CASE STUDY : Automated Meter Reading, Energy Audit and Availability Based Tariff for Transmission Company

CLIENT : Karnataka Power Transmission Company Ltd (KPTCL)

INTRODUCTION

The objective of the project was to perform Automated Energy Meter Reading from various substations involving more than 1000 energy meters in KPTCL, and to perform Energy Accounting and Analysis up to feeder level. The solution further provides ABT regulation compliance for KPTCL by supporting Energy Scheduling, Bulk Energy Billing functions and other functions like Balancing & Settlement, Open Access, and Bilateral Contract Management Modules. For a detailed feeder level Energy Analysis on the network, the non-ABT meters (Multi Function Transducers, more than 4000 MFTs to be read across various substations of KPTCL) were read from Network Manager SCADA of ABB. The integration of MFT data available in ABB Network Manager SCADA Avanti data base is done by using a set of standard APIs, and ODBC based interfaced supported by the SCADA as well as Kalkitech’s Market Management, Energy Analysis IT applications.

End user for the project is State Load Dispatch Centre (SLDC) of KPTCL who coordinates the power transmission activities as stipulated by ABT norms from CERC / KERC. This document covers the details of the Automated Meter Reading (AMR) software, the network solutions adopted and the EA EB ABT (Energy Audit Energy Billing and ABT) software.

The software was meant to enable the SLDC in coordinating the generation and consumption schedule between the Generating Companies, ESCOMs and KPTCL coming under the purview of the SLDC. The software allowed for tariff calculation and reconciliation as per the availability based tariff structure and billing for Generators. The software provided the required interface between the SLDC and open access customers and wheeling & banking customers to avail transmission facilities for power trading. Further the software enabled the user to do Energy Auditing for various levels as per specifications. It had validation Estimation Editing (VEE) function in operation when Multi Function Transducer (MFT) reading or SCADA reading is missing, thereby giving provision for the operator to assess missed / unobservable data. Further, the software also allowed manual entry for missing and unobservable data.

EXISTING KPTCL SYSTEM

KPTCL is the main company, which is handling the transmission and distribution of power in the state of Karnataka. They distribute the electricity to utilities like Bangalore Electric Supply Company, Mangalore Electric Supply Company, Hubli Electric Supply Company. Currently the customer is having very limited ABT system geographically.

In the system, the ABT software takes data supplied by a windows driver, which communicates with very small number of substation meters through PSTN modems. The technical disadvantage is that each substation can be updated in a sequential manner. The delay in update cycle and cost factor is very huge for this type of communication purpose.
Implementation of ABT system is unavoidable in today's Power sector distribution environment. This includes analysis of energy consumed, frequency, current and voltage. Based on these parameters, the calculations are done in the ABT software. Considering a large geographical area, the most critical part is the collection of these data. Nowadays, the Energy meter manufacturer provides this information over a communication channel through some protocol. The main intention of this project is to read this data from Energy Meters of different vendors and make it available for ABT software.

KALKITECH SOLUTION

The Overall solution comprises of three modules viz., Energy Auditing (EA), Energy Billing (EB) and Availability Based Tariff (ABT) scheduling.

ABT solution is sub-divided into ABT monitoring, ABT scheduling and Billing. Energy Billing is sub-divided into Generating Station billing for generators and Transmission Service Charges billing. The actual consumption / dispatch of energy were obtained by Automated Meter Reading Software. ABT scheduling was done on daily basis for the next day called the Day Ahead Scheduling. In Day Ahead Scheduling generating companies declares their availability online which was termed Form-A. On the
basis of declared availability by generating companies and predefined shares of distribution companies, the system generated entitlement of ESCOMs which was termed as Form-B. The distribution company submits their requirement based on Form-B which was termed as Form-C. Finally the system generated the dispatch schedule i.e. generation schedule for Generators and drawl schedule for ESCOMs.

The generation schedule and dispatch schedules are for 96 interval slots of the day, each slot being of 15 minutes duration. The ABT system also provided the running schedules as well as implemented schedules as a monitoring display to view the real-time system and other relevant parameters.

**Project Organization Architecture diagram**

![Project Organization Architecture diagram](image)

**Meter Reading System for EB/EA/ABT:**

In the proposed system, a similar windows driver feeds the data for ABT software. The AMR system gets data by periodic polling of meters through the data concentrator unit (MIC- Meter Interfacing Card as the same resides on the backplane of RTU-560) installed in RTUs across various sub-stations of KPTCL. Here the windows driver communicated with the MIC placed in each and every substation, instead of PSTN modems. The communication link between MIC windows driver and MIC is a combination network of Ethernet and VSAT. All the meters in a substation were connected to MIC of that station, over a RS485 multi drop network. The MIC updated the data from meter using the Energy Meter vendor's proprietary protocol, and stores it temporarily. This data was updated on a request from MIC windows driver. From the MIC windows driver, many substations were updated at the same time. This definitely reduced the delay. This mode of communication was effective than the existing one. The frequency of the reading of data was programmable from the EA/EB/ABT. ETVMs were time synchronised.
The Metering Interface card was a data acquisition card, which was interfaced to different types of energy meters on various proprietary and standard protocols. The MIC was inserted into the 19” rack of ET-22 cabinet of RTU 560. MIC was specifically used for collecting ABT information from Energy Meters. The following protocols were supported in this particular hardware.

1. L & T Proprietary Meter Protocol
2. Secure Proprietary Meter Protocol
3. Modbus Master Protocol

The data collected from various energy meters was converted into a standard ABT format used by the ABT application and was sent to the ABT server over TCP/UDP protocol. The following architecture shows the data transfer from ABT meters to the ABT application in the proposed scheme for KPTCL.
MIC was intended to provide the update of required data for ABT purpose. The main function of MIC was to update the data from Energy meters, and make it available in the form required by the ABT software. The communication between MIC and meters was through RS485 channel. The MIC hardware has a RS485 interface, which was multi dropped to maximum of 32 nodes. The communication with MICs' Windows driver was done through VSAT link. The detailed functional requirement is given below.

- MIC can communicate with L&T make and Secure make meters
- The meter data polling interval can be configurable
- A specified number of day's meter data is stored in the MIC
- MIC updates the data from meter and time stamp it with real-time
- Following parameters are uploaded from meter for ABT
  - Voltage
  - Current
  - Frequency (15 interval)
  - Reactive energy in
  - Reactive energy out
  - Active energy in
  - Active energy out
- These data may be uploaded to the ABT machine, when it was requested from the MIC Windows driver running in ABT server machine.
- MIC Windows driver issues following request to MIC
  - Latest 15 minute block of the day
  - One day data
  - 1 Week data
  - 1 Month data subject to successful testing
The MIC windows driver and MIC ensures a communication, which can detect any failures, handle retransmission, and a self reestablishing type

There are restrictions in the rate of data transfer as it cannot exceed maximum bandwidth allowed through VSAT

The request in the protocol used via VSAT, it contains a start character, maximum size to be transmitted in the reply, inter packet delay of the reply, date of the day's data to be transmitted, number of blocks of that particular day that has to be transmitted, preamble and end character, which ensures a VSAT communication without any over-head

All the communication between MIC windows driver and MIC uses a secure socket

The configuration tool is an easy to configure application

Has the provision to download/upload, monitor and diagnose the MIC, both locally and from remote

There is proper mechanism to scan all the hardware and connect to the same

In the configuration tool, there is a mechanism to recover any unexpected failures through firmware/patch updates

The worst case recovery is done through MIC console port

Assumptions, Constraints, Dependencies

It is assumed that meter reported load survey is the latest with respect to current time

It is assumed that the window machine, in which MIC windows driver application is running suits the performance specification of the same software.

When the number of multi dropped meter increases, the time taken to complete a poll cycle of all the meters increases

The VSAT bandwidth is a limitation, considering the data update rate

MIC queries each meters in a pre-configured interval in the proprietary formats in case of L&T and Secure ABT meters and in Modbus protocol for other meters. Only ABT specific information are extracted and filtered out from the proprietary details and converted to a common format specific to the requirement of ABT application. These details are sent to the ABT application server which is at the remote control center. The ABT parameters are calculated by the Energy Meters as 15 minute blocks, due to which the MIC has to retrieve this information once in 15 minutes and send to the ABT server. In normal case MIC sends only the last 15 minutes information and in case of communication break-up with the remote control centre MIC fails to send the particular 15 minutes blocks generated during the break up time. In this case the ABT application can query for any previous block which is not updated into the ABT server which is available in the meter. The meter can store at most 7 days information in its internal memory and hence the same can be retrieved by the MIC from the meter.

The data transmitted for ABT is critical information which is used for energy billing. This data transfer is protected against security vulnerabilities by following methods

a) Usage of Secured Socket connections
b) AES/DES Encryption before sending out from MIC
The AMR system has three applications:

1. **AMR Main Data application:**

   This application stores the meter data in a central data repository – available for analysis by user, for interfacing with other applications of the utility. The data read from the field and all processing is done on a server. The server is Windows based and database is Oracle. The application server also provides billing applications software or interface for a third party billing software of the utility. The proposed application was fully windows based GUI application providing user friendly interfaces to various functionality of the system like Scheduling, Reports, analyzing trends etc.

2. **Communication function:**

   This function is responsible for communication with Meters scattered over entire state covering transmission & distribution sub-stations. This application keeps record of the number of modem/ports available to the server in the working condition and use the multiple modems for the communication with different meters at the same time. This function also keeps record of the connect fail to specified meter for the retry. Communication server automatically takes next lot of the meters to be read from the database as soon as the current lot of meter gets cleared.

3. **Front End Processors functions of EA/EB system:**

   The EA/EB/ABT system houses within itself the FEP application to read the data from the field ETVM’s via RTU’s (through RTU & MCC) or directly.

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**Functionalities of the proposed EB/EA/ABT System**

**Proposed System Architecture**

![Proposed System Architecture Diagram](image-url)
The proposed EA/EB /ABT system is customised to have following main functionalities:

1. Meter Scheduler
2. Communication Application Module (Interrogation software and RoP)
3. Manual Data Entry and Data-updating module
4. Master containing database of meters, entitlement, tariffs and multiplying constants
5. Energy Billing Module
6. Energy Auditing Module
7. Post Audit module
8. ABT Module
9. ABT Monitoring Tool
10. Intra ABT Scheduler
11. Reports
12. Alarm and Logs
13. System Security
14. Open Access and Wheeling & Banking module

**Meter Scheduler:**
This allows the user to define the scheduling for the meter reading. The user can define the frequency of meter reading; time intervals of reading, start and stop time for the reading. Once a meter / RTU is defined in the scheduler for the reading, scheduler updates the same to communication server for the reading. Scheduler supports multiple type of reading schedules for the different Meters and RTUs’. The same meters can be scheduled for the different type of reading too.

**Communication Application Module**
This module takes care of the communication with meters and the RTU’s. The communication module gets the input from the scheduler and performs meter reading as per schedule. The communication modules analyze the data for the validations and security aspects. After proper validations it uploads the data to the database.

**Manual Data Entry and Data-updating module**
This module provides the necessary interface to users to upload the data by manual entry or from the other applications like MRI data either through mail or through manual update on the system, whenever the system cannot read a particular meter. Proper validations and security passwords are provided to ensure proper and secure data updates.

**Masters**
This module provides interface to the various master records of the system. The module also provides modification to the parameters for the ABT, EA and EB functions.

**Energy Billing Module**
This module takes care of billing with respect to the following areas:

1. Energy billing for Generators and ESCOMs: This considers the PPA parameter taking into account Capacity charge and Energy charge.
2. Transmission billing: This takes care of the Transmission charges to be paid to KPTCL
3. UI billing: This is in line with Intra State ABT guidelines issued by KERC
The sub-modules of the Energy billing module

Pre-Billing:

Pre-Billing facilitates carrying out those functions required prior to Bill generation. Transaction modules included are:

- Validation of readings
- Assessed values for non-acquired points
- Manual Entry for un-observable area
- Up-dating meter master database
- Meter replacement and Repair-updation
- Meter de-energisation and re-energisation
- Calculation of Consumption

Billing:

Following modules are included in Billing Function:

- Generation of Invoices
- Correction of Invoices
- Supplementary Invoice generation
- Invoice Authorization
- Invoice printing
- Invoice adjustment entries

ABT link billing sub-module:

Billing Software calculates the total UI Energy and transmit the same to all constituents block-wise. Consolidated weekly bill is generated. The S/W accounts the UI charges paid by ESCOMs within 10 days. It also accounts the payments by SLDC. The HAR details are used for the meeting of commercial “State Energy Accounting” (SEA) on every 20th of the Month.

Post Billing

Following modules constitute Post Billing activities:

- Payment Entry
- Validation of entered payments
- Off-setting payments for regular and supplementary Bills
- Invoice re-conciliation

Energy Auditing Module

The EA module provides reports and summary for the energy auditing. It has an Audit module for the auditing of system based on the data received from the TVEM’s, SCADA or manually entered in the AMR system. The audit module does the calculations and give various reports. The details specification of the audits are finalized during the SRS and design phase based upon the requirement of KPTCL. It performs Audit:

- for the Whole Grid
- Transmission Zone wise
- Distribution Company wise
- Transmission Voltage level wise
- Region wise
- Substation wise
Post Audit module
This module is responsible for the posting of data to the various Control centres or other system. The module sends data either in form of Email, XML, XLS

ABT Module
This module provides the ABT functions to the user. The ABT module uses the data collected from the TVEM reading, SCADA interface or from the manual entry. The ABT screen are created to show the various reading and ABT parameters. This screen is automatically refreshed periodically as set. As far as scheduling is concerned the users upload the ABT Schedule. Scheduler can be uploaded by automatic uploading to the Control centres or manual entry or by uploading file.

ABT Monitoring Tool
The ABT monitoring tool adopts the concept of the existing system in LDC. Per minute Energy values are required to provide the exact picture of demand and UI to the Constituents. This value are acquired from the MFT’s provided at the Interface points. Necessary calculated points are designed in the database to provide real time information on the ABT monitoring displays.

The ABT monitoring tool stores this information on the database and provides requisite displays for both Intra State ABT and Inter State ABT. Data for Inter State ABT is acquired from the XA21 through ICCP.

The ABT tool also lists the points of non-update and suggests the previous days value or the average or provides an option of manual data entry for the Operators. The ABT tool also helps to analyse the 15 minute data acquired from the MFT’s and the ETVM’s for the purposes of Energy audit and Error analysis.

Intra ABT Scheduler
This allows the user to define the Generation availability, obtain the Energy requirement of the constituents, declare the availability to the constituents, and also have a provision to change the schedule based on the time block limitations as per Intra ABT regulations. The Intra ABT schedule are available to all the Control centres and are updated as and when modified at LDC. The scheduler file format is decided during the system design.

ABT Displays and Screens: The ABT Displays and Screens adopts the concept of the existing system in LDC. Per minute Energy values are required to provide the exact picture of demand and UI to the constituents. These value are acquired from the MFT’s provided at the Interface points. Necessary calculated points are designed in the database to provide real time information on the ABT monitoring displays. The ABT Screen also shows the following information based on the data received from various sources like AMR, SCADA, Manual entry:

- Time Block and Actual Time
- Average Frequency
- Schedule for the block in MW’s
- Actual Load during the block in MW’s
- Cumulative Energy for the time block
- Minute-wise UI for the 15-minute block
- UI Rate at the instant for average frequency
- Share of generation in major Generating Stations and CGS
- CGS Schedule, Actual and UI drawing for the time block
Reports
The reports module provides different reports related to the system. The reports are configured during the detailed design of system. In addition to the system standard reports, the user specific reports and query based reports are also provided.

Alarm and Logs
The System provides alarms and logs in case of any abnormality reported by system. The users can define the alarms and exceptions. In addition to the normal logs the system also keeps a record for the Audit Trails & Tracking like user login and logouts.

System Security
The system is password protected. The user with specific password will be able to use the system. The level and role based access of the system is provided to the users

Open Access and Wheeling & Banking module
This module has necessary interfaces to update database with respect to the Open Access customers and Wheeling and Banking generators. The relative metering readings are available to modules like Energy billing, Energy audit for further processing. Also, necessary billing and reporting requirements are taken care by this module.

CONCLUSION
Kalkitech successfully performed Automated Energy Meter Reading from various substations involving more than 1000 energy meters for the client. Data from Energy Meters of different vendors were retrieved and was made readily available for ABT software. Energy Accounting & Analysis was also done up to feeder level. The solution further provided ABT regulation compliance for KPTCL by supporting Energy Scheduling, Bulk Energy Billing functions and other functions like Balancing & Settlement, Open Access, and Bilateral Contract Management Modules.