OPTIMISING RESOURCES UNDER NORMAL AND ADVERSE WEATHER CONDITIONS

Colin Edge - Change Management Director, Midlands Electricity
Frank Riley - Business Planning Manager, EA Technology
Frank Sharman - Principal Consultant, EA Technology
David Rigler - Development Engineer, EA Technology
Capenhurst, Chester, CH1 6ES, UK
0151 347 2293 email: rig@eatl.co.uk

ABSTRACT
This paper describes a novel method for optimising the use of resources (staff, materials, sites, etc.) and associated investment initiatives that will allow Midlands Electricity (MEB) to improve its response to overhead line fault situations, in an area of the business which carries significant cost. These options were developed through the creation of a combined business, engineering and logistical model of the Network Business and the restoration process in particular.

INTRODUCTION

The new model has allowed a wide range of business measures to be evaluated, including:

- ❑ Total resource requirements needed for unplanned work in average weather conditions to achieve the desired network performance standards.
- ❑ The sensitivity to the severity of weather conditions, having established the resource requirements for average conditions.
- ❑ Determination of the effect of failing to meet the target network performance, including customer and regulatory perspective.
- ❑ Options for the provision of resources and materials and the most efficient way of providing the required resources.
- ❑ Prioritisation of alternative investment options for improving network performance.

The paper will discuss the business drivers, overall philosophy adopted, modelling approach, data requirements, present limitations and plans for future enhancements, which allow a more integrated and rigorous economic and engineering analysis of a wide range of distribution business activities to be undertaken. Many aspects of this project have required the development of innovative software and techniques that have been well received and have made a significant contribution to the business success of MEB.

The information that is shown in the graphs in this paper has been randomly altered by small amounts so as to protect the confidential nature of the data. However, the trends in all of the graphs are accurate reflections of the real data.

NORMAL AND ADVERSE WEATHER

Under normal conditions an electricity distribution network suffers a few HV overhead faults each day. As shown in figure 1 for a typical network there are many days with up to 10 faults, but several times a year there are days with 50 or so faults, and occasionally there are days with 150 or more faults.

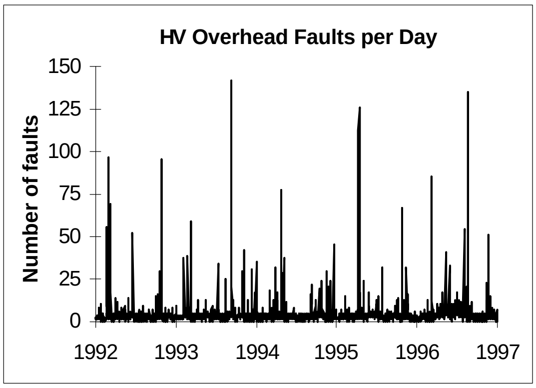

Figure 1: The number of faults per day

Figure 2 shows a histogram of the number of faults per day and it confirms how for most days there are up to 6 or 8 faults, but there are a few days with a large number of faults. All the days with more than 40 faults are grouped together in a single column.

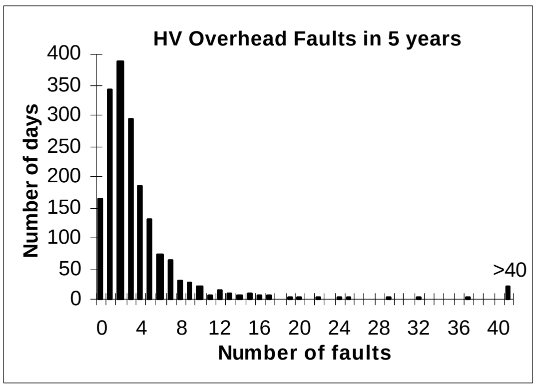

Figure 2: The histogram of faults per day

The Customer Minutes Lost (CML) is an important measure of network performance which multiplies the duration of each interruption by the number of customers affected. It is interesting to see in figure 3 how these were distributed between the many days with few faults and the few days with many faults.

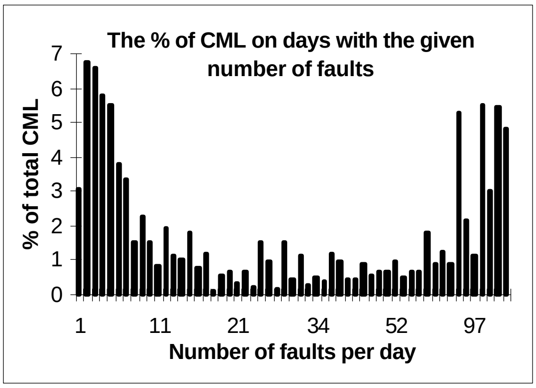

Figure 3: The distribution of CML

This chart can be summarised by saying that approximately 25% of CML occur on the very few days with over 90 faults, but that another 25% of CML occurs on days with less than 4 or 5 faults. This implies that to improve the network performance it is just as important to maintain a high efficiency on the many days with few faults as it is to improve the response on the few days with major emergencies.

BUSINESS DRIVERS

The real world is messy and strategy development must encompass eclectic demands. Companies continually compromise to satisfy opposing stakeholders, but often this leads to a fragmented approach to asset investment policy formulation. Internal drivers can be conflicting (e.g. Engineering versus Finance) while external forces such as Regulatory uncertainty can also play a significant role. Other forces influencing investment prioritisation include:

- Increasing uncertainty
- Accelerating pace of change
- Regulation
- Competition
- Profitability in the short, medium and long term
- New technology
- Environment and safety

For this project MEB chose the following business drivers:

- Profitability
- Cash Flow
- Customer minutes lost
- Customer interruptions
- % restoration in under 3 hours
- % restoration in under 24 hours
- Chances of success

MODELING APPROACH

The necessary modeling requires at least three facets:

- Network and asset modeling
- Logistic and operational modeling
- Economic and business modeling

This reflects the business reality of owning and operating a network whilst improving the share holder value. The suite of tools developed at EA Technology is designed to improve the maturity of the decision making process throughout the distribution business environment.

Network and Asset Modeling

EA Technology has developed a Network Simulation Facility (eaNSF) [1-5] that provides facilities for:

1. Accurate network modeling.
2. Quantitative analyses of capital expenditure and engineering for a range of investment options.
3. Sensitivity studies to a wide range of analyses.

The program eaNSF is flexible and provides editing tools for:

- Creating your own network data or loading network data from corporate databases via a defined neutral file format.
- Selecting your own asset performance parameters or using the delivered plant library.
- Using predefined performance criteria or selecting company specific data.

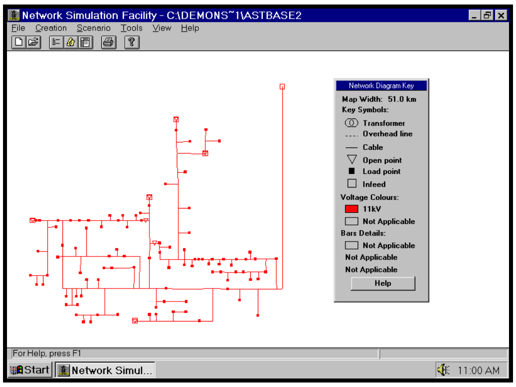

Figure 4: eaNSF and Company Database

Figure 4 shows a screen dump from eaNSF showing a schematic of a network extracted from a company database. Using eaNSF helps to elicit better network performance in terms of reliability, economics, losses and voltage constraints.

Logistic and resource modeling

This type of modeling has been possible as a result of the development of EA Technology's Fault Incident Resource Model (eaFIRM). The program eaFIRM is a system for investigating the effect of the number of fault response teams on the performance statistics of an electricity distribution company. It also provides a flexible way of evaluating the different strategies that can be used for team deployment. It operates by re-playing a set of fault records, but makes changes to number of repair teams, or to the strategy for their deployment. It answers questions like: If the company was organised differently could it have dealt better with the faults that occurred last year? What would it cost, and how much would the percentage of restorations within 3 hours improve?

The model deals with the number of teams on duty, plus two levels of standby, each with different response times. It allows the number of teams to vary between shifts and between weekdays and weekends, and it therefore enables the balance between teams on duty and on standby to be investigated. The use of different response times can also indicate the effect on performance of early or late mobilisation for a major incident, or the distances the teams have to travel.

The eaFIRM model can investigate the effect of giving priority to restoration switching, in preference to repairs. A fault response team would restore electricity to as many customers as possible just by switching operations, but would seek permission from the control room before carrying out repairs. Permission would usually be given, but when there are many faults awaiting attention it might be better to leave the repair until later and get the team to start the restoration switching of the next fault. This would restore more customers earlier, but would leave those affected by repairs off supply for longer, and it needs extra journeys to the repair site. There is therefore a balance between the earlier restoration for some customers and the later restoration for others, with a net benefit that depends critically on the journey times.

Investment in the network can reduce the number of faults and so eaFIRM can adjust the fault records, in order to show how the network performance would change if there were, for example, 10% more or fewer faults. Such changes might represent fluctuations in the weather, or they could result from engineering simulations which estimate improvements in equipment reliability.

The eaFIRM model can investigate the effect of engineering investments that affect the time needed for fault location, switching, or repair. For example the introduction of fault passage indicators might reduce the time taken on the first stage of every fault by an average of 20 minutes. By incorporating this into the simulation the resulting change in 3 hour restorations can be estimated.

The outputs from the model are the customer minutes off supply and the percentage of 3 hour and 24 hour restorations. The variable staffing costs such as call out fees, hourly overtime rates, etc. can be entered as data and added up during the course of the simulation according to the actual number of call outs or hours worked.

The eaFIRM fault replay model provides an unrivalled analysis tool for investigating the response to network faults, the costs, and the effects on the performance statistics.

Economic and Business Modeling

The approach used for economic and business modeling is described in more detail in the parallel paper [6], which describes the use of a multi-criteria decision support tool to assist in the decision making process.

A software program called EQUITY [7] has been the primary tool used in this process. The aim is to balance management judgement with quantitative data from other models (e.g. eaNSF and eaFIRM). The output can then be combined with the diverse management views implicit within most businesses to provide robust investment options and a coherent company vision.

This aspect of the project was split into stages:

A. Preparatory Studies
   1. Develop an understanding of the distribution system and present investment approach for quality of supply investments
   2. Analyse the 'drivers' of the business
   3. Gather relevant company data on quality of supply
   4. Carry out a Delphi[1] exercise with about 100 relevant managers and staff using a structured questionnaire consisting of three elements: the business environment, the quality of supply objectives, and the options for continuous improvement.

B. First Pass Analysis

A semi-formal workshop for a cross-section of key players was arranged about five to six weeks prior to the

[1] A structured questionnaire that broadens the base of understanding and consultation.

strategy conference to ensure that a suitable range of options were available for consideration and that areas of weakness had been identified.

An initial scan prioritisation of the options was carried out to ensure a manageable number of options were available for the strategy decision conference.

C. Facilitated Decision Conference

The key event was a two day strategy decision conference which was structured in the manner shown below. The meeting produced the 'pathfinder' quality of supply strategy from which investments of greatest added value and highest priority for the company could be established. In outline the process used is shown below:

1. Introductory Preamble:
   Each participant was invited to express their views and opinions.

2. The Business Direction and Focus:
   The business direction and focus were discussed to ensure the options available for improving quality of supply were aligned in terms of do-ability and viability, and to review interpretations. The time horizons both for the investment cycle, and the decision model were agreed.

3. Strategy Model Structure.
   The participants agreed the structure of the model.

4. Criteria
   Within each area of the strategy development model the participants generated a number of options for achieving the business targets, and a number of criteria were used in the model to judge the options.

5. Investment Options
   Information was generated from both the participants on the day and from Delphi exercise and from the First Pass Analysis Workshop.

6. Establishment of Preference Scales.
   The group agreed both the 'Cost' and the 'Relative Benefits' of each of the quality of supply investment options on a 0 to 100 scale.

7. Weighting of Criteria
   The relative importance of the judgement criteria was agreed.

8. Weighting of Scales
   The relative length of the 0 to 100 scales for each business area on each criterion was evaluated and internal consistency checking carried out with the group.

DATA REQUIREMENTS

The data requirements for this approach are significant. However, every effort has been made to ensure that as much information as possible can be extracted directly from company databases.

eaFIRM

The eaFIRM model requires a set of historic fault records, such as are already routinely collected by many network companies. In particular, it requires the date and time of the events that occurred, in addition to the number of customers affected and the duration of their interruptions. Where the interrupted supplies are restored in stages then the date, time, and number of customers is required separately for each of the stages.

The model has been used mainly for overhead line faults, because these are much more unpredictable than underground faults. It is important to select for the analysis not just faults on the overhead lines themselves, but also any others to which an overhead line team is usually sent. This includes faults on pole-mounted transformers and the pole boxes where overhead lines join underground cables.

In the past the dispatch time of the fault response team by the control room has not often been available. It must therefore be estimated from the site arrival time and the average travel time to the fault sites. If the dispatch time is available for each fault then these can be used to calculate the average travel time. If the dispatch times become generally available then the software will be modified to use it directly.

The software requires the previous and proposed staffing schedules in order to compare the effect of the changes on the performance. This includes the start time of each shift, the numbers of teams on duty on weekdays and weekends, days and nights,
the number of additional teams that can be called out during the day or the night,
the average delay between calling out the additional teams and their reporting for duty,
and the criterion used to decide when to call out the extra teams.

To calculate the total cost of variable payments requires the normal and emergency overtime rate, the call out availability fee, the call out payment each time the staff are called out, and the number of employees per team.

eaNSF

The Network Simulation Facility requires detailed network and asset data. The connectivity of networks can be accessed directly from company databases or can be entered by hand using the network editor. The asset data can be as detailed as required or the default data supplied with eaNSF can be used.

The input and output values for eaNSF are predominantly in the form of Excel spreadsheets. This means that it is very easy to update the asset details and to investigate sensitivities.

FUTURE ENHANCEMENTS

In the future it is essential that the progress made thus far is built upon to continually improve the business decisions that are being made. The individual models are being developed to provide additional functionality.

eaNSF Developments

The program eaNSF is now a commercially available product but this does not mean that there are no further developments in the pipeline. A collaborative development programme between EA Technology and the established users of eaNSF is ensuring that the development remains focused and that the tool will continue to provide valuable information for the distribution business.

eaFIRM Developments

The future development of eaFIRM has a number of possibilities, of which the most important is a widening of the alternative strategies for deploying the fault response teams. The model already separates the faults into several different types which need different treatment. Some of the fault records currently rejected as apparently inconsistent may reveal further types of faults with new modeling requirements. The ability to add and remove different types of fault from the fault record also needs to be extended. The development of a control room version of eaFIRM to facilitate the decision of when to call out extra resources is a strong possibility.

Equity

The development of EQUITY is continuing and more features are being added. This piece of software is presently very powerful and further enhancements will provide an unrivalled tool.

Business Evaluation and Analysis Methodology

It is the approach as a whole rather than the individual models that it is essential. Work is continuing to provide a unified approach for business evaluation and analysis. This involves the creation of coherent interface to all of the software modules and a documented methodology for implementation within the distribution business.

BUSINESS IMPACT

The integrated process methodology and software development set in the context of interactive working between EA Technology and MEB, has allowed MEB to generate a range of new business options and new management viewpoints. This approach has already had an impact on the way the network business is being reorganised and refocused and will generate considerable financial savings and improvement in performance. In addition, it allows modeling tools to be developed for future regulatory reviews based on both technical engineering models and broad based business decision models.

At a more specific level, the modeling for this specific project concentrated on the key factors affecting swift restoration of power in all weathers and conditions, including the organisation and deployment of personnel and materials, the use of new technologies to enhance the efficiency of maintenance and repairs, and the options for targeting investments in ways that will further network performance.

CONCLUSIONS

The result of this work is that cost justification of a preferred investment option, whether it be in terms of operational or capital expenditure, can be provided in a quantitative and auditable manner.

The methodology developed in this work is now being implemented within MEB's business. The software solutions that have been developed are not trivial and the methodology, although flexible, is very powerful.

The maturity in this approach will have long term benefits in relationships between managers and most importantly between companies and customers (particularly if represented by a regulatory body).

REFERENCES

[1] R. Owen, et al., "Automation strategies and solutions", Trends in Distribution Switchgear, IEE conference publication No.459, November 1998, pp96-101

[2] A.T. Brint, et al., "Evaluating strategies for reliable distribution", IEEE Computer Applications in Power, July 1998, pp 43-47.

[3] R.N. Allan, et al., "Distribution system reliability: the impact of automation", Proc. UPEC '97, September 1997, pp 1081-1084.

[4] R.N. Allan, et al."Quantitative reliability analysis of distribution systems: repair time", IEE Power Engineering Journal, August 1997, pp165-168.

[5] A.T. Brint, et al., "eaNSF: A simulation tool for evaluating network strategies", CIRED, June 1997, IEE conference publication No. 438, paper 6.26.

[6] F.D. Riley, “Methodologies for business development strategies in a changing environment”, CIRED, June 1999.

[7] L.D. Phillips, “Requisite decision modeling for technological projects”, Social decision methodology for technological projects edited by C Vlek and G Cvetkovich, Kluwer, 1988.

Acknowledgments

The Authors wish to acknowledge the contribution to this work by Vaughan Roberts, Jeff Douglas, Rob Peacock and Darren Green.

In particular, the authors would like to thank MEB’s management team for their support and enthusiasm.