QUANTIFYING ASSET RISK TO OPTIMISE INVESTMENT, A REALISTIC PROSPECT?

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ABSTRACT

In this paper, recent experience of using risk to assist with asset management decision making is discussed. A case study is presented that demonstrates both the viability and effectiveness of quantifying asset risk to optimise investment. The critical elements for successful risk based processes are considered.

INTRODUCTION

Managing risk and the use of risk based asset management processes is an aspiration for many distribution companies. Over the past 10 years EA Technology has worked extensively with distribution companies developing and applying condition and risk based processes both to optimise maintenance and more recently to assist with defining, justifying and even optimising investment to renew ageing networks.

One significant result of this work has been the creation and application, in conjunction with over 30 distribution and transmission companies worldwide, of the process known as Condition Based Risk Management (CBRM). The development and application of CBRM can be charted by reference to papers at the last four CIRED conferences[1],[2],[3],[4].

Our experience in this area indicates that:

- In order to enable assessment, comparison and optimisation of investment programmes, it is essential to derive risk at the individual asset level
- The asset information, engineering knowledge and practical experience necessary to quantify asset risk is available in most companies
- Quantifying asset risk is a viable and powerful basis for planning, justifying and optimising investment.

In this paper we discuss some recent experience and regulatory developments that support these conclusions.

CONDITION BASED RISK MANAGEMENT (CBRM)

CBRM is a process that uses asset information, engineering knowledge and practical experience of the assets to define condition, performance and risk.

The outputs from a CBRM model are for each asset:

- A health index - numeric definition of condition
- Probability of failure (POF)
- Risk - expressed in monetary terms (£s, $s or €s)

For asset groups:

- Health index profiles – overall distribution of health indices
- Failure rates
- Total risk

The process enables the current health index to be aged so that future, condition, performance (failures or failure rates) and risk can be estimated with and without interventions. Because of the granularity of the process, it is possible to factor in any combination of interventions.

Quantifying risk

The risk calculation is based on combining the POF value obtained from the health index with the consequences of failure. The consequences of failure are defined in several categories, typically network performance, safety, financial and environmental.

In each category the average consequences are estimated (based where possible on recent failures). In each of the categories the consequences have their own specific units (e.g. CMLs/CIS/SAIDI/CAIDI for network performance, fatalities and injuries for safety, £s, $s or €s for financial and litres of oil, kgs of SF_6, etc for environmental).

Each of these consequences is given a monetary value. The overall risk is therefore calculated in monetary terms.

The relative importance of individual assets can be accounted for by defining the ‘criticality’ of the asset separately in each of the categories.

The significance of risk

The significance of risk in asset management decision making terms is two fold. Firstly, it provides the opportunity to consider the criticality of individual assets. The asset in worst condition, with the highest POF, may not be the asset which poses the largest risk that may be a more critical asset in better condition.

Secondly, and more importantly, quantifying risk enables comparisons to be made across asset groups. Because the measure of risk is the same for all assets, the benefit (the reduction in risk) for any intervention involving any combination of different assets can be compared.

Therefore risk quantification potentially offers asset managers an invaluable planning tool, the ability to be able to rank all investment projects on the basis of cost/benefit and perhaps the ultimate ability to define the financially optimum risk profile and future investment plan. The potential power of this is illustrated further in the following section and case study.

Financial optimisation

By quantifying risk in financial terms, CBRM provides the possibility of financial optimisation of investment.

Using a simple Net Present Value (NPV) model the cost of investment which in NPV terms decreases if the investment is delayed, can be balanced against the increasing risk if an asset in poor condition, with an increasing POF and risk, is left on the network.

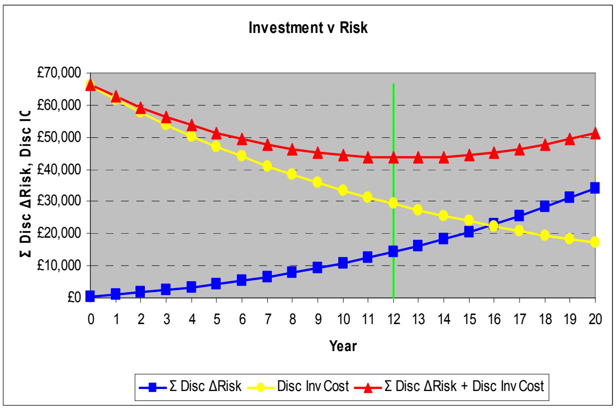

Figure 1, The NPV/risk curves for an individual asset, defining the optimum replacement year

For any asset the optimum replacement time (the time at which the sum of the investment cost and risk is at a minimum) can be calculated.

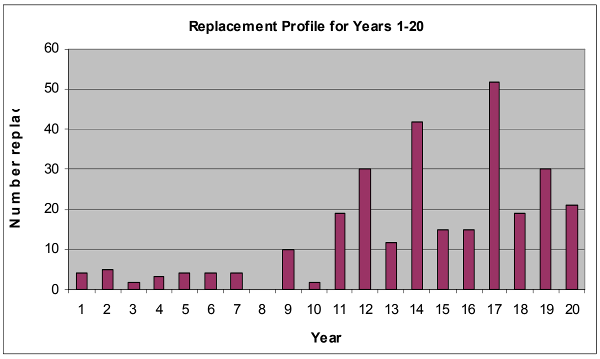

Figure 2, The optimum replacement profile for an asset group, derived from NPV/risk curves for individual assets

This provides a means to define the optimum replacement programme (the most cost effective programme) across all asset groups. This is the process used by Energex in the case study below that enabled them to define an asset replacement and renewal programme that maintained the current level of risk with a 30% saving in CAPEX compared to conventional age or condition based approaches.

A CASE STUDY – BUILDING A RISK BASED INVESTMENT PROGRAMME WITH ENERGEX

(Energex[5] is the Electricity Distribution Company for South East Queensland, Australia)

The background

In 2007 Energex was preparing for a regulatory submission to the newly formed national energy regulator (The AER). After a decade in which spending had been restricted, they felt there was the need to significantly increase the rate of investment for renewal of older parts of the network.

To define and justify a significant increase in capital spending Energex wanted to apply an effective condition and/or risk based process. After detailed discussion, demonstrations and meetings with previous users of CBRM, Energex engaged EA Technology to work with them.

The CBRM project

Between September 2007 and June 2008, EA Technology worked with Energex to build and populate CBRM models for 34 asset groups. These included all major assets from 132kV plant to LV overhead lines. The complexity and detail of the models varied, reflecting the level of information available for the different asset groups.

The CBRM models provide the means to estimate future condition, performance (failure rates) and risk (expressed as £ or $) in any year with any intervention. Potentially a huge array of results can be created.

Energex chose to use a 10 year horizon as the basis for planning future investment. For each asset group the condition, performance and risk were calculated (built up from the condition, performance and risk of individual assets). The current results were compared with the estimated results for year 10.

As the populations contained significant numbers of relatively old assets that had evidence of significant degradation, the estimated failure rates and risk in year 10 (with no intervention) were for many asset groups much higher than the current values. In fact the overall risk (for the 34 asset groups) was estimated to increase from $150M in the current year to over $350M by year 10.

The total risk expressed in monetary terms is perhaps difficult to understand, but the current figure is an overall measure of the current performance (a combination of network performance, safety, financial and environmental effects of asset failures). An increase of over 100% therefore represents a very serious degradation of performance.

Two strategies were applied to define and evaluate interventions designed to maintain the risk at acceptable levels over the next 10 years. Firstly, interventions were applied to each asset group to achieve a failure rate and risk in year 10 similar to the current level.

The second approach was to apply the NPV calculation to derive the 'financially' optimum intervention programme for each asset group. In this case the result was that in some groups less investment is made and the risk rises (as compared to the current risk), whereas in other groups more investment is made and the risk is reduced.

This optimising approach is essentially investing preferentially where the cost/benefit is highest. The overall results were very interesting. The overall risk for the 34 asset groups in year 10 in both cases was within 5% of the current value but there was a big difference in the cost (the investment). The estimated investment using the risk optimisation approach was over 30% less than simply maintaining the risk in each asset group.

The Investment Plan – Regulatory Submission

Energex used the results of the CBRM project to define their asset replacement and renewal budget in their regulatory submission to cover the period 2010/11 – 2014/15. Their proposed expenditure was based on the financial risk optimisation process described above.

The total expenditure proposed was $1,165m compared to $313m in the previous 5 year regulatory period. An increase of 273% !

To support this large increase Energex presented the full CBRM process, models and results to the Regulator.

The Regulator's verdict

The Regulator employed consultants (Parsons Brinckerhoff) to analyse and assess the Energex submission. The PB report is accessible on the AER website[6].

There is a significant section of the PB report dedicated to the proposed CAPEX for asset replacement and renewal. This includes an assessment of both the principles of CBRM and the inputs used by Energex.

They concluded that the information and other inputs to the models were well supported and appropriate and the proposed spending was prudent and efficient. They recommended that the proposed spending was accepted without change.

The Regulator's determination[7] (also available on the AER website) confirmed this decision.

THE VIABILITY OF BUILDING EFFECTIVE RISK MODELS TO DEFINE INVESTMENT PROGRAMMES

When considering the viability of building risk models, it is important to consider who the stake holders are. Who do we have to convince to claim that an approach and a set of results are valid?

As a consultant working with transmission & distribution (T&D) companies we see two primary stake holders. Firstly, the T&D company; we have to convince the asset managers, the experienced engineers and ultimately the senior management that the process we are going to jointly apply is valid and viable. They need to be confident that the process will produce significant, credible results that will help them make and justify effective asset management plans.

Secondly, the Regulator; unless the results from risk based models are accepted as justification for investment plans by regulators, distribution companies can quickly lose interest.

Over past 10 years EA Technology has worked with over 30 T&D companies worldwide building and populating CBRM models. We therefore have ample evidence that network operators are convinced of the viability of the process.

Although in recent years we have built and populated full CBRM models with many companies, in most cases in their submissions to regulators, the companies have concentrated on the condition and performance elements of CBRM to define and justify investment plans.

The significance of the Energex project is that it was the first time that a company was prepared to fully embrace 'risk' as a basis for building a replacement and renewal programme. The fact that the AER fully accepted a very large increase in spending appears to be a strong endorsement.

The analysis carried out by the AER's consultant provides further significant comments. The underlying reason why they found the CBRM risk process credible was that it was built up systematically and transparently from engineering knowledge and practical experience of the assets. This has always been at the core of CBRM.

The significance of risk optimisation to the positive Energex regulatory determination is further highlighted by a review for another distribution company in Australia that was published at the same time. In this case the company had also proposed a large increase in Capex for replacement and renewal but its case was built largely on the age of assets. The AER did not accept their proposal, citing failure to provide a detailed risk model as the reason for imposing a very significant cut to the proposed spending plan.

In the UK all the distribution companies have experience of applying the CBRM process and several used the condition and performance elements to justify future plans in the recent price review (DPCR 5). In general, OFGEM (the UK Regulator) received these positively.

As part of the DPCR5 process OFGEM reviewed the 'output' measures[8] used to define the effect of future investments. One of their proposals was that by the time of the next review companies should develop output measures (referred to as Tier 1 output measures) that provide a holistic view of network risk that can be used to assess the efficiency and effectiveness of investment plans. This is a good description of the CBRM risk output.

Currently the CBRM process is designed to deal with non load related asset replacement and renewal (driven by condition of ageing assets). OFGEM wants the Tier 1 output measures to deal with both load and non load related investments. To this effect they introduced 'load indices' as a reporting measure in DPRC5.

To satisfy this requirement an equivalent risk quantification process for load related issues needs to be developed. Our experience with condition based risk provides an excellent starting point. We believe we have the basis for a viable process to quantify load related risk.

Inevitably investments to address load and/or condition have some overlap, so combining the condition and load related risk processes should enable synergies to be correctly defined and managed.

CONCLUSIONS

EA Technology's experience working with many distribution and transmission companies, in different countries with different regulatory regimes, indicates that quantifying asset risk to plan, justify and optimize investment is very much a realistic prospect. Indeed as the Energex case study shows it is already being used very effectively to underpin capital spending plans. The experience with Energex and the reaction of the Australian Regulator to recent submissions suggests that they now expect spending plans to be justified by detailed risk models.

In the UK, OFGEM has clearly signalled that it expects similar output measures to support future regulatory submissions.

A very important aspect of the CBRM risk process is that it a 'bottom up' process. It is built by capturing and using detailed engineering knowledge and practical experience of the assets to derive quantify condition, performance and risk for individual assets. This provides both the credibility of the results and the ability to assess the effects (on condition, performance and risk) of individual intervention projects.

In our view these are critical elements for a successful risk based approach. The Regulator's consultant in Australia specifically commented that the underlying engineering knowledge and practical experience gave the models credibility.

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