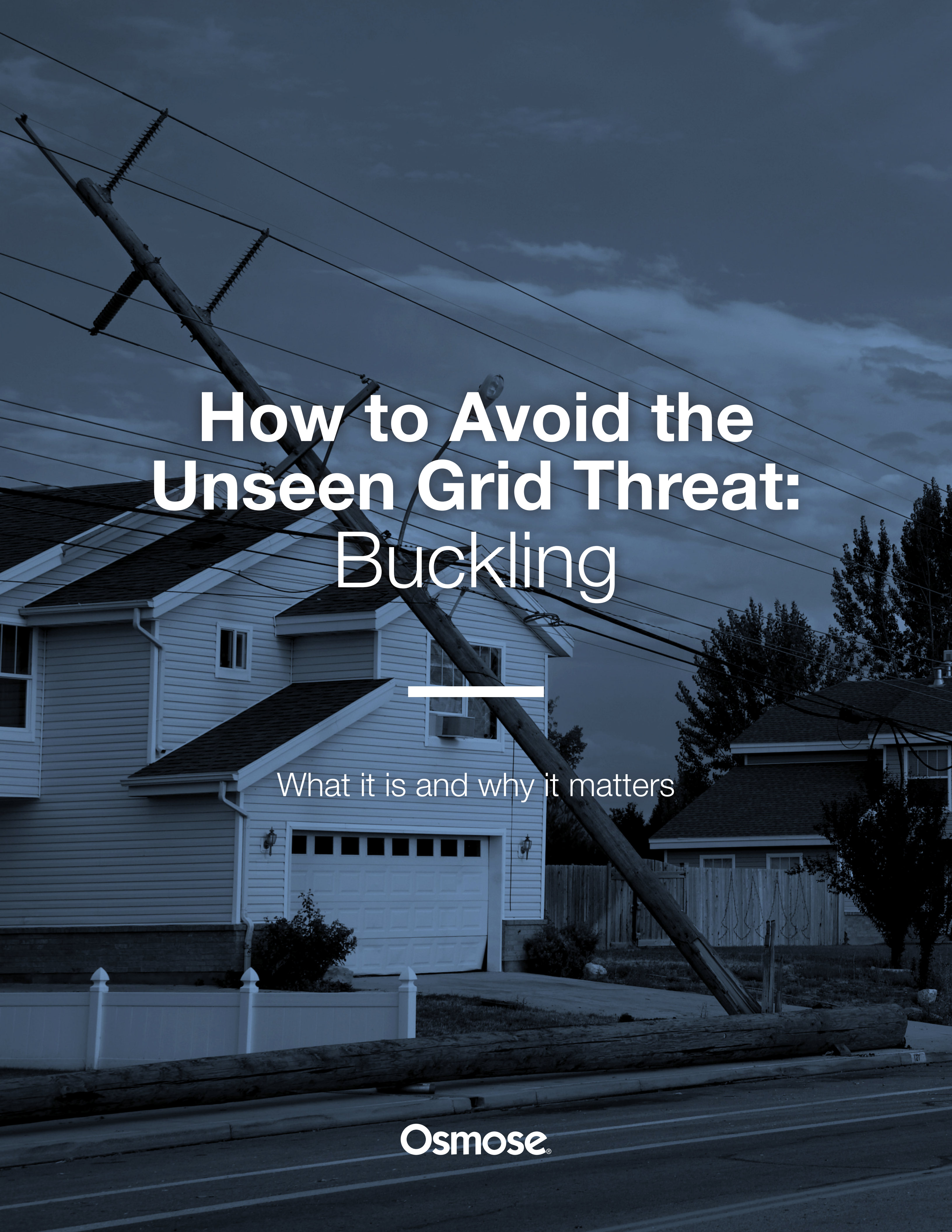

How to Avoid the Unseen Grid Threat: Buckling

What it is and why it matters

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It was a seemingly normal spring day in the western United States

when 26 utility poles crashed onto a busy six lane street. One of the poles barely missed a passing cyclist, while the crossarm of another landed between a couple driving their car. The two were trapped in their car for over an hour while rescue crews worked to de-energize the power lines and free the couple from their vehicle.

Apart from one report of lightning that turned out to be an electrical flash, it was typical April weather for the region—light rain with a maximum wind speed of less than 50 mph, certainly nothing that would normally bring down utility poles. What, then, led to this disastrous utility pole failure?

A later report from an investigation into the event revealed that several consecutive poles in the middle of the 26 had a "significant amount of internal groundline decay" and were the first poles to fail. Rather than breaking due to extreme winds, these poles buckled in the face of moderate gusts because internal rot left them with just a thin remaining outer shell at the ground line – which is the pole section from 6 inches above ground to 18 inches below. With two circuits of large diameter electric lines attached to these poles, the failure of the first poles caused others on both sides to be pulled down by the conductors in a domino fashion.

Over the past decade, innovative inspection service providers have developed new techniques to detect these unseen risks in a scalable way. Now, after extensive usage, data analysis shows significant savings from this more precise method – not just from earlier identification of poles that were higher risk than initially believed but also by avoiding the premature removal of others that were in better shape than old inspection approaches suggested.

Bending versus Buckling

Any executive responsible for risk management at an electric utility or telecommunications provider with wood pole overhead lines should understand the distinction between decayed poles that fail in a bending mode versus those that are likely to fail due to localized buckling. The likelihood of buckling often is not fully appreciated or even detected and can cause the most dangerous and expensive surprises. It is essential to know the difference between these failure modes because it impacts how these conditions can be detected as well as properly and economically addressed.

Bending and Breaking

A utility pole will break when the wind load exerted on the pole causes it to bend until the force exceeds the pole's bending strength capacity and it snaps, often in the ground line zone. It takes extreme wind to cause a healthy pole with a solid cross section to reach its ultimate bending capacity. External decay below ground causes a direct reduction in pole bending strength but is fairly easy to measure and the pole will still fail in a bending mode.

Buckling and Collapsing

When advanced internal decay occurs in a utility pole, the outer shell wall becomes thin – especially near the groundline of the pole – and localized buckling becomes a risk. It takes far less wind load to cause a thin-shelled pole – hiding hollow internal pockets created by decay – to buckle. With a moderate wind and a pole with advanced internal decay, the thin outer shell may collapse into itself causing the structure to fall. The key question to ask is, "Did our assessment of a pole's remaining strength account for advanced internal decay at the groundline?"

Figure 1 is an example of how poles without decay or with external decay typically fail in bending. **Figure 2** shows how a thin-walled steel pole fails due to localized buckling. While this article is about wood pole buckling, we use a steel pole example here simply to provide a clear illustration of the nature of localized buckling that occurs in a thin-walled cylinder.

As pole owners grapple with the specter of pricey, overdue pole replacements and a growing shortage of skilled utility line workers, the risk of misreading the threat of buckling is greater than ever. Accurate assessment is essential for appropriate handling of decay patterns that induce buckling. Application of effective supplemental preservatives can help prevent advanced internal decay and the risk of premature buckling failures. Restoration solutions such as steel trussing may also be used to mechanically restore strength to decaying poles. First, though, utilities need to adopt pole inspection practices that more accurately measure the strength-depleting impact of internal decay. They also need to implement more informative reporting that appropriately communicates buckling risk.

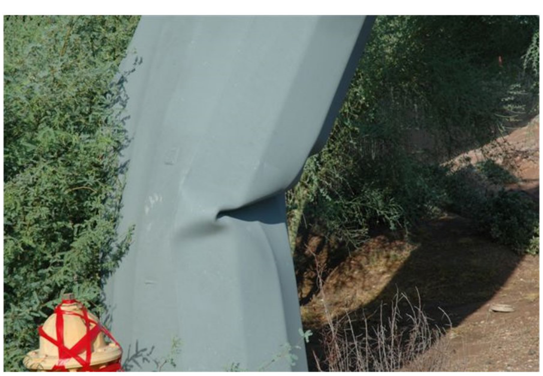
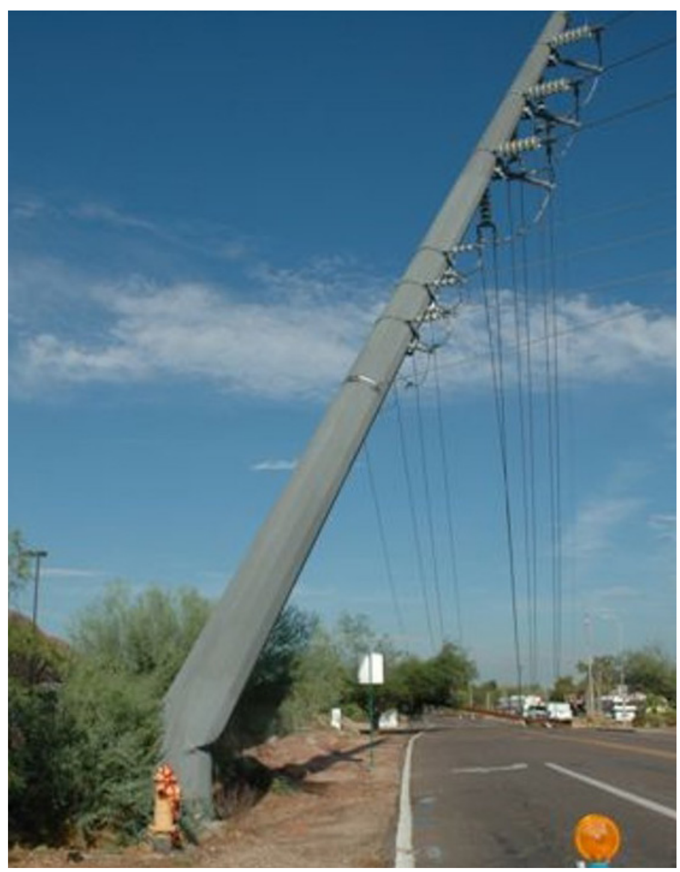


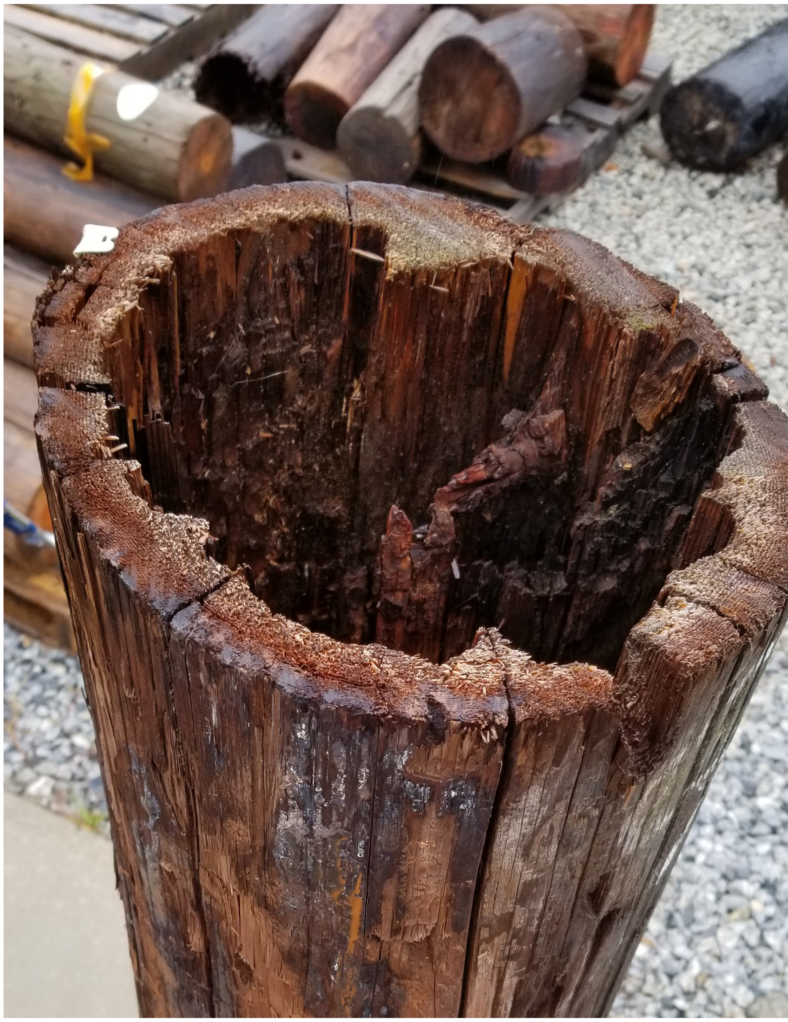
Figure 1. Wood Pole Bending Failure.

Figure 2. Steel Pole Localized Buckling Failure.



What You Can't See Can Hurt You

Wood poles support the overhead lines that provide critical electric and telecommunications services across the country. Those poles are treated with a preservative during manufacturing which helps poles resist decay deterioration. However, after many years of service, the level of the original treatment may no longer be adequate to resist decay – particularly at the groundline.



The groundline section of a pole is most prone to decay because that is where the necessary conditions of moisture, oxygen, food (untreated wood), and temperature exist. The outer shell of a pole below ground may be where decay begins, or decay may initiate internally which eventually leads to voids in the pole. Groundline decay causes a direct reduction in pole bending capacity since the groundline is where poles are likely to break when the applied ice and wind loading exceeds pole capacity. Advanced internal decay can transform solid wood poles into thin-walled cylinders. This shifts the potential failure mode of the pole from a risk of breakage due to bending to a risk of localized buckling.

The problem is: pole safety guidelines and inspection techniques are focused primarily on bending strength. They underestimate how large internal pockets of rot at the groundline may dramatically reduce the actual remaining strength of a pole.

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The National Electrical Safety Code (NESC) requires that if a wood pole deteriorates to the point where it has 2/3rds or less of the required strength, the structure needs to be rehabilitated or replaced. Historically, utilities have considered a pole's outer remaining circumference and average sound wood shell thickness as key factors in determining pass/fail criteria. For poles found to have significant internal decay, a common industry practice has been to reject a pole if the measured average sound shell thickness is found to be 2 inches or less for any distribution pole. Averages and "rule of thumb" parameters, however, don't account for the fact that shell thickness may not deteriorate evenly or consistently from within a pole.

Advanced enclosed decay pockets are characteristic of rot that leads to buckling. These pockets are off-center voids, which means the thickness of the remaining sound shell often varies at different points around the circumference of the pole. Certain quadrants of a pole's cross-section are more likely to cause buckling than others due to the relative orientation to wires, equipment, and wind load. If a significant void is aligned with the pole quadrant that is most likely to cause buckling there is a greater risk of buckling failure.

Making matters worse, there were no tools or methods that pole inspectors could use to factor for buckling risk when estimating the remaining strength. Utility pole owners accepted pass/fail decisions that were likely conservative on one hand and liberal on another. For smaller circumference poles, the remaining strength estimates were likely less than actual which prematurely identified poles for replacement. For larger poles, the remaining strength estimates were greater than actual strength, leaving unaddressed poles in the field below code requirements.

Most field methods to determine remaining strength values on thin-walled poles were based on bending capacity only, and therefore often overstated the expected capacity of larger poles. To more effectively account for buckling risk, the best assessment process is to determine the pole's remaining shell thickness in each quadrant around the pole by boring in the groundline zone. Rather than simply averaging the remaining sound wood shell thickness values measured, a weighted calculation that considers the relative risk of buckling due to void locations and remaining shell thickness for each quadrant should be used. To conduct this method efficiently, the industry needed a new, automated tool to process the right pole buckling risk factors in a fast, scalable, and accurate way.

A Better Way

In 2005, Osmose introduced StrengthCalc™ software that models the cross section of decaying poles in relation to the direction of wind loading. Through continuous improvement since its launch, StrengthCalc is able to account for the likelihood of buckling; aligning the severity of thin-walled conditions in each quadrant along with consideration for their orientation to the wind loading. This buckling algorithm delivers a more precise calculation that provide utilities with the effective remaining strength (adjusted for pole-specific buckling risk when necessary) as a percent of the original strength. StrengthCalc remains the only mobile pole strength calculation tool available that accounts for the threat of wood pole localized buckling.

Utility poles can fail for a variety of reasons, so how much of a difference does accounting for buckling risk using a calculator like StrengthCalc actually make? To answer this question, we evaluated the inspection results of over 59,300 hollow poles across the Osmose national database to see how many times the software tool properly identified poles that should have been removed from service.

Out of the 59,310 poles, approximately 19,050 had greater than 2 inches of average sound shell and 40,260 had 2 inches or less of average sound shell. Because of the unique functionality of StrengthCalc that accounts for buckling and orients shell thickness relative to the direction of wind loading, risk is more accurately reflected in the result.

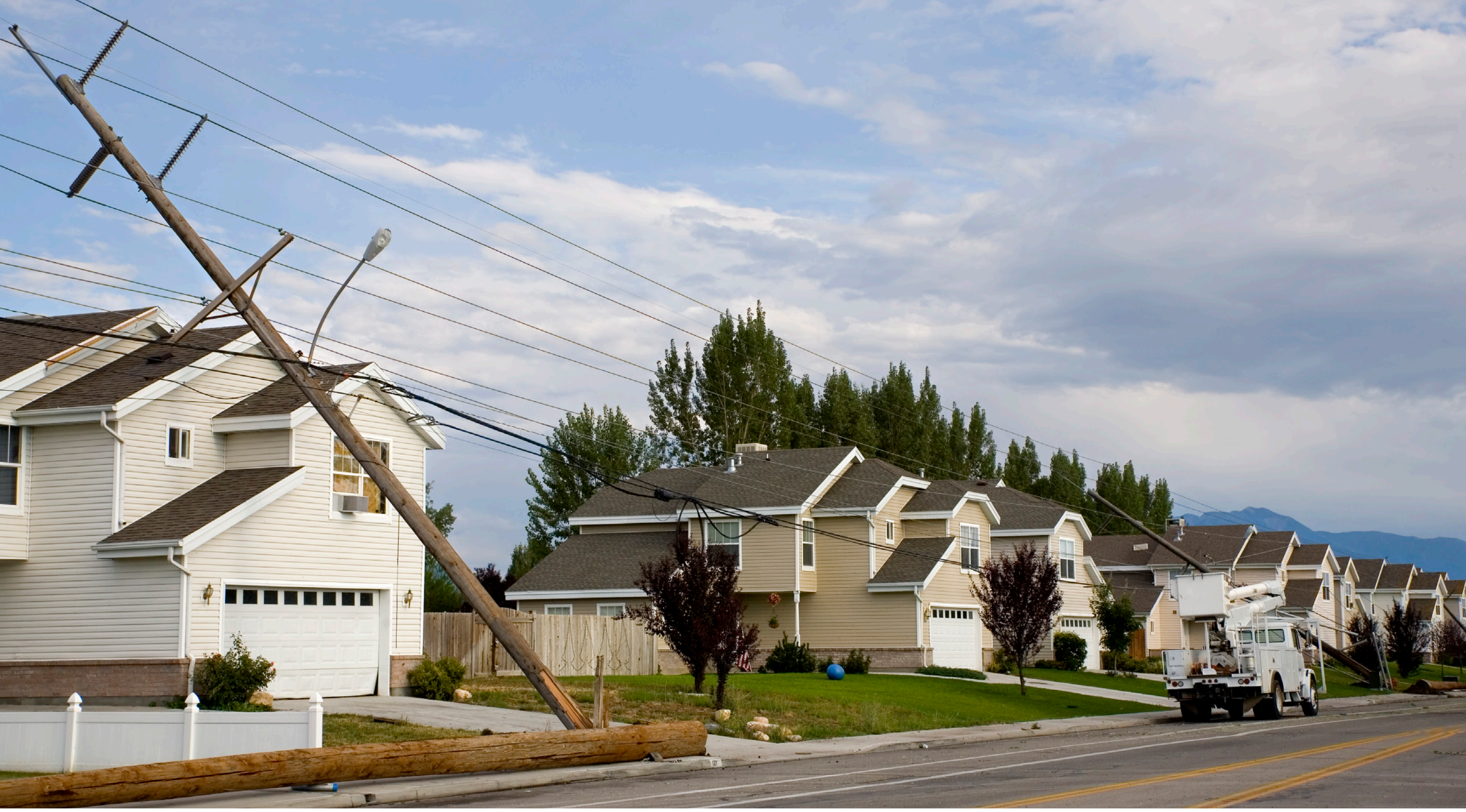
Of the 40,260 pole with 2 inches or less of average sound shell (the industry rule of thumb for rejecting a hollow pole), 3,130 poles were saved from being replaced prematurely using StrengthCalc. In other words, nearly 8% of hollow poles that would have otherwise been rejected using inspection methods without buckling considerations are able to remain in service and avoid costly replacement.

The cost and work force that would have otherwise been deployed to address these rejects can be redirected to the hollow poles with true risk of buckling. Of the 19,050 poles evaluated to have greater than 2 inches of average sound shell, 4,080 larger poles that were at higher risk of buckling were identified for restoration or replacement by StrengthCalc. This means that 21.4% (1 in 5) of these hollow poles with greater than 2 inches of average sound shell were properly identified as buckling risks and marked for restoration or replacement. This is a substantial reduction in risk, otherwise unknown to the utility.

How many hollow poles are found during the inspection of your wood pole plant?

Are those poles that are at higher buckling risk properly identified for restoration or replacement?

Are poles with adequate remaining strength prematurely identified for restoration or replacement?



Pole Buckling Can Be Avoided

Buckling isn't always on the top of people's minds when utilities evaluate risks related to their poles because the danger of buckling due to internal rot is hidden from view. However, it is a dangerous and potentially costly issue. Reconsidering the couple of poles that caused over two dozen to topple in the western United States, you can see why accurate assessment of internal decay and the likelihood of localized buckling rather than a bending failure is so important for determining remaining pole strength.

Thanks to innovative technology like StrengthCalc in the hands of highly trained inspectors, the hidden threat of buckling comes into full view. No longer unseen, proactive utility asset managers can make smarter decisions about pole maintenance and restoration.

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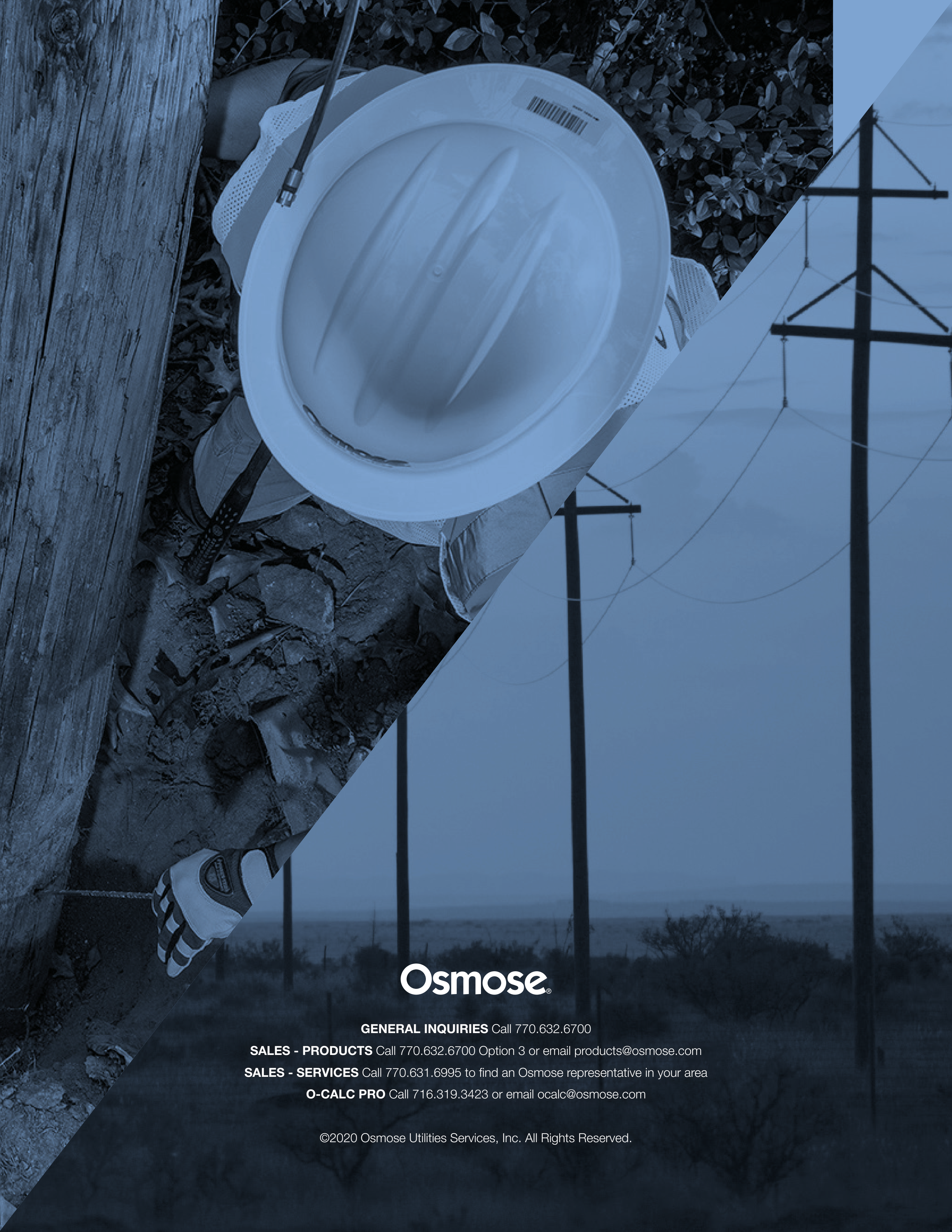

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