Technology Innovation Project

Closing Project Brief

TIP 25g: EPRI P37: Development of Substation Equipment Spares Strategy Methodology

Context

All utilities maintain inventories of spare substation equipment to mitigate the effects of equipment failures. Without available spares, replacement times may be extended by procurement and delivery delays. In particular, substation transformers may take months to replace, potentially prolonging outages and creating significant challenges for utilities striving to maintain reliability and control capital and operating costs.

There are significant costs associated with spares inventories including capital, storage, and, for some equipment, maintenance and testing. These costs and the potential benefits from spares are a function of the number of spares kept at hand. Keeping too few spares may prolong outages while too many spares would increase costs. However, there are no industry standards or guidelines to help utilities optimize the number or mix of spares.

Description

The first step for the project was to define the desired spares strategy methodology characteristics and features. The chosen spares strategy methodology addressed number and types of transformers (including mobiles) in inventory, spares store locations, spares allocation policies, spares reordering criteria and strategy planning horizon. Other variables include transportation times from stores to station and procurement times. The ability to describe both as probability distributions was also included. Additional variables may be identified for later versions.

Metrics were determined for evaluating or comparing the results of implementing various spares strategies. Costs of strategy implementation was not included in this initial development. Rather, it is expected that the cost metric will be based on a measure of operational risk associated with an unfilled transformer position.

The analytical methodology relates the strategy metric(s) to various user define inputs (e.g. reordering criteria, spares inventory) and system specifications (e.g. number and type of installed transformers by station) to allow for scenario and what-if studies. The metric or metrics and analytics provide views of a strategy and its constituent decisions' impact by various categories (e.g by fleet, station, transformer type, circuit or criticality group). The analytics allow the user to take into account the stochastic nature of age dependent transformer failure rates in addition to other possible natural or man-made hazards.

The initial beta version was developed to analyze test cases by project participants. It is anticipated that the spares strategy analytics will be incorporated into a software tool with a spreadsheet GUI. But additional software modules (i.e., VBA or C++) may be required. Depending on customer interest, a release version may be produced in a subsequent project phase.

Benefits

Project results may help utilities reduce capital costs and maintenance associated with spares inventories through the application of more analytical processes for determining spares strategies. Results may also help improve service availability and help keep electricity affordable by reducing unplanned outage duration and improving customer satisfaction.

Risk-based spares strategies would more appropriately align with the industry desire to incorporate asset management principles.

Accomplishments

The objectives for this project are to investigate and assess available methods for determining spares strategies, identify strengths and weaknesses and unmet needs and develop an enhanced analytical methodology for determining or evaluating spares strategies. The methodology takes advantage of other EPRI developments in the areas of fleet management and industry-wide data bases, as well as hazard rate analyses.

Deliverables

The non-proprietary results of this work will be incorporated into EPRI R&D program 37 (Substations) and made available to the public, for purchase or otherwise.

At the conclusion of BPA's participation in this program the following deliverables were delivered:

1. The functional requirements for an enhanced analytical methodology for determining or evaluating substation equipment spares strategies.

2. A prototype software version of new analytics for designing and evaluating spares strategies.

3. An evaluation of the prototype analytics based on the experience with a subset of utility transformer fleet and identification of any required enhancements.

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Project Start Date: January 2018

Project End Date: December 2021

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Participating Organizations

Electric Power Research Institute (EPRI)

Related Projects:

TIP 399: EPRI P34 Transmission Asset Management Analytics

Conclusions

The release version of this tool by EPRI. BPA has used the beta version of analytics for designing and evaluating spares strategies with a test case including a subset of transformer fleet data and evaluate the results to determine the usability and features of the program. The early version of the tool used R program language and was cumbersome to use. However, the proposed GUI that would greatly improve usability has been delayed due to the pandemic and fewer than expected participants. But EPRI continues to develop this tool and may add other features in later versions.

BPA will monitor the tools development at EPRI and consider further participation and additional test cases once these features are available. The BPA project manager says, "I support this project but ... a simpler version is needed to use it." In assessing the project over all, he notes, "Putting spare strategies together when you have transformers with multiple ratings along with mobile transformers is very complicated and EPRI's tool makes excellent use of the transformer industry-wide database."