Demand Side Management and Distribution System Automation: A Case Study on Indian Utility

Narayana Prasad Padhy

Abstract-In this paper the technology developed and progress made by the Indian state utilities, research laboratories, industries and technical institutions in the field of distribution system automation (DAS) and demand side management (DSM) has been discussed and analyzed. Cost effective studies and technically feasibility including all constraints taken into account has also been carried out for Indian utilities.

Index Terms-Demand side management and distribution automation system

I. INTRODUCTION

According to CII, the second generation of reforms in the energy sectors in India offers vast potential to developed countries including United States to join hands with state electricity boards which are unbundled and a new regulatory framework being evolved. CII observed that there were several opportunities especially for US power companies to invest in India in the area of distribution automation.

But unfortunately state electricity boards in India operate with different concepts and governed with different rules and with their poor financial conditions may not permit them to go for complete automation in one goal. Whereas it is must that we must move towards a complete automated Indian power system, functioning successfully. So it is the high time for all researchers to determine the potential areas and required to suggest the priority in which the country must move towards automation considering both the technical feasibility and cost effective studies.

Distribution automation system (DAS) refers to several functions that have been defined to automate otherwise leads to manual process on distribution feeders and customer services. The application of DAS system relies heavily on a variety of communication media that includes VHF and UHF radio, fiber optics, power line carriers and cabled systems because point to point wiring between the equipment controller and the RTU is expensive, difficult to maintain and impossible to migrate into future technologies[1].

In the event of a fault on any feeder section downstream, the C.B. at the 33kV substation trips (opens). As a result, there is a blackout over a large section of the distribution network if the faulty feeder segment could be precisely identified, it would be possible to substantially reduce the blackout area, by re-routing the power to the healthy feeder segments through the operation of switches placed at strategic locations in various feeder segments[2]. In a distribution automation system the various parameters are recorded in the field, using a data acquisition device called Remote Terminal Units (RTUs). These system quantities are transmitted on line to the base station through a variety of communication media. A distribution automation system must include SCADA / EMS which is an important building block and front end for managing field devices communication for many DAS applications[3].

The SCADA–RTU interfaces to control station equipment through interposing relays and measuring circuits through transducers, meters and other devices are of practical use now a days [4-6]. Two expert systems such as APEX and RESPONDD have also been developed, which are concerned with utilizing, to the best effect, the increasing volume of SCADA system data available to power system control[7].

The development of knowledge based software package for the analysis and control of electric distribution network[8] became a very common facility in developed countries. Expert System for substation fault diagnosis and alarm processing in real time has been developed by Electric Power Systems Laboratory of the National Technical University of Athens[9-10]. S.Humphreys [11] reviewed the impact that the PMI (also known as graphical user interface) has had on the substation operational systems of a number of Australian and North American power utilities. Software package for assessing system reconfiguration on opportunities and volt/var control on automated radial distribution feeders is also presented for modern distribution systems[12-13].

One of the most important function of DAS is demand side management through load control. A physically based model has been developed for industrial load management including practical constraints[14]. An expert system may be utilized to enhance the performance of the system by implementing the load shedding as one of the alternatives in the restoration of a large scale power system[15-16]. Whereas an alternative strategies for agricultural demand side management (DSM) based on utility equipment control under a set of unique conditions which is not only technically feasible, economically viable but also practically implement able has also been analyzed in India[17-22].

Narayana Prasad Padhy is with the Department of Electrical Engineering, Indian Institute of Technology, Roorkee-247 667, (email: nppeefee@iitr.ernet.in)
II. DISTRIBUTION-AUTOMATION SYSTEM AND DEMAND-SIDE MANAGEMENT

Distribution Automation System (DAS)

Recent years have shown almost uncontrollable pressure towards distribution automation of the power sectors throughout the world. Whereas in India the above process are in the form of proposals with many state. But few states have already started the process and/or implemented are not found to be very successful due to inadequate budget provisions, revenue shortfalls due to low tariffs, free electricity policy, non co-operation from the public and poor response from private investors. Today over 21% (theft apart) of the total electrical energy generated in India is lost in transmission (4-6%) and distribution (15-18%) the electrical power deficit in the country is currently about 18%. Clearly reduction in distribution losses can reduce this deficit significantly. It is possible to bring down the transmission losses to a 6-8% level in India with the help of newer technological options in the electrical power distribution sector, which will enable better monitoring and control[23].

In the distribution automation the various quantities (e.g., voltage, current, switch status, temperature and oil level) are recorded in the field at the distribution transformers and feeders, using a data acquisition device called Remote Terminal Unit (RTU). These system quantities are transmitted on-line to the base station (33kv substation) through a variety of communication media. The media could be either wireless (e.g., radio, and pager) or wired (e.g., Dial-up telephone, RS-485 multi-drop and Ethernet). The measured field data are processed at the base station for display of any operator selected system quantities through Graphic User Interface (GUI). In the event of a system quantity crossing a pre-defined threshold, an alarm is automatically generated for operator invention. Any control action (for opening or closing of the switch or circuit breaker) is initiated by the operator and transmitted from the 33kv base station through the communication channel to the remote terminal unit associated with the corresponding switch or C.B. Due to absence of monitoring, over loading occurs, which results in low voltage at the customer end and increase the risk of frequent breakdowns of transformer and feeders.

A DAS system basically consists of:
- SCADA
- DA application functions
- Communication system

SCADA

This makes sense to have the DA application as an integral part of the SCADA system as mentioned below:

- The ability to address multiple communications ports with different drivers/protocols
- On-line configuration
- Handling a large number of points while maintaining real time performance

DA functions

The following functions were set for the DAS:

1. Reduce peak load and power losses to overcome prevailing power shortages and defer construction of distribution facilities.
2. Improve the financial performance of the utility by improved cash flow, safeguarding revenues, and preventing theft of power.
3. Feeder deployment switching and automatic sectionalizing.
4. Integrated volt/ VAR control
5. Automated meter reading (AMR).
6. Load management
7. Frequency based automatic load shedding
8. Remote service connect / disconnect
9. Trouble call management system
10. Improve the reliability of supply by reducing the number and duration of outages, and improve the quality of service.

The operator can invoke any of the functions. The data that is required for these functions may be obtained from database. This data consists of both real time and static data. An application function interacts with the field equipment through SCADA.

Demand Side Management (DSM)

Though the power system has grown in terms of installed capacity from 1363MW in 1947 catering to the need for industrial customers in few urban areas to 72000MW in 1992 and today in 2002 the requirement is unlimited. There is a new emphasis upon managing demand. The result has been a revolution in utility planning, termed demand-side management. Demand side management activities are those which involve actions of the demand or customer side of the electric meter, either directly caused or indirectly stimulated by the utility. These activities include those commonly called load management. One common thread binds all of these customer side activities that they involve a deliberate intervention by the utility in the market place so as to change the configuration or magnitude of the load shape.

The term DSM describes activities designed to influence electricity demand for the mutual benefit of the utility and the customer. The DSM techniques can be broadly classified as direct control techniques in which loads are controlled by utility and indirect control techniques where the customers are motivated to deter the loads through the time of use pricing or other economic incentives[17]. Clearly, there is a
need to put in place a system that can achieve a finer resolution in load management with help of DAS.

III. INDIAN UTILITIES: A CASE STUDY

Country like ours, one end the country is increasingly facing shortage of power and maximum demand resulting in restrictions placed on the consumer and industry. In the other end the power available to customers are of poor quality due to harmonics present in the system and large amount of energy is wasted when it is freely available or theft of such energies is not uncommon. Thus to meet the increase load demand, to curtail the misuse of power and to provide quality power to customers various means such as optimal scope of restructuring of Indian power sector to meet the increase load demand and automation scheme to measure the quality of power and to curtail unaccounted or theft power are adopted. Hence to control the above two mentioned problems, Solution and optimal scope towards welcoming independent power producers, and restructuring the power sectors throughout the country is an urgent need. Automation using radio-operated relays and contactors or radio terminal units (RTUs) have found fairly wide acceptance and required to be implemented in the Indian power distribution system to cover a large geographical area. Such relays may remotely detect the harmonics content in the system and control the theft power.

DA systems are being adopted by utilities in some developed countries in a phased manner, primarily for reliability evaluation in a field environment. In India too, a small beginning has been made by a few state utilities (Andhra Pradesh, Assam, Kerala and Rajasthan), which are confining themselves initially to the automation of 33kV substations. Electronics Research and Development Centre, Trivandrum, and Computer Maintenance Corporation, Hyderabad, are involved in these early experiments, the main objective being the development of know-how and a better understanding of the issues involved in implementing DA systems indigenously. The utility environment in India is far different from that in most of the developed countries, because of the existing social scenario. Hence, technological solutions available for DA in developed countries cannot be directly implemented in India. Also, the cost of importing a DA system technology is prohibitive[3].

State Utility Developments

This section describes a study conducted by the Andhra Pradesh State Electricity Board, India, for the design of a distribution automation system[20]. Agricultural pump sets are used to lift the ground water make the largest contribution to peak demand in typical Indian utility. Therefore the most important function of the DAS is demand side management through load control. In India, electrical energy is extensively used to lift ground water for irrigation purposes. The number of Agricultural Pump sets in service in India in 1993 was about twelve million, and about half a million pump sets are added every sales and 80% of peak demand on APSEB’s rural distribution system. An optimal scheme has been suggested and implemented partially through automatic agricultural demand side management.

Technical Institution Development

A Technology Development Mission on Communication, Networking and Intelligent Automation, was jointly taken up by IIT Kharagpur and IIT Kanpur. While the mission focus at IIT Kharagpur is to develop technology for industrial automation, IIT Kanpur embarked upon the development of an integrated technology for power distribution automation system. IIT Kanpur has embarked on an effort to develop indigenous technology for an integrated power distribution automation system in collaboration with four industry partners (Secure Meters Limited, Udaipur; Indian Telephone Industries, Raebareli; DataPro Electronics Private Limited, Pune; and Danke Switchgears, Vadodara).

Some of the developments noted above are being implemented in the IIT Kanpur distribution network as a pilot level installation for field reliability evaluation with the following salient contributions:

- Communication and Networking Technology
- Remote Terminal Unit
- Remotely Operable Switch
- Application Specific Integrated Circuit
- DA software
- Distribution Network Simulator

Feasibility and Cost Effective Analysis

In this study, the following distribution automation functions were selected for feasibility and cost effective analysis taking three state electric utilities(Uttar Pradesh, Orissa and Tamilnadu).

- Load Control
- Feeder Automation
- Automatic Meter Reading

Based on the suggestion made by M. V. Krishna Rao et.al., the present worth value of benefits over a ten-year period was evaluated considering the growth rate of load during that time. The costs to develop, install and maintain each of the elements of the DAS were also considered. But the system considered for analysis deal with data’s those are mainly based on heuristic information and expert opinions. The following Table 1&2 shows the percentage energy sales corresponding to different class of customers and benefit/investment ratio obtained for different automation functions.
Table 1. Customers Percentage Energy Sales

<table>
<thead>
<tr>
<th>Category</th>
<th>Energy Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>16%</td>
</tr>
<tr>
<td>Agricultural</td>
<td>39%</td>
</tr>
<tr>
<td>Commercial</td>
<td>5%</td>
</tr>
<tr>
<td>Others</td>
<td>2%</td>
</tr>
<tr>
<td>Small Industries</td>
<td>10%</td>
</tr>
<tr>
<td>Medium Industries</td>
<td>15%</td>
</tr>
<tr>
<td>Large Industries</td>
<td>13%</td>
</tr>
</tbody>
</table>

Table 2. Benefit and Investment Ratio for different Automation Functions

<table>
<thead>
<tr>
<th>Distribution Automation Function</th>
<th>Benefit and Investment Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Control</td>
<td>6.5</td>
</tr>
<tr>
<td>Feeder Automation</td>
<td>2.5</td>
</tr>
<tr>
<td>Automatic Meter Reading</td>
<td>0.05</td>
</tr>
</tbody>
</table>

IV CONCLUSION

In the proposed study, it has been concluded that distribution automation became an urgent need to our state electric utilities. But distribution automation functions such as load control, feeder automation and automatic meter readings are found to very much useful compared to other functions.

V ACKNOWLEDGEMENTS

The author would like to express their gratitude to All India Council for Technical Education (AICTE) for their financial support for conducting the R&D project entitled Demandside Management and Distribution System Automation.

VI REFERENCES