The Neglected Option For Avoiding Electric System Storm Damage & Restoration Costs - Managing Tree Exposure

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Proprietary Notice

Every time a storm causes widespread power outages, there arises a hue and cry against the power companies[1 2], a call for investigations and the suggestion that the distribution system be buried[3 4]. Commonly, politicians feeling the heat direct their regulatory agencies to investigate the utility response to the storm event and search for ideas on how to reduce damage in future storm events.[5 6 7] This scenario plays itself out annually, usually in several localities. Yet, in my over 30 years in the electric utility business the only notable changes observed are an incremental improvement in restoration times and communication,[8 9] an increasing number of highly damaging storms[10 11 12] and diminishing public tolerance for storm damages as demonstrated by increasingly shrill accusations in their aftermath.[13 14 15]

So what is the problem? Why are we condemned to this recurring experience? Do we lack understanding how severe weather interrupts electric service? No. We know that whether it's a wind or ice storm, the primary cause of service interruptions is large branches and/or trees falling onto electrical equipment, breaking the continuity of the circuit or causing phase faults.[16 17 18 19 20 21] Surely, utilities along the eastern seaboard, which routinely experience damaging wind and ice storms[22 23], have studied all aspects of this cause and explored all possible means of averting the associated hazards, inconvenience and restorations costs.

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1 Burr, Thomas. 2004. Utah Power: We were snowed under. The Salt Lake Tribune, UT, Jan. 7, 2004.
2 Angry Storm Victims Demand Power. Palm Beach Post, Sept. 12, 2004.
3 Virginian – Pilot. 2003. Ed. In Isabel's Wake: A Political Storm About Dominion Virginia Power… Sept 27, 2003.
4 South Florida Sun-Sentinel. 2004. Some Florida officials want utility FPL to bury lines to minimize outages. South Florida Sun-Sentinel, FL, Sept. 13, 2004.
5 Mirabella, Lorraine. 2003. Maryland Legislators Grill Utilities on Isabel-Related Outages. The Baltimore Sun Knight Ridder/Tribune Business News. Oct. 2003.
6 Flores, Chris. 2003. Virginia Regulators Set Meeting to Air Details of Outages from Hurricane. Daily Press, Newport News, Va., Oct. 21, 2003.
7 Lippe, Ryan. 2005. Consumers' Counsel Responds to PUCO Report on Power Outages. PRNewswire, Jan. 19, 2005.
8 NCUC. 2003. Response of Electric Utilities to the December 2002 Ice Storm. Report of the North Carolina Utilities Commission and the Public Staff to the North Carolina Natural Disaster Preparedness Task Force, September 2003.
9 Barrington-Wellesley Group, Inc. 2003. Independent Management Audit of Duke Power Company's Restoration and Maintenance Practices. South Carolina Public Service Commission, November 2003.
10 Hadden, Elaine. 2001. Weather Lessons. Transmission & Distribution World, Apr. 1, 2001.
11 Rappold, Scott. 2003. Lower electric bills, longer power outages. Isabel's local winds may have uncovered real cost of deregulation. Three Mile Island Alert, Sept. 28, 2003.
12 Dobkin, Robert. 2003. Pepco Holdings, Inc. Estimates Hurricane Isabel Costs at Approxiamately $70 Million. PRNewswire, Washington, Oct. 21, 2003.
13 Tampa Tribune. 2004. Tampa, Fla. Utilities say tree trimming can't prevent all hurricane outages. Tampa Tribune, Sept. 17, 2004.
14 New York Times. 2003. Isabel Leads to Debate on Spending by Utilities. New York Times. Sept., 2003.
15 Hurtibise, Ron. 2004. Outages, response spark debate. Daytona Beach News-Journal, Aug. 22, 2004.
16 Tomich, Jeffrey, 2001. Arkansas Ice Storm Cruel to Poorly-Maintained Electric Lines. Arkansas Democrat-Gazette, Little Rock, AR, Jan. 9, 2001.
17 Everly, Steve. 2002. Month after Ice Storm, Power-Line Repairs Continue in Kansas City, Mo. The Kansas City Star, Mar. 2, 2002.
18 Wallach, Dan. 2002. Entery Corp. Executive Says Company Focused on Reliability of Service. The Beaumont Enterprise, TX, May 7, 2002
19 Edwards, Greg, Betty Booker. 2003. Virginia's Corporation Commission to Assess Utility's Response to Outages. Richmond Times-Dispatch, Va. Sept. 13, 2003.
20 Raabe, Steve. 2003. Blame Gusts for Big Fires in Colorado, Xcel Energy Says. The Denver Post, Oct. 31, 2003.
21 North Carolina Utilities Commission and Public Staff. 2003. Response of Electric Utilities to the December 2002 Ice Storm. Report of the North Carolina Utilities Commission and the Public Staff, Sept., 2003.
22 Keener, R.N. Jr. undated. The Estimated Impact of Weather on Daily Electric Utility Operations. Duke Power Company, Charlotte, NC. http://www.esig.ucar.edu/socasp/weather1/keener.html
23 Price, Dudley. 2003. Raleigh, N.C.-Area Electricity Customers May Pay Higher Rates after Hurricane. The News & Observer, Raleigh, N.C., Oct. 12, 2003.

This article will serve to make explicit why we as an industry, politicians, regulators and utilities alike, have restricted our analysis. It will also offer and justify a new approach to avoiding storm damage… an approach that will necessitate the active participation and support of politicians and regulators if it is to be acted upon.

We know that the location of the trees responsible for storm damages are predominantly outside the maintained right of way[24] [25] [26]… that is most are situated on private property. This constitutes a politically inconvenient fact. The primary cause of extensive storm damage rests in the ownership of the very public we serve and the community groups protesting restoration times and restricting maintenance practices.[27] [28] [29]

If we are to avoid storm damage to the electric system, we need to decrease the exposure of power lines to trees. There are only a few means available to achieve this:

- Underground the lines
- Decrease the probability of a tree-line strike by increasing the tree to conductor clearance or increasing conductor height

Tree trimming, or the lack thereof, is often cited as playing a significant role in the extent of storm damage. [30] [31] [32] [33] It does not, except where the pruning removes branches overhanging the conductor(s). Branches overhanging lines greatly increase the risk of service interruptions in ice storms.

Recent work on assessing the feasibility of undergrounding the electrical system has yet again confirmed the unacceptably high cost, necessitating rate increases of over 125%. The North Carolina Public Staff in their 2003 assessment concluded their utilities would need to add 5000 staff for a period of 25 years to accomplish the task.[34] [35] While the utilities in North Carolina are masters of the logistics for a response of this scale, the 25-year timeframe may prove taxing.

And that leaves the alternatives of removing overhanging branches and increasing the tree to conductor clearance or increasing conductor height, alternatives we have left unspoken and unexamined. Why are these unexamined? What politician or regulator has the temerity to hold the public to account, not by merely suggesting greater cooperation between utilities

[24] Reuters. 2003. Utility spending cuts exacerbated Isabel damage-report. Washington, Oct. 17, 2003.
[25] North Carolina Utilities Commission and Public Staff. 2003. Response of Electric Utilities to the December 2002 Ice Storm. Report of the North Carolina Utilities Commission and the Public Staff, Sept., 2003.
[26] Guggenmoos, S. *Effects of Tree Mortality on Power Line Security.* Journal of Arboriculture, 29(4), July 2003.
[27] Wallman, Brittany. 2002. Broward County, Fla., May Adopt Tough Rules for Utility's Tree Trimming. South Florida Sun-Sentinel, Mar. 6, 2002.
[28] Raleigh Residents Torn Between Preserving Trees, Protecting Power Lines. WRAL.com, Dec. 11, 2002.
[29] Kravetz, Andy. 2002. CILCO: Trimming a no-win situation. Peoria Journal Star, Feb. 7, 2002.
[30] New York Times. 2003. Isabel Leads to Debate on Spending by Utilities. New York Times. Sept., 2003.
[31] Cheek, Michael R. 2002. Kansas City on Ice – how Kansas City Power & Light managed major power outages, U.S. Transmission & Distribution World, August 1, 2002.
[32] Kravetz, Andy. 2002. CILCO: Trimming a no-win situation. Peoria Journal Star, Feb. 7, 2002.
[33] Tampa Tribune. 2004. Tampa, Fla. Utilities say tree trimming can't prevent all hurricane outages. Tampa Tribune, Sept. 17, 2004.
[34] NC Public Staff. 2003. The Feasibility of Placing Electric Distribution Facilities Underground. Report of the Public Staff to the North Carolina Natural Disaster Preparedness Task Force, Nov., 2003.
[35] Johnson, Brad. 2004. Out of Sight, Out of Mind? A study on the costs and benefits of undergrounding overhead power lines. Edison Electric Institute, January 2004.

and the public but obligating the public to greater tree-conductor clearances? When utilities are routinely challenged, in the courts[36] [37] for exercising their easement rights, using proper pruning techniques or setting tree to conductor clearances,[38] what utility executive has the mettle to say the electric system's tree exposure must be reduced? For anyone who's spent career time on the receiving end of the telephone, the thought of someone being so brash raises the spectre of paroxysms of public outrage. Hence, to avoid the potential invective of condemnation for suggesting more trees be removed, we have limited the discussion to the use of undergrounding as a palliative to storm damage.

However, we need recognize that being cowed into politically correct "green" thinking limits the solutions available to us. Do we not owe it to the ratepayers to state the full truth and to put before them all options for avoiding future storm damage?

No doubt trees provide both tangible and intangible benefits. They provide shade, act as wind, sound and traffic barriers, purify the air, beautify our landscapes with a myriad of shapes and colours and are a source of food and protection for wildlife. But frankly, what began as the greening of our communities has evolved into a fanaticism for tree preservation that is costing us dearly.

In the aftermath of tropical cyclone Isabel, Dr. Patrick J. Michaels wrote "A Passion That Leaves Us Powerless"[39]. It should be required reading for every politician, regulator, utility employee and civic employee having anything to do with storm response or restoration (go to http://www.cato.org/research/articles/michaels-031001.html). Dr. Michaels makes several fundamental points:

- While utilities were blamed for the devastating effects of Isabel, the real fault lies with an aged "arboreal jungle" cultivated and neglected by the public
- We have grown tree specimens to a size beyond the typical size and age attained in a natural forest setting
- Our urban forests are over-mature and consequently felled by even weak storms
- Isabel was "weenie" when it comes to wind-force storms (45 mph at Reagan International)
- The condition of our urban and suburban forests means we are vulnerable to being increasingly "powerless" in the face of progressively weaker storms.

The article provides the rationale for the observed increase in damaging storms. It also provides a clear indication that we cannot avoid addressing the extent of power line exposure to trees. However, Dr. Michaels' remedy of undergrounding for avoiding future storm damage is rejected. This rejection is based on two points: first, recent studies have

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[36] Ryckaert, Vic. 2002. Indianapolis Utility Must Stop Clear-Cutting Trees until Judge Rules. The Indianapolis Star, Sept. 25, 2002.
[37] Acron Beacon Journal. 2004. Cleveland-area property owners fight FirstEnergy over tree removal plan. Acron Beacon Journal, OH, 2004.
[38] Painter, Steve. 2002. Westar Energy's Tree Trims May Cost Wichita, Kan., Customers. The Wichita Eagle, KS, Mar. 1, 2002.
[39] Michaels, Patrick J. 2003. A Passion That Leaves Us Powerless. The Washington Post, Oct. 1, 2003. Reprinted at http://www.cato.org/research/articles/michaels-031001.html

confirmed undergrounding is neither affordable nor practicable;[40] [41] and secondly, undergrounding will have no less impact on trees than establishing greater tree to conductor clearances due to root severing while trenching.

What is the public's view of increasing tree to conductor clearances? A survey conducted by the Odum Institute, in the aftermath of the December 2002 ice storm in North Carolina, provides insight into what storm damage avoidance strategies the public may be willing to support.[42] Eighty percent of the households were willing to have trees trimmed further back from power lines. While undergrounding is always vigorously promoted as the solution to storm damage,[43] it would appear these suggestions are coming from a vocal minority as only 47% of households indicated a willingness to pay extra on their monthly utility bill to do so. Only 11% of households were willing to pay more than $10 per month to underground the electric system. Clearly, paying the additional $100 per month the North Carolina Public Staff found it would cost to convert the distribution to system to underground[44] is a non-starter. This survey suggests the majority of the public is far more open than the industry believes, to consider options involving greater tree to conductor clearances for avoiding future storm damage.

It is suggested that this openness be exploited by co-opting members of the public into being co-operators in electric system protection. While this could be accomplished by calling on the innate common sense and feeling of social responsibility of the majority of people, implementation and participation would be facilitated by meaningful recognition of their cooperation.

But before determining what comprises "meaningful recognition", it's necessary to know exactly what can be gained by increasing tree to conductor clearances. The 2003 work of the North Carolina Public Staff on the Feasibility of Placing Electric Distribution Facilities Underground and conditions in North Carolina will be used as a basis for analysis and comparison.

Modifying the Extent of Tree Exposure

All trees capable of striking a power line are a risk. This risk is most broadly realized as service interruptions during wind and ice storms when the stress loading exceeds what a given tree can withstand. While the stress loading a tree can withstand is dependent on several variables, all trees will fail given enough loading. Consequently, the risk of service interruption is directly related to the extent of tree exposure (number of trees). This relationship is not, however, linear as the proximity of a tree to the conductor also affects

[40] NC Public Staff. 2003. The Feasibility of Placing Electric Distribution Facilities Underground. Report of the Public Staff to the North Carolina Natural Disaster Preparedness Task Force, Nov., 2003.
[41] Johnson, Brad. 2004. Out of Sight, Out of Mind? A study on the costs and benefits of undergrounding overhead power lines. Edison Electric Institute, January 2004.
[42] The Odum Institute. 2003. Coping with Natural Disaster: North Carolina Households' Response to the December 2002 Ice Storm. The Howard W. Odum Institute for Research in Social Science, 2003. http://www.odum.unc.edu
[43] NC Public Staff. 2003. The Feasibility of Placing Electric Distribution Facilities Underground. Report of the Public Staff to the North Carolina Natural Disaster Preparedness Task Force, Nov., 2003.
[44] NC Public Staff. 2003. The Feasibility of Placing Electric Distribution Facilities Underground. Report of the Public Staff to the North Carolina Natural Disaster Preparedness Task Force, Nov., 2003.

the extent of the conductor exposed, or the probability of the tree intercepting the line on failure.

A tree capable of striking the line on failure has a specific arc of possible line contact. If we picture a tree standing in very close proximity to a power line but with no branches extending over the line, assuming an equal chance of the tree falling anywhere within the possible 360°, the probability of a line contact on tree failure is 0.5. This has implications for any branch overhangs as the risk of a line contact on tree failure is then necessarily always >0.5. By increasing the clear width (distance from outside conductor to tree trunks) we can reduce the arc of possible contact and thereby, the probability of a line contact. Increasing line height also reduces the arc of possible contact. The degree of risk associated with trees in proximity of power lines is derived by a process of triangulation, with consideration given to possible tree interactions, using the Optimal Clear Width Calculator (OCWC).[45] [46] [47]

The data provided by the North Carolina Public Staff in their 2003 reports[48] [49] on the utility response to the 2002 ice storm and the feasibility of undergrounding distribution provides a specific case against which alternative mitigation options can be assessed. It is in this context that the extent of possible mitigation of future storm damage via decreasing tree exposure is explored, assigned costs and compared to undergrounding.

First, general tree risks for North Carolina distribution lines are derived using the OCWC and its associated processes. A Line Strike Probability chart is produced, from which we can determine the current tree risk. Lacking data regarding the input variables, assumptions have been made applying information in the North Carolina Public Staff reports referenced, general knowledge of distribution line design characteristics, forest conditions and vegetation management costs. The following assumptions were used:

- Distribution system only
- Average line height (conductor) = 28 ft
- Average tree height = 75 ft
- Trees per acre = 200
- Clear width single-phase = 15 ft
- Cross arm width = 8 ft
- Clear width 3-phase = 11 ft
- Tree removal cost using a feller-buncher & mower for limb disposal = $8

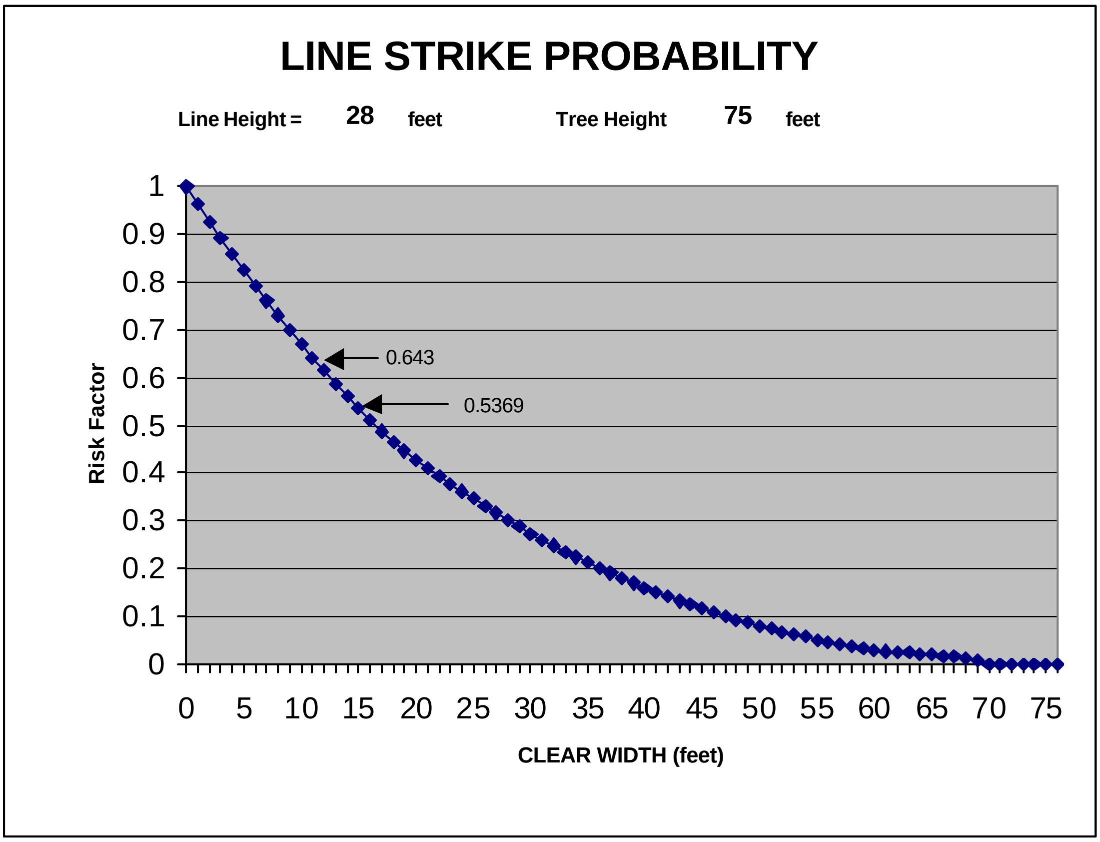
- Tree removal using chainsaw, chipper = $60
- Hazard tree identification and removal cycle = 5 yrs

[45] Guggenmoos, S. *Managing Tree-Conductor Conflicts by Risk Assessment*. UAA Quarterly, 9(4), Summer 2001.
[46] Guggenmoos, S. *Effects of Tree Mortality on Power Line Security.* Journal of Arboriculture, 29(4), July 2003.
[47] http://www.compusmart.ab.ca/ecosync/hzrdtree/ocwc.htm
[48] North Carolina Utilities Commission and Public Staff. 2003. Response of Electric Utilities to the December 2002 Ice Storm. Report of the North Carolina Utilities Commission and the Public Staff, Sept., 2003.
[49] NC Public Staff. 2003. The Feasibility of Placing Electric Distribution Facilities Underground. Report of the Public Staff to the North Carolina Natural Disaster Preparedness Task Force, Nov., 2003.

- Hazard trees removed per cycle per mile (one side) = 5

The Line Strike Probability chart (*Exhibit -1*) for 75-foot tall trees, numbering 200 trees per acre, adjacent to 28-foot high conductor follows. It reveals that the current risk, stated as a Risk Factor, based on the North Carolina standard right of way width of 30 feet, is 0.5369 for single phase where clear width (distance form conductor to tree boles) is 15 feet, and 0.643 for 3-phase lines with a clear width of 11 feet (15 ft less ½ cross arm). The tree Risk Factor is 0 when clear width reaches 70 feet. There is a diminishing return in line security for investment in increased clear width. From a strictly economic perspective, reducing tree exposure to zero is not justified. When considering increasing the clearance between conductors and trees, the curve suggests that the optimum balance between reliability and cost can be found at clear widths of 25 feet to 50 feet.

Exhibit –1
Line Strike Probability for North Carolina Distribution



The use of a standard right of way width for distribution lines results in a situation where 3-phase lines face a higher tree risk than single-phase lines. In exploring the adjustment of tree to conductor clearance as a storm damage mitigation strategy, a higher priority should be assigned 3-phase lines. For the purposes of this examination, total clear width is increased to

30 feet, equal that of single phase. Accordingly, it will be assumed that on 3-phase lines the clear width will be increased by 19 feet. This would provide a total clear width of 30 feet and a right of way width of 68 feet with a residual tree risk of 0.274. The resulting improvement in line security is 57% (*Exhibit -2*).

On single-phase lines, clear width is increased by 15 feet (*Exhibit -3*) for a total of 30 feet and a residual tree risk of 0.274. The resulting improvement in line security is 49%.

Exhibit -2
Line Security Benefit of Increasing Clear Width on 3-Phase Lines

Cost: Benefit Analysis

Line Segment Specific:		Ac/mi	Trees/mi	Cost/mi	Line Security Improvement
Line Height	28				
Tree Height	75				
Trees/Ac	200				
Current Clear Width	11				
Current Risk Factor	0.643				
Increase Width	19	2.30	461		
New Risk Factor	**0.274**				**57%**
Removal Cost/tree *	$8			$3,685	
Removal Cost/tree **	$60			$27,636	

* Using feller buncher
** Chainsaw removals

Exhibit -3
Line Security Benefit of Increasing Clear Width on Single Phase Lines

Cost: Benefit Analysis

Line Segment Specific:		Ac/mi	Trees/mi	Cost/mi	Line Security Improvement
Line Height	28				
Tree Height	75				
Trees/Ac	200				
Current Clear Width	15				
Current Risk Factor	0.537				
Increase Width	15	1.82	364		
New Risk Factor	**0.274**				**49%**
Removal Cost/tree *	$8			$2,909	
Removal Cost/tree **	$60			$21,818	

* Using feller buncher
** Chainsaw removals

Costs and Benefits of Modifying Tree Exposure Versus Undergrounding

The potential for avoiding (in the range of 50%) storm damage merits suspending any judgement about the public acceptance of clearing trees another 15 to 19 feet from the power line, until we've examined where it could be applied and quantify the costs and benefits of doing so.

Undergrounding the distribution facilities would in most but not necessarily all cases eliminate tree-caused interruptions. At the time of tropical cyclone Isabel, soils were saturated and a large number of trees were uprooted. Should such an event occur where the electric system has been underground for some time, it is possible that uprooted trees might cause some disruption to the underground system. In general, however, we could assume that there would be no tree-caused outages, representing a 100% improvement. The cost of attaining this improvement in North Carolina is presented in *Exhibit –4*. Based on these costs, each percentage point of avoided damage costs $408 million.

Exhibit -4
Cost of Undergrounding NC Distribution System

Type of Line	Miles of Line	Cost per Mile	Cost (Billions)
Heavy/Commercial Urban	3,004	$2,053,000	$6.2
Three-phase Suburban	13,129	$1,229,000	$16.1
Three-phase Rural	15,296	$523,000	$8.0
Single-phase	36,846	$284,000	$10.5
Total	**68,275**	**-**	**$40.8**

Source: The Feasibility of Placing Electric Distribution Facilities Underground. Report of the Public Staff to the North Carolina Natural Disaster Preparedness Task Force, Nov. 2003.

Exhibit -5 shows the costs of avoiding about 50% of storm damage by increasing tree to conductor clearance 15 feet on single-phase and 19 feet on 3-phase. An adjustment has been made for the percent of forest cover in North Carolina as this approach need only be applied over the miles that have trees adjacent to the power lines. It was assumed for the Heavy/Commercial Urban type of lines that there is no exposure to forests or natural tree stands. Any trees in the proximity of these power lines are likely single rows of boulevard trees that are not suitable for the proposed approach. The total cost of implementing the increased clear width on 3-phase suburban, 3-phase rural and single-phase lines is $271.7 million. That is, for 0.7% of the cost of undergrounding the system, half of future storm damage could be avoided. Based on these costs, each 1% of avoided damage costs $5 million.

Exhibit -5
Cost of Increasing Clear Width
Adjusted for % Forest Cover

Type of Line	Miles of Line	Increased Clear Width (%)	Cost per Mile	Cost (Millions)
Heavy/Commercial Urban	3,004	0	-	-
Three-phase Suburban	13,129	62	$21,818	$177.6
Three-phase Rural	15,296	62	$2,909	$27.6
Single-phase	36,846	62	$2,909	$66.5
Total	**68,275**			**$271.7**

In the foregoing discussion it has been suggested that the total potential avoided storm damage is about 50%. This estimate is tested by applying the specific line security improvement for each line type. The distribution of the North Carolina ice storm restoration costs over the various line types is assumed by assigning 5% of the total costs to transmission and assuming the extent of tree exposure for each distribution line type. Had the proposed tree to conductor clearances been established prior to the ice storm, $61.29 million (51%) of the $120 million distribution restoration costs could have been avoided. Admittedly, the assignment of the ice storm costs to the different line types is based on some conjecture and using simply the exposure to trees fails to capture the higher cost of restoration for 3-phase versus single-phase lines. However, better data would serve only to shift the avoided restoration costs between line types, not substantially alter the total costs avoided.

Exhibit -6
Potential NC Ice Storm Restoration Costs Avoided
By Reduced Tree Exposure

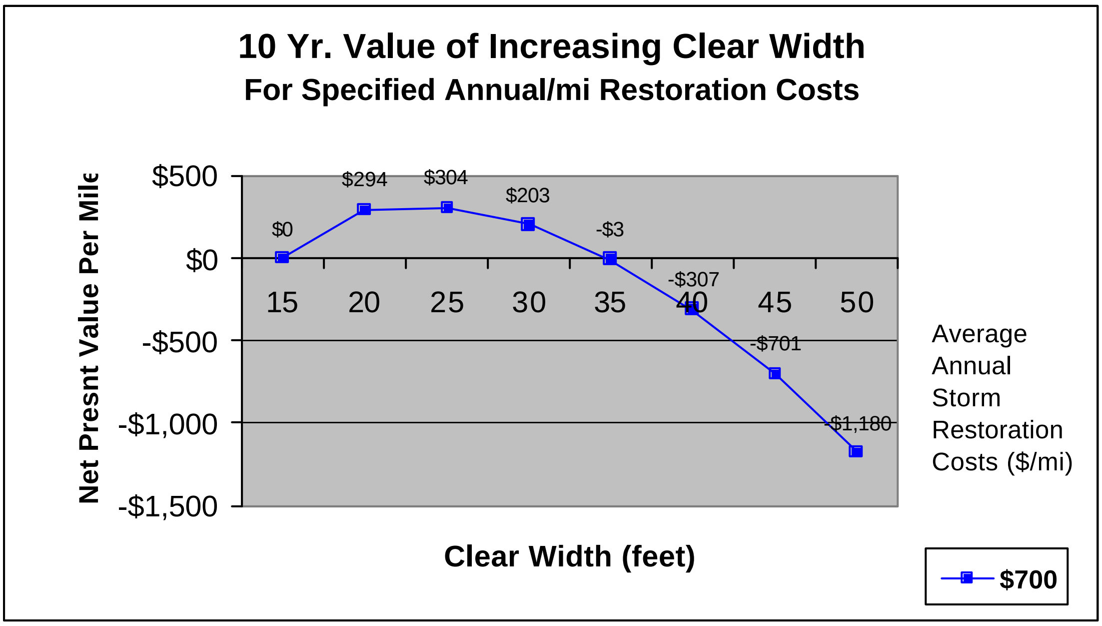
Type of Line	Miles of Line	% Assumed Exposure to Tree Damage	Miles Potentially Damaged by Trees	Distribution Restoration Costs (Millions)	Restoration Costs Avoided (Millions)
Heavy/Commercial Urban	3,004	15	451	$1.32	-
Three-phase Suburban	13,129	62	8,140	$23.87	$13.61
Three-phase Rural	15,296	62	9,484	$27.81	$15.85
Single-phase	36,846	62	22,845	$66.99	$32.83
Total	68,380		**40,920**	**$120**	**$61.29**

* 5% of damage assumed to be on transmission

Beyond Avoiding Storm Restoration Costs - It Pays to Reduce Tree Exposure

Part of any utility vegetation management program is the routine identification and removal of hazard trees. In reducing the residual tree exposure, the source of potential hazard trees is significantly reduced and this results in a reduced maintenance workload and further savings. For utilities that frequently experience damaging storms, such as those in the US East Coast,[50] a further analysis can be undertaken by considering the present value of avoided restoration, the cost of gaining additional clear width and the reduced need for future maintenance (*Exhibit -7*). Progress Energy Carolinas has reported that it spent over $300 million in storm repairs between 1996 and 2003.[51] When these costs are assigned to the treed distribution component of the system, average annual restoration costs are $700 per mile per year. Increasing the clear width from 15 feet to 30 feet yields a 10-year present value of $203 based on the previously stated hazard tree assumptions. That is, increasing the clear width has a positive rate of return.

Exhibit -7
Using Restoration Cost History to Determine Optimal Clear Width



Clearing the Myths to Reveal the Comparable Facts

Using the example of the North Carolina ice storm it has been illustrated that increasing the clear width to reduce the extent of tree exposure offers the opportunity for very substantial reductions in storm damage. It is a far more cost effective approach than undergrounding to

50 Johnson, Brad. 2004. Out of Sight, Out of Mind? Edison Electric Institute, Jan., 2004.
51 Price, Dudley. 2003. Raleigh, N.C.-Area Electricity Customers May Pay Higher Rates after Hurricane. The News & Observer, Raleigh, N.C., Oct. 12, 2003.

mitigating storm damage; and, it does not involve an investment of multiples of the current capital investment.

In the aftermath of the devastating 2004 Florida hurricanes, two themes emerged in media articles as a means of avoiding electric system damages in the future: more tree trimming[52] and burying lines.[53] [54] Each of these has associated myths that must be dispelled.

Tree trimming as it is normally conducted, has only a minor effect in reducing storm-related interruptions. Pruning, which effectively reduces storm damage, is crown height reduction to point where no line contact could be made on tree failure. It is highly unlikely that this is what the public, suggesting more tree trimming, envisions. Tree trimming that eliminates branches overhanging conductors may substantially reduce outage incidents when the nature of the storm event causes a lot of branch failure, as is typical in an ice storm. One of the challenges faced by North Carolina and other utilities are municipal ordinances restricting the extent of pruning. Returning to the previous example of the standard North Carolina pruning program that provides 15 feet of clearance to the side and above the line,[55] the line security improvement gained by removing all branches overhanging 3-phase conductors, where the greatest overhang is 15 feet, is 49%. While that is a substantial improvement, the benefit is only realized when the storm event causes predominantly branch failures. Tree trimming does not address the risk associated with trunk failures or uprooting. Only reducing the number of trees capable of interfering with lines can affect this risk.

The second myth is that burying lines will preserve trees. It will not unless the lines are to be put under the center of roadways. If lines are to be buried, essentially along the path of the current overhead system, the majority of trees within proximity of the line will have 25% to 40% of their roots severed by trenching and few will survive the experience.

Momentarily ignoring the economics, we currently have two approaches that can effectively reduce future storm damage to the electric system: undergrounding; and, the one introduced here, reducing the extent of tree exposure by increasing the clear width. Neither is friendly to trees. However, with increasing the clear width the impact on trees is immediately apparent while undergrounding will leave trees to die over a period of years and become a hazard and liability.

In 2004, electric system restoration costs in Florida alone were $1.2 billion.[56] Looking back ten years, the restoration costs for US East coast utilities exceeds $2 billion.[57] The potential to avoid half of these costs and thereby greatly reduce restoration times warrants an examination of how we might realize this saving.

52 Tampa Tribune. 2004. Tampa, Fla. Utilities say tree trimming can't prevent all hurricane outages. Tampa Tribune, Sept. 17, 2004.
53 South Florida Sun-Sentinel. 2004. Some Florida officials want utility FPL to bury lines to minimize outages. South Florida Sun-Sentinel, FL, Sept. 13, 2004.
54 Hurtibise, Ron. 2004. Outages, response spark debate. Daytona Beach News-Journal, Aug. 22, 2004.
55 North Carolina Utilities Commission and Public Staff. 2003. Response of Electric Utilities to the December 2002 Ice Storm. Report of the North Carolina Utilities Commission and the Public Staff, Sept., 2003.
56 Johnson, Bradley W. 2005. After The Storm. Electric Perspectives, May/June 2005.
57 Johnson, Bradley W. 2005. After The Storm. Electric Perspectives, May/June 2005. and media articles

Ratepayers as Partners In Storm Damage Avoidance

It was previously reported that a survey conducted following the 2002 North Carolina ice storm found 80% of households supported trimming trees further back. Far fewer, 49%, supported undergrounding and with only 11% willing to pay an additional $10 per month it may be surmised that none would support paying the actual costs which are ten times greater.

It is suggested that the public be engaged as co-operators in avoiding future storm damage. Gaining acceptance for greater tree to conductor clearances will require both an effective communication strategy and political and regulatory support. To a certain extent people can be engaged as co-operators in avoiding future storm damage by a direct contact, to communicate the necessity and benefit of the greater tree conductor clearance and soliciting their cooperation. If landowners are to become co-operators they must be treated as partners and this cannot be accomplished by written notification alone. Written material may serve as an adjunct to but not a replacement for face-to-face contacts. When properly trained personnel handle such property owner contacts, the result is a dialogue and a relationship. At the International Society of Arboriculture meeting in Toronto in 1990, TransAlta Utilities revealed a customer satisfaction rating of 96% for vegetation management work. In subsequent years the rating increased to 98%.[58] How could TransAlta experience the highest ratio of tree removals (75%) ever seen in the utility vegetation management business and obtain a 98% customer satisfaction rating? A contractor representative met each affected property owner face-to-face prior to the tree work. Essentially, through the relationship formed by the communication of needs and benefits of the proposed action, information exchange and the solicitation of the landowners' cooperation, the ratepayers became partners in the vegetation management program.

A study by Portland General Electric examining customer satisfaction with tree trimming found, of customers receiving crew contact prior to the work, 75% indicated being "more than satisfied" versus 33% for the customer group not contacted in advance. Further, all the customers contacted prior to work indicated performance met or exceeded expectations while 67% of the customers without crew contact felt performance was below expectations.

Meaningful Recognition of Co-operators

While these examples indicate a public openness to cooperating for the common good, the history of communities intervening in utility vegetation management programs[59] [60] [61] [62] indicates there will be some people who will strongly oppose greater tree clearances. Political and regulatory support, which acknowledges the role of, and provides an incentive to co-operators will be required to ensure a meaningful scale of implementation.

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58 Guggenmoos, S. 1995. *New program controls tree management.* Electric Light & Power, February 1995, p.15-18.

59 Wallman, Brittany. 2002. Broward County, Fla., May Adopt Tough Rules for Utility's Tree Trimming. South Florida Sun-Sentinel, Mar. 6, 2002.

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The regulatory actions required for meaningful recognition of the contribution of co-operators are:

1. To split customers into co-operators and non-co-operators
2. Provide a preferential rate for the co-operators, i.e., if the newly adopted clear width reduces the probability of tree-caused interruptions by 50%, then the co-operators would be assessed only 50% of the storm damage recovery
3. Require the utilities maintain a database of co-operators
4. Establish a process of periodic audits of the utilities' categorization of co-operators and non-co-operators

Finding Give to Soften the Take

We discussed, using North Carolina as an example, increasing clear width by another 15 feet. Let's be clear, this will have a major visual impact. Are there ways the utilities could support the potential co-operator, or generally, ameliorate the impact? There are. The first, will serve as a further incentive to become a co-operator and the second will ameliorate the visual impact. In rural areas, which are heavily treed, removing 15 feet of trees constitutes a timber harvesting operation. The utilities should seek to capture value for this timber and pass a net payment along to the cooperating landowner. The second involves providing the landowner with a tree vouchers for replacement trees for every tree removed that had historically been pruned. Of course, the replacement trees should be restricted to species, which at maturity will not interfere with power lines.

The intent in providing a tree voucher for replacement trees is to use the avoided cost of pruning to fund the tree replacement. Depending on the specifics of local pruning and nursery stock costs and the length of the pruning cycle, it may be possible to justify replacing every tree removed. As the avoided cost of pruning is greatly affected by the length of the pruning cycle, this possibility is most likely to arise in urban and suburban settings where current pruning cycles are of a shorter duration.

Exhibit - 8 presents the financial assessments of avoided pruning costs, which justify the provision of tree replacements. The following assumptions were used:

- 1 Span – length 330 ft.
- Trees regularly pruned situated in the first 7 ft of the 15 ft that will be cleared
- Pruning area represented = (330 ft X 7 ft)/43,560 ft^2 = .053 Acres
- Pruned trees represented = 200 trees/Ac X .053 Ac = 11 trees
- Trees to be removed = (330 ft X 15 ft)/43,560 ft^2 X 200 trees/Ac = 23 trees
- Cost of pruning = $35/tree
- Cost of tree voucher offered = $50
- Trees replaced = number of vouchers offered = 23
- Pruning maintenance cycle = every 3 years
- Discount rate = 10%

Typically, one would include the cost of the tree removal in the cost of the alternative. In this case, as we previously justified the cost of removal by avoided storm restoration costs, we ignore it. Thus, the cost of the alternative is the cost of the tree voucher times the number of trees removed.

Based on these assumptions, it would be possible to provide a tree voucher for every tree removed. This action is justified by 12 years of avoided pruning as the 11 trees previously pruned are among those removed (see Discounted Payback *Exhibit – 8*).

Exhibit -8
Economics of Reducing the Visual Impact

FINANCIAL ASSESSMENT OF ALTERNATIVES TO PRUNING
BASED ON PRESENT VALUE OF AVOIDED COST OF PRUNING

Pruning Cost	$35.00	Per Unit	**Landowner/Location Information**
Units to Prune	11	Number	
Trim Cycle	3	1 - 10 (Years)	
Tree Ownership	p	(P for private; M for municipality)	
Term	15	Years	
Discount Rate	10.00%	Based on required rate of return or opportunity cost	
Avoided Cost (PV)	**$1,270**	$ available for alternatives	
Cost of Alternative	$1,150	Total cost of implementing alternative	
Net Present Value	$120		© ECOSYNC 2003
			Resale and redistribution is prohibited.
Discounted Payback	12	Years	Serial Number: 00001
Internal Rate of Return	3.79%		

Assuming the benefits in reduced storm damage, outage duration and restoration costs of managing tree risks are effectively communicated to landowners, the visual impact of an additional 15 feet of clear width may still prove an irritant, even to understanding, cooperative property owners. Clearly, a process for the replacement of the trees removed, albeit with lower maturing trees, will serve to mitigate the impact and thereby increase landowner cooperation.

Conclusion

Areas routinely savaged by high wind and/or ice storms face not only the dangers and inconvenience of extended electric service interruptions but also the burden of elevated maintenance costs, as the electric system must be repeatedly rebuilt. As the costs of undergrounding the distribution system have been shown to be prohibitive, undergrounding does not represent a feasible approach to avoiding future storm damage.

Knowledge of the public passion for trees and fear of reprisal for suggesting greater tree to conductor clearances have kept the electric industry from full consideration of storm damage mitigation options. This omission, however, leaves us locked in the status quo of rebuilding the overhead electric system, further studying undergrounding only to conclude as we always have, that it is neither affordable nor feasible.

It is possible through a proper program of tree risk management to substantially reduce future storm damage. It's been illustrated that the avoidance of 50% of the currently experienced storm damage is within the realm of possibility. And in some cases, it will even pay to do so.