CIGRE-494

2022 CIGRE Canada Conference & Expo
Calgary, Alberta, Oct.31 – Nov. 3, 2022

Accelerating Infrastructure Planning Using a Grid-wide Approach

Ted Zalucki, P.Eng, M.Eng
Engineered Intelligence Inc
Canada

SUMMARY

Asset management and power system planning is becoming more and more difficult as assets age, employees retire, and expectations for reliability, resilience, and power quality increase. To plan for future work, electrical utilities must conduct more investment planning and outcome forecasting activities from high level to detailed plans for asset management, while also recognizing and assessing data maturity, project allocations and completions.

Due to the number of departments, grandfathered processes or changing requirements, assessments are often done one asset class at a time, one analytic at a time, in a series of initiatives which mix strategic asset management and tactical business work. The lack of consistency year over year and the leveraging of several software solutions to support the planning and budgeting cycle further reinforces the issue.

Several utility companies in Canada decided that they need to run more advanced planning analytics, by automating their asset risk framework, allowing them to derive repeatable, consistent and auditable results to support investment decisions. Planning for future and sustainable work requires a risk-based approach to asset investment and outcome forecasting. After all, risk is inevitable, and such an approach lays the foundation for continuous improvement and managing the risk. These utilities have upgraded their asset management procedure to achieve more reliable condition forecasts on a grid-wide, single-source dashboard, reducing timelines from 5 years to 5 months, and costs by over 80%. Their entire organization has direct access to asset insights, allowing them to manage degradation and replacement schedules while saving on management costs.

This paper and presentation will discuss how utilities are now able to consider an asset's condition and age, as well as historical failure patterns and external factors such as weather events, to calculate expected lifetimes of their assets and make predictions about when they might fail. Understanding the effects of unique operating conditions within the electric system on asset failure, provides great insight on asset risk. It enables asset managers to improve their

ted@engineeredintel.com

overall system reliability and initiate critical replacements prior to potentially detrimental outcomes.

Long-term investment forecasts, for capital and operational expenditures can be completed using some of the same data and analytics. Utility companies are provided with measurable and repeatable results to make data-driven decisions, backed up by ready-to-use, science-based analytics.

Data analysis, which could often take two days of reviewing spreadsheets and documents, is now cut down to two minutes, further improving accessibility, stability and usability of the system. It has become possible to institute more complex approaches, such as integrating traditional asset management with system planning, helping organizations better understand how risk exposure is impacted with transmission versus distribution solutions, and which is better for ratepayers.

This paper and presentation will touch on the status quo, motivations, experiences, analytics enabled, processes re-structured and plans for continued work towards building additional investment drivers such as load forecasting, capacity management, application performance management, use of artificial intelligence, machine learning and more.

KEYWORDS

Asset Management, Predictive Analytics, Forecasting, Quantitative Risk, Process Automation, Investment Planning.

INTRODUCTION

Asset management and power system planners are faced with aging assets, a retiring workforce, as well as increasing expectations for reliability, resilience, and power quality. It is becoming more and more difficult to effectively plan for future work. They are forced to conduct more elaborate investment planning and outcome forecasting activities ranging from high level, to more detailed asset management plans, while having to recognize and assess data maturity, project allocations and completions.

Utilities are often broken up into departments, each with their own grandfathered processes and priorities. Because of this and shifting requirements, assessments are often done one asset class at a time, one analytic at a time, in a series of initiatives which mix strategic asset management and tactical business work. The lack of consistency year over year and the leveraging of several software solutions to support the planning and budgeting cycle further reinforces the issue.

This has been the struggle for countless utilities, many of which are still very much in the same place today as they were 15 years ago, simply because of the cost and effort required to achieve consistent and complete modelling, system-wide. With the use of new technologies and software, the asset management transition can be a lot more cost effective, with tangible results within 5 months.

Several utility companies in Canada decided that they needed to run more advanced planning analytics, by automating their asset risk framework. This allowed them to derive repeatable, consistent, and auditable results to support their investment decisions. Planning for future and sustainable work requires a risk-based approach to asset investment and outcome forecasting. After all, operating with risk is inevitable, and such an approach lays the foundation for continuous improvement and management of that risk.

THE RISK-BASED APPROACH

An increasing number of utilities are striving to evaluate their asset management practices using standards such as ISO 55000, which perscribes a risk-based approach. In the utility world, if generation is not vertically integrated, there is typically no lost revenue to consider. In response to this, utilities have developed other measures of value such as lowering financial operating costs, avoiding safety incidents (which would affect insurance premiums), providing uninterrupted supply, and minimizing environmental impacts. Monetizing these values is the first step to assessing the significance of an investment and its level of impact to the overall system. Doing so wholistically, using the network topology and operating model, creates the foundation for nearly every other utility capital efficiency analysis from increases to crew productivity, automation of the system, and more. In fact, modeling an asset class without modeling the system, produces a highly innacurate risk analysis, as the problem becomes building asset consequence models of a system without modelling a system.

Financial costs considered within the risk-based approach include labour, material, and equipment for the asset, as well as its installation and energization. Safety costs include the small probability that a member of the public or utility staff are injured, as a result of operating a piece of equipment a certain way. The statistical value of a human life, training costs, and insurance payouts, are all monetized in order to compare the safety impact of one project over another. The cost of an interruption to service is something commercial and industrial customers have a very good grasp on. Many large power users are aware of their downtime costs, as they use the same figures internally to justify equipment asset management. Residential customers also value their service, although they rarely experience direct economic loss. The concepts of Customer Interruption Costs pioneered by Dr. Roy Billinton provide a framework by which utilities can assess the economic impact to even residential customers.

Aggregating all the unique costs associated with each asset type convey the impact variable of the risk equation. The probability is calculated directly from a statistical failure data analysis. The isolation of asset failures by causes, which are directly attributable to their normal operating state, creating histograms, and fitting statistical distributions, leads to the widely accepted failure curve, such as the age-based curve depicted below.

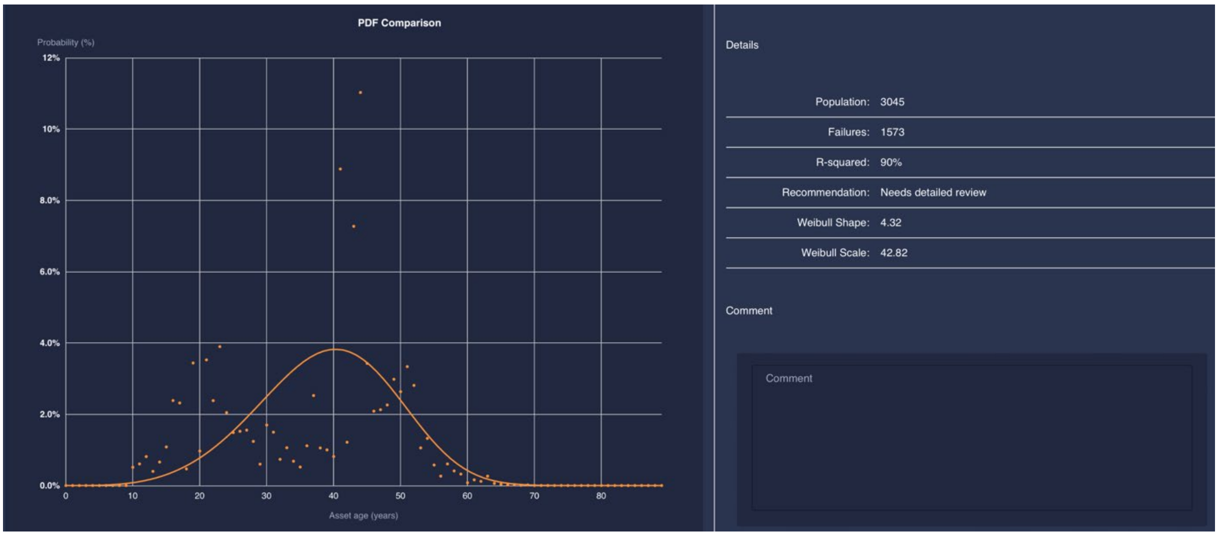


Figure 1: Example of an Automated Failure Statistic

The product of the cost of impact and the failure curve, provides the annual risk of an asset operating in its current state. It is important to note that as soon as the normal system state changes, the load on an asset changes, and subsequently, its outage impact is either increased or reduced. Figure 4, below, plots the total operating costs of an asset, and graphically demonstrates how the trade-off between investing and continued operation is made. The Equivalent Annualized Cost (EAC) is the lowest point on the total ownership cost curve, intuitively respresenting the prime replacement period for the utility to avoid operating with excess risk, but using the asset to its potential. Because the existing equipment in the field has no capital cost associated with it, the cost associated with the EAC becomes the highest cost associated with optimally operating the existing asset. The age at which this cost is achieved is when the existing asset requires some sort of intervention (whether it be replacement, or another alternative, such as reconfiguration of load, additional tie points, preventative maintenance etc.). Engineering is required to develop viable alternatives to investment. When the engineer develops a project scope, the economic analysis will vary based on the specific impacts of the work associated with that project. In some instances, the engineer may be able to identify that an asset does not necessarily require replacement, but rather, that adding isolating capabilities in surrounding areas will reduce risk costs and defer the investment.

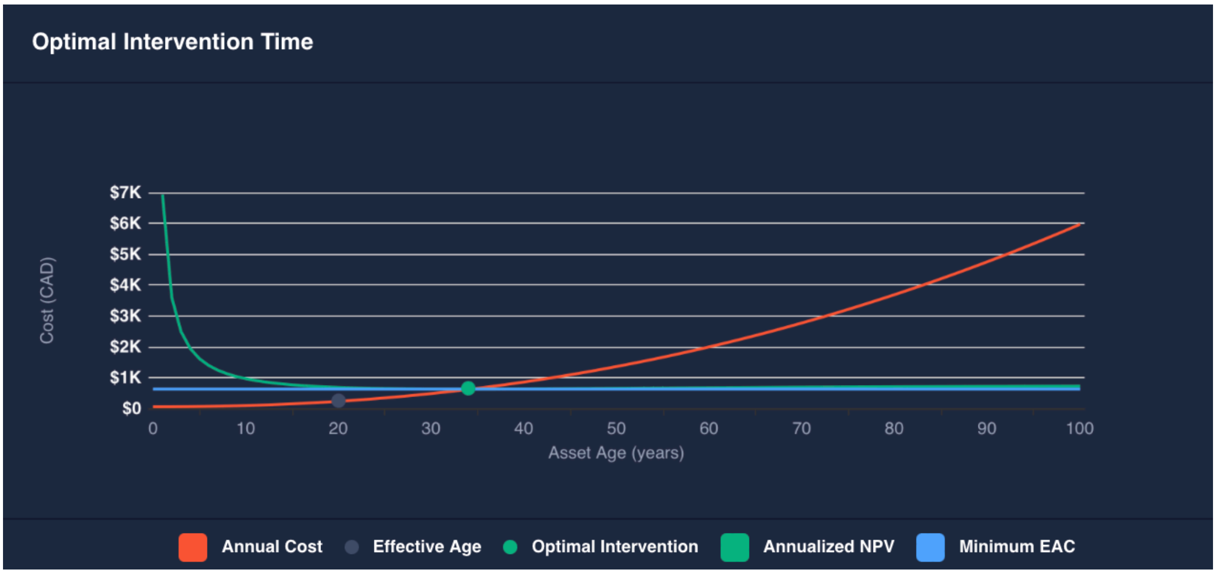
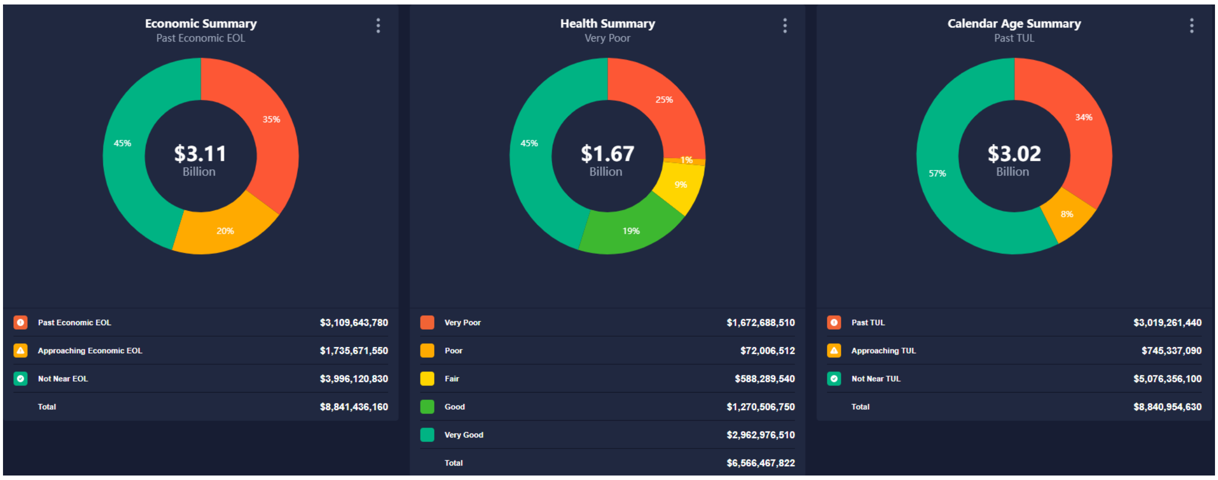


Figure 2: Automated calculation of risk optimized point of intervention

ACCELERATED INSIGHTS

Once they have modelled their entire grid, inclusive of all component relationships, operational responses, and a unique load at risk model with a contingency analysis for every point of delivery on the system, utilities can have the baseline from which risk reduction and capital spend efficiency can be measured. Upon review of all related end of life indicators, economic, health and calendar age, as demonstrated in the figure below, it is clear that within this particular system, there is close to equivalent system needs across all three metrics ranging from age to risk in complexity.

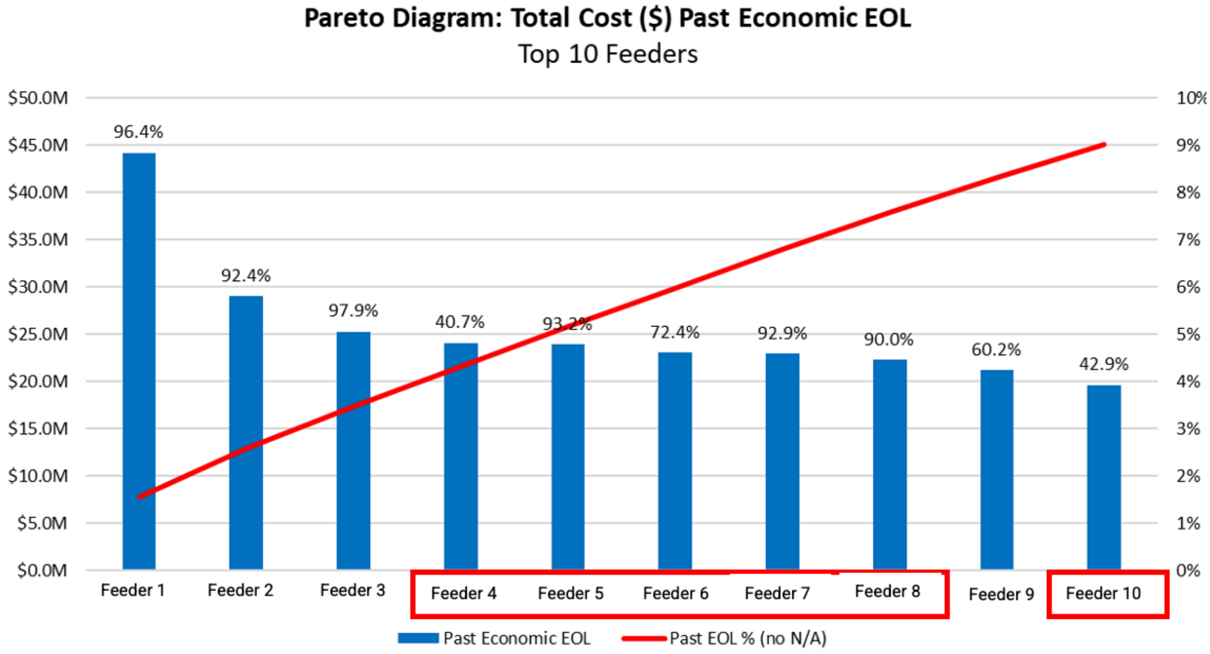


When seeking insights with a risk-based analysis, stratification in the network can be assessed, as well as the highest concentration of risk. With the use of software, this can be done in minutes with simple filtering capabilities by:

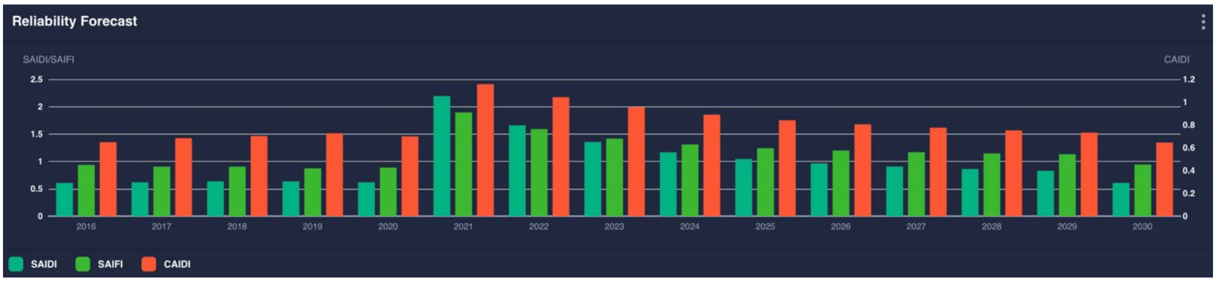
- Subsystem; transmission or distribution, underground or overhead, etc.
- Geographic location: downtown or suburban areas, specific postal codes, etc.
- Asset classes: poles, cable, transformers, breakers, etc.
- Feeders, lines, busses, etc.

- Specific equipment tags

The sample Pareto output below provides the key insight, that almost 10% of the economic risk in the network is stratified in only 10 out of 300+ circuits.



To develop portfolio level asset plans, teams no longer have to spend months assessing a single plan scenario. They can produce multiple distinctive investment plans and outcome projections, such as the reliability forecast below, in minutes.



Finally, given a baseline risk, alternative analyses can be created, resolving common questions such as;

- Should the cable be injected or replaced?
- Which switching points are ideal for automation?
- Should capacity/contingency solutions be added in the distribution network, or the transmission network?
- How executable projects be found to bundle assets while still accounting for individual risk?

With individual asset level risk cashflows for several asset lifecycles, and a network topology-based analysis, project level benefit cost ratios can be automatically developed for subsequent scoping stages, already inclusive of outage management constraints. The figure below provides a sample of such output.

CONCLUSIONS

With a full model of the grid, utility asset managers and planners can be prepared to answer not only questions about the past more effectively, and precisely, but this also lays the foundation for the questions of tomorrow. With a single network load at risk model, and a fully monetized lifecycle analysis, planners now have the ability to assess the capital cost efficiency of new technologies of interest. One such example that is being explored includes the addition of grid connected battery storage as an alternative reliability deferral solution to traditional renewal of bulk transmission systems, or the impacts of continuous diagnostics and mitigation (CDM) programs on network risk.

BIBLIOGRAPHY

[1] T. Zalucki "T&D Enginomics, Advanced Asset Management Frameworks" (CIGRE Canada Conference, 2018)
[2] "IEEE Guide for Electric Power Distribution Reliability Indices", IEEE, 2012
[3] "Outage Costs", Report #50/116, CEATI, 2015.
[4] "Statistics: Electrical Incidents in Alberta", Alberta Municipal Affairs, 2014
[5] "IEC 61649:2008 – Weibull Analysis", IEC, 2008
[6] Sullivan, M., Mercurio, M., Schellenberg, J., "Estimated Value of Service Reliability for Electric Utility Customers in the United States", Ernest Orlando Lawrence Berkeley National Laboratory/Freeman, Sullivan & Co., 2009.