What's holding up your modern smart grid?

An aging wood pole plant from the 1950s.

Why every electric utility should have a long-term resource plan for improving structural resilience.

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Hurricanes. Nor-easters. Ice storms. Straight-line winds. Outages. Risk. Liability.

This is the stuff of a utility asset manager's nightmares.

And yet not enough utilities are investing properly in the long-term health of the wooden infrastructure that keeps electricity flowing to homes and businesses throughout the U.S.

Conversely, utilities are pouring money into smart grid investments that may be obsolete in a decade or two. The industry has already spent billions and is projected to spend billions more on technology investments to expand and further improve smart grid infrastructure. But supporting all of this new technology is a very old one: a field force of wood utility poles in varying states of repair and with far too many only a few years from reject status—if they're not there already.

Ensuring the strength and resilience of the wood pole plant should be a key component of every utility's grid modernization investment. A successful, programmatic approach to wood pole inspection and treatment can be implemented at a fraction of the cost of the utility's overall smart grid investment—while delivering well-documented financial, operating and system resiliency returns.

And helping asset managers and executives to sleep a bit better at night.

What is "reject status"?

In the United States, the National Electrical Safety Code (NESC) establishes minimum criteria that allows for some strength loss in wood poles before a pole is rejected—and must be restored or replaced. Utilities generally follow those minimum criteria by restoring or replacing a pole that is evaluated to have 67% or less of its required bending strength.

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Utilities are investing billions in smart grid technologies.

According to the U.S. Department of Energy, "Smart grid technology is being deployed to improve operational efficiency, reliability and resilience, but also to address the integration and utilization of distributed energy resources (DERs) where they are being adopted." In a 2018 report, the department stated that annual smart grid investments rose 41% between 2014 and 2016 from $3.4 billion to $4.8 billion—and are expected to rise to $13.8 billion in 2024.

The Edison Electric Institute reports even higher investment. According to their numbers, EEI's member companies have invested nearly $1 trillion since 2010 to build smarter energy infrastructure and to integrate new generation. These companies continue to invest over $110 billion per year to that end.

As part of this effort, over 98 million smart meters have been deployed across the country, covering about 70% of U.S. households. Expect another round of meter investments to come soon. Smart meter vendors are readying their latest generation of technology which leap frogs the installed-base of equipment in edge-intelligence and enables utilities to deliver a new range of services. Entire smart communities are being "powered by smarter energy infrastructure," with projects underway in applications like transportation/ streetcars, parking sensors, electric vehicle (EV) charging stations, street lighting and highspeed internet access. EEI says members are spending about $1.4 billion on EV charging infrastructure alone.

Electric utilities are also heavily investing in distributed energy resources (DER). There are about two million distributed solar installations, for example, which are expected to double by 2023. And yet, Mackinnon Lawrence, Research Director at Navigant research, explains, "In the U.S., we haven't even begun to scratch the surface in terms of optimizing [DER] assets on the grid." DER could meet an estimated 20% of peak load by 2030. US energy storage annual capacity is also expected to keep growing—by 12 times—through 2024.

The numbers show that electric utilities have invested many billions of dollars to add smart technologies to the electric grid—and they'll continue to spend many more billions moving forward.

But what about the structures holding it all in the air?

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Wood pole infrastructure faces increased demands.

In addition to all of the smart technology that has been added to the electrical grid, fiber buildout continues at an aggressive pace, increasing demands on system capacity. The FCC recently authorized more than $240 million in new rural broadband subsidies—the ninth allocation from the 2018 Connect America Fund (CAF) Phase II auction, which allocated $1.488 billion for the initiative intended to connect 700,000 homes.

Add to this the coming wave of 5G technology which requires utilities to hang additional fiber lines plus backpack-sized antennas and batteries spaced at 1500-foot intervals along their distribution infrastructure. It's estimated that the load on poles will increase by 10 to 15% from 5G-related equipment alone.

Meanwhile, the electrical grid must now withstand a potential increase in the intensity and frequency of extreme weather events. The Center for Climate and Energy Solutions (C2ES) explains, "Based on complex modeling, NOAA has suggested that an increase in Category 4 and 5 hurricanes is likely, with hurricane wind speeds increasing by up to 10%. Warmer sea temperatures also are causing hurricanes to be wetter, with 10 to 15% more precipitation from cyclones projected in a 2 degrees Celsius scenario."

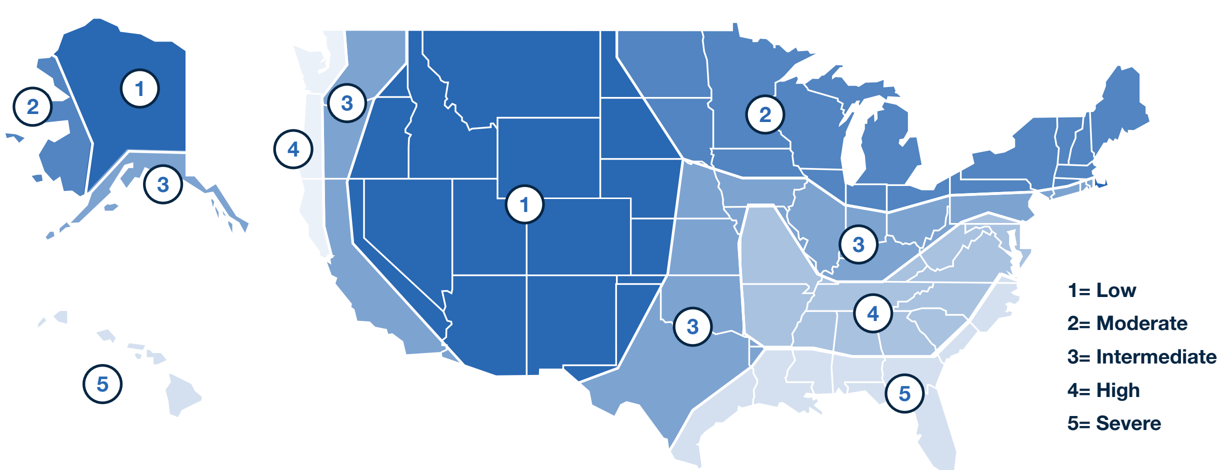
The situation is also worsening for other black sky events. In a recent Utility Dive article, Natalie Ambrosio, Communications Director for climate-related risk firm 427, explained, "More frequent climate change-related extreme weather is showing utilities the past is no longer an accurate representation of what the future might look like." Both increased demand and increasingly severe storms require a strong, healthy transmission and distribution (T&D) infrastructure to reliably deliver electricity with minimal disruptions. But, according to Utility Dive, "…maintaining a high functioning power system is getting harder, which makes the risks, costs, and value of resilience more important."

Smart grid investments sit atop a less-than-modern infrastructure.

Despite the steady influx of spending on grid modernization and the clear need for a strong T&D infrastructure, the wood pole plant in the U.S. has not been adequately maintained or prepared for new demands. The American Society of Civil Engineers' 2017 infrastructure report card gave the U.S. energy system a grade of D+, explaining: "Some parts of the U.S. electric grid predate the turn of the 20th century. Most T&D lines were constructed in the 1950s and 1960s with a 50-year life expectancy, and were not originally engineered to meet today's demand, nor severe weather events."

An estimated 150 million wood poles form the backbone of the electric grid, supporting the delivery of electricity and telecommunications across America. According to an Accenture study, poles and fixtures are the fourth largest distribution plant-in-service asset class after overhead and underground conductors and transformers, representing approximately 14% of the total plant investment. None of these assets is getting younger. Osmose data indicates the average age of wood poles in service on investor-owned systems is 33.9 years nationally, while the average age of reject status across the country is 45.3 years. However, these averages vary across regions or "decay zones," which are geographically defined by the American Wood Protection Association (AWPA) in Figure 1. For example, the average reject age in Zone 2 is nearly 57 years—but Zone 5 is only about 40 years.

Figure 1. Deterioration Zones



More telling is the data which shows that approximately 29% of the IOU wood pole plant is already 46 years old or older, with 19% older than 51 years. Large segments of the pole population that have not been maintained with supplemental treatments are currently reaching the end of their expected service life or exceeding their useful life, as defined by the National Electrical Safety Code® (NESC®) strength requirements for wood poles.

The cost of installing a new wood pole varies by company and service territory from about $2,000 on the low end to $8,000 or even $15,000 on the high end. Using a conservative estimate of $3,000 per pole, replacing 50% of the wood pole plant in the U.S. would cost the industry about $225 billion. Wholesale replacement of large groups of poles over the next decade and a half is clearly not a realistic possibility—even if utilities had the budgets, the required line crews or contractor resources would not be available.

Many pole maintenance programs lack rigor, increase utilities' risk and liability.

The original preservative treatment of in-service poles may deplete over time, losing the ability to resist decay. Once that happens, the pole is susceptible to decay and insect attack, and is likely to start losing strength—primarily from the groundline to 18" below. Many utilities have very basic inspection-only programs for their wood poles that identify only a portion of the reject poles, the "worst of the worst," for pole replacement. These programs fail to identify most of the poles that have less decay than a reject. Further, these programs do not include application of supplemental treatment that stops the decay process and extends pole life to greatly reduce the life cycle cost of pole ownership.

Often, limited operations and maintenance (O&M) budgets dictate that utilities must elect to inspect fewer poles with higher quality programs—or inspect a lot of poles with subpar programs that do little to extend the pole plant's useful life. In addition, there are often large pole replacement backlogs that go unaddressed for long periods of time.

With many unidentified and/or untreated rejects in service, each utility takes on additional risk and liability. Subpar wood pole programs increase the risk of pole failures, especially during storms, and often result in extended outages. Pole failures also open the utility up to additional liability in cases of property damage or injuries to the public—especially when no inspection program has been in place.

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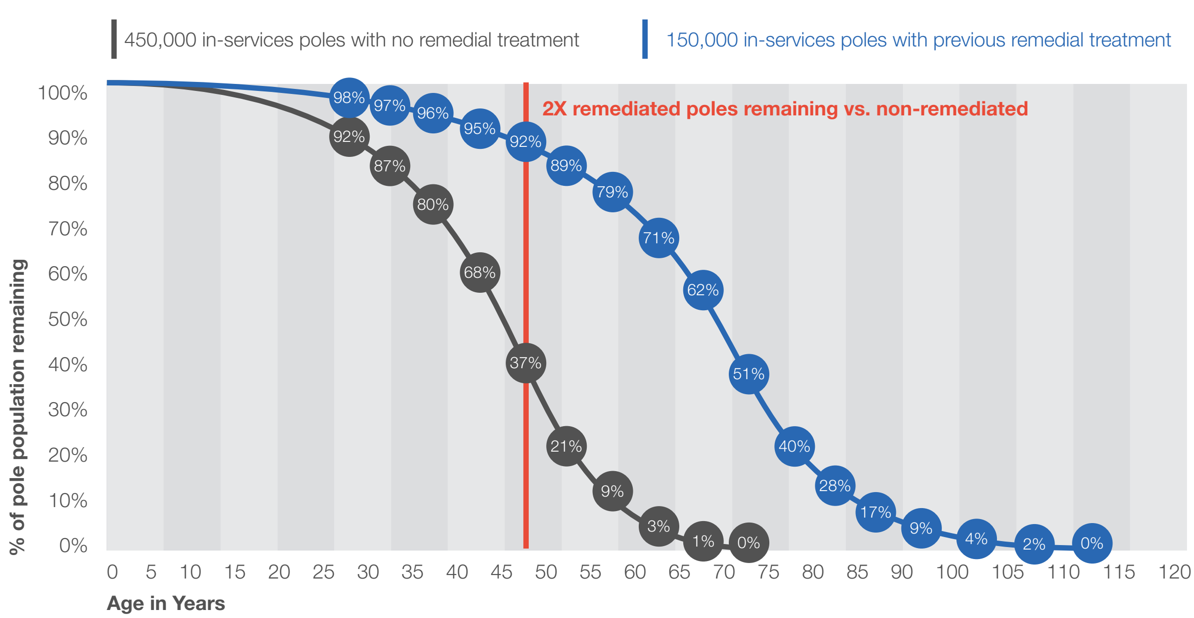
A comprehensive wood pole life extension program as a capital project supports the growing smart grid.

At the other end of the spectrum, comprehensive inspection programs that include multiple inspection tools and methods along with the application of remedial groundline treatments, have proven to extend useful life of wood poles. The total cost of a comprehensive program based on today's dollar is only about $200 over the service life of the pole.

The main barrier to better wood pole maintenance is the O&M budget—essentially, it's often shrinking while the pole plant is always aging. However, a life extension program can qualify as a betterment or substantial addition to the plant rather than simply a typical maintenance expense. As a result, many utility companies capitalize a significant portion of the program cost.

Pole data has historically been compiled and reported in the form of a survivor curve showing relative reject rates with and without pole inspection and remedial treatment. In this analysis conducted by Oliver Wyman—a leading global management consulting firm—data from 600,000 poles representing all five decay zones was analyzed. Actuarial survival analysis modeling was used to project expected pole failure ages. As shown in Figure 2, at the 46 to 50 year

Figure 2. Observed Survival Rates, Projected General Linear Model

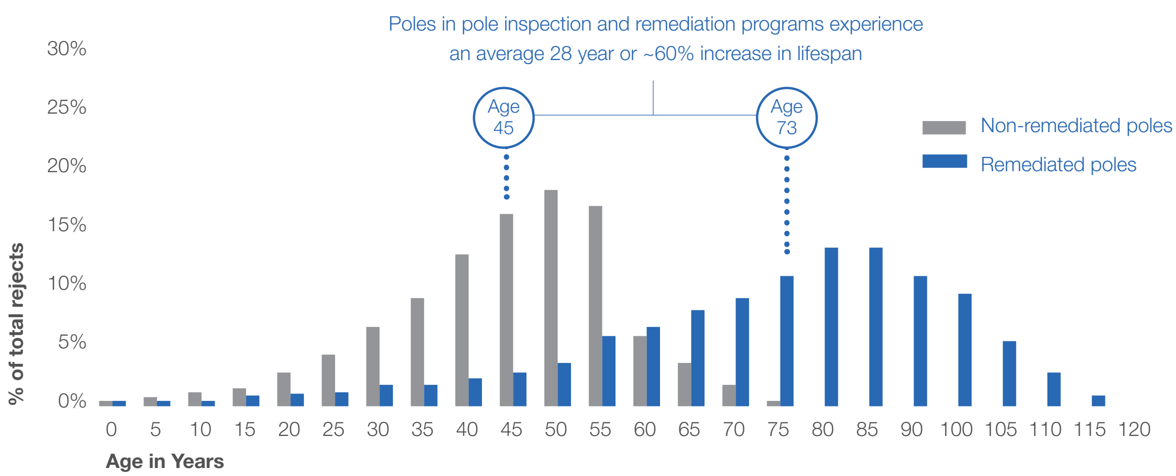


age band, there are twice the number of remediated versus non-remediated poles remaining in service. Meaningful separation begins to show in the 21 to 25 year age range.

The data can also be used to compare expected average life without remedial treatment to the extended average life with comprehensive inspection and treatment. Figure 3 shows the average life without remedial treatment is 45 years. With remedial treatment, the average wood pole life is 73 years—a 28-year or 60% increase. Individual utility calculations on useful life extension relative to their specific pole plants may be validated and adjusted based on local

Figure 3. Life Extension of the Asset, Projected General Linear Model

Projecting reject rates for poles past age 50 shows an even larger life extension due to pole inspection and remediation



environmental factors (geographic location, decay zone), asset demographics (wood species, original treatment) and past remedial treatment program history.

A comprehensive inspection program with remedial pole treatment can therefore be considered for capital spend with a well-documented and supportable life extension benefit. Ultimately, a life extension program for a utility's wood pole plant both extends the life of the plant while also reducing long-term costs to maintain the T&D system by deferring capital replacement costs. Proper investment levels through this approach also improve system resilience, which reduces outages, time of restoration and the cost of restoration. The result is a very effective asset investment strategy targeted at the wood pole plant

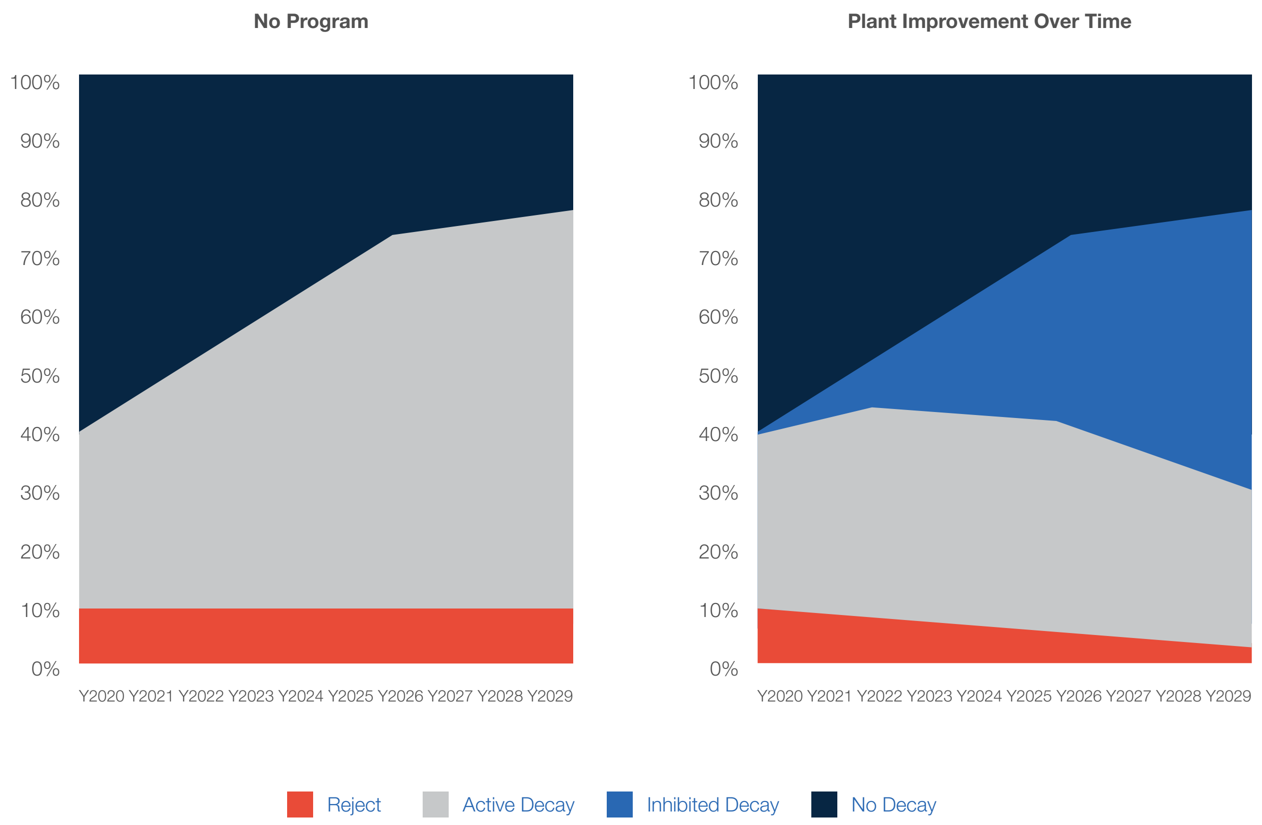
A life extension program for a utility's wood pole plant both extends the life of the plant while also reducing long-term costs to maintain the T&D system by deferring capital replacement costs.

which can be accomplished for a small fraction of the billions of dollars utilities are investing in their smart grid technologies. The utility (and the ratepayer) pays less over time and ends up with a more reliable, structurally resilient pole plant to support future smart grid investments.

As Brien Sheahan, Former Chair of the Illinois Commerce Commission, explained, "Regulators need to take leadership on the very difficult questions about the value of utility investments in resilience against the cost to consumers, because what we are seeing … shows that investment in resilience can be worth the cost."

Benefits of an optimized wood pole life extension program:

- Significantly extended useful life
- Lower total cost of ownership
- Improved structural resiliency
- Shorter outage restoration times
- Lower cost to ratepayer
- Significant plant improvement over time



Best-in-class programs see customer and system benefits—especially after black sky events.

Recent case studies have shown that utilities with an optimized, robust maintenance strategy experience up to 70% fewer pole failures during major storms (and achieve similarly faster system restoration times).

A large southeast utility, for example, suffered over 12,000 wood pole failures in 2005 with category 3 hurricane Wilma—and only 4% of those outages were restored within 24 hours. After this devastating storm, the utility decided to invest in hardening their wood pole plant. This investment included inspection and treatment of more than 1.2 million poles, as well as restoring and replacing rejected poles and other system hardening measures.

They were ready when category 4 hurricane Irma struck in 2017 and saw a 70% reduction in pole failures—even though it was a stronger storm and impacted their entire service territory (see Figure 4). In addition, they were able to restore 40% of their outages in the first 24 hours.

Figure 4.

2005 Hurricane Wilma	2006-2014 System Hardening Program	2017 Hurricane Irma	
Category 3 Hurricane	Inspect & treat > 1.2M Poles. Restore or replace rejected poles.	Category 4 Hurricane	
12,000+ Wood Pole Failures	130mph design. Strengthened 860+ feeders (CNET - Truss, replacements)	70% Fewer Pole Failures (0 due to wind)	70% REDUCTION
4% of Outages Restored in 24HRS	$2B+ Investment in Infrastructure (incl. metering & preventative maintenance)	40% of Outages Restored in 24HRS	10X IMPROVEMENT

In another black sky event, a hurricane struck a pair of coastal utilities with very different approaches to pole inspection and remediation. Utility A had a very limited program which identified only a small percentage of their reject poles. Utility B used a full excavate and treatment program and systematically identified and remediated a large percentage of their reject poles annually. In other words, Utility B was more reliably identifying issues, strengthening their pole plant and replacing poles as necessary.

The hurricane made landfall in Utility B's territory, yet Utility A's territory suffered much more significant outages and pole losses (Figure 5). With increased structural resilience, Utility B experienced fewer, less extended outages and was able to restore power to customers more quickly and at a much lower cost.

Figure 5. Neighboring Utilities Impacted by the Same Hurricane

	Utility A	Utility B	
Pole Inspection Reject Accuracy	98%	30%	
	Actual Numbers	Factored Numbers	
Wood Poles Replaced	152	2,790*	**18x**
Number of Peak Outages	95,000	487,984*	**5x**
Cost of Restoration	$20M	$310M	**16x**
Time of Restoration	100% in 5 days	100% in 13 days	

Investment in the wood pole plant is an investment in the future of the grid.

Thanks to low cost, ease of installation and favorable performance characteristics, wood poles are expected to remain the primary structures supporting the distribution grid going forward. Investment in the utility's wood poles equates to an investment in keeping the increasingly-smart grid secure and resilient—every utility should have robust, well designed life extension program in place for their pole plant.

Proactive utility asset managers may still have unsettling dreams about the next big storm, but they can rest more easily knowing that their wood pole program is retaining the strength of their plant rather than letting it gradually degrade. They can feel confident that they're doing all they can to limit outages, restoration times and system risk—while continuing to deliver customer value from new and exciting technologies, too.

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