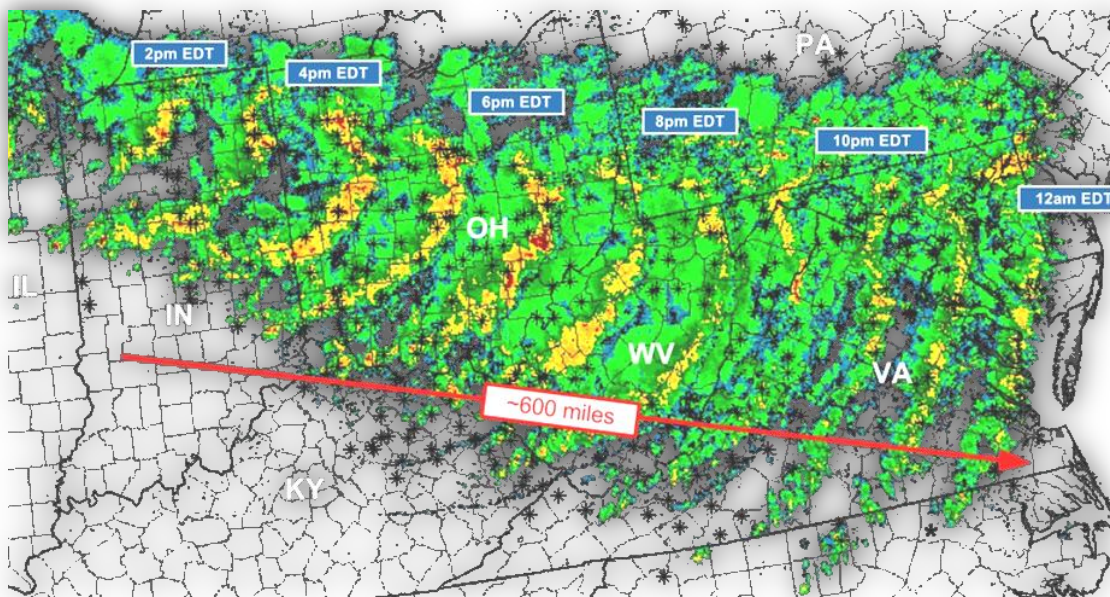


A Review of Power Outages and Restoration Following the June 2012 Derecho



Infrastructure Security and Energy Restoration
Office of Electricity Delivery and Energy Reliability
U.S. Department of Energy



August 2012

For Further Information

This report was prepared by the Office of Electricity Delivery and Energy Reliability under the direction of Patricia Hoffman, Assistant Secretary, and William Bryan, Deputy Assistant Secretary.

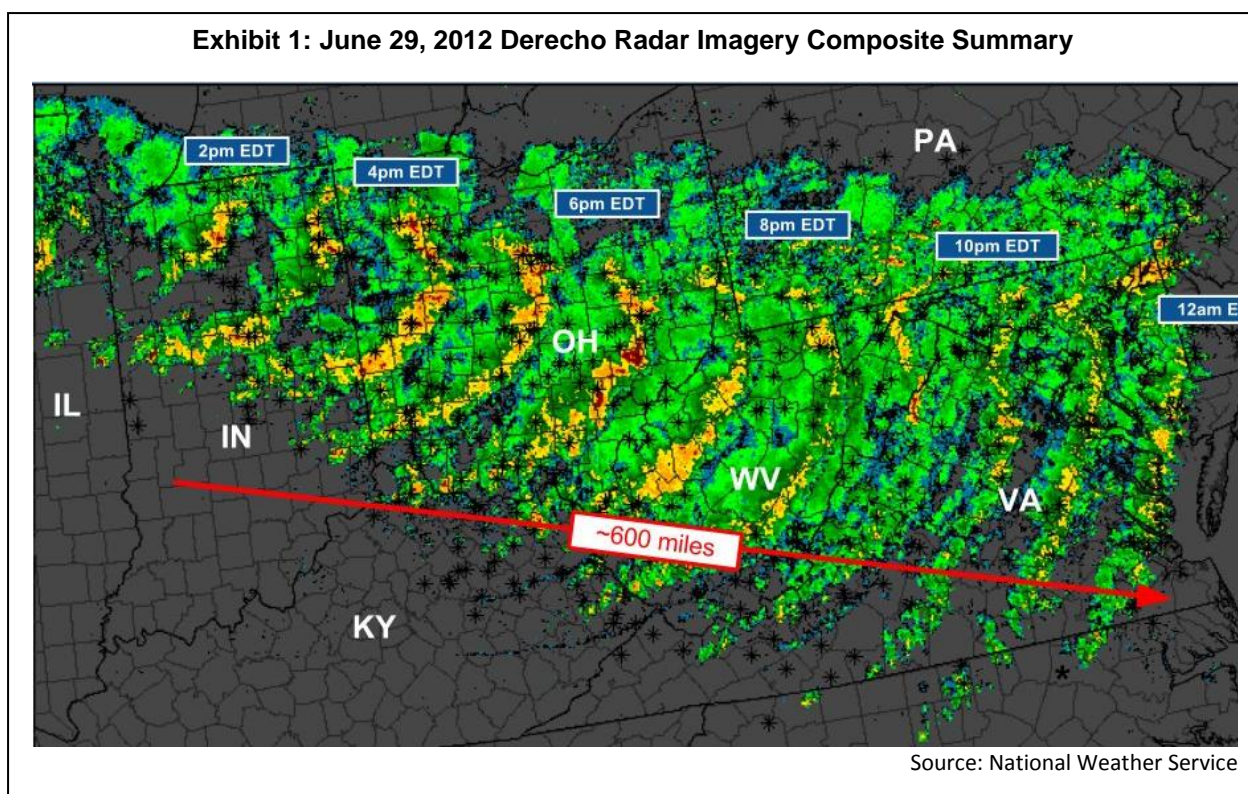
Specific questions about this report may be directed to Alice Lippert, Senior Technical Advisor (alice.lippert@hq.doe.gov).

(Cover image from the National Weather Service)

Background

On June 29, 2012, a major storm system known as a derecho (“deh-REY-cho”) formed and moved across Illinois through the Ohio Valley and Mid-Atlantic States, travelling roughly 600 miles in about 10 hours.¹ During the event, the National Weather Service received over 800 preliminary thunderstorm wind reports with peak wind gusts ranging from 80-100 miles per hour.² Exhibit 1 highlights the 2012 Derecho timeline. The morning after the event, electric utilities, cooperatives, and municipalities reported approximately 4.2 million customers without power across 11 States and the District of Columbia.³ Restoration efforts in many cases took 7 to 10 days and were complicated by several factors, which are discussed in this report.

The U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability (OE), Infrastructure Security and Energy Restoration Division (ISER) publishes situation reports during energy emergencies and analyses of past energy emergency events to provide information to Federal, State, and local governments as well as the public. Due to the unique nature of this storm compared to traditional summer seasonal storms and the extent of physical damage caused, ISER developed this report to assess whether the restoration period from the 2012 Derecho was consistent with other major storms and, if not, what caused the differences in restoration times.



¹ “Historic ‘Derecho’ Severe Wind Event Storms across the Midwest and Mid-Atlantic on June 29, 2012. NOAA Web site. http://www.erh.noaa.gov/rnk/events/2012/Jun29_derecho/summary.php (July 16, 2012).

² Ibid.

³ The outage estimate is based on the highest number of customers without power reported as of 9 a.m., June 30 2012, in OE/ISER’s Ohio Valley & Mid-Atlantic Summer Storm Situation Report #1. This estimate has been adjusted to include outage reports from New Jersey utilities, Ohio cooperatives, and Virginia cooperatives that were received after June 30.

Analysis Framework

This report compares the 2012 Derecho to severe weather events that occurred in the Ohio Valley and Mid-Atlantic regions from the mid-April through October time period over the past five years. Individual States included in each region are presented in the exhibit below.

Ohio Valley	Mid-Atlantic
Illinois	Delaware
Indiana	District of Columbia
Kentucky	Maryland
Ohio	New Jersey
West Virginia	North Carolina
	Pennsylvania
	Virginia

This report relies on data and information from *Situation Reports* and the *Energy Assurance Daily* published by OE/ISER, storm histories and forecasting as reported by the National Oceanic and Atmospheric Administration (NOAA), individual utility Web sites and press releases, State emergency management reports, and other reference material as cited.

Comparison of Storms and Power Outages

OE/ISER compared the 2012 Derecho with five other spring and summer storms from 2007 through 2011 that caused large scale power outages in the Ohio Valley and Mid-Atlantic regions. Details regarding these storms, including the date, region affected, and the highest number of customers reported without power, are summarized in Exhibit 3.

Exhibit 3: Spring and Summer Storms Impacting the Ohio Valley and Mid-Atlantic Regions

Storm Name/Type	Date	Region	Highest Outage Report
Wind Storm	April 2007	Mid-Atlantic	1,181,314
Summer Storm	June 2008	Mid-Atlantic	781,955
Hurricane Ike	September 2008	Ohio Valley	1,555,400
Summer Storm	July 2011	Ohio Valley	828,144
Hurricane Irene	August 2011	Mid-Atlantic	3,250,803
Derecho	June 2012	Mid-Atlantic & Ohio Valley	4,226,962 ⁴

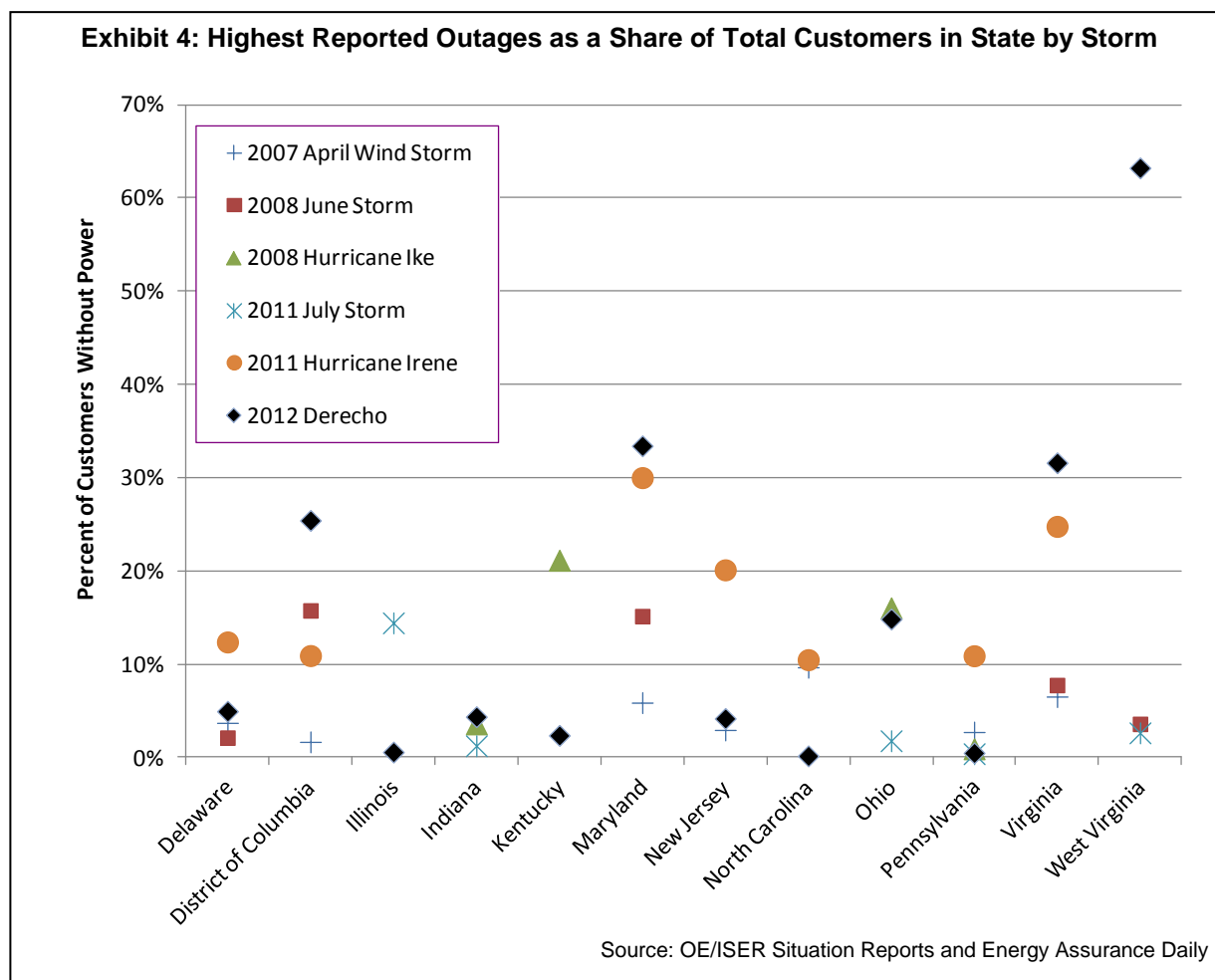
Source: OE/ISER Situation Reports and Energy Assurance Daily

Highest customer outage reports for each storm were obtained from data collected by OE/ISER on utility customer power outages in the aftermath of the storms.⁵ Some of the storms listed in Exhibit 3 affected many States, including States outside of the Ohio Valley and Mid-Atlantic regions. However, outage figures in Exhibit 3 include only utility outages for States in the Ohio Valley and Mid-Atlantic regions. For instance, Hurricane Ike caused power outages across eight States from Texas to New York but the number of outages for Hurricane Ike cited in Exhibit 3 only includes outages reported in Indiana, Kentucky, Ohio, and Pennsylvania. Exhibit 3 indicates that the June 2012 Derecho, which knocked out power to more than 4.2 million

⁴ See footnote 3.

customers in the Ohio Valley and Mid-Atlantic regions, caused more overall power outages than previous summer storms compared for this analysis.

Exhibit 4 presents the highest reported customer power outages by State as a share of total State customers for each storm. This exhibit indicates that of the storms analyzed for this report, the 2012 Derecho was the worst major summer storm to affect utilities in several States over the past five years. For example, West Virginia had 63 percent of electric utility customers without power after the storm, followed by Maryland with 33 percent, Virginia with 32 percent, and the District of Columbia with 25 percent, respectively. By contrast, New Jersey, Pennsylvania, North Carolina, and Delaware were more heavily affected by Hurricane Irene, while Ohio and Kentucky were most severely impacted by Hurricane Ike.

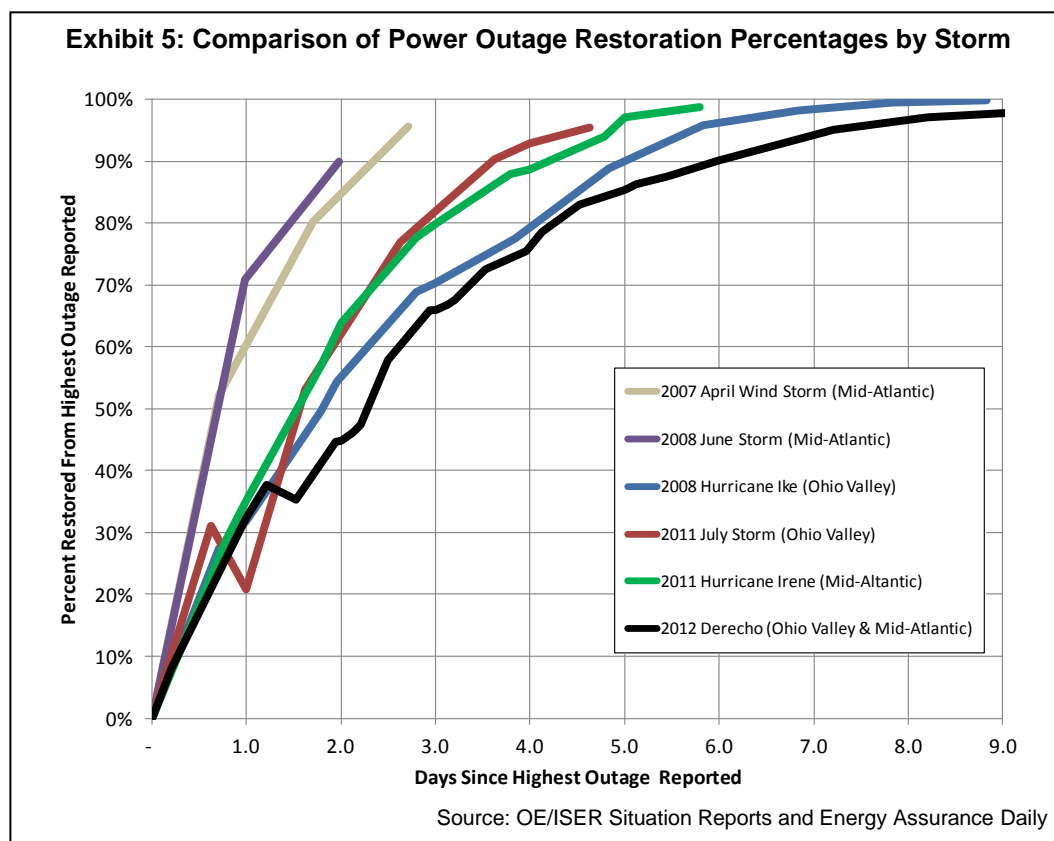


⁵ OE/ISER publishes this data in OE/ISER *Situation Reports*, as well as the *Energy Assurance Daily*, a daily newsletter detailing energy developments across the country.

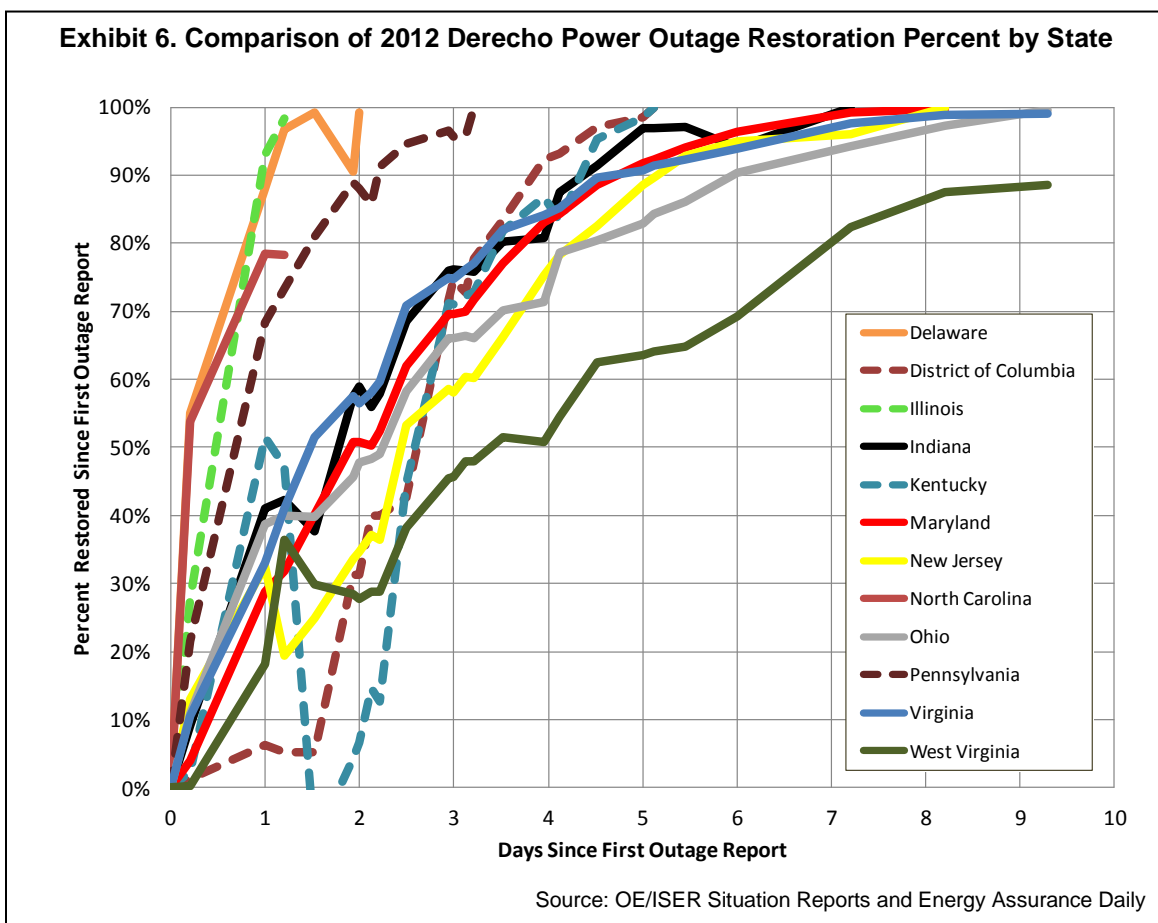
Comparison of Power Restoration

OE/ISER compared power restoration following the 2012 Derecho with restoration efforts following other major spring and summer storms that impacted the Ohio Valley and Mid-Atlantic regions over the past five years. Exhibit 5 plots a time series of power restoration following the 2012 Derecho in terms of the percent of customers restored since the highest number of customers reported without power. For the 2012 Derecho, time zero in the chart corresponds with the highest number of customers reported without power in the morning after the storm, at 9 a.m. EDT June 30, 2012. Power restoration time series for other major spring and summer storms that affected the Ohio Valley and/or Mid-Atlantic regions are also presented in Exhibit 5.

Exhibit 5 indicates that power restoration following the 2012 Derecho took longer than the restoration following other severe spring and summer storms affecting the Ohio Valley and Mid-Atlantic regions. However, over the first day following the highest outage report, power restoration largely kept pace with restoration following other major storms. New storms impacted the region during the second day of restoration, causing additional outages, and setting back restoration. Two days after the highest outage report, utilities had restored power to only 45 percent of affected customers following the 2012 Derecho, whereas utilities had achieved restoration rates of 55 percent or higher following other major storms. Utilities had achieved two-day restoration rates at or approaching 90 percent following major storms in April 2007 and June 2008. Had new storms not affected utilities during the second day of recovery, power restoration following the 2012 Derecho would have largely kept pace with restoration following Hurricane Ike, but would have remained slower than restoration efforts following other storms. The factors that contributed to this result, including the arrival of subsequent storms, are discussed in the next section of this report.



A State-by-State analysis of power outage restoration following the 2012 Derecho is presented in Exhibit 6 below. The exhibit indicates a high variation in restoration rates, particularly over the first two days of restoration. One day after the first outage report, only 6 percent of Washington D.C. customers who lost power had been restored, compared with more than 90 percent restoration for customers who lost power in Illinois. Of the States with the highest absolute number of outages (Maryland, Ohio, Virginia, and West Virginia), restoration in Maryland and Virginia proceeded at a faster rate, with more than 80 percent of customers who lost power in those States restored after four days, compared with restoration rates of roughly 71 percent for Ohio and 51 percent in West Virginia, respectively. It should be noted that restoration can vary by State for a number of reasons. Topography, population density, damage levels, tree removal and subsequent storms can all affect the rate of power restoration. The Ohio Valley region in particular experienced additional storms during the restoration period, adding new outages and slowing the pace of restoration in those States.



Restoration Factors and Analysis

There is no “normal” restoration curve following major storms, as each event offers a unique set of conditions and circumstances. However, utilities typically focus initial efforts on repairing utility-owned power plants, substations, and transmission lines that serve them. Next, utilities work to restore customers that provide essential services to the community, such as hospitals, police stations, and fire departments. Once essential customers are restored, utilities focus on completing repairs to circuits that serve the largest number of customers and can be restored in the least amount of time. After large circuits are repaired, restoration efforts typically experience diminishing returns, as crews turn their attention to circuits serving fewer customers. The final stages of restoration often take the longest, as utilities restore power to small groups and individual customers.⁶ The rate of restoration shown in Exhibit 5 reflects initial resolution of major outage areas for each observed storm, followed by slower progress as similar labor effort is required to restore power to damage sites, which impact fewer and even single customers.

The restoration performance following the 2012 Derecho was impeded by a number of factors that differentiate it from the storms compared for this report. These factors include the severity and scope of the storm and the resulting damage to electric infrastructure, storm preparation time, and post storm issues.

Storm Severity and Scope

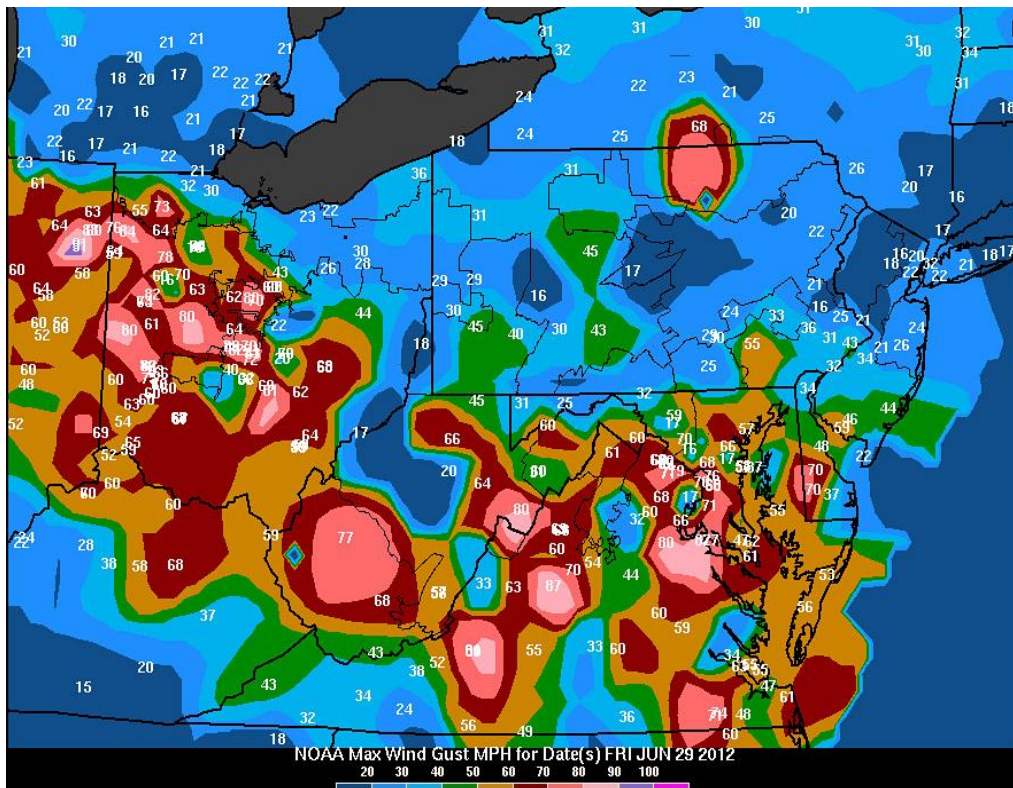
The 2012 Derecho was a particularly severe wind event that covered a large area across regions. According to the National Weather Service, the area impacted by the 2012 Derecho experienced wind speeds averaging 60 miles per hour with wind gusts in the range of 80 to 100 miles per hour over a 10 hour period.⁷ By comparison, a category 1 hurricane is characterized by sustained wind speeds in the range of 74 to 95 miles per hour, while a tropical storm is characterized by wind speeds ranging from 39 to 73 miles per hour.⁸ However, hurricanes and tropical storms typically deliver the most severe wind speeds to coastal areas, and lose considerable strength as they move inland. The 2012 Derecho, by contrast, delivered direct, straight-line winds, to a wide swath of the Ohio Valley and Mid-Atlantic. Exhibit 7 below, from NOAA, presents a map showing maximum wind gusts in the area impacted by the Derecho on June 29, 2012.

⁶ “FAQ About Power Outages.” Progress Energy Web site. <https://www.progress-energy.com/carolinas/home/storms-outages/faqpowerout.page> (July 16, 2012).

⁷ “Historic ‘Derecho’ Severe Wind Event Storms across the Midwest and Mid-Atlantic on June 29, 2012. NOAA Web site. http://www.erh.noaa.gov/rnk/events/2012/Jun29_derecho/summary.php (July 16, 2012).

⁸ “Saffir-Simpson Hurricane Wind Scale.” NOAA Web site. <http://www.nhc.noaa.gov/aboutsshws.php> (July 16, 2012).

Exhibit 7: Maximum Wind Gusts from 2012 Derecho



Source: FirstEnergy, NOAA

Exhibit 7 shows the greatest bandwidth of wind intensity covering a wide area of rural, heavily tree-covered areas. The wind damage to trees was very extensive over the entire storm area. The ability to remove trees quickly was limited due to the number of trees (many of massive size) which were felled onto power infrastructure located in many cases on consumer- and county-owned property. Power repair crews often required tree removal crews to clear the site first before power repairs could be started.

Damages to Electric Power Infrastructure

The damaging winds and wind gusts experienced during the 2012 Derecho brought down trees in the impacted area, causing physical damage to electric power infrastructure, including transmission and distribution lines, substations, and utility poles. This report provides details of damage based on publicly available utility press releases and statements, as well damage from the other comparison storms. However, not all utilities in the affected area provide detailed information on such impacts, and those that do report impacts do not often provide details in a uniform way. Consequently, it is not possible to directly compare the damage to power infrastructure between storms or even between utilities or States within the same storm. Publicly available damage information is presented by storm in the sections below in order to provide some perspective on the unique characteristics and impact of the 2012 Derecho versus other

storms.⁹ Detailed damage information was only available for the 2012 Derecho, Hurricane Ike, and Hurricane Irene.

2012 Derecho

The 2012 Derecho disrupted power to more customers in the Ohio Valley and Mid-Atlantic than any of the storms highlighted in this report. The 2012 Derecho delivered wind speeds and gusts that devastated trees and neighboring power lines throughout the impacted regions. More than 4 million customers lost power in the District of Columbia, Delaware, Illinois, Indiana, Kentucky, Maryland, New Jersey, North Carolina, Ohio, Pennsylvania, Virginia, and West Virginia.

Exhibit 8: Reported Damage Statistics from 2012 Derecho

Utility	Damage Locations	Substations	Transmission Lines	Poles	Personnel (peak)
Appalachian Power	NR	90+	100	500	5,100
Allegheny Power	27,000	NR	NR	600	6,300
Pepco	NR	NR	NR	260	3,000
Dominion	25,000	NR	NR	NR	5,600
BGE	NR	NR	NR	NR	4,700

NR = Not Reported

Hurricane Irene 2011

Hurricane Irene moved along the U.S. East Coast and made landfall as a Category 1 hurricane on August 27, 2011, on the Outer Banks of North Carolina. Irene weakened to a tropical storm as it battered the U.S. Mid-Atlantic and Northeast. There were at peak 3.25 million customers out of power in the District of Columbia, Delaware, Maryland, New Jersey, North Carolina, Pennsylvania, and Virginia.

Exhibit 9: Reported Damage Statistics from Hurricane Irene

Utility	Damage Locations	Substations	Transmission Lines	Poles	Personnel (peak)
Pepco	NR	5	131	NR	2,500
Dominion	35,000	NR	NR	NR	7,000
BGE	NR	NR	NR	NR	5,500

NR = Not Reported

Hurricane Ike 2008

Hurricane Ike made landfall on the U.S. mainland in Texas as a strong Category 2 hurricane on September 13, 2008. More than 1.5 million customers lost power in Indiana, Kentucky, Ohio, and Pennsylvania as Ike moved further inland from the Gulf Coast bringing heavy rainfall and strong winds to areas of the Midwest.

⁹ All restoration data cited comes from company press releases.

Exhibit 10: Reported Damage Statistics from Hurricane Ike

Utility	Damage Locations	Substations	Transmission Lines	Poles	Personnel (peak)
AEP Ohio	NR	NR	NR	NR	3,000
First Energy Ohio	9,200	NR	NR	NR	2,500
Duke Energy	NR	NR	NR	1,300	NR

NR = Not Reported

Due to the limited and inconsistent nature of the data reported in Exhibits 8 through 10, conclusive statements comparing damage by storm or utility are not possible. However, the 2012 Derecho caused more customer power outages to five States in the Ohio Valley and Mid-Atlantic regions (see Exhibit 4) than other major storms, suggesting that the Derecho may have caused more damage to electric infrastructure for some utilities in those States. Utilities did not report specific damage information for the April 2007, June 2008, or July 2011 storms. This lack of information may be indicative of the relatively faster restoration times from these storms, which were not as severe as the 2012 Derecho or Hurricanes Irene and Ike.

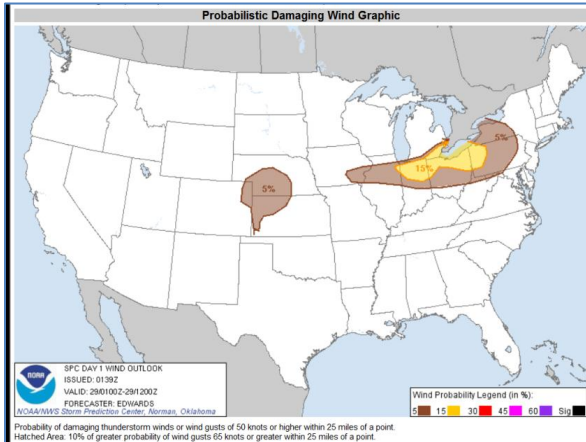
Minimal Storm Preparation Time

Utilities received little advanced warning of the 2012 Derecho, a factor which reduced preparation time and may have lengthened restoration time. By contrast, utilities received warnings days in advance of Hurricanes Ike and Irene, clarifying the storms' timing, expected wind speeds, and the scope of the expected areas of impact. This advance notice allowed utilities to stage repair crews and call center operations and arrange in advance for assistance from regions outside the expected impact areas.

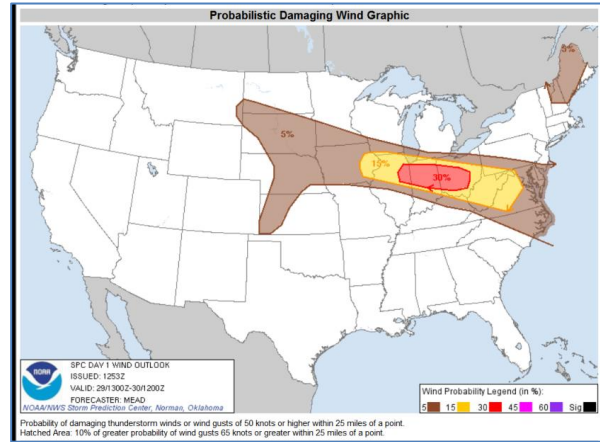
Analysis of forecasting prior to the 2012 Derecho indicates that there was minimal notice to any of the utilities in impacted areas that a storm of the 2012 Derecho's magnitude was likely. Exhibit 11 below shows forecast wind maps from the NOAA. At 9 p.m. EDT on June 28—the day before the storm—NOAA forecasted low to moderate winds across the northern portion of Illinois and Indiana, the southern portion of Michigan, most of Ohio, and large parts of western New York and Pennsylvania. At 11 a.m. EDT, June 29—just three hours before the storm began in Illinois—NOAA significantly increased its wind forecast for the region, expanding its wind probability zone across much of the northern Midwest and Mid-Atlantic. At 6 p.m. EDT, after the storm had already begun impacting Illinois, Indiana, and Ohio, NOAA again expanded the area it expected to receive damaging thunderstorm winds and began forecasting severe winds at or above 65 knots for parts of Indiana, Ohio, and West Virginia.

Exhibit 11: NOAA Convective Outlook Comparison, June 28-29, 2012

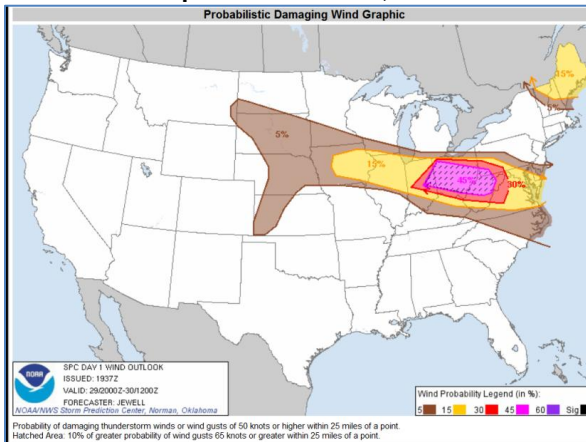
9 p.m. EDT June 28, 2012



11 a.m. EDT June 29, 2012



6 p.m. EDT June 29, 2012



Source: NOAA, <http://www.spc.noaa.gov/archive/>

Exhibit 11 indicates that over the 24 hours preceding the 2012 Derecho, forecasts changed from predicting a storm with relatively moderate wind speeds and a limited geographic scope to predicting a devastating storm with damaging wind speeds covering a much broader area of the country. This afforded little time for utilities to conduct resource planning and mobilization, particularly for utilities serving parts of southern Ohio, West Virginia, Maryland, and Virginia, which were not in the area of expected storm activity predicted by NOAA's 9 p.m. June 28 forecast.

Post-Storm Issues Impacting Restoration

Several factors affected restoration in the aftermath of the 2012 Derecho, including additional storms and excessive heat. Conditions such as high heat and humidity may have made it more difficult for tree removal and utility repair crews to work efficiently.

Additional Storms

A series of severe thunderstorms passed through the Ohio Valley region after the Derecho struck on June 29, 2012, causing new outages and slowing restoration efforts. Appalachian Power in Virginia and West Virginia was the hardest hit utility with four additional storms

following the Derecho. These storms occurred on July 1, 3, 5, and 8, creating new outages of 30,000, 6,000, 40,000 and 30,000 customers, respectively.¹⁰ These additional storms hindered restoration efforts and lengthened the time it took to restore power to customers.

Illinois, which registered approximately 32,000 customers without power the morning after the 2012 Derecho, had restored power to all but 520 affected customers by the afternoon of July 1, when new storms increased outages to nearly 180,000 customers on the evening of July 1.¹¹ Similarly, Kentucky, which had reduced outages from 53,000 to 28,000 customers by the afternoon of July 1, saw new storms increase outages to 57,000 customers on the evening of July 1.¹²

By contrast, the other recent spring and summer storms analyzed in this report were not followed by comparable weather events during their restoration periods (with the exception of the July 2011 storm). After Hurricane Irene in 2011 and Hurricane Ike in 2008, for example, there were no subsequent storms that affected the outage area. Similarly, the April 15-16, 2007 storms along the East Coast and the June 4-6, 2008 storms in the Mid-Atlantic did not experience any severe storms during their restoration periods.¹³

Excessive Heat

Extreme temperatures that followed the 2012 Derecho may have complicated restoration efforts for many utilities. Extreme heat can pose a safety risk to utility crews and lower restoration efficiency. Several utilities reported taking extra measures, such as distributing water and energy drinks, and supplying ice to utility crews to combat the heat.¹⁴ AEP Ohio reported that five of its utility workers were treated for heat-related injuries as they worked to restore power amid 100°F temperatures between July 2 and July 6.¹⁵ Exhibit 12 compares the average high temperatures from the 2012 Derecho with other recent spring and summer storms discussed above.¹⁶ It shows the temperatures the day of the storm and the days following it (the restoration period). Average post-storm temperatures in the 2012 Derecho impact area consistently stayed above 94°F and far exceeded the temperatures following other storms.

¹⁰ DOE OE/ISER *Energy Assurance Daily*.

¹¹ DOE OE/ISER *Emergency Situation Report #4*, July 1, 2012 (3:00 PM), http://www.oe.netl.doe.gov/docs/2012_SR4%20SevereStorm_OVMASS_070112_3pm.pdf, and ComEd Twitter Post 6AM, June 30, 2012. <https://twitter.com/ComEd>.

¹² Ibid.

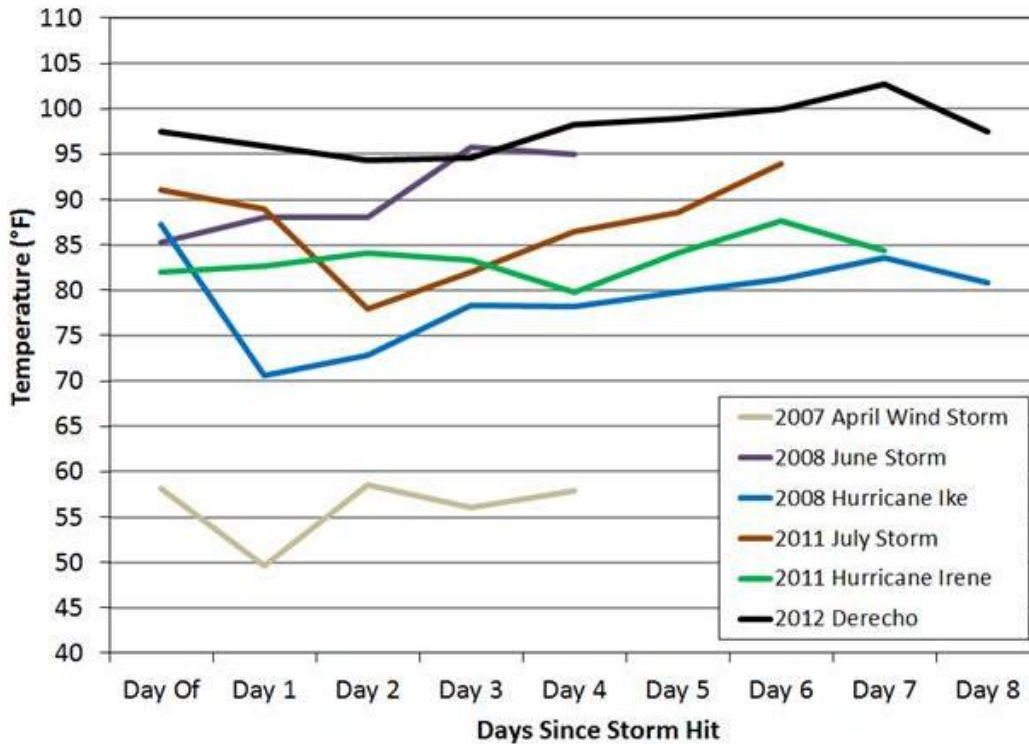
¹³ DOE OE/ISER *Energy Assurance Daily* and NOAA's National Weather Service Storm Prediction Center (SPC) Reports.

¹⁴ "Pepco Completes Full Restoration of Customers Impacted by Derecho." Pepco Completes Full Restoration of Customers Impacted by Derecho." Press Release. July 08, 2012. <http://www.pepco.com/welcome/news/releases/archives/2012/article.aspx?cid=2088> (July 16, 2012).

¹⁵ "Crews still working through heat advisory to restore power." AthensOhioToday.com. July 6, 2012. http://www.athensohiotoday.com/news_advisories/crews-still-working-through-heat-advisory-to-restore-power/article_57d4e03a-c77c-11e1-ba5e-001a4bcf887a.html (July 16, 2012).

¹⁶ Exhibit 12 temperatures are from NOAA. The average high temperatures of each day are averages of major cities throughout the affected period. 2012 Derecho: Chicago, IL; Fort Wayne, IN; Columbus, OH; Cincinnati, OH; Lexington, KY; Charleston, WV; Atlantic City, NJ; Baltimore, MD; Washington, DC; Richmond, VA. 2011 Hurricane Irene: Newark, NJ; Philadelphia, PA; Baltimore, MD; Washington, DC; Richmond, VA; Raleigh, NC. July 2011 storm: Chicago, IL; Dayton, OH. 2008 Hurricane Ike: Fort Wayne, IN; Columbus, OH; Cincinnati, OH; Lexington, KY; Pittsburgh, PA. 2008 June storm: Baltimore, MD; Washington, DC; Richmond, VA; Charleston, WV. 2007 April storm: Newark, NJ; Philadelphia, PA; Baltimore, MD; Washington, DC; Richmond, VA; Raleigh, NC.

Exhibit 12: Average Daily Temperature Highs during the Restoration Period by Storm



Source: National Weather Service

Conclusions

Power outage restoration following the 2012 Derecho proceeded at a slower pace than restoration following other spring and summer storms that impacted the Ohio Valley and Mid-Atlantic, including Hurricane Ike, the remnants of which moved through the Ohio Valley in September 2008; Hurricane Irene, which hit Mid-Atlantic in August 2011. The 2012 Derecho restoration was influenced by a number of factors that differentiate the storm from the other comparative storms. These factors included the following:

- 1) The 2012 Derecho was a **severe storm with a wide geographic area**. The storm brought sustained winds of 60 miles per hour with wind gusts ranging from 80-100 miles per hour across a 600-mile swath of the country. The storm damaged electric infrastructure, leaving 4.2 million customers without power the morning after the storm—more outages than any other storm to hit the Ohio Valley or Mid-Atlantic regions over the past five years. Restoration efforts were further complicated in many of the impacted areas as extensive debris and tree removal were required before power repairs could be made.
- 2) Utilities had **minimal preparation time** before the 2012 Derecho, as weather forecasts did not indicate a major storm event was likely. Due to the suddenness of the storm, utilities had virtually no time to develop restoration plans and pre-stage resources in expected areas of impact. Furthermore, access to repair crews from outside the expected storm area could not be arranged and positioned in advance of the storm. The suddenness of the 2012 Derecho contrasts with Hurricanes Ike and Irene, for which

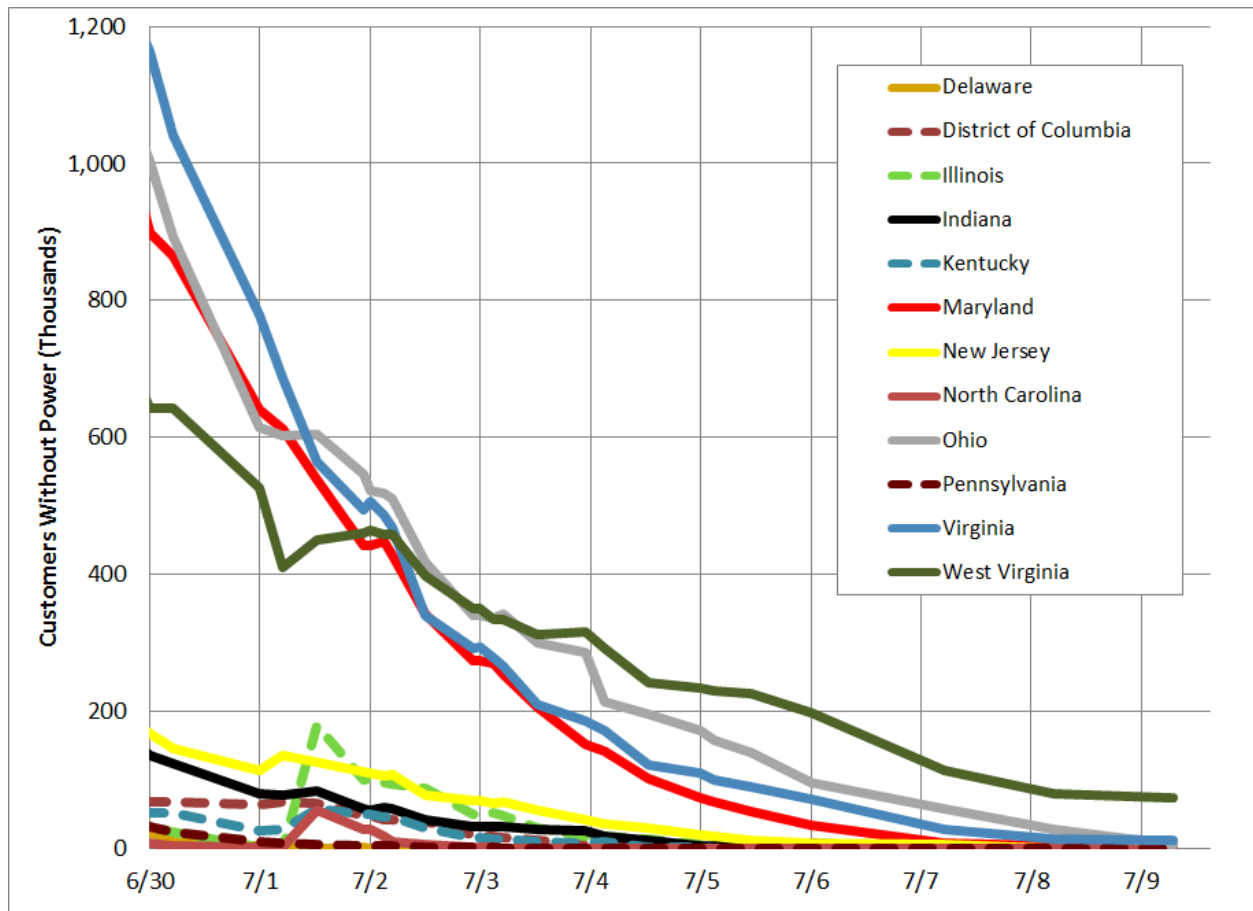
there was considerable advance warning, and other summer and spring storms in this report that weather forecasts may have predicted.

- 3) **Post-storm issues** during the restoration period, including additional storms and excessive heat in the impacted areas, lengthened restoration times causing additional power outages and complicating restoration efforts.

The 2012 Derecho was a unique storm due to its unforeseen intensity, area of impact, and post-storm conditions. As a result of these factors, the power restoration timeline following the Derecho lagged compared to other major storms that impacted the Ohio Valley and Mid-Atlantic regions, including Hurricanes Ike and Irene.

APPENDICES

APPENDIX 1: 2012 DERECHO POWER OUTAGES BY STATE



Source: OE/ISER Situation Reports

APPENDIX 2: SOURCES FOR INFRASTRUCTURE DAMAGE REPORTS

AEP Ohio: <https://www.aepohio.com/info/news/NewsReleases.aspx>

Allegheny Power: https://www.firstenergycorp.com/newsroom/news_releases.html

Appalachian Power: <https://www.appalachianpower.com/info/news/NewsReleases.aspx>

Baltimore Gas & Electric (BGE): <http://www.bge.com/newsmedia/pages/press-releases.aspx>

Dominion: <http://dom.mediaroom.com/news>

First Energy Ohio: https://www.firstenergycorp.com/newsroom/news_releases.html

Pepco: <http://www.pepco.com/welcome/news/releases/>