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Smart Metering System for Energy Conservation and its Implementation in Assam

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Preface

The publication of this series of working papers is a reflection of the endeavour of the University's commitment towards promoting research excellence among the faculty members of the University. Through this series, the University seeks to broaden the horizon of liberal thought, expression and ideas among the faculty members working in this University which is based on a liberal approach towards taking up fruitful discussions across fields and disciplines of socio-cultural relevance. Moreover, it also encompasses the conventional academic disciplines.

With the philosophy of encouraging free flow of ideas in view, the University has adopted an approach to do away with the process of peer review of the working papers. However, to provide an overall guidance, the University has made presentation of the working paper at an Academic Presentation mandatory, before its publication. We believe that this series of working papers would enable the faculty members to publish their advanced research works by bringing them into the public domain which would help them receive further constructive criticisms, feedback and suggestions from the readers across different space. Such working papers would also help the aspiring research scholars of the Universities in the region and beyond.

The broad areas of discussion in this year's working papers stems from the academic disciplines of Philosophy, Political Science, Education, English, Management and Technological Sciences. The working paper entitled *Smart Metering System for Energy Conservation and its Implementation in Assam* by Ms. Antara Mahanta Barua describes the various modules of the smart metering system and the current status of the system implementation in the state Assam. Apart from that, the paper also presents a pilot study on load patterns with the current energy meter and after replaced by the smart meter. The paper makes some observations based on experimental studies in three electrical sub-divisions, viz., Paltan Bazar, Ulubari and Narengi in the city of Guwahati.

Arupjyoti Choudhury, Chairperson.

January 01, 2018. Bhaskar Sarmah, Convenor.

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Smart Metering System for Energy Conservation and its Implementation in Assam

Abstract

Smart Metering System is a new technical innovation that revolutionized the existing power sector in conservation of energy by reducing the power consumption. The key drivers for launching of smart metering system in our country are energy efficiency, reduction of energy consumption, improvement of power quality and protecting the environment by reducing global warming and carbon emissions. This system allows the consumers for monitoring their electricity usage patterns and helps to achieve energy saving by controlling their energy consumption. This paper describes the various modules of the smart metering system and the current status of the system implementation in the state of Assam. It also presents a pilot study on load patterns with the current energy meter and after it is replaced by the smart meter.

Key words: AMI, DCU, energy consumption, smart meter

1.0 Introduction

The power industry in our country is modernizing its existing electric grid. Using advanced technologies, electric utility providers are developing a smart grid infrastructure that will become an important technological innovation of the modern world. It will deliver more reliable power to consumers across the country and allow two-way communication between consumers and their utility providers at the meter level. Installing smart meters is an important step in developing the smart grid infrastructure in the country. These advanced meters enable consumers to track their power usage and learn more about the way they use electricity and will help the consumers for better management of electricity in future. Smart meter technology also allows utility provider to detect power outages[1] more precisely and to restore power promptly. In fact, some outages of power may be avoided by giving the utility provider more options to reduce demand when the system is under stress. It can be done by using Demand Response Event (DRE) (Lipski, 2011) in which utility provider will inform their consumers about which power appliances are not to be utilised by the consumer during peak load hours. The smart meters also provide data to utility providers through remote communication technologies, enabling them to operate the electric grid more efficiently. Most of the smart meters send power consumption data to the utility provider one to four times a day. Also, some systems are programmed to send data as often as every 15 minutes. The utility provider is constantly monitoring and testing the data transmitted from the smart meters to ensure that the power consumption of the consumers is within expected range. If readings show a significant difference from normal levels of use, technicians will be able to inspect the smart meters.

1. A power outage is the loss of the electric power at a particular area which may cause due to the faults in power distribution system, damage in transmission lines, power theft, short circuit etc. (https:/ en.wikipedia.org/wiki/Power_outage)

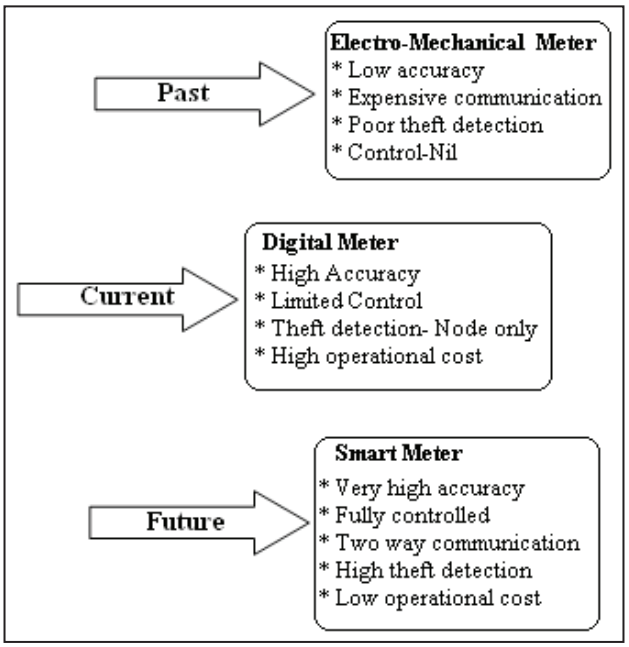
2.0 Motivation

The efficient and prudent use of energy has become a global demand. Nowadays energy conservation has become a well considered field for researchers across the globe. Energy expenditures will be decreased by increasing the possibility of reduced consumption using the smart meter. Although, the advancement of traditional grid, introduces abundant development in electricity generation, transmission and distribution, there are various problems with distribution, metering and billing of electrical energy and its consumption measurement. There is inclusion of wastage of energy and man power in the use of traditional meters.

Generally, consumers demand better customer service, higher power quality, higher energy measurement accuracy and more timely data. Utility companies are responsible for the fulfillment of these customers' demand. The possible solutions are smart grid system and Advance Metering Infrastructure (AMI)/ Automated Meter Reading (AMR) (Paul, 2016). Smart metering is an important system involving AMI that minimises the errors that occur in case of conventional energy meters. It can reduce the gap between consumers and energy utilities and can communicate more efficiently through the implementation and help in distributing quality power.

A comparison of different energy meters has been shown in Figure 1.

Figure 1 Comparison of Different Energy Meters



One of the benefits of smart metering system with communication capabilities is the ability to use real time metering data to generate and analyse power consumption patterns and peak energy demands of each individual consumer. This information can be used by the utility provider, as well as, the consumer and the consumers should be educated on smart metering and its benefits so that they become aware about their energy consumption pattern.

3.0 Theoretical Background

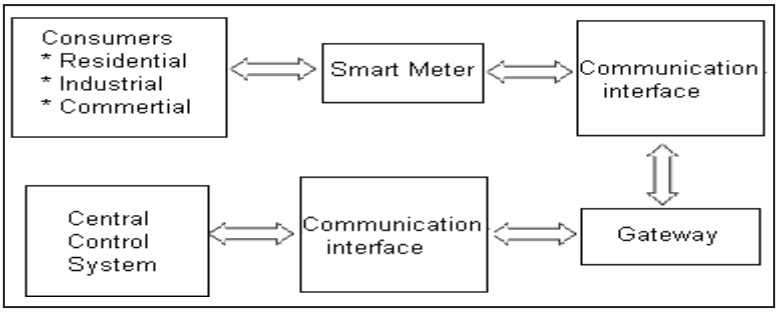
The concept of a Smart Meter and the various components of a Smart Metering System are highlighted in this section.

A Smart Metering system involves the integration of a heterogeneous infrastructure, including metering devices, communication networks, data gathering and processing systems, and a centralised control system. A Smart Metering system is based on four main pillars:

- A Smart Metering device, Smart Meter (SM);
- A data gathering device, Data Concentrator Unit (DCU);
- A communication system used for data flow;
- A centralised management and control system, Central Control System (CCS). (Luis, Vega & Angulo, 2016, p. 2)

An architectural model of Smart Metering System is shown in Figure 2.

Figure 2 Architecture of Smart Metering System



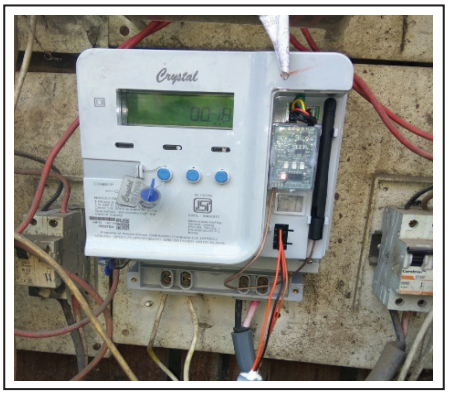
3.1 Smart meter

A smart meter is an electronic device that records power consumption by a consumer at regular intervals and communicates that information to the utility's central control systems. Smart meter can read real time power consumption information including the value of voltage, phase angle, frequency and power factor. A smart meter has the facility of remote connection and disconnection of the appliances when they are not in use. It looks similar to digital solid state meters, but the digital technology inside the meter makes it more efficient. The main capabilities of Smart Meters are as follows:

- Bidirectional data communications
- Remote disconnection and reconnection
- Recording energy consumption at regular intervals of time and deliver at least once per day
- Remote programming
- Communicate outages and restorations
- Support time-of-use and real-time pricing programs
- Provide customers direct access to consumption and pricing information.

A smart meter installed in the Narengi electrical sub-division is in shown in Figure 3.

Figure 3 Installed Smart Meter (Source: APDCL)



3.2 Data concentrator unit

The Data Concentration Unit (DCU) is a device that stores meter information, load profiles and events from Smart Meters and feeds the traffic to the Central Control System (CCS). It acts as a communication hub collecting and encoding data from multiple smart meters in a Neighborhood Area Network (NAN) (P. Prakash. Report). The main function of the DCU is to gather metering data from the SMs via RF/PLC/ZigBee communication technology and transmit the same to the CCS in an encrypted and compressed form via GPRS (General Packet Radio Service) technology. It provides metering data as per schedule or on demand from specific and/or all meters in the NAN (India Smart Grid Forum [ISGF], 2015).

3.3 Communication system

Communication system can be broadly classified into two types: Wireless and Wired. In wireless communication technology micro-waves or radio-waves are used to transmit information whereas in wired communication technology a physical medium like cable is required to transmit information. Utilities can choose either one of the technologies depending on their unique needs and their existing infrastructure. The most important wireless technologies that are used in smart metering system are Bluetooth, Wi-Fi, ZigBee, GSM, GPRS, 3G-4G, WiMAX and the available wired communication technologies are Power Line Communication (PLC), Broadband over Power Lines (BPL), Digital Subscriber Lines (DSL) and Optical Fiber (Elyengui, Bouhouchi & Ezzedine, 2013). The transmission of data must be guaranteed in terms of quality, time, and security. Therefore, the communication technologies play a key role, as they have to be cost-efficient and provide good coverage, security features, bandwidth, and power quality.

3.4 Central control system

The Central Control System (CCS) is in charge of receiving and storing the metering data for processing purposes. It receives the meter data over the digital cellular or WAN connections. The CCS can be seen as a modular system formed by the Meter Data Management System (MDMS), which manages the metering data, Network Management

System (NMS) and additional secondary modules in charge of end-users applications, geographical information systems, control applications, and load management, among others. The MDMS includes the tools that enable communication among different modules, as well as being in charge of validating, processing, and editing the metering data for a suitable information interchange among the different parts of the Smart Metering system.

4.0 Implementation of Smart Metering System in India

The Indian power sector has started its journey to cope with new challenges. Government of India (GOI) has taken various initiatives to upgrade the generation, transmission and distribution sectors of the power system. The main priorities for establishing smart grid technology in India are zero power cuts, prosumer[2] enablement, reduced transmission and distribution losses, improved quality of supply, revenue cycle optimisation, managing peak power, demanding response, integrating renewable / distributed generation efficiently etc.

India Smart Grid Forum (ISGF) and India Smart Grid Task Force (ISGTF) are the two groups of organisation initiated by the Ministry of Power (MoP), Government of India for accelerated development of smart grid technologies in the Indian power sector. The Government of India is planning to invest up to $21 billion in smart grid technology by 2025 (ISGF, 2014). In the Indian, Ministry of Power has allocated 14 smart grid pilot projects that are implementing by state-owned distribution utilities in India. At present, there are total 10 smart grid pilot projects are under implementation stage. All selected pilot projects involve installation of Smart Meters for the purpose of reduction in distribution losses and reliability improvement. The Functionalities covered under these projects are Advanced Metering Infrastructure (AMI), Power Quality Management (PQM), Outage Management System (OMS), Peak Load Managements (PLM), and Decentralised Generation (DG) (ISGF, 2017).

Implementing a smart metering system, as a pilot, a number of key stages are required.

4.1 Design stage

The main areas included in the design stage are:

- Overall solution architecture
- Functionality of the system
- Communications performance model
- Data model
- Meter type and scheme
- Security architecture
- Documentation and implementation plan

2. Prosumer is a consumer of electricity who also produces it and can sell it back to the grid, usually through a rooftop solar photovoltaic system.

4.2 Testing and quality assurance stage

This stage has multiple phases of testing that are mentioned below.

- Meter testing: All meters are tested to check whether the meters meets the functionalities requirements or not.
- Full metering system testing: Tested the functionality of the complete metering system, including the Meter Data Management System (MDMS), Network Management System (NMS), Communication devices and their integration with sample meters.
- *Field testing:* This test involves site selection, stress and volume testing. It also involves installing a small number of meters in the production environment and verifying that they operate correctly over a reasonable period of time.

4.3 Deployment, upgrades and enhancements stages of the system in the field

This stage involves the following processes.

- Selection of the network, meter position and customer types.
- Customer communication and respond to their queries.
- Development of communication model and identify the best places to locate the communication devices.

4.4 Measurement and evaluation stage

In this stage, the performance of the system in relation to the various functionalities is measured.

5.0 Smart Metering Deployment in Assam

Smart Grid is an emerging technology which has already been implemented in many countries and now is the time for this rapidly growing technology to flourish in our own city of Guwahati, Assam. In Assam, smart metering implementation programme was introduced by "Assam Power Distribution Company Limited" (APDCL) in 2013. APDCL utility has awarded the pilot project to M/S Phoenix IT Solutions; a Hyderabad based company and estimated 15083 numbers of consumers to get the smart metering connectivity in 3 Sub-Divisions of Guwahati, namely: Paltan Bazar, Narengi and Ulubari.

The main objectives of this pilot are peak load management with the other interventions such as Industrial and Residential AMI, integration of Distributed Generation, Power Quality Management and Outage Management System (ISGF, 2017). Implementation of this scheme will bring a major switch in the society from manual billing, high losses, and power-cuts to a more effective and automated process of electricity usage wherein consumers will be benefited with the improved and uninterrupted electricity supply with fair pricing. A major benefit of Smart Grid is that it empowers consumer to drastically improve the management of their individual energy usage. This technology will help the consumers to understand the consumption of electricity by them.

In Narengi sub-division two DCUs are installed. There are 40 Smart Meters are connected in RF mesh network and linked to one DCU and the other DCU is linked to 60

Smart Meters. Therefore, in total 100 Smart Meters are installed comprising Field Area Network (FAN) in the Narengi sub-division.

In Paltan Bazar sub-division 98 DCUs are estimated to be connected. The optimal distance FAN is about 80 metres. In Ulubari sub-division, 77 DCUs are projected to connect the smart meters to cover a total of 9070 consumers. There are total 177 numbers of DCU are connected for 15083 numbers of consumers.

In the design of smart metering infrastructure by APDCL, the smart meters are composed in a mesh network. A mesh network is a network in which all nodes are interconnected. The number of meters to be connected to a DCU will depend on the capacity of the DCU and concentration of the meters in the area and other technical consideration. There is a Subscriber Identity Module (SIM) in each DCU which stores all meter data. Information from DCU are transmitted through GPRS wireless network to the Vodafone server from which it goes to Central Control System through Multi Protocol Label Switching (MPLS) using Backhaul drive.

6.0 Experimental Details

With the present energy meter in the three electrical sub-divisions, viz., Paltan Bazar, Ulubari and Narengi, the power consumption of a definite number of consumers and their demands are analysed and the load profile after replacement of the traditional meter with the smart meter is compared.

The following tables show the summary of the consumers, total load, maximum demand and expected reduction of load for three electrical sub-divisions.

6.1 Paltan Bazar electrical sub-division

In Paltan Bazar sub-division, 11 nos. of 11 KV feeders and 5878 no. of consumers are considered with an overall consumption of 50021 KW per month. The maximum peak demand of the area is 13 MW and AT&C losses are estimated to 12.63%. Expected reduction due to the installation of smart meter is projected as 2 MW.

Table 1 Load/Loss value under the pilot project of Paltan Bazar sub-division

Category	No. of Consumer	Connected Load	Maximum Demand	Expected Reduction	AT&C Loss	Expected Reduction
Upto 5 KW	2191	50021 KW	13 MW	2MW	12.63%	2.63%
5-20 KW	3390					
20-84 KW	204					
85 KW and above	93					
Total	5878					

6.2 Ulubari electrical sub-division

In Ulubari sub-division, 5 nos. of feeders with 9070 consumers are considered.

Table 2 Load/Loss value of Ulubari sub-division

Category	No. of Consumer	Connected Load	Maximum Demand	Expected Reduction	AT&C Loss	Expected Reduction
Upto 5 KW	5653	76663KW	20 MW	3MW	20.76%	5.76%
5-20 KW	3173					
20-84 KW	188					
85 KW and above	56					
Total	9070					

6.3 Narengi electrical sub-division

One Industrial feeder of Narengi sub-divison having 135 consumers mostly industrial are considered.

Table 3 Load/Loss value of Narengi sub-division

Category	No. of Consumer	Connected Load	Maximum Demand	Expected Reduction	AT&C Loss	Expected Reduction
Upto 5 KW	32	5540 KW	2.5 MW	0.25 MW	6.83%	Nominal
5-20 KW	80					
20-84 KW	12					
85 KW and above	11					
Total	135					

The consumers do not know about their daily energy consumption, their daily/ hourly demand, which appliances are consuming more energy, how much energy they are consuming compared to their neighbours and how they could manage their consumption better. In case of smart metering system, real time rates and reduction of losses can be calculated based on the state of maximum demand.

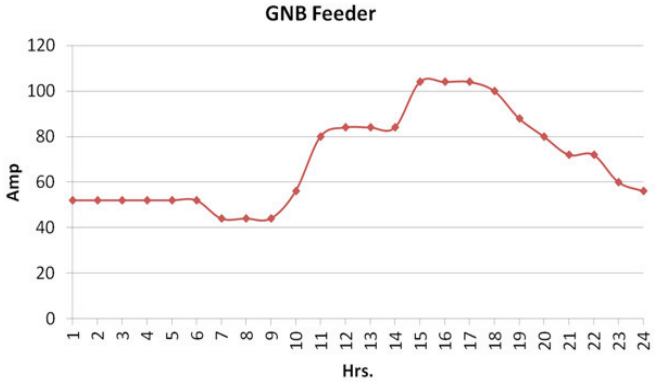
6.4 Comparison of two load curve before and after installation of smart metering system

A comparison of two load curve before and after installation of smart metering system in two different feeders[3] is included in the following figures (Figure 4 to Figure 8).

(a) Load Curve before installation of Smart Metering System: GNB Feeder

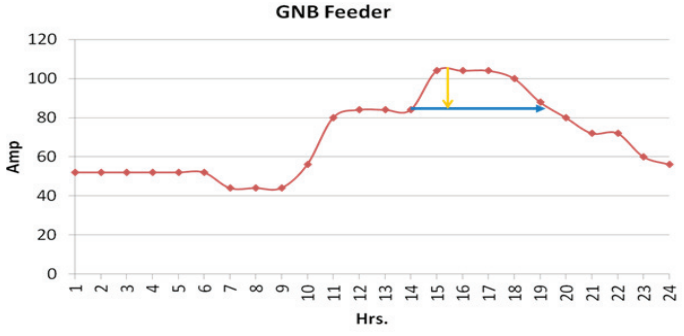
3. To supply the power at consumer's end, the distributor substation has transformer to step down the voltage level and a feeder circuit is used to transmit this voltage to various distribution transformers.

Figure 4 The Load shape before installation of Smart Meter. The x-axis is hour of the day, and y- axis is the load.



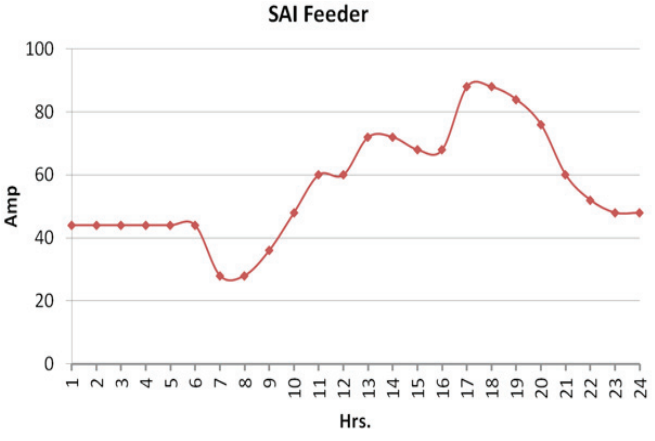
(b) Expected Load Curve after installation of Smart Metering System: GNB Feeder

Figure 5 The Load shape after installation of Smart Meter. The x-axis is hour of the day, and y- axis is the load.



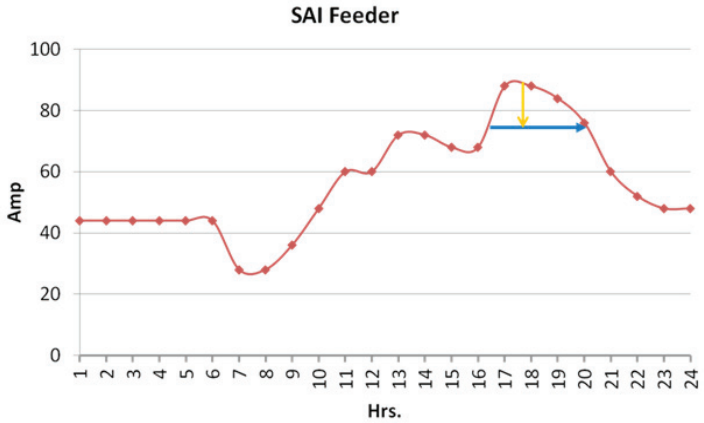
(c) Load Curve before installation of Smart Metering System: SAI Feeder

Figure 7 The Load shape before installation of Smart Meter. The x-axis is hour of the day, and y- axis is the load.



(d) Expected Load Curve after installation of Smart Metering System: SAI Feeder

Figure 8 The Load shape after installation of Smart Meter. The x-axis is hour of the day, and y- axis is the load.



In GNB feeder under Ulubari sub-division, the maximum demand at the peak hours is increased by 20 MW. With the connection of smart meters the peak load will be reduced and remain same value as that of the off peak load. In SAI feeder under Paltanbazar sub-division, the maximum demand at the peak hours is increased by 13 MW from the off peak load and those peaks can be cut down to some extents through demand side management of smart metering system.

7.0 Conclusion

Smart metering system is the modern technology for energy efficiency and conservation in today's world. It is designed to save costs of power usage and the environment by merging the information technology and wireless networking of the household electrical appliances. There are still many challenges in the transition from the existing metering system to the next generation smart meter. Some of them are technology, standardization, demand management approach, cyber security, lack of awareness, financial issues etc. Strong initiative needs to be taken to establish the consumer relationship with the smart meter before implementing the smart metering concept and we can expect the future smart metering network will connect different types of consumers in a highly populous country like India.

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