JOINT U.S.-CANADA POWER SYSTEM OUTAGE TASK FORCE

UTILITY VEGETATION MANAGEMENT INITIAL REPORT

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INITIAL REPORT
UTILITY VEGETATION MANAGEMENT

BACKGROUND

CN Utility Consulting, (an industry firm specializing in Utility Vegetation Management), was asked to perform the following three tasks:

1. Perform field investigations and outage analysis at four suspect locations on transmission right-of-ways maintained by either FirstEnergy (FE) or American Electric Power (AEP). Three of the sites were located in FE's service territory and one site was located in AEP's service territory.
2. Collect and analyze information and data regarding transmission right-of-way vegetation management practices at FE, AEP, and Cinergy, in order to assess the strengths and weaknesses of each Company's vegetation management program.
3. Identify generic best practices for transmission level vegetation management to enhance system performance and transmission reliability.

This initial report provides introductory information related to utility vegetation management activities, and findings related to Task 1. Tasks 2 and 3 will be addressed in the final report.

INTRODUCTION

Utility Vegetation Management (UVM) programs represent one of the largest re-occurring maintenance expenses for electric utility companies in North America. Indeed, keeping trees and vegetation from conflicting with overhead conductors is a critical, and expensive, responsibility of all utility companies concerned about electric service reliability and fire mitigation.

The vast majority of work in this multi-billion dollar a year industry is not performed by utility personnel, but rather outsourced to specialized tree and vegetation management contractors. These contractors typically work under the aegis, and direction, of a Utility Company Arborist or Forester who is charged with overall management of the UVM program.

A typical UVM program can include all, or some, of the following activities:

1. Tree pruning and removal
2. Vegetation control around poles, substations, and other electric facilities
3. Manual, mechanical, or chemical control of vegetation along rights-of-way
4. Pre and post inspections of required work
5. Tree planting and transplanting
6. Research & development
7. Public education
8. Tree inventories, work management systems, and sundry computerized functions

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THE PURPOSE OF UVM: WHEN TREES AND POWER LINES CONFLICT

It is appropriate to begin with an explanation of why a UVM program is critical to any utility company that maintains overhead energized lines. The two most often cited reasons are as follows:

1. **Electric Service Reliability**
   It is generally accepted that the majority of electric power outages occur when trees, or portions of trees, grow or fall into overhead electric power lines. While not as prevalent, outages can also occur when overhead conductors sag into trees due to increased load or due to a change in ambient conditions, e.g., high air temperature or low wind speed.

2. **Fires**
   Arcing between any part of a tree and a bare high-voltage conductor has the potential to occur if the physical separation between both is not maintained (arcing distances vary based on such factors as voltage and ambient conditions). If, for example, arcing does occur between a twig and a high-voltage line, there is the possibility that the twig can ignite and fall to the ground. If flammable material is present on the ground, it could cause a fire. While the incidence of fires caused by tree and power line conflicts appears to be relatively low (less than 1% of wildland fires nationally) the potential for large conflagrations does still exist. This problem is particularly pronounced in the west, southwest, and pacific northwest parts of both the US and Canada.

TRANSMISSION AND DISTRIBUTION (T&D) UVM ACTIVITIES

While this investigation has focused on transmission UVM activities, it is important to note the relationship with distribution UVM operations. This discussion is necessary in that most utility companies have one program that deals with both transmission and distribution UVM activities. Additionally, many lower voltage transmission poles do have distribution circuits located on the same pole. This is typically referred to as “under-build facilities”. While T&D UVM operations typically share the same administration and oversight, there are general differences in the type of work that is performed. The following is a brief description of the types of work associated with each of these UVM programs.

Distribution UVM

By far, distribution UVM activities comprise the largest part of an electric utility’s efforts in managing trees and vegetation near power lines. At many utilities, the distribution part of a program may utilize 80-90% of utility funding and resources for managing vegetation. This does not however mean that distribution UVM is any more, or less, important than transmission work. It is only a by-product of having significantly more miles of distribution lines (and exposure), than there are transmission lines.

Distribution programs typically prune more trees than they remove, and the costs (on a per tree basis) are higher than equivalent work on transmission lines. This is primarily due to the fact that most distribution tree pruning or removal is done in front of someone's home, and on community streets. Distribution UVM work is more visible to the public, and as such, requires more upfront notification, coordination with agencies, and a greater amount of personal and public education prior to commencing the work.

Transmission UVM

The primary difference between T&D UVM work can be summed-up as follows. The vast majority of Transmission rights-of-way have documented provisions allowing the utility to clear and maintain the vegetation in order to provide safe and reliable electric power. These easements, in essence, give the utility a greater amount of control over the landscape, than what is experienced adjacent to distribution lines. In the latter case, little, if any, documentation exists giving the utility the right to perform whatever UVM work is required to maintain the distribution lines free of vegetation.

Given the greater rights associated with transmission UVM work, it is common to see less pruning and more removals related to transmission work than are typically seen in a distribution program. The unit costs are also typically lower for transmission UVM work than are experienced in distribution activities (fewer customers and landowners to negotiate with). These documented rights also result in greater use of mechanical and chemical UVM tools on transmission rights-of-way. This includes mechanical mowers and the wider use of appropriate herbicides.

Laws and regulations

Our final report will include a review of current laws and regulations that either mandate or influence transmission UVM activities. The following is a brief discussion of these requirements based on our initial investigation findings.

With the exception of California[1], there are no statewide Commission promulgated mandatory clearance requirements. In other words, we found no evidence that mandatory clearances between vegetation and high-voltage lines must be maintained at all times.

The most often referenced requirement for UVM work is found in the NESC Rule 218, which has been promulgated in most states. The Rule itself requires:

> General:
> Trees that may interfere with ungrounded supply conductors should be trimmed or removed.
>
> NOTE: Normal tree growth, the combined movement of trees and conductors under adverse weather conditions, voltage, and sagging of conductors at elevated temperatures are among the factors to be considered in determining the extent of trimming required.

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[1] California's General Order 95, Rule 35 requires utility companies to maintain specific clearances between vegetation and energized conductors. These clearances are dependent on and vary by voltages.

> Where trimming or removal is not practical, the conductor should be separated from the tree with suitable materials or devices to avoid conductor damage by abrasion and grounding of the circuit through the tree.
>
> At Line Crossings, Railroad Crossings, and Limited-Access Highway Crossings: the crossing span and the adjoining span on each side of the crossing should be kept free from overhanging or decayed trees or limbs that otherwise might fall into the line.

This industry dominant rule appears to be very general in nature, and vague on specifics. As such, we do not believe it provides adequate instruction to utility companies in maintaining power lines clear of vegetation. We are however aware of a current industry effort to improve this NESC Rule and will provide additional information regarding this effort in the final report.

In addition to the NESC, there are requirements for UVM work found in various model fire codes such as the Uniform Fire Code (UFC) and the Urban-Wildland Interface Code (UWIC). Both codes have been adopted on a state and local basis in various parts of the US.

FINDINGS AS THEY RELATE TO THE AUGUST 14TH OUTAGE

A review of available documentation and field investigations at FE and AEP suggest that four of the line outages were, in fact, caused by conflicts between high voltage transmission lines and vegetation.

The following contains an overview of our findings of FE and AEP line outages, and identified contributing and/or mitigating factors. We will begin with a brief discussion of conductor sag, and follow this up with our investigation protocol and findings.

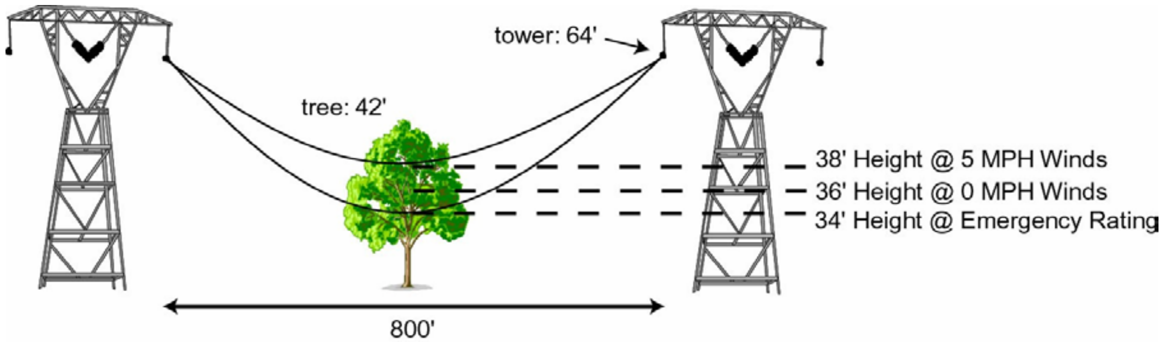
Conductor Sag

A key consideration during the design, construction, and maintenance of transmission lines is that of conductor sag. The height of transmission conductors does not remain static once it is installed, due in part to such factors as temperature and wind velocity.

Temperatures typically increase during the summer months requiring additional power to accommodate air conditioning load. As the load increases over transmission lines, the temperature increases and the conductors, typically aluminum, expand. The effect of this expansion is a lengthening of the conductors. This, in effect, causes them to sag closer to the ground.

The presence of wind also acts to influence conductor sag. Wind, at high enough velocity, provides a cooling effect on the conductors. This cooling of the conductors reduces the amount of sag that would be encountered on a calm day.

The following graphic provides an example of how conductor height can vary depending on load and wind velocity.



Field Investigation Protocol

The investigation team consisted of Richard Dearman (TVA), Saeed Farrokhpay (FERC), and Stephen Cieslewicz and Robert Novembri of CN Utility Consulting. The investigation consisted of a review of prepared responses and documents provided by FE and AEP, field visits to three suspect locations at FE and one suspect location at AEP, and interviews with FE and AEP contract personnel. Appropriate photographs, GPS readings, measurements and calculations were made at each location.

General Findings

Overgrown trees, as opposed to excessive conductor sag beyond design, appear to be the cause of these faults.

Each of these lines were predisposed to fault under system sag conditions well within normal operating parameters.

Incremental increases in amperage and temperature caused an incremental sag increase on the Stuart – Atlanta (AEP) line, causing it to fault and lock out due to contact with vegetation.

Incremental increases in amperage and temperature increased the sag on the Star – South Canton (FE) line causing it to fault and reclose due to contact with vegetation. This line tripped three additional times over a period of 1¼ hours before locking out.

Incremental increases in amperage and temperature increased the sag on the Chamberlin – Harding (FE) line, causing it to fault and lock out due to contact with vegetation.

Again, incremental amperage and temperature increases, escalated by the loss of the Chamberlin – Harding line, caused further incremental sag increases on the Hanna – Juniper (FE) and it faulted and locked out due to contact with vegetation.

We have field evidence of tree contact at three locations. At the fourth location, Hanna – Juniper, the tree was removed before we arrived, but the fault was visually (time/date) confirmed during the occurrence and pictures of the tree before it was removed support the visual observation. We also have a revised calculated fault location, provided by FE, for the Star – South Canton line that matches the location of the confirmed tree fault.

While conductor sag may have contributed in a small way to these events, the direct cause of these incidents can be attributed to overgrown trees. .

FE Documented Easements and Cycle

The following is language taken from a typical FE easement document that describes the actual rights of the utility regarding what can be pruned or removed in these particular rights-of-way.

> "The easement and rights herein granted shall include the right to erect, inspect, operate, replace, relocate, repair, patrol and permanently maintain upon, over, under and along the above described right of way across said premises all necessary structures, wires, cables and other usual fixtures and appurtenances used for or in connection with the transmission and distribution of electric current, including telephone and telegraph, and the right to trim, cut, remove or control by any other means at any and all times such trees, limbs and underbrush within or adjacent to said right of way as may interfere with or endanger said structures, wires or appurtenances, or their operations."

FE claims a 5-year cycle for transmission lines (all required vegetation work completed in a five year period for all circuits). It appears that had these rights (as documented above) been fully exercised, these trees could possibly have been removed in prior cycles.

It should be noted that a 5-year cycle is consistent with industry standards, and the phenomena of not fully exercising easement rights (as they pertain to transmission rights-of-way) is common in the industry.

An evaluation of AEP's stated cycle and documented rights will be included in the final report.

FAULT CHRONOLOGY, OBSERVATIONS AT FIELD SITES AND COMMENTS

Stuart – Atlanta (345 kV) AEP

14:02:00.0 Line trips and locks out.

No calculated fault location provided by AEP for this outage.

Evidence of tree contact was observed between towers 222 and 223. Conductor height of north phase measured 39 feet at tree location and point of contact. Center phase measured 41 feet and south phase measured 47 feet.

Trees and brush were felled on or after August 14th. Debris was left on site and inspected.

Two ailanthus trees showed evidence of significant fault current damage and were de-barked. One measured 2.5” diameter at ground line, and the other measured 6” diameter at ground line.

Both trees estimated to be 30 to 35 feet tall. Other trees in the area showed evidence of fault current damage as well.

The following readings were provided by AEP at the approximate time conductor height measurements were taken.

Time: 10:00 EDT
Date: 10/22/03
Temperature Reading: 55.6°
Wind Speed: N/A
Conductor Height: 39'

Loading:
Stuart – 950 amps
Atlanta – N/A

Star – South Canton (345 kV) FirstEnergy

14:27:15.880	Line trips and recloses (both ends).
15:38:47.770	Line trips and recloses (both ends).
15:41:33.43	Line trips and recloses (both ends). Retrips at South Canton.
15:42:07.0	Line recloses at South Canton, retrips and locks out. Line already open at Star.

Calculated Fault Location (revised): 20.5% from Star Substation, Span 40375 – 40376

Inspected conditions at structure 40404 and right-of-way toward 40401 (between 6.7% and 8%). No vegetation conflicts observed in this area. Did not review 40399 (9.1%).

Inspected tree conditions at structure 40376 (20.5%) between towers 40375 and 40376. Trees and vegetation were felled on or after August 14th. Debris and tree parts were inspected on site.

Conductor height measured 44' 9". Tree height measured at 30 feet, although we could not verify location of the stump, or missing section of tree. Obvious significant fault damage to clustered trees. Charred limbs, and de-barked by fault current.

Topsoil in the area of trunk was disturbed, discolored and broken up at site. This would be indicative of a higher magnitude fault or multiple faults.

Tree to structure 40375 measured 511' 7". Fourteen year-old tree in the middle of the right-of-way was removed.

The following readings were provided by FE at the approximate time conductor height measurements were taken.

Time: 14:14 EDT
Date: 10/16/03
Temperature Reading: 47°
Wind Speed: 1 mph (Wadsworth, OH)
Conductor Height: 44' 9"

Loading:
Star – 836 amps
South Canton – N/A

Harding – Chamberlin (345 kV) FirstEnergy

15:05:41.0 Line trips and locks out.

Calculated Fault Location: 11.3% from Chamberlin Substation, Tower 42852

No evidence of vegetation at calculated fault location (11.3%). See photo below.

At 17.7%, between towers 42861 and 42860 we inspected vegetation. Trees and brush were felled on or after August 14th. Conductor height measured at 46' 7", tree height measured at 42'. Locust tree showed evidence of fault current damage. Tree damage indicated a lower level of fault current.

Burn marks were observed at 35' 8" up tree. Portions of the tree had been removed from the site making it difficult to determine exact height of contact, implying that the height is a minimum, and likely 3-4 feet higher than verifiable.

Other vegetation along the right-of-way measured between two and five inches in diameter at ground line. The following photo depicts a tree located in the right-of-way that was over six years old, as indicated by the growth rings.

The following readings were provided by FE at the approximate time conductor height measurements were taken.

Time: 11:58 EDT
Date: 10/16/03
Temperature Reading: 47°
Wind Speed: 2 mph (Wadsworth, OH)
Conductor Height: 46' 7"

Loading:
Chamberlin – 405 amps
Harding – 400 amps

Hanna – Juniper (345 kV) FirstEnergy

15:32:03.0 Line trips and locks out.

Conductor height measured 48' 9" at fault location. No evidence of tree debris at site. Walnut tree stump measured 14" diameter at ground line.

Subsequent clearing left trees and brush that, in our opinion, could have been removed as indicated by the photo below on the left. This photo was taken in the same span as the fault occurred. Other trees were pruned and left in the right-of-way as part of a landscaped area as indicated by the photo on the right. This photo was taken within one span of the fault.

The contract foreman who witnessed the event on August 14th was interviewed. He described the fault and provided a definitive time/date stamp for the incident.

Per FE field personnel, the schedule for completing work on this circuit had been advanced by one year (we have not yet verified this assertion and will need to confirm with follow-up requested documents).

Surrounding trees were 18” in diameter at ground line and 60’ in height (not near lines). Other locations at this site had numerous (estimated 20+) trees in this right-of-way.

South phase, where contact occurred, is lower than center phase due to construction design. Subsequently, FE provided photographs that clearly indicate that the tree was of excessive height.

The following readings were provided by FE at the approximate time conductor height measurements were taken.

Time: 09:31 EDT
Date: 10/16/03
Temperature Reading: 44°
Wind Speed: 3 mph (Wadsworth, OH)
Conductor Height: 48’ 9”

Loading:
Hanna – 900 amps
Juniper – 970 amps

Columbus – Bedford (345kV) Cinergy

12:08:40.0 Line trips and locks out.
18:23:00.0 Line returned to service.

Just prior to submitting this initial report we had the opportunity to perform an initial review of a transmission fault experienced on the Cinergy system on August 14th in Indiana. While it does not appear that the fault was connected to the blackout, this situation does provide a very good example of the obstacles placed in front of utilities that are attempting to manage vegetation near overhead power lines. We will discuss these issues in greater detail in the final report. In the interim, we do believe that a brief description of what occurred on the Columbus – Bedford circuit is an appropriate.

Based on discussions with Cinergy, this transmission line fault occurred as a result of tree contact in one span of the Columbus – Bedford circuit. See photo below.

Apparently work on this span had been halted various times by the owner of the property. The owner of the property had severely limited the ability to achieve necessary clearances, and apply subsequent herbicides to control future growth. While Cinergy does, in fact, have documented rights to perform this work (documented easement), this landowner has successfully halted work from proceeding on several occasions. This included the homeowner obtaining a court granted temporary injunction halting work by Cinergy. Note: the required work was finally completed on October 9, 2003 as depicted in the photo below.

We bring this up to illustrate that there are many hurdles every utility company must face when trying to maintain lines clear of vegetation. In this particular case, it was a landowner that halted work. In other cases we are aware of, it can be local, state, or even federal agencies that hinder progress. In our final report we will include a detailed discussion of the types of obstacles that utilities face when trying to complete required UVM work in a timely manner.

PROGRAM ASSESSMENTS

A complete assessment of each of the three programs reviewed will be provided in the final report and will be based on a thorough review of the UVM program and activities at FirstEnergy, AEP, and Cinergy.