Overview of Smart Metering Initiatives

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ABSTRACT

Recently smart metering initiatives began to attract much attention worldwide. Smart metering promises many benefits and projects in various countries show that smart metering is techno-economically feasible. Due to cost-effectiveness and to maximize energy efficiency, several governments are thinking of giving mandate for advanced metering. The Advanced Metering Infrastructure will allow electricity to be charged according to demand based tariffs. However future of Smart metering depends upon the various policies by governments and regulatory bodies. Energy savings and an increased security of supply will be main drivers for smart metering and as a means to reach these goals. This paper describes the purpose of smart metering, advanced metering infrastructure and use of smart meters to achieve smart grid. This paper also discusses the progress of implementation in various countries and initiatives taken up in India. Extensive literature survey has been done to describe the smart metering concepts, implementation aspects and the initiatives taken worldwide.

I. INTRODUCTION

Smart Metering is a combination of Smart Meters, Smart Concentrators (or eventually Gateways), Information Technology (IT), and two-way communication systems. Smart Metering is a major building block towards the implementation of Smart Grid for which Utilities are preparing. We can say therefore that Smart Metering systems must be “Smart Grid Ready”. A smart grid uses high-performance communications, advanced sensing and enterprise analysis to transform the existing electric grid into dynamic self-healing, self-optimizing transmission & distribution system. [1] Because critical grid events often require real-time recognition and response, a smart grid solution uses IP-based, open standard, low latency communications to measure real-time events – such as congestion, system stability, equipment health, outages and demand response events – and to link these events with the appropriate responses to improve the efficiency and reliability of the entire grid. A fully functional smart grid employs widely distributed intelligent sensors to collect and analyze data from throughout the distribution system. The true situational awareness of a smart grid comes from extracting meaningful information that the utility or its customers can act upon, such as actionable intelligence, in the time frame necessary to achieve the desired result.[2] As the smart grid includes many of these actions becomes further automated enabling a more dynamic,self-adjusting-grid. This paper essentially is a result of survey of extensive literature on Smart Metering Initiatives and the present status of implementation across the world.

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II. PURPOSE OF SMART METERING

Since the inception of electricity de-regulation and market-driven pricing throughout the world, government regulators have been looking for a means to match consumption with generation. Traditional electrical meters only measure total consumption and as such, provide no information of when the energy was consumed. Smart meters provide an economical way of measuring this information, allowing price setting agencies to introduce different prices for consumption based on the time of day and the season. Electricity pricing usually peaks at certain predictable times of the day and the season. In particular, if generation is constrained, prices can rise or more costly generation is brough online.[3]

It is believed that billing customers by how much is consumed and at what time of day will force consumers to adjust their consumption habits to be more responsive to market prices. Regulatory and market design agencies hope these "price signals" will delay the construction of additional generation or atleast the purchase of energy from higher priced sources, thereby controlling the steady and rapid increase of electricity prices. The implementations of advanced meters are capable of collecting interval data and remotely communicate with meter data agencies, either on a predefined schedule or an adhoc basis.

III. ADVANCE METERING INFRASTRUCTURE (AMI)

A. Advantages of AMI

Advance Metering Infrastructure in Transmission and distribution sector is a system that measure, collect and analyze energy usage, and interact with advanced devices such as electricity meters through various communication media either on request (on-demand) or on pre-defined schedules. This infrastructure includes hardware, software, communications, consumer energy displays and controllers, customer associated systems, Meter Data Management (MDM) software, supplier and network distribution business systems, etc. The general architecture of AMI is depicted in fig -1.[4]

The network between the measurement devices and business systems allows collection and distribution of information to customers, suppliers, utility companies and service providers. This enables these businesses to either participate in, or provide, demand response solutions, products and services. By providing information to customers, the system assists a change in energy usage from their normal consumption patterns, either in response to changes in price or as incentives designed to encourage lower energy usage at times of peak-demand periods or higher wholesale prices or during periods of low operational system reliability[3].

AMI differs from traditional Automatic meter reading (AMR) in that it enables two-way communications with the meter. Systems only capable of collecting meter

readings do not qualify as AMI systems. Advanced Metering Infrastructure is currently rolling out across the globe. The Advanced Metering Infrastructure will allow electricity to be charged according to demand based tariffs. Fig – 2 shows the comparison between AMR and AMI.[4]

B. Features of AMI

Meter Design. Currently there is no universally adopted specification for the design of a smart meter. The functionality that is required within the meter needs to be carefully defined including its capability for communication, local data storage and retrieval, and processing. The access to the meter (use of split terminal covers) will be a peculiar attribute of the Indian market.

Architecture The general configuration of the communication arrangements for gathering data recorded by a smart meter is through Local Area Network (LAN) over which data can be fed to a "concentrator" and then for a wireless network (WAN) to communicate data back to a central processor. Having gathered the data a number of possibilities then exist as to how the processed information could be used by the supplier and the customer. The most economic arrangement and technology for this general design will need to be identified and its application linked to particular geographic areas.

Meter testing Testing of candidate meters need to be conducted to prove their capability and establish their performance prior to large scale roll out.

Remote meter reading An obvious attribute of a smart metering system is its ability to dispense with conventional meter reading practices. The recording and remote collection of interval consumption data presents an opportunity for its use for a variety of applications including the accommodation of import and export for micro generation installations.

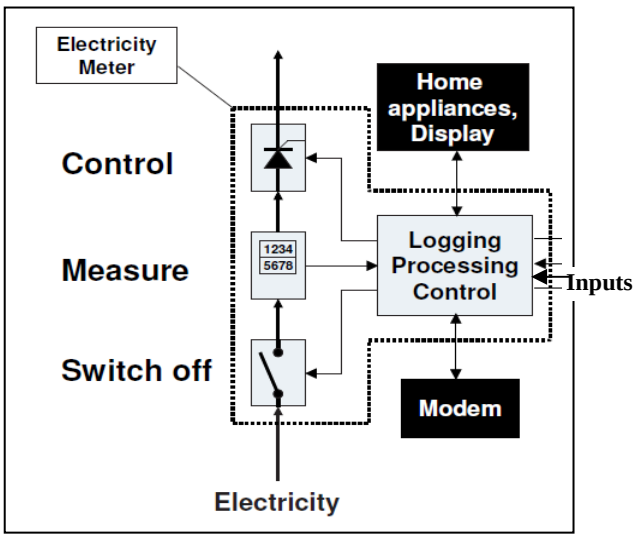

Fig – 1 General Architecture

Remote connection/disconnection. The ability to allow electricity to be cut off or restored remotely would obviate need for visits by field staff. It may also be appropriate to contemplate functionality whereby supplies could be given at a reduced capacity which might support circumstances where there were bill collection problems. Fault monitoring is also possible for detecting faults by monitoring the status of smart meters.

Theft. Smart meters have the ability to be equipped with tamper detection facilities. Software that can detect abnormal trends in consumption would also be a functionality that would help prevent theft and measure losses more accurately.

Quality of supply measurement. Smart meters could also be used to record outages and supply quality such as voltage abnormalities at different locations. [5]

IV. BENEFITS OF SMART METERING & SMART GRID

Smart metering is an essential component of the "smart grid", which has the potential to transform the entire energy system. Not only does it make it easier to integrate renewable energy, it can transform their economic viability. Although smart metering on its own will produce significant savings, these will just come from identifying areas of inefficiency. But it has the potential to deliver much more. One of its main benefits is that it facilitates what is known as the Smart Grid. This is not a physical entity in the same way as the wires of the national grid system are – although it includes those wires. The smart grid is a series of connecting devices that will allow the control of electricity flow. Smart meter is the most important building block of the smart grid. It is a first step in a larger transformation of the entire network. The impact of smart meters on various stakeholders viz, suppliers Distribution system operators (DSO), customers and society as a whole is depicted in fig – 3. [6]

Operational Benefit
Smart metering lowers the cost per read. Having frequent meter readings and on-demand readings can eliminate the need for field service calls and reduce insurance, repair and maintenance costs. This level of data can also speed up resolution of customer service telephone calls.

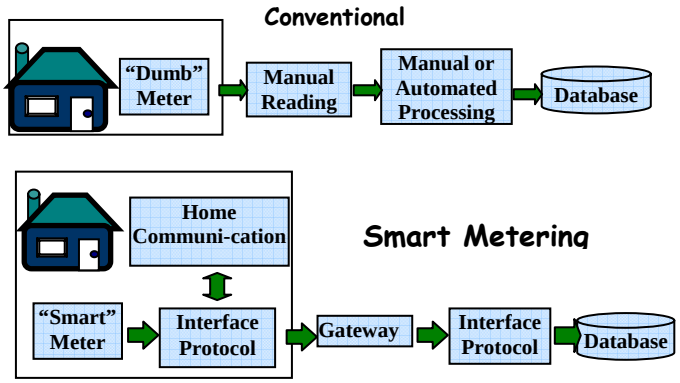

Fig – 2 Comparison between Conventional Metering & Smart Metering

Energy Conservation

Smart metering technology provides the infrastructure for demand response and direct load control, two energy management strategies that lower price. It also increases reliability, and has a small impact on overall energy consumption. AMI provides the time-differentiated meter readings needed to support time-based rates, which can lower energy consumption by 4-5 percent. [7]

Support to grid operators

Smart metering provides data about who uses how much of what commodity, where they use it and when they use it. Without this level of information, it's difficult for the transmission and distribution system to be smart about self-optimizing and self-healing.

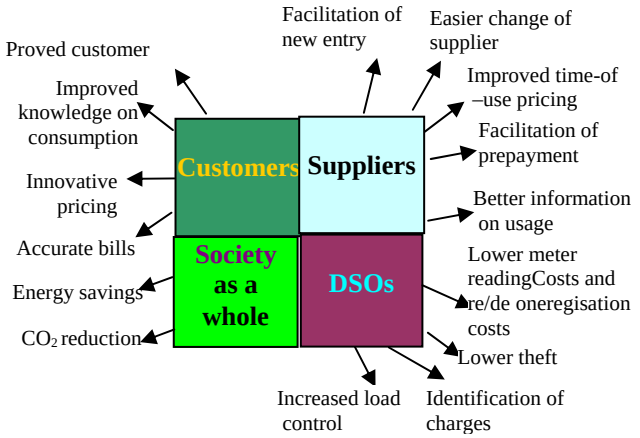

Fig – 3 Impact of smart metering on stakeholders

Smart meters are capable of limiting or even cutting the energy use when triggered by market developments. [6]

When all households and small to medium enterprises (SME's) in a country would be able to adapt their energy use during a period of high prices or diminished availability, this would improve the reliability of supply, enhance energy market transactions, energy savings & energy awareness. When all energy use is monitored by smart meters, grid companies will receive a much more actual and accurate overview of energy consumption in their region. This means they can examine suspicious areas where energy use is higher than expected, and thus smart metering will provide suppliers with a tool to detect fraud. In times of electricity shortage, the grid operator has the option to limit electricity use. Gathering all data, the grid operator will be able to predict electricity flows more accurately and use this knowledge in network and maintenance planning. The automation of the data collection process, with more, recent data on a higher frequency, will put higher requirements on systems. This will also have impact on market facilitating processes.

V. IMPLEMENTATION IN VARIOUS COUNTRIES

This section contain an overview of smart metering initiatives in various countries including India

Italy

The world's largest smart meter deployment was undertaken by Enel SpA, the dominant utility in Italy with over 27 million customers. Between 2000 and 2005 Enel deployed smart meters to its entire customer base.

These meters are fully electronic and smart, with integrated bi-directional communications, advanced power measurement and management capabilities, an integrated, software-controllable disconnect switch, and all solid-state design. They communicate over low voltage power line using standards-based power line technology from the implementing agency to the data concentrators at which point they communicate via IP to the agency's servers.

The system provides a wide range of advanced features, including the ability to remotely turn power on or off to a customer, read usage information from a meter, detect a service outage, detect the unauthorized use of electricity, change the maximum amount of electricity that a customer can demand at any time; and remotely change the meter's billing plan from credit to prepay as well as from flat-rate to multi-tariff [3].

United Kingdom

Smart meters were first introduced as a standard in the United Kingdom in September 2008 by First Utility, primarily for their customers in the East and West Midlands. In December 2009 the United Kingdom the Department of Energy and Climate Change announced its intention to have smart meters in all homes by 2020. While the government considers the domestic requirements for smart metering, corporate and business users are being serviced by companies within the UK who provide advanced innovative metering to businesses and consumers to monitor their electricity usage/wastage.

France

A smart metering pilot project is being conducted by Electricité Réseau Distribution France (ERDF) involving 300,000 clients supplied by 7,000 low-voltage transformers. In June 2008 ERDF awarded the Advance Metering Management (AMM) pilot project to a consortium managed by Atos Origin, including Actaris, Landis+Gyr, and Iskraemeco. The aim of the trial is to deploy 3 Lac meters and 6000 concentrators in two distinct geographic areas, the Indre-et-Loire department and the Lyon urban region. The general deployment phase, involving replacement of 35 million meters, will start in 2012 and continue through 2017.

United States

Oncor Electric Delivery, based in Dallas, Texas is currently deploying smart meters to over three million customers in North Texas. Oncor's full deployment is scheduled to be complete by the end of 2012. The Oncor Advanced Metering System (AMS) currently supports 15 minute

interval data, remote disconnects, and a Home Area Network (HAN) using ZigBee Smart Energy Protocol 1.0. The AMS supports text messages, pricing signals, and load control to the home user through the Smart Meter Texas Portal which is a joint project by Oncor, CenterPoint, and AEP Texas under the direction of the Texas Public Utility Commission.

Nordic countries

Northern Europe became the hotspot for AMM in Europe in 2003 when Sweden announced the decision to require monthly readings of all electricity meters by 2009. Soon activities spread to the other Nordic countries. Vattenfall, Fortum and E.ON decided to deploy AMM in Finland as well as in Sweden, as the leading industry players in both countries at the time. Developments in Denmark took off in 2004 with several ambitious projects being announced by the country's largest utilities. Norway has taken a more cautious stance, but in June 2007 the Norwegian energy authority NVE declared that it would recommend new legislation requiring smart meters to take effect in 2013.[3]

Implementation in India

Grinpal Energy Management, the energy-producing arm of Saab Grintek, has begun deploying smart meters and advanced metering infrastructure in New Delhi, India.

The first deployment began in the Tata area, where Grinpal hopes to have 500,000 installations completes by 2010. It has taken some time to familiarize Indian power distributors with the prepaid smart meter system that the company is introducing. This education process has taken nearly two years. Negotiations started in 2005, and the agreement was signed in November 2006 with the final contract agreed upon in December 2007. The Indian government needed clarity on the prepaid system because India uses the post paid meter system; Grinpal had to introduce the system from the beginning and also prove that the system will enable India to manage their energy wisely.

The new smart meters will provide Indian consumers with information regarding energy consumption that was not previously available with a traditional meter. The prepayment system will allow the easy disconnection of defaulted customers and power connections from a remote site. The new smart system is also capable of instantly detecting tampering with the power lines and sends signals to security personnel if necessary. Utility employees will also have the ability to change a customer's billing method from pre paid to post paid in a matter of seconds, without having to physically visit the meter. The smart metering system comes with a load limiter. This mechanism sends a command to every energy user to reduce electricity usage when the demand for energy gets out of control," The new smart system informs Indian consumers about power shutoffs by sending text messages to a cell phone or the in-home display on the smart meter. The smart meter makes a buzzing sound to let a ratepayer know that the utility company has sent a message. This same process will be used to notify consumers that some drastic load shedding or a power outage is scheduled.

VI. FUTURE SCOPE

No doubt smart metering will become common technology for utilities within the next decade. Potential benefits of smart metering are countless. Smart meters appear to be the biggest innovative development in the last few years and indispensable for all market players:

- For metering companies to decrease meter reading costs
- For grid operators who want to prepare their grid of the future
- For energy suppliers who want to introduce new, customer made services and reduce call centre cost
- For governments to reach energy saving & efficiency targets and to improve free market processes
- For end users to increase energy awareness and decrease energy use and energy cost.[4]

Further in the era of availability based tariff in India the utilities should aim to develop and install fully intelligent smart meters which are capable to micro monitor and control every KWH across the system, in addition to automated remote meter reading. These meters should be made capable of monitoring load, voltage profile with additional capabilities like remote connect/disconnect and local level feedback for grid disturbances and accounting discrepancies by using latest IT technology. In addition, such a system could offer consumers higher availability and quality of power, increasing their satisfaction and willingness to pay. If a full IT system is employed then instead of merely theft reduction, we could expect significant operational and cost improvements, in the power sector, especially if coupled to consumption equipment (appliances and Heating / Ventilation/ Air conditioning-HVAC systems). The demand side management could also be done through such a system by shifting the loads to off peak periods and there could be significant savings for the utility and to consumers who might be receiving specialized pricing or might simply be able to receive more reliable and better quality power. To summarize an IT vision for India's power sector needs to be considered carefully with long term goals. The biggest requirement for long term benefits is a vision for how such a system would allow consumer demand management.[8]

Introduction of smart metering concept seems to be a logical step in a world where all communication is digitalized and standardized (Internet, E-mail, SMS, chat boxes etc.) and where cost of digital intelligence are still rapidly decreasing. Moreover, an advanced metering infrastructure offers more than just reading and controlling smart meters. It can be seen as a dedicated gateway to the customer's home, offering additional energy related services. It can be used both for demand response and demand side management. Moreover future of smart metering will depend heavily on the energy policy and decision taken by the governmental/regulatory bodies involved. Energy savings and an increased security

of supply will be main drivers in implementing smart metering as a means to reach these goals.

The Hon'ble Commission has to take initiative to work in this field with all stakeholders in structuring and implementing the role out of an optimally designed universal smart metering programme that will embrace all aspects of smart metering relevant to the Indian electricity market. The functionality required by different parts of the market, and the benefits that will arise are likely to be different in each sector of the energy market.

VII. CONCLUSION

Smart Metering is nothing but smart thinking. Smart Metering is now no longer a question of "GO" or "NO GO". It is now only a question of 'How' & 'When'. Smart Metering represents a paradigm change for the energy sector and provides strategic benefits from Smart Grid by transforming current electricity grids into innovative real-time interactive (between customers, suppliers, distributors, Transmitters) service networks. Transmission system operators were managing the generation side: distribution system operators will now manage the demand side and the supply side. By strongly reducing manual reading and interventions on the meters, by allowing decentralized electricity generation and storage, by saving distribution losses, we can reap the benefits of Smart Metering and Smart Grid. It is expected that new entrepreneurs will take advantage in the coming years, of the enormous potential of Smart Metering and Smart Grid to propose new innovative services. Benefits listed in this paper, accrue to all along the value chain from the power generator to the end customer.

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