State of Rhode Island
Division of Public Utilities and Carriers

STATE OF RHODE ISLAND
DIVISION OF PUBLIC UTILITIES AND CARRIERS
WARWICK, RHODE ISLAND

REVIEW OF

NATIONAL GRID STORM PREPAREDNESS, RESPONSE, AND RESTORATION EFFORTS

Prepared By:

Power Services
Engineering & Management Services®

Gregory L. Booth, PE, PLS
1616 E. Millbrook Road, Suite 210
Raleigh, North Carolina 27609

February 2012

State of Rhode Island
Division of Public Utilities and Carriers

STATE OF RHODE ISLAND
DIVISION OF PUBLIC UTILITIES AND CARRIERS
WARWICK, RHODE ISLAND

REVIEW OF

NATIONAL GRID STORM PREPAREDNESS, RESPONSE, AND RESTORATION EFFORTS

Power Services

Engineering & Management Services®

Engineering License No.: 5923
d/b/a Power Services and Consulting, Inc.
1616 East Millbrook Road, Suite 210
Raleigh, North Carolina 27609
Phone: (919) 256-5900

I hereby certify this document was prepared by me or under my direct supervision. I also certify I am a duly registered professional engineer under the laws of the State of Rhode Island, Registration No. 8078.

GREGORY L. BOOTH
STATE OF RHODE ISLAND
No. 8078
HOPE
REGISTERED PROFESSIONAL ENGINEER (ELECTRICAL)

3/5/12

Gregory L. Booth, PE

Table of Contents

1. Introduction

PowerServices, Inc. was engaged by the State of Rhode Island Division of Public Utilities and Carriers ("Division") to evaluate the preparedness of National Grid to deal with the outages and damage associated with Tropical Storm Irene and the effectiveness of the efforts of the utility to restore power to its customers in the State. The engagement was initiated in October 2011. PowerServices assigned a team of engineers and management staff with extensive utility experience, including leading storm restoration responses to over 25 east coast hurricanes. PowerServices role is to conduct a review of events and an assessment of the National Grid restoration process, and provide the Division with a written report of our findings and evaluation. PowerServices was given the task to make recommendations for improvements, as may be needed, to National Grid's preparedness and storm response. Our findings, conclusions, and recommendations are contained in this report. Additionally, PowerServices is available to present its findings as may be requested.

PowerServices, Inc. has performed prior work for the Division including evaluating National Grid's system reliability, infrastructure, and recent Infrastructure, Safety and Reliability Plans for FY 2012 and FY 2013. Our prior knowledge of National Grid's system and processes allowed for a more focused approach regarding our storm restoration assessment and this report on the Irene storm response.

Our core engineering team for this project was made up of Gregory L. Booth, R.L. Willoughby, Mike White, Mike Jenkins, and Lloyd Shank. All of these team members have from 20 to 45 years of experience consulting with or operating electric utility systems, serving as electric municipal system managers, Utility Directors, and as Electric System Engineers. All of our team members have significant experience with planning and managing electric system recovery after major storms. All of these team members also have experience in evaluating utility storm recovery responses.

As part of this report, PowerServices obtained information from other utilities that were affected by either Hurricane Irene or Tropical Storm Irene. PowerServices researched available data, including National Weather Service reports related to the storm as it progressed up the eastern United States. We compared the statistical performance of National Grid to other utilities affected by the storm, including wind speeds, customer outages, restoration time, and overall impact to other utility systems. We reviewed both public information available on National Grid and information derived from a series of data requests served on National Grid. PowerServices requested interviews with certain levels of management, engineering, and responders to the storm in order to achieve a comprehensive understanding of all the related issues of National Grid's storm response. Even though these interviews were declined by National Grid, PowerServices used its experience to analyze the material to develop our opinions and conclusions related to National Grid's performance. Our recommendations are intended to enhance future system resilience, storm preparedness, and restoration response.

We transmitted the first data request to National Grid in early October 2011. We received the initial response to this request on December 14, 2011. Based on National Grid's data responses we developed extensive follow-up interview questions for key members of National Grid's storm response team. We requested interviews with a variety of National Grid staff on December 19, 2011. The interviews we requested were eventually declined in early January 2012, as National Grid asked that follow-up questions be made in written form, and written responses would be provided by the appropriate personnel. A second written data request was transmitted on January 13, 2012, from which we received the responses to our second Data Request on February 7, 2012.

The following report is structured to outline a clear picture of the storm's track and impact along the east coast with an overview of the effects on other utilities as well as National Grid. It is essential to have the appropriate perspective of the storm in order to adequately evaluate the performance of National Grid.

Three key observations are (1) the storm delivered much less wind force in Rhode Island compared to many of the states impacted south of Rhode Island; (2) the storm was a relatively slow moving storm providing a sufficient window of pre-incident planning for many utilities; (3) the customary resources National Grid would rely upon for outside assistance included utilities dealing with their own storm restoration as well as contractors previously obligated and working at utilities south of Rhode Island for many days after the storm had already impacted National Grid's system.

2. Report

A. General

The report describes the breadth of impact that Hurricane Irene and eventually Tropical Storm Irene had on the East Coast. From our discussions of the storm's events, we make "Observations" which are an essential component of our subsequent conclusions and recommendations. One such observation is that the wind speeds in Rhode Island were less than half of what they were when the storm first impacted the East Coast.

B. Storm Track Evaluation

The impact from the damage resulting from Hurricane Irene was reported by CNN as one of the most significant weather events of 2011. The hurricane was responsible for widespread property damages and power outages along the East Coast. More than 7 million homes and businesses lost power during the storm, and Irene caused at least 45 deaths and more than $7.3 billion in damages. Irene was the first hurricane to make landfall in the United States since Hurricane Ike in September 2008, and was the most significant tropical system to make a direct landfall in the Northeast since Hurricane Bob in 1991, and only the second hurricane since 1851 to hit New Jersey.

Irene formed on August 15, as a tropical wave off the coast of Africa moving slowly to the west. By the time the wave approached the Leeward Islands on

August 21; the system began to develop and eventually became Tropical Storm Irene. Beginning on August 23, shown below in *Figure 1*, the National Hurricane Center forecasted a hurricane track that would affect the Northeast. Approximately 2.3 million people throughout New Jersey, Maryland, North Carolina, Virginia, Delaware, and New York City were under mandatory evacuation orders.

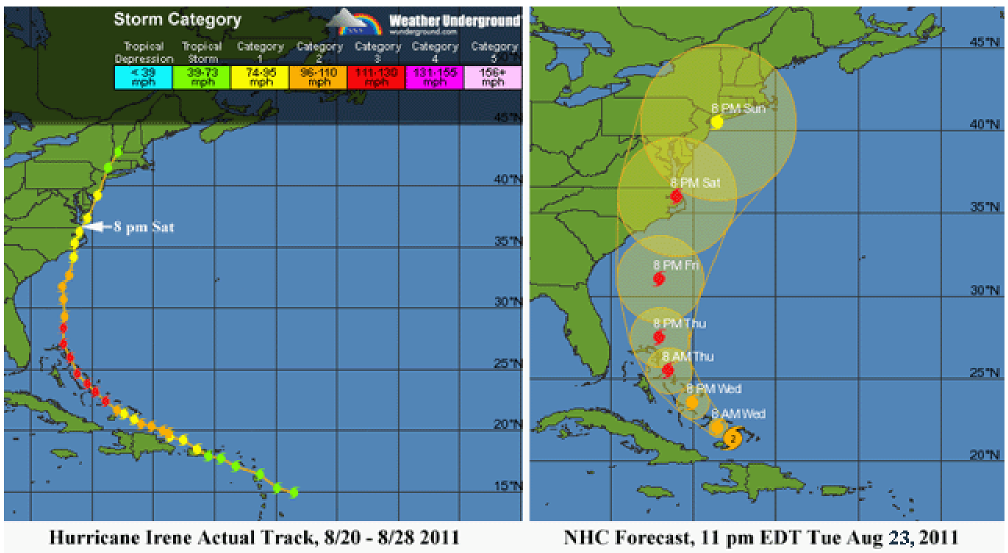


Figure 1: A comparison of the National Hurricane Center forecast for Hurricane Irene issued August 23, 2011 compared with the actual track of Irene. (Source: Weather Underground, wunderground.com, Dr. Jeff Masters)

On Saturday, August 27, Irene's hurricane force winds extended outward up to 90 miles from the eye and tropical storm force winds extended outward up to 290 miles. Irene first struck the U.S. as a Category 1 hurricane (sustained winds of 85 miles per hour) near Cape Lookout, North Carolina on Saturday morning, August 27, and then moved northward along the Atlantic Coast. Wind damage in coastal North Carolina, Virginia, and Maryland was moderate with considerable damage resulting from falling trees and power lines.

On August 28, Irene made a second landfall at Little Egg Inlet, New Jersey as a 75 mph hurricane. At 9 a.m. EDT, Irene made its final landfall as a tropical storm over Long Island, NY, and New York City with 65 mph winds and dropped torrential rainfall in the Northeast that caused widespread flooding. Hurricane Irene brought significant rains and numerous rivers and creeks throughout the Northeast crested above their highest flood stages on record. River flooding records were broken for 26 rivers in New Jersey, New York, and Vermont. The additional rainfall from Irene also resulted in August 2011 having the highest precipitation on record for that month in many areas in the Northeast, with the entire region experiencing above normal monthly precipitation, as shown by *Figure 2*.

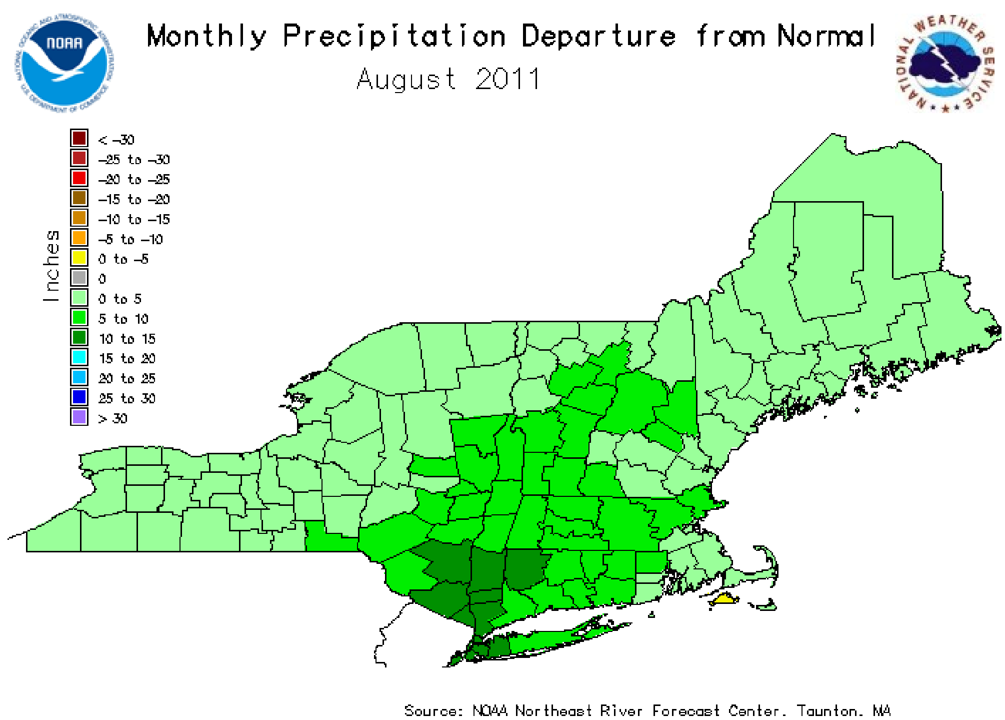


Figure 2: Monthly Precipitation Departure from Normal (Source: NOAA)

Observation: These facts are very important to this report and our assessment of the National Grid storm response and decision process. Considering the National Hurricane Center forecast that was issued for Hurricane Irene on August 23, 2011, National Grid should have recognized that its required resources for outage response would need to come from locales well outside of its customary utility and contractor aide resources. The decision to utilize mobile contractor and utility storm response resources from distant geographic areas should have been made much earlier, and certainly prior to the actual realization that most of the normal resources were already being used by utilities that were impacted by Irene before the storm hit Rhode Island.

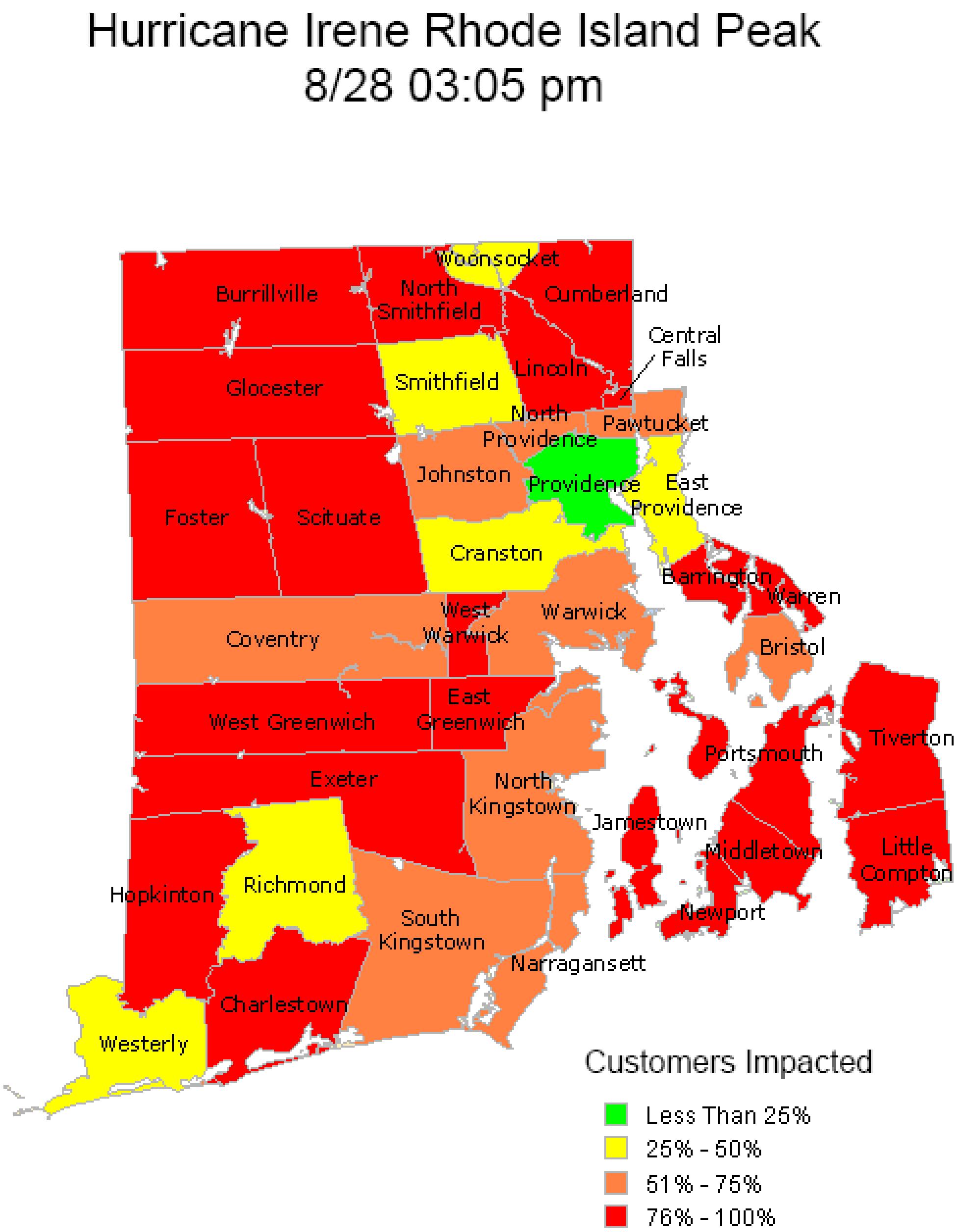
<u>Hurricane Irene's Impact on Rhode Island</u>

During the early morning hours on Sunday, August 28, areas of Rhode Island began experiencing the effects of Hurricane Irene. Although Hurricane Irene had weakened in its track into the northeast, the storm system continued to pack strong winds and rain. The hurricane's path passed west of Rhode Island to the extent that the rainfall totals across the state were not as heavy as those experienced in other states. According to the National Weather Service, Warren, RI reported the highest rainfall total attributed to storm, 5.37 inches, with most of the state receiving 2-4 inches.

While the heaviest rain did remain to the west of Rhode Island, the eastern edge of Hurricane Irene did bring strong winds. The maximum recorded wind gust was 83 mph at Conimicut (Warwick), RI with wind gusts greater than 60 mph in multiple areas around Narragansett Bay, and the remainder of the state reported gusts greater than 53 mph (National Weather Service). National Grid measured wind gusts of 55 mph at Providence RI, and 54 mph at N. Kingstown, RI. In addition, the slow-moving storm battered the state for approximately a day with sustained winds of at least 37 mph. National Grid measured sustained winds of 39 mph at Providence RI, and 36 mph at N. Kingstown, RI.

Observation: These facts directly correlate with our concerns associated with overhead power line structure strength. Generally, we do not observe the degree of failure on other utility systems that was experienced in Rhode Island with wind speeds at the levels that occurred in Rhode Island during Irene.

The following page is a pictorial of the areas in Rhode Island and the percentage of customers impacted. This shows a widespread impact on a large percentage of customers on the first day Tropical Storm Irene reached Rhode Island.



C. Hurricane Irene's Power Outages and East Coast Restoration Process

As the hurricane moved along the coast, strong winds, thunderstorms, tornados, saturated soil conditions, and flooding were contributing factors to the widespread electric system damage throughout several states. The

Department of Energy (DOE) reported a peak of nearly 6 million customers without power across several states during Sunday, August 28 as shown in *Figure 3*.

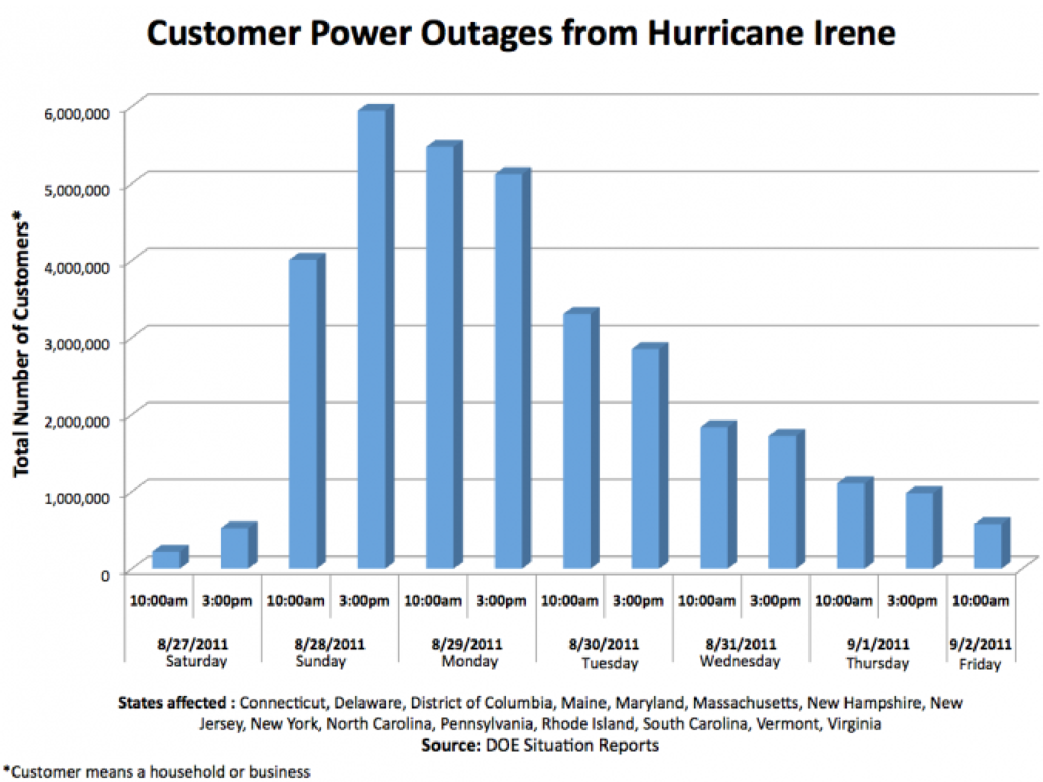


Figure 3: Power outages from Hurricane Irene as reported to DOE (Source: Situational Reports, DOE.gov)

Across all the regions impacted by the hurricane, customer service was affected due to damaged transmission and distribution structures, transformers, conductors, and crossarms caused by strong winds, flooding, and fallen trees. Although outages were widespread, the direct effect of the storm on individual electric systems was varied, as was the time required to restore service to customers. Provided in the section below is a summary for each state describing the damage caused by Hurricane Irene, the number of utility outages, and the timing of power restoration. *Appendix A: Table of Utility Outage Response Comparisons* is a graphical summary, by utility, of the outages caused by Hurricane Irene, with the reported customer restoration dates.

Virginia - After making landfall in North Carolina, the eye of Hurricane Irene moved over the eastern shore of Virginia beginning at 7 p.m. Saturday, August 27, with sustained winds of 80 mph. It is important to note these wind speeds are more than 2 times those sustained in Rhode Island. Irene dumped 7-10 inches of rain over most of eastern Virginia and several inches over the middle of the state, clearing the area Sunday morning as it headed for the Northeast. Hurricane Irene caused the second largest power outage in Virginia history, as 2.5 million people lost power, and resulted in several deaths.

1. Rappahannock Electric Cooperative (REC)

   REC serves over 155,000 customers in 22 northern Virginia counties, 29,000 (almost 19%) of those customers lost power due to Hurricane Irene. By 3:30 p.m. Saturday, August 27, REC had approximately 11,000 scattered outages. Nearly half of those outages were restored by 7 p.m. on August 28. Over 70 percent were restored by Monday, August 29. By Tuesday, August 30, over 25,000 of the 29,000 affected customers had been restored. The last customer was restored on Thursday, September 1.

2. Dominion Power

   Dominion Power serves 2.4 million customers in Virginia and Northeastern North Carolina with 1.2 million customers losing power due to Hurricane Irene. By noon on Monday, August 29, 600,000 customers had been restored. By 2 p.m. on August 30, 800,000 customers had been restored, accounting for 7,700 damage locations out of 20,000. By the end of the day August 30, all VA / DC Metro customers had been restored. On August 31, 920,000 customer power outages at 8,500 damage locations had been restored. More than 1.1 million restorations were completed by Friday, September 2 with the last customer restored on Monday, September 5.

3. A&N Electric Cooperative

A&N Electric Cooperative, headquartered in Tasley, VA and serving all of Virginia's Eastern Shore, reported outages of about 32% on August 27 of its 34,600 consumers without power. Up to 11,000 of its consumers were out at sporadic times. By the end of the day on August 28, all 34,600 consumers had their power restored. There were no transmission line outages.

Maryland/Delaware - The eye of Hurricane Irene passed just off the coast of Maryland around 2 am on Sunday, August 28, with sustained winds of up to 80 mph. Reports from Delaware tell of inland wind gusts over 70 mph and a tornado spawned from Irene that touched down near Lewes, Delaware.

1. Potomac Electric Power Company (PEPCO)

PEPCO serves 778,000 customers in the District of Columbia and its Maryland suburbs. PEPCO reported winds gusting as high as 65 mph.

The capital area experienced less rainfall and flooding from the storm than many other areas.

At its peak, the storm left 220,000 PEPCO customers without power (about 28%): 63,000 in Montgomery County, MD, 126,000 in Prince George's County, MD and 31,000 in the District of Columbia. As of 7:30 a.m. Sunday, August 28, 26,000 customers had been restored. By the end of Monday, August 29, 75% of all outages had been restored and all PEPCO substations were returned to service. By the end of August 30, 95% of the customer outages had been restored. The last customer was restored on Thursday, September 1.

2. Potomac Edison (First Energy)

Potomac Edison serves approximately 250,000 customers in seven Maryland counties and 135,000 customers in the eastern panhandle of West Virginia. It was reported that 19,000 (less than 5%) Potomac Edison customers in Maryland experienced outages from Irene. All outages were restored by Monday, August 29.

3. Delmarva Power

Delmarva serves 498,000 customers in Delaware and along the Eastern Shore of Maryland. Approximately 220,000 of these customers experienced outages due to Irene with a peak of 165,000 outages Sunday morning and 91,000 customers were restored on Sunday, August 28. Delmarva restored service to more than 99% of affected customers on

Wednesday, August 31. The last customer was restored on Friday, September 2.

4. Choptank Electric Cooperative (CEC)

Choptank Electric Cooperative (CEC) serves approximately 52,243 electric customers in all nine counties of Maryland's eastern shore. CEC experienced about 11,990 total outages due to Hurricane Irene, 23% of their system.

As Hurricane Irene reached across Maryland's shore, CEC reported 11,663 members without power. By 9 p.m. Sunday, August 28 around 9,300 services had been restored representing over 75% of the total outages. The storm restoration was complete by 11:50 p.m. Monday, August 29.

Pennsylvania - Prior to Hurricane Irene, Pennsylvania experienced the wettest month on record, leaving the ground damp and especially prone to flooding. Irene traveled up the New Jersey coastline on the evening on Sunday, August 28 with sustained winds of 75 mph, battering eastern Pennsylvania with wind and even more rain.

1. Metropolitan Edison (Met-Ed) (First Energy)

Met-Ed serves 560,000 customers in 13 eastern Pennsylvania counties. Approximately 200,000 customers, nearly 36%, experienced outages with 167,000 outages restored on Tuesday, August 30. More than 185,000 had been restored on August 31, fewer than 4,000 remained without power on Friday, September 2, and full restoration was on Sunday, September 4.

2. Penelec (First Energy)

Penelec serves 600,000 customers in 31 Pennsylvania counties, mainly in the western part of the state. About 6% of Penelec's customers experienced outages from Irene (37,000 customer outages). Over 85% of the customer outages were restored by Tuesday, August 30, and nearly all outages were restored by Thursday, September 1.

New Jersey - Wind and rain from the outer bands reached New Jersey midday Saturday, August 27. Irene made landfall in New Jersey around 5:30 a.m. Sunday, August 28. New Jersey reported gusts up to 75 mph with sustained winds in excess of 70 mph. Recorded rainfall totals averaged 6-12 inches throughout the state. As Hurricane Irene left the state Sunday evening there was a peak of approximately 930,000 customers without power.

1. Jersey Power & Light (JCP&L) (First Energy)

JCP&L serves 1.1 million customers in 13 New Jersey counties. According to JCP&L press releases, the utility experienced a total of 670,000 customer outages. However, according to a New Jersey Board of Public Utilities report, JCP&L had 780,000 total outages (71% of the total system), with a momentary peak of more than 400,000 outages. By the end of Saturday, August 27 more than 400,000 JCP&L customers were without power. By the evening of Tuesday, August 30, only 200,000 remained without power. Approximately, 98% of customers were restored by 8 p.m. on Saturday, September 3. The last customer was restored on Monday, September 5.

2. Public Service Enterprise Group (PSE&G)

PSE&G serves approximately 2.2 million customers (1,834,407 residential customers) in central New Jersey. According to the NJBPU report, nearly 40%, 872,492 customers experienced outages with 95% being restored by 7 p.m. on August 31, and the last customer was restored on Sunday, September 4.

3. Rockland Electric (RECO)

RECO serves approximately 70,900 customers (61,109 residential customers) in northern New Jersey. According to the NJBPU report, about 38% of the total system, 27,220 customers experienced outages. Of the customer outages, 95% of these were restored by 2 p.m. on September 1 and the last customer was restored on Sunday, September 4.

4. Atlantic City Electric (ACE)

ACE serves approximately 530,000 customers (61,109 residential customers) in south New Jersey. According to the NJBPU report, nearly 51%, 273,898 customers experienced outages with 97% of these customers restored by 8 p.m. August 29 and the last customer was restored on Thursday, September 1.

Connecticut - Rain and wind from Tropical Storm Irene reached Connecticut late on Saturday, August 27. The state reported wind gust over 60 mph, 3-6 inches of rain, and extensive tidal flooding.

1. Connecticut Light and Power (CLP)

   CLP is the largest Connecticut utility, serving 1.2 million customers in 149 communities across Connecticut, covering 4,400 square miles. CLP experienced more than 700,000 customer outages as a result of Irene, with a peak of 671,000. CLP experienced transmission outages resulting in tens of thousands of outages. These transmission outages were restored by August 29th. 50% of customer outages were restored within 3 days, 70% within 4.5 days, and 95% within 7 days of the storm passing. Full restoration of all customers took 9 days.

2. United Illuminating Company (UI)

   UI provided transmission and delivery of electricity for 325,000 customers in Connecticut's Greater New Haven and Bridgeport areas. UI experienced 210,000 outages as a result of the storm, with 158,000 customers out at peak. Half of the 210,000 outages were restored within 2 days, 70% in a little more than 3 days, and 95% within 6 days. Full restoration of all outages was achieved 8 days after Irene passed.

Massachusetts - Rain and wind from Tropical Storm Irene reached Massachusetts early morning of Sunday, August 28. The state reported wind gusts up to 80 mph, 5-8 inches of rain, and extensive flooding.

1. NSTAR

NSTAR provides electricity for 1.1 million customers in 81 eastern and central Massachusetts communities. NSTAR experienced more than 250,000 customer outages as a result of Tropical Storm Irene. On Monday, August 29, 200,000 NSTAR customers were without power. By August 31, only 29,000 remained in the dark, the full restoration was predicted to take up to 1 week, however the remaining customers were restored on Friday, September 2.

2. Western Massachusetts Electric (WMECO)

WMECO serves more than 200,000 customers in western Massachusetts. WMECO experienced only 36,000 outages, and all of those were restored on August 30, less than 2 days after the storm hit.

The following is a chart summarizing in graphical form the above discussions by utility data collected.

Affected Customers by Utility

Utility	Total Outages	Total Consumers Served	Peak Outage %	Full Restoration (days)
VIRGINIA				
REC	29,000	155,000	18.71%	4.3
PGEC	10,975	11,151	98.42%	6.8
Dominion	1,200,000	2,400,000	50.00%	8.75
A&N	11,000	34,600	31.79%	1
MARYLAND/DELAWARE				
PEPCO	220,000	778,000	28.28%	4.1
Potomac Edison	19,000	385,000	4.94%	1.3
Delmarva	220,000	498,000	44.18%	5.1
Choptank	11,990	52,243	22.95%	1.2
PENNSYLVANIA				
Met-Ed	200,000	560,000	35.71%	6.9
Penelec	37,000	600,000	6.17%	3.9
NEW JERSEY				
JCP&L	670,000	1,100,000	60.91%	7.75
PSE&G	872,492	2,200,000	39.66%	6.25
RECO	27,220	70,900	38.39%	7
ACE	273,898	530,000	51.68%	4.25
CONNECTICUT				
CLP	700,000	1,200,000	58.33%	9
UI	210,000	325,000	64.62%	8
MASSACHUSETTS				
NSTAR	250,000	1,100,000	22.73%	4.5
UI	36,000	200,000	18.00%	1.5
VERMONT				
CVPS	73,000	159,000	45.91%	5.5
RHODE ISLAND				
NEC	359,569	479,000	75.07%	7.1

D. Hurricane Irene's Impact on National Grid

Beginning on August 28, at approximately 2:03 AM, the storm began impacting National Grid's electric system. Customer service was affected due to the damage to transmission and distribution structures, conductors, and crossarms caused by strong winds and fallen trees. The storm caused significant damage to the electric system with power interruptions ultimately affecting 359,569 [1] customers in Rhode Island representing 75 percent of National Grid total customers. Nearly all service was restored by Sunday, September 4 with the final storm related outages restored by Monday, September 5. The customer power outages were wide spread and affected all areas of the state. *Appendix B: Maps of National Grid Outage Areas* shows the outage statistics for each city and town in Rhode Island by the reported time periods. Following is a summary of **transmission** assets impacted by the storm in Rhode Island:

- 8 Transmission lines damaged [2]
- 29 Sub transmission lines outages [2]
- 37 Substations out of service [1]

Following is a summary of **distribution** assets impacted by the storm in Rhode Island:

- 206 distribution feeder circuit protective device lockouts [1]
- 207 pole replacements [3]
- 100 distribution transformers damaged [3]

- Approximately 800 tree conditions that needed to be addressed by crews [1]
- Over 1140 sections of wire down, resulting in the replacement of 23,000 feet of wire [3 5]
  - 225 sections of primary three-phase wire down
  - 483 sections of primary single-phase wire down
  - Over 435 sections of secondary wire down (customer services)

1 National Grid- Responses to Division Data Requests- Set 1: Division 1-5

2 National Grid- Responses to Division Data Requests- Set 2: Division 2-4

3 National Grid- Responses to Division Data Requests- Set 2: Division 2-14

4 The Narragansett Electric Company d/b/a National Grid Docket 2509. Report on Tropical Storm Irene Preparedness, Damage Assessment and Service Restoration Efforts

5 National Grid Presentation: Lessons Learned

Observation: The facts of Hurricane Irene's storm track, wind speeds, and duration combined with the associated utility system outages (failures) and restoration duration provides a series of comparisons which can be drawn between the utility's resilience and storm response effectiveness. Many of our observations related to National Grid's storm response utilize not only our years of experience with hurricane storm restoration, but, more importantly, are measured against other utilities affected by Hurricane Irene and magnitude of its force on each utility. Overall, most utilities south of Rhode Island experienced wind speeds twice those impacting Rhode Island and the utilities systems were impacted no worse and often less, with outage restoration time equal to or better than National Grid, even when those utilities experienced far more severe storm conditions.

E. Summary of Pre-Storm Planning and Mobilization

Tuesday, August 23

- National Grid conducts its first System Storm Call.
- National Grid began discussions with its Alliance vendors to tentatively secure any resources that were readily available. Alliance vendors are National Grid's preferred contractors who are currently working within the National Grid service territory. Approximately 25 Alliance two-person crews were made available Tuesday evening for support in New England.

Wednesday, August 24

- In accordance with the its Electric Emergency Plan (EEP), National Grid activated the System Incident Commander with responsibility for the areas serving Massachusetts, Rhode Island, New Hampshire, and New York on Wednesday, August 24. The System Incident Commander was primarily responsible for establishing both the projected and actual Incident Classification Level for Irene. The System Incident Commander, with support of the Company's emergency planning organization, considered a number of factors in establishing or revising the incident classification level.
- The System Emergency Operations Center and Regional Emergency Operations Center were located in Northborough, MA.
- From Wednesday, August 24 until Friday, September 3, National Grid worked with internal, contract, and mutual assistance contacts to procure additional crews.

- The Regional Incident Commander directed the Planning Section Chief to secure 200 additional contract distribution line crews for New England. By Wednesday evening, 160 crews had been confirmed.
- National Grid completed an assessment of its local contract tree crews which were currently performing scheduled work as part of their annual contracts. National Grid determined that additional resources would be needed to supplement the baseline support that local contractors could provide. National Grid contacted forestry contractors to identify and secure crew resources.
- The logistics team was contacted by email to activate the three-day pre-storm checklists. Logistics team initiated its pre-event activities. The staging site core team members were contacted and notified of the possibility of activating multiple staging sites. National Grid also contacted Base Logistics, a third party vendor, in the event that additional support might be needed.
- The Meals and Lodging Team prepared for activation and began acquiring hotel inventories based upon the location of the staging sites.
- Inventory Management contacted materials suppliers and began preparations for material needs and scheduling for materials. Inventory management ordered 1,000 additional poles for delivery to the New England Distribution Center (NEDC). During the duration of the storm, inventory management and procurement coordinated four daily storm calls to identify any issues related to supply.

Thursday, August 25

- National Grid activated the Regional Incident Commander for New England on Thursday, August 25. The Regional Incident Commander made FEMA Incident Command System (ICS) position assignments in accordance with the EEP plan.
- National Grid secured over 200 crews by Thursday morning.
- The Edison Electric Institute (EEI) mutual assistance process was initiated Thursday morning when Northeast Mutual Assistance Group (NEMAG) convened a conference call to discuss Irene. The conference call included representatives from fourteen utilities. The conclusion of the call was that all utilities were holding their respective crews and monitoring the storm's progress.
- National Grid participated in a second conference call with representatives from NEMAG, New York Mutual Assistance Group (NYMAG), Southeast Electricity Exchange (SEE), and the Midwest Mutual Assistance Group. No additional crews were secured as a direct result of this conference call.
- The core logistics team completed its review of pre-negotiated staging sites and confirms staging site availability. National Grid decided to establish staging sites along the perimeter of where the greatest anticipated damage would be likely to occur. Based upon this review, the core team selected Raynham, MA to support restoration activities in southern Massachusetts and Rhode Island.
- The staging site teams began daily discussions and coordination with the meals and lodging team, inventory management, and fleet management to

confirm the staging site locations, determine stock level requirements, and to provide overnight fueling.

- The Meals and Lodging Team setup operations and began to secure hotels near Lincoln RI, Warwick RI, and Marlborough, MA.
- Preparations for distribution damage assessment began including staff assignments, vehicle requests, appraisal forms, and circuit prints.

Friday, August 26

- The Regional Incident Commander appointed additional ICS position assignments including a Branch Director for NE-North. Additional assignments were made for areas below the Branch Directors.
- The anticipated incident classification level was revised from Level 5 to Level 4 based mainly upon information provided to National Grid by its weather service provider, Telvent.
- Alliance crews were staged in local areas to where they had been working on Friday, August 26. Many of the local vendors remained staged at their places of business and ready to deploy when requested by National Grid. Most of the local vendors were staged in Massachusetts in the communities of Woburn, Billerica, Abington, Canton, Holbrook, and Bedford. These local resources were not dedicated to any one service area in New England but deployed to areas as needed by National Grid in Massachusetts, Rhode Island, and New Hampshire.
- National Grid's emergency planning group and Regional Planning Section Chief continued attempts to secure an additional 400 crew resources.

- The Meals and Lodging Team was fully operational at the Northborough Customer Contact Center providing hotel and meal updates.
- All routine deliveries for Monday were moved up and delivered Friday or over the weekend prior to Irene.
- National Grid provided Damage Appraisal refresher training in Waltham, MA to those individuals assigned storm restoration activity.

<u>Saturday, August 27</u>

- National Grid anticipates Irene's incident classification level to be level 4.
- Irene reached landfall in the continental United States in North Carolina on August 27.
- Construction crews from vendors arriving on Saturday were staged where lodging was available.
- National Grid pre-staged 152 transmission line workers in Rhode Island, of which 17 were internal and 135 were contract workers.
- The NEMAG mutual assistance conference call added representatives from the Great Lakes Mutual Assistance Group and the Mid-Atlantic Mutual Assistance Group. No additional mutual assistance resources were made available.
- All forestry contractors were onsite and staged at locations across the New England region, including 182 tree crews in Rhode Island.
- The staging site team activated the staging sites in Marlborough MA, Raynham MA, and Rockingham Park, NH for the purpose of staging line crews in advance of Irene.

- National Grid commenced round-the-clock staffing for fleet operations and 12-hour shifts were established in Rhode Island fleet garage locations. Rental sedans and Sport Utility Vehicles were delivered and available for dispatch.

<u>Sunday, August 28</u>

- Irene makes landfall in Rhode Island. By Sunday afternoon, approximately 321,600 customers are without power, with National Grid now expecting the restoration to exceed 72 hours. The incident classification level was revised to Level 5.
- National Grid continued attempts to secure an additional 400 crew resources from NEMAG, however no additional crew resources were made available.

Observation: National Grid generally followed its Storm Response Plan, however neither it's Storm Response Plan or its actions accounted for a hurricane event that moved up the coastline, impacting many regions, and utilizing the storm response resources which National Grid could normally rely upon. In its Hurricane Irene Preparedness Report, National Grid accurately states "With a greater number of utilities competing for the same resources, National Grid encountered more challenges in securing crew resources for Irene than is typical for less intense storm events." [1] Although this statement is accurate, it fails to point to the reason this adversely impacted the National Grid storm restoration process. It was not so much the storms intensity that created the problem because, frankly, it was not that intense a hurricane and certainly wasn't by the time it reached Rhode Island. It was the path and the number of states and utility systems the storm impacted before reaching Rhode Island that presented the greatest resource challenge. The storm track and impact area along the East Coast was a fact that was already predicted by the National Weather Service by August 23 when National Grid conducted its first System Storm Call. The storm was moving slowly causing delays in each state's response. However this gave National Grid more time to plan and prepare. Most importantly, National Grid appears to have made little adjustments in its planning, preparedness, and crew resource acquisition when armed with the knowledge of the (1) storm's track, (2) the competition for the same nearby resources from utilities that would be impacted earlier than National Grid, and (3) the knowledge that it would need more crew resources by August 28 than could be secured in a area of less than eight (8) hours travel. This is observed as one of the major contributing factors to the duration of the restoration process in Rhode Island.

1 The Narragansett Electric Company d/b/a National Grid Docket 2509 Report on Tropical Storm Irene Preparedness, Damage Assessment and Service Restoration Efforts: Page 15 of 43

F. Post Storm Activities and Processes

National Grid began significant restoration efforts on Monday, August 29 and had restored 68 percent of customers by Tuesday, August 30 and 90 percent by Thursday, September 1. Nearly all service was restored by Sunday, September 4 with the final storm related outages restored by Monday, September 5. Shown in *Table 1* is a summary of the outage and restoration statistics related to Hurricane Irene, including the number of customers without power and the number of customers restored by National Grid for each day of the restoration effort. Also shown in *Figure 4* is the trend between the cumulative outages, cumulative restorations, and customers out during the restoration effort.

National Grid Outage and Restoration Summary [1, 2]						
Date	Cumulative Outages	Cumulative Restorations	Daily Active Outages	Daily Restorations	Customers Out of Service	% Restored
8/28/2012	321,600	86,491	321,600	86,491	235,109	26.9%
8/29/2012	331,500	194,337	245,009	107,846	137,163	58.6%
8/30/2012	341,523	244,855	147,186	50,518	96,668	71.7%
8/31/2012	348,309	297,177	103,454	52,322	51,132	85.3%
9/1/2012	352,770	324,743	55,593	27,566	28,027	92.1%
9/2/2012	355,441	344,571	30,698	19,828	10,870	96.9%
9/3/2012	356,868	355,778	12,297	11,207	1,090	99.7%
9/4/2012	358,921	358,917	3,143	3,139	4	99.999%
9/5/2012	359,569	359,569	652	652	0	100.0%

Table 1: National Grid Customer Outage and Restoration Summary

1 National Grid- Responses to Division Data Requests- Set 2: Division 2-2
2 Restoration Percentage shown is the ratio of the cumulative outages to the cumulative restorations

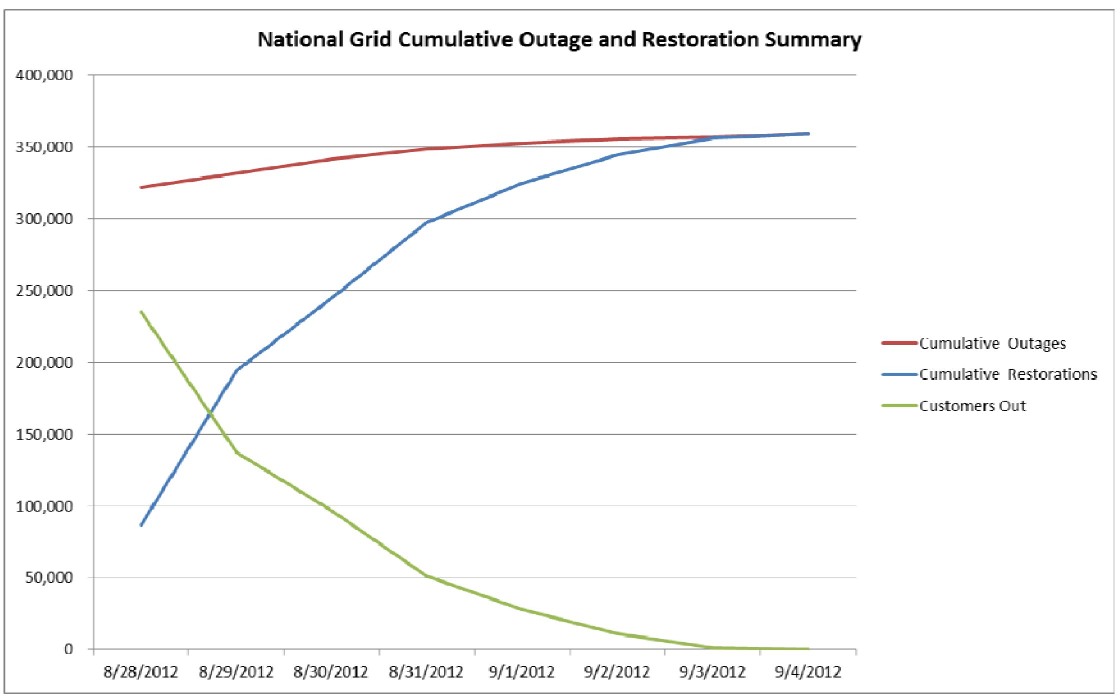


Figure 4: National Grid Cumulative Outage and Restoration Summary

System Damage and Appraisal

Upon the arrival of Irene, the first actions taken by National Grid were to safely deploy damage appraisers to patrol lines and assess the restoration work needed. The storm damage appraisal process is performed after a storm event to collect and assess the level of physical damage on overhead distribution and transmission facilities. The field information collected is used to route restoration resources and create construction work packages. National Grid had damage appraisal resources available and staged on Sunday, August 28 for both the transmission and distribution system. However, due to the risk to employee safety, limited patrols were conducted until the peak storm wind subsided on Monday, August 29. This was a correct and prudent process consistent with any utility storm response process.

On Monday, August 29, the winds subsided enough to allow National Grid to perform an aerial patrol of their transmission and sub-transmission facilities. Patrols were assigned by region and each helicopter operator was assigned a National Grid spotter. In many cases, National Grid's transmission control center was able to restore service to affected substations by switching transmission supplies. All transmission related outages were repaired and back in service on Monday, August 29, limiting most transmission outages to less than 24 hours from the storm's onset. However, there were a number of outages on the sub-transmission level (69 kV and less) that extended into Wednesday, August 31.

Observation: There are two observations concerning the transmission outages. First, a transmission structure failure due to 50 mph winds in not generally expected. Second, a transmission system should be robust enough that performance of a system patrol and having to reclose breakers, at most, should be expected with wind speeds at the Irene level in Rhode Island.

Damage appraisals for the distribution system also began on Monday, August 29 with Phase 1 patrols, which are focused on restoration of the mainline circuit three phase lines. Phase 1 patrols were completed on Tuesday August 30, and Phase 2 patrols began. Phase 2 patrols included single phase lines, fused taps, and services. The Phase 2 patrols were completely finished by Thursday, September 1 allowing the damage appraisers to focus on outages issued from National Grid's outage management system. Each evening as patrols were completed, construction work packets were created and issued the next morning to tree and line construction crews. In Rhode Island, National Grid completed patrols covering 75% of the distribution circuits. Again, this is standard protocol for major storms and was conducted by National Grid efficiently.

Restoration Process and Personnel

National Grid implemented a system of prioritization that first focused on public safety and secondly maximizing customer restoration when restoring service. This was accomplished by initially focusing on restoring transmission lines, sub-transmission lines, substations, and mainline distribution feeders, balancing the workforce between damaged areas to effectively restore the largest area possible. Next, National Grid prioritized distribution lines, taps, and single customer services. *Figure 5* shows the number of customers without power and the number of customers restored by National Grid for each day of the restoration effort.

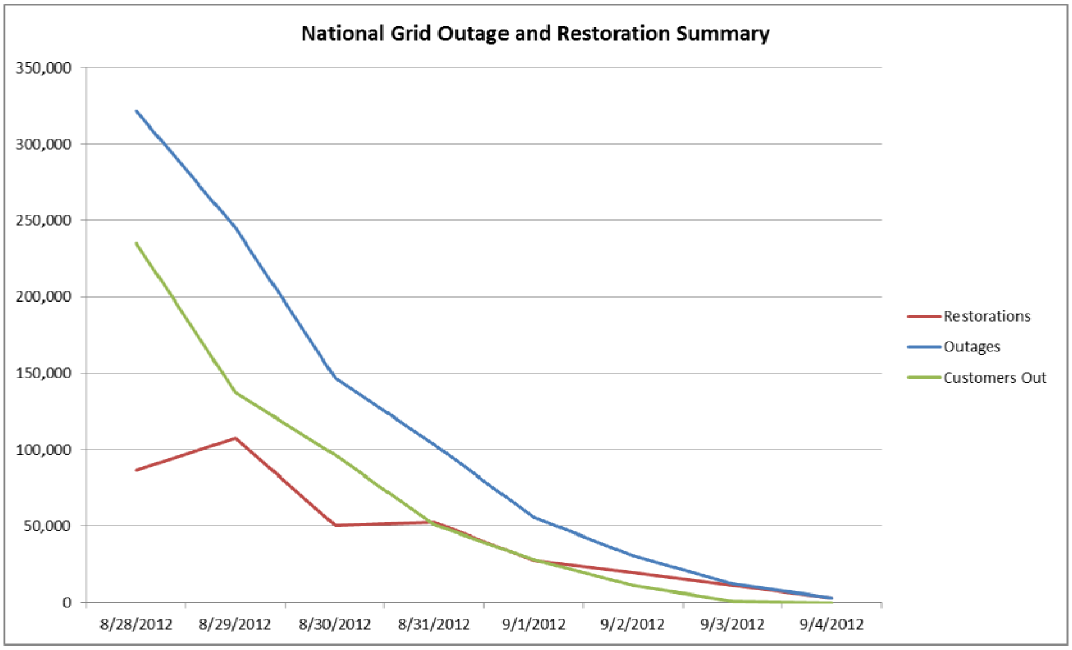


Figure 5: National Grid Outage and Restoration Summary

To improve restoration effectiveness, National Grid decentralized its service restoration on Sunday, August 28, at 6:00 a.m. allowing for the analysis, assignment, dispatch, repair, and closeout functions to be coordinated from multiple functional areas. National Grid established two Branch Emergency Operation Centers (EOC) in Rhode Island, initially using its office at Melrose Street in Providence then adding on Monday, August 29, the office at North Kingstown. Throughout the restoration, the Northborough Control Room and Branch EOCs focused on 911 priority calls, public safety issues, and wires down support. As more crews arrived in Rhode Island, two staging sites were established starting Tuesday, August 30: one at the Twin River Casino in

Lincoln and the other at the Warwick campus of Community College of Rhode Island (CCRI).

Summary charts given below in *Figures 6 through 9*, show the resources that were utilized during the restoration process. For each restoration day, the maximum number of resources utilized for any reported 6-hour interval has been collected by type. Also, the detailed listing of resources by National Grid is contained in *Appendix C: List of Outside Resources Mobilized*. National Grid exhibited the ability to adjust its plan and processes during the storm damage appraisal and restoration process to be more effective with available resources and changing resource levels.

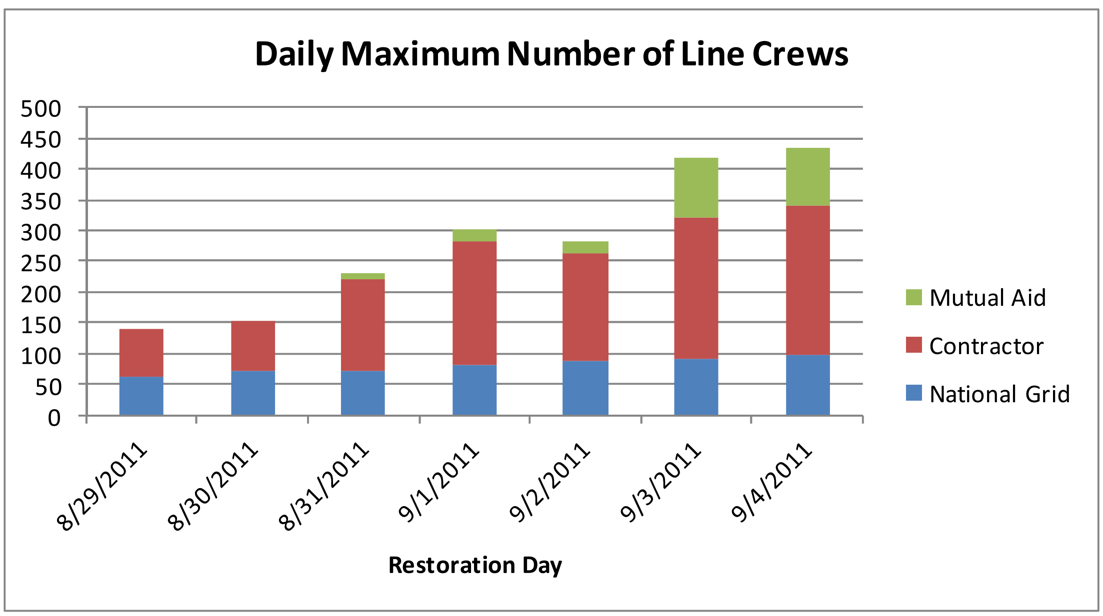


Figure 6: Summary of Line Crew Resources

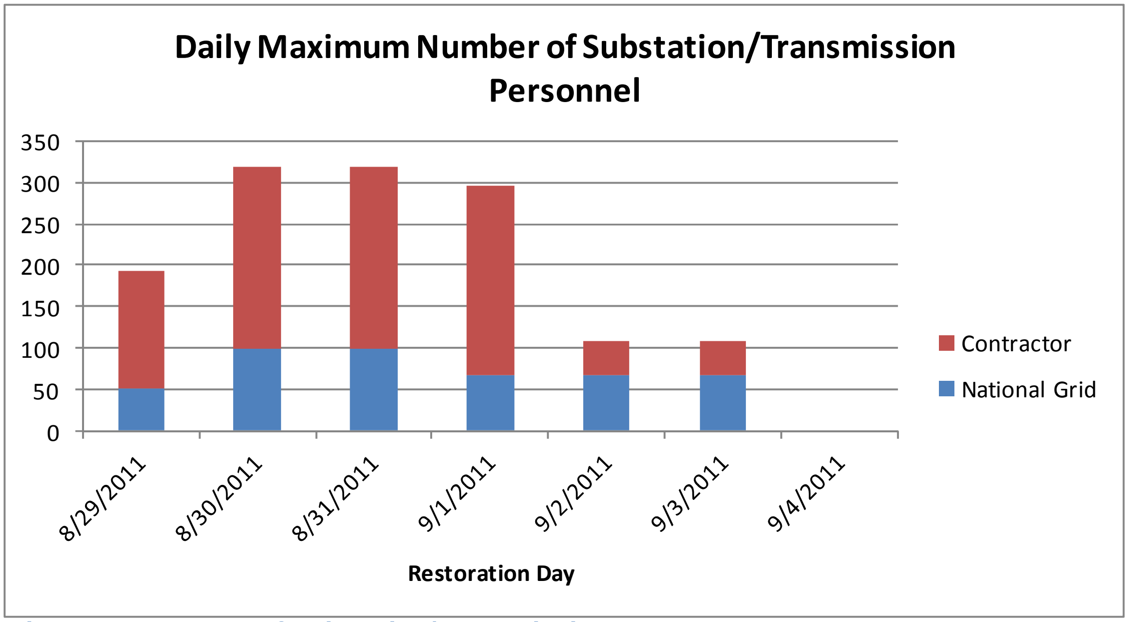


Figure 7: Summary of Substation/Transmission Resources

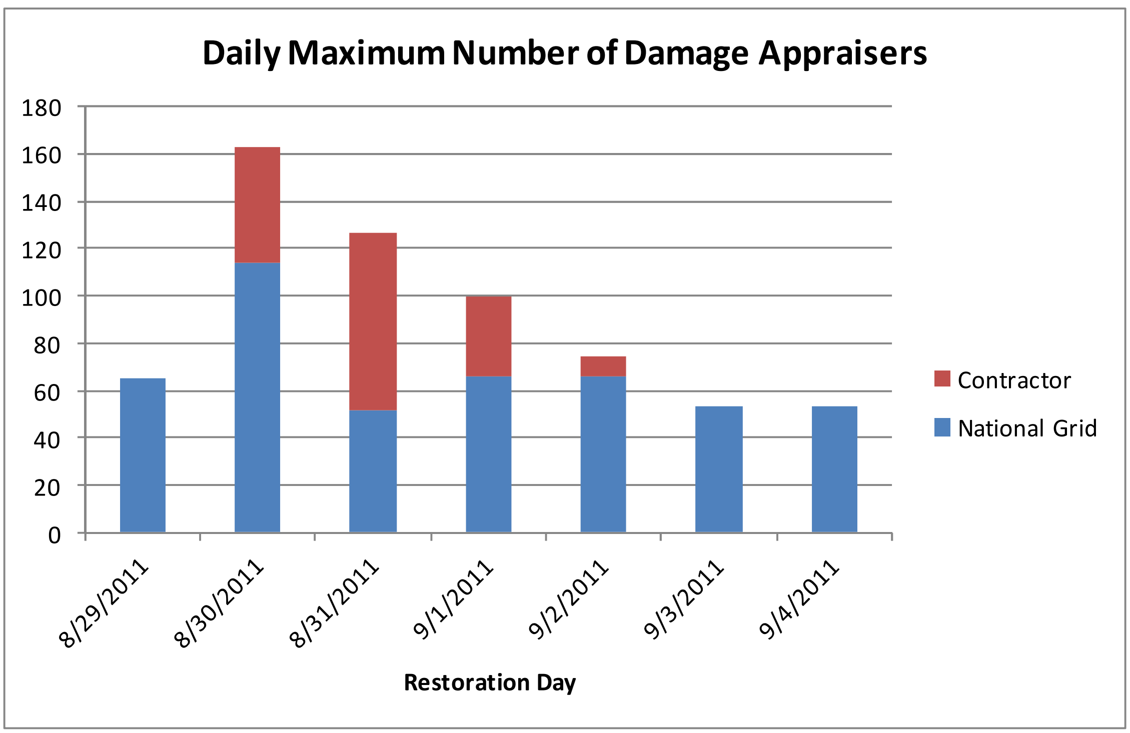


Figure 8: Summary of Damage Appraisal Resources

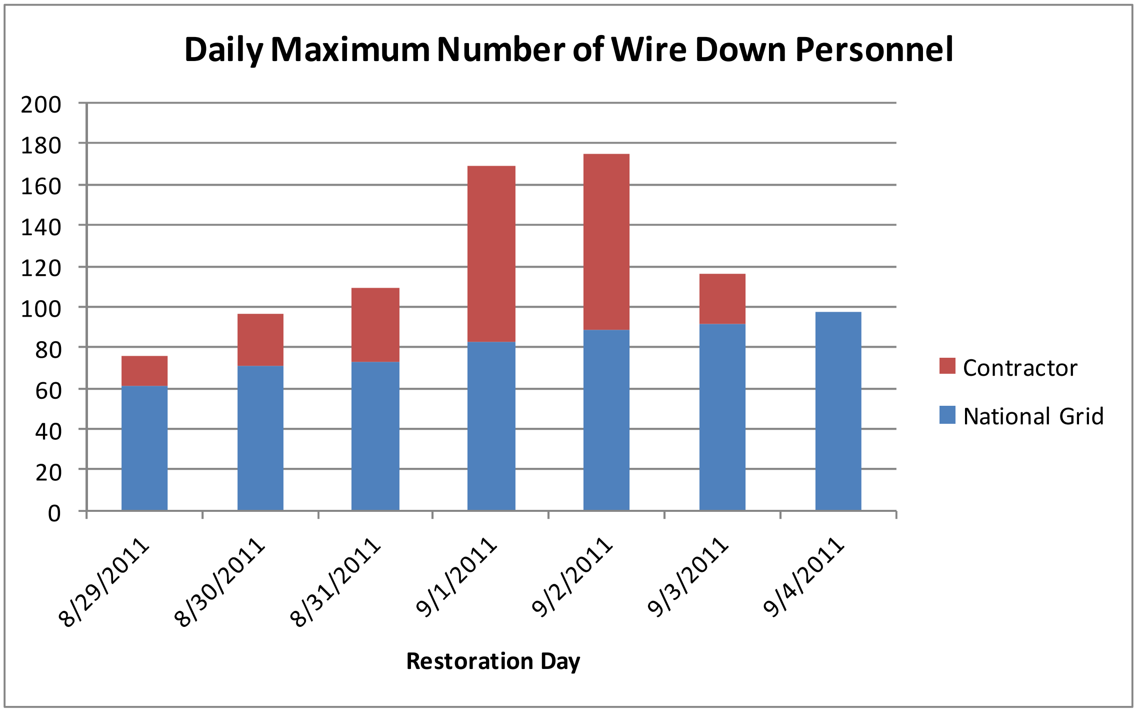


Figure 9: Summary of Wires Down Resources

G. Conformance with EEP Plan

National Grid, in general, conformed to their Electric Emergency Plan (EEP) during the restoration of outages caused by Tropical Storm Irene. The EEP is so general and non-specific that it is merely an organizational guide for response to large system outages. The EEP does not serve as a tool that is actually useful during storm recovery planning or storm recovery except to set up the organization. In addition, PowerServices found several areas of deficiency which are summarized below:

a. The EEP plan does not tie to the new National Grid Corporate Crisis Management Plan. National Grid's current US Strategic Response Plan ("SRP") states that the Corporate Crisis Management ("CMP") plan has been superseded by the US Strategic Response Plan dated 6/17/2011. However, the EEP does not reference the SRP.

b. National Grid's EEP does not provide any planning scenarios to prepare for the challenges created by an incident on the scale of Hurricane Irene, particularly one affecting a large portion of the East Coast and potential resources relied upon by National Grid.

c. National Grid did not implement the Strategic Response Team (SRT) even though natural disasters are clearly listed in the examples of when the SRT can be invoked in the new "US Strategic Response Plan" (SRP) initiated in June of 2011. Failing to implement the SRT denied National Grid of the wisdom and experience of top company leaders. According to the SRP the SRT is only formed if the Technical Incident Commander asks for the assistance.

PowerServices believes that the SRT would not have significantly affected the timeliness of the recovery from Irene as well as the cost to the company. However, had the SRT been formed and taken the occasion to follow the storm recovery effort more closely, they would have learned significant information about the condition of their electric system in Rhode Island and any inefficiencies associated with the management of the storm recovery. Also, upper storm response management would have learned about the inefficiencies in their storm response organization. Management must take advantage of the opportunity to learn about the condition of their system and the management challenges that a mass storm recovery presents. Storm response management should have been the first to understand that winds speeds less than an afternoon thunderstorm could produce such devastating damage. The SRT should have been alerted early in the process that assistance from mutual aide would be sparse at best, and that this would lead to one of the major storm response deficiencies.

d. National Grid did not take advantage of a truly decentralized storm management organization. A decentralized organization would have managed the distribution system recovery by local service units. These local service units are more effective in storm recovery because they have the personal knowledge of the local electric system, the customers, and the weak spots in the system. Local service units no larger than a single city or county would have instant appreciation of which damaged section to address with resources to yield the greatest good. National Grid maintained three service area branches for the Massachusetts, New Hampshire, and Rhode Island territories. The branch covering Rhode Island was not initially located in Rhode Island. Several days after the storm hit, the Rhode Island branch was divided into two branches. National Grid proposed to use the FEMA Incident Command System (ICS). However, one of the tenants of the ICS is to limit the span of control to a manageable area. This is another area where future improvements should expedite storm damage response and power restoration.

e. The EEP covers the corporate structure but does not drill down to the branches and local service personnel so that each local service area is prepared to perform their responsibilities during a storm event. The local service areas should be incorporated in the EEP for major storms.

f. The EEP borrows a buzz word from FEMA's **<u>Incident Command System</u>** but fails to measure up to the name.

Unlike the ideals of the FEMA ICS the National Grid EEP does not provide:

- Manageable Span of Control
- Incident Action Planning
- Incident Facilities and Locations
- Establishment and Transfer of Command
- Comprehensive Resource Management
- Information Management

PowerServices recommends National Grid appraise the benefits of expanding the EEP to incorporate these areas.

H. Storm Restoration Successes

a. National Grid personnel are to be recognized for making an enormous effort to restore electric service to the citizens of Rhode Island following the significant damage of Tropical Storm Irene. With over

200 poles down, approximately 1,100 hundred power lines down, and hundreds of other instances of storm damage, National Grid employees and contractors worked diligently to restore power. PowerServices does not criticize or find fault with the effort of the National Grid employees and contractors after the storm had passed. PowerServices' evaluation identified system condition deficiencies, a lack of preparedness, and organizational inefficiencies.

b. PowerServices found National Grid's intent and desire to keep their customers informed of their progress of getting power returned acceptable. However these efforts were greatly limited by the intermittent failure of key technology systems creating a lack of timely and accurate outage information.

c. National Grid's management started storm preparations on August 22, which was as early as would be expected. Irene originated on August 15, 2011[1] and was named a tropical storm on August 21 with a predicted track to hit Florida. The history of the forecast tracks shows the storm hitting New England as early as August 23.

d. There were no reported major injuries reported by National Grid's personnel involved in the response to Tropical Storm Irene. This points to an excellent overall focus on safety from all levels of the National Grid organization.

[1] NOAA Synoptic History

I. Storm Restoration Deficiencies

a. National Grid underestimated the possible impact from Hurricane Irene to its Rhode Island service territory.

   i. The goal of storm damage prediction is to forecast the amount of damage to the electric system that future weather conditions would create. Determining a gauge of the resources that could be required to restore service is an essential part of the storm management process. Storm prediction is based upon accurate weather forecasts to determine the path and amount of elements that are damaging to the electric system. Furthermore, the breadth and scope of a storm must be evaluated to determine its impact on all customarily relied upon resources, including crew resources. There is little evidence National Grid did any scenario and impact pre-planning.

   ii. National Grid used the weather forecasts from Telvent. National Grid states that the Telvent reports described a possible path for the hurricane that would yield less impact in Rhode Island. The incident classification was reduced to Level 4 (on a scale from 1 to 5) on Friday, August 26 and remained as such until the storm made landfall on Sunday, August 28. It remains unclear why this reduction in the anticipated damage from Irene would have been justified considering the preexisting wet conditions within Rhode Island coupled with the forecast wind intensity. The National

Hurricane Center track and predictions were very accurate and should have guided a much more comprehensive response plan.

iii. Storm tracks from NOAA and other sources were ultimately accurate both on the landfall location and predicted time of landfall within six (6) hours based upon forecasts as early as Tuesday, August 23. National Grid simply failed to use or accurately assess the data and the need for adjustments to its customary methods.

b. National Grid was not prepared to manage widespread customer outages in Rhode Island.

i. From National Grid's Electric Emergency Plan (EEP), a Level 5 Catastrophic Event classification (National Grid's highest) considers an event with greater than 9% of the total customers without power and an anticipated outage duration of greater than 72 hours. The plan's maximum event level was eclipsed by the number of outages created within the region by Irene, for Rhode Island the outages totaled 359,569 interruptions, or 75% of the customers. National Grid's EEP doesn't provide any planning scenarios to prepare for or scale to the challenges created by an incident on the magnitude of Hurricane Irene.

ii. Undoubtedly, as National Grid was quickly inundated with outages and customer calls, it became evident that the storm incident would be widespread with resources spread across multiple fronts. National Grid's EEP doesn't provide any planning scenarios to specifically address the capability needs and resource coordination required to address widespread outages, as occurred with Irene, across Rhode Island.

iii. National Grid decentralized its service restoration on Sunday, August 28, at 6:00 a.m. initially using its office at Melrose Street, Providence and creating a Branch Director for Rhode Island. The postponement in decentralizing the customer service restoration process until the storm was upon the service area created delays in responsibility assignments and resource allocations. Furthermore, given the five (5) days of advance notice of the storm's path, breadth of impact, and projected strength, National Grid should have been better prepared before Rhode Island was impacted.

iv. Rhode Island's restoration area wasn't further localized until Tuesday, August 30. The addition of the office at North Kingstown, RI allowed for more effective management of resources. However, the delay in setting up the additional branch would have been compounded by the need to staff the branch and orient the staff to take over the responsibilities. Again, a lack of prior scenario planning and adequate assessment of readily available information points to a lack of experienced storm response management direction. Simply stated, if you have never been there before you cannot react appropriately in a timely manner. This leads us to conclude that management at all levels did not dictate that adequate scenario planning be performed as part of its preparedness.

c. National Grid underestimated the resources that would be required to efficiently restore service to customers in Rhode Island.

i. The internal resources, for the daily utility operation throughout National Grid's operating territories, especially in Rhode Island were overwhelmed by the damage created by Irene's winds. One of the most compelling questions is why were they not prepared and why was the system not more resilient.

ii. National Grid's contractor assistance resources were initially limited and were delayed in responding. National Grid did secure a block of resources for the New England Region; however these resources were not distributed to Rhode Island until later in the restoration process. The number of line crews able to assist with the restoration process didn't significantly increase until Wednesday, August 31 with some crews diverted to the southern Rhode Island restoration area established Tuesday, August 30.

iii. At the storm's onset National Grid only operated 10 line trucks in Rhode Island; however the storm created 200+ broken poles to be restored. Ultimately, additional crews and resources arrived during various stages of the restoration. However, National Grid gas construction crews were dispatched to assist with digging holes for pole replacements.

iv. National Grid also experienced some difficulty in addressing the number of priority calls from customers and municipalities with locations requiring emergency services stand-by for days. During the restoration, the limited availability of Wires Down and Cut and

Clear resources delayed the resolution of possible safety situations and diverted line construction resources from areas of widespread circuit damage.

v. National Grid's damage appraisal process did not adequately scale to assess damage created by the storm. While the start of the overall damage appraisal process was not delayed after the departure of the storm, damage appraisers were not available for all circuits compounding assessment delays in those areas until later in the restoration. Phase 1 damage assessments were not completed within 24 hours as planned for in National Grid's EEP Plan. Likewise Phase 2 assessments were not completed in the 48 hours as planned.

vi. National Grid had limited success in securing mutual assistance crews. National Grid worked diligently through conference calls and other contacts to secure additional resources. National Grid finally secured a significant block of support near the restoration's conclusion. In our view this was the result of lack of scenario planning, failure to rely on readily available information, lack of prior planning development, and the fact that this group of individuals, though hard working had not experienced a similar event either in reality or through scenario planning.

d. National Grid's initial restoration response and crew staging was not central to the construction efforts in Rhode Island.

i. During the initial stages of the restoration, the additional travel time required of construction crews resulted in significant nonproductive crew-hours. Rhode Island crew staging sites were not established until Tuesday, August 30: one at Twin River in Lincoln and the other at the Warwick campus of Community College of Rhode Island (CCRI).

ii. Later in the restoration, starting with the evening of Friday, September 1, many community related events scheduled for the weekend quickly drained local hotel room availability. National Grid worked diligently to address the situation, however many workers had to finish a hard day of work with a 1 ½ hour bus ride.

e. National Grid's communication of outage information to local government and residents was neither timely nor accurate.

i. National Grid's internal and external IT systems used for outage information experienced intermittent performance issues.

ii. Customers experienced frustration in accessing outage restoration information and updates especially during the first days after the storm. These issues were caused, at least in part, by customer demand on the Outage Demand website in trying to access outage information.

iii. Restoration time estimates provided in some cases would depend on damage assessment updates from the field. However, even when this critical information started coming in, National Grid's internal online systems experienced issues leading to further delays in providing detailed information. This would have directly impacted the ability of National Grid representatives to communicate updates to local government officials.

iv. Undoubtedly, local governments and customers would have experienced frustration in obtaining outage updates with the inaccuracies and lack of available information from National Grid's web, municipal room, and conference calls. This was evident from the National Grid provided municipal storm call transcripts from which there were times that National Grid could not provide updated ETR's or answer questions about when crews would be available in area.

v. National Grid has stated that it is currently reviewing ways to improve its external website, Outage Central, and internal systems.

f. Conclusions

PowerServices and the Division requested an interview process which would have allowed our team to accurately assess the National Grid team's prior experience and scenario planning expertise. Based on National Grid's declining to make the requested individuals available for interviews, combined with all of the facts gathered, we are left with only one logical conclusion. National Grid lacked the experience and prior scenario planning necessary to respond more effectively to the events of Irene. This is disturbing, considering the criticality of the electric infrastructure and power supply to facilitate all other emergency responses to human safety. Emergency management activities and their effectiveness are significantly enhanced by the availability of electric utility service.

J. System Weaknesses or Deficiencies

a. National Grid's electric system experienced structural failures that are inconsistent with the typical performance of similar facilities designed using adequate engineering criteria under a comprehensive maintenance program. The visual review of the broken and downed transmission line poles indicate insufficient engineering design and maintenance.

In addition, since 2005, many utilities with transmission line facilities in proximity to coastal areas have implemented "System Hardening" improvements. With this in mind, it appears that the damaged facilities were not designed to appropriate reliability standards and this deficiency became a major weak link to the grid and consumers served. From the meteorological data provided, the winds presented throughout the system fall far below National Electrical Safety Code (NESC) worst-case conditions to impose stress on transmission facilities. For this geographical area of the state, all transmission and sub-transmission line facilities should be designed and maintained for worst case conditions beyond mere tropical storm wind forces. See *Figure 10* below.

Figure 10: Damage Picture from National Grid's Irene Preparedness Report (Page 3 of 43).

b. National Grid’s electric system experienced line failures that are consistent with issues stemming from insufficient engineering design standards, construction practices, or maintenance and system replacement or rehabilitation standards anticipated by the NESC and extend beyond the transmission system. From the meteorological data and our visual review of the leaning poles with downed conductors, there appears to be indications of inadequacies including: insufficient pole burial depths for soil conditions, lack of engineering consideration of the effect of additional pole attachments, and poorly attached conductors to electric structures. With this in mind, it is obvious the damaged facilities such as those shown in *Figure 11*, were not designed, constructed, and maintained to proper industry standards. Deficiencies in these areas became evident after the storm and ultimately affected the consumers served.

Figure 11: Distribution Damage Grand Ave, Cranston RI, picture from the article: National Grid Learns Lessons from Irene (The Providence Journal; Date: Dec 18, 2011).

c. National Grid needs to review and supplement its distribution engineering practices and standards when designing, maintaining, and upgrading distribution pole structures with attachments. In general, distribution poles are not subject to the loading requirements of extreme wind (NESC Rule 250C) and extreme ice with concurrent wind (NESC Rule 250D) because most distribution lines don't have structures that exceed 60 feet aboveground. Due to this, the NESC district loading requirements of NESC Rule 250B will most always be the governing load case in determining strength parameters of distribution poles.

Vertical loads on a conductor shall include the weight of the conductor plus the weight of any conductors, spacers, or equipment it supports, with the appropriate amount of radial ice, where required by NESC Rule 250.

Horizontal loads shall use the horizontal wind pressure per NESC Rule 250 applied at right angles to the projected area of the conductor and any spacers or equipment supported with the appropriate amount of radial ice, where required by NESC Rule 250. The total load on each conductor shall be the resultant of the vertical load and horizontal load components, calculated at the applicable loading district temperature. The above loads, in addition to any transverse and/or longitudinal loading resulting from wire tension, shall be multiplied by the appropriate load factor for the applicable grade of construction. These loads shall be calculated for all conductors and associated equipment on a pole, including those of communication lines.

In determining the required class of a distribution pole, the appropriate strength factor for the type of pole material and grade of construction shall be applied. Where it is not known the number and type of joint-use attachments that may be added to the pole, conservative design estimates should be made if the likelihood of such attachments is anticipated. Otherwise, pole analyses will need to be performed for each application of joint-use attachment to verify the pole's capability to withstand the additional loads resulting from the communication lines.

3. Recommendations and Storm Restoration Enhancements

Outage Avoidance

a. National Grid needs to evaluate further options to improve its sub-transmission and transmission pole inspection programs. National Grid has an Inspection and Maintenance program for transmission and sub-transmission assets. The transmission program consists of helicopter visual patrols twice per year and infrared patrol once per year. In addition, a ground based visual patrol is scheduled every five (5) years [1]. The sub-transmission program consists of a helicopter visual patrol once per year. PowerServices recommends that all transmission structures be visually inspected annually, and sub-transmission structures should be visually inspected every two years.

1 National Grid- Responses to Division Data Requests- Set 2: Division 2-6

b. National Grid should evaluate the structural loading for all transmission structures based upon the current NESC loading criteria. Analysis should consider the degradation of facilities from aging and additional storm hardening measures such as increased pole classes and storm guying for structures with coastal exposure. Since, National Grid does not utilize a specific hardening program for transmission or sub-transmission structures, all asset replacement and/or maintenance work is identified during periodic inspections based on condition-based assessments driven by the I & M Program [2]. PowerServices recommends these additional analyses and upgrades be integrated into National Grid's existing I & M Program.

2 National Grid- Responses to Division Data Requests- Set 2: Division 2-7

c. National Grid should develop a process for fully documenting the replacement of poles in a major outage event and then conduct a post-storm analysis to correlate the downed poles age, previous condition based on inspection information, and failure cause. This analysis will assist

National Grid in accurately gauging the condition of the distribution and transmission system and its performance in various incident conditions. These findings would be implemented as additional criteria to more effectively guide Inspection and Maintenance (I&M) improvement dollars.

d. National Grid should follow the current National Electrical Safety Code ("NESC") requirement stipulating that structures shall be replaced or rehabilitated when deterioration reduces the structure strength to 2/3 of that required when installed.

e. National Grid's response to Division 2-8 (Engineering and Design) outlines an appropriate Joint-Use Pole "Make Ready" process. Our observation, however, leads us to believe the process described is either not followed by all joint-use parties or the "shared responsibility" process lacks an ultimate responsible party and some deficiencies in strength arise. We recommend National Grid perform a post storm strength assessment on 30 miles of joint-use pole lines, randomly selected, that were involved in line outages, particularly lines in which poles failed or leaned over.

<u>Pre-Storm Planning</u>

Predicting Storm Damage

a. National Grid needs to improve its storm damage prediction processes. Additional weather forecasts should be considered when evaluating future weather conditions to improve accuracy. National Grid should implement a process that better utilizes the outside support of a weather analyst to evaluate forecast conditions and provide guidance whenever expected conditions could warrant an EEP Level 4 or 5 emergency response. During the anticipation phase preceding the storm event, National Grid's interpretation of the storm's relative strength and impact from a change in tracking undershot the event. Furthermore, for hurricanes or tropical storms which provide significant time for planning, National Grid needs complete and adequate scenario planning incorporated into its processes and documentation.

b. Prediction tools should be developed that consider storm damage history, operational capability, and susceptibility to damage to determine approximate crew requirements based upon forecast conditions. The ability of these new processes should also incorporate the ability to scale resources based upon the duration of the event. National Grid's planning and response management ultimately considered a 3-day event restoration window for Hurricane Irene was most likely. This underestimate in preparedness planning undoubtedly created a bottleneck later in the restoration process as additional resources were needed. Furthermore, adequate plans will outline the alternative resources for materials, crews, and support services well outside of the customary area of availability.

Activation of EEP

a. National Grid did initiate its EEP processes preceding the storm event. However, the corporate storm response management team was not fully integrated into the restoration process. National Grid should implement the Strategic Response Team (SRT) as clearly provided for in the EEP process and can be invoked as listed in the new "US Strategic Response Plan" (SRP) initiated in June of 2011.

Mobilization

a. National Grid needs to evaluate and improve its processes in procuring additional restoration resources. During the anticipation phase, National Grid did participate in NEMAG conference calls. However, these activities did not guarantee or establish significant crews for National Grid until well into the restoration process. National Grid needs to establish further mutual aide agreements with various organizations such as NEPPA to take advantage of their 74 member utilities, surrounding cooperation utilities in Vermont, Maine, New Hampshire, New York, and the New York Power Authority. National Grid should also contract with the larger utility contractors in the Southeast and Midwest to be able to place their personnel and equipment on various levels of standby.

b. National Grid has a serious deficiency in digger/derrick line trucks in Rhode Island. One of the reasons is that National Grid probably has not been replacing a suitable number of poles. PowerServices compared the State of Rhode Island to other similar sized utilities. Jacksonville Electric Authority (JEA) in Florida is a similar physical and electric load size to Rhode Island. JEA maintains 26 digger/derrick line trucks compared to the 10 that National Grid had available in Rhode Island before the Irene restoration. Similar to the State of Florida's electric structure hardening requirements, the RIPUC should consider adopting a mandate to have each distribution pole tested on an eight year cycle. The reports from these pole tests will produce a list of danger poles and marginal poles. Danger poles should be changed immediately and marginal poles should be changed within the next twelve months. Because this pole work would be continuing, National Grid should plan to change them with local internal resources. A larger compliment of digger/derrick line trucks will be required to address pole replacements within Rhode Island.

Storm Restoration-Response

Restoration Priority

a. National Grid currently uses a simplistic approach to setting restoration priority. National Grid states that the largest number of customers will receive attention first. The problem with this approach is that it does not maximize the effectiveness of the available labor hours.

b. National Grid already seems to be fairly efficient in their transmission restoration process as demonstrated during the Irene restoration.

c. PowerServices suggests the following priority:

   i. Personnel would be dispatched from their local service areas to outages based on:

      (1) Restoring transmission/sub-transmission

      (2) Restoring substation power supply

      (3) Restoring circuits

      (4) Restoring major taps

(5) Restoring minor taps

(6) Restoring individual customers

Note: This process will naturally limit the effects of cold load pick up suddenly overloading a line section.

ii. The highest priority should be given to electric circuits serving electric loads critical to health, environment, and commerce.

(1) Hospitals, Water Plants, and Sewer Plants

(2) Traffic signals at major intersections, toll booths, guarded railway crossings, and movable bridges.

(3) Industrial Centers, Ports, Commercial Centers, Farms

iii. National Grid should work with local agencies to set up care shelters for critical need customers. The centers should have backup generators with food, water, and oxygen. The first communications before the storm arrives would be to communicate with critical care customers the need to relocate to a shelter.

iv. The first activities after the storm would be to isolate effective areas to be able to get the substations and then circuit main lines back on. The initial phase of storm damage evaluation can take place as experienced crews are dispatched to isolate switches and tap lines. Dispatching construction crews should not wait upon damage assessment but should be a part of damage assessment.

v. Electric system planning should consider this priority list when scheduling rebuilding lines and facilities. The highest priority circuits should be constructed with back up loop feeds to assure these can be restored first.

Damage Assessment

a. An inefficient damage assessment process can be effectively a bottleneck in the storm restoration process. Typically, the main forces of construction crews will not be effectively dispatched until the assessment results are analyzed and processed. National Grid should take additional steps to improve the time required to complete Phase 1 and 2 damage assessments.

   i. Analyze, process map, and evaluate methods that would streamline all areas within the Damage Assessment process.

   ii. Insure that the processes and systems are scalable to manage the volume of information in a major event.

   iii. National Grid needs to increase the frequency of refresher training for damage assessors and wires down personnel to twice per year.

Technology/Communications

a. National Grid should evaluate all technology and communication systems that are currently employed as part of the outage process. National Grid experienced performance issues during Irene that hindered timely and accurate outage information and Estimated Time of Restoration (ETR's) to National Grid employees, local government representatives, and electric customers. Part of this evaluation should include supporting internal and external information delivery from the system incidents during both a centralized outage response and a decentralized response. Technology systems should have access to backup and recovery options that will allow branch divisions to operate during system incidents. During Irene many of the technology issues encountered were from the inability of the centralized systems to handle the scale of the information requests.

Emergency Preparedness Plan

a. National Grid's EEP should be sufficiently comprehensive and specific to use as a handbook during any electric system emergency. Develop a pocket guide that can be distributed to each storm participant. The guide should define the management process, positions, and organization structure used to prepare for, plan, and respond to incident conditions. The objective of the guide would be to give employees specific guidance in a concise format to aid in responding to all sizes and types of events.

b. National Grid should review the response levels in the emergency plans to determine whether to modify or add a response level for an event the severity of Irene or greater. The current EEP's maximum event level was eclipsed by the number of outages created within the region by Irene, for Rhode Island, the outages totaled nearly 360,000 interruptions, approximately 75% of the customers.

c. National Grid needs to implement specific operational plans that consider and address all local offices (branch, wires down, etc), staging sites, and material yards based upon the increased local area restoration efforts. The requirements necessary to adequately operate each type of site needs to be evaluated and addressed as needed. Support logistics, material inventory, operations, and fleet all need to consider worst-case scenarios for dealing with restorations on the scale created by Irene. These plans would be in concert with EEP; however, these specific plans would need to be updated at least quarterly.

d. National Grid's EEP should contain specific scenarios for restoration in Rhode Island. Efficient restoration of distribution outages is best managed by local service areas. The benefit would be that resources that are already in the area and familiar with the area would know that they are assigned to their home area for a storm recovery event. The local service area size should be based on the number of customers and number of circuits that can be reasonably managed in an Irene type outage or severe snow or ice storm. Also, the management team size should be limited by the number of crews they can reasonably manage. In the case of Tropical Storm Irene the Branch Director for Rhode Island was responsible for 78 bucket trucks, ten line trucks, and 378 other vehicles. A single branch office directing the recovery could not possibly dispatch and understand the location and activity of these crews throughout the entire State of Rhode Island. The large number of outage events and the large number of crews would lead to a lot of standby time for the crews and inefficient dispatching. The objective in the local service area management approach is to put as many people as possible working on the various outage incidents that restores service to the greatest numbers of customers the fastest. Manpower in standby or while traveling are not effective in meeting this goal. Therefore, the outage management centers need to be localized to minimize the stand-by time and travel. Pictures of mass truck parks are impressive but are inherently inefficient. Crews must wait in line for supplies, fuel, and work assignments. Construction crews should be placed in the field as quickly as possible. When a crew finished a task they should have been ready and immediately dispatched to the next task. A crew should not have to return to the rallying location except to start in the morning and when finished for the day. The management team is responsible for keeping track of where crews are located in the service area and making efficient decisions as to the best use of the available resources. For example, a crew foreman sees that he can clear a tap line with two minutes work while he is already in the area. The foreman should have the freedom to make such decisions to improve recovery efficiency even though the tap line does not fit in the written priority scheme.

e. National Grid's EEP should make provisions for the entire National Grid service territory to be divided into local service areas sufficiently small that several persons have local knowledge of the streets, feeders, and substations and the following:

    i. Circuit switching locations
    ii. Feeder protective device locations
    iii. Feeder routing
    iv. Familiar with circuit voltage, conductor size and loading characteristics

v. Familiar with weak points such as old and/or small conductor

vi. At least one of these knowledgeable individuals needs to be the local area manager or have someone knowledgeable available to advise the local area manager during the restoration process.

f. The EEP should contain strategies to recover from any problem faced during the emergency. For example: If the communications system fails, how will information be passed to protect employees when a line section is re-energized? When the substation batteries fail what source of power is available to re-energize the system?

g. The EEP should contain precise strategies for facing various scenarios of damage to the electric system including individual major pieces of equipment to various intensities of system damage.

h. The EEP should contain local power company facility maps and contact information.

i. The EEP should contain special safety instructions to be used during the recovery period including LOCK/OUT-TAG/OUT. With numerous instances of lines laying on the ground and multiple crews working on lines the standard rule should be to work behind a visible open point with the immediate system grounded. During the process of re-energizing a line section there is a brief period when the grounds are removed and the protective device or switch used to re-energize the line. Knowledge of where the section being energized feeds is of paramount importance. However, communicating with the crews working in the area to insure that they are in the clear is even more important to protect crews and the public. This process falls under a written LOCK/OUT-TAG/OUT scheme that all personnel involved in the recovery must understand and follow.

j. Tropical Storm Irene involved mass circuit outages. The first step in the distribution system process is to recover and re-energize circuits quickly. Therefore, the first exercise toward restoration should be to travel each main line of each circuit, record the physical damage, and isolate each switch point and protective device tap. The open points need to be marked in such a way to let other repair workers know that the open point is dedicated to future work and not to close it. That way, the main trunk of the feeder can be re-energized when the substation is energized and the main trunk is free of defects.

k. National Grid should create or expand partnerships with local and State emergency managers. To further strengthen these relationships, management-level personnel should be authorized to make operational decisions and work routinely with local and State emergency service agencies. National Grid operational personnel need to make contact with their counterparts in local government public works and transportation agencies. The purpose is to initiate a joint planning process among the utility and public sectors. National Grid should also make every effort to improve communication links with emergency service agencies by integrating the following into the EEP and restoration process.

i. Contact information for local emergency and governmental authorities

ii. National Grid should participate with local authorities with mutual aide support agreements.

iii. A National Grid representative should accompany each local emergency service vehicle throughout the main traffic arteries to insure that the first responders do not face any electrical hazards. When trees are down in streets local governments will be clearing the streets as quickly as possible. By coordinating with the local government, National Grid might use their heavy equipment to clear large trees from power lines saving time and expense in the restoration effort.

iv. National Grid should provide training to local emergency personnel and utility workers to recognize the hazards of a downed power line or a cablevision or phone line.

v. National Grid in concert with the local governments should establish a generator policy so that lines down might not be energized by a generator back feed.

vi. National Grid should cooperate with local authorities in establishing a shelter where at risk residents can have power for medical devices. Thereby, National Grid can direct high risk customers to these shelters while awaiting system recovery.

vii. Lists of local government facilities with critical power needs:

i. Critical traffic intersections

ii. Critical pumping stations (water , sewer, and storm sewer)

iii. Critical government facilities and shelters

Division

1. The Division should encourage and implement the following activities:
    a. Electric utilities in the State of Rhode Island should adopt mutual aide and assistance agreements with utilities in neighboring states including the electric municipal utilities.
    b. In conjunction with the efforts of the Rhode Island Emergency Association (REMA), local governments should make agreements for mutual aide with each other, state department resources, and the private utilities. These parties should coordinate annual incident response drills to verify the effectiveness of these coordinated responses.
    c. Require hourly utility reporting during major system outage events and a final comprehensive report should be filed within 90 days by National Grid similar to the requirements now mandated in the State of Massachusetts.

4. Conclusion

In August 2011, Hurricane Irene caused significant damage and outages across the State of Rhode Island. While power was restored to 359,569 customers over a 9-day period, many residents and local officials were left frustrated with their power supplier, National Grid. Overall, PowerServices found the degree of power interruption to exceed expectations from a tropical storm with the degree of wind speed experienced in Rhode Island. The number of customers impacted combined with the duration of the restoration process are the primary focus of the report's observations and recommendations. During PowerServices' review, multiple issues and challenges were identified in the pre-storm decision-making, securing, and staging mutual aid and contract workers, and response management organization. Concerns and recommendations have also been cited concerning the performance, design, and maintenance of electric system pole structures.

The National Grid Hurricane Irene storm response was evaluated from 12 separate aspects and numerous subcategories.

- Storm Preparedness Plan
- Pre-storm planning
- Pre-storm resource staging
- Management decision process
- Storm tracking
- Comparable utility responses to Irene
- Storm and post storm response
  - Materials
  - Labor
  - Crew availability
  - Dispatch and escort staff
  - Coverage and hours worked
- Outage restoration process and prioritization
- Facility failures

  - Transmission and sub-transmission
  - Distribution
  - Joint-use lines
- National Electrical Safety Code and strength compliance
- Post storm assessments
- Lessons learned evaluations

This assessment was done in the context of this specific storm and the unique challenges that a hurricane presents, particularly when it travels up the coastline versus making landfall and moving inland, only affecting a few states and utilities. Irene was unique due to its path and the fact it impacted numerous electric utilities along the East Coast across several states. The electric utility industry as a whole has created a mutual aide working relationship among the utilities and their contractors, which customarily allows for a rapid response from many resources during a major storm event. With all the superb benefits of such a response scheme across the electric utility industry, it has one unavoidable deficiency. That deficiency is its limitation to provide adequate and rapid storm response when a storm is widespread and impacts many states and regions, as occurred with Hurricane Irene. Therefore, the last areas impacted by Hurricane Irene were unable to receive rapid assistance from the customary surrounding areas because the utilities in those areas were already using all of the available resources for their own outage restoration processes. During times of limited resource availability is when efficient emergency planning is vital in limiting the impact to customer service. National Grid should have recognized much earlier that its generally available mutual aide resources from other utilities and contractors would simply not be immediately available, as customarily relied upon.

Since ice and snow storms, not hurricanes, are the more prevalent major storm events which National Grid storm response processes deal with, it failed to recognize and have a Storm Response Immediate Contingency Plan in place to initiate acquisition of resources outside of the customary area of available resources. Simply stated, utilities are going to absorb nearly all readily available, geographically close, resources during their collective storm responses, which in the case of Hurricane Irene began days before Rhode Island. This meant National Grid was going to either have to wait for outside assistance, causing response delays, or it needed to mobilize resources from well outside the impacted areas and the adjacent regions first responding to utilities south of Rhode Island.

Section 3 contains the detailed discussion of our recommendations. PowerServices recommends National Grid initiate several actions intended to address the deficiencies in its response performance prior to and during the August 2011 Tropical Storm Irene event. Our recommendations are categorized in a number of major areas including:

1. EEP expansion to include scenario planning
2. Transmission and distribution line strength evaluations
3. Implementation of a local assessment and restoration control process
4. Pre-Storm planning and mobilization
5. System restoration processes and improvements

The Electric Emergency Plan as it exists is simply too generic and non-specific to serve as an adequate tool for major regional or east coast storm response actions. Report sections we address in detail are observations and identified deficiencies on planning. National Grid should revamp its New England Electric Emergency Plan (EEP) through a comprehensive internal process based on the lessons learned from recent storms and the detailed observations throughout this report. This revision and expansion of the EEP should specifically outline when and how to implement the Strategic Response Team (SRT) while melding in the U.S. Strategic Response Plan of June 2011 guidelines. Furthermore, the FEMA Incident Command System (ICS) model utilization in the EEP should incorporate very detailed specifics to provide:

- Information and intelligence management
- Manageable span of control (local service units)
- Incident action planning
- Incident facilities and locations
- Establishment and transfer of command
- Comprehensive resource management

As seasoned utility staff continues to retire, a more comprehensive scenario planning and training process is required. Individuals or a team cannot be expected to respond efficiently or effectively if they have not been previously exposed to the same event and circumstances, whether in actual events or simulated events. Major storm scenario planning, lessons learned, and team training are all part of both developing a comprehensive EEP and response efficiency level. The EEP must integrate an enhanced predictive model and data assessment with the pre-planned event response scenarios.

The winds encountered in Rhode Island should not have caused transmission structure failures or caused the degree of distribution pole failure or line distortion identified. Our observations of structure failures, including evaluation of National Grid's Data Responses, lead us to make many recommendations related to transmission and distribution line strength requirements. We believe, contrary to some of the general responses to Data Request No. 2, there are design and strength issues with structures. Fifty miles per hour (mph) winds should not fail transmission structures which are designed, constructed, and maintained to adequate standards. National Grid's responses and calculations indicated the structure that failed would not be overloaded during a 90 mph extreme wind loading, and yet it did fail, causing a significant number of customer outages. In addition, National Grid's response to Division 2-8 outlines an appropriate Joint-Use Pole "Make Ready" process. Our observation, however, lead us to believe the process described is either not followed by all joint-use parties or the "shared responsibility" process lacks an ultimate responsible party and some deficiencies in strength arise.

The initial storm management organization established 3 service area branches which were all outside of Rhode Island. We find the lack of local service units and control is an impediment to the most accurate assessment of damage and to the efficient response for the restoration process. National Grid should implement, within its storm response process, a specific decentralized storm management organization which effectively limits the span of control to a manageable area.

Throughout the report we have made the distinction between the pre-storm activities, system strength and resiliency and the post storm efforts. Although we have some organizational post storm recommendations they primarily focus on what should have existed in the pre-storm process. The National Grid employees, after the storm passed, put forth a tremendous effort in restoring power even under the difficult circumstances of dealing with the delays in getting outside assistance and the identified deficiencies of the overall planning process.

Our assessment and recommendations should lead to one final question that should be answered. National Grid, as part of the reliability enhancement process driven by the Division's 2000 Reliability Assessments, implemented a "Storm Hardening" program. National Grid has spent substantial dollars on that program and its continuation through the ISR Plan process on inspection and maintenance and reliability related projects. Given the efforts it reports to the Division and Commission and the dollars expended on reliability and storm hardening, the overriding question from this storm that should be addressed by National Grid is: "Why did the system not perform better under a tropical storm event with relatively low wind speeds?"

5. Appendices

Appendix A - Table of Utility Outage Response Comparisons

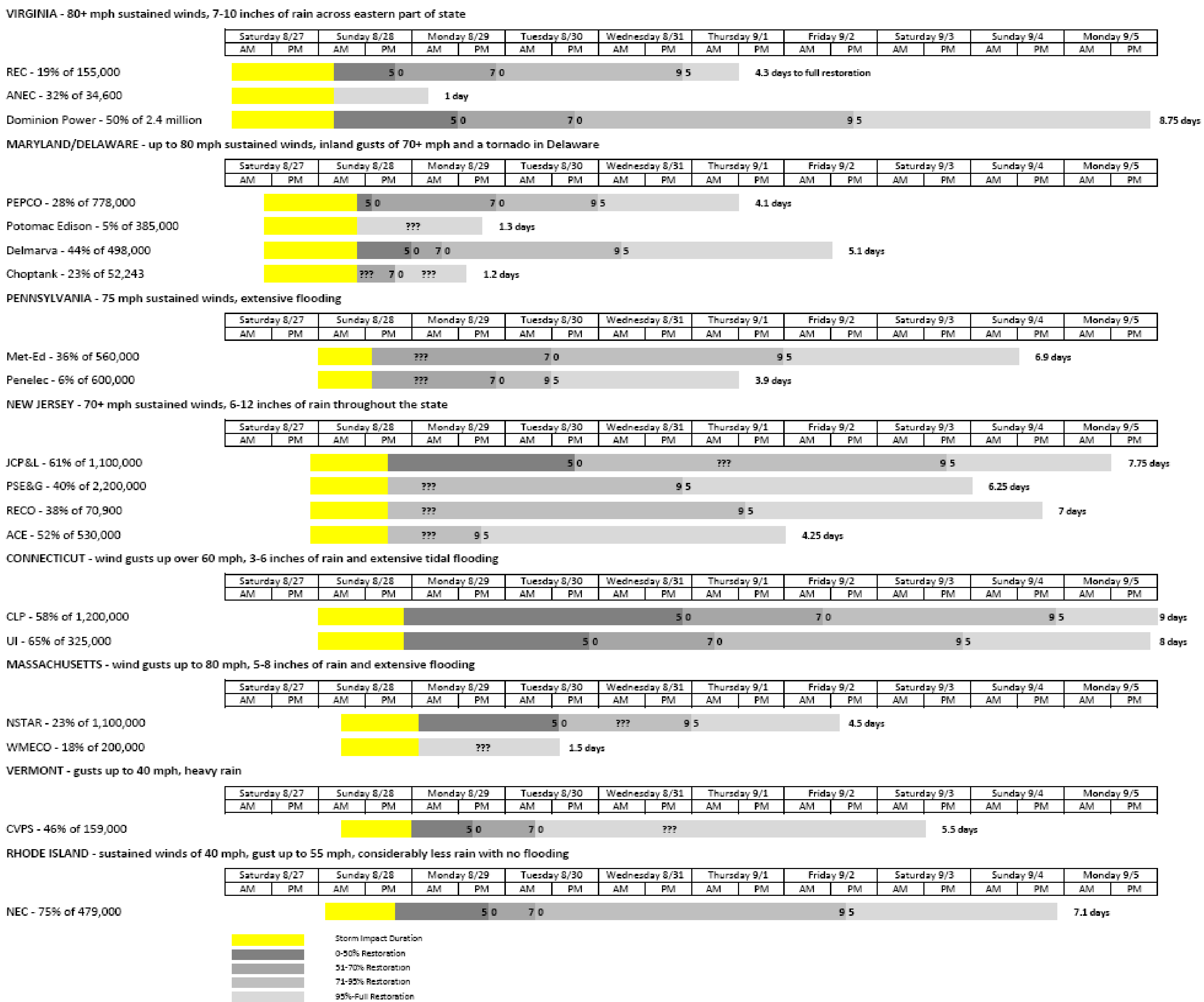
Appendix B - Maps of National Grid Outage Areas

Appendix C - List of Outside Resources Mobilized

Appendix A

Table of Utility Outage Response Comparisons

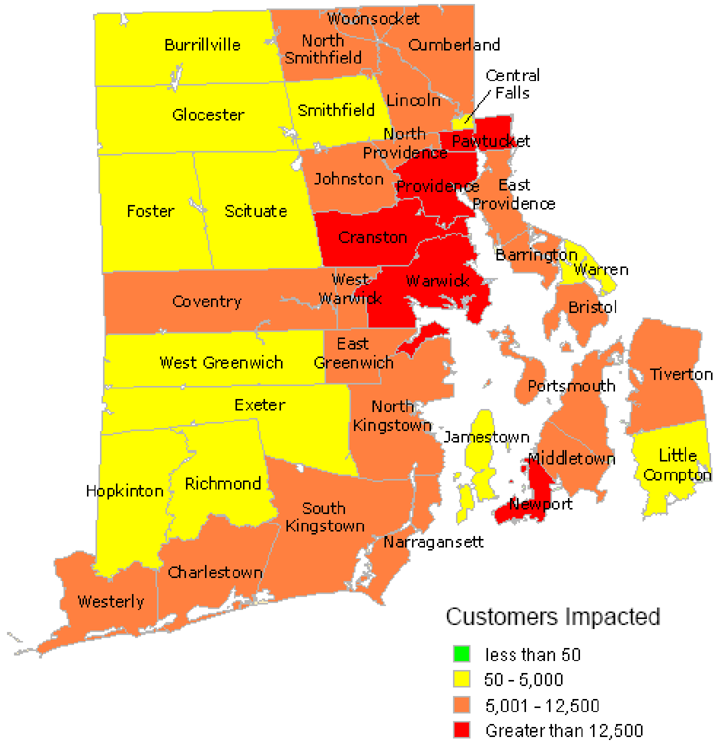
Hurricane Irene Affected Customers - Percent Restored Over Time (August 27, 2011 - September 5, 2011)



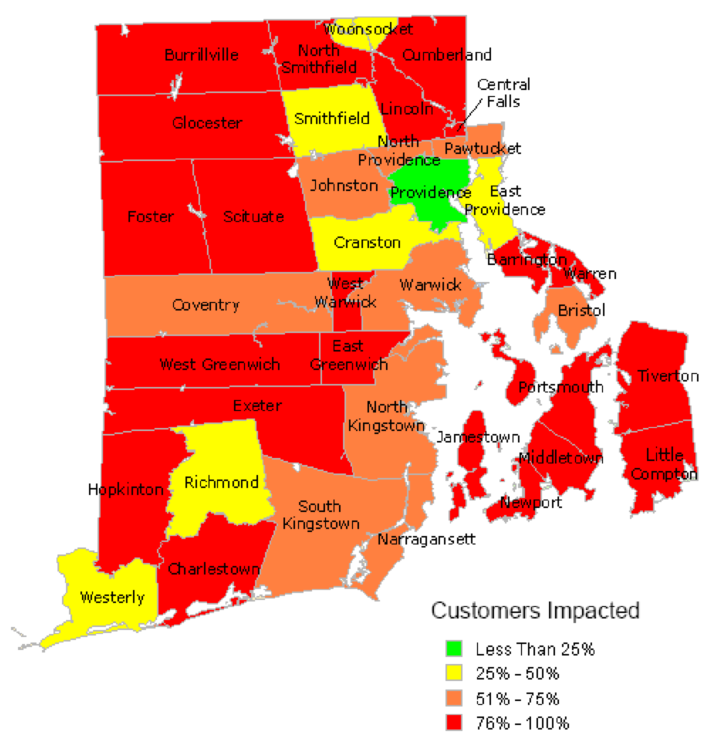
Appendix B

Maps of National Grid Outage Areas

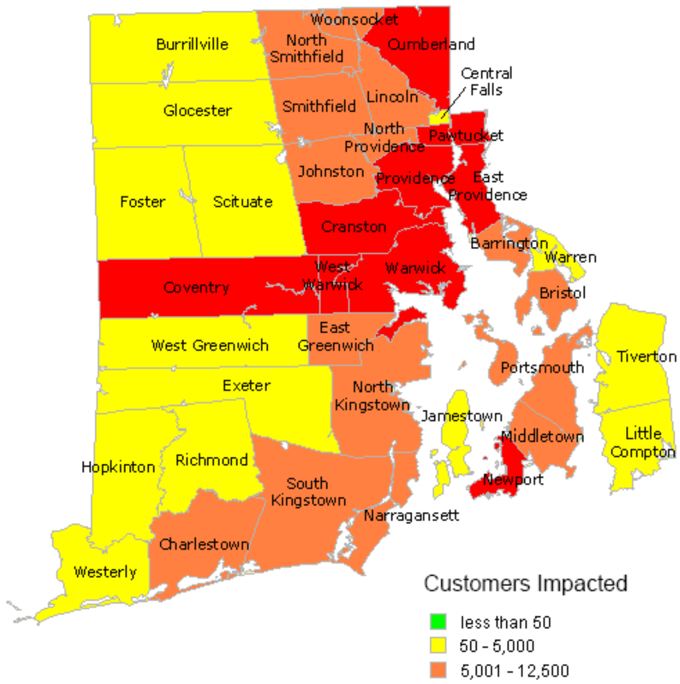
Hurricane Irene Rhode Island Peak
8/28 03:05 pm



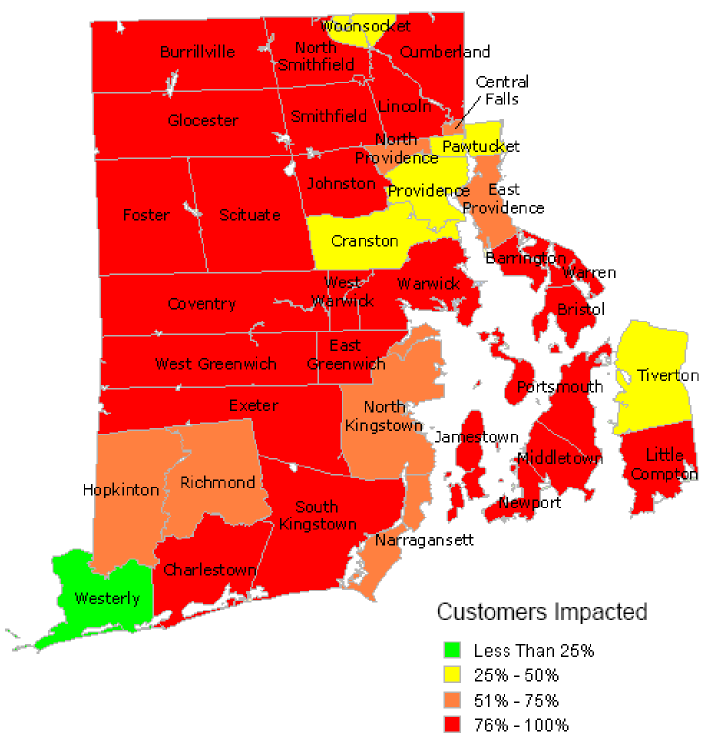
Hurricane Irene Rhode Island Peak
8/28 03:05 pm



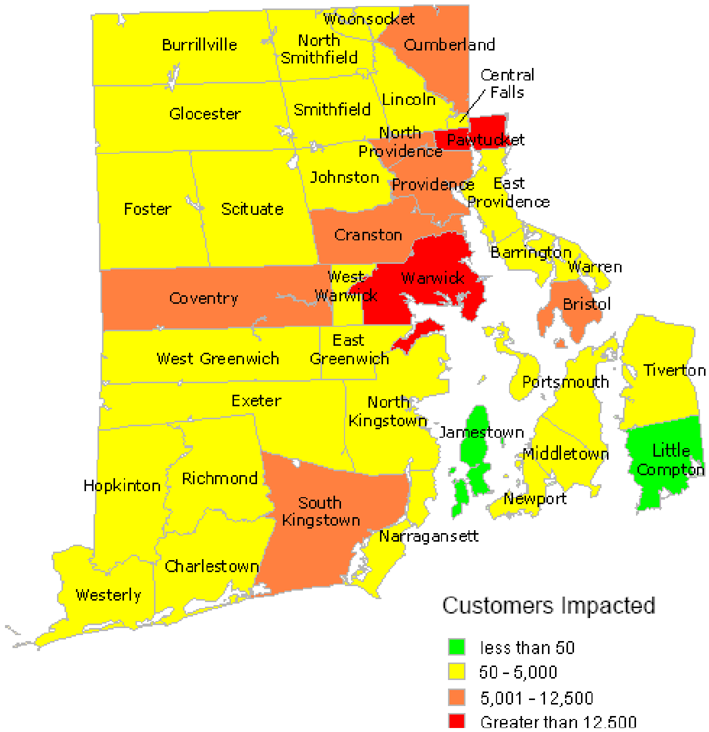
Hurricane Irene Rhode Island Outages
8/28 9:20 pm



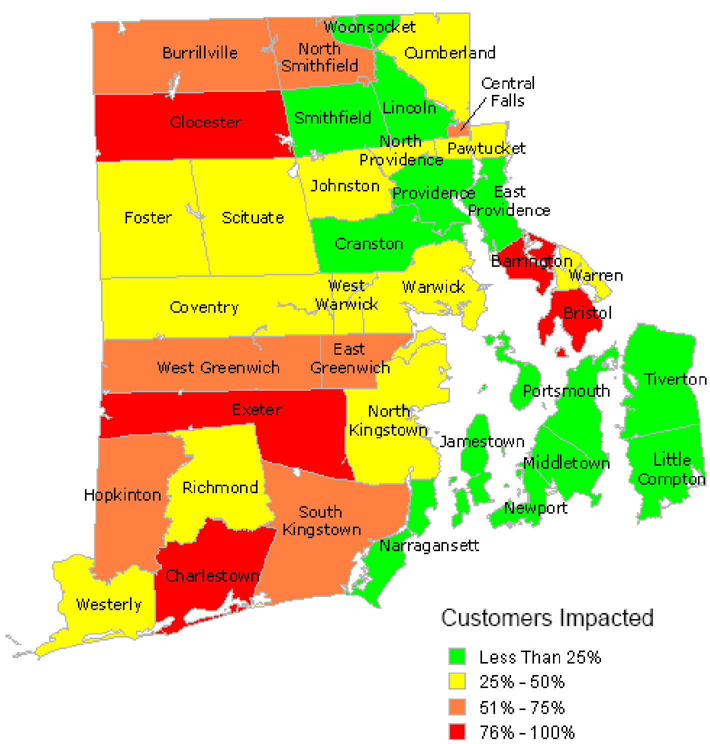
Hurricane Irene Rhode Island Outages
8/28 9:20 pm



Hurricane Irene Rhode Island Outages
8/30 7:57 am

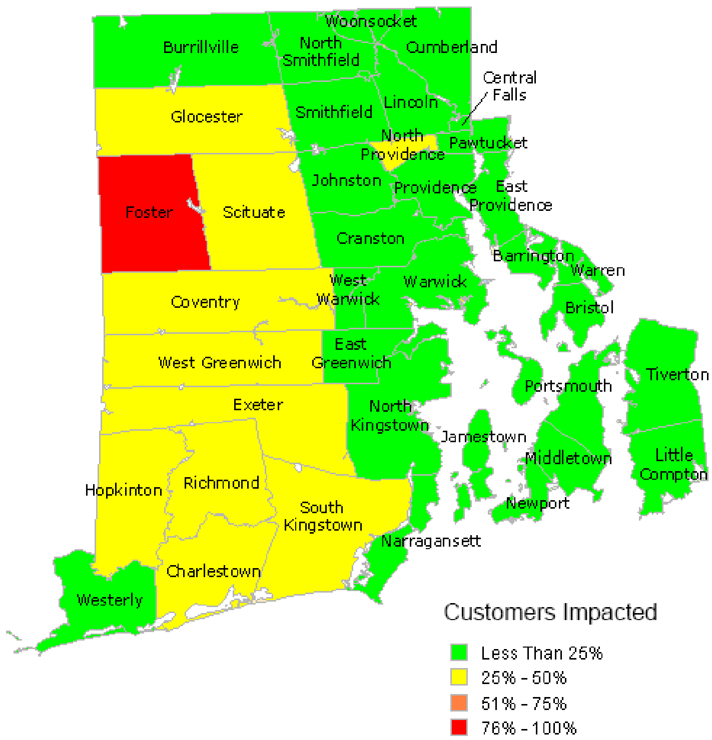


Hurricane Irene Rhode Island Outages
8/30 7:57 am

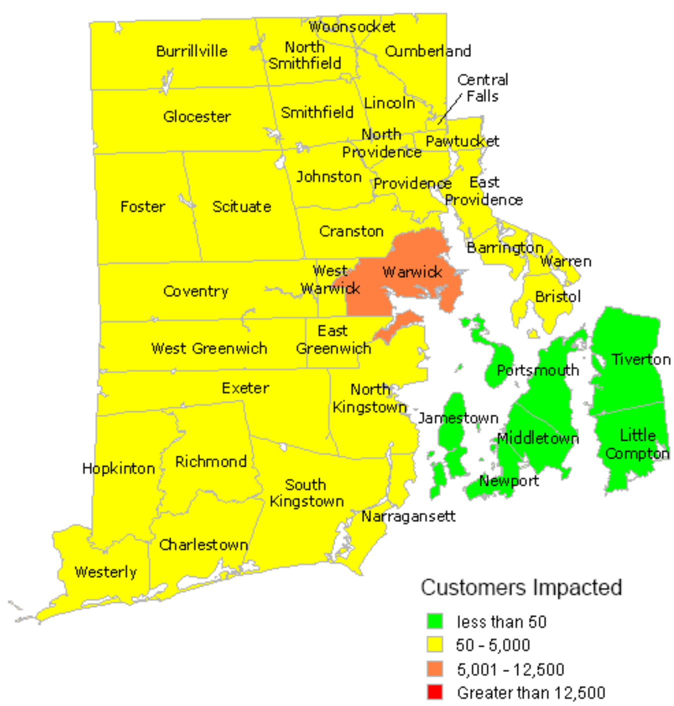


Power Services
Engineering & Management Services

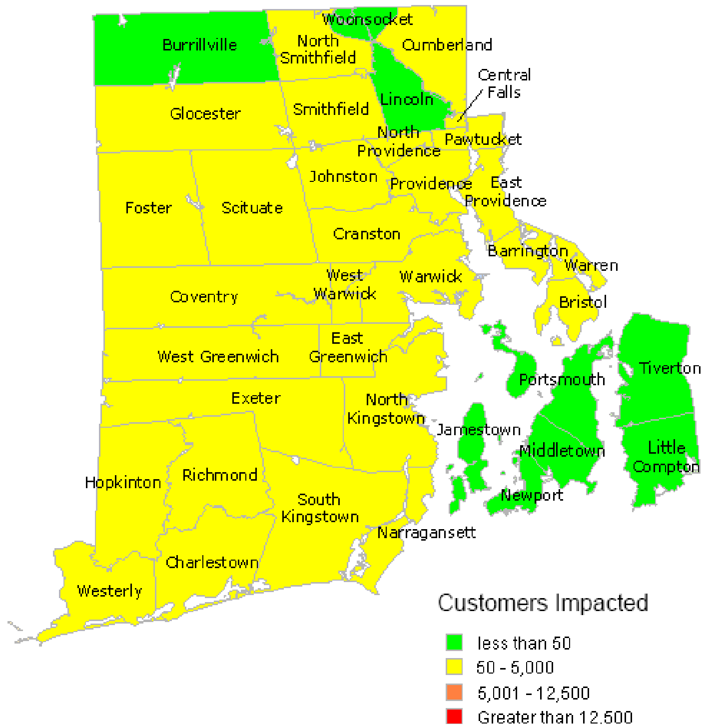
Hurricane Irene Rhode Island Outages
9/1 7:52 am



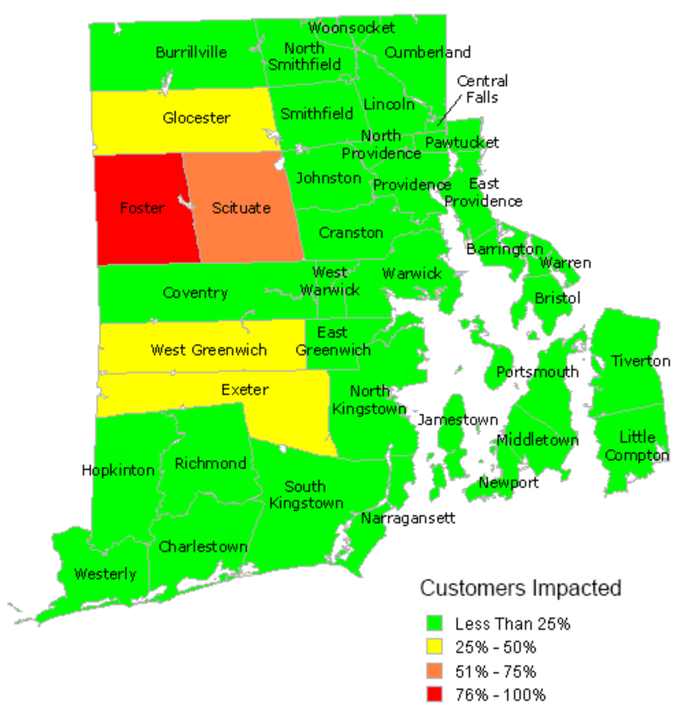
Hurricane Irene Rhode Island Outages
9/1 7:52 am



Hurricane Irene Rhode Island Outages
9/2 7:40 pm



Hurricane Irene Rhode Island Outages
9/2 7:40 pm



Appendix C

List of Outside Resources Mobilized

Hurricane Irene - Rhode Island Resources

	Date	Time		
	2011 08 29			
Data	600	1200	1800	2400
Number of Company Line Crews		61	57	56
Number of Company Tree Crews		-	-	-
Number of Company Wire Down Personnel		83	116	59
Number of Company Damage Appraiser Personnel		65	65	15
Number of Company Substation/Transmission Personnel		51	51	-
Total Company	-	**260**	**289**	**130**
Number of Contractor Line Crews		80	48	-
Number of Contractor Tree Crews		143	143	-
Number of Contractor Wire Down Personnel		-	15	15
Number of Contractor Damage Appraiser Personnel		-	-	-
Number of Contractor Substation/Transmission Personnel		141	141	-
Total Contractor	-	**364**	**347**	**15**
Number of In-State Mutual Aid Line Crews		-	-	-
Number of In-State Mutual Aid Tree Crews		-	-	-
Number of In-State Mutual Aid Wire Down Personnel		-	-	-
Number of In-State Mutual Aid Damage Appraiser Personnel		-	-	-
In-State Mutual Aid Substation/Transmission Personnel		-	-	-
Total In-State Mutual Aid	-	-	-	-
Number of Out-of-State Mutual Aid Line Crews		-	-	-
Number of Out-of-State Mutual Aid Tree Crews		-	-	-
Number of Out-of-State Mutual Aid Wire Down Personnel		-	-	-
Number of Out-of-State Mutual Aid Damage Appraiser Personnel		-	-	-
Out-of- State Mutual Aid Substation/Transmission Personnel		-	-	-
Total Out-of-State Mutual Aid	-	-	-	-
Total # of Crews and Personnel Working		**624**	**636**	**145**
Sum of Number of Company Support Personnel Used		95	118	54

Hurricane Irene - Rhode Island Resources

	Date	Time		
	2011 08 30			
Data	600	1200	1800	2400
Number of Company Line Crews	65	71	64	19
Number of Company Tree Crews	-	-	-	-
Number of Company Wire Down Personnel	113	157	162	78
Number of Company Damage Appraiser Personnel	114	97	48	25
Number of Company Substation/Transmission Personnel	51	99	99	-
Total Company	**343**	**424**	**373**	**122**
Number of Contractor Line Crews	83	81	81	-
Number of Contractor Tree Crews	143	160	177	7
Number of Contractor Wire Down Personnel	15	13	26	10
Number of Contractor Damage Appraiser Personnel	-	-	49	-
Number of Contractor Substation/Transmission Personnel	141	219	219	-
Total Contractor	**382**	**473**	**552**	**17**
Number of In-State Mutual Aid Line Crews	-	-	-	-
Number of In-State Mutual Aid Tree Crews	-	-	-	-
Number of In-State Mutual Aid Wire Down Personnel	-	-	-	-
Number of In-State Mutual Aid Damage Appraiser Personnel	-	-	-	-
In-State Mutual Aid Substation/Transmission Personnel	-	-	-	-
Total In-State Mutual Aid	**-**	**-**	**-**	**-**
Number of Out-of-State Mutual Aid Line Crews	-	-	-	-
Number of Out-of-State Mutual Aid Tree Crews	-	-	-	-
Number of Out-of-State Mutual Aid Wire Down Personnel	-	-	-	-
Number of Out-of-State Mutual Aid Damage Appraiser Personnel	-	-	-	-
Out-of- State Mutual Aid Substation/Transmission Personnel	-	-	-	-
Total Out-of-State Mutual Aid	**-**	**-**	**-**	**-**
Total # of Crews and Personnel Working	**725**	**897**	**925**	**139**
Sum of Number of Company Support Personnel Used	118	124	126	60

Hurricane Irene - Rhode Island Resources

	Date	Time			
	2011 08 31				
Data	600	900	1200	1800	2400
Number of Company Line Crews	61	61	62	73	21
Number of Company Tree Crews	-	-	-	-	-
Number of Company Wire Down Personnel	142	145	160	298	160
Number of Company Damage Appraiser Personnel	48	46	47	52	25
Number of Company Substation/Transmission Personnel	99	95	95	95	-
Total Company	**350**	**347**	**364**	**518**	**206**
Number of Contractor Line Crews	81	76	149	149	-
Number of Contractor Tree Crews	177	176	176	175	-
Number of Contractor Wire Down Personnel	26	26	34	34	36
Number of Contractor Damage Appraiser Personnel	49	75	75	45	-
Number of Contractor Substation/Transmission Personnel	219	204	204	213	-
Total Contractor	**552**	**557**	**638**	**616**	**36**
Number of In-State Mutual Aid Line Crews	-	-	-	-	-
Number of In-State Mutual Aid Tree Crews	-	-	-	-	-
Number of In-State Mutual Aid Wire Down Personnel	-	-	-	-	-
Number of In-State Mutual Aid Damage Appraiser Personnel	-	-	-	-	-
In-State Mutual Aid Substation/Transmission Personnel	-	-	-	-	-
Total In-State Mutual Aid	-	-	-	-	-
Number of Out-of-State Mutual Aid Line Crews	-	7	7	7	-
Number of Out-of-State Mutual Aid Tree Crews	-	-	-	-	-
Number of Out-of-State Mutual Aid Wire Down Personnel	-	-	-	-	-
Number of Out-of-State Mutual Aid Damage Appraiser Personnel	-	-	-	-	-
Out-of- State Mutual Aid Substation/Transmission Personnel	-	-	-	-	-
Total Out-of-State Mutual Aid	-	**7**	**7**	**7**	-
Total # of Crews and Personnel Working	**902**	**911**	**1,009**	**1,141**	**242**
Sum of Number of Company Support Personnel Used	126	129	127	132	60

Hurricane Irene - Rhode Island Resources

	Date	Time			
	2011 09 01				
Data	600	900	1200	1800	2400
Number of Company Line Crews	75	77	75	83	21
Number of Company Tree Crews	-	-	-	-	-
Number of Company Wire Down Personnel	217	217	352	352	171
Number of Company Damage Appraiser Personnel	51	52	54	66	25
Number of Company Substation/Transmission Personnel	55	55	55	68	-
Total Company	**398**	**401**	**536**	**569**	**217**
Number of Contractor Line Crews	182	200	182	174	-
Number of Contractor Tree Crews	175	182	182	173	-
Number of Contractor Wire Down Personnel	62	62	86	86	36
Number of Contractor Damage Appraiser Personnel	34	34	20	8	-
Number of Contractor Substation/Transmission Personnel	228	38	38	40	-
Total Contractor	**681**	**516**	**508**	**481**	**36**
Number of In-State Mutual Aid Line Crews	-	-	-	-	-
Number of In-State Mutual Aid Tree Crews	-	-	-	-	-
Number of In-State Mutual Aid Wire Down Personnel	-	-	-	-	-
Number of In-State Mutual Aid Damage Appraiser Personnel	-	-	-	-	-
In-State Mutual Aid Substation/Transmission Personnel	-	-	-	-	-
Total In-State Mutual Aid	-	-	-	-	-
Number of Out-of-State Mutual Aid Line Crews	18	18	18	18	-
Number of Out-of-State Mutual Aid Tree Crews	-	-	-	-	-
Number of Out-of-State Mutual Aid Wire Down Personnel	-	-	-	-	-
Number of Out-of-State Mutual Aid Damage Appraiser Personnel	-	-	-	-	-
Out-of- State Mutual Aid Substation/Transmission Personnel	-	-	-	-	-
Total Out-of-State Mutual Aid	**18**	**18**	**18**	**18**	**-**
Total # of Crews and Personnel Working	**1,097**	**935**	**1,062**	**1,068**	**253**
Sum of Number of Company Support Personnel Used	132	132	145	146	60

Power Services
Engineering & Management Services

Hurricane Irene - Rhode Island Resources

	Date Time				
	2011 09 02				
Data	600	900	1200	1800	2400
Number of Company Line Crews	88	88	89	79	21
Number of Company Tree Crews	-	-	-	-	-
Number of Company Wire Down Personnel	294	299	299	312	98
Number of Company Damage Appraiser Personnel	66	66	65	65	7
Number of Company Substation/Transmission Personnel	68	68	68	68	-
Total Company	**516**	**521**	**521**	**524**	**126**
Number of Contractor Line Crews	174	174	175	175	-
Number of Contractor Tree Crews	173	173	173	173	-
Number of Contractor Wire Down Personnel	86	86	86	86	-
Number of Contractor Damage Appraiser Personnel	8	8	8	8	-
Number of Contractor Substation/Transmission Personnel	40	40	40	40	-
Total Contractor	**481**	**481**	**482**	**482**	-
Number of In-State Mutual Aid Line Crews	-	-	-	-	-
Number of In-State Mutual Aid Tree Crews	-	-	-	-	-
Number of In-State Mutual Aid Wire Down Personnel	-	-	-	-	-
Number of In-State Mutual Aid Damage Appraiser Personnel	-	-	-	-	-
In-State Mutual Aid Substation/Transmission Personnel	-	-	-	-	-
Total In-State Mutual Aid	-	-	-	-	-
Number of Out-of-State Mutual Aid Line Crews	18	18	18	18	-
Number of Out-of-State Mutual Aid Tree Crews	-	-	-	-	-
Number of Out-of-State Mutual Aid Wire Down Personnel	-	-	-	-	-
Number of Out-of-State Mutual Aid Damage Appraiser Personnel	-	-	-	-	-
Out-of- State Mutual Aid Substation/Transmission Personnel	-	-	-	-	-
Total Out-of-State Mutual Aid	**18**	**18**	**18**	**18**	-
Total # of Crews and Personnel Working	**1,015**	**1,020**	**1,021**	**1,024**	**126**
Sum of Number of Company Support Personnel Used	146	150	150	150	60

Power Services
Engineering & Management Services

Hurricane Irene - Rhode Island Resources

	Date Time				
	2011 09 03				
Data	600	900	1200	1800	2400
Number of Company Line Crews	81	81	92	92	21
Number of Company Tree Crews	-	-	-	-	-
Number of Company Wire Down Personnel	155	111	111	111	-
Number of Company Damage Appraiser Personnel	50	50	53	53	7
Number of Company Substation/Transmission Personnel	68	68	68	68	-
Total Company	**354**	**310**	**324**	**324**	**28**
Number of Contractor Line Crews	230	186	201	152	-
Number of Contractor Tree Crews	173	81	81	69	-
Number of Contractor Wire Down Personnel	24	24	24	24	-
Number of Contractor Damage Appraiser Personnel	-	-	-	-	-
Number of Contractor Substation/Transmission Personnel	40	-	-	-	-
Total Contractor	**467**	**291**	**306**	**245**	-
Number of In-State Mutual Aid Line Crews	-	-	-	-	-
Number of In-State Mutual Aid Tree Crews	-	-	-	-	-
Number of In-State Mutual Aid Wire Down Personnel	-	-	-	-	-
Number of In-State Mutual Aid Damage Appraiser Personnel	-	-	-	-	-
In-State Mutual Aid Substation/Transmission Personnel	-	-	-	-	-
Total In-State Mutual Aid	-	-	-	-	-
Number of Out-of-State Mutual Aid Line Crews	18	62	95	95	-
Number of Out-of-State Mutual Aid Tree Crews	-	-	-	-	-
Number of Out-of-State Mutual Aid Wire Down Personnel	-	-	-	-	-
Number of Out-of-State Mutual Aid Damage Appraiser Personnel	-	-	-	-	-
Out-of- State Mutual Aid Substation/Transmission Personnel	-	-	-	-	-
Total Out-of-State Mutual Aid	**18**	**62**	**95**	**95**	-
Total # of Crews and Personnel Working	**839**	**663**	**725**	**664**	**28**
Sum of Number of Company Support Personnel Used	138	137	122	121	41

Hurricane Irene - Rhode Island Resources

	Date Time				
	2011 09 04				
Data	600	900	1200	1800	2400
Number of Company Line Crews	92	90	98	18	18
Number of Company Tree Crews	-	-	-	-	-
Number of Company Wire Down Personnel	50	-	-	-	-
Number of Company Damage Appraiser Personnel	53	-	-	-	-
Number of Company Substation/Transmission Personnel	-	-	-	-	-
Total Company	**195**	**90**	**98**	**18**	**18**
Number of Contractor Line Crews	152	242	242	20	-
Number of Contractor Tree Crews	69	37	37	-	-
Number of Contractor Wire Down Personnel	-	-	-	-	-
Number of Contractor Damage Appraiser Personnel	-	-	-	-	-
Number of Contractor Substation/Transmission Personnel	-	-	-	-	-
Total Contractor	**221**	**279**	**279**	**20**	-
Number of In-State Mutual Aid Line Crews	-	-	-	-	-
Number of In-State Mutual Aid Tree Crews	-	-	-	-	-
Number of In-State Mutual Aid Wire Down Personnel	-	-	-	-	-
Number of In-State Mutual Aid Damage Appraiser Personnel	-	-	-	-	-
In-State Mutual Aid Substation/Transmission Personnel	-	-	-	-	-
Total In-State Mutual Aid	-	-	-	-	-
Number of Out-of-State Mutual Aid Line Crews	95	95	95	-	-
Number of Out-of-State Mutual Aid Tree Crews	-	-	-	-	-
Number of Out-of-State Mutual Aid Wire Down Personnel	-	-	-	-	-
Number of Out-of-State Mutual Aid Damage Appraiser Personnel	-	-	-	-	-
Out-of- State Mutual Aid Substation/Transmission Personnel	-	-	-	-	-
Total Out-of-State Mutual Aid	**95**	**95**	**95**	-	-
Total # of Crews and Personnel Working	**511**	**464**	**472**	**38**	**18**
Sum of Number of Company Support Personnel Used	69	61	53	10	4