A BALANCING ACT

Dimensioning a utility scale sparing concept based on potential revenue losses and additional investments

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Abstract

This paper presents a data driven methodology for optimizing a spare transformer concept using the investment cost, risk of lost profit, transformer reliability, and the downtimes in case of failure as the prime analysis parameters.

In the case presented in this paper an energy utility uses the Systecon software OPUS10, a spare part inventory and logistic support optimization tool, to analyze and develop a spare transformer concept for its fleet of step-up transformers.

The results from the analysis details which transformers that it is profitable to keep spares for, and at which power plants the respective spare units should be kept for optimal operations.

By conducting the analysis, the utility stands prepared for failures on the critical sub systems that the transformers represent and can at the same time rest assured that it has not overinvested, and tied up capital, in costly spare units. The methodology used by the utility ensures that the risk reducing spare investments is proportional to, and well balanced with, the economic risk of losing generation.

Furthermore, the case presented in this paper shows how OPUS10 can be successfully employed, and deliver fact-based results, also in cases where the systems have long MTBFs.

Background

A large energy utility has identified a need to develop a sparing concept for the company's step-up transformers.

The utility wish to investigate and analyze if additional investments in spare transformers can be economically motivated, and if so, which they should buy?

The Case

The transformers included in the analysis are those transformers that connects power plants to the grid. In case of failure of a transformer included in the concept the power plant is cut off, left unable to deliver electricity to the grid, and hence the revenue from that power plant will be lost until it's back online, i.e., until the transformer is replaced or repaired.

The utility has decided that repairable transformer failures (direct repairs) will not be allowed to drive the need of spare units. Replacing a transformer for the duration of its repair is not considered profitable, and therefore are only total transformer breakdowns, that will require replacements with new units, included in this analysis.

The question that the company seeks to analyze and answer is if there are investments in spare transformers that can be economically motivated, i.e., can a balance between the risk of losing production and the cost of keeping spare units be found?

Data sources

The utility had the following data (Table 1) available:

Table 1: Available Transformer data

Parameter	Description
Power Plant	Name of power plant
Manufacture	Manufature of transformer
Apparent Power	The magnitude of the complex power [VA]
Voltage Ratio Max/Min	Ratio between LV and HV side
Vector Group	Winding configuration of 3-phase transformers
Existing Spare Transformer	If spare unit exist and its location
Quality/Reliability	Reliability of transfomer
Transformer Price	Price of transformer [EUR]
Downtime in case of spare	Time duration required to replace if spare exist
Downtime in case of no spare	Time duration required to replace if no spare exist
Expected annual gross margin of block	Expected gross margin per annum if no unavailability

The information concerning down times, with and without spare units, and the data relating to the expected gross margin, enabled the utility to assess what unproductive durations would imply in terms of lost profit.

Together with reliability data and the price of each transformer the risk of losing profit could be evaluated against the risk mitigation of investing in spare units.

Methodology

The utility used the spare part and logistic support optimization tool OPUS10 to model and analyze their transformer case. The basics of the methodology is depicted below in Figure 1.

OPUS10 is an analytical tool that uses turn-around-times, reliability, and price data together with information concerning logistics, maintenance, and other technical aspects to calculate the optimal assortment and allocation of spares from a system- and cost-effectiveness perspective.

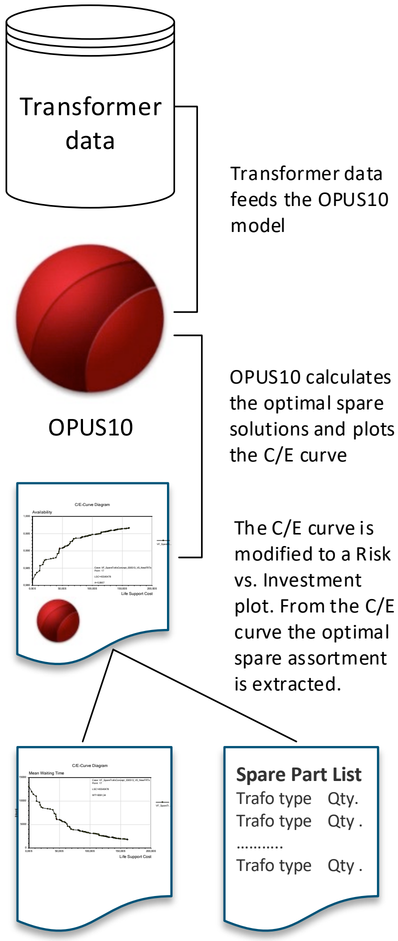

Figure 1: Overview of the analysis methodology.

The C/E (cost/effectiveness) curve that the utility generated using OPUS10 plots the spare investments against the availability of the whole system, i.e., the average availability of all transformers. Each point on the C/E-curve represents the optimal sparing solution for a specific budget frame.

As one progress to the right in the C/E-curve the total investments increases as OPUS10 buys more transformers. Having more spare units also implies having a higher readiness for random failures, and hence, the resulting system availability also increases as one progress to the right in the C/E-curve.

Different power plants have different profitability, meaning that the value of availability differs between transformers in this case. The utility took advantage of the possibility to prioritize the plants in the OPUS10 model and used the expected annual gross margin as a priority factor in the model.

Once the C/E-curve had been established the utility extracted the availability for each transformer in the case, and for every point on the curve. Together with the information about the expected annual gross margin the C/E-curve was modified to a Risk vs. Investment curve.

Results

Figure 2 shows how the investments in spares influence the lost profits due to down time caused by transformer failures. Naturally, lost production, and hence lost revenues, decreases with higher investment levels in spare transformers.

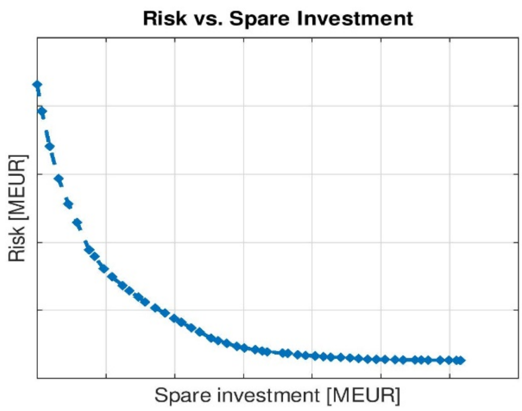

Figure 2: Risk vs. Spare investment.

The utility was interested to evaluate how many, and which, transformers that could be economically motivated to purchase as spares. Therefore, the delta risk reduction was divided with each respective spare investment to create Figure 3 below.

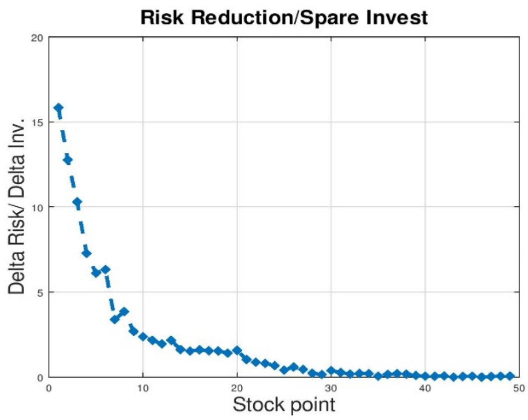

Figure 3: Delta risk/delta investment.

In the plot above the unitless ratio between risk reduction in MEUR and investment in MEUR is depict. If this ratio is below one (1) the investment is inevitably not profitable. However, all ratios above one (1) will not likely prove themselves profitable since there is uncertainty built in to the risk value.

The utility opted to vary different input parameter, e.g. the failure frequencies of the transformers, to study the sensitivity of the results. Results from three scenarios with different failure rates are shown below in Figure 4.

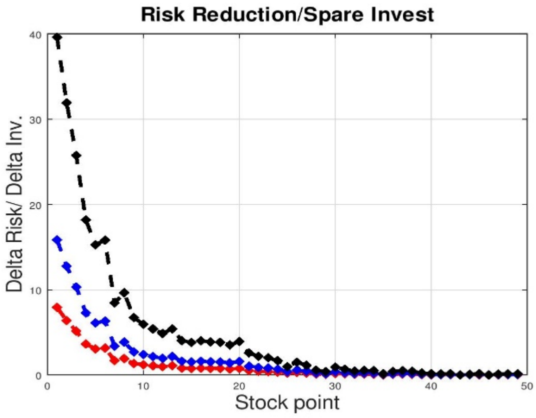

Figure 4: Delta risk/delta investment at different failure scenarios.

Properly investigating the sensitivity of the results was an integral part of the analysis. The absolute availability levels were not the priority of the analysis, more so was formulating a short list of transformers to invest in. After evaluating the case in different scenarios, the utility could select a ratio between risk reduction and spare investment with good judgment and formulate a short list of transformers for their investment program. Additionally, OPUS10 also specifies the best allocation of the spare units, i.e., at which power plant the different spare transformers should be stored at for maximum efficiency.

Summary

This paper has presented a data driven methodology for optimizing a spare transformer concept using the investment cost, risk of lost profit, transformer reliability, and the downtimes in case of failure as the prime analysis parameters.

The results from the analysis details which transformers that it is profitable to keep spares for, and at which power plants the respective spare units should be stored for optimal operations.

By conducting the analysis, the utility stands prepared for failures and at the same time the company can be confident that it has not over invested in spare units. The methodology used by the utility ensures that the risk reducing spare investments is proportional to, and well balanced with, the economic risk of losing generation.

Moreover, the case presented in this paper shows how OPUS10 can be successfully employed, and deliver fact-based results, also in cases with low overall failure rates.

About Systecon

Systecon is a software and service provider specialised in analytical life cycle asset management. Systecon's Opus Suite includes three modules, all developed to support heavy asset owners and operators in managing their assets.

- OPUS10 – Spare part, and spare part logistics, optimization.
- SIMLOX – Support system simulation. Operational availability & resource utilization.
- CATLOC – Life Cycle Cost/Profit. Cost driver identification. Budgeting & forecasting.

Systecon's outlook on asset management is from a data driven and analytical perspective, where effective use of information through strong analytical capability, leads to informed decisions with high risk awareness. Opus Suite is used in various asset intense industries, e.g. defence, railway, energy, and commercial aviation, throughout the world.