NORTH AMERICAN WOOD POLE COUNCIL

TECHNICAL BULLETIN

The Hardening of Utility Lines — Implications for Utility Pole Design and Use

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Abstract

The hurricanes of 2005 caused unprecedented damage to critical infrastructure on the Gulf Coast, including electric utility distribution and transmission systems. Significant damage has also been caused recently by ice storms and extreme wind events in other parts of the country. The Public Service Commissions of several states questioned the performance of the power delivery systems in these storms, and initiated work to investigate the potential need and effectiveness of "hardening" the system to improve performance in future storms. This paper provides a qualitative evaluation of the expected and actual response of the electrical distribution system in these storms. In general, the system performed as expected and potential actions to "harden" the system could be very expensive and the potential benefits are unquantifiable.

Introduction

Hurricane Camille, which struck the Mississippi Coast in 1969, had long been considered the yardstick by which all other storms were measured. However, the devastation of Hurricane Katrina in 2005 made all prior storms look tame in comparison. Hurricane Katrina caused over 80 billion dollars in damage and easily became the most expensive natural disaster in history. The 2005 hurricane season was possibly the most active Atlantic hurricane season on record, with a total of 28 storms, 15 hurricanes and 7 major hurricanes. Four of the major storms, Dennis, Katrina, Rita, and Wilma, struck the Gulf Coast with total damages exceeding 120 billion dollars and more than 2,200 fatalities.

In December of 2006, the Pacific Northwest experienced an extreme wind event that caused more than 1.5 million customers to lose power. Also in December of 2006, a severe winter storm resulted in heavy icing in portions of the Midwest. More than 500,000 public utility customers lost power in Missouri and Illinois alone.

These extreme weather events have caused the public to question whether more can be done to prevent these outages or reduce time to restore power, and this has resulted in the Public Service Commissions (PSCs) of several states starting formal inquiries into the need to harden the systems.

Discussion

The investigations by the various state PSCs have not focused only on hardening the system as a means to improve extreme weather performance. Vegetation management, line inspection and maintenance, line relocation, and undergrounding are among the other opportunities identified for improved storm performance.

The basis for reaching decisions concerning system improvement must be founded in an accurate forensic analysis of actual failure mechanisms. The various states have found that this information is very difficult to determine with a reasonable degree of certainty. In some cases, it has been possible to develop qualitative data to confirm or deny some early hypotheses. In the Gulf Coast region, initially the performance of wood poles was questioned. Both the States of Texas and Florida considered eliminating the use of wood transmission poles.

The facts did not support these concerns. In the 2005 hurricanes, transmission and distribution poles of all materials failed. Information provided to the Florida PSC indicated proportionate failures of wood and concrete distribution poles. Forensic studies of wood pole failures found few failures associated with groundline decay. Florida Power and Light (FP&L) reported that only approximately 1% of distribution poles that experienced hurricane force winds in Hurricane Wilma failed, and that most failures were associated with fallen trees or windblown debris. FP&L reported installing 930 miles of overhead distribution conductor, 570 miles of overhead service conductor, and making 1.1 million overhead splices, but only replaced 12,632 distribution poles as a result of the 2005 hurricanes. Wood and non-wood transmission lines also suffered damage in Wilma, including a section of a major 500 KV steel transmission line. The result of FP&L's forensic analysis was that the poles in its system performed as expected. (Florida Power and Light Presentation at June 2006 Public Utility Research Center Workshop)

In Hurricane Katrina, Mississippi Power Company (MPC), which serves most of coastal Mississippi, bore the brunt of the damage, but significant damage occurred as far north as Starkville and beyond. The author's observations in the area of his home, which is in Gulfport, Mississippi, and about 15 miles from the coast, were that 80% or more of the wood distribution poles were still standing, but virtually 100% of the spans were on the ground, primarily as a result of fallen trees and other debris. The author's communication with the Corporate Information Manager with MPC confirmed this phenomenon. Mississippi Power reportedly sustained damage to about 65% of its transmission and distribution system which consists of approximately 6,000 miles of line. There were approximately 26,500 spans down, but they replaced only about 9,000 poles out of their standing inventory of approximately 200,000 poles.

In September of 2005, Hurricane Rita struck western Louisiana and eastern Texas causing extensive damage in the coastal areas. Entergy reported 77% of its 372,891 Texas customers were without power for some period of time. Approximately 8,870 distribution poles, or approximately 2.8% of its standing distribution inventory, were replaced. Approximately 5.6% of its 142,358 distribution transformers were replaced. In addition, approximately 981, or 2.8%, of the 34,600 wood transmission poles were replaced, and 26, or 2.8%, of the 940 steel lattice transmission towers required replacement. (Entergy presentation filed with Texas PUC on January 30, 2006)

On November 30 - December 1, 2006, an ice storm hit portions of the Midwest. AmerenEU reported to the Missouri PSC that approximately 270,000 customers experienced a power outage. At the peak of the restoration effort, 4,391 personnel were involved. A total of 214 miles of new conductor were installed and many miles of downed conductor were reinstalled, yet AmerenUE reported replacing only 392 poles in Missouri.

Based on these field reports, it appears that wood poles performed well and that the failure rate of poles was much lower than the failure rate of other system components.

Even though it is apparent that wood poles and other system components have performed as expected in these extreme weather events, the various PSCs continue to evaluate means to improve system performance. From a system design and construction perspective, there are some obvious avenues to investigate. Overhead systems can be made stronger by using stronger poles and other system components, reducing spans, increasing guying, increasing safety factors using present design loads or increasing extreme weather design loads to higher values. The difficulty is not in the design or construction of a hardened system, the difficulty is in the ability to quantitate the expected performance improvement so that rational decisions can be made regarding increased costs, which must be paid by the consumer, versus an anticipated future benefit. The actual loads imposed by extreme weather events are difficult to quantify. The load of a 40 mph wind on a conductor covered with 1/2 inch of radial ice is quantifiable, but the load of an ice-covered tree blown into a line, or a section of mobile home blown into a line is not readily quantifiable. The Florida PSC considered requiring that all distribution lines be designed to the NESC extreme wind loading criteria. The current NESC exempts structures 60 feet and less in height from the extreme wind loading criteria of Section 250C of the code. For the last several code cycles, proposals have been made to remove the 60-foot exemption. The overwhelming comments received on the proposals were that most storm failures are associated with secondary damage effects and that designing to extreme wind would have little effect on observed damage. Based on these field comments, the NESC has retained the 60-foot exemption.

Greatly reducing span length and greatly increasing the number of poles per mile is one way to meet the extreme wind criteria. If secondary damage effects are indeed responsible for most pole failures, then this approach could result in more pole failures rather than fewer and the time to restore service could be longer rather than shorter. The utilities in Florida indicated that requiring distribution systems to be designed to extreme wind criteria would double to quadruple the cost. Based on this feedback from utilities, the Florida PSC dropped its demand that all distribution lines be designed to the NESC extreme wind load criteria. Instead, they have asked the utilities to harden lines serving critical infrastructure such as hospitals, police stations, and fuel terminals, and to complete forensic analyses in future storms to evaluate the effectiveness of the targeted hardening. In addition, Florida has mandated inspections at set frequencies for all lines and improved vegetation management for all lines. There is a vigorous debate going on in Florida over how the costs of hardening will be distributed between the utilities and the third party attachers.

Another way of potentially improving storm performance is to move overhead systems to underground. This approach is generally popular with the public until the potential impact on rates is understood. It is true that underground lines are generally less exposed to the large physical loads associated with extreme weather events. However, they are not totally immune to failure in storms. Pad-mounted transformers are subject to storm surge and other secondary damage effects. On the Alabama coast in Hurricane Ivan in 2004, many miles of underground lines were physically uncovered and destroyed due to wave action and storm surge. Some locations in this area were without power for more than a year as a result.

Although underground lines may be less likely to have an outage, the time to locate and repair the outage is much longer than for overhead. A study published by Edison Electric Institute (EEI) in 2006 (Out of Sight, Out of Mind?, July 2006) reports that overhead lines in the State of Virginia in 2003 experienced outages at rates 4 to 5 times that of underground, but the average duration of the outage for underground systems was about 2.5 times that of overhead systems. A study by the North Carolina Utilities Commission (The Feasibility of Placing Electric Distribution Facilities Underground, November 2003) for the years 1998 - 2002 showed that underground systems experienced about half the outages of overhead, but the duration of the underground outages was 1.6 times longer. Therefore, much of the reduced frequency advantage of underground is offset by the increased duration of the outages.

The EEI report also contains some information that suggests that the outage advantage of underground diminishes as the system ages. One utility reported better reliability in 40-year-old overhead lines than 20-year-old underground lines. Maryland utilities reported underground systems were becoming unreliable after 15 to 20 years and that they were nearing the end of their service life in 25 to 35 years.

Although a significant portion of new distribution lines are going underground, cost remains a significant deterrent to replacing existing lines with underground. The increased cost for installation of new lines is typically paid by the developer who simply rolls those costs into the price of the lots being sold. The rate-payer would have to bear the cost for undergrounding existing lines. The EEI report and the North Carolina Utilities Commission study indicate that the cost of underground construction may be about 10 times the cost of overhead. North Carolina concluded that embarking on a state-wide program to replace overhead lines with underground would require a 122% increase in utility bills, and it would require 25 years to complete the work. Based on this data, North Carolina concluded that it was not financially feasible to pursue. The EEI study found that the cost to underground was typically about 10 times more than consumers were willing to pay.

Summary and Conclusions

The desire to improve the performance of utility systems in extreme weather events is shared by consumers, utilities, and state regulatory commissions. Given that it is impossible to design and build a system that can not be damaged by catastrophic natural events, the question becomes one of balancing increased costs and potential benefits. While increased costs can be calculated for any incremental level of system hardening, the potential benefits are largely unquantifiable because of the difficulty in determining the frequency distribution of actual loads that may be placed on the system in an extreme weather event.

Considering these difficulties, the prudent approach would appear to be one which provides targeted hardening of certain lines or line segments and comparing the response of these lines to lines of normal construction located in the same area and subjected to similar conditions in terms of wind exposure and secondary damage.

Only through forensic analysis of the performance of various designs and construction methods can rational decisions be made regarding whether present designs and construction are optional from a storm response perspective.

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