DISTRIBUTION WOOD POLE MANAGEMENT PRACTICES IN THE ELECTRIC UTILITY

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I. INTRODUCTION

This report presents results taken from work done in 2006 through 2012, including a poll of 31 utilities during a meeting of the Electric Energy Delivery Planning Consortium on aging infrastructure management practices, polls carried out at workshops on aging infrastructure and distribution planning held by Quanta Technology, and follow-up discussions and projects Quanta Technology had with utilities during this period. This work reported here was done in order to gain insight into the overall experience and approaches utilities have and are taking with regard to their aging wooden distribution structure asset bases. As a group, the utilities surveyed serve roughly 40% of the connected electric meters in the US and own roughly 60 million poles in 50 states. The focus of this work was on distribution-level poles - those generally placed in easements rather than rights-of-way and used for electric power voltages of 34.5 kV or below along with telephone and cable applications. Experience at the transmission level may be different.

II. LONG BUT VARIABLE SERVICE LIFETIMES

Like all utility equipment, wooden utility poles have finite lifetimes: the wear and tear of service will eventually result in each pole reaching a point where it cannot do its job: it will collapse or otherwise fail in some way important to the role it has in the utility system. This occurs because long service wears down a pole gradually due to rot, fatigue from stress, weather conditions, and other factors. Over time material strength drops. The “tear” of service comes from storm damage-- from wind, ice and snow loads, possible adverse contact with motor vehicles, lightning strikes, and perhaps other causes as well.

The word that came up over and over again in discussions and polling of utilities with regard to their experience with utility pole lifetime was “varies.” All poles deteriorate due to the wear and tear of service, but results vary: some last longer than others, even within the same utility or area of the system. Regionally, experience with pole lifetimes has a definite pattern. A major cause of gradual pole deterioration, and the cause of pole failure most often attributed to end of life by utilities surveyed, is rot. Utility poles are treated with anti-fungal preservatives to retard rotting, but over decades of service, this loses its effectiveness because it leeches out of the pole or otherwise deteriorates itself in effectiveness. Eventually, most poles not retreated will rot.

Regional Differences

Some areas of North America are much more benign with respect to the progression of rot than others. Figure 1 shows a map of the United States with areas identified by *wood protection hazard zone.* These zones go from 1, low hazard, to 5, severe hazard. Generally, what determines if a region is more of less hazardous to wood pole decay is its climate. Numerous factors including average temperature, soil acidity, etc., determine the amount of decay hazard a region has, but by far the most important factor is humidity and moisture. Very dry desert areas, whether warm or cold, and regardless of soil type, are more likely to be zone 1, whereas humid areas and those where there is a good deal of rainfall are more likely to be in a higher hazard zone, with those areas that are both wet and hot (e.g., along the Gulf Coast and SE being where most zone 5 areas are found.

Overall, Quanta Technology estimates that nationally wooden utility poles that are not maintained (this will be discussed later) have an average expected service lifetime of 53 years. However, Table 1 shows how poll and follow-up interviews with utilities indicated that this average varies with wood protection hazard zone:

a) Expected service lifetimes of poles that are not maintained average somewhere around 50-60 years if in a wood protection hazard zone 1 or 2.

b) Wood protection hazard zone 5 cuts expected lifetime by a factor of about 30% to 40%.

Figure 1: Map of the United States showing what are called wood protection hazard zones or wood decay hazard zones. Areas marked 1 are the most benign environment for wood pole,s and those marked 5 (SE US) being the harshest.

Table 1: Expected Lifetime of Wooden Utility Poles Without Comprehensive Maintenance

Area	Expected Age
U.S. avg	53
Zone 1	62
Zone 2	52
Zone 3	46
Zone 4	44
Zone 5	41

Failure and breakdown rates for wood poles are thought to increase exponentially with deterioration and advancing time in service. Many utilities reported that they have only limited quantitative data on failure rates as a function of age or condition, but that they see patterns of greatly increasing problems in areas where older poles predominate. Figure 2 shows the type of strictly increasing failure rate curve seen in most utilities systems: quantitative results vary but the overall nature of the curve everywhere seems to be as shown. Data for Figure 2 came from a detailed study of wood poles in which Quanta Technology worked for a large investor-owned electric utility in the Northern US in 2009-2010.

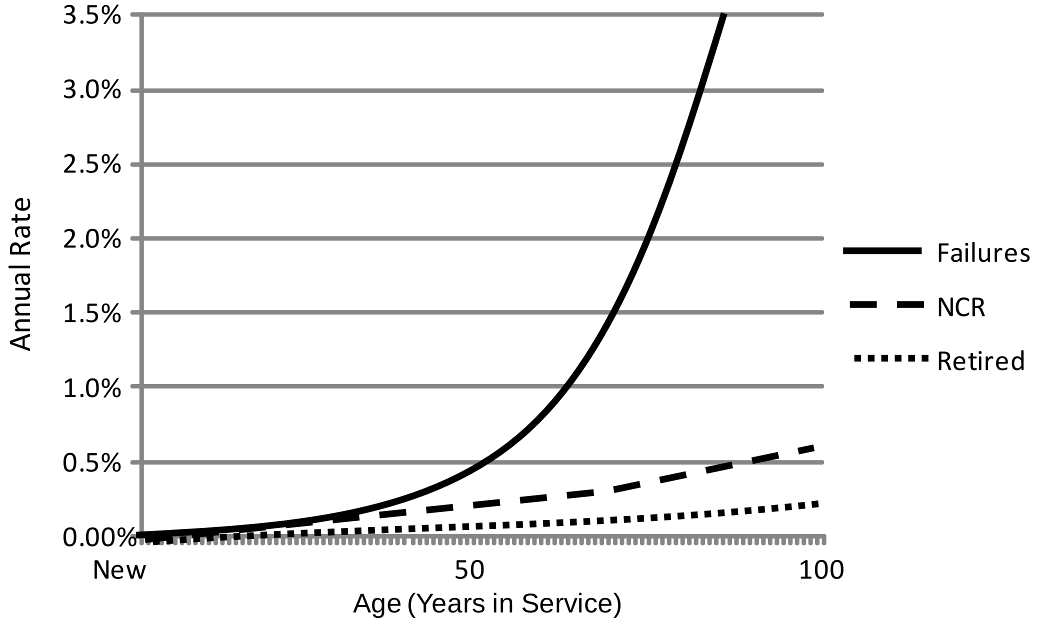

Figure 2: Annual rate of failure of wooden utility poles for a utility system in the Midwest United States (hazard zone 3) is given by the solid line - the statistical likelihood that a pole fails in a calendar year as a function of age (time in service) at the beginning of that year. This shows the typical progression of deterioration and cumulative damage of poles: failure rate both worsens over time and the rate of it worsening increases as well. Dotted and dashed lines refer to the likelihood that the pole is removed from service for reasons not related to its condition, such as the utility putting its utility line underground, etc. From *Aging Power Delivery Infrastructures – Second Edition,* expected to be published by CRC Francis and Taylor Publishers, New York and Boca Raton, in late 2012.

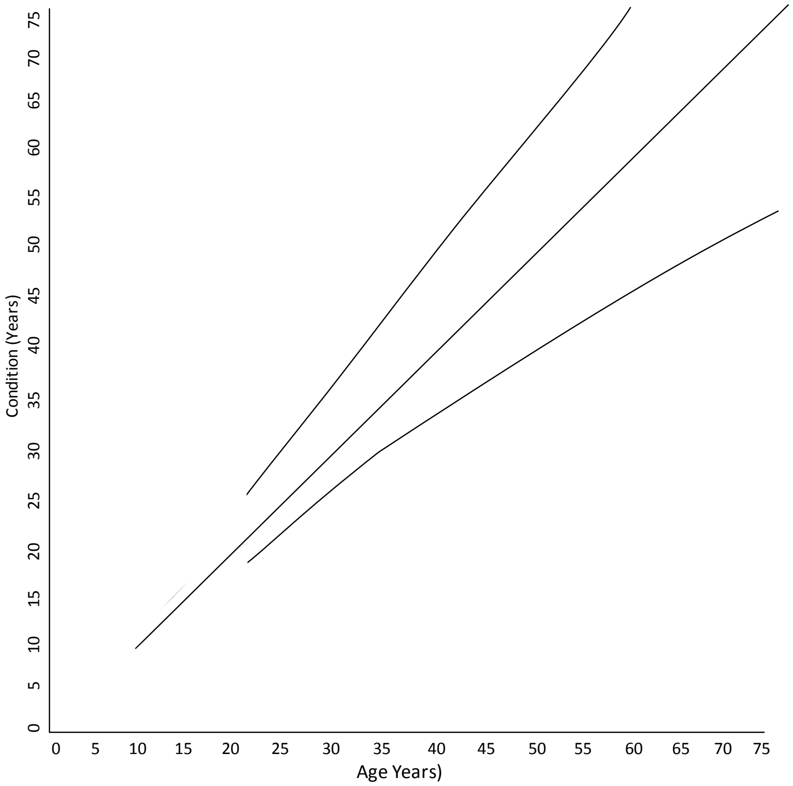

Figure 3 The variation in condition of any group of poles will broaden with age. These data were determined by actual examination of about 1,100 poles withdrawn from service over a period of years by a utility in the northern Midwest due to non-failure reasons (retirement, etc.) and then and destructively tested. Here, condition of poles is measured in "equivalent age." Average condition (middle line) is a linear function of estimated age because condition here is *defined* as deterioration equal to the average for that estimated age. Thus, a pole that is evaluated as condition = 50 years has deteriorated in strength to the point that it is as strong as the *average* fifty-year old pole, while one that is condition = 30 will have deteriorated to the average for 30-year old poles, regardless of its actual age. The upper and lower lines in the drawing above show the standard deviation of strength among poles of a certain age. While the average condition of 50 year old poles is condition = 50 years, the lower standard deviation is 37 years – nearly one in six poles that have been in service fifty years have deteriorated in strength only to the equivalent of just 37 years in service. They are in somewhat better condition than average for fifty years of service. On the other hand, the upper line shows that roughly the same number have deteriorated to the point that they are equivalent to the average 62-year old pole. From *Aging Power Delivery Infrastructures – Second Edition,* expected to be published by CRC Francis and Taylor Publishers, New York and Boca Raton, in late 2012.

Results Vary a Lot within a Zone, Utility, or Area of the System

All utilities reported that results with respect to wood pole deterioration, needs and lifetimes vary across their system. Some of this variation is clearly due to their service territories overlapping different wood protection hazard zones. American Electric Power, for example, serves load in hazard zones 1, 3, 4, and 5. However, all reported that wood pole deterioration and lifetimes will vary greatly within a region or even small area of their system. But while it is possible to anticipate that any particular pole will gradually lose strength over time, and to statistically predict the *average* loss of strength or failure rates for a large group of poles (Figure 1), the actual condition of any particular pole is not accurately predictable based only on data about its age, type, and location. Furthermore, after several decades in service, a group of poles that were very similar in size, type and strength when new will vary considerably as to deterioration and remaining strength. There average strength and the expected trend in that average can be discerned from statistical study of field survey and condition tracking results, but that analysis will also show that as poles age, the standard deviation of their deterioration and remaining strength increases. Figure 2 shows the condition standard deviation for the group of poles whose average is plotted in Figure 1.

Inspection and Maintenance Programs Can Roughly Double Pole Lifetimes

Results given in Table 1 are estimates of wood utility pole lifetimes when not “maintained.” Maintenance practices and needs vary depending on specifics of the situation and will be discussed later, but in general pole maintenance means periodic checking and anti-fungal re-treatment, perhaps every decade, with repairs made in a timely manner when and if rot, splitting, severe scaling, damage or other detectable problems are found. Table 2 gives estimated lifetimes expected with such comprehensive periodic maintenance developed by Quanta Technology from the poll results. Again, a wide standard deviation exists among older poles even when well maintained. Routine inspection and condition tracking can reduce the standard deviation of the utility’s knowledge of the deterioration and condition of specific poles noticeably, but not eliminate it altogether.

Table 2: Expected Lifetime of Wooden Utility Poles With Comprehensive Maintenance

Area	Expected Age
U.S. avg	96
Zone 1	112
Zone 2	103
Zone 3	96
Zone 4	89
Zone 5	82

INDUSTRY PRACTICE WITH REGARD TO INSPECTING AND MAINTAINING UTILITY POLES

Table 3 shows both how inspection and maintenance practices vary across those utilities Quanta Technology polled and worked with in the study reported here. Utilities surveyed included a cross-section of electric, telephone and cable, investor-owned, public, and utility co-operatives. Average results listed at the bottom on the table are weighted by number of poles the utility owns – results reported by a utility with a million poles were weighted twice as much as those with half a million, etc. The last row gives estimated results extrapolated to the entire United States based on utility type and size. From left to right, the data columns indicate the following data items.

Size – is the approximate number of poles, in thousands, owned by the utility as of 2010.

Except – Fd is marked with an "X" if the utility practices field exception inspections, which means that if its personnel working on any activity in the field see something that needs attention they report it and it is inspected. This is one of only two practices that were found to be essentially uniform (done by all utilities).

Patrol is marked with an "X" if the utility schedules routine, periodic patrol surveys of its electric, cable, or TV lines, as the case may be.

Vis Insp means visual inspection, and is marked with an "X" if the utility schedules routine visual inspections of its electric, cable, or TV lines and poles, as the case may be, on a periodic basis.

The difference between a patrol and a visual inspection is that the patrol is typically done from a vehicle and or helicopter where possible, whereas visual inspection involves inspectors walking or otherwise traveling the lines (horse, ATV) to get a much closer proximity at each pole inspected.

Pole inspection is marked with an X if the utility inspects all poles beyond a certain age on a periodic rotating basis with on-site inspections involving examination of the pole at and slightly below ground level. The most common age to begin inspection is around 22 years. An asterisk means the utility inspects some but not all poles in its system. In the majority of those cases this indicates the utility inspects poles in urban and suburban areas but not rural areas.

Anti-fungal is marked with an X if the utility applies anti-fungal compounds during inspections. This is almost a uniform practice in the industry: if pole inspections are done, so is antifungal treatment at that time.

Insp Verif is marked with a "X" if the utility independently verifies the accuracy of inspections in follow-up work by checking and tracking the quality of the data reported. About 83% (49% of the 59%) of utilities that do inspections do some amount of work to independently access the accuracy or dependability of the inspection results as part of their routine follow-up.

Rotation gives the number of years between the utility's periodic inspections. In some cases a range is given. This means the utility prioritizes more frequent inspections in some areas, usually older parts of the system, than in others. Industry average is to inspect about every ten years.

Table 3: Wood Pole Management Practices Study

Utility Description		Size	Except Fd	Patrol	Vis Insp	Pole Inspection	Anti-fungal?	Insp. Verif?	Rotation - Years	Begin inspect?	Archive/Condition	Number Archived	Maint Follow Up - Months	Capital Aging Infra Program
Type	**Region**													
Investor Owned Utility	Midwest	10065	X	X	X	*	*	X	10 to 15	25	urb-sub	3	12	targeted
Co-operative	East coast	135	X	X	X								1	
Investor Owned Utility	West coast	4850	X	X	X	*	*	X	10	25	circuit	4	12	all
Investor Owned Utility	West coast	5445	X	X		X	*	X	10	20	circuit	4	6	all
Investor Owned Utility	West coast	2475	X	X	X	*	*	X	5 to 20	30	urb-sub	2	24	targeted
Investor Owned Utility	Southeast	2255	X	X	X	X	X	X	5 to 10	10	urb-sub	3	12	all
Investor Owned Utility	Southeast	5500	X		X	X	*	X	2 to 10	20	sub circ	4	12	targeted
Investor Owned Utility	New England	6710	X	X	X	X	X	X	10 to 20	30			12	all
Municiple Utility	West coast	418	X	X		*	*	X	10	25			12	
Co-operative	Central US	275	X		X	*	*	X	15	30			12	
Investor Owned Utility	East coast	4675	X	X	X	*	*	X	10	20	pole	1	12	targeted
Municiple Utility	Central US	220	X		X								6	targeted
Municiple Utility	Central US	275	X	X	X	*	*	*	10 to 20	30	pole	2	12	
Investor Owned Utility	Central US	110	X	X	X	X	X	X	10	30	pole	3	12	
Co-operative	Central US	2310	X	X	X								2	
Investor Owned Utility	Midwest	275	X	X	X	*	*	X	10 to 20	20	circuit	1	12	targeted
Investor Owned Utility	East coast	2145	X	X	X	X	X	X	10	25	circuit	2	12	targeted
Investor Owned Utility	Central US	495	X								circuit	1	9	
Co-operative	Central US	440	X	X									36	
Municiple Utility	West coast	165	X		X						circuit	0	18	
Investor Owned Utility	Central US	1430	X	X	X	X	X	X	10 to 20	30	circuit	1	18	prioritizd
Investor Owned Utility	East coast	1430	X	X	X	X	X	X	10	20	circuit	2	4	prioritizd
Investor Owned Utility	Central US	825	X		X	*	*	*	10 to 20	30			12	
Investor Owned Utility	Southeast	4125	X	X		X	X	X	5 to 15	20	urb-sub	0 to 3	36	
Investor Owned Utility	West	4400	X	X	X	*	*	X	10 to 20	30	urb-sub	1 to 4	24	
Investor Owned Utility	East coast	1155	X	X	X	*	*	X	10	20		2	12	targeted
Investor Owned Utility	Northeast US	3905	X	X	X				5 to 10	25	40%	0 to 7	18	targeted
Investor Owned Utility	Midwest	715	X										6	
Investor Owned Utility	Midwest	1485	X											
Municiple Utility	New England	1155	X	X	X			X					24	prioritizd
	Modeled Result		100%	84%	87%	59%	59%	49%	10	22	56%	2.09	14	90%
	Extrapolated to United States Overall		100%	80%	80%	55%	55%	50%	10	25	55%	1.40	15	60%

Begin inspect is the age of a pole, or circuit area in the case of utilities that organize inspections by circuit of area, when the pole inspections and anti-fungal treatments begin. Average age when this occurs, nationwide, is about 22 years.

Archive/Condition means that the utility retains past inspection results and/or condition estimates of poles in an electronic format so that past and current inspection results can be compared to track trends and produce statistics on any given set of poles. "Urb-sub" means the utility does this only in non-rural areas of its system. "Circuit" or "sub-cir" means the utility keeps the information about pole condition on a line or circuit basis – organized into groups or poles by area of the system. "Pole" indicates the database has an entry and is searchable for every individual pole.

Number archived indicates how many past inspections, including the latest, the utility reported are in its database. As mentioned in Section II, many utilities began aging infrastructure programs in the 1990s: using an average ten-year inspection cycle, most now have only two or three inspection cycles archived. The average is slightly less than two.

Maint Follow-Up Months refers to the period after inspection, in months, within which the utility reported it would definitely complete all non-urgent repairs and maintenance called for in that inspection. The average is 15 months.

Capital Aging Infra Program indicates is the utility has a pro-active program in which it invests in pro-active replacement or refurbishment of poles and other attached hardware in order to control the aggregate condition of its system. "All" means the program is applied across the entire system, whereas "Targeted" indicates the programs is limited or aimed at specific areas of the system, usually those that are older. Both terms also mean the utility in using a method that focuses on managing or stabilized condition of poles and attached hardware. "Prioritized" indicates the utility uses instead a business-based approach called Asset Management. At least conceptually, that method applies across the entire system and prioritizes spending based not on condition alone, but on the expected improvement in business results such as customer satisfaction and reduction of future maintenance costs.

Inspection and Maintenance

Periodic inspection of utility poles is mandated in some regulatory jurisdictions but more utilities than those required to do so by regulators maintain an ongoing process of inspecting poles. Requirements vary but the most common regulatory requirement is around ten years. Most utilities reported that they do inspections either more thoroughly, or inspect and attend to poles slightly more often than mandated, at least in areas they have identified as more problematic (either due to age or systemic problems such as all poles in an area being of a type known to have shorter lifetimes). Visual inspection of poles is often done on a five- year basis. More detailed on-site inspection averages about ten years. The decision to inspect and maintain poles in the absence of or beyond regulatory requirements is justified by the reduction in the expected cost of repairs and replacements, and the longer service lifetimes, higher customer service reliability, and improved public and employee safety that will result. Utilities that have condition tracking systems reported the most satisfactory results.

Storm Restoration and Hardening

A few utilities have determined that inspection and maintenance also results in reduced system trauma during storms – fewer poles are damaged – thus yielding quicker system restoration times after the storm. Only one utility reported that it had already taken this benefit into account in its asset management decisions about the benefit/cost of inspection and maintenance program for its distribution plant. However, others noted they had seen this pattern and intended to both investigate and take it into account. Although tornadoes, hurricanes, and severe ice storms are in some sense "equal opportunity destroyers" of poles in the sense that they can knock down new as well as old utility poles, experience shows that well-maintained poles suffer as little as one-third the storm related failure rates of poles that are not comprehensively maintained. Thus, a comprehensive inspection and maintenance program is an effective first step in utility "storm hardening" programs.

Condition Evaluation and Condition Tracking

Many utilities reported that they archive results from past periodic inspections so they can not only refer to past inspection results and maintenance records, but study and track condition and other trends and patterns analytically Some classify the condition of equipment and required actions with condition gradation or health-index system like those shown in Table 4 and 5, while others maintain and study inspection results without classification and consider the cumulative trend of past and most recent inspections in managing their asset base. These condition tracking programs provide three benefits.

- They lead to improved data quality and consistency.
- They provide data the utility can use to better understand the amount and type of inspection, maintenance, and management methods it needs to obtain the results it wants.
- Tracking is useful in determining the condition of individual poles. A pole that deteriorated at a much faster rate in the most recent inspection period compared to the past is likely to continue to deteriorate at an accelerated rate.

Table 4: Condition Code Set Used By One Utility

Condition	Meaning	Actions
A	as new	Service and inspection as prescribed for "as new units" in Company Asset Management Guidelines
B	normal	Service and inspection as prescribed for "normal" units in Company Asset Management Guidelines
C	acceptable	Service and inspection as prescribed for "acceptable" units in the company's guidelines.
D	poor	Needs attention now. Service and inspect as prescribed for "poor" units.
E	very poor	Withdraw from service immediately

Table 5: Summary of Condition Evaluation Criteria for One Utility

Condition	Meaning	Criteria
A	as new	No visible or detectable difference from new equipment.
B	normal	Signs of service in surface weathering and fading. No sign of damage or deterioration.
C	acceptable	Signs of long service including heavy weathering, slight scaling. No signs of significant rot, splitting, damage, or scaling.
D	poor	Heavy scaling, and/or of incipient or active rot of less than 20% of cross-section. Noticeable damage. Assessed remaining strength within 10% of requirements.
E	very poor	Heavy scaling, splitting, or damage. Rot accounting for more than 20% of cross-section. Assessed strength less than requirements.

Inspection Follow Up

Inspection results alone, particularly if tracking over time to identify trends overall and specific to individual poles or areas of poles, do provide some value in and of themselves, giving the utility more information from which it can predict costs and performance and make plans. The roughly doubling of pole lifetimes that is shown between Tables 1 and 2, however, comes from maintenance: specifically, the anti-fungal re-treatment on a periodic basis, and follow-up to make repairs and fix problems found before they have much time escalate. Common utility practice is to replace or repair poles that are identified in an inspection as deficient or defective with two levels of priority. All utilities reported that defects or situations that are deemed urgent are done immediately or made while the inspection is taking place - on a "must do now" basis. Less urgent and routine maintenance found to be needed during inspections is scheduled for to be taken care of during on-going maintenance and service programs. Ihe typical period or cycle for this maintenance is about twelve to eighteen months.

For more information about this study

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