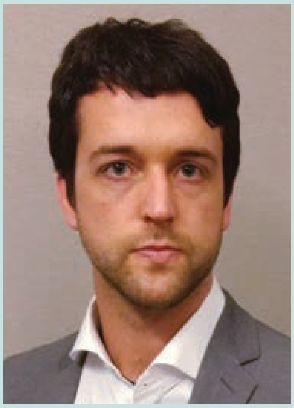
Asset Replacement Based on Risk Modeling – Emerging Best Practice?

Challenging Utility Grid Hardening Proposals

Part I


By Paul Alvarez, Sean Ericson, and Dennis Stephens of the Wired Group

U.S. state regulators are increasingly being asked to rule on multi-year, multi-billion-dollar electric grid hardening investment proposals from investor owned utilities. Intended to improve reliability and supported by knowledgeable and experienced IOU employees and experts, regulators can find it difficult to objectively evaluate IOU claims regarding the cost-effectiveness of such proposals.

It can be difficult for U.S. state regulators to rule against grid hardening proposals. After all, who wouldn't like a more reliable grid? The opposing view is that the U.S. economy can ill-afford rate increases, particularly those of uncertain benefit, and particularly now, during a recession. Others agree and add that rate increases should be judiciously reserved for future investments related to distributed energy resource accommodation as capacity reaches high levels on certain circuits.

The right answer is somewhere between the extremes. But of the technologies and capabilities proposed, how can regulators and staff with limited grid planning, operations, and asset management experience choose wisely?

With increasing frequency, large portions of grid hardening proposals are dedicated to prospective replacement of assets identified by IOUs as high risk for failure, backed by models that IOUs claim can accurately predict asset failure.

Part one of this two-part article examines the growing phenomenon of prospective asset replacement based on risk modeling, which is supported by IOUs, industry consultants, and software developers as an emerging best practice.

These new practices are compared to historical best practices. In part two we will examine how prospective asset replacement, in conjunction with other common IOU practices, vastly overstates the economic benefits to customers and communities relative to grid hardening costs.

We begin part one by examining IOUs' fundamental grid hardening assumption: greater capital investment delivers better reliability. FERC Form 1 and EIA Form 861 data indicates this is not the case, confirming the findings of LBNL research (LBNL-188741) by noted reliability experts Peter Larsen, Joseph Eto, and their colleagues.

See Figure 1.

Common measures of reliability have deteriorated in recent years despite exceptional growth in distribution rate base during a period of flat to falling peak demand. In response to IOU claims that newer equipment is the appropriate response to increasingly extreme weather, data says otherwise.

See Figure 2.

Not surprisingly, extreme weather cannot distinguish between new and old equipment when causing damage (hurricanes Harvey and Irma in 2017, and Florence and Michael in 2018). Furthermore, the aforementioned LBNL research indicates that increasingly extreme weather, and perhaps better reliability reporting, are the principal contributors to observed deterioration in reliability performance over time.

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Objective, Standard Approaches to Identifying Assets for Replacement

In response to IOU calls for prospective asset replacement, a description of historical best practices in distribution asset management is in order. Standard industry practices to identifying assets in need of replacement include objective testing, formal inspection, and historical observation.

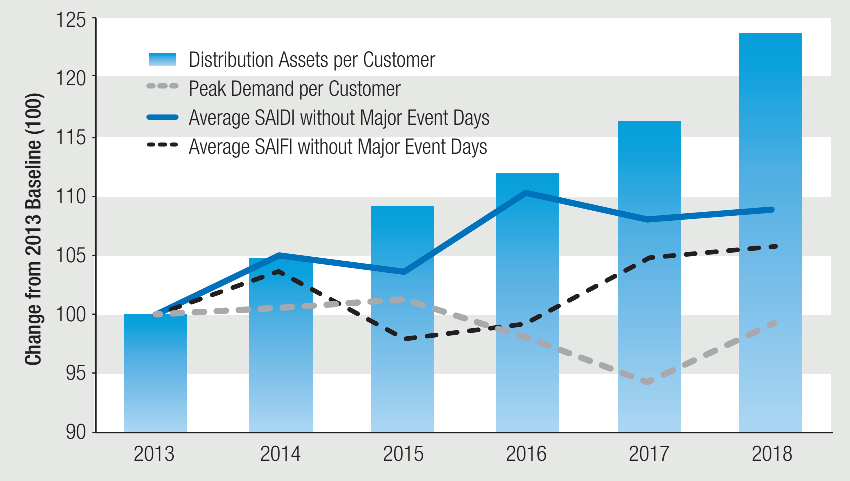
Run-to-failure is also employed for mass assets serving very few customers, such as distribution transformers. Historical best practices have resulted in the combination of affordability and reliability U.S. electric consumers enjoy today: 99.973 percent uptime, or 2.35 hours of downtime annually, including the impact of major events like storms.

Asset Testing: Asset testing is an objective method for identifying assets likely to fail in the near future, and in need of replacement. Substation and transmission assets, due to the large numbers of customers impacted as a result of asset failures, are the primary focus of asset testing.

Chemical tests are available to identify substation and

Fig. 1 **U.S. IOU Distribution Rate Base**

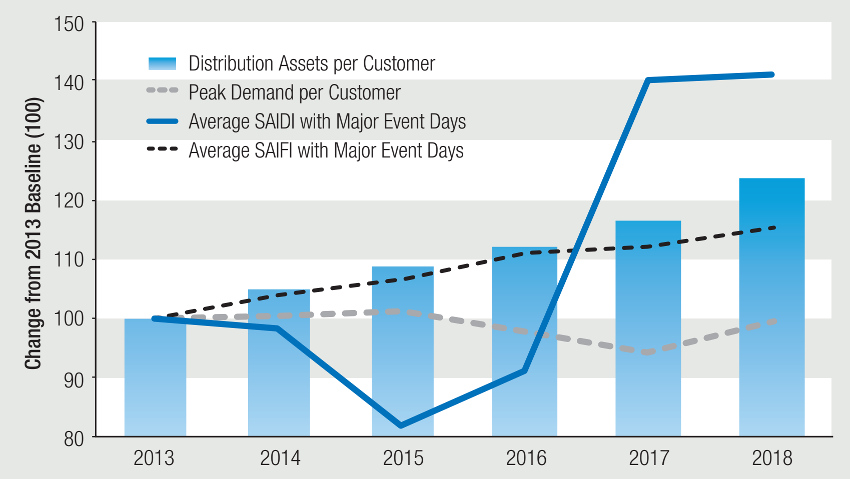
Relative to peak demand and reliability performance, without major event days. Selected data, all U.S. IOUs (N = 128)



Source: FERC Form 1, EIA Form 861

Fig. 2 **U.S. IOU Distribution Rate Base**

Relative to peak demand and reliability performance, with major event days. Selected data, all U.S. IOUs (N = 128)



Source: FERC Form 1, EIA Form 861

transmission transformers at risk of failure and in need of replacement. Electrical tests are available to identify circuit breakers and relays at risk of failure and in need of replacement.

Most utilities test all substation and transmission transformers, circuit breakers, and relays at regular intervals (for example, once every five years) as part of routine operating and maintenance practices. Manufacturers rate circuit breakers as to the number of operations (a trip or open) they can be expected to deliver before failing; most utilities track the number of times each circuit breaker operates for this reason.

Some utilities replace substation and transmission circuit breakers when the number of rated operations is reached regardless of test results. However, since transmission and substation circuit breaker operations are extremely infrequent, this is a rare circumstance.

Formal Asset Inspection: Another standard industry practice is visual inspection. Most utilities maintain formal inspection programs in which checklists are used to pass or fail assets as part of routine operations and maintenance policies.

Due to the reliability and public safety risks involved, wooden utility poles (distribution) and steel towers (transmission) are the primary focus of formal inspections, conducted at specified intervals, such as once every ten years.

In addition, field personnel (linemen and troublemen) are trained to conduct visual inspections as they go about their jobs, and frequently identify assets in need of replacement outside of formal inspection processes.

Historical Observation: Underground cable remediation (primary, less costly approach) or replacement (secondary, very costly approach) is identified through historical observation of failure rates. Utilities typically track the counts of failures in underground cable by type/manufacturer and location.

Once the frequency of failure reaches a level previously established as unacceptable, remediation or replacement is executed. While on the subjects of standard practices and undergrounding, it should be noted that independent LBNL research (LBNL 1006394) confirms that the undergrounding of overhead lines is not standard industry practice, nor is it cost-effective.

Run-to-Failure: Though not an objective test, run-to-failure is a standard industry practice that merits mention. Some assets, as a result of the low numbers of customers served, large asset quantities, and low failure rates, do not justify testing or inspection.

In these situations, the cost of testing or inspection far outweigh minor reliability and/or safety benefits available. The primary example is the distribution transformer, which in the U.S. serves about three to five customers each, number in the tens of thousands at most large utilities and fail at a frequency of less than one percent per year. Overhead conductor is another example; the authors are aware of overhead conductor operating safely and reliably at a hundred and seven years of age.

Subjective, Non-standard Approaches to Identifying Assets for Replacement

Assets that are fully depreciated earn no authorized rate of return. This motivates an IOU to replace such assets with new ones.

Fig. 3 **Substation Circuit Breaker Survivor Curve**

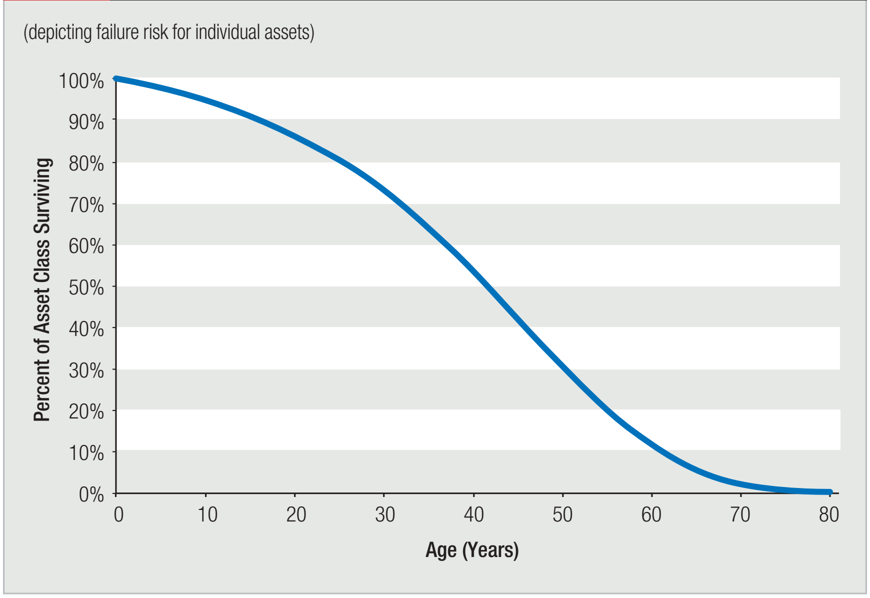
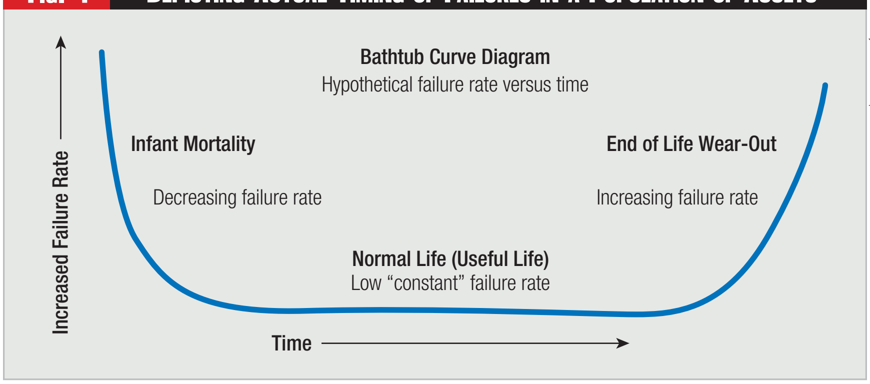


Fig. 4 **Depicting Actual Timing of Failures in a Population of Assets**



Source: Courtesy of ReliaSoft Corporation

The authors have observed an increased incidence in IOU proposals to replace assets prospectively based on modeling and subjective estimations of risk, rather than on the objective testing, inspection, and historical observation practices described above.

Perhaps more alarming, IOUs claim that modeling and subjective risk estimates are an emerging best practice. This is simply not the case, as proven through decades of practice, which remain the standards for non-profit utilities not motivated to replace assets that are fully depreciated.

Backed by reliability improvement claims from respected engineering firms' depreciation experts, regulators can find it difficult to reject such proposals. Regulators should recognize that consulting engineers stand to gain revenues from large, prospective asset replacement proposals. Further, regulators should question the survivor curves and subjective asset condition modeling the depreciation experts use. Regulators may also wish to distinguish between accounting practices and operating practices, and to appreciate differences in the goals of each.

To understand why, a brief tutorial on survivor curves and asset depreciation is in order. Survivor curves have been used by depreciation experts for decades to justify depreciation rates. In studies of failure rates of different types of assets, depreciation experts have observed that the longer an individual asset operates, the greater its risk of failure.

An example of survivor curves for substation circuit breakers from a depreciation expert supporting prospective asset replacement in a state regulatory proceeding is presented here.

See Figure 3.

Note that while some substation circuit breakers will operate reliably for as long as sixty or seventy years, the average life of a circuit breaker is thirty to thirty-five years. This average life is thus chosen as the appropriate depreciation rate for substation circuit breakers. (The authors note that shorter average asset lifespans relate to faster depreciation, which in turn represents a faster return of capital – an outcome of great interest to an IOU.)

However, this does not mean that the assets in the pool that are still operating in year thirty-one should be replaced. Using accounting data to make operating decisions has profound cost implications. This is because, according to the accounting data, fifty percent of assets will still be operating in year thirty-one.

According to the survivor curves in Figure 3, seventy percent of assets will still be operating in year thirty-one. These assets have decades of reliable operation remaining. Average life is a depreciation concept, not an operating concept, and should not serve as a basis for selecting assets for replacement.

The problem with the survivor curves approach is that age is a terrible predictor of any individual asset's failure. A substation circuit breaker installed this week may fail in five years, or in seventy-five years. In fact, individual assets are more likely to fail either early in life, due to defects in manufacturing, installation,

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or application design processes, or late in life, due to wear and tear over time.

The bathtub curve, also known as the Weibull distribution, shown in Figure 4 describes this phenomenon.

See Figure 4.

The difficulty in predicting any individual asset's failure due to age is precisely why the objective testing, formal inspection, and historical observation practices described above were developed.

These practices' demonstrated successes in identifying assets in need of prospective replacement, and resulting cost-effective improvements in reliability, are precisely why they became standards, over decades of experience.

These testing and inspection practices are objective measures of the stresses to which an individual asset has been subjected over its lifetime. They are designed to identify individual, high-consequence assets for prospective replacement before each hits the right-hand tail of its bathtub curve.

In the case of underground cable, as described above, historical failure rates are tracked to identify when the right-hand tail of the bathtub curb is being reached for any particular cable/manufacturer type or location.

When objective measures or historical failure rate tracking fail to deliver the quantity of prospective asset replacements and corresponding rate base growth an IOU would prefer to pursue, the IOU summons depreciation experts to justify a higher quantity of replacements.

Depreciation experts supportive of IOU prospective asset replacement proposals turn to subjective evaluations of the stresses to which an asset has been exposed over its lifetime. This is far different from objective measures, which are, in effect, an objective way to measure the stresses to which an asset has been exposed over its lifetime.

Subjective evaluations involve the opinions of IOU engineers – who will always favor new equipment over old equipment, as it makes their lives easier – who are asked to make asset-specific, subjective evaluations of the stresses placed on an asset over its lifetime based on historical loading, cycling, operation counts, maintenance and service records, and weathering, as well as compounded combinations of these.

The experts then apply the subjective evaluations and compounding to each asset's position on the survivor curves for its asset class, based on age, to model the likelihood that each will fail in coming years.

In effect, depreciation experts are using accounting practices, augmented by subjective evaluations of lifetime asset stresses, to inform asset replacement through subjective asset condition modeling.

They legitimize the approach with impressive names, such as, asset health indices, or condition-based modeling. They often cite ISO (International Organization for Standardization) asset management standard 55000, which makes no mention of subjective asset condition modeling.

It is unclear to the authors why subjectivity and modeling should supplant objective measures that have proven their worth in decades of experience and have become standard industry practice as a result.

To the authors' knowledge, no such modeling has been proven to be more accurate at predicting asset failure than objective tests, inspection results, or historic failure rates, nor have they been proven to result in greater reliability, nor have they been shown to deliver benefit-to-cost ratios superior to those delivered by these standard industry practices.

These practices' demonstrated successes in identifying assets in need of prospective replacement, and resulting cost-effective improvements in reliability, are precisely why they became standards.

Further, the authors know of no justification for using accounting practices to inform operating practices. But the outcome of subjective modeling is abundantly clear: it results in a dramatic increase in asset replacement rates over objective methods.

The acid test is to compare historical annual failure rates of various asset classes, expressed as a percent of assets in operation, to the failure rates predicted by the depreciation experts' models. In several cases before state regulators in which the authors have testified, the failure rates predicted by the models always exceed historical failures by a wide margin, sometimes as great as several multiples of ten.

To add insult to injury, IOUs recover the costs of depreciation experts hired to model asset failure risk in customer rates. Some IOUs go so far as to capitalize depreciation expert costs so as to earn profits on such work.

The authors strongly encourage any regulator considering IOU prospective asset replacement proposals to compare modeled failure rate assumptions to historical actual failure rates for each asset class for which prospective replacement is being proposed.

The authors hope they have instilled in readers a healthy skepticism for subjective risk modeling approaches to asset failure prediction. In Part Two, to be published in the next issue of Public Utilities Fortnightly, the authors will critique the manner in which IOUs translate reductions in asset failure rates, often exaggerated by subjective risk modeling, into economic benefits for customers. Part Two will also include the authors' annual IOU Customer Value Rankings for 2019. PUF