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Smart Grid experimentation Plan for Load Forecasting -A Case studyof a large power distribution company

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***Abstract*-Load forecasting is important for the electric industry in the deregulated economy. It has many applications including planning the generation and transmission network, load switching, contract evaluation etc. New Forecasting Models Must Work with Smart Grid Technologies. This paper throws light on the use of smart grid technolgy for forecasting adopted by Power distrbution company.*GoI* has launched the R-APDRP initiative to create base IT infrastructure, seamless applications and commercial and technical data base. This infrastructure is to be further integrated with SCADA and consumer level Smart Grid tools.The aim of this paper is to analyze requirements and work out solutions for daily used processes like Load Forecasting.Load forecasting software is used to analyse the results.**

***Key words*-**Smart Grid, Load Forecasting, Electricity Distribution Company Limited (EDCL)

1. INTRODUCTION

Large Electricity Distribution Company Limited (Large EDCL) is a largest power distribution company in the country, focusing on modernization and IT implementation in its system. This reserch project paper deals with application of Smart Grid Solution in State's Power distribution sector. Smart Grid solutions are mostly adapted by the western countries and it needs some customization before implementing them in the Indian power sector.

This project is focusing on implementation of software modules for Load Forecasting in the current LargeEDCL's system, hence it will deals with study of well-run resources available in the market, study of current practices in Large EDCL, study of Rules and Regulations made under the Electricity Act and study of customization needed for developing a path for smooth implementation of Smart Grid solution in Large EDCL.

2. METHODOLOGY

There are several modules which are included in the Smart Grid solution. As far as **the scope of this project** is concerned, we will only study and analyze one module dealing with commercial and operational activities in the distribution utility. Module under consideration is Load Forecasting & Automated Meter reading etc.

The **methodology adopted** for this project would be as follows:

1) Description of a module under consideration, and feature involved in it.
2) Current practices in Large EDCL dealing with the same problems included in above module
3) Rules and Regulations made by the authorities as per various provisions under Electricity Act, 2003.
4) Listing out customization needed , data retrieval system
5) Discussing ways to implement those customizations
6) Listing out expected results and report formats to help management take important decisions.

3. EXPECTED OUTCOMES

This reserchproject paper will develop a roadmap for smooth implentation of Smart Grid Solution in Large EDCL.

After brief analysis of each module, required customization of that module will be discussed, listing out specific customization needed before implementing it in Large EDCL system, the ways in which that module can be applied to the Large EDCL system. The report generation for a particular module will be listed out at end of the respective module.

It is expected that after successful implementation of these modules under there will be substantial reduction in the administrative cost of the system. These modules will provide greater accountability for assets and energy in the system; improve the planning processes due to network modeling, and better utilization of power due to most effective demand side management.

The suggestion on implementation of these modules will provide most economical approach while implementing smart grid solution in the power distribution system

4. SMART GRID TECHNOLOGY

A. Quick Facts

The smart grid is a concept referring to the application of digital technology to the electric power sector to improve

reliability, reduce cost, increase efficiency, and enable new components and applications.

Compared to the existing grid, the smart grid promises improvements in reliability, power quality, efficiency, information flow, and improved support for renewable and other technologies.

Smart grid technologies, including communication networks, advanced sensors, and monitoring devices, form the foundation of new ways for utilities to generate and deliver power and for consumers to understand and control their electricity consumption.

Smart grid technologies could contribute to greenhouse gas emission reductions by increasing efficiency and conservation, facilitating renewable energy integration, and enabling plug-in hybrid electric vehicles.

5. ADVANTAGES OF SMART GRID TECHNOLOGY

The key additions to a smart grid compared to the traditional grid include:

- An intelligent monitoring system including a net metering system to keep track of all electricity flowing in the system
- Superconductive transmission lines to integrate renewable electricity such as solar and wind to the grid and ensure less transmission loss
- Internet protocol based smart grid communication technologies on home devices to maintain live and automatic communication between the utility service provider and the customer

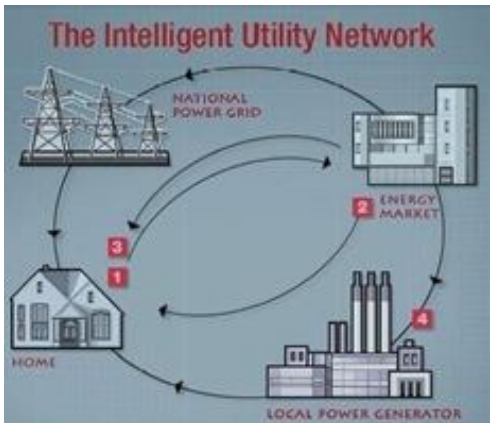


Figure1. Smart Grid

6. MEETING SMART GRID CHALLENGES THROUGH FORECASTING

Many utilities already use forecasting to address their current challenges, butforecasting will increase in importance because of the growing complexityof challenges and the availability of more data inputs from a data-rich smartgrid environment.Forecasting is a data-intensive numeric discipline that utilities use for a wide range ofplanning, investment and decision-making purposes. Simply put, forecasters attemptto determine how customers will use energy and then plan utilities' operationsaround that possible use. Forecasters try to understand, on an hourly or monthlybasis, how customers respond to prices, weather, climate change concerns andpersonal economic conditions. They also look at new factors, such as energymanagement software or electric vehicle recharging concerns.In short, forecasters try to predict patterns of behavior using a wide range of factors.Understanding and quantifying these factors helps build forecast models. Applyingcustomer segmentation techniques makes these models even more precise.New Forecasting Models Must Work with Smart GridTechnologiesMost utility forecasters have been working with models they have developed over thelast 15-20 years – models developed in mostly good economic times. The forecastmodels tended to perform well simply because there was not a lot of volatility ineither the data or the variables affecting customer demand.That relative stability is evaporating quickly because of the new challenges tothe industry and the rapid expansion of smart grid projects that enable greaterefficiencies at the utility and customer levels.Today, energy efficiency programs and growing customer awareness about energyconsumption are forcing forecasters to make wholesale changes to their models.Many existing models are not performing to the standards that utilities or theirregulators expect. Utilities are being forced to look at their models and reconsiderhow they evaluate, manage and select data in order to create models that answerRegulators' questions regarding efficiency and operational questions comingfrom management.

7. UNDERSTANDING LARGE EDCL

Large State Electricity Distribution Company Limited - controlled by State Government, is a public sector company which distributes electricity to all regions of the state; except some city and the most part of its suburban region, where private electricity distribution companies are the only distributors.

Electricity Act, 2003 of Government of India, the old state owned company was split into three companiesA holding entity 'Holding Company' was created holds the entire stake in these three companies.

MSEDCL has a large consumer base of around 1.57 Cr. distributed in the state and having the annual revenue collection of around 21,278 Cr.

The brief infrastructure of thecompany can be summarized as follows;

1) Lines
   a) 33 kV
      29, 592 km
   b) 22 kV
      22,939 km
   c) 11 k V
      1, 86,888 km
   d) LT Lines
      4, 89,334 km
2) Distribution Transformer
   2, 56,793 Nos.
3) 33/11 kV, 22/11 kV Substations / Switching Stn
   1,889 Nos.

4) High Voltage Feeders
10,240 Nos.
5) Transformer Capacity
i) 33/11 kV, 33/22 kV & 22/11 kV Capacity 19,142 MVA
ii) 33/0.4, 22/0.4 & 11/0.4 kV DTC Capacity 28,055 MVA

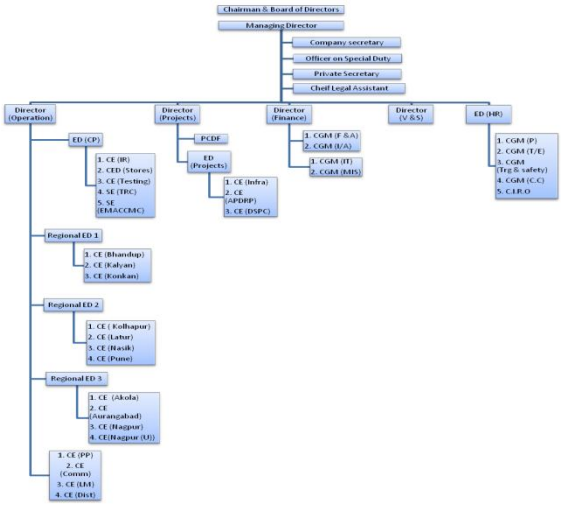
8. ORGANISATION STRUCTURE OF LARGEEDCL

Large EDCL's organization structure comprises of various Sub-division offices, Division offices, Circle offices, Zone offices & a Corporate office which can be viewed as follows.

Every Sub-division comprises of 4 -5 Operation & Maintenance (O & M) section offices assigned with specific operational area.

Large EDCL has workforce of over 75,000 employees with over 10,000 Engineering staff & over 6,000 employees in its other officer's cadre.

Organization structure at corporate office is shown as follows:



Abbreviations:-

1) ED : Executive Director 2) V & S : Vigilance and security 3) CGM : Chief General Manager 4) CE: Chief Engineer 5) HR : Human Resource 6) CP : Corporate Planning 7) IR : Internal Reforms 8) TRC : Tariff Regulatory Cell 9) PP : Power Purchase 10) Comm: Commercial 11) Dist : Distribution 12) DSPC : Distribution Special Project Cell 13) PCDF : Principle consultant Distribution Franchisee 14) F & A : Finance & Accounts 15) I/A : Internal Audit 16) IT : Information Technology 17) P: Personal 18) TE : Technical Establishment 19) Trg & Safety : Training & Safety 20) CC : Corporate Communication 21) EMACCMC : Estate Management And Civil Construction cum Maintenance Circle

9. LOAD FORECASTING

Load forecasting software can be used to improve area planning for electric utilities. It provides the tools to analyze the dynamics of changes of electrical loads at different areas and to estimate the weather-normalized load trends. The utilities spend significant resources to maintain and upgrade their infrastructure and the described system improves decision-making capabilities relevant to capital expenditures. The appropriate investments in the company infrastructure lead to the increase of the system reliability and reduce the probability of blackouts.

The software analyzes the historical weather and load data, estimates weather-normalized electric loads, computes design-day parameters, computes weather normalized factors, estimates trends, and calculates the probability distribution of the peak load for the next year. The software takes into account that weather conditions in different areas can vary from one area to another. In addition, the weather conditions change from one year to another in the same area. The software estimates the weather-normalized load trends and estimates the deviation from these trends for particular years due to specific weather conditions. The software can be used for one or several load pockets. It demonstrated a high level of accuracy of produced models. The software can be used for standard 50-50% planning scenarios traditionally used by utility companies or it can be used to make decisions to satisfy electric demand with higher probabilities.

The input data required by the software are hourly weather and load data. The Hourly data can be provided though the AMR metering at Substation and Feeder levels, while the weather report has to be gather from the regional weather monitoring center or from the sources available on the internet.

Taking into account the weather influence on electric loads improves the accuracy of the forecasts. There are several weather variables that are responsible for changes in load such as dry bulb temperature, wet bulb temperature, dew point, humidity, wind speed, wind direction, sky cover, and sunshine.

The software contains the probability distribution calculator of the peak load for the next year. The user has two input parameters: the load and the probability. The user may see the probability that the load will exceed a particular value. For any probability, the user can see the load value that the peak demand will not exceed with the given probability. This peak distribution analysis is available for both pocket and system peak data.

This software allows a utility to estimate load trends at different locations called load pockets, to estimate next-year peaks for various load pockets, to calculate weather normalized factors, and to estimate the probabilities of the peak load for next summer in various load pockets. The use of this software improves the decision-making capabilities of the area planning group, improves the utility's capabilities to allocate and manage their capital expenditures, and to improve the reliability of service to their customers.

10 LOAD FORECASTING: CURRENT PRACTICES IN LARGE EDCL

Large EDCL has its own years old mechanism for load forecasting. The data of daily peak and minimum demand is collected from every substation and recorded at a DSS Control room situated at the zone offices. The zonal offices then forward this consolidated information for a previous day to DSS control room at head office. The data for demand & supply of electricity for the same day is also obtained from the State Load Dispatch centre (SLDC). Data received from the field offices are checked for its accuracy by comparing it with data received from the SLDC. Considering the load growth for the year, the data is further analyzed providing the reference value for a day ahead scheduling. A day ahead scheduling is nothing but a day ahead load forecast and load management plan for the system.

Large EDCL has in recent years started collecting feeder wise hourly data from each sub-division on a weekly /monthly basis through its load data software. The data so generated at sub-division level is forwarded to IT centers situated at each circle offices and then consolidated data is forwarded to the IT department situated at the head office.

Data obtained through above exercise is mainly used for monitoring load shedding implementation instead of load forecasting purpose.

11. GENERATING LOAD FORECASTING CUSTOMIZATION AND IMPLEMENTATION IN LARGE EDCL

Large EDCL has a very huge distribution system spread over entire state except certain small region and covers vast geographical area. Load data is generated by the sub-division offices on weekly/monthly basis may not be usable in the load forecasting software for the day ahead scheduling.

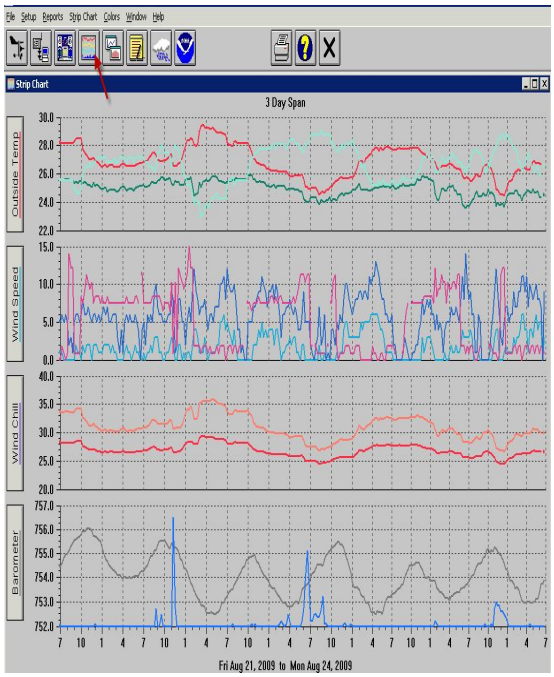
Considering the infrastructure required for Automated Meter Reading and Load forecasting, both the activities should be carried out in unison to reduce cost impact on the system. It is recommended to carry out automated meter reading facility at different nodes such as receiving sub-station and that data may be uploaded in the centralized system, where weather reports for various regions is obtained from regional weather forecast center or national weather forecast center. The data so obtained will be analyzed in the load forecast software for scheduling the power demand.

A **multi-dimensional weather forecasting** approach can also be adopted with some further customization of data input. Multidimensional weather forecast approach has four essential steps

1. *Conduct Traditional Top-Down Forecasting.* Standard econometric models are developed with a focus on overall energy sales, peak demand, and customer growth. While utilities often produce these forecasts by jurisdiction and revenue class, their distinguishing characteristic is they are highly aggregated to support overall system planning activities.
2. *Perform Data Mining and Market Segmentation Analysis.* This analysis takes advantage of existing utility knowledge and micro-level data (customers, distribution points, geographies, load profiles, climates, rates, and other market dimensions of interest) to create information subsets necessary to support forecasting at desired detail levels.
3. *Conduct Bottom-Up Forecasting.* Potentially thousands of separate series—one for each market subset developed in Step 2—are analyzed and forecasted. Batch processing allows this to happen quickly and cost-effectively, with the best forecast for each series chosen using pre-specified decision criteria.
4. *Calibrate Forecasts.* Once top-down and bottom-up forecasts have been developed, it is crucial they become fully calibrated to one another. This process ensures decision makers across the organization are operating from common, internally consistent forecasts.

Multi dimensional load forecast can be explained with the diagram.

12. GENERATING REPORTS AND ANALYSING RESULTS



Load forecasting is carried out through series of processes; it starts with getting data from various AMR instruments, getting data from weather forecast centers and analyzing the conditions with system built algorithms and

past data. The series of activities are captured as screen shots are represented for having a brief idea about the type of reports generated in the load forecast software.This help management take important decisions.

13. CONCLUSION

After successful implementation of this Load forecasting module:

- There will be substantial reduction in the administrative cost of the system.
- This experimentation will provide greater accountability for assets and energy in the system
- This reserch project study will improve the planning processes due to Network modeling, and better utilization of power due to most effective demand side management.

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FIELD VISITS

1. Large power distribution companies in India
2. Electrical industries in India
3. Load dispatch center in india

ACRONYMS

AMI -Advanced metering infrastructure
APDRP -Accelerated Power Development and Reform Programme
BEE- Bureau of Energy Efficiency
BIS -Bureau of Indian Standards
CBA- Cost-benefit analysis
CDM -Clean Development Mechanism
CEA -Central Electricity Authority
CERC- Central Electricity Regulatory Commission
CPRI- Central Power Research Institute
CRM -Customer relations management
DMS -Distribution management systems
DNO -Distribution network operator
DOE -Department of Energy (US)
DSM- Demand-side management
EE- Energy efficiency
EPRI -Electric Power Research Institute
FERC- Federal Energy Regulatory Commission (US)
GIS -Geographic information system
GOI- Government of India
ICT- Information and communications technology
MoP- Ministry of Power
R-APDRP- Restructured Accelerated Power Development and Reform Programme
SCADA- Supervisory control and data acquisition
SEB- State Electricity Board
SERC- State Electricity Regulatory Commissions
T&D- Transmission and distribution