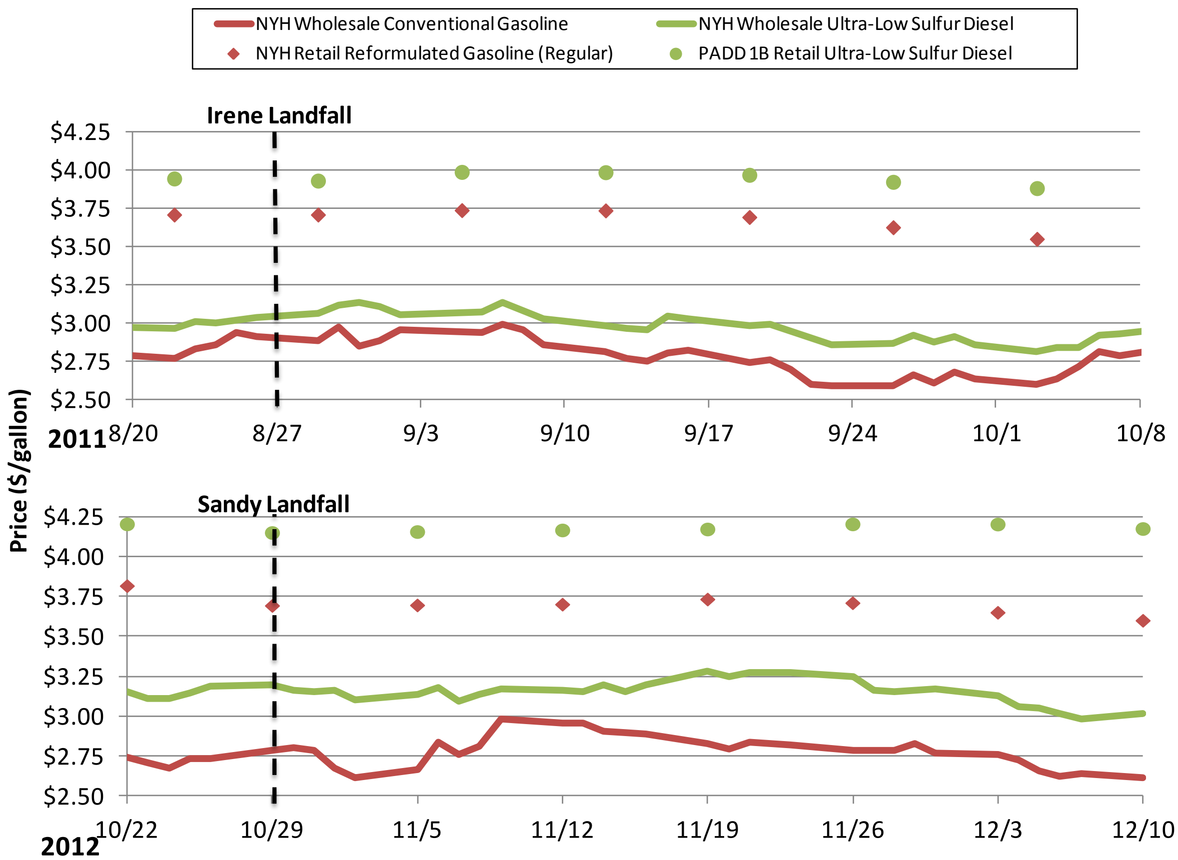
Prices & Stocks

Hurricanes Irene and Sandy disrupted the petroleum supply chain, impacting petroleum product stocks and prices in the Northeast. Figure 9 summarizes the daily spot prices for conventional gasoline and ultra-low sulfur diesel (ULSD) traded in New York Harbor (NYH), as well as weekly

[18] The weekly data presented in Figure 8 are aggregated at the regional level and may mask port-specific impacts. For instance, product shipments into New York Harbor remained reduced 1 week after Sandy's landfall, but increased shipments to other East Coast ports may have offset this in the regional data.

retail prices for reformulated gasoline in New York Harbor and ULSD in the Mid-Atlantic region (PADD 1B), in the weeks leading up to and following the two storms. West Texas Intermediate and Brent crude spot prices were not affected by Irene and Sandy and therefore are not shown in Figure 9. A detailed analysis of gasoline and distillate stocks and prices appears later in this report.

Figure 9. Selected Daily Wholesale and Weekly Retail Petroleum Product Prices



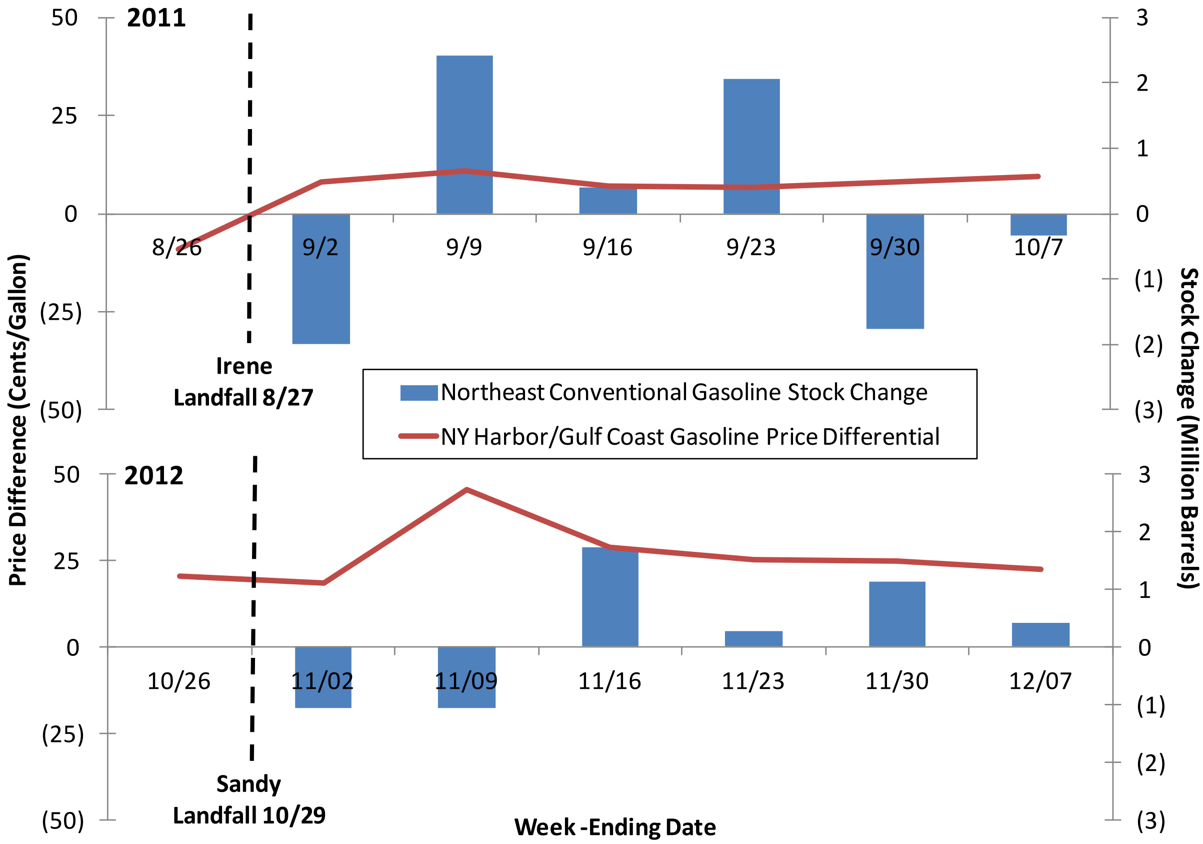
Source: EIA

Gasoline

Disruptions to refineries and petroleum transportation infrastructure caused by Hurricanes Irene and Sandy forced regional gasoline distributors to draw down gasoline stocks and led to temporary increases in spot gasoline price differentials. Figure 10 plots the change in week-ending (Friday) stocks of conventional gasoline in the Northeast—a combination of the New England (PADD 1A) and Mid-Atlantic (PADD 1B) regions—against the difference between the week-ending (Friday) spot gasoline price in New York Harbor and the week-ending spot gasoline price in the Gulf Coast for the weeks leading up to and following Hurricanes Irene and Sandy.

The New York Harbor/U.S. Gulf Coast (NYH/USGC) gasoline price differential measures the difference in the price of gasoline in the two regions. Because the Northeast receives gasoline shipments by pipeline from the Gulf Coast, the price of gasoline in New York Harbor is typically higher than the price of gasoline in the Gulf Coast due to the added transportation costs. An increase in the NYH/USGC differential may indicate that regional factors—such as storm-related supply disruptions—could have increased the New York Harbor gasoline price relative to the price in the Gulf Coast.

Figure 10. New York Harbor Gasoline Stock Changes and Spot Price Differentials



Source: EIA

Figure 10 indicates that Northeast gasoline stocks experienced a large 1-week draw down following Hurricane Irene. The day before Irene made landfall, gasoline stocks in the Northeast stood at 29.9 million barrels. By September 2, 2011—6 days after the storm made landfall—the region's gasoline stocks had fallen by 2 million barrels, or roughly 7 percent, from pre-storm levels. The draw down following Irene was short-lived; by September 9—13 days after landfall—Northeast gasoline stocks had recovered to surpass pre-storm levels.

Regional gasoline prices also experienced a temporary increase in the weeks following Irene's landfall. By September 2, the NYH/USGC conventional gasoline price differential had increased by 17 cents from a week earlier—from negative 9 cents per gallon (indicating a surplus gasoline situation in New York Harbor) to positive 8 cents per gallon (indicating a shift to much tighter supply in New York Harbor). In the following weeks, New York Harbor gasoline remained at a premium to the Gulf Coast despite the recovery in the Northeast gasoline stocks. However, as previously noted, New York Harbor gasoline prices typically exhibit a small premium to Gulf Coast gasoline prices under normal market conditions.

The impact to Northeast gasoline stocks and prices from Hurricane Sandy was slower to develop but larger and longer-lasting than the impact from Irene. On October 26, 2012—3 days before Sandy made landfall—Northeast gasoline stocks stood at 26.8 million barrels, or roughly 10 percent below where they stood prior to Irene. Over the next 2 weeks, Northeast stocks fell by 2.2 million barrels, or roughly 8 percent, from pre-storm levels. Stocks began to build again in the third week after landfall but did not return to pre-storm levels until November 30, the fifth week after landfall.

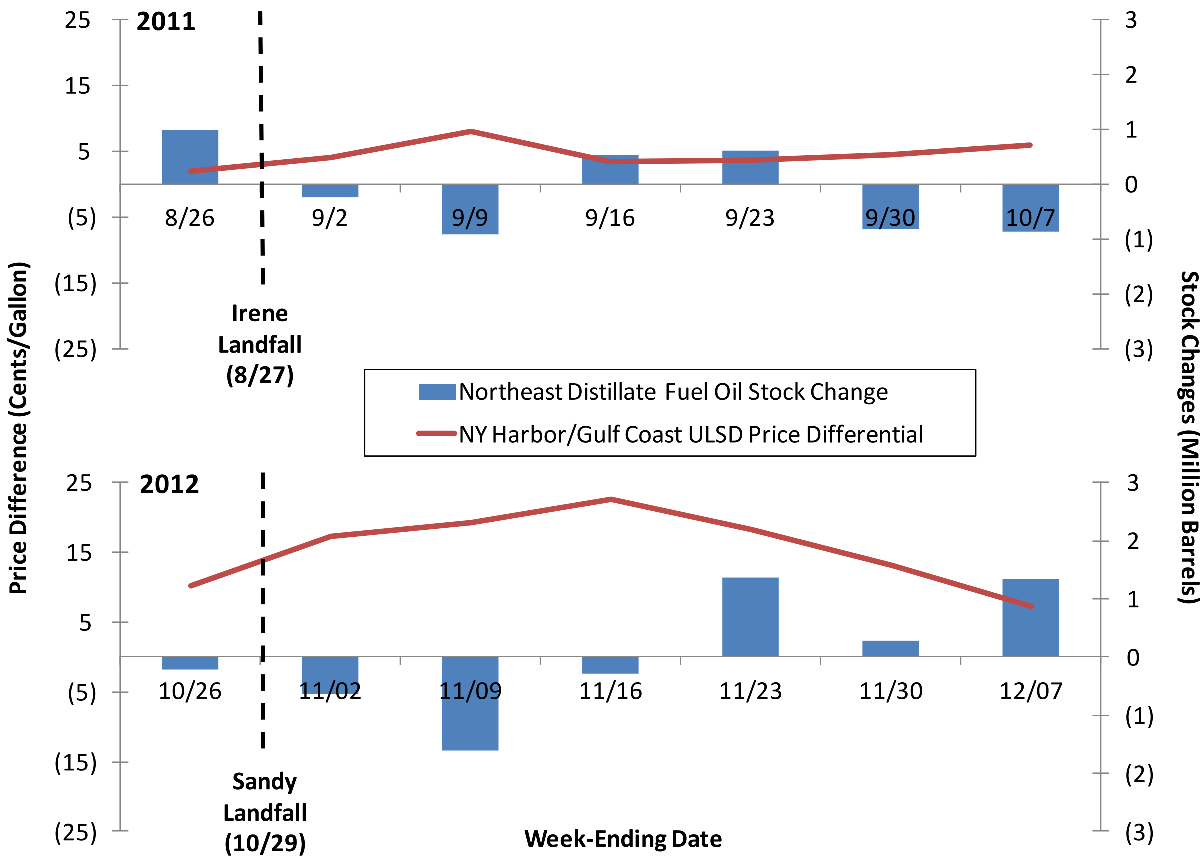
Although slower to develop, the temporary increase in the NYH/USGC gasoline price differential was larger following Hurricane Sandy than Hurricane Irene. By November 2—4 days after Sandy made landfall—the differential fell 2 cents from the previous week. This may have been due to lower demand as drivers stayed off the road while recovery efforts continued, and as many stores and business remained closed. A week later, drivers had returned to the roads but the petroleum supply chain remained disrupted. As a result, the New York Harbor premium more than doubled from 18 cents per gallon on November 2, to 46 cents per gallon on November 9, an increase of 28 cents. In the following weeks, the New York Harbor premium fell from its peak but remained higher than before the storm.

Distillate

Disruptions to petroleum supply infrastructure by Hurricanes Irene and Sandy also affected the distillate fuel oil market. Figure 11 plots the weekly change in stocks of distillate fuel oil in the Northeast against the difference between the spot ULSD price in New York Harbor and the spot ULSD price in the U.S. Gulf Coast (the NYH/USGC differential) for the weeks leading up to and following Hurricane Irene and Sandy. Note that ULSD, the fuel used for the price analysis, represents only a portion of total distillate stocks in the Northeast, although ULSD prices and other distillate fuel oil prices typically closely follow one another.[19]

[19] ULSD represented 28 percent of total Northeast distillate fuel oil stocks in the week prior to Irene and 35 percent prior to Sandy.

Figure 11. New York Harbor Distillate Stock Changes and ULSD Spot Price Differentials



Source: EIA

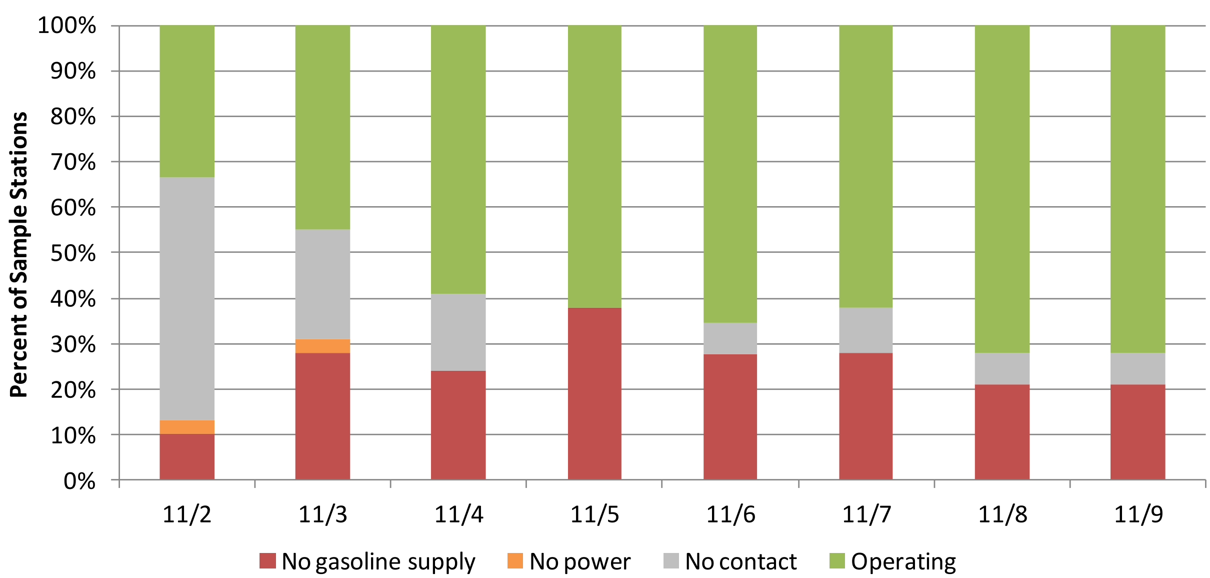
Hurricane Irene had a modest impact on Northeast distillate markets. Prior to Irene, Northeast distillate fuel oil stocks stood at 48.4 million barrels. In the weeks after Irene made landfall, stocks fell by 1.1 million barrels, or about 4 percent, leading to a 6-cent increase in the week-ending NYH/USGC ULSD spot price differential, from 2 cents per gallon on August 26, 2011 to 8 cents per gallon on September 9.

Hurricane Sandy (and the Nor'easter that followed), on the other hand, had a larger impact on Northeast distillate markets than Irene. Prior to Sandy, Northeast distillate fuel oil stocks stood at 28.6 million barrels, more than 40 percent below where they stood prior to Irene. In the weeks following Sandy, distillate stocks fell by a total of 2.8 million barrels, or 10 percent, from pre-storm levels. This large draw down in stocks was likely due to both supply disruptions caused by Hurricane Sandy as well high demand for heating oil due to cold weather in the Northeast, including the effects of the Nor'easter in early-to-mid November. In the weeks after Sandy made landfall, the week-ending NYH/USGC price differential more than doubled from 10 cents per gallon on October 26, 2012 to 23 cents per gallon on November 16.

Retail Stations

Petroleum supply chain disruptions and power outages caused by Hurricane Sandy led to widespread fuel outages at retail fueling stations in the New York City metropolitan area, which includes parts of southeastern New York, Long Island, northern New Jersey, and western Connecticut. In response to the problems caused by Sandy, EIA conducted an emergency survey to monitor the vehicle fuel supply conditions in the New York City metropolitan area from November 2 to November 9, 2012 (See Figure 12) The survey found that a large portion of the retail fueling stations could not operate—due to a lack of fuel or a lack of power—over the survey timeframe. On November 2, only one-third of gas stations sampled by EIA were operational (assuming that the stations that could not be contacted were not operational). A week later, on November 9, the share of gas stations operating had risen to 72 percent. No widespread shortages were reported at retail fuel stations in the aftermath of Hurricane Irene.

Figure 12. Availability of Gasoline in the New York City Metropolitan Area



Source: New York City Metropolitan Area Retail Motor Gasoline Supply Report, EIA

Retail Prices

Retail prices of gasoline and ULSD were not significantly affected by Hurricanes Irene or Sandy. Retail prices experienced modest increases in response to increases in spot prices but remained relatively stable in the aftermath of each storm (See Figure 9 for weekly retail prices, taken on Monday).

Natural Gas

Hurricanes Irene and Sandy did not have a major impact on natural gas infrastructure and supplies in the Northeast. Flooding and power outages were a concern at compressor stations along some interstate pipelines following both storms, but natural gas flows were not interrupted. Natural gas utilities in areas affected by flooding shut off service as a precaution until home inspections could be completed.

Transmission Pipelines

Following Hurricane Irene, three interstate natural gas transmission pipelines—Transcontinental Gas Pipeline, Tennessee Gas Pipeline, and Iroquois Gas Transmission—reported that they continued to operate during the storm but monitored low-lying areas of their systems for flooding. Transcontinental reported that some of its pumping stations lost power and/or had minor flooding. Iroquois reported that it used backup generators at some of its facilities.

Following Hurricane Sandy, Spectra Energy reported that power and communications were out at the majority of its facilities in New Jersey. The company also reported that two compressor stations on its Texas Eastern Transmission pipeline in northern New Jersey went down due to the loss of commercial power and the failure of backup generation to operate as intended. Tennessee Gas Pipeline, Columbia Gas Transmission, and the Interstate Natural Gas Association of America reported no impact to operations.[20]

Local Distribution Companies

Following Hurricane Irene, two local distribution companies—Orange & Rockland (O&R) in New York and PECO in southeastern Pennsylvania—reported natural gas shut-offs to customers due to flooding. O&R reported that 500 of its gas customers were shut off as a precautionary measure due to extensive flooding, and PECO reported that it shut off 1,204 of its gas customers at various locations due to flooding.

Following Hurricane Sandy, New Jersey Natural Gas (NJNG) shut down part of its natural gas infrastructure serving Ocean and Monmouth counties including Long Beach Island and the barrier islands from Bay Head to Seaside Park. As part of the shutdown, NJNG vented gas from its distribution pipelines, allowing water to infiltrate the pipes. The damage caused by the water was severe enough that some portions of the distribution system needed to be completely rebuilt. The shut-downs affected approximately 32,000 of NJNG's customers.[21] As of early January 2013, more than 8,000 NJNG customers remained without service.[22]

[20] "US Northeast gas pipelines weather storm despite power outages." Platts. October 30, 2012. http://www.platts.com/RSSFeedDetailedNews/RSSFeed/NaturalGas/7205010
[21] "Important Update on Damage from Hurricane Sandy." New Jersey Natural Gas. November 8, 2012. http://www.njresources.com/news/releases/2012/njng/Thursday11812Statement.asp
[22] "NJNG Provides Weekly Update on Service Restoration Efforts." New Jersey Natural Gas. January 1, 2013. http://www.njresources.com//news/releases/2013/njng/Friday010413.asp

Federal Actions

Numerous Federal agencies coordinated their response to the energy emergencies following Hurricanes Irene and Sandy to provide situational awareness, facilitate power restoration, release fuel reserves, and ease regulations. Federal agencies involved in these efforts included the Department of Energy (DOE), the Department of Homeland Security (DHS), the Federal Emergency Management Agency (FEMA), the Department of Transportation (DOT), the Environmental Protection Agency (EPA), the Federal Energy Regulatory Commission (FERC), the U.S. Army Corps of Engineers (USACE), the U.S. Coast Guard (USCG), and the Department of Defense (DOD).

Providing Situational Awareness

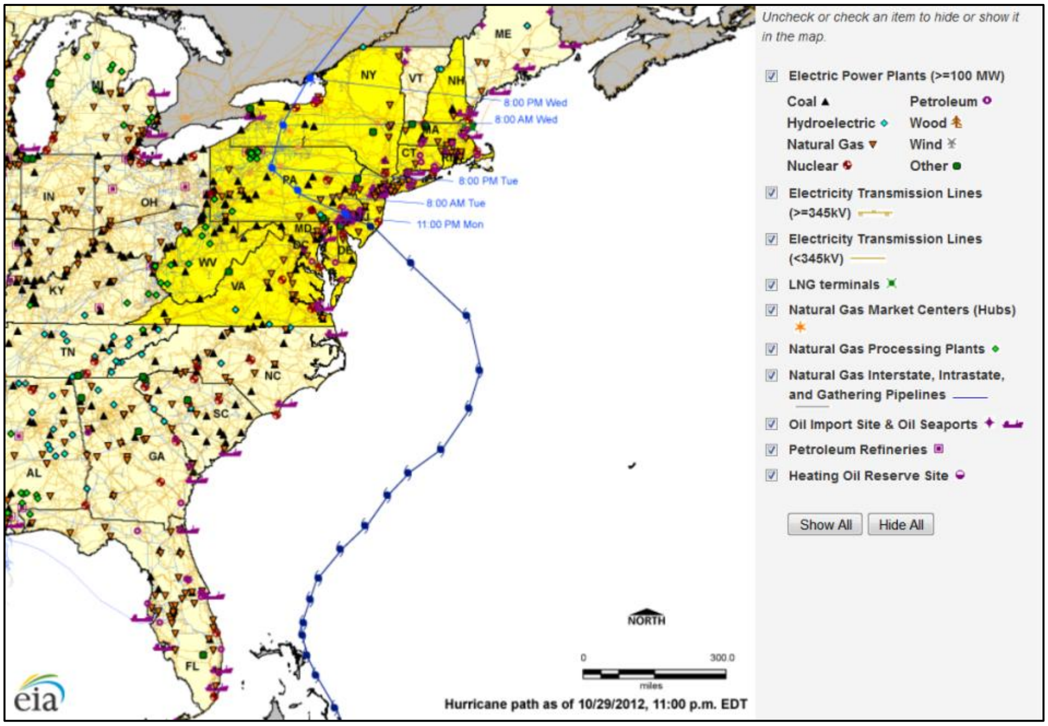
DOE is the lead agency for Emergency Support Function #12 (ESF-12), which is intended to facilitate the restoration of damaged energy systems and components when activated by FEMA for incidents requiring a coordinated Federal response. ESF-12 is an integral part of the larger DOE responsibility of maintaining continuous and reliable energy supplies for the United States through preventive measures and restoration and recovery actions. ESF-12 collects, evaluates, and shares information on energy system damages and estimates the impact of energy system outages within affected areas. Additionally, ESF-12 responders provide information concerning the energy restoration process, such as projected schedules, percent restored, and the geographic progression of restoration.

In the aftermath of Hurricanes Irene and Sandy, DOE produced and publicly disseminated Emergency Situation Reports that provided a detailed summary of the impacts to the energy sector—power outages, and the status of petroleum refineries, pipelines, storage terminals, natural gas pipelines, and nuclear power plants—and the status of restoration activities to the impacted systems and facilities. During the most active days of restoration, DOE released Situation Reports twice daily. Between August 26 and September 4, 2011, DOE released 16 Situation Reports covering energy impacts from Hurricane Irene. Between October 28 and December 3, 2012, DOE released 33 Situation Reports—20 reports covering impacts from Hurricane Sandy and 13 reports covering the combined impact of Hurricane Sandy and the November 2012 Nor'easter.[23]

EIA provided informational resources on its website prior to Hurricanes Irene and Sandy and conducted emergency fuel surveys in the aftermath of Sandy. Prior to both storms, EIA posted an interactive mapping tool on its website that allowed users see the projected path of the storms relative to major energy infrastructure—power plants, storage terminals, pipelines, petroleum refineries, liquefied natural gas terminals, natural gas processing facilities, and electricity transmission lines—on the East Coast of the United States (See Figure 13).

[23] The emergency situation reports are posted on OE/ISER's public website: http://www.oe.netl.doe.gov/emergency_sit_rpt.aspx

Figure 13. EIA's Interactive Infrastructure Map for Hurricane Sandy



Source: EIA

In response to the widespread fuel supply issues following Hurricane Sandy, EIA conducted two emergency surveys. EIA's New York City Metropolitan Area Retail Motor Gasoline Supply Report monitored vehicle fuel supply conditions in the New York City metropolitan area on a temporary basis from November 2 to November 9, 2012 (See results of the survey in Figure 12). EIA's Petroleum Terminal Survey, conducted with the help of the National Petroleum Council and with the voluntary participation of the industry, evaluated petroleum product flows in the New York Harbor area both prior to Hurricane Sandy and as of Tuesday, November 13, 2012.

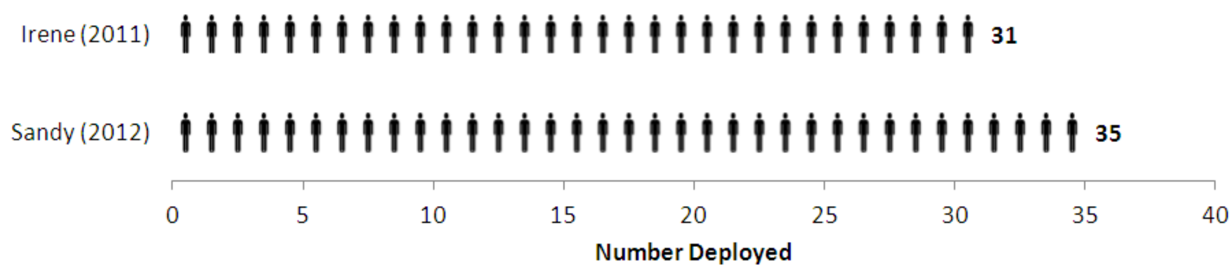
DOE also partnered with Google Crisis Maps to provide real-time information to users in need. Google Crisis Map showed power outage information, shelter and recovery centers, local emergency Twitter feeds, FEMA's disaster-declared areas and more. It also gave users the ability to find open gas stations and food stores in New Jersey and New York City.

Facilitating Restoration

DOE provides 24/7 coverage of the ESF-12 desk at FEMA response centers when they are activated during an emergency. During Hurricanes Irene and Sandy, DOE staff deployed to various FEMA sites to support Federal response efforts, working closely with other Federal partners, State and local government entities, and representatives from the energy sector. During the Irene response, 31 DOE staff deployed to the National Response Coordination Center (NRCC) in Washington, DC; the Region I Regional Response Coordination Center (RRCC) in Boston, Massachusetts, the Region II RRCC in New York, New York, the Region III RRCC in Philadelphia, Pennsylvania, and the Region IV RRCC in Atlanta, Georgia; and the

Virginia Emergency Operations Center (EOC). To respond to Sandy, 35 DOE staff members deployed to the NRCC, the RRCCs for Region I, Region II (in Colt's Neck, New Jersey), and Region III; and the New York State EOC in Albany, New York. Figure 14 compares the number ESF-12 responders deployed for each storm.

Figure 14. ESF-12 Responders Deployed by Storm



Source: OE/ISER

Following Hurricane Irene, DOE sent senior officials to Connecticut and Rhode Island to meet with executives from utilities, governors, and elected representatives to discuss issues impeding restoration.

Following Hurricane Sandy, due to the extent of the damage to energy facilities, the Federal response was more involved than that following Irene. To facilitate restoration in the wake of Hurricane Sandy, an assessment team of experts from DOE performed damage assessments of some of the hardest-hit areas and met with local officials and utility representatives to discuss their needs. Secretary of Energy Steven Chu also toured the devastated region where he consulted with utility crews, State and local leaders, and industry officials to discuss ongoing response and recovery efforts. The Secretary participated in daily conference calls with DOE senior staff and with CEOs and other executives from the impacted utilities to ensure the Department was doing everything possible to aid the restoration process.

In addition, the President approved a 100 percent cost share under the Stafford Act to conduct emergency power restoration and emergency public transportation assistance, including direct federal assistance, within counties designated for public assistance in New Jersey, New York, and Connecticut. The 100 percent cost share was in place from October 30 until November 9, 2012. The cost share provided flexibility in post-disaster power restoration as States and municipalities did not have to bear any of the costs associated with eligible work for the duration of the program.

Also following Hurricane Sandy, DOE led an interagency Energy Restoration Task Force, based out of FEMA's NRCC. This Task Force was established to more efficiently coordinate and deploy the resources of the Federal Government and eliminate impediments to the restoration process in the energy sector. The Task Force focused on eliminating bureaucratic roadblocks or red tape that could delay utility teams in their efforts to restore power; identifying specific steps and additional resources that could help to get power back up as quickly as possible; facilitating the movement of utility workers, including by working with DOT to issue the appropriate permits for utility trucks crossing State lines; developing new communications systems and an internal clearinghouse to help local and State law enforcement officials track the routes for utility teams coming into their States; identifying which electric and petroleum facilities could best utilize generators and water pumps supplied by the USACE; and coordinating with the USCG in their assessments of the petroleum terminals' marine facilities.

The Task Force engaged three of DOE's Power Marketing Administrations (PMAs)—Bonneville Power Administration, Southwestern Power Administration (SWPA), and Western Area Power Administration (WAPA)—which sent 235 staff and 200 pieces of equipment to help repair downed power lines and damaged substations in storm-impacted areas. The PMA crews were initially brought in using funding from the Stafford Act but were later retained by Jersey Central Power & Light under a mutual assistance agreement. This was the first time WAPA or SWPA engaged in mutual aid with an investor-owned utility.

The Task Force also engaged DOD resources to airlift personnel and equipment to New Jersey, and Federal resources through the DOT and other partner agencies worked with State and local authorities to ensure utility crews were able to reach the places where they were most needed. This included plowing snow or clearing fallen trees or other debris from the roads ahead of utility teams. In addition, utility trucks were—for the first time—classified as emergency response vehicles, allowing them to access fuel lines/delivery locations intended only for emergency responders.

DOE also worked to address the fuel supply chain disruptions caused by Hurricane Sandy. DOE worked with utility and fuel companies to assess their needs and to ensure that they were prioritizing repairs and power restoration to critical fuel infrastructure like terminals and refineries. DOE worked to identify gas stations that could use generators and coordinated with the USACE and the National Guard to deliver generators to those stations, so they could resume pumping gasoline prior to the restoration of commercial power. Additionally, the U.S. Coast Guard worked to ensure that ports and harbors were ready to receive shipments of oil and fuels.

DOE and its Federal partners remain engaged in ongoing efforts, including the Hurricane Sandy Rebuilding Task Force, a White House-sponsored Federal task force to support State and local governments as they work to rebuild stronger, safer, and more resilient communities.

Releasing Fuel Reserves

To ease fuel supply issues in the wake of Hurricane Sandy, the President directed DOE on November 2, 2012 to loan ultra low sulfur diesel (ULSD) fuel from the Northeast Home Heating Oil Reserve to the DOD's Defense Logistics Agency (DLA). DLA distributed the ULSD to State, local, and Federal responders in New York and New Jersey, to fuel their emergency equipment, such as generators and water pumps, and to fuel responder vehicles. This was the first time that a release from the reserve had been authorized since its founding in 2000. Two additional requests for ULSD were received on November 7 after the Nor'easter compounded the fuel challenges in the Northeast. Those requests were promptly approved and loading from the reserve was accomplished on November 12 and 25, 2012. In total, over 120,000 barrels (more than 5 million gallons) of fuel were provided to support emergency relief efforts.[24] No releases from the reserve were authorized following Hurricane Irene.

Easing Regulations

To address fuel issues caused by Sandy, DHS, in coordination with DOD, DOE, and the Maritime Administration (MARAD), waived the Merchant Marine Act of 1920 (known as the Jones Act), allowing foreign vessels to ship fuel supplies from the U.S. Gulf Coast to the Northeast. Federal environmental regulations were also waived, allowing the use of a wider variety of fuel products in areas experiencing fuel shortages. In addition, Federal transportation regulations were waived, allowing more drivers, including utility and fuel truck drivers, to work longer hours to deliver goods to storm-affected areas.

Jones Act Waiver

In response to fuel supply disruptions caused by Hurricane Sandy, DHS, in coordination with DOE, MARAD, and DOD, waived the Jones Act on November 2, 2012, allowing foreign vessels to ship petroleum products from the U.S. Gulf Coast to Northeastern ports. The Jones Act prohibits foreign-built, foreign-owned, or foreign-flagged vessels from carrying goods between U.S. ports. The waiver was modified on November 3 to additionally allow the transportation of other feedstock, blending components, and additives used to produce fuels.[25]

The Jones Act waiver allowed 11 vessels to deliver more than 2.7 million barrels (about 115 million gallons) of fuel from the Gulf Coast to ports in the Northeast in the wake of Hurricane Sandy. The majority of this fuel (1.9 million barrels) was gasoline, gasoline blendstock, or gasoline blending components. Diesel, kerosene, and ethanol made up the remainder of the shipments. New York Harbor (including Stapleton, New York) was the most popular destination for deliveries, receiving 1.3 million barrels, or nearly half of all Jones Act volumes. Table 9 summarizes volumes of petroleum products delivered under the Jones Act waiver by port of receipt. Appendix 3 shows Jones Act waiver deliveries by port and product. Following Irene, DHS issued no waivers of the Jones Act.

[24] "Emergency Loans after Hurricane Sandy." U.S. Department of Energy. http://www.fossil.energy.gov/programs/reserves/heatingoil/index.html

[25] "Maritime Administration Reporting Requirements for the Special Purpose Jones Act Waiver Issued In Connection With Hurricane Sandy Recovery." U.S. Maritime Administration. http://www.marad.dot.gov/ships_shipping_landing_page/domestic_shipping/hurricane_sandy_special_waiver/hurricane_sandy_special_waiver.htm

Table 9. Hurricane Sandy Jones Act Waiver Vessel Deliveries by Port

Port	Deliveries (barrels)
Curtis Bay, MD	286,600
Paulsboro, NJ	95,745
New York Harbor*	1,289,853
Albany, NY	86,018
New Haven, CT	288,653
Everett, MA	270,000
Newington, NH	90,000
Portsmouth, NH	65,000
Portland, ME	200,350
Searsport, ME	60,000
Total	**2,732,219**

*Includes Stapleton, NY
Source: MARAD

EPA Fuel Waivers

Following Hurricane Sandy, EPA waived certain fuel requirements under the Clean Air Act in order to facilitate supply logistics and increase import flexibility in affected States. DOE worked closely with EPA to provide due diligence in considering whether to waive requirements related to the sale, distribution, and use of Reformulated Gasoline (RFG) and ULSD. No waivers were deemed necessary following Hurricane Irene.

EPA's Multi-State Fuel Waiver, issued October 31, 2012, waived requirements for the use of RFG in Connecticut, Delaware, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Virginia, and the District of Columbia following Sandy. It also waived additional requirements prohibiting the blending of certain types of gasoline in the previously listed States, as well as in Mississippi, Alabama, Georgia, Tennessee, South Carolina, and North Carolina, to facilitate the distribution of fuel to areas affected by Sandy.[26]

EPA also waived requirements for the use of ULSD (thus allowing the use of home heating oil) in certain generators and pumps used for emergency purposes in New Jersey, beginning October 31, 2012, and in emergency response vehicles in New Jersey, beginning November 1, 2012. EPA waived ULSD requirements for emergency response vehicles and equipment in Pennsylvania; the five boroughs of New York City; and Nassau, Suffolk, Rockland, and Westchester counties in New York, beginning November 2, 2012.[27]

[26] "2012 Fuels Waivers." U.S. Environmental Protection Agency. http://www.epa.gov/enforcement/air/fuel-waivers.html#2012
[27] Ibid.

The EPA waivers relating to RFG and ULSD expired on November 20, 2012. Due to continued fuel-related impacts, the waivers for New York and New Jersey were later extended through December 7, 2012.[28]

EPA also issued a No Action Assurance (NAA), beginning November 2, 2012, which allowed fuel loading and unloading without the use of vapor recovery or vapor combustion devices at bulk gasoline and marine loading terminals and associated truck racks in New York and New Jersey. On November 5, EPA extended the NAA to Maryland and Massachusetts.[29] The NAA allowed operations to resume at terminals where vapor recovery/combustion devices were disabled due to damage or loss of power, and it also allowed operations to resume at fuel loading/unloading facilities that were not equipped with such devices. The NAA for all States terminated on November 17, 2012. Table 10 summarizes the fuel waivers issued by the EPA following Hurricane Sandy.

Table 10. EPA Fuel Waivers Issued Following Hurricane Sandy

Waiver	Applies to	States	From	To
Reformulated Gasoline	All Vehicles	CT, DC, DE, MD, MA, NH, PA, RI, VA	10/31/2012	11/20/2012
		NJ, NY	10/31/2012	12/7/2012
Ultra-Low Sulfur Diesel	Emergency Generators	NJ	10/31/2012	11/20/2012
Ultra-Low Sulfur Diesel	Emergency Response Vehicles	NJ	11/1/2012	12/7/2012
		NY	11/2/2012	12/7/2012
		PA	11/2/2012	11/20/2012
NAA for the Use of Vapor Recovery Systems	Terminals, Pipelines	NJ, NY	11/2/2012	11/17/2012
		MA, MD	11/5/2012	11/17/2012

Source: EPA

Transportation Waivers

Hours-of-Service (HOS) regulations restrict the amount of time drivers are allowed to operate commercial vehicles and mandate time-off requirements between shifts to ensure on-road safety. For interstate commerce—the transportation of goods across State boundaries—the DOT's Federal Motor Carrier Safety Administration (FMCSA) sets HOS regulations. For intrastate commerce—the transportation of goods within a State boundary—State-level HOS regulations may apply (See the State & Local Actions section of this report). During emergency situations, FMCSA may waive interstate regulations and State governments may waive intrastate regulations for vehicles assisting in emergency response. These waivers are often applied to utility trucks and fuel carriers.

Following Hurricane Sandy, FMCSA issued a regional emergency declaration and waived Federal regulations applying to motor vehicles engaged in interstate commerce, including driver

[28] "October and November 2012 Fuel Waivers Related to Hurricane Sandy." U.S. Environmental Protection Agency. November 16, 2012.http://www.epa.gov/enforcement/air/documents/fuelwaivers/nynj-fuelwaiver111612.pdf
[29] "No Action Assurance for the Use of Vapor Recovery Systems Related to Hurricane Sandy." U.S. Environmental Protection Agency. November 5, 2012. http://www.epa.gov/enforcement/air/documents/policies/mobile/naa-vaporrecoverymamd110512.pdf

qualification requirements, HOS requirements, and maintenance requirements. The waiver applied to commercial vehicles transporting emergency materials, including utility trucks and fuel carriers, in the Eastern Region: Connecticut, Delaware, the District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia. The waiver was effective from October 29 to November 27, 2012.[30] The DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA) also issued a waiver allowing non-DOT specification cargo tank motor vehicles to transport gasoline to the Hurricane Sandy disaster relief area.[31] FMCSA did not waive interstate HOS regulations following Irene.

[30] "Declaration of Regional Emergency in Response to Hurricane Sandy." Federal Motor Carrier Safety Administration. U.S. Department of Transportation. http://www.fmcsa.dot.gov/about/alerts/hurricane-sandy-2012-response.aspx

[31] Emergency Special Permit. Pipeline and Hazardous Materials Safety Administration. U.S. Department of Transportation. http://phmsa.dot.gov/staticfiles/PHMSA/SPA_App/OfferDocuments/SP15752_2012110433.pdf

State & Local Actions

State and local governments took measures to ration fuel, ease State regulations, enforce price gouging laws and facilitate power restoration in the aftermath of Hurricane Sandy.

Major Disaster and Emergency Declarations

The first response to a disaster is the job of a local government's emergency response services, with help from nearby municipalities, the State, and volunteer agencies. In a catastrophic disaster, a State's governor can request Federal resources mobilized through FEMA, which can provide search and rescue assistance, help in restoring electrical power, as well as food, water, shelter, and supplies needed to meet other basic human needs. Following Hurricanes Irene and Sandy, numerous State governors requested Federal assistance through Major Disaster Declarations and Emergency Declarations.

A major disaster can result from hurricanes, earthquakes, tornados, or any other natural catastrophe, or regardless of cause, any major fire, flood, or explosion. The President must first determine whether State and local governments will require supplemental Federal aid in responding to the disaster. The event must clearly present more of a challenge than State or local governments can handle alone. If a Major Disaster Declaration is issued, funding comes from the President's Disaster Relief Fund, which is managed by FEMA and the disaster aid programs of other participating Federal agencies.

An Emergency Declaration is more limited in scope and doesn't result in the long-term Federal recovery programs that follow a Major Disaster Declaration. Generally, Federal assistance and funding are provided to meet a specific emergency need, or to help prevent a major disaster from occurring.

Table 11 shows the duration in days of Emergency Declarations and Major Disaster Declarations for States and territories affected by Hurricanes Irene and Sandy. Following Hurricane Irene, the President issued Major Disaster Declarations for 13 States, the District of Columbia, and Puerto Rico. The average duration of each declaration was 6 days. Maryland's declaration lasted the longest, at 12 days. Following Sandy, Major Disaster Declarations were issued for 12 States and the District of Columbia. The average duration of each declaration was 10 days, and the longest declarations (13 days) were issued for New Hampshire, New Jersey, Pennsylvania, and Virginia. Appendix 4 lists more details on incident dates and the durations of Emergency and Major Disaster Declarations following Irene and Sandy.

Table 11. Duration (Days) of Emergency and Major Disaster Declarations by State and Storm

State	Irene		Sandy	
	Emergency	Major Disaster	Emergency	Major Disaster
Connecticut	6	5	12	12
Delaware	n/a	6	12	12
District of Columbia	6	6	3	5
Maine		2		
Maryland	10	12	13	9
Massachusetts	10	2	12	12
New Hampshire	n/a	10	5	13
New Jersey	10	9	13	13
New York	11	7	12	12
North Carolina	7	7		
Ohio				1
Pennsylvania	19	4	13	13
Puerto Rico	3	3		
Rhode Island	3	2	13	5
Vermont	7	6		
Virginia	9	2	6	13
West Virginia			10	10

n/a – Duration not available
Source: FEMA

Rationing Fuel

Due to fuel shortages caused by Hurricane Sandy and the subsequent Nor'easter, the State of New Jersey, New York City, and two New York counties established fuel rationing programs in order to alleviate long lines at fueling stations.

On November 3, 2012, New Jersey established an odd-even license plate system for gasoline and diesel purchases in 12 New Jersey counties.[32] Under the program, which remained in effect until November 13, motorists were allowed to purchase fuel only every other day; motorists with license plates ending with an odd number were allowed to purchase fuel only on odd-numbered days, and motorists with even-numbered plates, on even-numbered days.[33] In addition to its fuel rationing program, New Jersey also established a telephone hotline for gas

[32] "Governor Christie Takes Action to Ease Gas Station Waits with Move to Odd-Even Rationing for Gasoline Purchases in 12 New Jersey Counties." Press Release. November 2, 2012. http://nj.gov/governor/news/news/552012/approved/20121102n.html
[33] "Christie Administration Announces Reinstatement of Pre-Sandy Fueling Practices at 6:00 A.M. Tuesday." Press Release. November 12, 2012. http://nj.gov/governor/news/news/552012/approved/20121112c.html

station owners to report problems at their station, which helped officials respond more effectively to their issues.[34]

On November 8, New York City, Nassau County, and Suffolk County established similar odd-even license plate fuel rationing systems after a power outage led to the partial failure of a terminal served by the Buckeye Pipeline, which pumps approximately 4.5 million gallons of gasoline per day to New York City and Long Island.[35] New York City's fuel rationing system was extended on November 18, at which time an estimated 30 percent of the City's gas stations were still not operating.[36] The system was lifted on November 23.

Easing Regulations

The State of New Jersey and New York State, along with the New York City government, issued temporary waivers on certain State and local fuel regulations in order to alleviate fuel shortages in the aftermath of Hurricane Sandy. On October 31, 2012, The State of New Jersey waived its low sulfur diesel requirement for emergency generators operating in the public interest for two weeks.[37] On November 3, New York State temporarily eased restrictions on vapor pressure requirements for gasoline and waived the ultra-low sulfur diesel requirement for home heating oil.[38] On November 8, New York City temporarily suspended the City's low sulfur and biodiesel requirements for heating oil.[39] On November 8, New Jersey temporarily authorized the use of dyed diesel (intended for off-road use) to be used in on-road vehicles.[40]

The State of New Jersey and New York State governments also issued waivers relating to licensing and contracting regulations for fuel distributors in order to expand their access of fuel supplies. Both New Jersey and New York waived licensing requirements, which temporarily allowed all merchants to buy fuel from out of State for their in-State customers. Under normal conditions, merchants not licensed to import fuel can't legally buy and import gasoline and

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[34] "Christie Administration Launches Hotline for Gas Stations to Report Service Delivery Problems." Press Release. November 3, 2012. http://nj.gov/governor/news/news/552012/approved/20121103g.html

[35] "Mayor Bloomberg Signs Emergency Order to Establish Odd-Even License Plate System for Gasoline Purchases to Reduce Wait Times." Press Release. November 8, 2012. http://www.nyc.gov/portal/site/nycgov/menuitem.c0935b9a57bb4ef3daf2f1c701c789a0/index.jsp?pageID=mayor_press_release&catID=1194&doc_name=http%3A%2F%2Fwww.nyc.gov%2Fhtml%2Fom%2Fhtml%2F2012b%2Fpr406-12.html&cc=unused1978&rc=1194&ndi=1 and "Statement by Governor Cuomo on Nassau and Suffolk Counties, New York City Implementing Temporary Gasoline Management Plan." Press Release. November 8, 2012. http://www.governor.ny.gov/press/11082012-temp-gas-mgmtplan

[36] "Mayor Bloomberg Extends Emergency Order for Odd-Even License Plate System for Gasoline Purchases." Press Release." November 18, 2012. http://www.nyc.gov/portal/site/nycgov/menuitem.c0935b9a57bb4ef3daf2f1c701c789a0/index.jsp?pageID=mayor_press_release&catID=1194&doc_name=http%3A%2F%2Fwww.nyc.gov%2Fhtml%2Fom%2Fhtml%2F2012b%2Fpr429-12.html&cc=unused1978&rc=1194&ndi=1

[37] "Christie Administration Eases Fuel Requirements for Certain Emergency Generators in Storm Aftermath." Press Release. October 31, 2012. http://nj.gov/governor/news/news/552012/approved/20121031j.html

[38] "Governor Cuomo Updates New Yorkers on Progress to Address Gas Shortage." Press Release. November 3, 2012. http://www.governor.ny.gov/press/11032012gasshortageupdate

[39] "Mayor Bloomberg Announces New Temporary Guidelines to Speed Heating Oil Deliveries and Boiler Repairs to Ensure New Yorkers Can Heat Homes and Businesses." Press Release. November 8, 2012. http://www.nyc.gov/portal/site/nycgov/menuitem.c0935b9a57bb4ef3daf2f1c701c789a0/index.jsp?pageID=mayor_press_release&catID=1194&doc_name=http%3A%2F%2Fwww.nyc.gov%2Fhtml%2Fom%2Fhtml%2F2012b%2Fpr404-12.html&cc=unused1978&rc=1194&ndi=1

[40] "Governor Christie Takes Further Actions to Bolster New Jersey's Supply of Gasoline and Diesel Fuel." Press Release. November 8, 2012. http://nj.gov/governor/news/news/552012/approved/20121108b.html

diesel from out of State.[41] New Jersey also suspended restrictions in New Jersey State law that placed limitations on the source of fuel that branded fuel retailers are allowed to sell, thus broadening the supply network for wholesale and retail gasoline sellers.[42]

Following Hurricane Irene, at least seven States issued intrastate HOS waivers, including Maryland, New Jersey, New York, North Carolina, Pennsylvania, Vermont, and Virginia.[43] Following Hurricane Sandy, State regulations were waived in 15 States and the District of Columbia, including Connecticut, Delaware, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia.[44]

Enforcing Price Gouging Laws

New Jersey, New York, and Connecticut monitored price gouging in the aftermath of Hurricanes Irene and Sandy. New Jersey defines price gouging as a price increase of more than 10 percent above the price of the good during the normal course of business, prior to the state of emergency. The law does allow merchants to raise prices when they face additional costs imposed by suppliers or legitimate logistical concerns. A price increase is considered excessive if it is more than 10 percent above the amount of markup from cost, compared with the markup normally applied. New York and Connecticut have similar price gouging laws prohibiting “unconscionably excessive” prices on essential consumer goods after a major disaster. Following Irene, New Jersey investigated roughly 50 complaints of price gouging, including complaints against fuel retailers.[45] In September 2012, New Jersey reached a settlement with a northwestern New Jersey gas station accused of price gouging in the days after Irene.[46]

Prior to Hurricane Sandy, and in the storm’s aftermath, New Jersey, New York, and Connecticut issued forceful reminders to merchants, including retail gas stations and hardware stores selling generators during and after the State of Emergency. Following Sandy’s passage, New Jersey deployed teams of investigators to investigate claims of price gouging and by November 2, the State had brought subpoenas against 65 businesses across the State. Complaints were lodged primarily in northern New Jersey, with the highest number of complaints against gasoline merchants, who allegedly increased prices by $1 or more per gallon at some retail stations. Merchants selling generators, batteries, and non-gasoline fuels, such as propane were also

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[41] “Governor Christie Acts to Boost Gasoline, Diesel Supplies.” Press Release. October 31, 2012. http://nj.gov/governor/news/news/552012/approved/20121031o.html and “Christie Administration Activates Temporary Hotlines to Report Price Gouging during Declared State of Emergency.” Press Release. October 30, 2012. http://nj.gov/governor/news/news/552012/approved/20121030i.html

[42] “Governor Chris Christie Continues Action to Broaden Access to Fuel for New Jerseyans.” Press Release. November 4, 2012. http://nj.gov/governor/news/news/552012/approved/20121104g.html and “Governor Cuomo Signs Executive Order to Suspend Restrictions for Gas Distributors after Hurricane Sandy.” Press Release. November 2, 2012. http://www.governor.ny.gov/press/11022012-executive-order-gas-distribution

[43] “HOS Rules Waived for Relief Trucks in 10 Storm-Struck States.” Truckaccidents.com. http://blog.truckaccidents.com/2011/09/12/hos-rules-waived-for-relief-trucks-in-10-storm-struck-states/

[44] See Footnote 30.

[45] “NJ Officials Investigating Claims of Price Gouging in Wake of Irene.” CBS New York. August 31, 2011. http://newyork.cbslocal.com/2011/08/31/nj-officials-investigating-claims-of-price-gouging-in-wake-of-irene/

[46] “NJ settles Irene-related gas price gouging claim.” Yahoo Finance. September 26, 2012. http://finance.yahoo.com/news/nj-settles-irene-related-gas-161040403.html

highly cited. Generator prices at some stores allegedly doubled from pre-storm prices.[47] In New York, the State brought price gouging charges against merchants at 25 gas stations in New York, Long Island, and Westchester County.[48] In Connecticut, 30 complaints of price gouging were filed, mostly against fuel providers.[49] In January 2013 retailers serving a gas station in Norwalk, Connecticut settled a price gouging case with the State.[50]

Facilitating Restoration

The New York State government deployed 680 New York National Guard troops to Westchester County, Rockland County, and Long Island to work with electric utility repair crews. The National Guard troops were trained to identify downed power lines and properly mark them so that members of the public were not endangered as the repair process moved forward. Allocating the National Guard to this mission freed up utility employees to focus on the technical work of repairing lines and restoring power.[51]

The New York City government, in partnership with FEMA, launched the "NYC Rapid Repairs" program to send teams of contractors and City inspectors into neighborhoods impacted by Hurricane Sandy to make emergency repairs, including permanent or temporary restoration of heat, power, and hot water, and other limited repairs to protect a home from further significant damage. The program helped expedite repairs at homes where utilities were unable to restore power or gas service due to damage within the customer's homes—to electrical equipment, the gas line, a boiler, and other equipment. At the time the program was launched, 90,000 customers remained without power in New York City, and the majority could not be restored due to damage within their homes.[52] By November 21, the City reported that more than 6,000 homeowners had enrolled in NYC Rapid Repairs, and teams had visited nearly 1,700 homes.[53] On November 26, New York City's Mayor Michael Bloomberg ordered landlords of storm-damaged buildings to make repairs to restore heat and power or to sign up for the Rapid

[47] "Christie Administration Subpoenas 65 Businesses in Investigations Into Post-Hurricane Price Gouging." Press Release. November 2, 2012. http://nj.gov/governor/news/news/552012/approved/20121102h.html
[48] "A.G. Schneiderman Announces 12 More Enforcement Actions Against Gas Retailers in Post-sandy Price Gouging Investigation." Press Release. New York State Office of the Attorney General. November 29, 2012. http://www.ag.ny.gov/press-release/ag-schneiderman-announces-12-more-enforcement-actions-against-gas-retailers-post-sandy
[49] "Price Gouging Complaints Rise after Sandy." NBC Connecticut. November 5, 2012. http://www.nbcconnecticut.com/investigations/Price-Gouging-Complaints-Rise-After-Sandy-177345271.html
[50] "Norwalk Gas Station Settles Allegations of Storm Sandy-Related Price Gouging." Press Release. New Jersey Department of Consumer Protection. January 17, 2013. http://www.ct.gov/dcp/cwp/view.asp?A=4187&Q=517192
[51] "Governor Cuomo Deploys 600 Additional Troops to Help in Power Restoration in Westchester and Rockland Counties." Press Release. November 2, 2012. http://www.governor.ny.gov/press/11022012additionaltroopdeployment
[52] "Mayor Bloomberg Announces New Program to Repair Damaged Homes and Updates New Yorkers on City Response to Hurricane Sandy." Press Release. November 9, 2012. http://www.nyc.gov/portal/site/nycgov/menuitem.c0935b9a57bb4ef3daf2f1c701c789a0/index.jsp?pageID=mayor_press_release&catID=1194&doc_name=http%3A%2F%2Fwww.nyc.gov%2Fhtml%2Fom%2Fhtml%2F2012b%2Fpr412-12.html&cc=unused1978&rc=1194&ndi=1
[53] "Mayor Bloomberg Announces $500 Million for NYC Rapid Repairs Program to Restore Power, Heat and Hot Water to Homes Damaged by Hurricane Sandy." Press Release. November 21, 2012. http://www.nyc.gov/portal/site/nycgov/menuitem.c0935b9a57bb4ef3daf2f1c701c789a0/index.jsp?pageID=mayor_press_release&catID=1194&doc_name=http%3A%2F%2Fwww.nyc.gov%2Fhtml%2Fom%2Fhtml%2F2012b%2Fpr437-12.html&cc=unused1978&rc=1194&ndi=1

Repairs program.[54] In addition to the Rapid Repairs program, the New York City government streamlined emergency work permits for boiler repairs and replacements to reduce the application timeline by as much as 2 weeks.[55]

54 "Mayor Bloomberg Announces Landlords of Storm-Damaged Buildings Must Immediately Take Action to Restore Heat and Electricity." Press Release. November 26, 2012. http://www.nyc.gov/portal/site/nycgov/menuitem.c0935b9a57bb4ef3daf2f1c701c789a0/index.jsp?pageID=mayor_press_release&catID=1194&doc_name=http%3A%2F%2Fwww.nyc.gov%2Fhtml%2Fom%2Fhtml%2F2012b%2Fpr444-12.html&cc=unused1978&rc=1194&ndi=1

55 "Mayor Bloomberg Announces New Temporary Guidelines to Speed Heating Oil Deliveries and Boiler Repairs to Ensure New Yorkers Can Heat Homes and Businesses." Press Release. November 8, 2012. http://www.nyc.gov/portal/site/nycgov/menuitem.c0935b9a57bb4ef3daf2f1c701c789a0/index.jsp?pageID=mayor_press_release&catID=1194&doc_name=http%3A%2F%2Fwww.nyc.gov%2Fhtml%2Fom%2Fhtml%2F2012b%2Fpr404-12.html&cc=unused1978&rc=1194&ndi=1

Conclusion

Hurricanes Irene and Sandy caused extensive damage to energy infrastructure in the Northeast and Mid-Atlantic, knocking out power to millions of customers and disrupting key pieces of the petroleum supply chain. Although Sandy was a weaker storm at landfall, it brought tropical storm-force winds (as well as blizzard conditions) to a larger area and ultimately had a greater impact on the region's energy infrastructure and supply. Customer power outages from Sandy (and the November 2012 Nor'easter) totaled 8.66 million, compared with total outages of 6.69 million from Irene. Ninety-five percent restoration following Sandy took 10 days—twice as long as following Irene.

Sandy also had a greater impact on the region's petroleum infrastructure and supply. In particular, extensive storm damage, flooding, and power outages at refineries and pipeline and marine receipt terminals in the New York Harbor area depressed petroleum product supply in the region for several weeks after the storm's landfall. These supply chain problems, combined with power outages at retail filling stations, led to a widespread shortage of fuel in the New York City metropolitan area.

Overall, the energy impacts following Sandy were more severe than those following Irene, and they necessitated a greater response from Federal, State, and local governments. Following both storms, the Federal Government worked to provide situational awareness, facilitate restoration, and ease regulations. Following Sandy, for the first time, DOE's Power Marketing Administrations worked alongside investor-owned utility workers under mutual aid agreements to restore power, utility trucks were classified as emergency response vehicles, and fuel from DOE's Home Heating Oil Reserve was released. The Federal Government also issued a greater number of waivers after Sandy, to help move fuel from the Gulf Coast to Northeast, and to provide greater fuel-use flexibility for certain emergency response applications. State and local governments also initiated several programs to address energy issues following Sandy, including implementing fuel rationing programs to reduce lines at retail filling stations.

Hurricanes Irene and Sandy caused widespread damage to energy infrastructure in the Northeast, including systems supplying power, petroleum products, and natural gas. Faced with these challenges, Federal, State, and local governments worked with industry to restore energy systems and supplies as quickly as possible.

Appendices

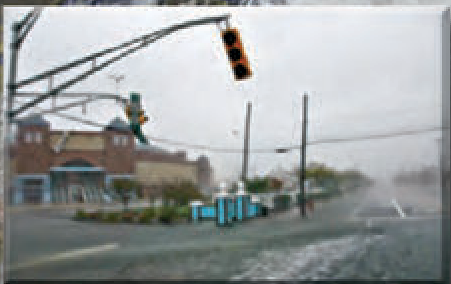
Appendix 1. Peak Customer Power Outages by States

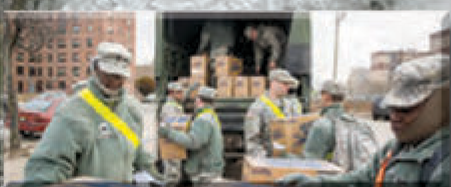
State	Peak Outages		Total Customers	Share of Total	
	Irene	Sandy		Irene	Sandy
Connecticut	702,154	626,559	2,047,240	34%	31%
Delaware	56,901	45,137	459,831	12%	10%
District of Columbia	29,447	3,583	269,815	11%	1%
Illinois		1,149	5,742,146	0%	0%
Indiana		9,224	3,103,313	0%	0%
Kentucky		8,379	2,234,984	0%	0%
Maine	201,663	90,727	1,568,419	13%	6%
Maryland	807,445	311,020	2,691,403	30%	12%
Massachusetts	567,000	298,072	3,451,306	16%	9%
Michigan		120,637	4,785,627	0%	3%
New Hampshire	116,766	141,992	715,797	16%	20%
New Jersey	810,847	2,615,291	4,031,813	20%	65%
New York	941,914	2,097,933	9,303,419	10%	23%
North Carolina	507,063	15,466	4,841,173	10%	0%
Ohio		267,323	6,759,784	0%	4%
Pennsylvania	707,155	1,267,512	6,491,718	11%	20%
Rhode Island	282,280	116,592	498,551	57%	23%
South Carolina	3,940		2,434,144	0%	0%
Tennessee		2,120	3,166,486	0%	0%
Vermont	47,557	17,959	358,678	13%	5%
Virginia	912,715	182,811	3,684,290	25%	5%
West Virginia		271,765	1,017,506	0%	27%
Hurricane Subtotal	6,694,847	8,511,251			
2012 Nor'easter Outages		150,276			
Total	**6,694,847**	**8,661,527**			

Source: OE/ISER Emergency Situation Reports

DEFENSE LOGISTICS AGENCY
JANUARY – FEBRUARY 2013

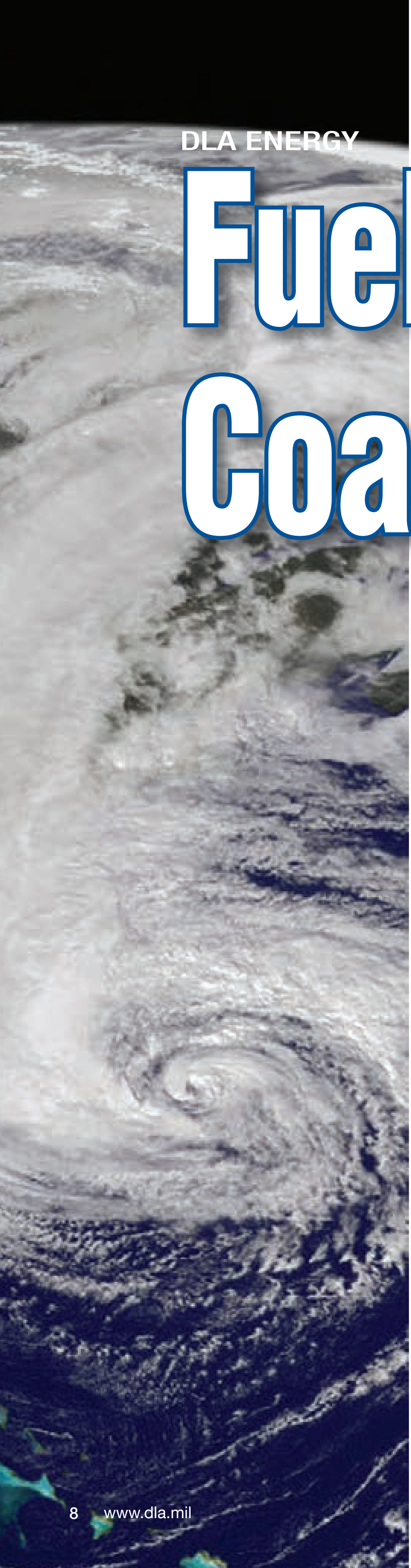
LOGLINES





RELIEF EFFORTS

HURRICANE SANDY



Fueling East Coast Relief

Story by Terry Shawn

As Hurricane Sandy moved up the East Coast, Defense Logistics Agency Energy personnel devised a strategy to provide support for what would turn into a storm of historic proportions.

DLA Energy began tracking Hurricane Sandy Oct. 25, and DLA Energy Americas prepared to support the organization's ground fuel contingency contract with the Federal Emergency Management Agency from Joint Base McGuire-Dix-Lakehurst, N.J.

"When Hurricane Sandy hit, our team was already in place, trained and ready to go," DLA Energy Commander Air Force Brig. Gen. Giovanni Tuck said. "DLA remained committed in our support to our federal and civilian partners on the relief efforts for those impacted by Hurricane Sandy."

Army Col. Ron Ross, DLA Energy Americas commander, led his team and established operations at Joint Base McGuire-Dix-Lakehurst, working with DLA fuel contractor Foster Fuels to help answer fuel needs in New York and New Jersey. Anticipating fuel requirements from FEMA, DLA Energy had the contractor dispatch 60 trucks containing 175,000 gallons of diesel fuel and 25,000 gallons of motor gasoline from Foster Fuels' Brookneal, Va., facility.

"Fort Dix was established as an intermediate staging base," Ross said. "Foster Fuels started with 40 [fuel trucks] at Fort Dix and 20 at Westover Air Reserve Base in Massachusetts, another established ISB. All assets were then consolidated to Fort Dix, totaling 60 assets, and as the operations grew, these assets expanded to approximately 285-300 fueling assets."

Ross' 15-person team provided contingency support to FEMA to meet critical fuel requirements.

The task force from DLA Energy Americas coordinated with Fort Dix personnel and received "first-class support," with a fenced motor pool, generators, light sets, tents, and 24/7 maintenance support for life support equipment, Ross said.

"A team effort … allowed the area to expand, supporting approximately 300 fueling assets, vehicle and equipment maintenance, defueling operations, life support, which included a heated tent for eating and a catering area, latrines and an operations center for Foster

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Terry Shawn is a writer for DLA Energy Public Affairs.

Army Maj. John Adams

Fuel trucks wait for police escort at Joint Base McGuire-Dix-Lakehurst, N.J. DLA coordinated with state and local officials to deliver fuel to areas affected by Hurricane Sandy in direct support of the Federal Emergency Management Agency.

Fuels and [DLA Energy] Americas' task force," Ross said.

Ross went on to praise Joint Base McGuire-Dix-Lakehurst for providing additional lodging in the barracks for drivers, defense fuel acquisition center support personnel and police escorts.

"The Fort Dix leadership checked in with us daily to ensure we were being supported and if there were any needs not being met. This phenomenal support had a major and direct impact on the successful execution of the mission," Ross said.

DLA Energy personnel worked closely with state and local authorities. As one example, Navy Cmdr. Bruce Kong, DLA Energy's inventory management deputy division chief, was embedded in the New York governor's office in Manhattan as a liaison officer.

"My role was to ensure DLA Energy provided the appropriate level of support to the governor's office, City of New York and impacted counties, FEMA and Defense Coordinating Office with fuel-relief efforts," Kong said.

Kong worked directly with FEMA's Joint Fuel Office to establish communication with state and local officials, emergency responders from each county, National Guard troops at Floyd Bennett Field, assorted power companies, and the 12 hospitals that make up the Greater New York Hospital Association to ensure they had the fuel they needed to accomplish their missions.

Sandy Moves Nearer and Conditions Deteriorate

After Sandy made landfall in New Jersey, more than 8.5 million people in 21 states lost power. In response to the outages in New York and New Jersey, DLA Energy issued a warning order to Foster Fuels in anticipation of emergency fuel requirements resulting from the storm.

By this time, DLA Energy had contracted for 200,000 gallons of fuel per day: 175,000 gallons of diesel and 25,000 gallons of motor gasoline for first-responder vehicles and power-restoration equipment.

Coordinating fuel deliveries and dispatching trucks to locations identified by FEMA was an around-the-clock operation, Ross said. Operations rapidly grew from approximately 300 assets supporting three first-responder sites to about 51 first-responder sites throughout the region.

"As the full extent of the storm was recognized, we realized that the first-responder requirements would increase," said Air Force Lt. Col. Tam Gaffney, DLA Energy Americas at San Pedro, Calif., commander and a member of the team. "Foster Fuels immediately ordered an additional 50 trucks to support the increased requirements, and there was no hesitation from drivers and subcontractors."

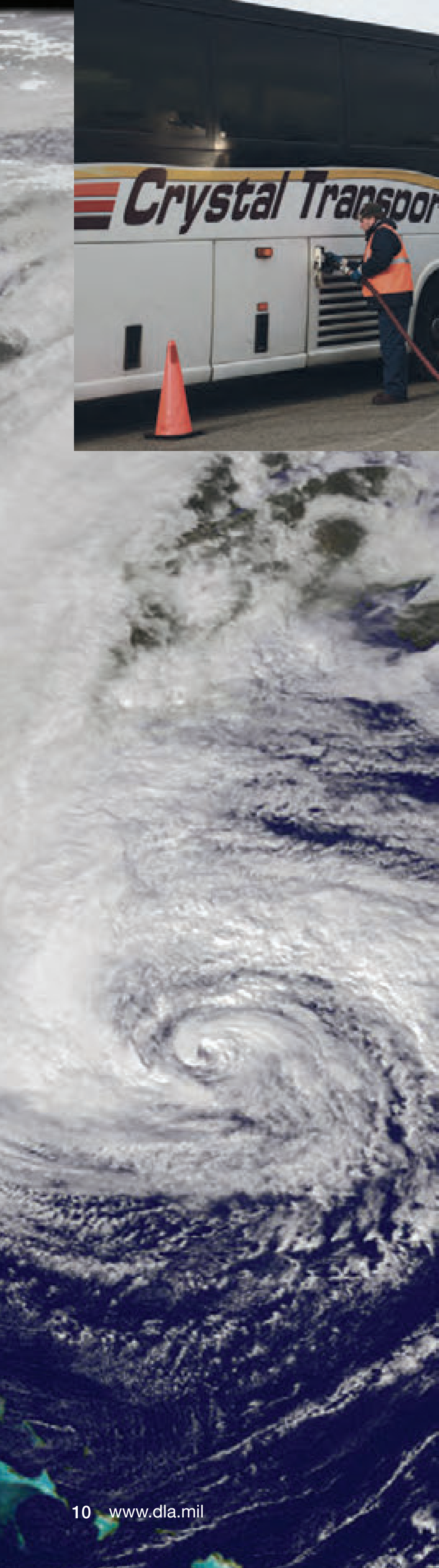


Photo courtesy Foster Fuels

A Foster Fuels employee fills a bus with gasoline. DLA Energy worked with the contractor to answer fuel needs in New York and New Jersey.

Gaffney served as the night-shift officer in charge at the intermediate staging base along with Army Lt. Col. Martine Kidd, DLA Energy Americas at Houston commander, who served as Ross' deputy during fuel-relief operations and day-shift officer in charge. The two were able to assimilate into new roles within the ad hoc organization, which included personnel from DLA Energy Americas and DLA Energy defense fuel support point managers, Kidd said. There were multiple challenges, and one of the first was the lack of a standard tasking system, Gaffney said.

"We were receiving fuel requirements from multiple organizations in multiple formats, from emails to phone calls, and the required eTasker system was largely ignored due to the fast and furious pace of the operation, but our team didn't miss a beat," she said.

The task force quickly adapted into a single team and developed procedures that enabled officials to control the support being delivered by the contingency contractor and satisfy information demands that were sent around the clock, Kidd said.

"As the operation matured, we established an efficient battle rhythm. Day shift often put out fires, allowing night shift to concentrate on accounting and prepping for the next day's missions," Gaffney said.

Another challenge the team encountered was managing the ever-increasing demand for information.

"We were trying to balance mission execution with accounting and reporting requirements in an extremely high-visibility environment. Through the often-manic pace of the operation, we never lost sight of the end goal: to provide emergency and essential fuel to those devastated by the super storm," Gaffney said. "In doing so, our team quickly developed tracking and reporting mechanisms to ensure all the requirements were met, tracked, as well as accurately reported."

This was no small feat considering the team initially operated with a group of quality assurance representatives and no accounting or inventory management experts, Gaffney said.

FEMA Calls for Support

The team got its first fuel request from FEMA – to establish fuel sites at West Orange, Freehold and Vineland, N.J. – Nov.1, said Karen Hammack, the DLA Energy contract specialist responsible for the FEMA-DLA Energy contingency contract.

Because DLA Energy had pre-positioned the contractor's fuel trucks at Joint Base McGuire-Dix-Lakehurst, trucks were dispatched to locations within an hour of the request, DLA Energy Americas Deputy Director Frank Wright said.

It was a risk, Tuck said.

"We decided to lean forward; we put risk out there," Tuck said. "Within the span of 24 hours, we closed 95-98 percent of our requirements."

DFSP managers worked closely with Bill Pollock, DLA Energy's FEMA ordering officer, to validate all requirements, Gaffney said.

"Our resourceful and proactive [non-commissioned officers] on the ground developed an internal tasking process, translating Pollock's requirements into taskings that were coordinated with Foster Fuels," she said.

DLA Energy Plans and Operations Director Stephen Grace said the organization issued about 1.1 million gallons of motor gasoline and 333,000 gallons of diesel fuel to New York and New Jersey from Oct. 29-Nov. 7. New York received 52 percent of that fuel.

DLA Energy officials, who had already requested the contractor double its supply to 400,000 gallons of fuels per day, prepared for fuel resupply by tugboat and fuel barge in the event roads became impassable.

In less than three weeks, estimated DLA Energy fuel support to FEMA in New York and New Jersey included:

- 80,000 gallons of unleaded fuel and 8,000 gallons of diesel dispatched to 230 civilian gas stations.
- Almost 90,000 gallons of unleaded fuel and nearly 80,000 gallons of diesel fuel dispatched to 38 first-responder sites.
- Fuel to Operate 11 Red Cross mobile kitchens.
- About 3,500 gallons of unleaded fuel and 3,500 gallons of diesel dispatched to support mass transit at the New Jersey Meadowlands.
- 73,500 gallons of unleaded fuel and 173,000 gallons of diesel dispatched to New York's Floyd Bennett Field first-responder and transit site.

Ross had high praise for the fuel contractor.

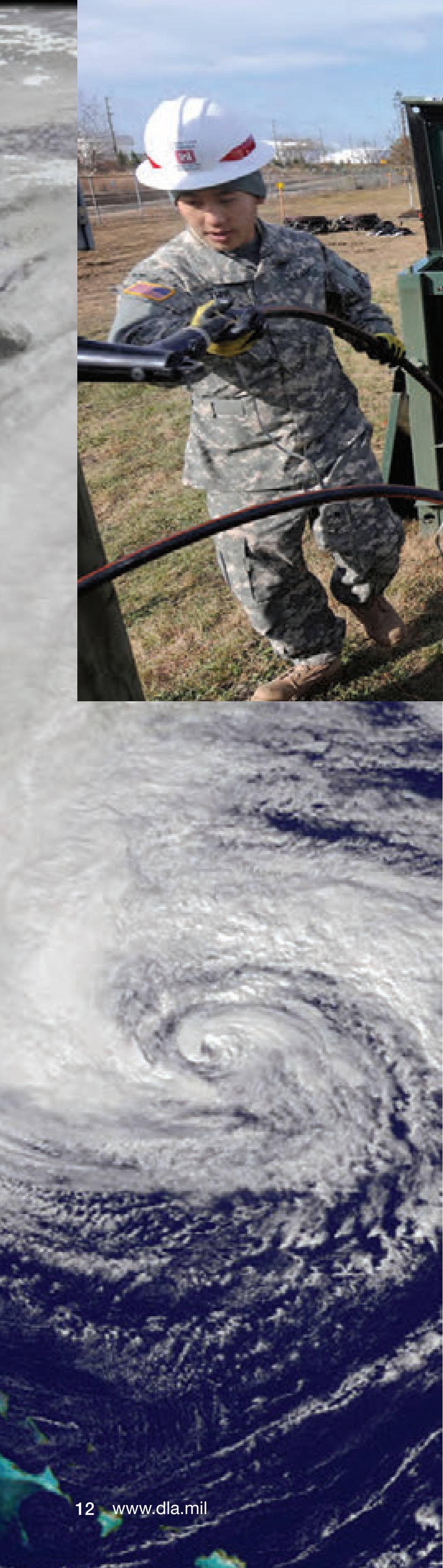
"Foster Fuels was adaptive, flexible and mission success-focused 24/7. They executed like a military operation by building a coalition and partnership with many of the top petroleum and environmental companies as part of their team," he said.

Ross attributed daily safety briefings by the contractor as the reason there were no accidents or spills of any kind during the fuel-support operations. He said that was an impressive feat for an operation of this size.

"[The company] is attuned to the importance of the environmental and

Service members distribute fuel to Hurricane Sandy survivors at New York City's Staten Island Armory. DLA Energy provided fuel to the Federal Emergency Management Agency to be distributed at armories throughout New York and northern New Jersey.

Army Sgt. 1st Class Jon Soucy



E.J. Hersom

Soldiers install electrical generator equipment at a Carteret, N.J., fuel depot that lost power during Hurricane Sandy. DLA Energy provided fuel to state, local and federal responders for electric generators and water pumps.

hazardous material handling, and this performance is truly award-winning in that regard," Ross said.

Tapping the Heating Oil Reserves

At the request of the state of Connecticut, the Department of Energy loaned DLA Energy 4.2 million gallons of ultra-low-sulfur diesel fuel from the Northeast Home Heating Oil Reserve to deliver to Connecticut fuel distributors to address fuel shortages. This was a continuation of an agreement announced Nov. 2, when President Obama declared that Hurricane Sandy had created a severe energy supply interruption.

The fuel, which was distributed to state, local and federal responders in the impacted area, was used to provide additional supplies to ensure continued response and recovery efforts. This included fuel for emergency equipment and buildings, including electric generators, water pumps, federal buildings, trucks and other vehicles, according to an Energy Department release.

To satisfy the requirement, DLA Energy arranged for barge shipments to transport the fuel from storage facilities in Groton, Conn., to New Haven, Conn. DLA Energy Americas maintains surveillance of the heating reserves and regularly tests to ensure the fuel is usable, Quality Assurance Manager Scott Artrip said.

"We were proud to be part of the Energy team that quickly responded to the needs of the state of Connecticut, ensuring an uninterrupted supply chain," Ross said.

Two more transfers of ULSD from the reseve were transported by barge to New Haven, totaling more than 5 million gallons.

Returning to Houston

After receiving deactivation guidance from FEMA, Ross' team began demobilizing Nov. 16.

Photo courtesy Foster Fuels

A truck prepares to leave Foster Fuels' Brookneal, Va., facility. In anticipation of fuel requirements from the Federal Emergency Management Agency, DLA Energy officials had the contractor dispatch 60 trucks containing 175,000 gallons of diesel fuel and 25,000 gallons of motor gasoline to areas affected by Hurricane Sandy.

After three weeks of round-the-clock oversight of the operations, all personnel returned to their home stations safely Nov. 21, said Army 1st Sgt. Pete Martinez Jr. of DLA Energy Task Force Americas.

Gaffney said the successful operation was due to the teamwork of many individuals, including the drivers, subcontractors and National Guardsmen.

"In retrospect, the DLA and DLA Energy response to Hurricane Sandy will be viewed as unprecedented, I believe," Kidd said. "It goes without saying, but it is great to be part of an organization that makes things happen by ... delivering to those in need when it matters most."

The estimated account of DLA Energy's assistance includes:

- 6.9 million gallons of unleaded fuel and 4.1 million gallons of diesel fuel dispatched to New Jersey.
- 2.6 million gallons of unleaded fuel and 387,000 gallons of diesel fuel dispatched to New York.
- More than 5 million gallons of ultra-low sulfur diesel fuel to Connecticut.
- Fuel to 272 civilian gas stations in New York and New Jersey.

Ross said his team and its partners worked well together to bring relief to Sandy's survivors.

"This [relief operation] was seamless as the partners embedded in the operations performed as one organization," Ross said. "This was a DLA team success story."

Editor's note: Numbers in this article are the best estimates available at press time. Final numbers will not be known until after reconciliations are finished with Foster Fuels.

Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities

March 2013

Prepared for:

Oak Ridge National Laboratory

ICF International

1725 Eye St. NW

Washington D.C. 20006

202-862-1200

Introduction

The U.S. electric power system is vast and complex, with thousands of miles of high-voltage cables that serve millions of customers around the clock, 365 days per year. Although normally this "instant" supply of electricity is taken for granted, terrorist attacks and natural disasters remind us how dependent we are on electricity and how fragile the grid can be. Nearly every critical infrastructure (CI) application, including – water systems; oil and gas pipelines; communications systems; residential, commercial, industrial, and institutional buildings; transportation; healthcare systems; and emergency operations; is in some way dependent on electricity.

CI collectively refers to those assets, systems, and networks that, if incapacitated, would have a substantial negative impact on national or regional security, economic operations, or public health and safety.[3] These applications include hospitals, water and wastewater treatment facilities, police and security services, and places of refuge. Prior to September 11, 2001, emergency management planning focused primarily on preparedness and response—that is, what happens at the moment of an emergency and in the minutes, hours, days, and weeks thereafter. In the years since 2001, the idea of infrastructure resilience—the ability to maintain operations despite a devastating event—has become a key principle in disaster preparedness. Natural disasters such as Superstorm Sandy remind us how dependent we are on electricity and how fragile the grid can be. During times of crisis, it is especially vital that critical infrastructure facilities be without power disruption.

Combined heat and power (CHP) offers the opportunity to improve CI resiliency, mitigating the impacts of an emergency by keeping critical facilities running without any interruption in electric or thermal service. If the electricity grid is impaired, a specially configured CHP system can continue to operate, ensuring an uninterrupted supply of power and heating or cooling to the host facility.

CHP systems are a highly efficient form of distributed generation, typically designed to power a single large building, campus or group of facilities. In the context of critical infrastructure applications, these CHP systems are comprised of on-site electrical generators (primarily fueled with natural gas) that achieve high efficiency by capturing heat, a byproduct of electricity production that would otherwise be wasted. The captured heat can be used to provide steam or hot water to the facility for space heating, cooling, or other processes. Capturing and using the waste heat allows CHP systems to reach fuel efficiencies of up to 80%, compared with about 45% for conventional separate heat and power.[4] This is both environmentally and economically advantageous. CHP systems can use the existing, centralized electricity grid as a backup source to meet peak electricity needs and provide power when the CHP system is down for maintenance or in an emergency outage. If the electricity grid is impaired, the CHP system continues to operate, ensuring an uninterrupted supply of electricity to the host facility.[5]

On October 28, 2012, Superstorm Sandy slammed into the eastern United States, wreaking havoc on local economies, infrastructure, and communities. The storm caused widespread damage and economic

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[3] Patriot Act of 2001 Section 1016 (e)
[4] US Department of Energy, Combined Heat and Power Basics, http://www1.eere.energy.gov/manufacturing/distributedenergy/chp_basics.html
[5] The supply of natural gas is not, in general, dependent on electricity from the grid.

losses across New Jersey, New York, and Connecticut. Extended power outages affected the region for days. At the height of the blackout, 2.6 million facilities, businesses and homes were without power in New Jersey, 2.1 million in New York, and 630,000 in Connecticut.[6] This tri-state area was among the most heavily-hit regions in terms of power outages, and these states were Federal Emergency Management Agency (FEMA)-declared disaster areas.

Figure 2.[7] **FEMA Disaster Areas**

Some commercial and industrial facilities in the area were able to power through Superstorm Sandy due to CHP. This report summarizes how CI facilities with CHP systems operated during this storm. Several examples from other storms and blackout events in other regions of the country are also included. This report also provides information on the use of CHP for reliability purposes, as well as state and local policies designed to promote CHP in CI applications.

[6] "Powering Through the Storms," Pace Energy and Climate Center.
[7] http://www.fema.gov/disasters

Reliability Benefits of CHP

CHP systems, when designed to operate independently from the grid, can provide critical power reliability for a variety of businesses and organizations while providing electric and thermal energy to the sites on a continuous basis, resulting in daily operating cost savings. CHP systems can be configured in a number of ways to meet the specific reliability needs and risk profiles of various customers, and to offset the capital cost investment for traditional backup power measures.

CI facilities typically have backup generators onsite to supply electricity in the case of a grid failure; however, CHP systems offer several advantages over backup generators. In some sectors, such as hospitals, the presence of a CHP system may not override the necessity of having a backup generator, which is required by law. CHP systems provide regular benefits to their host facilities, rather than just during emergencies. Some advantages that CHP systems have over backup generators include:

- Backup generators are seldom used and are sometimes poorly maintained, so they can encounter problems during an actual emergency. Most CHP systems run daily and are typically better maintained.
- Backup generators typically rely on a finite supply of fuel on site, often only enough for a few hours or days, after which more fuel must be delivered if the grid outage continues. Many CHP systems have a permanent source of fuel on demand; for example, most natural gas infrastructure is underground and rarely impacted by severe weather events.[8]
- Backup generators may take time to start up after grid failure and this lag time, even though it may be brief, can result in the shutdown of critical systems. In many cases, backup generators not permanently located on-site must be delivered to the sites where they are needed, leading to further delays in critical infrastructure recovery. CHP systems are the permanent and primary source of electricity[9] for the site they serve, and if properly sized and configured, are not impacted by grid failure.
- Backup generators typically rely on reciprocating engines burning diesel fuel, a polluting method of generating electricity. CHP systems typically burn natural gas, a cleaner fuel, and achieve significantly greater efficiencies, lower fuel costs, and lower emissions.
- Backup generators only supply electricity; whereas, CHP systems supply thermal loads (heating, cooling, chilled water) as well as electricity to keep facilities operating as usual.

Overall, a CHP system that runs every day and saves money continuously is more reliable in an emergency than a backup generator system that only runs during emergencies.[10] During Superstorm Sandy there were multiple cases of emergency generators that did not function properly such as the

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[8] http://www.naturalgas.org/naturalgas/transport.asp

[9] CHP can be designed to meet some or all of a facility's electricity needs. CI facilities often have ensured their CHP facility is sized to provide the electricity to their top priority energy loads.

[10] NYSERDA collects information on the reliability and availability of some of the CHP demonstration projects funded in New York. Overall, the CHP system reliability figures have shown that they systems are highly reliable. http://chp.nyserda.ny.gov/home/index.cfm

back-up generator at NYU Langone Medical Center[11] and fuel pumps for backup generators failed at Bellevue Hospital after the basement flooded.[12] This forced the hospitals to evacuate patients to other medical centers with CHP systems or backup generators that remained operational during the storm. During the Northeast blackout in 2003, half of New York City's 58 hospitals suffered backup generator failures[13], and the lack of backup power allowed 145 million gallons of raw sewage to be released from a Manhattan pumping station.[14]

Following SuperStorm Sandy, the New York State Energy Research and Development Authority (NYSERDA) conducted an analysis of the operation of CHP systems at sites that had received NYSERDA funding and were located in areas affected by the storm. NYSERDA project managers contacted the 24 sites in affected areas individually. Each site was grouped into one of the following four categories:

- Category 1: Site lost grid power, and the CHP system was designed to operate during a grid outage and operated as expected.
- Category 2: Site lost grid power, and the CHP system was designed to operate during a grid outage, but it failed to operate correctly.
- Category 3: Site never lost power and the CHP system was not put to the test.
- Category 4: Site lost grid power, but the CHP system was an induction unit and not designed to run during a grid outage.

Among the sites that lost grid power, and where the CHP unit was designed to operate during a grid outage, ALL of the CHP systems did perform as expected. There was not a single site that lost grid power, where the CHP unit failed to perform as expected.[15]

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[11] http://www.forbes.com/sites/gregorymcneal/2012/10/29/nyu-hospital-without-power-evacuation-underway/.
[12] http://well.blogs.nytimes.com/2012/11/26/a-return-to-bellevue-after-the-storm/
[13] http://www.txsecurepower.org/Portals/23/Webinar%201_HB%201831.pdf
[14] Ibid.
[15] Email communication from Elizabeth Markham, NYSERDA Assistant Project Coordinator on January 14, 2013 to Northeast CEAC Staff, Timothy Banach and Tom Bourgeois

Context for CHP in Critical Infrastructure Applications

Background on Grid Outages and Critical Infrastructure Needs

Following the Northeast blackout in 2003, and natural disasters such as Hurricane Katrina in 2005, Hurricane Ike in 2008, and Superstorm Sandy in 2012, disaster preparedness planners have become increasingly aware of the need to protect critical infrastructure facilities and to better prepare for energy emergencies. Resilient CI facilities enable a faster response to disasters when they occur, mitigate the extent of damage and suffering that communities endure, and speed the recovery of critical functions. CHP can answer this need while making energy more cost- and fuel-efficient for the user, as well as more reliable and environmentally friendly for society at large. By installing properly sized and configured CHP systems, CI facilities can effectively insulate themselves from a grid failure, providing continuity of critical services and freeing power restoration efforts to focus on other facilities.

The use of CHP systems for CI facilities can also improve overall grid resiliency[16] and performance by removing significant electrical load from key areas of the grid. This is possible when CHP is installed in areas where the local electricity distribution network is constrained or where load pockets exist. The use of CHP in these areas eases constraints by reducing load on the grid. For this reason, CHP placement can be coordinated with the utility; this allows CHP design to be based on the conditions and needs of the host facility, but also on the conditions and needs of the local grid system. Both facility- and grid-level assessments should be part of the cost/benefit analysis for any proposed CHP system at CI facilities.

To ensure continued progress towards addressing grid and CI resiliency through technologies such as CHP, improved coordination between government emergency planners and the electricity sector must occur. Appropriately sized CHP in CI will allow for the continued operation of critical facilities, particularly waste-water treatment plants and medical facilities, during a grid outage. Having critical infrastructure facilities operational during and after a natural disaster will reduce response times of emergency workers to community needs, and allow limited government resources to be utilized in other post-recovery efforts, resulting in a quicker recovery of the community.

CHP Design for Reliability

The aging U.S. electricity infrastructure presents a significant concern to CI facilities in meeting their power needs, as grid outages become increasingly frequent. At a recent electric industry meeting, a representative from the Electric Power Research Institute (EPRI) stated that over $150 billion per year is lost by U.S. industries due to electric network (reliability) problems, and that 500,000 customers are without electricity for a minimum of 1 hour every day in the U.S.[17] CHP systems have demonstrated their ability to provide CI facilities with electric and thermal power during instantaneous as well as prolonged electric utility grid outages (see below case studies).

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[16] Resiliency is defined as the ability of a system to return to its original state after being disturbed. In this paper resiliency refers to the ability to quickly return to a "business as usual" state after a natural disaster or other event causing an electric grid outage.

[17] http://www.galvinpower.org/sites/default/files/Electricity_Reliability_031611.pdf

The primary benefit of a CHP system is that it produces power and thermal energy for the user at a lower cost than the separate heat and power supply it replaces. An additional benefit can be increased energy reliability for the facility if properly incorporated into CHP system design. The reliability of power supply from a typical CHP configuration– a baseload CHP system providing a significant portion of the facility's power and heating/cooling needs with the remaining power needs supplied by the grid – can be higher than the reliability currently offered by grid-only power. In a CHP system designed for reliability, the grid serves as the first level of back-up to the CHP system. When the CHP system is down, either for planned maintenance or due to an unscheduled incident, the grid supplies the entire electricity load to the plant. In the unlikely event that both the CHP system and the grid are down at the same time, critical loads could be maintained through the use of standby generators. In many applications, the value of this additional reliability can outweigh all other factors in the investment decision.

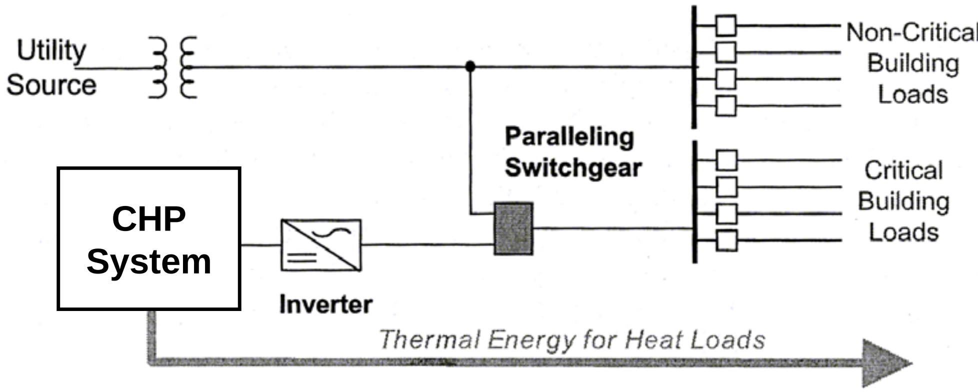
The requirements for a CHP system to deliver power reliability to a CI facility, are straightforward, but often add to system costs relative to CHP located at a non-critical facility (see Table A-1 in the Appendix). While CHP systems may or may not be designed to meet the entire power demand for a facility, the system can be configured to maintain power to critical loads in the event of a utility grid outage. In order to implement this capability, there are often added costs to tie into the critical electrical systems and to devise a load shedding strategy and capabilities. These costs can include engineering, controls, labor and materials. The engineering required to analyze the existing electrical system, determine critical loads, provide a design and determine cost to provide back-up power from the system, may itself be fairly extensive. A system designed to supply the entire power needs of a facility during an outage may need to be oversized compared to the optimal design or require redundant units that would add to the cost.

To ensure uninterrupted operation during a utility system outage, the CHP system must have the following features:

1) ***Black start capability*** – The CHP system needs a battery powered starting device or other supplemental electricity supply system, such as a backup generator, that will allow it to start up independently from the grid.
2) ***Generator capable of operating independently of the utility grid*** – The CHP electric generator must be able to continue operation without the grid power signal (e.g., synchronous generators and supporting controls). High frequency generators (microturbines) or DC generators (fuel cells) need to have inverter technology that can operate grid independently.
3) ***Ample carrying capacity*** – The size of the CHP systems must be matched to the critical loads in the facility.
4) ***Parallel utility interconnection and switchgear controls*** – The CHP system must be able to properly disconnect itself from the utility grid and switch over to providing electricity to critical facility loads. The system must also be able to reconnect itself smoothly after an event. Transfer requirements themselves will impact equipment needs and costs. Facilities that can tolerate a brief power outage while the system is manually transferred to islanding mode will impact costs less than facilities that need to use equipment and controls that provide a seamless transfer.

Figure 1 shows a diagram of a CHP system that is used for power reliability. Further information on the design characteristics of CHP for reliability is provided in Appendix A.

Figure 1. CHP System with Backup Responsibility for Critical Loads[18]



Financial Impact of Grid Outages

Power outages can cause significant financial impacts. For instance, Superstorm Sandy resulted in considerable disruption to businesses. The economic research firm Moody's Analytics attributed nearly $20 billion in losses from suspended business activity.[19] Wall Street's extended closure during Superstorm Sandy included a two-day shutdown of the New York Stock Exchange, which halted financial market trading at a cost of about an estimated $7 billion.[20] IHS Global Insight estimated that the lost output and overall effects of the storms could shave as much as 0.6 percentage points off of annualized fourth-quarter economic growth; and combining all disruptions, early estimates indicate total economic losses to be around $30 to $50 billion dollars.[21] The major disruptions leading to these economic losses included the cancellation of thousands of flights and closure of other transportation services, the two-day shutdown of the New York Stock Exchange, and a number of refineries and several nuclear facilities that were either shutdown or run at a lower capacity.[22]

Rutgers recently published a report on "The Economic and Fiscal Impacts of Hurricane Sandy in New Jersey" that estimates economic losses, not including damages to physical structures, of approximately $11.7 billion in state GDP. [23] The study found that overall GDP losses could have been reduced in New

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[18] EPA CHP Partnership. http://www.epa.gov/chp/basic/benefits.html
[19] http://money.cnn.com/2012/10/29/news/economy/hurricane-sandy-business/index.html
[20] Ibid.
[21] IHS Global Insights. http://press.ihs.com/press-release/country-industry-forecasting/hurricane-sandy-monster-storm-just-time-halloween
[22] Ibid.
[23] Rutgers Regional Report, *The Economic and Fiscal Impacts of Hurricane Sandy in New Jersey*, January 2013. http://policy.rutgers.edu/reports/rrr/RRR34jan13.pdf. This analysis assumed a loss of one week's output for two-thirds of the state's GDP, and then assumes that half of the loss was restored in week two, and the other half in week three. The loss of one week's output for two-thirds of the state's GDP was estimated at $5.56 billion, with losses of $2.78 billion in week two and then $1.39 billion in week three, for a total loss of $9.72 billion over the

Jersey if there had been additional backup sources of power such as CHP, which would have lessened the economic losses associated with power outages.

Other reports have previously analyzed the business implications of power outages.[24] In a 2001 report, EPRI evaluated two million industrial and digital economy businesses to determine the economic costs of power outages and power quality disturbances.[25] The report looked at three specific sectors:

1. Digital Economy (DE) sector: comprised mainly of data storage and retrieval, data processing, or research and development operations such as the telecommunications, data storage, biotechnology, electronics manufacturing, and the financial industry.

2. Continuous Process Manufacturing (CPM) sector: comprised of manufacturing facilities that continuously feed raw materials through an industrial process such as the paper, chemical, petroleum, rubber and plastics, stone, clay, glass, and primary metals industries.

3. Fabrication and Essential Services (F&ES) sector: comprised of all other manufacturing industries, plus utilities and transportation facilities like railroads and mass transit, water and wastewater treatment, and gas utilities and pipelines.

Although the two million businesses analyzed only accounted for 17% of all U.S. businesses, they amounted to 40% of U.S. GDP. Additionally, disruptions in each of these sectors, especially DE and F&ES, have an almost instantaneous effect on other sectors that are dependent on the services they provide. The EPRI study found that industrial and digital economy firms are losing about $45.7 billion per year due to power outages. An additional $6.7 billion in costs resulted from power quality disturbances other than outages. The cost for all industry combined is an estimated at $120 to $190 billion per year. According to the study, New York ranks third in the U.S., behind California and Texas, with an estimated $8.0 to $12.6 billion in costs associated with outages and power quality phenomena.

The New York Times published an article about the struggle that businesses were facing trying to get back to normal operations after Sandy.[26] The article highlights the challenges that core businesses, such as Verizon Communications, the largest telecommunications phone provider in New York, were facing. Verizon's backup power systems failed, leading to a loss in voice, internet, and telephone services in that area. Losses in the financial sector were not as bad as they could have been due in part to backup generators at key financial industry data centers. For example, the New York Stock Exchange has a data

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three weeks. Rutgers estimates that based on current dollars, this yielded a $11.66 billion dollar loss in the fourth quarter of 2012. In calculating this loss, Rutgers included the reduction of residential energy usage to zero for two-thirds of the state for 10-days due to power outages.

[24] Hedman, Bruce and Ken Darrow, EEA, The Role of Distributed Generation in Power Quality and Reliability, Final Report, December 2005, Prepared for NYSERDA, http://www.localpower.org/documents/reporto_nyserda_reliability.pdf.

[25] Consortium for Electric Infrastructure to Support a Digital Society (CEIDS), An Initiative by EPRI and the Electricity Innovation Institute, *The Cost of Power Disturbances to Industrial & Digital Economy Companies*, June 2001, http://www.empoweret.com/wp-content/uploads/2008/09/cost_of_power_outages.pdf.

[26] Schwartz, Nelson, *After Storm, Businesses try to Keep Moving*, The New York Times, October 30, 2012, http://www.nytimes.com/2012/10/31/business/after-hurricane-sandy-businesses-try-to-restore-service.html?pagewanted=all.

center located in Mahwah, New Jersey, which has backup generators, although not CHP, and was able to continue operation during the storm.[27] An outage occurred at 111 8th Avenue, the Google-owned "carrier hotel" in New York. The building houses major data center operations for Digital Realty Trust, Equinix, Telx and many other providers and networks, as well as 500,000 square feet of office space for Google.[28] Tenants at the 111 8th Avenue complex all experienced some issues related to fuel line and generator failures, along with cooling issues.[29]

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27 http://www.tradersmagazine.com/news/stock-exchanges-going-live-on-halloween-110473-1.html.
28 http://www.datacenterknowledge.com/archives/2010/12/03/wsj-google-has-bought-111-8th-avenue/
29 Ibid.

Policies Promoting CHP in Critical Infrastructure

During and after a natural or man-made disaster, CHP can play a vital role in ensuring that the appropriate emergency response services are available and critical infrastructure remains operational. These recent natural disasters have spurred greater focus by state and local policymakers and planners on the role of CHP. For example, the damage caused by hurricanes along the Texas and Louisiana Gulf Coast in the past several years acted as a focusing event, which propelled the adoption of critical infrastructure policies in these two states.[51] Additionally, due in part to the Northeast Blackout in 2003, storm events, security threats and other concerns, New York State has also been a strong proponent of CHP at critical infrastructure facilities.

Texas and Louisiana are leaders in the deployment of CHP because of the large industrial base in the region. Although a significant portion of CHP has been implemented in this region, its use has been largely limited to industry and has been deployed primarily for economic purposes. The damage caused by the previous hurricanes made it apparent to policy makers that critical infrastructure needs to be re-enforced with reliable sources of power, and reliability and survivability improved, during natural disasters. The result was the passage of critical infrastructure policies in Texas and Louisiana.

Texas bills HB 1831 and HB 4409[52] and Louisiana resolution No. 171, passed in 2009 and 2012, respectively, require that all government entities (including all state agencies and all political subdivisions of the state such as cities, counties, school districts, institutes of higher education, and municipal utility districts) must:

- Identify which government owned buildings and facilities are critical in an emergency situation.
- Prior to constructing or making extensive renovations to a critical governmental facility, the entity in control of the facility must obtain a feasibility study to consider the technical opportunities and economic value of implementing CHP.

The State Energy Conservation Office in Texas and the Department of Natural Resources and the Louisiana Public Services Commission are tasked to establish guidelines to evaluate CHP feasibility in critical government facilities. This legislation was enacted because of several major natural disasters (hurricanes Katrina, Rita, and Ike) that showed the vulnerability of the state's critical infrastructure. It was found that these natural disasters could knock out portions of the electric grid for weeks and backup generators were not necessarily reliable. Texas and Louisiana have found that the high pressure pipeline system that supplies natural gas throughout the state has provided highly reliable service throughout recent hurricanes. Underground natural gas pipelines provide a secure source of energy to

[51] One must keep in mind that the power outage does not even have to be a major natural disaster to cause significant societal and economic disruption. For example, the Northeast Blackout of 2003, putting 55 million people without power, was largely caused by tree branches tripping a wire. The outage affected water supply, communication and transportation, as well as industry. The event that caused the blackout was hundreds of miles from much of the population that was affected. CHP can help prevent the wide-spread outages and minimize the effect.

[52] http://www.txsecurepower.org/

on-site CHP systems, which can then deliver electricity, steam, and chilled water securely throughout the facility.

In both states, a government building or facility is deemed "critical," if it meets the following criteria:

- Is owned by the state or a political subdivision of the state;
- Is expected to continue serving a critical public health or safety function throughout a natural disaster or other emergency situation, even when a widespread power outage may exist for days or weeks;
- Is continuously occupied and maintains operations for at least 6,000 hours each year; and
- Has a peak electricity demand exceeding 500 kilowatts.

Examples of government buildings and facilities that may meet the "critical" definition include hospitals, nursing homes, command and control centers, shelters, prisons and jails, police and fire stations, communications and data centers, water or wastewater facilities, research facilities, food preparation or food storage facilities, hazardous waste storage facilities, and similar operations.

For both states, CHP may be deemed feasible if it can provide a facility with 100% of its critical electricity needs, can sustain emergency operations for at least 14 days, and meets a minimum efficiency of 60%. The energy savings must also exceed installation, operating and maintenance costs over a 20-year period.[53]

New York - The New York State Energy Research and Development Authority (NYSERDA) has been a strong supporter of CHP technology development and implementation for over 10 years. NYSERDA created a strategic partnership with the New York State Office of Emergency Management to educate the state's emergency managers about CHP so that it can be included in strategic plans for emergency facilities and places of refuge. The purpose of this partnership was to provide the "connecting links" between national homeland security efforts and regional/state infrastructure resiliency activities. The partnership produced a report[54] in 2009 detailing the CHP potential in critical infrastructure applications in New York. The partnership provided outreach information to these sectors (e.g., hospitals, water treatment plants, places of refuge etc.) by scheduling presentations at their meetings or other gatherings to present the benefits of CHP to infrastructure resiliency.

On February 14, 2013, New York Governor Andrew Cuomo announced that a $20 million investment will be made towards clean energy projects, specifically those aimed at providing continuous power and heat during power outages.[55] This investment is based on recommendations made by NYS 2100, one of the three commissions Governor Cuomo created in the aftermath of Superstorm Sandy to improve the State's emergency preparedness and response to natural disasters. The program will be administered by

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[53] http://files.harc.edu/sites/gulfcoastchp/newsletters/Newsletter_20120626.pdf
[54] http://www.nyserda.ny.gov/en/Publications/Research-and-Development/~/media/Files/Publications/Research/Other%20Technical%20Reports/nyserda-chp-final-report-optimized.ashx
[55] http://www.governor.ny.gov/press/02142013-20million-for-combined-heat-and-power

NYSERDA. NYSERDA will only fund those CHP systems that can continue operations during grid outages. Additionally, all fund applicants in flood zones must meet a "high and dry" requirement, meaning they must install CHP systems that would be above the flood plain in a worst-case flood scenario. Incentives will be paid up to $1.5 million per project for projects 50 kW to 1.3 MW in capacity. Funding is available on a first-come, first-serve basis through December 31, 2016, or until funds are exhausted. Only CHP systems installed at sites that pay the System Benefits Charge are eligible for funding.[56]

New Jersey is attempting to improve its energy resilience through the New Jersey Energy Master Plan[57]. As a part of this plan, the New Jersey Economic Development Authority and Board of Public Utilities, under Governor Chris Christie, issued another round of funding to assist in improving grid reliability in the state through CHP. On January 17, 2013, the state issued a second round of the Large Scale Combined Heat and Power/Fuel Cell Program. This is a $25 million rolling grant program that will provide incentives to projects greater than 1 MW in size. The maximum incentive for the project is $3 million or 30% of total project costs, whichever is greater. Any New Jersey based governmental, commercial, institutional or industrial entity is eligible to participate.[58]

Emergency Planning and Risk Mitigation with CHP

Some state and other local governments have developed, or are in the process of developing, policies to include CHP in critical infrastructure planning, to ensure the energy security and reliability of emergency facilities. A focus of infrastructure resilience is investing in resources that allow for as much of the relevant critical infrastructure system as possible to remain functional in the event of an attack or disaster, and for compromised parts of the system to resume functionality as quickly as possible. In this context, the value of CHP to infrastructure resilience becomes clear; critical assets across sectors can be insulated from disruptions to the electricity grid through the use of CHP and other forms of distributed energy.[59] For successful implementation of critical infrastructure policies there must be considerable interaction between the utility, government emergency planners, and facility operators. A first step in identifying and prioritizing critical infrastructure assets, and how to incorporate CHP, is to review the Department of Homeland Security's National Infrastructure and Protection Plan (NIPP).[60] The NIPP helps emergency planners determine how to prioritize its critical infrastructure assets through a variety of assessment tools.

The first assessment recommended by the NIPP is to determine which facilities and services are most important for the safety and recovery of the community, and then rank these facilities in order of their importance. The assessment will help determine the problems a community may face if a specific facility

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[56] All Investor Owned Utilities in New York pay the Systems Benefits Charge (Consolidated Edison, Orange & Rockland, Rochester Gas & Electric, Central Hudson Gas & Electric, Niagara Mohawk, New York State Electric and Gas).
[57] State of New Jersey, Energy Master Plan. http://nj.gov/emp/
[58] http://www.njeda.com/web/pdf/LargeScaleCHPFuelCellsSolicitation.pdf
[59] When designing a CHP system for a critical infrastructure application it is important that the system can operate independently from the grid. The system must be designed to be "islanded," meaning that the system is self-contained and can operate separate from the grid.
[60] http://www.dhs.gov/xlibrary/assets/NIPP_Plan.pdf

or piece of infrastructure is not operational by looking first at the human impact, followed by the economic impact, the impact to public confidence, and the impact on government continuity. This impact analysis also helps pinpoint the best sites for CHP development.

NYSERDA has conducted an assessment with the assistance of the NIPP, and found that the most appropriate focus and prioritization of CHP review should be at hospitals and water treatment/sanitary facilities, followed by nursing homes, prisons, and places of refuge.[61] To ensure continued progress towards addressing grid and critical infrastructure resilience through technologies such as CHP, improved coordination between government emergency planners and the electricity sector must occur. State utility regulators can facilitate that coordination and help reduce regulatory barriers to CHP so that these systems can be safely and more easily installed in critical infrastructure applications. Having specific resolutions or policies in place facilitates the deployment of CHP and can help promote the development of this resource and ensure its inclusion in the emergency planning process.

There are other barriers to the development of CHP at CI facilities besides technical and economic feasibility that should also be addressed. Education about the benefits of CHP systems to CI facilities is necessary. One of the main challenges is to move beyond standard back-up generation implementation. The practice of continuing to install diesel or natural gas back-up generation is largely a result of institutional inertia; however, it can also be due to state mandates. Certain critical facilities such as hospitals with life-safety needs are required to install backup generators for their critical loads. CHP systems can serve this function and may be able to be substituted for backup generators if designed appropriately. Backup generator systems are known and familiar to emergency planners and facility operators, typically have lower up-front costs than CHP, and are easier to install and get online than a CHP system. The result is that standard back-up generation is the default choice in most instances, but with greater information and understanding, CI facilities may choose to invest in CHP.

Conclusions

CHP may be a good investment for critical infrastructure facilities due to its opportunity to improve resiliency, mitigate the impacts of a disaster, provide energy cost savings, greater efficiencies, and reduced overall emissions, all while providing reliability during grid outages. There are numerous examples of CI facilities with CHP that operated during disasters, including Superstorm Sandy. Successful application of CHP in critical infrastructure applications requires engaging decision-makers who build, manage, and operate these facilities, as well as emergency management professionals and state and local policy makers.

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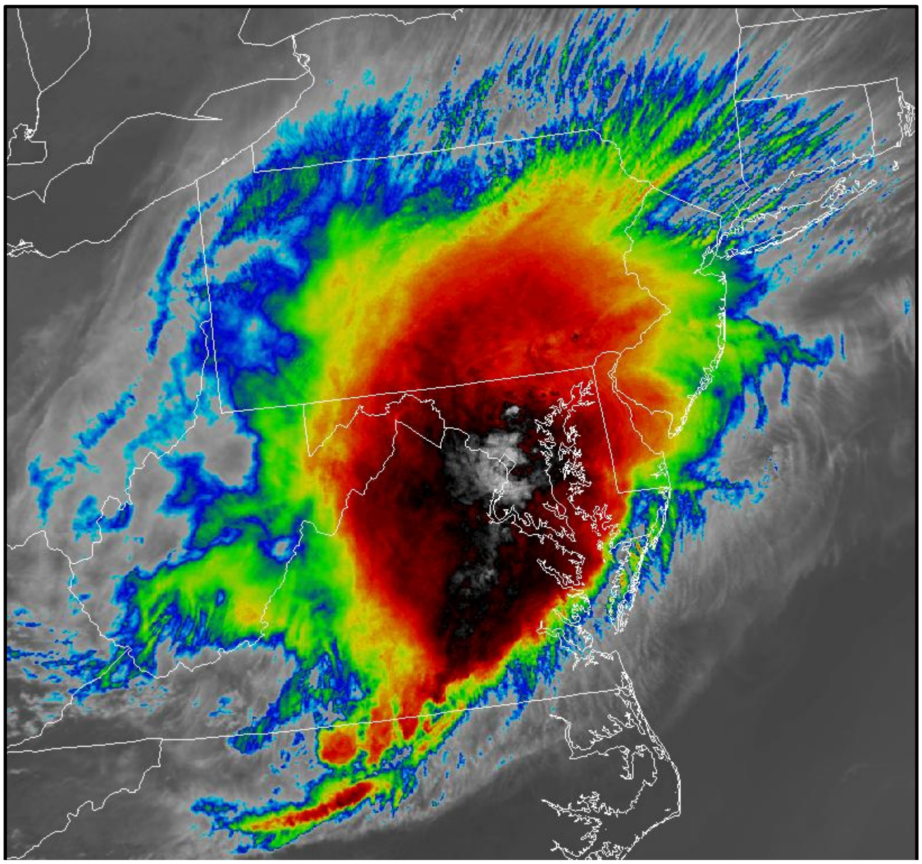
[61] The Contribution of CHP to Infrastructure Resiliency in New York State, Final Report, April 2009, New York State Energy Research and Development Authority.
http://www.energetics.com/resourcecenter/products/studies/Pages/CHP-Contribution-Infrastructure-NY.aspx

WEATHERING THE STORM

Report of the Grid Resiliency Task Force



September 24, 2012
Office of Governor Martin O'Malley
Executive Order 01.01.2012.15

Figure 5 - Distribution Substation

Source: PHI

B. How does Maryland regulate its electric distribution utilities?

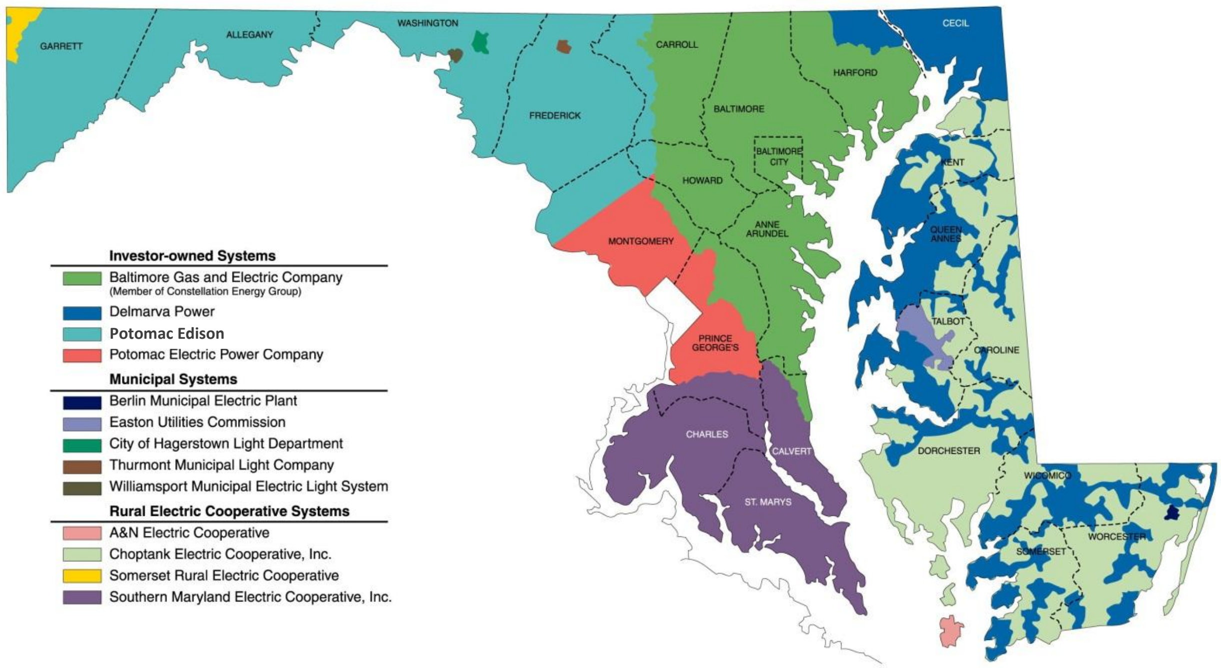
The electric distribution utilities' core function is to ensure "safe and reliable service" to Maryland consumers. This well-established statutory and regulatory construct has been codified, with some changes, over the last century. The distribution of electricity to utility customers differs from many other products and services that Marylanders purchase because the utility owning the distribution system is granted a natural monopoly. In other words, there can be only one set of wires owned by one electric distribution utility that provides electricity to a home or business. Society permits the monopoly because the alternative – having multiple lines, poles, transformers and other electric distribution equipment from different utility companies serving the same geographic area – would be impractical and unwieldy on many levels. To avoid subjecting society to the high costs of duplicative infrastructure, a monopoly is granted to a distribution utility for a specified geographic area.

In exchange for this monopoly, distribution companies in Maryland are subject to regulation by the PSC. This arrangement is frequently referred to as "the regulatory compact." The regulatory compact is essentially a deal between the public and a utility company that allows the utility company to earn a defined (and regulated) return on assets and cost recovery for prudently incurred expenses. In exchange, the public benefits from investment in essential services as well as regulatory oversight of the utility.

Utilities obtain the right to act as a monopoly in a specified geographic area through the grant by the Maryland General Assembly of a utility franchise. Once a utility company receives a franchise, the PSC must authorize the exercise of that franchise before the utility company is permitted to provide electric service to customers in the designated service territory.[2] Once the permission to exercise the franchise is approved, the PSC regulates the utility's activities and the rates the utility is permitted to charge its customers, all to ensure that the utility company is providing safe and reliable service at a just and reasonable rates, as required by Maryland law.[3]

[2] Section 5-201, Public Utility Companies Article, Annotated Code of Maryland.
[3] Sections 4-201 and 5-303, Public Utility Companies Article, Annotated Code of Maryland.

Figure 6 - Service Territories of Maryland Utilities



The number of customers in each utility varies based on the geography that the utility services. Table 1 shows the latest data available for the four investor owned utilities, as well as data for the two coops with reliability targets. Not surprisingly, due to the inclusion of large population centers around Baltimore and Washington, D.C., BG&E has the largest customer base. Pepco has the next highest customer count, followed by Potomac Edison, Delmarva Power and Light, SMECO, and Choptank. In addition to the six utilities with reliability requirements, there are seven other coops and municipal utilities that are regulated by the PSC. Combined, these seven companies serve approximately 35,000 customers.[4]

Table 1 - Customer Counts for Selected Utilities and Coops

Distribution Utility	Residential	Small C & I	Mid C & I	Large C & I	All C & I	Total
Baltimore Gas and Electric	1,115,274	103,539	26,259	670	130,468	1,245,742
Choptank	47,179				5,064	52,243
Delmarva Power & Light	173,946	26,942	5,067	79	32,088	206,034
Potomac Edison	221,470	28,300	6,454	106	34,860	256,330
Potomac Electric Power	488,555	31,676	16,915	553	49,144	537,699
SMECO	136,191				13,961	150,152
Total	**2,182,615**	**190,457**	**54,695**	**1,408**	**265,585**	**2,448,200**

[4] Data taken from July 2012 PSC Electric Choice Enrollment Monthly Reports, except for Choptank and SMECO, which were taken from PSC Ten Year Plan 2011-2020

1. How does Maryland measure reliability?

One way in which the PSC ensures that the utilities are providing reliable service is through regulation. During the 2011 Maryland General Assembly Session, Governor O'Malley co-sponsored, and the General Assembly passed, legislation requiring the PSC to adopt stricter regulations regarding utility performance by July 1, 2012. The legislation also raised the maximum penalty for failure to comply with the regulations from $500 to $25,000 per violation.

Approved by the PSC in April 2012, the regulations that resulted from the PSC's Rule Making 43 proceeding ("RM43") established minimum service quality and reliability standards for Maryland's electric companies.[5] The regulations set minimum reliability metrics for each utility based on past performance, established a mandatory annual performance reporting system, set up a customer communication survey, and mandated vegetation management and periodic inspections. In addition, RM43 requires utilities to submit a major outage event report within three weeks of a major outage, as well as a restoration plan detailing the utilities' response to a major event. The PSC retains the right to enact civil penalties and disallow costs should a utility fail to comply with the regulations.

2. What do Maryland's reliability metrics mean?

RM43 requires utilities to report on three industry-standard indexes: CAIDI, SAIDI, and SAIFI; additionally, the regulations require the utilities to meet specific metrics with regard to the latter two indexes.

The Customer Average Interruption Duration Index ("CAIDI") represents the average outage duration any customer who experienced an outage would experience over the course of a year. It can also be viewed as the average customer restoration time. CAIDI is measured in units of time.

The System Average Interruption Duration Index ("SAIDI") represents the average outage duration for each customer in the service territory over the course of a year. SAIDI is measured units of time.

The System Average Interruption Frequency Index ("SAIFI") represents the average number of interruptions that a customer would experience over the course of a year. Unlike CAIDI and SAIDI figures, which represent interruption durations, SAIFI is measured in units of interruptions per customer.

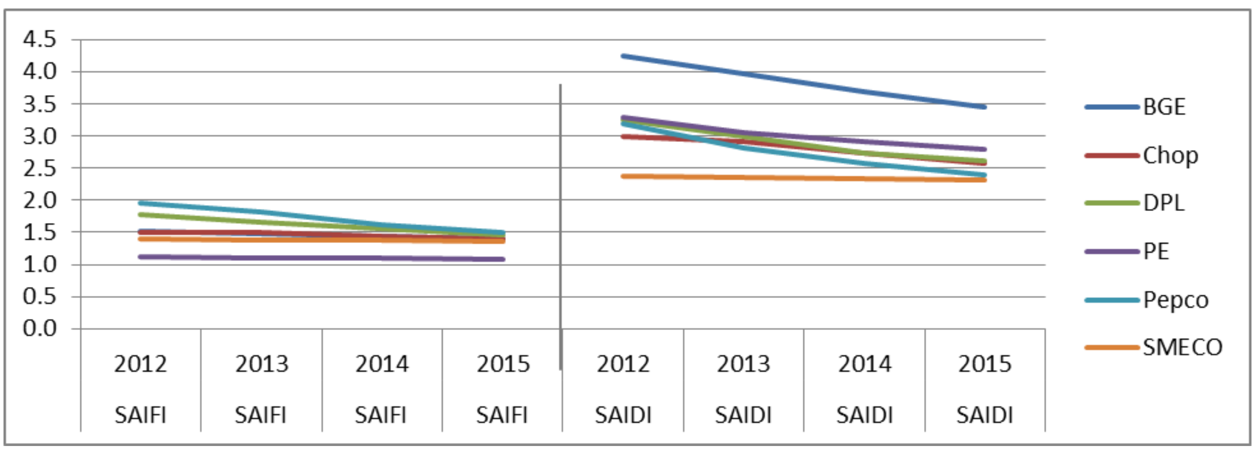
As specified by RM43, each utility's reliability requirements ramp up over time. The PSC based these requirements on past utility performance with the goal of setting realistic metrics to improve performance. Each utility's reliability requirements are reproduced below.

[5] The revisions to COMAR pertaining to RM43 may be found online here: http://webapp.psc.State.md.us/intranet/AdminDocket/CaseAction_new.cfm?CaseNumber=RM43

Table 2 - RM43 Reliability Requirements by Utility

	2012	2013	2014	2015
BGE				
SAIDI	4.24	3.96	3.69	3.44
SAIFI	1.51	1.47	1.43	1.39
Choptank				
SAIDI	2.99	2.92	2.74	2.58
SAIFI	1.50	1.49	1.44	1.39
Delmarva				
SAIDI	3.25	2.99	2.74	2.62
SAIFI	1.77	1.65	1.55	1.46
Potomac Edison				
SAIDI	3.28	3.05	2.92	2.79
SAIFI	1.11	1.10	1.09	1.08
Pepco				
SAIDI	3.18	2.82	2.58	2.39
SAIFI	1.95	1.81	1.61	1.49
SMECO				
SAIDI	2.37	2.35	2.33	2.32
SAIFI	1.39	1.38	1.37	1.36

Figure 7 - RM43 Reliability Requirements by Utility



IV. How is Maryland's electric distribution grid currently functioning?

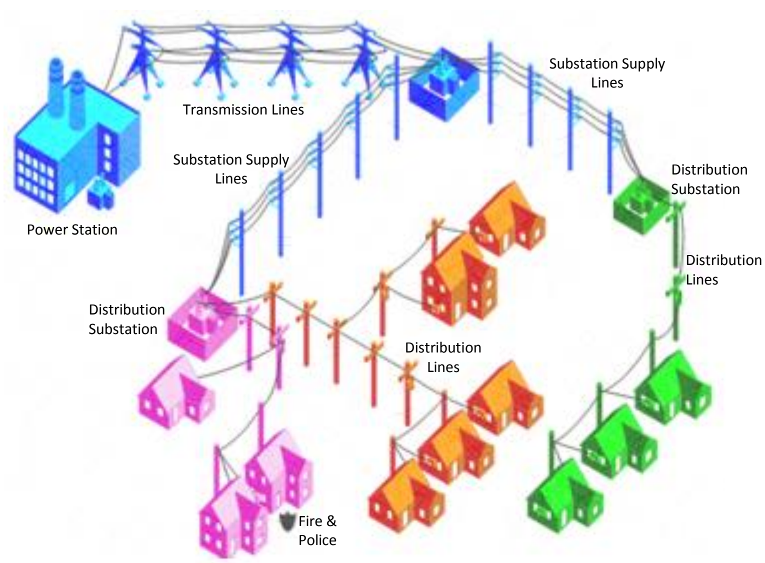
To begin to answer this question, the Task Force relied on the principle that infuses all of Governor O'Malley's endeavors, namely, informed decisions must be guided by data.

A. What does the data indicate about the distribution system's performance during recent major storms?

With that principle in mind, the Task Force endeavored to take a deeper look at three relatively recent major storms: Snowmageddon (2/2/2010 – 2/12/2010); Hurricane Irene (8/27/2011 – 9/6/2011); and the Derecho (6/29/2012 – 7/8/2012). The group hoped to answer three questions when undertaking this analysis. First, what components of a utility's network are the most vulnerable to storms? Second, do undergrounded portions of the distribution system experience fewer outages during major storms? Third, do certain geographic areas experience repeated outages while others are spared? The Task Force's recommendations would then be informed by this analysis.

Three Maryland utilities (Pepco, BGE, and Potomac Edison) voluntarily provided data on the three events, including how various components of their systems were affected by each storm.

Figure 8 - Illustration of Power System Components



Source: PHI

In addition to those components pictured above (and described in Section III.A of this Report), the three utilities also reported on circuit breakers, fuses, line reclosers (overcurrent protection), transformers, and service lines.

Circuit breakers, line reclosers and fuses are protective devices. Circuit breakers are located at substations; they turn off power to an entire distribution feeder in the event of a fault or short circuit. For instance, a tree branch that falls during a windstorm and lands on the line may cause a fault that could cause damage. A significant portion or even an entire distribution line can be out of service while the repair crew finds the fault, repairs any damage, and resets the circuit breaker.

Line reclosers and fuses are usually located along distribution lines. Both devices divide distribution lines into smaller sections. For instance, in the illustration above, each branch point of the distribution lines might be equipped with a either a fuse or a recloser. Reclosers and fuses, because of their position in the network, handle much less power than the circuit breakers at the substations and therefore can be set to trip at much lower power levels. This means that a single event on the grid, for example, a branch on a wire, will cut off only the section handled by the single recloser or fuse. Moreover, some reclosers can automatically re-connect after a brief interval. There is a chance that the fault/interruption will be gone when the power is restored, as with the example of a branch that falls on a wire but then falls to the ground without actually breaking the wire. Fuses, on the other hand, must be reset by a manual process involving a line crew before power to customers can be restored.

Transformers exist at many places in the electric distribution system. In this context, the term refers to the transformers located near the customer end of the distribution system. Overhead transformers are mounted on utility poles (or, in the case of underground installations, are pad mounted transformers) and step down power from distribution line level voltages, sending it to service lines that carry the power the last length from the pole to the customer's home or business.

Table 4 below illustrates the portfolio of each utility's distribution system.

Table 4 - Profile of Electric Systems Currently Operated In Maryland

System Components	BGE	Pepco	Potomac Edison
Transmission Lines	143	121	42
Circuit Miles	1,288	1,009	627
Underground	8%	16%	0%
Transmission Substations	74	14	33
Substation Supply Lines	253	97	65
Circuit Miles	1,428	1,827	494
Underground	24%	9%	0%
Distribution Substations	195	61	81
Fuses	48,834	18.397	33,375
Distribution Lines	1,295	693	323
Circuit Miles	23,568	8,399	8,581
Underground	65%	59%	38%
Reclosers	2,179	109	1,639
Transformers	217,148	76,040	93,962

Note: Some substations function as both a transmission substation and distribution substation. In this table, single locations that serve both functions are counted twice.

1. What effect do major storms have on utility infrastructure?

The tables below show how Snowmaggedon, Hurricane Irene, and the Derecho affected the various components of the three utilities' distribution systems. The numbers represent the cumulative amount of customers who experienced an outage due to an "interruption" associated with a specific system component.

The data is organized in the same sequence that electricity travels from the generating stations to a customer's house or business. Further, they are mutually exclusive, meaning that a system component failure is assigned only to the specific component, and does not impact downstream reporting. In this sense the data represent the incremental failures of the system as one follows the path of electricity. While clearly every customer outage was caused by at least one interruption, multiple interruptions upstream of a home or business are common.

Table 5 shows the estimated number of customer interruptions for each utility by components of its system in each of the three storms. For example, the distribution substation row indicates that problems at distribution substations during these storms were very uncommon. Across the three companies, only 852 customers experienced an interruption because of a malfunction at the substation upstream of their home or business.

Table 5 - Total Customer Interruptions Associated with System Components

	Snowmageddon 2/2/2010 – 2/12/2010			Hurricane Irene 8/27/2011 – 9/6/2011			Derecho 6/29/2012 – 7/8/2012		
System Components	**BGE**	**Pepco**	**Potomac Edison**	**BGE**	**Pepco**	**Potomac Edison**	**BGE**	**Pepco**	**Potomac Edison**
Transmission Lines	0	0	0	0	0	0	0	0	0
Transmission Substations	0	0	0	0	0	0	0	0	0
Substation Supply Lines	4,503	28,637	2,662	65,045	89,233	4,370	113,502	270,012	17,185
Distribution Substations	0	0	0	0	0	0	0	0	852
Fuses	47,742	16,571	1,998	253,622	30,058	3,847	248,710	49,387	3,266
Distribution Lines	38,674	198,508	5,034	182,406	274,382	7,755	160,544	598,161	51,819
Reclosers	48,670	4,579	2,368	238,565	11,405	3,557	216,268	18,076	16,954
Transformers	1,613	2,728	416	9,007	3,869	173	14,492	17,656	391
Service Lines	1,026	740		7,750	1,366		9,265	5,271	
Total Customer Interruptions	**142,228**	**251,763**	**12,478**	**756,395**	**410,313**	**19,702**	**762,781**	**958,563**	**90,467**

Table 6 puts the same information in percentage terms. This shows the aforementioned 852 customer interruptions represented only 1% of the customer interruptions experienced by Potomac Edison customers during the Derecho. The data does not mean, however, that distribution substations were always functional during the storms. Rather, as shown in Figure 8 above, substation supply lines carry power to distribution substations. While each substation is usually fed by multiple supply lines, the substation will go dark if enough supply lines are interrupted. Examination of the rows entitled "Substation Supply Lines" in Tables 5 and 6 below reveals that this happened in each storm. For example, Pepco customers experienced 270,012 interruptions during the Derecho due to substation supply lines going out of service and the corresponding substations going dark.

Table 6 - Percent of Customer Interruptions Associated With System Components

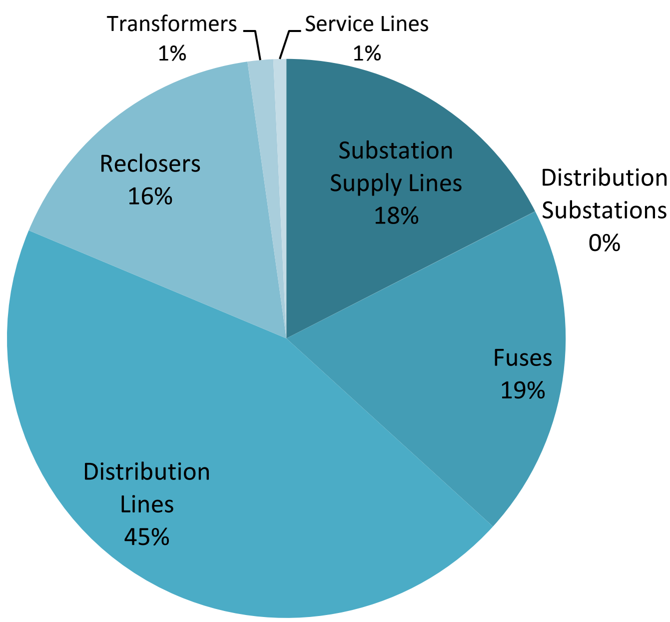
	Snowmageddon 2/2/2010 – 2/12/2010			Hurricane Irene 8/27/2011 – 9/6/2011			Derecho 6/29/2012 – 7/8/2012		
System Components	**BGE**	**Pepco**	**Potomac Edison**	**BGE**	**Pepco**	**Potomac Edison**	**BGE**	**Pepco**	**Potomac Edison**
Transmission Lines	0%	0%	0%	0%	0%	0%	0%	0%	0%
Transmission Substations	0%	0%	0%	0%	0%	0%	0%	0%	0%
Substation Supply Lines	3%	11%	21%	9%	22%	22%	15%	28%	19%
Distribution Substations	0%	0%	0%	0%	0%	0%	0%	0%	1%
Fuses	34%	7%	16%	34%	7%	20%	33%	5%	4%
Distribution Lines	27%	79%	40%	24%	67%	39%	21%	62%	57%
Reclosers	34%	2%	19%	32%	3%	18%	28%	2%	19%
Transformers	1%	1%	3%	1%	1%	1%	2%	2%	0%
Service Lines	1%	0%	unknown	1%	0%	unknown	1%	1%	unknown

Table 7 takes the same interruption data from all three companies and aggregates it. The pie chart in Figure 9 shows percentages. At 45%, damage to distribution lines caused the most interruptions across the three companies. Thus, increasing reliability of the distribution lines should also be a focus of the Task Force.

Table 7 - Cumulative Customer Interruptions Associated with System Component

	Cumulative Three Storms			
System Components	**BGE**	**Pepco**	**Potomac Edison**	**Total**
Transmission Lines	-	-	-	-
Transmission Substations	-	-	-	-
Substation Supply Lines	183,050	387,882	24,217	595,149
Distribution Substations	-	-	852	852
Fuses	550,074	96,016	9,111	655,201
Distribution Lines	381,624	1,071,051	64,608	1,517,283
Reclosers	503,503	34,060	22,879	560,442
Transformers	25,112	24,253	980	50,345
Service Lines	18,041	7,377	-	25,418

Figure 9 - System Component Responsible for Interruption



As the above data demonstrates, these storms did not have a uniform impact on the three utilities. On one hand, Potomac Edison, located in Western Maryland, was not severely affected by Snowmaggedon or Hurricane Irene, but was affected by the Derecho. On the other hand, BGE and Pepco were severely affected by all three storms. Utilities differ in design and location. There is no one size fits all fix. Rather, any solution needs to consider a utility's unique infrastructure, geography, and community. For example, Pepco has historically operated significantly fewer reclosers than the other utilities, because the limitations of recloser technology have prevented its utilization in Pepco's dense network. In recent years, however, improvements in recloser technology have made it possible for Pepco to obtain reclosers that can be used in a dense distribution system with higher fault currents. This, along with other automated distribution equipment, is being funded, in part, by a federal Department of Energy stimulus grant.

The data in the above tables also demonstrates that generation and transmission components remained operational during storms. The integrity of substations (transmission or distribution) was not a significant problem. One data point to note: while there are relatively few substation supply lines, they accounted for 18 % of the system disruptions. Distribution lines and related components also represented the largest vulnerability for each utility in each storm.

To help determine where utilities should focus their efforts, one can determine and compare the number of customer interruptions per circuit miles; the higher the number, the more people that can be helped by an improvement to that line. Tables 8 and 9 show that on a per circuit mile basis, substation supply lines going out of service accounted for significantly more customer interruptions than distribution lines going out of service. This is true even if fuser and recloser interruptions are included in the comparison. This data can be instructive in assisting utilities and regulators in determining the most impactful places to target infrastructure investments.

Table 8 - Getting Power from Transmission Substations and Distribution Substations

	BGE	Pepco	Potomac Edison
Substation Supply Lines	253	97	65
Circuit miles	1,428	1,827	494
Cumulative interruptions three storms	183,050	387,882	24,217
Cumulative customer interruptions per circuit mile	128.19	212.31	49.02

Table 9 - Getting Power from Distribution Substations to Customers

	BGE	Pepco	Potomac Edison
Distribution Lines	1,295	693	323
Circuit miles	23,568	8,399	8,581
Cumulative interruptions three storms	381,624	1,071,051	64,608
Cumulative customer interruptions per circuit mile	16.19	127.52	7.53
Cumulative customer interruptions including fuses and reclosers	1,435,201	1,201,127	96,598
Cumulative customer interruptions including fuses and reclosers per circuit mile	60.90	143.01	11.26

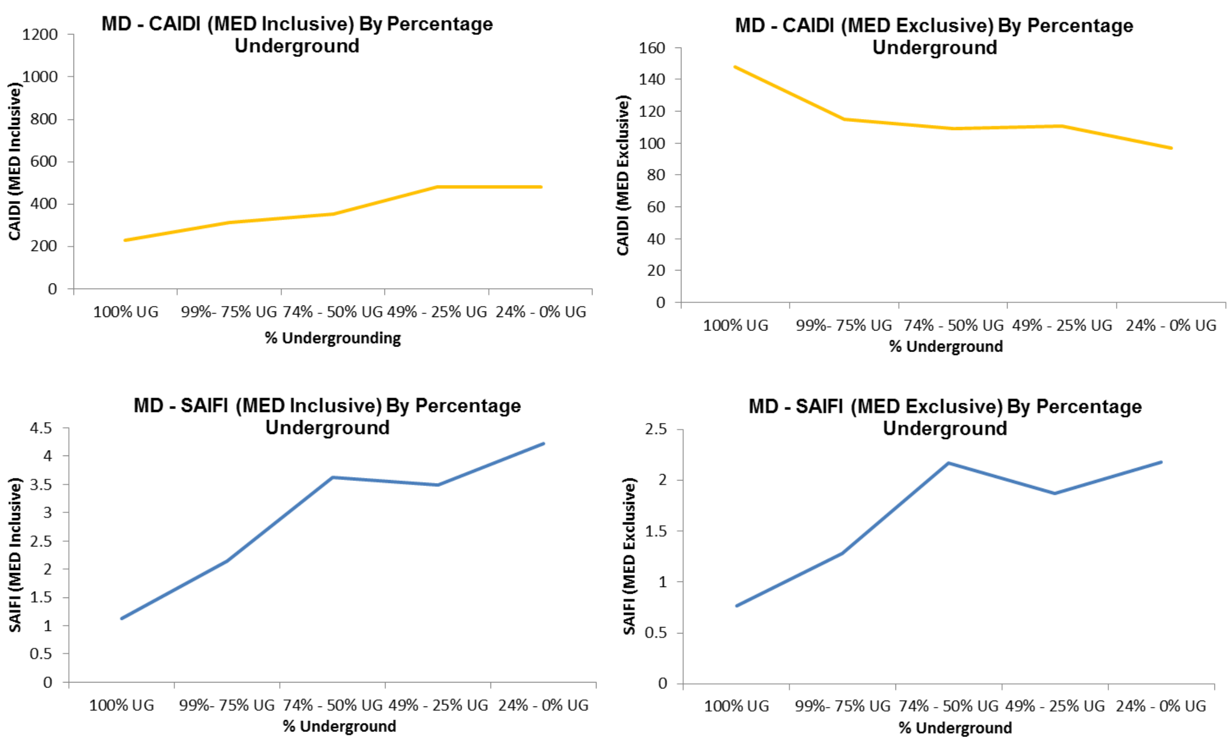
The data contained in this section helps answer the first question: what components of a utility's network are the most vulnerable to storms? Figure 9 answers the question on volume alone: 45% of the outages during the three storms resulted from damage to the distribution lines. However, overlaying this data with an analysis of how many customers are affected per circuit mile, as done in Tables 8 and 9, reveals that modifications to the substation supply lines may be an appropriate investment. The inquiry, however, does not end there. The Task Force also inquired as to whether the location of the components affected vulnerability to storms.

2. How do above ground, underground, and mixed lines affect grid resiliency?

The Task Force was also interested in how the location of a line, i.e., whether it was 100% overhead, 100% underground, or a mix of both, affected its resiliency during major storms. The utilities provided data on this as well.

One interesting data point is based on information that compares various lines with differing locations. As seen below, the graphs on the left include major event days, such as the Derecho, while the graphs on the right exclude such days. The CAIDI graphs (top line) show that Pepco's underground lines reduce outage times during major event days, but actually increase outage times during non-major event days. The SAIFI graphs (bottom line) show that Pepco's underground lines decrease the frequency of outages during both major event days and non-major event days.

Figure 10 - Reliability Comparison of Pepco Overhead and Underground Systems



MED = major event days *Source: PHI*

Tables 10, 11, and 12, the next series of tables, compare the reliability of above and below ground infrastructure. Table 10 shows the storm history for substation supply lines. Substation supply lines have redundancy, but if enough supply lines are damaged, entire substations loose supply. The substations are accounted for in Table 11 and the service territories for the substations that lost supply in two storms are shown on Maps 1 and 3. Table 12 provides the storm history data for distribution lines and the maps show the services territories of the distribution lines that lost power in at least two of the three storms.

Table 10 - Substation Supply Lines

	Predominant Relationship to Ground	BGE		PEPCO	
		Number	% of Above, Mixed, Below Ground	Number	% of Above, Mixed, Below Ground
System Total	Above	118		42	
	Mixed	60		18	
	Below	75		37	
Remained Functional in All 3 Storms	Above	75	64%	3	7%
	Mixed	46	77%	0	0%
	Below	75	100%	37	100%
Interruption in 1 of 3 Storms	Above	34	29%	15	36%
	Mixed	11	18%	7	39%
	Below	0	0%	0	0%
Interruption in 2 of 3 Storms	Above	9	8%	19	45%
	Mixed	3	5%	8	44%
	Below	0	0%	0	0%
Interruption in 3 of 3 Storms	Above	0	0%	5	12%
	Mixed	0	0%	3	17%
	Below	0	0%	0	0%

Note: Potomac Edison was not included in this analysis because its system was only seriously affected by one of the three storms.

Table 11 - Distribution Substations

	BGE			PEPCO		
	Number	**Estimated Cumulative Customer Interruptions**	**% Estimated Cumulative Customer Interruptions**	**Number**	**Estimated Cumulative Customer Interruptions**	**% Estimated Cumulative Customer Interruptions**
System Total	195			61		
Remained Functional in All 3 Storms	169			30		
Lost supply 1 of 3 Storms	24	103,414	97.2%	23	209,426	54.0%
Lost supply in 2 of 3 Storms	2	3,006	2.8%	8	178,456	46.0%
Lost supply in 3 of 3 Storms	0	0	0%	0	0	0%

Note: Potomac Edison was not included in this analysis. Its system was only seriously affected by one of the three storms.

Table 12 - Distribution Lines

BGE

		Number	% of Above, Mixed, Below	Estimated Cumulative Customer Interruptions	% Estimated Cumulative Customer Interruptions
System Total	Above	105			
	Mixed	606			
	Below	584			
Remained Functional in All 3 Storms	Above	58	55%		
	Mixed	393	65%		
	Below	471	81%		
Interruption in 1 of 3 Storms	Above	36	34%	74,639	11%
	Mixed	169	28%	238,894	36.5%
	Below	94	16%	125,475	19%
Interruption in 2 of 3 Storms	Above	11	10%	35,804	5%
	Mixed	44	7%	126,396	19%
	Below	18	3%	51,952	8%
Interruption in 3 of 3 Storms	Above	0	0%	0	0%
	Mixed	1	0.2%	3,132	0.5%
	Below	0	0%	0	0%

PEPCO

		Number	% of Above, Mixed, Below	Estimated Cumulative Customer Interruptions	% Estimated Cumulative Customer Interruptions
System Total	Above	529			
	Mixed	0			
	Below	164			
Remained Functional in All 3 Storms	Above	60	11%		
	Mixed	0	0%		
	Below	90	55%		
Interruption in 1 of 3 Storms	Above	221	42%	184,993	23%
	Mixed	0	0%	0	0%
	Below	47	29%	22,281	3%
Interruption in 2 of 3 Storms	Above	211	40%	453,758	57%
	Mixed	0	0%	0	0%
	Below	26	16%	19,740	2%
Interruption in 3 of 3 Storms	Above	37	7%	119,547	15%
	Mixed	0	0%	0	0%
	Below	0	0%	0	0%

The data contained in these tables helps answer several questions. First, this data answered the inquiry regarding whether underground lines are better able to withstand storms than above-ground lines. The data indicates that the answer is yes; underground lines did offer better protection from the three storms. For example, 100 % of BGE's and Pepco's underground substation supply lines remained operational during all three storms. In comparison, only 64 % of BGE's and 7% of Pepco's above-ground substation supply lines remained operational during all three storms. Again not surprisingly, the survival rate of BGE's mixed lines was 77 % better than the record for above-ground lines, but less than the perfect record of the equivalent underground lines. Second, this data helps determine if underground lines are in fact stormproof. The data says almost. One hundred percent of the substation supply lines that were totally underground remained functional during all three storms. On the distribution line front, 81% of BGE's distribution lines and 55% of Pepco's distribution lines that were totally underground remained operational during all three storms.

Third, this data helps pinpoint whether outages are region and/or circuit specific. BGE's substation loss-of-supply interruptions were more widely and evenly distributed than Pepco's. Neither company had a substation that lost supply in all three storms. Only one BGE substation lost supply in two storms, and it had relatively few customers. Pepco had eight substations, or an estimated 30% associated customer interruptions, from substations that lost supply in two storms. Distribution lines serve particular territories/neighborhoods. BGE's outages were widely distributed: 67% of customer interruptions were associated with distribution lines that lost power in only one of the three storms. The remaining 33% were associated with lines that lost service in two of three storms. Pepco's outages were more concentrated: 15% of customer interruptions were associated with distribution lines that failed in all three storms. While not a perfect science, this data will assist all parties to determine the locations and infrastructure that merit a closer look for investment upgrades.

3. Storm Outage Maps

Using the data provided by Pepco and BGE, the Task Force created the following maps, which provide a visual representation of the information contained in the tables above. Specifically, the maps display the location of each distribution utility's inoperable substations and distribution lines during two or three previous major storms. The areas in orange and red are the neighborhoods where the citizens, on average, have been most affected by the frequency of outages.

V. What can be done to improve the resiliency of Maryland's electric distribution system?

During the course of the eight roundtable discussions, the Task Force investigated various ways to strengthen the resiliency of Maryland's electric distribution system, as well as improve the State's emergency response processes. The remedies that the group explored were varied and included technological solutions, infrastructure improvements, regulatory changes, and process improvements. The Task Force also considered various cost recovery mechanisms to pay for improvements.

A. Is undergrounding an appropriate choice?

The first charge of the Executive Order was to evaluate the "effectiveness and feasibility of undergrounding supply and distribution and substation lines in selected areas as a way to strengthen the grid and improve the resiliency of Maryland's electric distribution system." Accordingly, the Task Force spent a great deal of time discussing this option.

1. What are the benefits and detriments of undergrounding lines?

Throughout Maryland, electric distribution lines can be found both overhead and underground. As demonstrated in the data in Section IV above, underground lines provide many benefits during a major storm. For example, the more circuits that are underground, the less frequent outages are on that line during a storm. Additionally, underground lines require significantly less vegetation management. Many communities also find that underground lines provide better aesthetics by delivering electricity without crowding airspace or blighting the viewscape. (Poles would still be visible, however, to carry other utilities, unless all were also undergrounded). There are, however, some negative aspects of underground lines, including higher initial construction costs than overhead lines, potential shorter line life expectancy due to chemicals and abrasions that can degrade the insulation in underground lines, and longer repair times due to increased durations to locate and repair line outages.

A review of the data in Section IV reveals that during major storms, underground lines offer significant improvements in terms of number of outages as opposed to overhead lines.

2. What existing regulations address undergrounding?

Existing Maryland regulations recognize the benefits associated with underground distribution lines and therefore require that most new electric distribution line extensions be placed underground. For example, after August 28, 1969, any extension of an electric distribution line under 33kV that is (1) on property owned or leased by the entity seeking electric service through the line extension, (2) in an industrial park, (3) necessary to deliver electric service to new commercial and industrial buildings, or (4) serving new multiple-occupant buildings, must be placed underground rather than overhead.[13] Similarly, after June 5, 1968, any extension of an electric distribution line necessary to furnish

[13] COMAR 20.85.01.01.

permanent electric service to new residential buildings and mobile homes shall be placed underground.[14] While these regulations require undergrounding for specific types of new lines, there is currently no requirement that existing overhead lines be undergrounded, nor is there any requirement that extension of existing overhead lines be built underground. The effect of these regulations is that nearly all new electricity distribution lines put in service in Maryland after 1969 were placed underground.

Today, Maryland utility companies have a significant portion of their electric distribution system undergrounded. For example, Pepco has undergrounded 48% of its Maryland system, and both SMECO and BGE have undergrounded approximately 65% of their electric distribution systems. This is partly the effect of the COMAR regulations and partly the effect of the utilities' individual initiatives to place underground certain segments of overhead distribution lines that had proven over time to be problematic and subject to frequent outages.

Figure 15 - Underground Distribution Conduit Installation

Source: PHI

3. How much does undergrounding cost?

The costs associated with building underground electric distribution lines are greater than the costs of comparable overhead lines. Based on estimates developed by the Edison Electric Institute ("EEI"), new underground distribution construction and overhead-to-underground conversions can cost five to ten times more than comparable overhead construction.[15] The substantial variability in costs results from local-area and site conditions and prevailing labor rates.

The higher development costs associated with new underground utility facilities relative to overhead facilities are largely driven by higher labor and material costs, longer installation times, and additional logistical and design complexities. A 2005 report from the Virginia State Corporation Commission

[14] COMAR 20.85.03.01.
[15] Edison Electric Institute. *Out of Sight, Out of Mind Revisited*, December 2009, Page 23.

identifies the primary cost components associated with converting existing overhead electric distribution facilities to underground:

- Materials associated with new underground facilities (net of salvage value of existing overhead facilities);
- Labor associated with removal of the existing overhead facilities and installation of the new underground facilities (mostly trenching/boring);
- Planning, design and engineering;
- General, administrative, construction, and material overheads;
- Contingencies; and
- Acquisition of easements.[16]

The EEI study referenced above utilized survey data from utilities to estimate the cost per mile for new overhead construction, new underground construction, and the cost to convert from overhead to underground. Importantly, costs are affected by customer density, soil conditions (e.g., sandy, rocky, etc.), prevailing labor costs, construction techniques used, type and density of vegetation, and voltage levels.[17] The EEI study identifies costs for three distinct customer density categories:

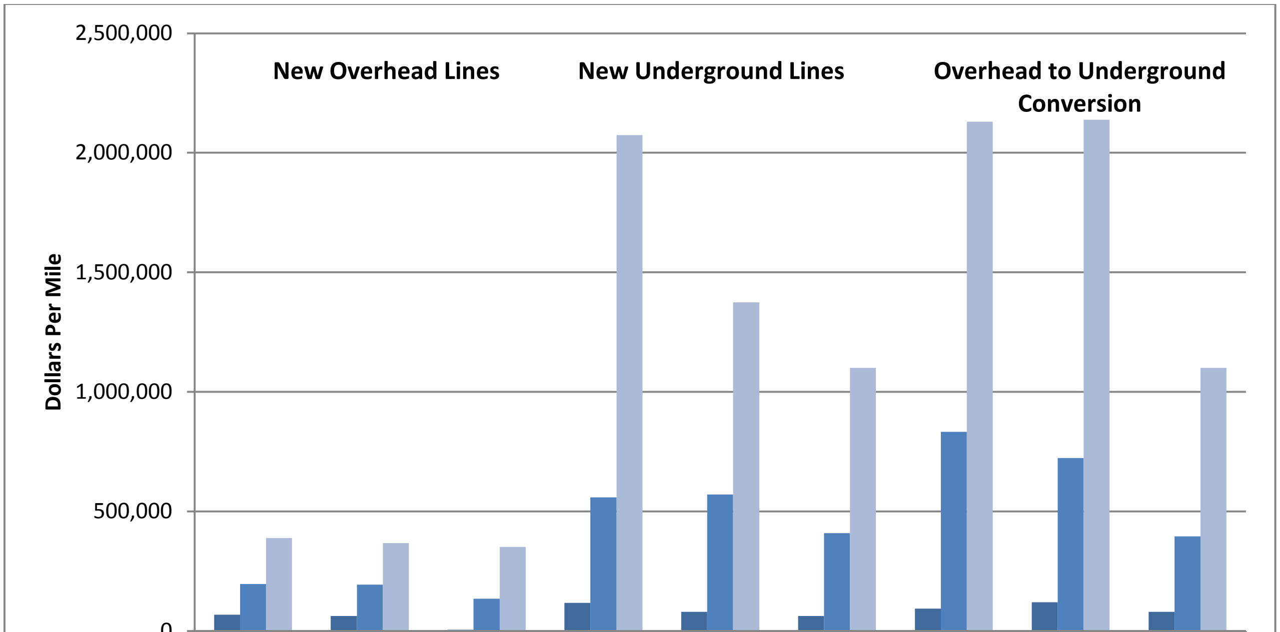
- Urban – 150+ customers per square mile;
- Suburban – 51 to 149 customers per square mile; and
- Rural – 50 or fewer customers per square mile.

To put these population density numbers in some perspective, the population density for Maryland is 595 people per square mile. Baltimore City has a population density of 7,670 people per square mile; Annapolis, Gaithersburg, and Bethesda all have population densities of between 4,500 and 5,900 people per square mile; and Silver Spring has a population density of over 9,000 people per square mile.[18]

Figure 16 below shows the estimated cost-per-mile for the construction of new overhead and underground utility distribution lines, and the estimated cost-per-mile of undergrounding existing overhead utility distribution lines. These data, extracted from the EEI study, include minimum, average, and maximum costs. As shown in Figure 16, the construction costs associated with underground utility line construction are uniformly greater than the costs associated with overhead utility line construction.

[16] Virginia State Corporation Commission. *Placement of Utility Distribution Lines Underground*, January 2005, Page 18.
[17] Edison Electric Institute. *Out of Sight, Out of Mind Revisited*, December 2009, Page 23.
[18] These figures are based on 2010 U.S. Census data.

Figure 16 - Cost of Distribution Power Lines (Dollars per Mile)



	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
Minimum	67,892	63,000	5,300	117,000	80,000	63,000	93,202	120,000	80,000
Average	196,628	193,850	135,307	559,293	571,400	408,532	832,383	723,692	395,874
Maximum	388,600	367,000	351,000	2,074,000	1,375,000	1,100,000	2,130,000	2,138,400	1,100,000

Source: Edison Electric Institute, *Out of Sight, Out of Mind Revisited*, December 2009

Based on the data shown in Figure 16, the costs of building new electric distribution lines or converting from an overhead to an underground system can vary significantly. For example, the cost of new underground lines in urban areas is shown to vary between approximately $120,000 per mile and $2.1 million per mile, that is, the maximum cost shown is more than 17 times the minimum cost and the cost-per-mile differential is almost $2 million. The 2005 report from the Virginia State Corporation Commission found that the main factors that influence undergrounding conversion costs are the extent of community development, soil conditions, and burial methods.[19] Cost differences can also be attributed to different work methods, engineering design, and the materials utilized by the utility.[20]

A 2010 study conducted by Shaw Consultants International, Inc. for the Public Service Commission of the District of Columbia addressed the costs of converting a specific distribution line (10 circuit miles) from overhead to underground in the District of Columbia.[21] The Shaw cost estimate was $3.0 million per mile. The $3.0 million cost-per-mile estimate developed by Shaw Consultants is higher than the EEI

[19] Virginia State Corporation Commission. *Placement of Utility Distribution Lines Underground*, Jan. 2005, 5.
[20] Public Staff of the North Carolina Utilities Commission. *The Feasibility of Placing Electric Distribution Facilities Underground*, November 2003, 20.
[21] Shaw Consultants International, Inc. *Study of the Feasibility and Reliability of Undergrounding Electric Distribution Lines in the District of Columbia – Formal Case No. 1026*, prepared for the Public Service Commission of the District of Columbia, July 1, 2010, Pages 69-76.

estimates, but includes recognition of the reduced construction workday due to District of Columbia regulations that restrict construction work to between 9:30 am and 3:30 pm. if the work entails roadway interference. That restriction resulted in an added cost of approximately $200,000 per mile.[22] The project also entailed concrete encasement of conduit and repaving of the entire roadway (due to District of Columbia regulations). With recognition of these factors that would upwardly affect overall project costs, along with the purely urban setting in which the project was located, the costs estimated by Shaw Consulting are roughly consistent with the higher end of the cost ranges developed by EEI.

The EEI study included a review of estimated/actual undergrounding costs from various state studies and actual projects. Table 14 below shows the cost range associated with the various projects and state estimates. As indicated above, actual costs are specific to each project and are influenced by numerous factors.

Table 14 - Undergrounding Cost Comparison

State (Year of Study)	Estimate / Actual Cost	Description	Cost per Mile
EEI (2009)	Estimate	Minimum Cost	**$80,000**
North Carolina (2003)	Estimate	Minimum Cost	**$151,000**
Maryland (1999)	Estimate	Minimum Cost	**$350,000**
Florida (2007)	Actual	Allison Island	**$414,802**
Florida (2007)	Actual	County Road 30A	**$883,470**
Florida (2007)	Actual	Sand Key	**$917,532**
Virginia (2005)	Estimate	Average Cost	**$1,195,000**
Oklahoma (2008)	Estimate	Average Cost	**$1,540,000**
Florida (2007)	Actual	Pensacola Beach	**$1,686,275**
Maryland (1999)	Estimate	Maximum Cost	**$2,000,000**
EEI (2009)	Estimate	Maximum Cost	**$2,130,000**
North Carolina (2003)	**Estimate**	**Maximum Cost**	**$3,000,000**

Source: Edison Electric Institute. *Out of Sight, Out of Mind Revisited,* December 2009

The Shaw study also reported undergrounding cost estimates prepared by or for other states and found that these costs ranged between $400,000 to $1.6 million per circuit mile depending on the type of construction, the relevant topography, and congestion.[23] Average installation costs were assessed to be approximately $1 million per circuit mile. The states for which costs studies were obtained included Oklahoma (2008), Florida (2006), and Maryland (2000).[24]

When analyzing the statement that underground electric utility systems can be more expensive to operate and maintain than comparable overhead systems, the EEI study identified several reasons why

[22] *Id.* at 73.
[23] *Id.* at 12.
[24] *Id.* at 13–14.

operation and maintenance costs may be more costly for underground systems. Repair times for underground lines are longer than for overhead lines, which can drive up maintenance costs. Because visual inspection is impossible with underground systems, damage to underground facilities typically takes longer to locate and longer to repair than similar damage to overhead facilities. In addition, underground systems generally have more complex operational needs, which can make them more difficult and costly to maintain and repair. Furthermore, underground facilities are generally less flexible than overhead facilities (e.g., more difficult to upgrade capacity, add unplanned transformers, etc.). Underground facilities are also subject to damage from dig-ins, and specialized training and equipment may be required for manhole/vault access. Finally, installation of underground services typically requires much more coordination between the utility and customer than similar overhead service installations.[25] Conversion to underground lines, however, can serve to improve service reliability, discussed elsewhere in this Report.

In addition to the direct costs of undergrounding electric lines, i.e., the actual costs incurred by the utility including capital costs and the incremental operation and maintenance costs of underground lines, there are also indirect costs. Indirect costs can be broadly defined as the additional costs to customers, municipalities/governments, and other utilities that may result from the conversion to underground lines. Individual customers and municipalities, for instance, may have to bear the costs associated with adapting their facilities to accept underground service. In addition, burying power lines requires disrupting existing landscapes, which can affect anything from the aesthetic benefits of a flower bed in a front yard to traffic flows on major roadways.[26] If the trenching takes place near existing trees, there is the possibility that root systems will be damaged and eventually weaken or kill the trees. A properly maintained underground right-of-way must be kept clear of trees. Thus, while properly trimmed trees can grow near overhead power lines, no trees would be permitted in the underground right-of-way. These costs, however, are not easily quantifiable. Furthermore, other utilities, such as land-line telephone companies, cable television companies, and internet service providers may share space on utility poles with the electric service. If power lines are buried to eliminate the utility poles, the lines from these other services will also have to be buried, presenting another set of indirect cost that must be taken into consideration.[27]

Indirect costs can also be defined as "… costs that [are] incurred, but not directly assignable to a project."[28] One such indirect cost is road-user costs stemming from construction and the resulting detour delays due to undergrounding overhead utility lines.[29] Although not easily quantified, time lost is an actual cost borne by road users. Further, added fuel costs and the health costs associated with increased automobile emissions should be included in the accounting.

[25] Edison Electric Institute. *Out of Sight, Out of Mind Revisited*, December 2009, 20-21.
[26] Public Staff of the North Carolina Utilities Commission, *The Feasibility of Placing Electric Distribution Facilities Underground*. Raleigh, North Carolina. November 2003, 30-31.
[27] *Id*. at 32.
[28] Paul Goodrum, et al. *An Analysis of the Direct and Indirect Costs of Utility and Right-of-Way Conflicts on Construction Roadway Projects*. Lexington, Kentucky: University of Kentucky, College of Engineering. Prepared for the Kentucky Transportation Center. August 2006, 24.
[29] *Id. at* 24.

Another indirect cost identified includes the monetary impacts sustained by businesses affected by the conversion.[30] Such impacts could result from the temporary loss of power or disruptions from trenching on nearby roadways and sidewalks. Costs borne due to disruptions incurred by a business, however, may be largely a distributional issue, meaning that the impacts are specific to an individual business and do not result in overall efficiency losses in the economy. For example, if a restaurant loses a customer because the sidewalk in front is temporarily closed, there would not be an efficiency loss if the potential customer chose to dine at a nearby restaurant. If, however, road closures dissuaded a potential customer from going out to dinner for the evening, there would be an overall loss in the economy. As a practical matter, there are both distributional issues and efficiency issues associated with undergrounding.

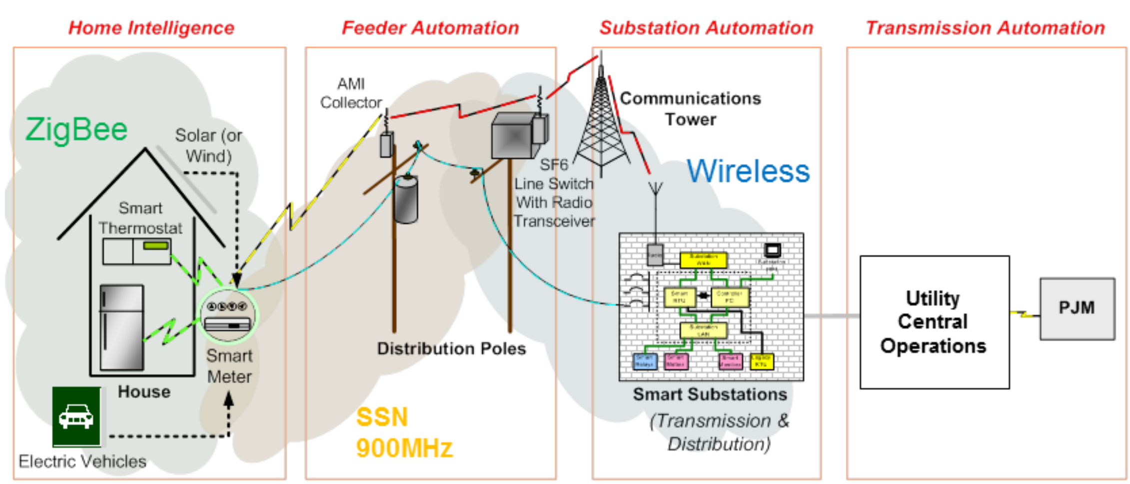
B. Are there other infrastructure investments that improve the resiliency of the distribution grid?

The Task Force also discussed other infrastructure investments that could be made to improve the resiliency of the distribution grid during major storms. The data gathered from the three large storms indicates that the majority of outages happen on the overhead distribution lines. Anything that can be done to lessen the likelihood that those lines fail will improve the resiliency of the distribution system.

1. How will the Smart Grid affect reliability and resiliency?

Maryland is at the forefront of the implementation of smart meters. By 2014, BGE and Pepco together will have installed over 1.6 million smart meters in the central region of Maryland. Delmarva Power has a smart grid program approved, and SMECO is currently seeking approval. Following installation and implementation of the smart meters, or advanced meter infrastructure ("AMI"), it is likely that there will be an improvement in reliability and resiliency in several important ways, though the improvements will have limited applicability in major storm events.

Figure 17 - "Smart Grid" Design Features



Source: PHI

[30] *Id.*

The AMI system will work in unison with new automated restoration systems during electrical interruption events to try to automatically restore power. For example, in blue sky outages and small storms, the automated system will be able to recognize an outage and utilize the reclosers on the grid to isolate the outage and reroute the flow of electricity around the outage, thereby reducing the number of customers affected by an interruption. This development, while important, will not have as large of an impact in a significant storm as there will not be sufficient lines operable to reroute the flow of electricity.

Smart meters will also allow utilities to receive notification of power outages immediately. Using smart grid technology, utilities will be able to "ping" smart meters to determine if they are receiving electricity. This will provide utilities with a more contemporaneous indication of when power is out. While this may reduce the time required to assess the initial outage situation, it will not negate the need for the utility to do a visual damage inspection. Therefore, this functionality will not greatly improve resiliency, though it could impact the ease with which underground faults are identified. Successful meter pings, however, will reduce some truck rolls to check that power has been restored, thereby increasing the efficiencies and reducing time from the end of outage restoration activities following a major event.

The Task Force also discussed how smart grid technology will allow utilities to conduct preventative maintenance. A series of sensors on the distribution network will allow utilities to monitor equipment in real time and repair or replace equipment before it fails.

2. Are there other infrastructure investments that should be considered?

As mentioned in the previous section on AMI, sensors and automated devices on the distribution grid may also contribute to increased reliability and resiliency of the system. For example, automated reclosers and sectionalizers improve reliability and resiliency on blue sky days and during minor storms.[31] Using feeder sectionalizing, utilities can cut off feeder lines at certain points. If lines are down at one point on the feeder's system, this allows utilities to provide service to some customers while shutting down the portion of the line in need of a repair. However, their effectiveness decreases during major events because there is nowhere to switch load. Utilities find that returns diminish as they install more reclosers and sectionalizers. To this end, BGE has automated only about 40% of its reclosers.

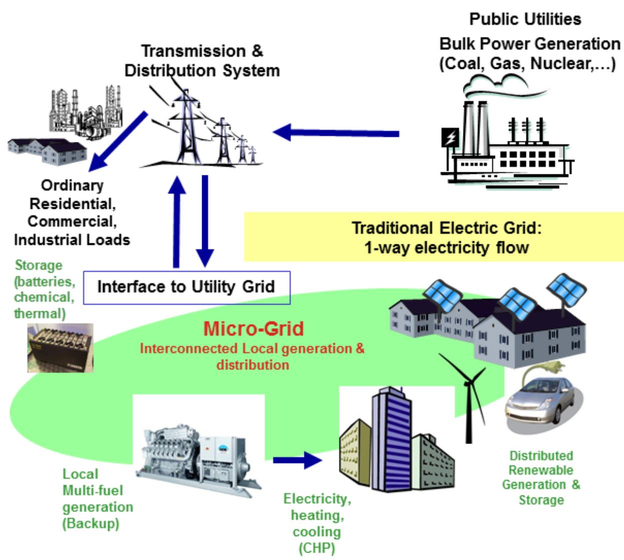
The Task Force also explored the various available wiring options. It appears that Maryland's utilities are already employing the appropriate wire strength. The group also discussed potential future improvements, such as the use of insulated wires on overhead lines and improved hydrophobic coatings. The group also investigated whether improvements to the pole and wire design could improve the resiliency of the system. For example, during the Derecho, Pepco alone had to replace 220 broken utility poles. While pole replacement can be a time-consuming process, it is only a small percentage of the outage jobs during the storm. Utilities in other parts of the country prone to hurricanes frequently use poles made of concrete or other more substantial material. This may be worth pursing here in Maryland.

[31] A recloser is an electrical isolating device that can automatically close the breaker when a fault clears, thereby restoring customers to service. Sectionalizers work in unison with reclosers to redirect power around faults in the event a fault persists on a portion of the distribution system.

3. Can microgrids increase the reliability of Maryland's electricity supply?

Microgrids are networks of distributed energy resources, energy storage devices, and interconnected loads typically across multiple buildings within clearly defined electrical boundaries. These networks act as single controllable entities with respect to the grid and can connect and disconnect from the grid to enable it to operate in either grid-connected or island-mode. Islanded distributed generation ("IDG") functions similarly to a microgrid but on a smaller scale, typically on a building-by-building basis. Importantly, IDG differs from ordinary distributed generation because it allows buildings to separate from the macrogrid and remain fully operational.

Figure 18 - Example of Microgrid Structure



Microgrids are a welcome and appropriate solution for customers whose need for consistent and reliable electricity is paramount. For example, labs with hundreds of thousands of dollars in research that will be lost if power goes out clearly put more emphasis on an uninterruptible power supply than a residence that can absorb intermittent outages with minimal disruption. The Federal Department of Agriculture in White Oak, Maryland has installed a microgrid on its campus to protect the valuable work that is happening there.

The Task Force generally agreed that microgrids are currently not feasible for private residential settings due to a number of factors including cost constraints and federal and State regulatory barriers.

The Task Force also recognized the potential for on-site generation as a backup energy source during power outages. Fuel cells can run on a number of fuels, including natural gas, and can provide base-load power generation without battery backup. Distributed solar PV generation coupled with battery backup represents another solution. However, due to safety concerns, distributed generation systems are currently required to shut off when the utility grid shuts down. That said, there may be opportunities for distributed generation combined, as appropriate, with battery storage to provide a backup generation solution for customers desiring or requiring higher levels of reliability than their local distribution grid can provide. In all installations, IDGs and microgrids must be wired appropriately and be able to be separated (islanded) from the utility grid.

C. Are there regulatory changes that can improve the resiliency of the distribution grid?

The Task Force acknowledges that the recent reliability regulations issued by the PSC represent a tremendous amount of work by the stakeholders and mark a significant development in ensuring reliable service in Maryland. The Task Force, however, evaluated whether certain improvements could be made to the regulations to offer additional transparency, encourage specific outcomes, and accelerate progress.

1. How are the poorest performing feeders handled?

Under COMAR 20.50.12.03(A)(4), utilities must identify the three percent worst performing feeders in their service territories, both in storm and excluding storm conditions. According to the PSC, if those two lists are different, then the utility should compile one list for remediation that contains the lowest 3% overall.

2. How is vegetation management handled?

There was consensus at numerous roundtable discussions that appropriate vegetation management is one of the most effective ways to improve the resiliency of the grid; the fewer trees that are likely to fall on lines, the more likely the system is to weather the storm. The following is an evaluation of the statutory and regulatory framework that affects Maryland's trees.

Trees are one of Maryland's most treasured and important natural and economic resources. Among other things, they create critical wildlife habitat, help mitigate climate change and protect the Chesapeake Bay, and are an integral feature of Maryland's esthetic and cultural landscape. Fallen trees, branches, and overgrown vegetation, however, account for one of the most common causes of power outages in Maryland. Thus, proper planting and maintenance of trees and other vegetation is essential for providing reliable electric service to Maryland customers. There is a complex structure of State and local laws, regulations, ordinances, and private property rights that affect the tree trimming, clearing, and vegetation management practices of Maryland's electric utilities.

a) Roadside Tree Law

Maryland's Roadside Tree Law is defined in Subtitle 4 of the Maryland Code, Natural Resources Article. The Roadside Tree Law regulates the trimming, removal, planting, and care of trees and shrubs growing partly or fully within the right of way of any public road. This law potentially impacts the vegetation management practices of most Maryland utilities because the distribution infrastructure is frequently co-located with or adjacent to these public roadways with a significant, mature tree canopy. The Forest Service at the Maryland Department of Natural Resources administers the Roadside Tree Law.

- *Permit Required* – A person, including a utility, must obtain a permit from the Forest Service before trimming, removing or performing tree care on roadside trees.[32]

- *Required Tree Care Standards* – The regulations implementing the Roadside Tree Law establish several detailed tree care standards, including tree clearance standards for overhead utility lines.[33] According to the regulation, "a person who trims a tree to provide clearance for utility wires, cables, or other facilities shall: (a) allow sufficient clearance for 2 years growth normally expected after trimming, unless otherwise directed by the Forest Service."[34] DNR interprets this regulation to mean that trees should be trimmed to allow for *at least* two years of growth. While trimming, the health of the tree must be "taken into account" and cuts must be made that "direct growth away from overhead wires and facilities in compliance with safety standards and government regulations."[35]

- *Replacement of Trees* – Under the regulations, if a trimmed tree dies within 1 year or is in poor condition due to trimming, if required by the Forest Service, the permittee shall remove the tree and replace it in a location to be determined by the Forest Service. The Forest Service also maintains a list of recommended trees.

- *Underground Facilities* – The regulations protect roadside trees and tree roots during excavation, including excavation for installation and maintenance of electric cable or conduits.

b) RM43 Vegetation Management Standards

With RM43, the PSC recently adopted vegetation management regulations that became effective on May 28, 2012.[36] These regulations establish, for the first time in Maryland, vegetation management standards for distribution and transmission lines not regulated by FERC.

- *Other Laws/Regulations and Property/Contractual Rights* – The vegetation management regulations establish minimum standards applying "to the extent not limited by contract rights, property rights, or any controlling law or regulation of any unit of State or local government."

- *Required Vegetation Management Program* – Utilities are required to develop vegetation management programs that address several technical requirements such as tree pruning and removal, vegetation management around poles, substations and overhead lines, vegetation management along rights of way, inspection of vegetation management, public education and notice, and debris management. The programs are to be filed with the PSC within 90 days of the effective date of the regulations, and no later than 30 days of implementing any changes to such programs, except in exigent circumstances.

[32] Md. Code, NR 5-406; COMAR 08.07.02.03.
[33] *See* COMAR 08.07.02.07.
[34] *Id.*
[35] *Id.*
[36] *See* COMAR 20.50.12.01, *et seq.*

- *Site Specific Vegetation Management Factors* – Utilities are to determine the extent and priority of vegetation management at a site based on several factors set forth in the regulations, such as the voltage of the conductor, relative importance of the affected conductor in maintaining reliable and safe power, likely regrowth rate, potential movement of conductors and vegetation during various weather conditions, legal rights to access area where vegetation management is to be performed, State/local laws and regulations that affect vegetation management at the site, customer acceptance of vegetation management at the site, maturity of the vegetation, and identification of structural condition of the vegetation.

- *Training Recordkeeping and Reporting* – Requires utilities to adopt proper standards for tree and shrub care, including safety standards. Also requires utilities to monitor and document vegetation management practices, including when a utility is not able remove a tree or limb due to lack of consent. Such information is to be provided to the PSC as part of the utility's annual performance report, which shall also include prior year expenditures on vegetation management and vegetation management budget for current calendar year.

- *Public Notice and Outreach* – Requires utilities to make reasonable attempts to notify owners/occupants of all properties on which cyclical, planned vegetation management is to occur, including written notice to each county/municipality affected. Also requires utilities to conduct annual public education programs on the importance of vegetation management.

- *Vegetation Management Schedule* – Regulations establish a vegetation management schedule that, over the next four years, requires utilities to perform vegetation management on an increasing percentage of its total distribution miles, until, within about 4 or 5 years, the utilities will have performed vegetation management on 100% of their total distribution miles. For example, beginning on January 1, 2013, a utility with a 4-year trim cycle shall, within 12 months, perform vegetation management on not less than 15% of its total distribution miles. That percent increases to 40% within 24 months, 70% within 36 months, and 100% within 4 years.

- *Minimum Clearances* – Regulations set minimum clearances of vegetation from conductors, to the extent not limited by contract/property rights or other controlling legal authority. The regulations set both horizontal and vertical minimum clearances and vary depending on the voltage of the conductor. Mature trees may be exempt from the minimum clearance requirements "at the utility's reasonable discretion" for voltage levels at 34.5 and below.

c) Local Laws/Regulations and Private Property Rights

Local laws and regulations also impact vegetation management practices. Several municipalities, for example, have ordinances that impact utility vegetation management practices with respect to trees and shrubs. Additionally, private property and contractual rights impact utility vegetation management practices. According to the report of the RM43 Working Group, most of Maryland's electric distribution lines are located on property not owned by a utility. Rather, utilities usually acquire right of way easements on property.

The terms of right of way easements vary and impact the extent to which a utility can perform vegetation management on the property. The utility may need to obtain the consent of the property owner to allow vegetation management work to proceed. Similarly, if large trees grow on private property that is adjacent to a utility's right of way, the utility needs to obtain the adjacent property owner's consent in order to perform vegetation management on such trees. Even if landowner consent is obtained, the RM43 Working Group noted that other State, county or municipal regulations may impose additional obligations and restrictions on vegetation management.

3. Penalties

The PSC also has authority to assess penalties against utilities. If the PSC finds a utility has violated a statute, regulation, or order, it may assess a civil penalty for the violation up to exceeding $25,000, with each day a separate violation. In addition to or instead of enacting a civil penalty, the PSC may revoke or suspend the license of an electricity supplier. Utilities pay civil penalties into the Maryland General Fund and not directly to the customer, as the PSC has no authority to direct the electric companies to pay customers compensatory or monetary damages. The PSC, through its consideration of utility rate cases may, and has, considered service quality in its evaluation of requests for rate increases.[37]

~~D. Do the utilities have sufficient personnel to ensure a reliable electric distribution system and adequate storm response?~~

~~The Task Force evaluated several factors related to utility staffing levels, including a comparison of staff over a number of years, the mutual aid system, and whether Maryland utilities are adequately preparing for the aging ("graying") of the utility work force.~~

~~1. How do historic personnel levels compare with current ones?~~

~~Any discussion of extended power outages must include an inquiry into whether the utilities have sufficient personnel available to conduct restoration efforts. Such an inquiry also leads, inevitably, to questions about historic staffing levels. Have utilities reduced personnel over the past decade? If so, can any conclusions be drawn between decreased staffing levels and reliability metrics? In order to better understand these questions, the Task Force asked the utilities to provide information about historic staffing levels. The raw data received from them is reproduced below and, while informative, must be overlaid with other changes that happened during the same twelve year period in order to allow meaningful analysis.~~

~~The data below includes only Maryland-assigned resources for utilities whose service territory spans multiple states. For certain utilities, this method may underreport their ability to react to major storm events in Maryland as they could be able to utilize their resources from adjoining states if they are available.~~

[37] *See* SECTION II.E.3, *infra*.