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SMART METER- READY TO MARKET SOLUTION ANALYSIS

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Abstract:*This work is focused on a specific segment of devices that facilitate a smart use of energy. Throughout this document a Smart Meters Solutions analysis will be showcased. The aim of this work is to combine and explain key information about the technology being implemented, analysis of the market solutions, basic types of smart meter systems as well as hardware and software combinations.*
Key words: *smart meter, smart meter systems, analysis, hardware, software*

1. INTRODUCTION

Energy and its sustainable use has become the top priority for both developing and developed countries. With the upcoming growth of both population and energy consumption, being able to be more efficient and effective with the allocation of this resource is a challenge that the world and its leaders are embracing. Although of the efforts the impacts of an unbalanced use of natural resources have led the world to a critical situation where the environment and the society are under an unhealthy and dangerous burden. The development of technologies and the engagement of energy users towards a more conscious use of the energy they consume is critical, as well as, the development of the market to allow this innovative solutions to be both reliable and affordable to ensure that their potential is achieved and their expected benefits delivered.

2. SMART METERS AND SMART METER SYSTEMS

Understanding the role of smart metering and how these systems bring value to the consumer by supporting the sustainable development of the market is a critical step to overcome uncertainty regarding their accuracy and safety.

The concept of smart meter can be defined in general terms as [1] electronic measurements devices, installed by the utilities at the consumer facilities to allow communication of the consumption of energy (gas, electricity, water). These devices have been used by utilities to deliver accurate billing information, for a part of their customers. A first the devices were mainly used by industrial consumers given the higher consumption and the need of specific consumption data, to allow the right and best quality service to be delivered, and also to provide specific and detailed billing data. The evolution of the market and consumer needs facilitated a decreased price on the technology, and increased need of information by all consumers, leading to the migration of these systems from the industrial sector to all customer classes. From the consumer side smart meters can be defined as [2] communication and control systems, which have the ability to directly empower the consumers to understand, control, produce and earn from energy. Through this definition the consumer becomes an equal partner in the energy value chain. A broad view of smart metering, published by the European Commission [3] states that an intelligent metering system or "smart meter" consists of an electronic device used to measure the consumption of energy, delivering more information than a conventional meter, and that can transmit data through a communication network. In this perspective, the key feature of a smart meter is the possibility of bidirectional communication between the consumer and the supplier/operator; the system should also promote the dissemination of services that improve energy efficiency within the home. On a market perspective, shifting from old and static meters to smart active devices is a matter of increased importance for competition in energy markets.

A considerable array of definitions for what smart meter and smart metering is, are available in the literature and in industry reports. From the definitions stated above [1], [2], [3] it is possible to build a comparison table to highlight different focus of different authors (Table 1.)

Table 1. Smart meter definition comparison

Smart meter definition comparison			
Author	(Obenchain *et al*, 2011)	(SEDC, 2012)	(Martin, 2011)
Key concept	Electronic devices, providing billing information to allow better management by the companies and utilities.	Electronic devices, that allows consumers to manage and benefit from a better control of their energy expenditure.	Intelligent meters, that provide more and better information, allowing energy efficiency to be improved, while increasing competitiveness of the energy market.
Focus on	Utility benefits from smart meters, and management of resources	Consumer benefits from smart meter, as well as, utilities.	Consumer, utilities and the market benefit from the roll-out of smart meter technologies.

The general structure of the smart meter (Figure 1.) consists on a hardware combination of the meter and the platforms needed to gather the information, and the necessary software and communication layer that transmits, processes and enables the system to communicate consumption data for accurate billing, controlling and monitoring purposes.

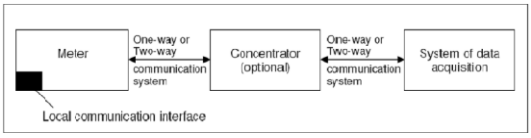

Figure 1. The general structure of a smart meter

The general system architecture as demonstrated in Figure 1. represents the possibility of "one-way" or "two-way" communications between the different layers of the structure.

The evolution of the systems technology from "one-way" communications to "two-way" communications is linked with the shifting from the Advanced Meter Reading (AMR) systems (one-way communication) to the Advanced Metering Infrastructure, AMI, (two-way communication). The main differences between these two systems, AMI and AMR, are [1]:

AMI: Consists on the combination of the electronic meters with two way communication technology, for information, monitoring and controlling energy use;

AMR: Utilized one-way communications to collect meter data only.

The evolution of the communication system and its impacts on the smart meters capabilities are represented on the diagram below (Figure 2.), including the evolution of functionalities and the stakeholder benefits as a result of these evolutions.

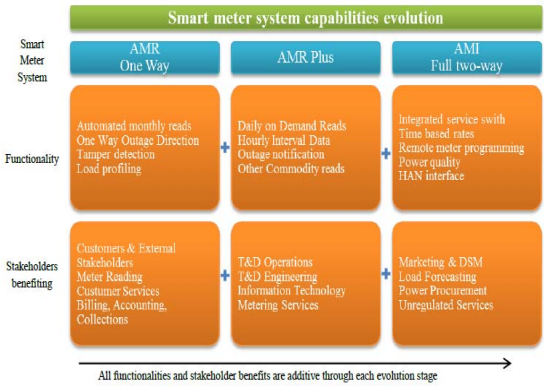

Figure 2. Smart meter system capabilities evolution, adapted from [1]

3. READY TO MARKET SOLUTIONS ANALYSIS

Smart meters combine an electricity, gas or water meter with a communication module which enables communication over a network with the utility / energy service provider. The meter market is dominated by a few large international groups such as Itron, Elster and Landis+Gyr.Some smaller specialized companies are active in the network equipment market.

a) Analysis framework and characterization

According to a research carried out in the UK, as many as one in three people confuse smart meters with energy monitors, or in-home display monitors[3]. This is not a big surprise as is through devices that people receive data from their smart meters. Market solutions for advanced metering infrastructures typically include both of these devices, as well as other hardware and software.

This section presents an overview of smart meters and accompanying technologies, firstly by explaining the basic communications network between the smart meter and utility companies, followed by combinations of customer interfaces and software solutions for energy consumption monitoring by the end user.

Smart Meter Technologies

Smart Meter Systems are varied in technology and design but operate through a simple general process. The Smart Meters collect data locally and transmit via a Local Area Network (LAN) to a data collector. This transmission can occur as often as 15 minutes or as infrequently as daily according to the use of the data. The collector retrieves the data and may or may not carry out any processing of the data. Data is transmitted via a Wide Area Network (WAN) to the utility central collection point for processing and use by business applications (Obenchain*et al*, 2011). Since the communications path is two -way, signals or commands can be sent directly to the meters, customer premise or distribution device.

Basic Types of Smart Meter Systems

There are two basic categories of Smart Meter System technologies as defined by their LAN. They are Radio Frequency (RF) and Power Line Carrier (PLC). Each of these technologies has its own advantages and disadvantages in application. The utility selects the best technology to meet its demographic and business needs. Factors that impact the selection of the technology include evaluation of existing infrastructure; impact on utility legacy equipment, functionality, technical requirements as well has the economic impact to the utility's customers (Obenchain*et al*, 2011).

Radio Frequency – RF

Smart Meter measurements and other data are transmitted by wireless radio from the meter to a collection point. The data is then delivered by various methods to the utility data systems for processing at a central location. The utility billing,

outage management, and other systems use the data for operational purposes. RF technologies are usually two different types:

- **MeshTechnology-** The smart meters talk to each other (hop) to form a LAN cloud to a collector. The collector transmits the data using various WAN methods to the utility central location. Mesh RF Technologies' advantages include acceptable latency, large bandwidth, and typically operate at 9157 MHz frequencies. Mesh technologies disadvantages include terrain and distance challenges for rural areas, proprietary communications, and multiple collection points (Obenchain*etal,* 2011).
- **Point to PointTechnology-** The smart meters talk directly to a collector, usually a tower. The tower collector transmits the data using various methods to the utility central location for processing. Point to Point RF technologies advantages include little or no latency, direct communication with each endpoint, large bandwidth for better throughput, some are licensed spectrum, and can cover longer distances. The disadvantages of point to point RF networks are licensing (not for 900MHz), terrain may prove challenging in rural areas (Line of Sight), proprietary communications used for some technologies, and less interface with DA devices.

Power Line Carrier - PLC

Smart Meter measurements and other data can be transmitted across the utility power lines from the meter to a collection point, usually in the distribution substation feeding the meter. The data is then delivered to the utility data systems for processing at a central location. The utility billing, outage management, and other systems use the data for operational purposes (Obenchain*et al,* 2011).

- PLC technology advantages include leveraging the use of existing utility infrastructure of poles & wires, improved cost effectiveness for rural lines, more effective in challenging terrain, and the capability to work over long distances.
- PLC disadvantages include longer data transmit time (more latency), less bandwidth and throughput, limited interface with Distribution Automation (DA) devices , and higher cost in urban and suburban locations.

There are other Smart Meter Systems in use that differ from those described above. However, these are generally a hybrid or combination design, a slight variation of the basic types, or niche products. The major Smart Meter System Technologies in use today are of one of these basic types.

Data management

Planning for proper data interfaces of the Smart Meter System and the utility legacy systems is imperative. The correct meter, at the correct premise, communicating properly to the utility billing system, with correct data will insure an accurate and timely bill generated for the customer.

A software system not part of the utilities' traditional metering systems but required to operate a Smart Meter System is a Meter Data Management System (MDMS). MDMS is a major component of Smart Meter deployment and operations. This software platform receives meter data from one or multiple Smart Meter technologies, verifies and stores the data, and delivers data subsets to the utility operations applications such as billing (Obenchain*et al,* 2011). An MDMS is installed and operational prior to Smart Meter deployment and is designed to meet the utilities core business needs as well as Smart Meter support.

The data system required for supporting Smart Meter deployments is determined by data requirements and number of customers. For small utilities, usually less than 100,000 customers, the Smart Meter head-end can handle the data management needs. For medium and large deployments of Smart Meters, however, the massive data and functional requirements demands a more sophisticated data management system.

b) Hardware and Software combinations

There are numerous hardware and software solutions in the AMI market. Typically they include a smart meter providing data through an in-home display with various output functions. Data is accessed through the in-home display or through web-based applications for PC and as of recently mobile applications. In-home displays can also receive consumption data from home networked smart devices (washing machines, fridges, televisions, A/C, etc.).

These devices are very diverse, presenting data in various shapes and forms, ranging from simple displays that provide information on energy consumption in kWh, projected resulting GHG emissions and past, present and future prices, to more elaborate displays mimicking speedometers or providing color coded signals to consumers on their consumption patterns. The following section provides an overview of some devices and their applications available to consumers.

i. Tendril Insight (http://www.tendrilinc.com)

The display communicates with networked smart devices, such as thermostats and electricity meters, within the home; to provide data on the consumption rate in kWh and also the cost of energy usage, current and previous. Data collect from the Insight is sent to the utility provider, allowing them to produce accurate monthly bills. The device also acts as a platform for the utility provider to send messages to the customer, informing them of the latest offers and rates of electricity.

ii. GEO – Minim Energy Monitor

(http://www.greenenergyoptions.co.uk)

Originally designed for British Gas, this device displays how much energy is used within the household. The speedometer shows the amount of

energy currently being used, the center shows the total amount of electricity that has been consumed, whilst the bottom bar allows setting monthly consumption targets.

iii. Tendril Vision (http://www.tendrilinc.com)

The Tendril Vision allows consumers to manage their energy consumption in an easy to use manner that keeps them engaged and participating in the process. Providing current and historical household energy usage, as well as calculating the real time price of their usage. Customers can create their own rules for consumption over different periods of time; an alert is created if the terms of the rule are broken. The vision shares data between the customer and utility provider over the Tendril Platform, which requires internet access. The platform contains characterization software which analyses, predicts and compares the consumption of the user with that of others, providing useful features for utilities. The device has features such as current weather and forecast information, thermostat features and a clock. This data can be used to predict how much energy consumption will occur in certain weathers. The vision also has a color scheme, allowing the consumer to easily distinguish between energy consumption.

iv. GEO – Solo

http://www.greenenergyoptions.co.uk)

The GEO – Solo is has features such a speedometer and total electricity consumption. The Solo also has a fuel gauge resembling feature which acts as a target setter for the day, if the reading is below that of the bar, then energy has been saved. This function tells the user that they are not only saving energy, but also money. The Solo will also alert users to any unusual amounts of energy consumption for the time of day.The Solo is ideal for collecting data as it can back up data for up to two years on an internal SD card. Data can be downloaded GEO online platform, providing a more in-depth analysis of energy consumption.

vi. Alert Me Smart Energy (www.alertme.com)

The Alert Me Smart Energy meter communicates energy usage to the display unit, online platforms and mobiles through apps. Operating at a frequency of 2.4 GHz, the alert me meter is capable of ignoring most interference. From your display unit, online or mobile apps consumers can monitor how much energy their household is consuming and get an accurate estimate of what likely bills. The device also monitors what appliances are on all the time and calculates a base load. From that information the meter will generate alerts if it notices any anomalous readings. If the Smart Meter is in combination with Smart Plugs the device enables monitoring the individual energy consumption of each appliance. The traffic light system shows what appliances are saving or wasting energy. Furthermore, appliances can be turned on and off from mobile phones.

4. CONCLUSION

Smart metering is a way to reduce energy consumption, which is otherwise projected to keep growing across the Europe over the next two decades. Smart meters have the proven ability to enable significant changes to the current scenario regarding energy consumption. Their purpose is to improve efficiency, not just at the household level, but utility-wide. For energy providers, smart meters promise to slash uncertainties in electricity consumption data and billing, eliminate the cost of manual meter readings and alert utilities to problems and outages more quickly and effectively.

The development of smart metering and the evolution on has the potential to change the energy industry and the interactions between consumers and distributors of electricity. Providing more and better quality information, these devices set the basis for realistic demand side programs and initiatives, focused on reducing unnecessary consumption, and shifting flexible load outside of peak hours. Reducing the peaks on demand will be possible through dynamic pricing, feedback and strong consumer engagement.

The array of smart meter enabled in-home displays on today's market is very broad. As can be concluded from the above examples, some devices provide superior functionality and data than others. Marketed solutions are continuously improved to provide customers with a better overview of their energy consumption and more advanced controls such as remote monitoring and control of appliances. More advanced functions come with a higher price. The consumers will choose which device they will acquire based on their needs, their level of adoption of sustainable energy practices and the investment they are willing to incur. The next section explores in greater detail software solutions for energy consumption monitoring.

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