

EXECUTIVE SUMMARY

Distribution Grid Reliability & Resiliency Investment Decision Model

Decision Support Tool — Executive Summary

Prepared by Planmetrix LLC

This executive summary describes a Microsoft Excel-based decision support tool developed by Planmetrix LLC to assist electric utilities in evaluating and prioritizing investments in distribution grid reliability and resiliency. The model provides a structured, data-driven methodology for comparing remediation options across multiple circuits and circuit segments within a defined budget.

Key Research Question

How can electric utilities objectively compare, rank, and prioritize competing distribution reliability and resiliency investment options — across multiple circuits and remediation strategies — within defined budget constraints, in a way that accounts for both the probability of future outage events and their consequences to customers?

Background

Electric utilities face complex, resource-constrained decisions when investing in the reliability and resiliency of their distribution systems. Circuits vary in age, construction type, exposure to environmental risk, historical performance, and the number and mix of customers they serve. Candidate projects are often justified using different data sets, different engineering assumptions, and different units of measure — making direct comparison difficult without a common analytical framework.

To address this challenge, Planmetrix LLC developed a prototype investment decision model introducing a multiple criteria decision analysis (MCDA) approach to circuit scoring — enabling planners to compare resiliency remediation options on a consistent, relative scale. The enhanced model described in this report significantly extends the capabilities of that prototype, transforming it into a fully operational, utility-configurable decision support tool suitable for system-wide deployment.

| Planning Challenge | How the Model Addresses It |
|--|---|
| Capital prioritization | Ranks competing projects using a consistent score-per-dollar framework rather than relying on engineering judgment or first-cost comparisons alone. |
| Mixed reliability & resiliency screening | Allows both historical performance indicators and forward-looking circuit risk factors to be included in the same analysis. |
| Segment-level investment analysis | Evaluates remediations on full circuits or selected circuit portions such as overhead mainline, underground sections, or user-defined zones. |
| Budget-constrained decision making | Highlights circuit/remediation combinations that fall within a user-defined investment threshold. |

Model Overview

The Distribution Grid Reliability and Resiliency Investment Decision Model is implemented in Microsoft Excel and guides the user through a structured four-step workflow. The model produces a ranked list of

circuit and remediation combinations, sorted by return on investment — referred to as "bang for the buck" — enabling planners to identify the highest-value investments within a defined budget.

The model is built on a two-component risk scoring framework grounded in classical risk theory: risk is a function of both the probability of an adverse event and its consequence.

| Risk Component | Represented By | Role in Model |
|----------------|---|---|
| Probability | Circuit reliability & resiliency risk factors | Predicts likelihood of future outage events based on circuit characteristics and historical performance |
| Consequence | Number of customers impacted by the remediation | Captures the magnitude of customer impact if a reliability or resiliency event occurs |

The model evaluates both components for every circuit-remediation combination under analysis, standardizes them onto a common scale using statistical Z-scores, applies user-defined weightings, and divides the resulting composite score by cost to produce the final ranking. The result is a relative prioritization metric — not an absolute prediction of avoided outages — whose strength lies in making all assumptions explicit and applying the same logic consistently across every candidate investment.

Key Enhancements Over Prior Prototype

The enhanced model introduces four major functional improvements that substantially increase its applicability for real-world utility planning:

- **Configurable risk factors and remediations:** The model supports up to ten user-defined risk factors and up to twenty remediation options, allowing each utility to tailor the tool to its own data, planning priorities, and available toolbox.
- **Sub-circuit (segment-level) analysis:** Remediations can now be targeted to specific portions or segments of a circuit rather than requiring application to the full circuit. Users define what mileage type and percentage of each circuit is remediated, enabling more realistic cost and impact calculations.
- **Multi-circuit portfolio comparison:** The enhanced model compares and ranks remediation options simultaneously across all selected circuits in the system — not just one circuit at a time. This enables planners to optimize across an entire portfolio of investment candidates.
- **Budget threshold and investment screening:** A budget constraint can be specified within the model. All circuit-remediation alternatives are evaluated against this threshold, and those falling within budget are ranked and highlighted automatically in the results report.

Four-Step Workflow

Users interact with the model through four sequential tabs in the Excel workbook, each corresponding to a distinct phase of the analysis process:

Step 1 — Setup: Defining Tables and Fields

The Setup tab is an administrative step in which the user defines the structure of the analysis. Decisions made here determine the quality and usefulness of every subsequent calculation. Once all fields are configured, clicking "Create Tables" builds the data structures used in subsequent steps.

| Setup Area | Purpose | Typical Inputs |
|------------------------------|--|--|
| Circuit filtering properties | Define attributes used to select the circuit population for analysis. | Circuit ID, region, district, substation, SAIFI, SAIDI |
| Circuit length properties | Define total circuit length and selectable segment types for remediation. | Total miles, overhead miles, underground miles, mainline, laterals, zones |
| Customer fields | Capture the number and type of customers that may benefit from an investment. | Residential, commercial, industrial, and priority/critical customer classes |
| Risk factors | Identify asset, exposure, or performance variables that indicate reliability or resiliency risk. | Circuit age, vegetation density, small conductor %, interruptions per mile, SAIFI, SAIDI |
| Remediation options | Create the list of improvement measures to be compared in the analysis. | Vegetation management, reconductoring, automation, sectionalizing, hardening, undergrounding |

Step 2 — Configuration: Populating Reference Tables

The Configuration tab is used to populate the reference tables generated during Setup. These tables contain the assumptions that drive the investment analysis.

- **Cost Table:** Requires both fixed costs (mobilization, engineering, project initiation) and variable costs per mile for every remediation type. Because cost is the denominator in the final score-per-dollar calculation, incomplete or unrealistic cost inputs can materially distort rankings.
- **Customer Weighting Table:** Allows priority customers to be converted into a weighted consequence measure. Circuits serving critical or priority customers receive a higher consequence score, enabling the model to reflect utility policy and emergency management priorities in the investment ranking.
- **Default Mileage Type Table:** Identifies the default segment length type used when the data table is first created, reducing data-entry burden across large circuit populations.
- **Customer and Risk Concentration Tables:** Set default concentration values system-wide, accounting for the uneven distribution of customers and risk factors along circuits before individual circuit-level adjustments are made.
- **Risk/Remediation Improvement Table:** The most analytically critical configuration input. For each combination of risk factor and remediation option, the user enters the expected percentage reduction in that risk factor. These values drive the benefit side of the model and should be grounded in historical performance data, post-project reviews, or engineering studies.

Critical Configuration Note

The Risk/Remediation Improvement Table is the single most judgment-intensive input in the model. A carefully calibrated table turns the model into a reliable planning tool; an uncalibrated table can generate rankings that appear precise but primarily reflect unsupported assumptions. These values should be reviewed and updated as new post-project performance data becomes available.

Step 3 — Data: Entering Circuit Information

The Data tab holds the core circuit inventory. Users import or paste their circuit data into the table — circuit ID, length, customer counts by class, historical performance metrics, and risk factor values per mile. After data entry, clicking "Enable Input" triggers the model to calculate SAIFI and SAIDI quartile values for each circuit, enabling filtering by historical reliability performance.

Circuit selection is managed through interactive slicer controls that allow filtering by substation, district, reliability index quartile, or any categorical field defined during Setup. For each selected circuit, users then refine three key inputs:

- **Segment distance:** Select the mileage type (total miles, overhead miles, etc.) and optionally enter a percentage of that mileage to be remediated, allowing targeted segment-level analysis.
- **Customer concentration:** Override the default proportional assumption about how customers are distributed across the remediated segment — for example, where field knowledge indicates a higher density of customers in the targeted zone than the circuit average would suggest.
- **Risk factor concentration:** Similarly, override the default risk distribution for the remediated segment to reflect known concentrations of vegetation risk, aging infrastructure, or historical outage patterns.

Step 4 — Analysis: Running the Model and Reviewing Results

The Analysis tab is where the model is executed and results are reviewed. After completing all selections, clicking "Calculate Score" produces a ranked results report listing every circuit-remediation combination in descending order of bang for the buck.

| Analysis Control | Decision Role |
|---------------------------------|--|
| Remediation selection | Limits the run to improvement options relevant to the current planning question — enabling scenario analysis by technology type. |
| Risk factor selection & weights | Determines which predictors drive the risk improvement score and how strongly each is weighted relative to others. |
| Customer priority weighting | Optionally elevates the consequence score for circuits serving critical or priority customers. |
| Risk vs. customer weighting | Sets the balance between reducing modeled risk and benefiting larger or higher-priority customer groups. Default is equal weighting. |
| Budget threshold | Flags circuit/remediation combinations that fall within the available capital budget, enabling rapid portfolio assembly. |
| Single remediation per circuit | Simplifies output by displaying only the highest-ranked remediation for each circuit rather than all combinations. |

Scoring Methodology

Risk Factor Improvement

For each circuit and remediation combination, the model calculates the improvement in each selected risk factor by comparing conditions before and after the remediation is applied to the designated circuit segment. The improvement is expressed as the reduction in the total risk factor value — for example, fewer vegetation outages per mile — attributable to the remediation. User-defined concentration percentages allow the model to account for uneven distributions of risk along a circuit.

Z-Score Standardization

Because different risk factors are measured in different units (outages per mile, customer interruptions, circuit age in years, and so on), the model cannot aggregate these values directly. It converts all risk factor improvement values and customer impact values into Z-scores — a standard statistical technique that expresses each value as the number of standard deviations it falls from the mean of the analysis population, producing unit-free, directly comparable scores across all circuits and risk dimensions.

For risk factor improvements, sample mean and standard deviation are used. For customer impact, population mean and standard deviation are applied — ensuring that small differences in customer count

across similar circuits do not produce artificially large score differences relative to what is genuinely meaningful to a reliability planner.

Weighted Score and Final Ranking

The standardized risk factor Z-scores for each circuit are aggregated into a Weighted Risk Improvement Score, with optional user-defined weights applied to individual risk factors to reflect their relative analytical significance. This weighted risk score is then combined with the customer impact Z-score using a second weighting step, where users control the balance between risk reduction and customer impact. The composite Weighted Score is then divided by the total remediation cost — fixed plus variable — for each circuit-remediation combination to produce the final bang for the buck ranking.

| Calculation Stage | Output | Purpose |
|-------------------------|--|---|
| Risk factor improvement | Raw improvement value per risk factor, per circuit | Quantifies the benefit of each remediation on each risk dimension |
| Z-score conversion | Standardized, unit-free score for each metric | Enables aggregation across unlike measurements and scales |
| Weighted risk score | Composite risk improvement score per circuit | Applies user priorities across individual risk factors |
| Weighted overall score | Combined risk + customer impact score | Balances probability and consequence of outage events |
| Bang for the buck | Weighted score per dollar of remediation cost | Enables direct investment prioritization and budget screening |

Why This Matters

Distribution utilities are under increasing pressure to justify capital and O&M expenditures for reliability and resiliency improvements to regulators, executives, and customers — often within constrained budgets. The Distribution Grid Reliability and Resiliency Investment Decision Model provides a transparent, repeatable, and auditable analytical process for these decisions, replacing ad hoc judgment with a documented, data-driven methodology.

By enabling simultaneous comparison of remediation options across an entire circuit portfolio under a defined budget, the model gives planners the ability to identify the set of investments that delivers the greatest system-wide reliability and resiliency return — rather than optimizing one circuit at a time in isolation. Its value comes specifically from making all assumptions explicit, normalizing unlike data onto a common scale, and showing how rankings change when planners adjust risk factors, customer weights, cost inputs, or budget thresholds.

How to Apply the Model

The model requires Microsoft Excel with macro support enabled. Input data requirements include circuit inventory information (length, customer composition, substation and district identifiers), historical reliability performance data (SAIFI, SAIDI, or equivalent risk factor metrics), and fixed and variable cost estimates for each remediation type. The model is designed to be configured and maintained by distribution planning or engineering staff with access to this data.

Recommended Analytical Approach

The most effective use of the model is as a repeatable, two-pass portfolio screening process. In the first pass, planners run the model across a district, region, or system-wide circuit population to identify the highest-ranked circuit-remediation combinations within budget. In the second pass, engineers review top candidates for constructability, field conditions, asset condition, protection impacts, and interactions with

other capital programs. The model is designed to narrow the field of options — it is not a final project approval mechanism.

Rankings should also be tested under multiple sensitivity scenarios — varying risk factor selections, risk weights, customer weights, alternate cost assumptions, and alternate remediation-effectiveness estimates. Projects that remain highly ranked across scenarios are stronger candidates than those that only rank well under one narrow set of assumptions.

Implementation Practices

- **Govern the inputs:** Create a controlled library of risk factors, remediation types, cost assumptions, and customer weights so that model runs are repeatable and comparable across planning cycles.
- **Calibrate improvement percentages:** Use historical outage data, post-project measurement, and engineering studies to calibrate and update the Risk/Remediation Improvement Table on a recurring basis.
- **Standardize segment definitions:** Define segment names and mileage fields consistently across GIS, asset management, planning, and reliability systems to ensure comparability across model runs.
- **Run sensitivity scenarios:** Test multiple weighting and cost scenarios before selecting a project portfolio, particularly when rankings are sensitive to a single assumption.
- **Pair with engineering review:** Treat ranked output as a screening list, then apply constructability, operations, customer, environmental, and regulatory review before committing funds.