



The Importance of Grid Asset Data in Support of Distribution Resilience Planning

READi Insights

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Grid asset data for distribution system resilience planning includes, but is not limited to, information about the state of distribution infrastructure. For example, the state of poles can be described by their strength, age/condition, material, location, augmentation, etc. Assets and their attributes inform the grid's ability to withstand and recover from extreme weather events.

DISTRIBUTION RESILIENCE ASSESSMENT

EPRI is developing a framework for climate-informed distribution resilience planning using grid asset data as part of the Climate Resilience and Adaptation initiative (Climate READi). The objective of this framework is to provide a holistic view of the distribution grid's resilience to future climate hazards and to enable decisions to prioritize resilience investments based on current infrastructure and future system needs. Strategic decisions can be made to implement resilience investments and/or update resilience planning standards to reduce potential impacts from future climate events.

Enabling this framework as well as other resilience planning assessment methods will likely involve utilities knowing more about the grid itself. Utilities are likely to benefit from the collection of information on the status and condition of their grid assets to understand the vulnerabilities and potential consequences that may result during future climate hazards. Some utilities already collect data on certain grid assets, typically as a part of periodic inspection and maintenance programs, but these inspections are not always aligned to resilience planning. To make these inspections more applicable, these inspections can be augmented to collect additional grid attributes and archive that data to support distribution resilience planning.

This READi Insight:

1. Highlights how expected grid asset performance can be derived
2. Illustrates the importance of grid asset data in resilience planning
3. Raises awareness for utilities to collect additional grid data for resilience planning

DERIVING GRID ASSET PERFORMANCE

The Climate READi distribution resilience assessment is forward-looking, using the expected performance of installed grid assets during future climate events. The expected performance of grid assets can be derived in various ways by utilizing historical grid performance during past events or utilizing the theoretical limits of grid assets based on their design and a range of climate hazards. Utilizing either of these methods requires knowledge of Grid Asset Data.

When utilizing historical grid performance, the status and condition of the grid at the time of the specific event can help to generalize an impact model for those specific assets to better inform expected failures of grid assets during similar events in the future. For example, if a distribution feeder is composed of identical wooden poles and 5% of poles failed in a past storm event, an event of similar magnitude occurring on another feeder with similar wood poles might be expected to cause a similar 5% failure rate. Performance data can be more thoroughly mined by considering additional attributes of the grid assets such as age/condition, material, class, etc., as well as additional aspects of the weather and environmental conditions, both preceding and during the event. These additional aspects may include tree coverage, vegetation management practices, or soil moisture prior to the event. Coupled with hazard assessments, the expected performance of each asset group can be derived and used to consider grid exposure, vulnerability, and expected failure if an event were to occur on different areas of the grid. The benefit of this approach is that outage performance data is commonly available. The limitation, however, is that the performance is only based on the events that have occurred and the assets exposed. It may therefore be difficult to extrapolate historical performance to assess new events. Furthermore, the status and condition of exposed assets that failed are often not recorded. Additionally, replacing failed assets with newer assets, or with assets with different designs that have not been subjected to events, might require theoretical shifts in their expected performance. This leads to the second method that leverages the theoretical limits of grid assets.

When utilizing the theoretical limits of grid assets to climate hazards, a fragility curve can be derived from the design and distribution of that asset's strength. This mathematical approach does not require the asset to have been previously exposed to an event, but it does require extensive knowledge to understand the relative importance of various asset attributes on performance. For example, attributes such as number of conductors and span length are attributes that affect the expected performance of utility pole failure subjected to high wind events.

These approaches can also be used together, allowing utilities to leverage data more readily available to refine/adjust the expected performance for future grid conditions. This hybrid approach may help to fill gaps regarding, for example, compound-hazard performance or event severities not yet experienced in the historical record.

IMPORTANCE OF GRID ASSET DATA

Grid asset data is essential to make the forward-looking resilience assessment as accurate as possible. Assets such as overhead structures are a good example to illustrate attribute importance. Attributes such as the class of distribution poles define their strength when subjected to wind loading. The intersections of wind force and pole strength shown in Figure 1 show how different class poles can withstand different event magnitudes (e.g., 3-second wind gusts). Class is an overhead structure attribute that can be found in GIS databases or can be assessed based on planning standards.

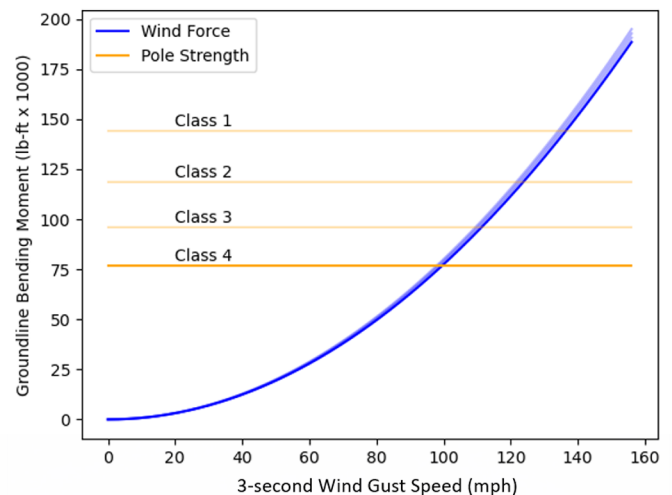


Figure 1. Increasing the class size of a pole increases its strength but has minimal impact on the wind force loading. Higher class poles (lower number) have a higher expected failure point identified by the intersection between pole strength and wind force loading.

Another attribute of interest is the remaining life of poles. As these assets age, their remaining strength may decrease as shown in Figure 2, which identifies adjusted failure points. As poles age, they are expected to fail at lower wind gust speeds due to deterioration and other factors. One of the most reliable sources of current asset health/remaining life is acquired by regular inspections. This sort of ongoing

activity could be further augmented to collect additional grid asset data as necessary.

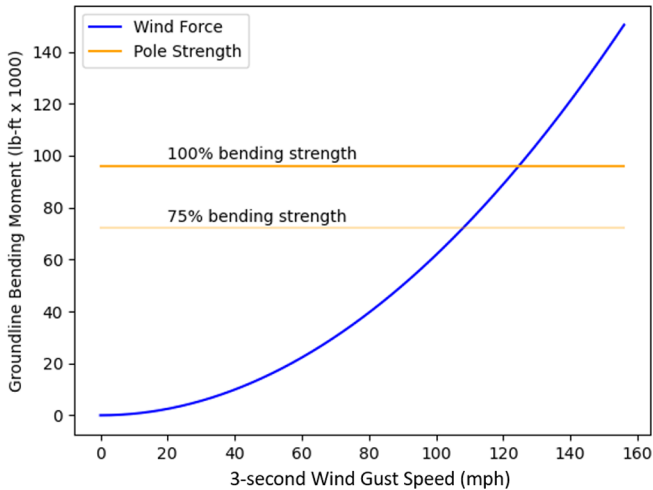


Figure 2. Pole condition is a critical attribute for accurately modeling the relationship between pole strength and wind speed. As poles age, they lose strength and are expected to fail at lower wind speeds due to deterioration and other factors.

An additional attribute of keen interest is the distance between adjacent poles, i.e. the conductor span, as shown in Figure 3. As the span length between poles increases, the loading on each connected pole also increases, which results in expected failure at lower wind gust speeds. The influence of this attribute gets scaled further when considering more/fewer conductors and third-party attachments that span between poles.

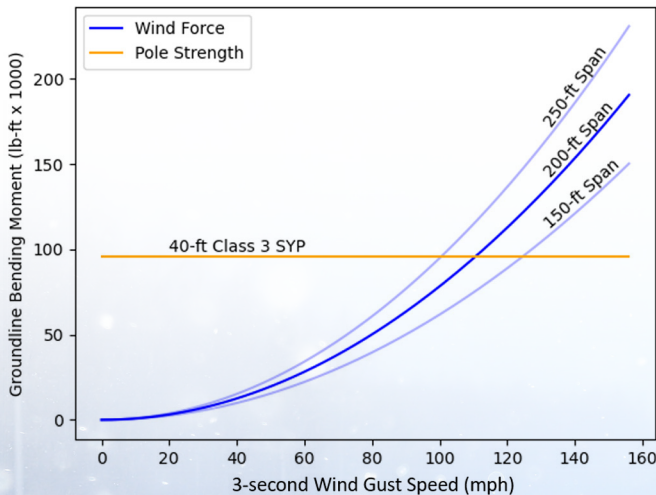


Figure 3. Increasing the span length between poles increases the wind force loading but has no impact on the strength of that pole. As the span length between poles increases, failure is expected at lower wind gust speeds.

In each of the previous examples, the intersection of pole strength and wind force loading defines the gust wind speed that should theoretically cause an overhead structure with particular attributes to fail. However, there is variability in materials like wood poles as shown in Figure 4. Natural materials generally have greater variability in strength than manufactured materials such as steel or fiberglass composite. Therefore, knowledge of the asset material can be an important grid asset attribute considered in resilience planning to calculate the percentage of assets expected to fail.

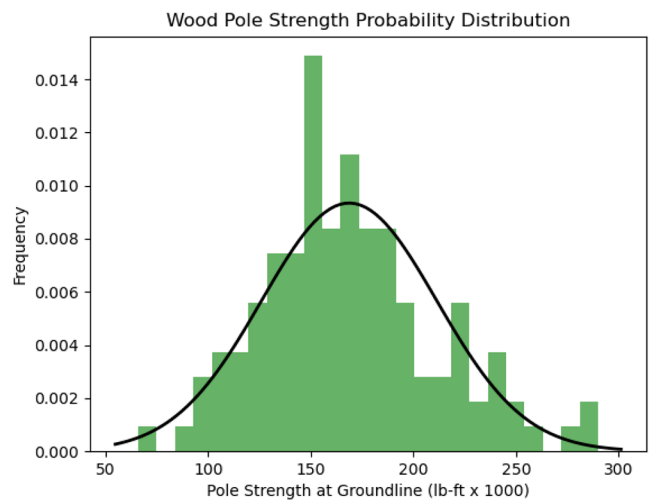


Figure 4. Observed (histogram) and fit (line) illustrating range in wood pole strength due to it being a natural material. This introduces a significant amount of uncertainty into any failure calculation.

Overall, not all attributes are equally important for assessing asset performance. Understanding the relative impacts of these attributes on expected performance can help prioritize grid asset data collection efforts. To demonstrate the relative impact of several grid asset attributes for a high-wind hazard, each is independently adjusted in Table 1. The table displays the resulting change in the critical wind speed, i.e., the wind speed at which the wind force loading surpasses the pole strength. The asset attribute influencing the largest change in critical wind speed might be prioritized in data collection efforts to improve knowledge of expected failure. Note that the influence will be dependent on the level of increment for each attribute as well as the hazard being considered.

Table 1. Impact of grid data asset attributes on critical wind gust speed. Not all attributes are equally influential, thus critical attributes can be prioritized in data collection efforts.

RANK	ASSET ATTRIBUTE	ORIGINAL ATTRIBUTE	INCREMENTED ATTRIBUTE	CHANGE IN CRITICAL WIND SPEED
1	Number of Conductors	3	1	15%
2	Span Length	200 feet	150 feet	13%
3	Class	Class 3	Class 4	-11%
4	Pole % Remaining Strength	100%	85%	-9%

Additional factors that can influence expected performance during high-wind events include soil saturation, ice, foliage fall-in, and cascading failure. In addition to adding weight, ice accumulation along the conductors increases the surface area exposed to wind pressure that is supported by a pole. A pole supporting conductors with accumulated ice will fail at a lower wind speed than the same pole when no ice is present. Tree fall-in is another factor that can add a large amount of additional force and lead to higher failure rates in areas with heavy tree cover. Poles can receive structural support from adjacent poles, however, a failing pole can also be the cause of subsequent pole failures as is the case in a structural cascade where a series of poles fail due to a ‘domino effect.’ These dependencies are not captured in the previous analysis but are areas to further investigate, leveraging historically measured and theoretically calculated failure points if possible.

MOVING FORWARD WITH DATA COLLECTION

Through GIS databases, inspection reports, planning standards, and historical grid performance data, utilities currently have a wealth of information to conduct resilience planning assessments. These assessments can be improved with a more thorough understanding of grid asset data. This paper specifically focused on an example of distribution overhead structure data and wind events. However, the methodologies and approaches discussed can be applied to other asset categories and climate hazards. Grid asset data is essential to understand the asset’s impact on past and future grid performance, and this knowledge can aid in decision-making regarding the type of adaptations best able to improve resilience for given assets and locations subject to climate hazards.

As discussed in this paper, grid asset data is required, but assumptions can be applied now while data is collected. For example, if pole class is unknown, design standards can be utilized to assume the pole class used in the grid. The collection of grid data can be increased over time with more critical asset attributes acquired earlier in the process. Pole class and pole material are fundamental inputs for predicting the future performance of overhead structures during wind events. The remaining strength of the structures, the span length between adjacent structures, and the number of conductors and third-party attachments they support are also attributes with a high relative impact on asset performance. Utilities may consider developing programs to prioritize the collection of these data to better support resilience planning.

All grid data is a utility asset just like the physical assets in the field. The data needs to be collected, regularly assessed, and maintained so the utility engineer has a complete understanding of the grid. Doing so will allow utility companies to better reach the full potential and benefit available from assessments like resilience planning.

About Climate ReadI

Climate READI (**RE**silience and **AD**aptation initiative) is seeking to address the challenges of assessing the impacts of physical climate risks on the power system, convening global thought leaders, members of the scientific community, and other stakeholders necessary to build a consistent, industry-accepted framework to identify optimal adaptation and resilience investments. For more information, visit www.epri.com/readi or contact ClimateREADI@epri.com.

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