In deregulated markets, network planning and operations within a Distribution Company (DISCO) must be related both to the inputs from the regulator's office and the company's need to generate profit. The regulator, on behalf of the customer base, carries out benchmarks, studies previous utility performance, and lays down a set of criteria for a given period. Depending on the local situation these criteria may be more or less harsh, when applied to the investments that a utility may need to make to remain competitive in this regime. Thus, investment strategies must be made which provide the optimal network enhancement, and at the same time minimise the cost of the enhancement, particularly within the regulatory period. This situation leads to the need when planning upgrades in the network, not only to consider, as in the past, the security and reliability enhancements that will be achieved, but also to be able to evaluate the related cost benefit of various scenarios. The use of automation in the previously manually operated distribution network is a major method to achieve results without large infrastructure investments. Planning the optimal automation system (where to automate, what technologies to implement, how to adjust operational thinking with automation) can no longer be undertaken without providing an analysis of the financial benefits which can be achieved. The paper describes the results obtained from the new types of tools being used to extend the traditional planning tools with the financial aspects of implementing network changes and automation strategies. The consideration of these realistic case studies demonstrate where automation solutions bring the best cost-benefit for the utility.
ACHIEVING REAL BENEFITS BY DISTRIBUTION AUTOMATION SOLUTIONS

P. Dondi, Y. Peeters, N. Singh

ABB Power Automation Ltd, Switzerland

SUMMARY

In deregulated markets, network planning and operations within a Distribution Company (DISCO) must be related both to the inputs from the regulator's office and the company's need to generate profit. The regulator, on behalf of the customer base, carries out benchmarks, studies previous utility performance, and lays down a set of criteria for a given period. Depending on the local situation these criteria may be more or less harsh, when applied to the investments that a utility may need to make to remain competitive in this regime. Thus, investment strategies must be made which provide the optimal network enhancement, and at the same time minimise the cost of the enhancement, particularly within the regulatory period. This situation leads to the need when planning upgrades in the network, not only to consider, as in the past, the security and reliability enhancements that will be achieved, but also to be able to evaluate the related cost benefit of various scenarios. The use of automation in the previously manually operated distribution network is a major method to achieve results without large infrastructure investments. Planning the optimal automation system (where to automate, what technologies to implement, how to adjust operational thinking with automation) can no longer be undertaken without providing an analysis of the financial benefits which can be achieved. The paper describes the results obtained from the new types of tools being used to extend the traditional planning tools with the financial aspects of implementing network changes and automation strategies. The consideration of these realistic case studies demonstrate where automation solutions bring the best cost-benefit for the utility.

INTRODUCTION

The deregulation and opening of electrical markets, technological advances and socio-political forces are driving a rethinking in design, operation and maintenance of distribution utility networks. The cost pressures, customer service, quality of supply, best use of installed base and environmental factors are the order of the day in taking any decision to embark on new project. Advanced distribution automation (DA) and Demand side management (DSM) systems can help the utilities to reduce the costs while maintaining the desired level of quality of supply. DA/DSM technology has been steadily developing to match the needs in terms of cost-effectiveness of the utility. This paper analyses the deregulated environment and structure of a distribution utility and demonstrates the real benefits in relation to the costs incurred in implementing such schemes. Projections of future cash flow improvement are at the basis of real business examples. Quick payback schemes that allow high return on investment (high net present value) can be derived from these cash flow estimates, incorporating the cost of capital applicable for any specific customer situation.

Based on a general description of an enterprise model of a distribution utility, the differences of the energy distribution process in a vertically integrated company or in a deregulated environment are highlighted. Furthermore, because in the vertical utility, more emphasis was put on the generation and transmission of electrical energy it will be demonstrated that the optimisation potential in most distribution networks is therefore high. Distributors have in their hands the possibility to strive for improved power quality and reliability at a competitive price, by optimising the asset base and automating operations.

In fact, by breaking up the value-added stream of traditional vertically integrated utilities from the power generation to the end customer, the distribution companies have become exposed to new market forces. The bargaining power of suppliers (e.g. power factor, low peak/average load ratio) and bargaining power of end customers (e.g. high power quality and reliability, low cost), reinforced by regulatory body requirements (i.e. penalty schemes) collectively provide the impetus for DISCOs to optimise their networks. The main leverage factors available for optimisation schemes are discussed in this paper.

The first Section reviews the drivers for DA/DSM. Since the characteristics of Distribution utilities vary considerably across the globe, both in business mandate and network infrastructure, the drivers are prioritised according to typical characteristics of the various types of utility mandate and network. These include:

Network
- Size, density and growth
- Urban/Rural
- Underground/Overhead
- Operational strategies

Mandate
- Network
- Metering
- Supply
- Embedded Generation
- Regulator structured
In most cases, the DA/DSM practices relate to the operation and maintenance activities of the distribution utility, although it is also possible that implementation of automation can lead to deferred investment in primary equipment. The latter effect will not be discussed here, but it is of course also necessary to point out that improvement of primary equipment and improved network design, although outside the scope of this paper have a large influence on successful operation. The second section details real case studies for high priority drivers and reviews the cost-benefit to the utility of implementation of such automation schemes. The paper is concluded by a brief review of the status of implementation of automation schemes, with respect to the positive results described in the paper.

**DRivers FOR Da/DSM**

Distribution automation (DA) and demand side management (DSM) systems for distribution utilities can be used to support:

1) reduced the operational costs by  
   - reducing energy bills  
   - reducing distribution losses  
   - reducing outage time

2) improved asset utilisation by  
   - improving load factor  
   - improving power factor  
   - improving maintenance practices  
   - reducing equipment damage  
   - deferring investments in new equipment

3) improved power quality by  
   - improving voltage profile  
   - log and prepare for audit  
   - increase availability and reliability of supply

4) improved customer service by  
   - reducing down-time  
   - improving power quality  
   - providing customised energy products  
   - improving public relations

The degree of importance of these drivers varies with the type of utility and its business environment. Penalty schemes for bad power quality or reliability imposed by the regulator represent a major influence on the cost/benefit of automation solutions, within the particular utility business environment. Other cost savings achieved by implementing efficient distribution solutions, such as the minimisation of technical losses, are not related to regulatory requirements and hence can be obtained on a purely independent basis. Optimisation of asset utilisation avoids foregone revenue, which represents an opportunity cost, hence contributes to a higher economic value obtained from the installed base.

Let us assume a liberalised market environment, in which the regulator requires the mandate-holding DISCO to deliver a reliability of supply against a penalty scheme. Despite not having sold energy during an outage (foregone revenue) the cost of the penalty payments liable to the end customers (consumers) lead to the DISCO looking to improve its supply infrastructure. Feeder and Distribution Automation (FA/DA) can help to achieve this goal. Furthermore, the open market structure will in many cases lead to complex energy tariff structures. Demand Side Management, i.e. load balancing, low peak to average power ratios and power factor improvement will lower the cost per kWh for the utility. The real benefits of the technology put in place will, depending on the importance of the drivers imposed by the regulator, lead to higher competitiveness and profitability of the DISCO.

Furthermore, the drivers for DA/DSM will depend on typical characteristics of the various types of utility mandate and network. In sparsely populated areas automation of pole mounted switches may be treated as high priority, whereas automation of commercial premise metering may be more important in urban underground environments. A priority ranking of the required applications will be made in accordance with the specific needs of the DISCO given by network, business mandate and economic environment.

The interactions, which now occur between the various parties active due to unbundling and liberalisation of the market demonstrate the complex organisation structure in which the industry is operating (Figure 1). The major changes can be grouped in network planning and operation, energy trading, customer contacts and business processes. The UML based modeling is used to highlight the differences [1][2].

The changes in the network operation are more predominant. In a classical utility the distribution did not have to plan for ancillary services. The reserve monitoring, voltage profile, contingency analysis and cost optimisation were done centrally and in most cases implemented by the transmission system. As can be seen from figure 4, in the changed scenario the DISCO has to take care of its own reserves and buy or outsource these if necessary. The loss minimisation and reliability improvements are more explicitly allocated to the DISCO. It has to decide at which point the energy supplier should be connected to reduce losses and provide higher reliability. The decision regarding operating voltage is also left to its own judgement rather than being prescribed by transmission system. The fault location, isolation and restoration are crucial for business and gain more importance in an open market scenario.
Depending on the energy market practices the Independent System Operator or Transmission system operator is responsible for the secure operation of transmission system or bulk energy transfer. The DISCO has to report all contracts and scheduled energy exchanges to TSO / ISO, which has authority to approve or reject the proposed business deal.

Energy trading is a relatively new responsibility at the distribution level. Unbundling demands that network operation be split from generation. The decision to choose a reliable and economical energy supplier lies solely with the Distribution Company. The exception to this are the DISCOs, which serve only as providers for distribution services, and do not handle energy trading. In an the energy market the DISCO can buy energy from Independent Power Producers (IPP), Generator Companies (GENCO), Power Brokers or on the spot market. The decision process is driven from the market price and the demand.

CASE STUDIES

From the previous discussion, it can be deduced that in most cases the three strongest drivers and their business impact are:

♦ Loss Minimisation
♦ Outage time reduction
♦ Power factor improvement

Case Study 1 - Loss minimisation

The loss minimisation is one of the major drivers of Feeder and Distribution Automation applications[3]. The actions, which can be taken to reduce the losses, are:

♦ Optimising the normally open points on the feeders
♦ Installing Power factor improvement devices
♦ Boost the voltage

The case study is performed on an outgoing feeder, which loops over a normally open point back to the other side of the main supplying 11kV feeder. Although at the design stage the normally open points are planned in a way that both sides of the feeders have almost equal load, load growth and time dependent loads lead to significant variations during the day or in different seasons. DA provides the tools to move normally open points to balance the load in a dynamic environment. The case study analyses the effect of this movement of normal open point on the losses of the system.

One arm of the feeder is loaded with 1 MW, whereas the other side supplies 1.5 MW. The normal open point would ideally be shifted (position 4 in Figure 2) such that both loads, left and right of the normal open point, are equal. This optimum position will result in the lowest possible power losses. Figure 2 shows that the more the normal open point is shifted away from this optimum, the higher the sum of the power losses in both feeders.
feeders become. Hence, the graph shows the improvement potential of the feeders, by introducing the automatic shift of the normal open point, depending on the load imbalance, as it occurs throughout the day.

The saving potential per normal open point depends on the load diversity, time of use and number of sections, which could be automated and cost per kWh. In a typical case the saving could vary from 10 to 60 k€ per pair of open feeders, per year. In some cases, the benefits of loss minimisation alone justify the investment of feeder automation schemes, for the example above at a load imbalance of 50 % the payback on an investment of 70 k€ (reclosers, RTUs and communication) can be as short as 2 years.

**Case Study 2 - Outage time reduction**

With the help of automation schemes the outage time can be drastically reduced. In a non-automated system the fault is brought to the notice of an operator either through customer calls or through the maintenance crew. In a system without automation the steps to restore the power supply includes

- Calling the crew
- Waiting for the crew
- Travel time of the crew to faulty feeder
- Manual observation of the faulty feeder
- Manual reclosing and tripping to find the faulty segment
- De-energising the faulty segment
- Restoring the power from the other side, if available

In automated feeders the typical time for fault location, isolation and re-energising is of the order of minutes. Thus outage time directly results in loss of sale of energy during the down time period and poor customer service. In deregulated distribution companies, the regulators are discussing penalties of 200 times the cost of one unit of energy (e.g. Scandinavia) for bad customer service. Even without these penalties, the automation schemes would have a very reasonable pay back period.

**Case Study 3 - Energy Bill reduction due to power factor improvements**

A further opportunity for financial improvement lies in best handling of the power factor. It may be that the distribution utility or bulk energy consumers have...
contracts with their energy supplier to maintain the power factor of the load in a specified range.

In which case, there are penalties for poor power factor or rewards for improvement in the power factor. In effect both energy supplier and energy consumer benefit from a power factor improvement. The overall losses are reduced, more KW are delivered with the same installed KVA reducing the equipment size and space requirement. This case study has been done for a 50 MW industrial distribution system, demonstrating the opportunistic saving potential. In the case study performed for a heavy industry which had a energy budget of roughly 11MUS$, a good power factor improvement scheme could save the industry typically 500 to 800 KUS$ per year. Which gives a payback period of 12 to 18 months depending on process load and production plan of the industry.

CONCLUSIONS

The case studies have demonstrated that DA/DSM technology, which has reached a high level of maturity, can be applied in order to obtain real financial benefits, that can be estimated fairly accurately, prior to investment. The technology is available and easy to implement. However, the most benefits can be obtained by taking a holistic approach, i.e. by good overall system integration. This is especially true for vital elements of the automation infrastructure. In particular, a consistent approach to data handling from the concept of which protocols are being implemented, which data is to be collected and with what priority, and how the database is defined is necessary. Furthermore, to perform a wide variety of tasks from switch automation through equipment monitoring to meter reading requires also a consistent and well defined approach to the communication system (be it a dedicated infrastructure or service provider channels).

The benefits, which can be achieved, beside being related to the business environment of the utility, depend on the soundness of the primary equipment planning. A inherently bad network design will not profit to the full extent even with the most aggressive and modern DA/DSM implementation. One has to perform an overall and thorough ranking of measures, in order to get the most benefits of the systems put in place, and hence, the money invested.

Even with such sound business opportunities, as demonstrated in the case studies, investment in DA/DSM has been controversial[7]. This is related to a number of problems. Firstly, clear models of the financial aspects of the improvements discussed are only now being used to demonstrate where the potential lies. Secondly, there are still a number of uncertainties related to how the deregulation will be implemented over time, how long will certain rulings be maintained, and when they are replaced, will they imply stranded investments. However, the drivers for DA/DSM appear to be concrete and are leading to increasing needs to gain an understanding of the technical viability of DA/DSM applications and the resulting financial benefits.

For many utilities, the financial justification as demonstrated in the paper provides a solid basis towards a higher degree of network automation. On the other hand, such analyses also enable suppliers to offer performance guaranteed maintenance contracts as a long term solution to utility services. Independently of how the approach to automation develops, a well designed and integrated concept, which supports multiple uses of infrastructure (such as communications[7], intelligent nodes data engineering etc.) also improves the financial benefit for the utility.

REFERENCES

[1] Select enterprise: an object oriented approach of enterprise modelling