CHAPTER-2

SURVEY OF A SMART METERING PROJECT IN INDIA

2.1 INTRODUCTION

In smart grid architecture, it is important to monitor from the control centre, consumers demand, voltage, frequency and power factor accurately, on regular basis. This may become possible with installation of smart meters, which records these variables and sends them to Central Data Collection System through fast satellite communication link. Smart meters give information regarding the consumption of energy in real time to all consumers through display device. To enable remote monitoring of substations, Automatic Meter Reading (AMR) obtained by smart meters may be interfaced by Data Collecting Devices (DCDs) installed at substations, which may further transmit the data to Central Data Collection System through two-way communication link.

In this chapter, a survey on the smart metering project by the company Kalkitech in south area of Delhi has been presented. Case studies were performed on this project to examine benefits of smart metering scheme. Measurements obtained from an existing special energy meter as well as from smart energy meter has been presented in this chapter. Working methodology and approach of AMR system with different communication devices and their protocols i.e. SYNC 2000 & SYNC 5000 has been elaborated. It was observed that Automatic Meter Reading (AMR) with its interface meters (Smart Energy Meters or SEM) and Data Collection from Data Collecting Devices (DCDs) at substations may be quite fruitful in monitoring consumers. Implementation of these projects would instill India with advanced capabilities of remote monitoring and control of its substations, with centralized data collection & processing, and this would reduce the maintenance and monitoring costs over time thereby improving overall efficiency of the grid. The project proposes a use of SYNC interface communication unit i.e. SYNC 2000 data concentrator unit and SYNC 5000 meter data acquisition system. These units may collect the data from the meters, convert it into the Device Language Message Specification (DLMS) protocol and transmit it to the Northern Regional Load Dispatch Centre (NRLDC), which may act as the Central Data Collection System (CDCS).

2.2 PROTOCOLS GATEWAY USED

Two types of field gateway converter may be used as a communication controller in smart grid that supports different types of protocols such as IEC-61850, IEC 101/102/103, DNP 3 and DLMS. The two field gateway converters are presented below.

2.2.1 SYNC 2000

SYNC 2000 is generally used protocol gateway controller that supports different types of protocols like- IEC-61850, IEC 101/102/103, DNP 3 and DLMS. It has wide applications both in the transmission & distribution systems. It comprises of different protocols like DLMS, Linux operating system, Modbus. It also supports Virtual Private Network (VPN) connection and latest 3G and GPRS technologies. Fig. 2.1 shows the SYNC 2000 that includes 1 Ethernet and 6 serial ports that help in input-output expansion, support and diagnosis. This device is used to connect all the down-stream devices to the Supervisory Control and Data Acquisition (SCADA).

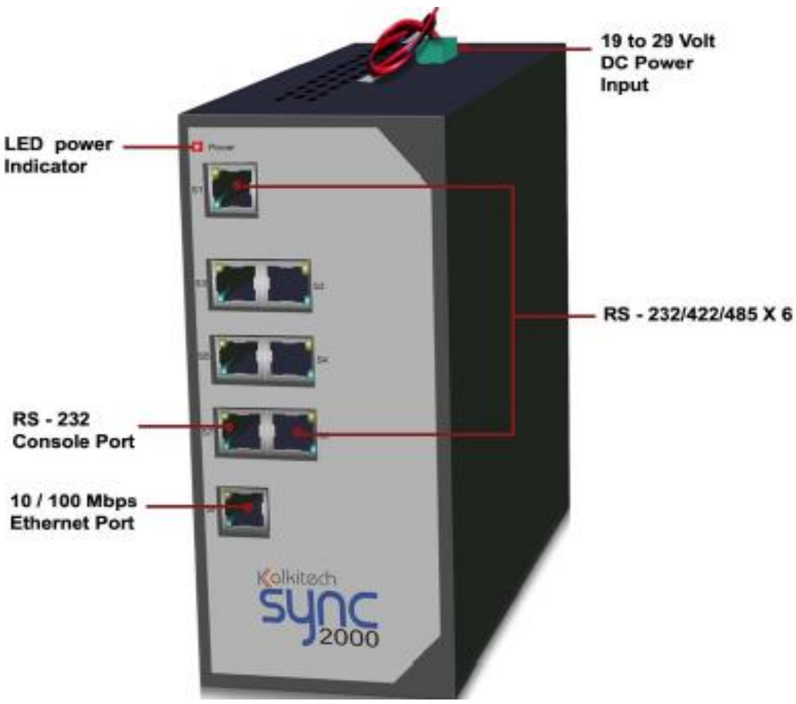

Fig. 2.1 SYNC 2000 protocol gateway

2.2.2 SYNC 5000

SYNC 5000 is head end software that helps in automatic meter reading with the analysis of the stored data through smart meters. It is also called Meter Data Acquisition System (MDAS), which performs automatic meter reading through end to end metering, at the consumer side metering, Demand Side Management (DSM), and also in grid metering using communication media like GPRS, GSM, Code Division Multiple Access (CDMA), RS232 etc. It generally supports up to maximum of one lakh meters at the consumer side and up to 5000 meters at the grid side. It supports different protocols like IEC-61850, IEC-101/102/103, DNP 3 and DLMS. Data collected from the smart meters get stored in center data base management system permanently, in case if there is any failure. Fig. 2.2 shows SYNC 5000 that helps in AMR.

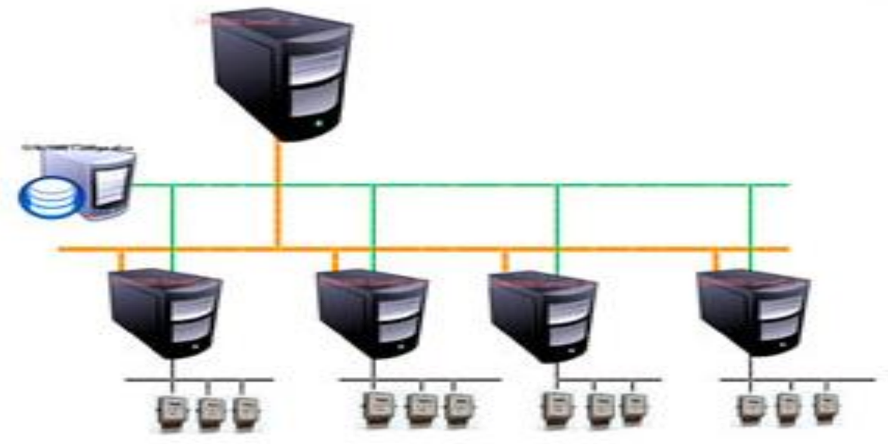

Fig. 2.2 SYNC 5000 high end MDAS

2.3 METHODOLOGY AND APPROACH

The existing special energy meters are microprocessor based energy meters as shown in Fig. 2.3. These meters have non-volatile memory which can store the data. Data recorded by the meters is converted to the readable text file form for computation & analysis and then, is emailed to the load dispatch centre. Due to remote location of number of substations, data measured from special energy meters are to be transmitted via a Universal Serial Bus (USB) device to the nearest town from where these are to be mailed to load dispatch centre on a weekly basis. Since, readings are manually taken from special energy meters and mailed to load dispatch centre, it may lead to human errors. Such errors may result in loss of revenue. Smart energy meter utilizing 3G communication media General Packet Radio Services (GPRS) technique forms two way communications between substation and control centre. It automatically sends the data via a communication GPRS media at an instant to the load dispatch centre. Fig. 2.4 shows the smart meter installed at one of the site of Northern Regional Load Dispatch Centre (NRLDC), that record and stores the consumption of electric energy and sends to control centre via communication media.

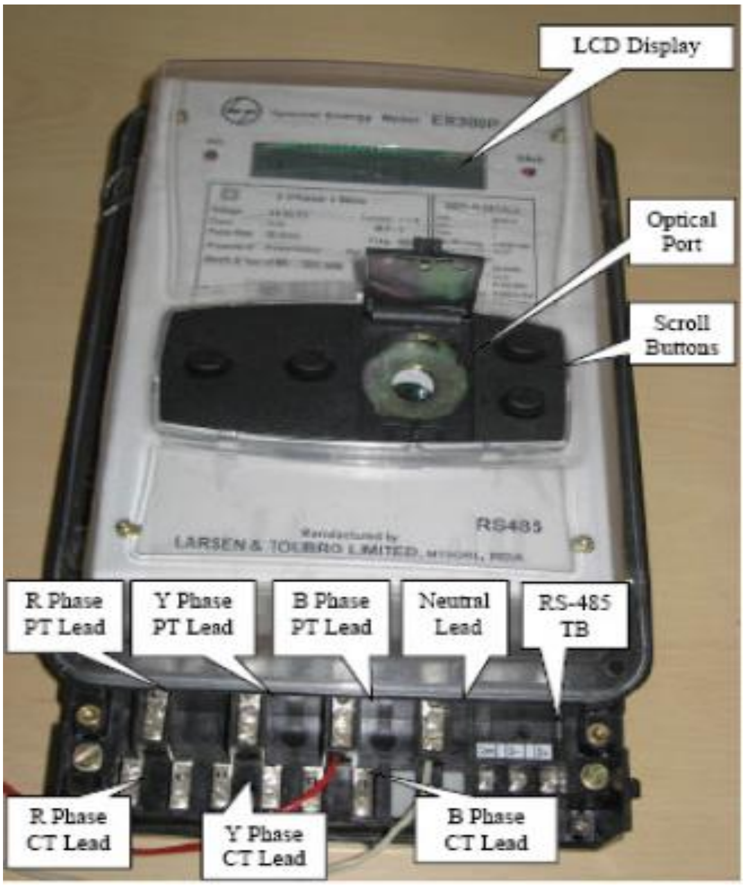

Fig. 2.3 Existing special energy meter

In case of Existing meters the data is recorded in every block:-

- Net Active Energy (Wh) in 15 min.
- Average (Ave.) Frequency (f) is 15 min, and it records the frequency ranging from: 49Hz<f<51Hz.

Data are recorded once in a day at 0.0hrs and it consists of serial number of meter, High voltage reactive energy register-H, Cumulative active energy register-C, Low voltage reactive energy register-L and Date.

Fig. 2.4 Smart energy meter installed at the site

With the introduction of smart meters in Northern region (NR) AMR project in India, the NRLDC may hope to rectify the drawbacks of existing special energy meters, and may improve the overall efficiency in the operation and maintenance of the distribution network. The AMR system hierarchy has been shown in Fig. 2.5. The Central Data Collection System (CDCS) is at the top of the hierarchy. Central Transmission Utility (CTU) may be given the responsibility for the installation of Smart Energy Meters (SEMs).

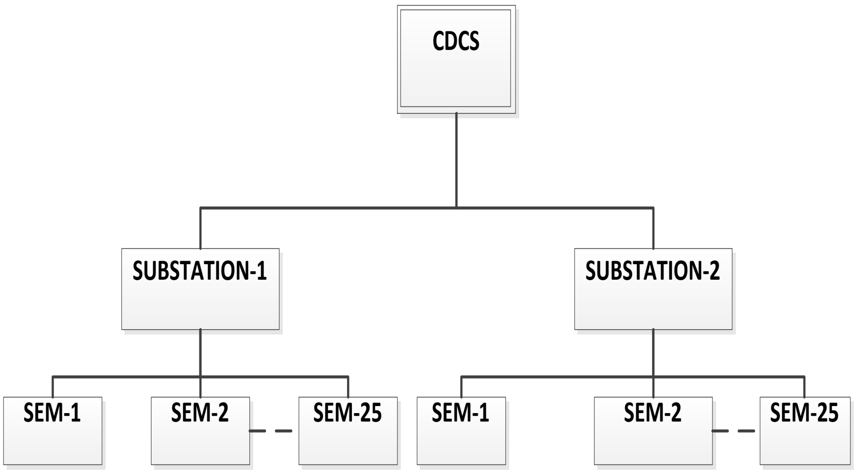

Fig. 2.5 AMR System Hierarchy

The NRLDC may act as Central Data Collection System responsible for collecting and processing the metered data of the northern region. At each substation, variable number of meters ranging from 2 to 25 or more may be installed. The entire AMR system may be controlled from the Central Data collection Centre at Delhi.

The basic high level architecture of the complete AMR System is shown in Fig. 2.6. The IEC 61107 protocol may be used to collect the data from the smart meters and is transmitted to the NRLDC via General Packet Radio Service (GPRS) with Virtual Private Network (VPN) encryption technology and the Device Language Messaging Specification (DLMS) protocol may be used to relay the data from the substation to the control centre.

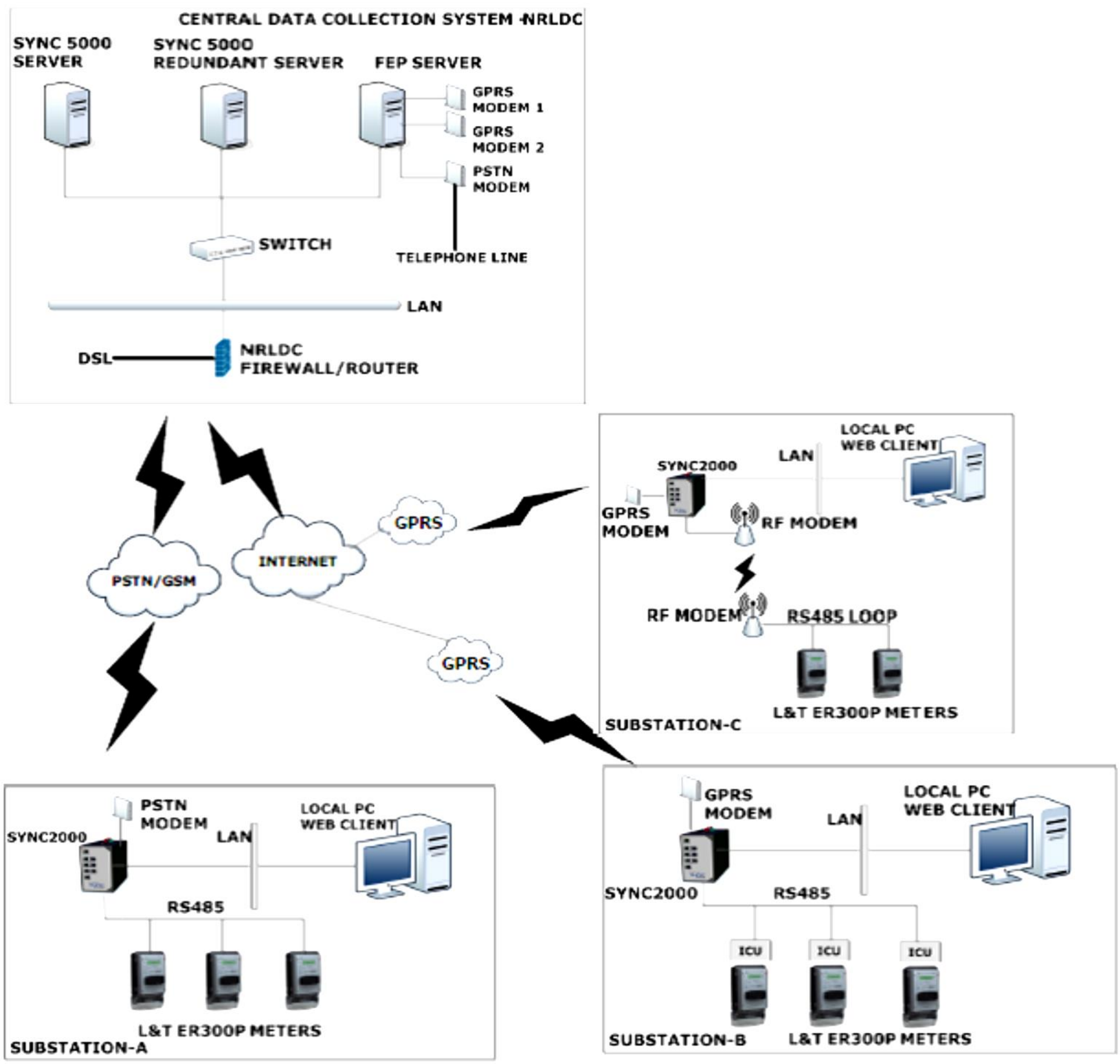

Fig. 2.6 Architectural diagram of the AMR Project

2.4 WORKING/CASE STUDY OF THE PROJECT

Implementation of this AMR Project is based on installing three communication devices for collecting data from the meters and then converting this data to the DLMS Protocol which is used to relay data from the substation to the control centre with the help of:

A. SYNC Interface Communication Unit.

B. SYNC 2000 Data concentration Unit.

C. SYNC 5000 Meter Data Acquisition System.

2.4.1 SYNC Interface Communication Unit (ICU)

SYNC- ICU efficiently collects the required information from ports and transmits it to the Data Concentrator Unit at the substation via a serial connection. The Interface Communication Unit consists of an additional optical interface output, so that the operator at the remote location has not to remove the ICU device for manual reading of the meter data.

2.4.2 SYNC-2000 Data Concentration Unit (DCU)

Data collected from all the meters are finally collected in the SYNC-2000 at the substation level and collected data is transmitted to CDCS. SYNC 2000 converts the data from the meters into the DLMS protocol which is transmitted over a VPN based encrypted GPRS network.

2.4.3 SYNC-5000 Meter Data Acquisition System (MDAS)

SYNC-5000 Meter Data Acquisition System (MDAS) collects the data in the DLMS Protocol format for sending the information to Enterprise Resource Planning (ERP) systems from the SYNC-2000 and also provides the interface and features to achieve configuration, data retrieval and data analysis.

A case study for implementing an AMR project is presented which is carried out on special energy meter as well as smart energy meter installed by the company Kalkitech at Badarpur in south area of Delhi. The reading of special and smart energy meters for a period of one week were noted and have been shown in Table 2.1.

Energy consumption noted in smart meter for one week i.e. from 7-Mar-2015 to 13-Mar-2015 is 28.024kWh (46.659kWh-18.635kWh), whereas energy consumption noted in existing special energy meter is 28 kWh (629kWh-601kWh).Thus, it is observed that smart energy meter performs measurements more accurately as compared to existing energy meter. A difference of 0.024 kWh seems to be small for one week period, but when error gets propagated, it may lead to large error in a year. This may result in lot of billing difference and revenue loss. Power factor and peak demand for the periods 07/03/2015, 7.00 AM to 13/03/2015 7.00 AM were measured from smart energy meter and have been plotted. The plots of power factor versus time and peak demand versus time for one week of period have been shown in Fig. 2.7 & Fig. 2.8, respectively. Based on variation of power factor and peak demand, tariff can be designed. Measured data may be transmitted to CDCS, where billing may be done based on specially designed tariff. Consumers with high power factor loads, and using loads in off-peak periods may be given incentives, whereas, others may be penalized. This may lead to best utilization of generation resources, encouragement to promising consumers, proper revenue collection and consumer satisfaction.

TABLE 2.1 COMPARISON OF THE READINGS OF SMART ENERGY METER WITH EXISTING SPECIAL ENERGY METER FOR ONE WEEK PERIOD

Smart Meter Readings									Existing Energy Meter Readings
Date	**Time**	**Volts L-N**	**Amps Ave.**	**Frequency**	**kVA Total**	**Power Factor**	**kW Total**	**Meter Reading kWh**	**Meter Reading kWh**
07/03/2015	7.00 AM	251.5	1.220	50.03	0.124	0.653	0.068	18.635	601
	10.00AM	243.5	0.486	48.95	0.113	0.610	0.065	19.323	603
	7.00 PM	249.8	0.495	50.06	0.256	0.481	0.152	20.265	604
	10.00PM	250.5	1.200	50.03	0.356	0.652	0.241	22.118	605
08/03/2015	7.00 AM	246.3	09.94	49.23	0.265	0.573	0.695	23.254	606
	10.00AM	251.8	1.240	50.89	0.245	0.907	0.456	24.590	607
	7.00 PM	248.6	0.485	50.73	0.125	0.502	0.256	26.415	608
	10.00PM	254.9	1.500	50.0	0.136	0.643	0.158	27.670	609
09/03/2015	7.00 AM	251.5	1.240	48.96	0.256	0.466	0.365	27.409	610
	10.00AM	248.6	0.486	49.93	0.356	0.485	1.356	28.260	611
	7.00 PM	238.2	0.398	50.10	0.256	0.836	0.853	30.174	612
	10.00PM	246.2	0.456	49.15	0.123	0.599	1.297	31.652	613
10/03/2015	7.00 AM	254.9	1.510	49.93	0.190	0.602	1.569	31.952	614
	10.00AM	254.6	1.490	5.013	0.200	0.620	0.036	32.731	615
	7.00 PM	248.6	0.487	50.06	0.120	0.629	0.986	33.862	616
	10.00PM	259.5	1.600	50.09	0.370	0.775	1.56	34.706	617
11/03/2015	7.00 AM	246.5	08.10	50.16	0.250	0.997	0.238	35.430	618
	10.00AM	252.3	1.420	49.35	0.289	0.605	0.698	36.261	619
	7.00 PM	255.3	1.650	49.95	0.370	0.805	0.548	37.298	620
	10.00PM	251.3	1.260	49.54	0.356	0.650	1.569	38.847	621
12/03/2015	7.00 AM	249.5	0.569	48.99	0.246	0.630	1.657	39.387	622
	10.00AM	248.3	0.554	49.35	0.298	0.605	1.687	41.016	623
	7.00 PM	251.6	1.250	50.00	0.239	0.457	0.365	41.523	624

	10.00PM	252.6	1.260	50.96	0.150	0.798	0.036	42.610	625
13/03/2015	7.00 AM	254.3	1.390	50.23	0.256	0.536	0.045	43.267	626
	10.00AM	256.5	1.46	49.93	0.356	0.685	0.125	44.772	627
	7.00 PM	254.8	10.40	49.65	0.348	0.785	1.265	45.387	628
	10.00PM	248.6	0.562	49.93	0.289	0.844	1.023	46.659	629

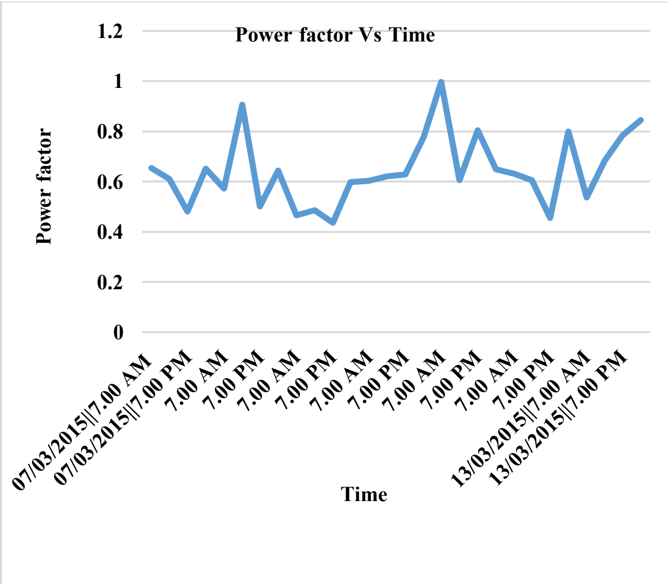

Fig. 2.7 Power factor monitoring curve of smart meter

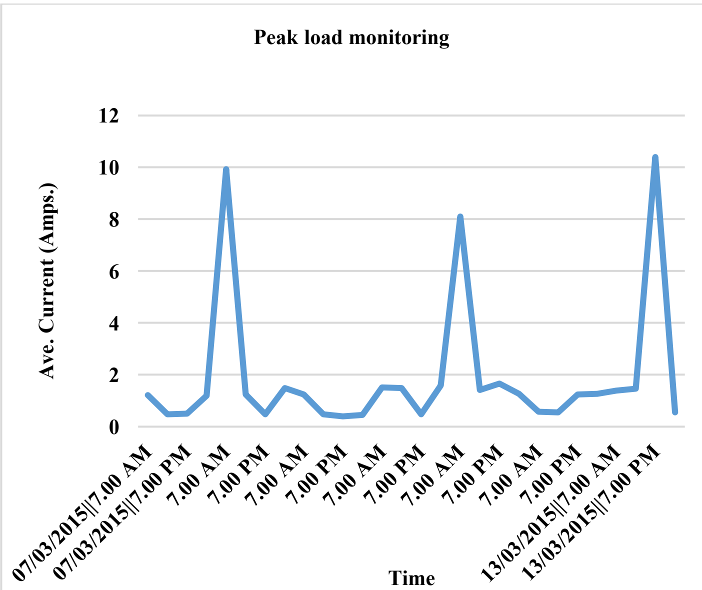

Fig. 2.8 Load monitoring curve of smart meter

2.5 SUMMARY

The successful implementation of AMR project will help to remotely monitor and control its substations in the country's northern region and enable centralized data collection and processing. This will significantly reduce maintenance and monitoring cost over time, and vastly improve response times to real-time issues, thereby improving efficiency of the overall grid. Consumer will also be able to monitor its energy consumption and plan their load switching period, installation of power factor improvement plant (in case of commercial and industrial consumers), and may also act as prosumers where they can also produce and supply electricity to grid in peak hours and earn money. Further, it may increase the ability of utility to reduce the billing time, thereby improving their revenue collection efficiency. Due to accurate measurements, billing becomes accurate which satisfies both utility and consumers.