BUILDING RISK BASED INVESTMENT PROGRAMMES

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ABSTRACT

Risk models, built by accessing and using detailed asset information in conjunction with engineering knowledge and experience, have been shown to be a very powerful basis for defining, justifying and optimising investment to renew ageing networks.

The opportunity now exists to extend the use of asset based risk models to assist with building investment programmes in other important areas. Potential applications to load related investment and the development of smart grids are considered in this paper.

INTRODUCTION

Risk based asset management decision making has long been an aspiration of distribution companies. The continuing interest in this area was evident at the CIRED 2010 workshop at which many papers dealt with methods and processes to quantify asset related risk.

Over the past 10 years the authors have worked with many distribution and transmission companies worldwide to develop and apply condition and risk based processes to assist investment decision making. This work reported at previous CIRED events [1],[2],[3],[4],[5] has been based on the Condition Based Risk Management (CBRM) process that combines asset information and engineering knowledge/experience to define current and future condition, performance and risk. The process has been developed specifically to assist companies define, justify and optimise one particular area of investment; non load related investment, i.e. the replacement or renewal of ageing assets to prevent increasing failure rates and maintain an acceptable level of network performance.

This paper highlights the features and successes of CBRM and considers the opportunities to expand 'risk based decision making' to other important areas of investment. In particular, to address: (1) load related investment and (2), the adoption of new technologies to create 'smart grids'.

THE SIGNIFICANCE OF 'RISK'

Generally risk is defined as a measure that reflects both probability and consequences of (unwanted) events and therefore provides a sensible basis for determining the appropriate level of investment to manage the unwanted events.

The nature of risks facing any business is wide ranging. For an operator of an electricity network these include both technical risks related to the performance of their assets and general business/financial risks related to interest rates, availability of capital, skill shortages etc.

The CBRM process has been developed to address one specific area of technical risk, namely the potential increase in asset failures for ageing assets whose condition is deteriorating. The process is designed to enable investment necessary for asset/network renewal to be justified and targeted. Risk associated with ageing assets is expressed in monetary terms thus allowing the cost of investment to be balanced against the benefit in terms of reduced risk.

The success of CBRM has led to consideration of how the lessons learnt can be applied to other investment areas.

TYPES OF RISK MODEL

Broadly speaking, risk models can be categorised as either top down or bottom up.

The conventional corporate risk processes are generally top down models. Two common approaches are; (i), to define a number of risk categories and a series of levels in each category (typically 5 levels) to produce a series of risk matrices (severity or impact vs. likelihood or probability), (ii) to create a risk register in which events that potentially present a significant risk are identified and mitigation measures defined.

Such approaches provide a means for companies to demonstrate and refine their understanding of the risks they face and are useful as background/input to developing and justifying investment programmes. One of the great attractions of this approach is that realistic models can be created with quite limited effort.

While these top down models are strategically useful they are essentially qualitative and do not enable the cost/benefit (reduction in risk) of programmes to be quantified. The point of a bottom up (asset based) approach is that it does enable the cost/benefit of individual programmes to be assessed down to a very detailed (individual asset) level. It enables quantification of the overall risk for complete investment packages and can provide a powerful link between technical and financial issues.

Asset based (bottom up) approaches do require much more work (in terms of accessing and using detailed asset information) than the high level top down approaches. However, network operators are generally rich in asset information and engineering knowledge/experience. Indeed, for an asset management organisation, this information/knowledge/experience is one of their most valuable resources.

The opportunity therefore exists to build bottom up risk models that genuinely enable companies to manage risk. Relying only on top down models does not enable quantifiable risk management and fails to utilise a hugely valuable resource (asset/engineering information, knowledge, experience). CBRM is an example of a bottom up (asset based) risk model designed to address non load related investment. We are now considering extending this approach to deal with other areas of investment. Some of the opportunities are discussed in the following sections.

CBRM: AN EXAMPLE OF THE POTENTIAL OF BOTTOM UP RISK MODELS

CBRM is a process that uses asset information, engineering knowledge and practical experience of the assets to define condition, performance and risk. It is very much a bottom up process requiring access to, and use of, detailed information and engineering knowledge of the assets

The outputs from a CBRM model are as follows.
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 in investment planning

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 that is 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 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.

Financial optimisation

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

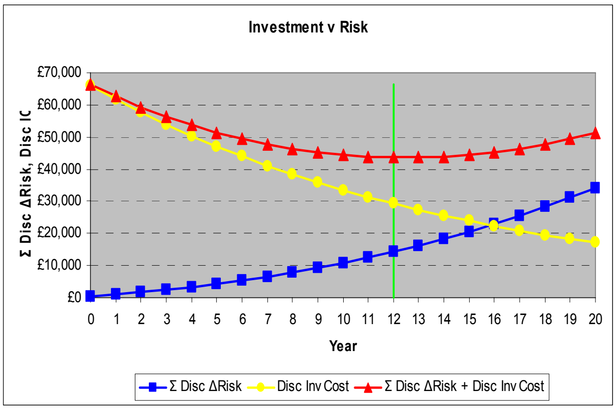

Figure 1, The NPV/risk curves for an individual asset, defining the optimum replacement year

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.

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.

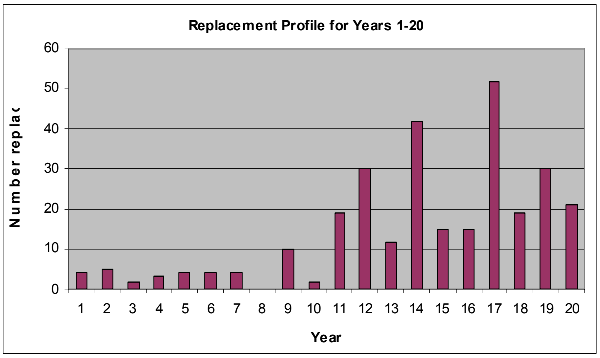

Figure 2, The optimum replacement profile for an asset group, derived from NPV/risk curves for individual assets

This provides a means to define the optimum replacement programme (the most cost effective programme) across all asset groups. A case study that illustrates the huge benefits that can arise from adopting this approach was included in the paper presented at the CIRED workshop in 2010 [5].

LOAD RELATED INVESTMENT AND ‘SMART GRIDS’

Similar bottom up (asset based) approaches can be applied to other areas of major investment. Two particular areas that are currently being addressed are (1), load related investment and (2), the adoption of new technologies to create ‘smart grids’.

Load related risk

The UK regulator, OFGEM, is encouraging UK DNO’s to develop ‘a holistic output measure that reflects both probability and consequences, covering both load and non load related investment’. The current CBRM process satisfies the holistic description for non load related risk; a similar asset based process for load related risk would complete the picture.

Outline of process to quantify load related risk

The ‘probability’ element of load related risk can be derived either directly from % of firm capacity or from the load index. Whatever measure is used it should reflect both the maximum load, the time the maximum load is above the firm capacity and the ability to transfer load to other assets/substations. All these quantities are currently available along with future load forecasts.

What are the consequences/risks if the load approaches and exceeds the firm capacity? The primary risk is the ability to supply customers (network performance). Our proposal is to extend the current CBRM method of quantifying network performance risk to reflect the significance of load. In fact load is already used as a criticality factor in some CBRM applications. Are there any other elements of risk relating to load; safety, financial environmental or other? If there are, these can be quantified in the same direct way as in CBRM.

In CBRM models the network performance risk for ‘n-1’ assets is quantified by; (i) determining the load at risk (usually based on the firm capacity of the substation or the rating of the cable/OHL), (ii) applying a low probability/risk factor reflecting that for normal circumstances (load < firm capacity) the risk of customer interruptions when an asset fails is low.

As the load on a substation or asset approaches and then exceeds the firm capacity the risk (of a significant customer interruption) rises rapidly. The proposal would therefore be to use load (as a function of firm capacity) or some calculation of load index (as a value on a continuous scale, not simply a 1-5 band) to create a strong criticality factor resulting in a rapid rise in risk as the load passes through the firm capacity. The exact shape of the criticality factor v load is something that requires some thought. However, it is likely to be similar to the HI v POF curve used in CBRM.

In CBRM one of the underlying ‘calibration’ references is the acknowledgement (based on engineering experience) that seriously degraded assets with a significantly increased POF should be replaced. Therefore the increase in risk as the asset HI moves through the 6-8 region should be sufficient to justify replacement. (The exact HI at which asset replacement is indicated by the NPV calculation will depend on the individual criticality).

On the load side for, engineering experience and practice is that investment is necessary when the firm capacity is exceeded. This is often expressly defined in security of supply standards and is therefore treated as an absolute requirement. Any model that quantifies load related risk should result in output (the increase in risk as the load passes the firm capacity) that is, at least in general terms, consistent with this. Thus providing an initial reference to calibrate the severity of the load based criticality factor.

Building a model of this type will result in the load related risk being both a product of condition (probability of failure) and load. This is surely correct. Assets approaching firm capacity but in good condition (with a low POF) present less risk than assets with similar loadings but in poor condition.

The output of such a model will be a measure of risk (ultimately expressed in £s, $s or €s) that will quantify the change in risk as loading on assets changes. The rapid increase in risk as the load on individual assets or groups of assets approaches and exceeds the firm capacity will provide the financial justification for investment.

We believe this approach offers an effective means of producing a 'bottom up' (asset based) risk model that will enable the benefit (reduction in risk) of load related investment plans to be quantified in a similar manner to the non load investment with CBRM.

Investment in smart grids

Building 'smart grids' will require the introduction of novel equipment and new technologies. In order to achieve financially efficient outcomes, some means of assessing the cost/benefit of different schemes will be required. A detailed asset/network based risk model will provide this capability.

The initial versions of CBRM concentrated on quantifying the negative consequences of not replacing assets. In these cases the driver for investment is primarily the reduction in negative consequences achieved by replacing old, poor condition assets with new assets thus reducing the number of failures.

However, it soon became apparent that in some cases the introduction of new equipment brings with it additional benefits, reduced maintenance, reduced losses, increased functionality etc. Quantifying these as benefits, using the same explicit categories and valuation processes employed in CBRM to quantify the risks and benefits associated with increasing failure rates for ageing assets, provides further justification for investment often bringing forward the optimum replacement time.

Indeed for some 'secondary' systems, such as protection, the quantification of the benefits with modern equipment and systems (rather than the reduction in risk with the existing) has successfully been used to justify investment.

Extension of these principles, involving the detailed quantification of the benefits of new technologies in explicit categories, can provide an important element to assist with identifying the financially viable smart grid opportunities.

CONCLUSIONS

Extensive application of CBRM has demonstrated that building detailed asset based risk models (bottom up risk models) is both viable and provides an extremely powerful basis for defining, justifying and optimising investment.

Creation of asset based risk models requires accessing and utilising detailed asset information and available engineering knowledge and experience. Inevitably such activities are relatively labour intensive and therefore require a significant commitment of time and resources.

The asset information and engineering knowledge and experience represent one of the most significant resources available to Network Operators. Utilising this resource provides credibility to the output and a clear audit trail for the process. Also detailed asset based models provide the level of granularity necessary to plan and evaluate detailed (asset specific) investment programmes.

To date, our experience is limited to building risk models to address non load related asset replacement. We are currently extending the approach to cover other major areas of investment. Two areas currently attracting great interest, are load related investment and the implementation of smart grids.

We believe application of asset based risk models (built by utilising detailed asset information and engineering knowledge and experience) are essential to achieve genuine risk based asset management.

REFERENCES

[1] D Hughes, 'The use of health indices to determine remnant life for distribution assets', CIRED 2003
[2] D Hughes, 'CBRM, enabling condition information to influence AM decision making', CIRED 2005
[3] D Hughes & T Pears, 'CBRM a process to link engineering knowledge to investment planning', CIRED 2007
[4] D Hughes & P Barnfather, 'CBRM, bringing AM excellence into the boardroom', CIRED 2009
[5] D Hughes, P Barnfather & T Pears, 'Quantifying asset risk to optimise investment', CIRED workshop 2010