Forward Thinking
ENERGY INFRASTRUCTURE CONSULTING

PROBABILISTIC RISK ASSESSMENT · DISTRIBUTION ASSETS

Asset-to-System Probabilistic Risk Assessment for Distribution Assets

From component failure probabilities to system-level risk, and from risk to an inspection and maintenance investment plan

CLIENT
Electric distribution utility, ~1 million customers

SERVICE LINES
Probabilistic Risk Assessment, Decision Support Tools

SCOPE
Poles, crossarms, conductors, transformers, switches, reclosers, and protective devices

DURATION
12 months

7
asset classes modeled with health-based failure curves

~15%
of assets driving the majority of system-level risk

10-yr
risk-optimized inspection and replacement plan

Same budget
re-sequenced to deliver more risk reduction

THE CHALLENGE

The utility inspected and replaced distribution assets largely on fixed time cycles and age. Two poles of the same age in different environments were treated the same way, while the consequence of a failure (a rural feeder tap versus a hospital-serving trunk line) did not enter the prioritization at all.

Regulators and the utility's own planners wanted a risk-based justification for the inspection, maintenance, and replacement budget: which assets to inspect more often, which to replace early, and where the current cycle was over-investing in low-risk equipment.

WHAT WE DID

1. **Asset-level failure probability.** For each asset class we built condition- and age-based failure probability models from the utility's inspection findings, failure records, and environmental exposure (coastal corrosion, wind, vegetation density). Where data were sparse, industry reliability data were blended in using Bayesian updating so that every asset had a defensible estimate with a stated uncertainty.
2. **Consequence of failure.** Each asset was linked to what it serves. Failure consequence combined customer-minutes of interruption, critical-customer exposure, safety (public contact, fire), and repair cost, using the utility's connectivity model.
3. **Aggregation to system level.** Asset-level risks were rolled up through feeder, substation, and district hierarchies. This revealed which feeders carried disproportionate risk and separated risk that was driven by many moderately degraded assets from risk driven by a few critical ones.
4. **Intervention modeling.** We modeled how each intervention (inspection at a given interval, targeted maintenance, or replacement) shifts the failure curve, and what it costs, to produce risk reduction per dollar for every asset–intervention pair.
5. **Investment optimization.** A portfolio optimization selected the set of interventions that maximized risk reduction under the annual budget and crew constraints, producing a ten-year plan with year-by-year work lists.

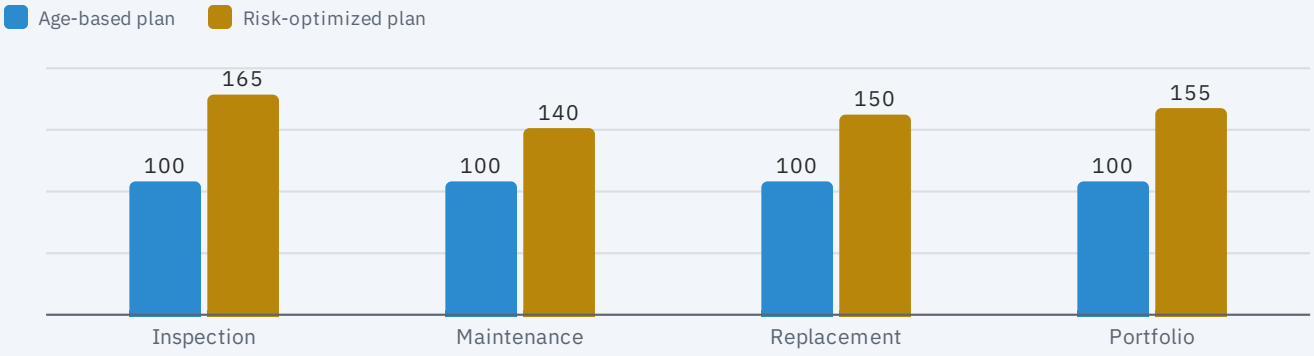
RESULTS

Roughly 15% of assets accounted for the majority of system-level risk. The analysis identified assets that were young but high-consequence and poorly inspected, as well as older assets on low-consequence taps where the existing replacement cycle was spending ahead of need.

Re-sequencing the existing inspection and replacement budget on risk (rather than age) delivered a substantially larger modeled reduction in customer-minutes and safety risk over ten years than the cycle-based plan, with no increase in spend.

Inspection intervals were differentiated by risk class: shortened for high-risk assets, lengthened for low-risk ones, freeing inspection capacity for the assets that needed it.

Modeled ten-year risk reduction per $ invested by intervention type (index, age-based plan = 100)



Illustrative comparison between the legacy age-based plan and the risk-optimized plan for the same budget.

IMPACT FOR THE CLIENT

The utility now has an asset-to-system risk model it can rerun each year as inspection data arrive, giving a rolling, evidence-based capital and O&M plan.

Budget conversations with regulators moved from “how many poles per year” to “how much risk is removed per dollar,” a framing that has proved easier to defend.

WHAT WE DELIVERED

- Condition-based failure probability models for seven asset classes
- Asset-level risk scores with consequence mapping
- Feeder, substation, and district risk aggregation views
- Intervention cost-effectiveness library
- Ten-year risk-optimized inspection, maintenance, and replacement plan

METHODS AND STANDARDS

Probabilistic risk assessment · Survival and degradation modeling · Bayesian data blending · Consequence-of-failure modeling · Budget-constrained portfolio optimization