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Smart Meters in Smart Grid: An Overview

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***Abstract*-- Smart meter is one of the most important devices used in the smart grid (SG). The smart meter is an advanced energy meter that obtains information from the end users' load devices and measures the energy consumption of the consumers and then provides added information to the utility company and/or system operator. Several sensors and control devices, supported by dedicated communication infrastructure, are utilized in a smart meter.**

This paper outlines some smart meter's aspects and functions of smart meter. In addition, it introduces two basic types of smart meter system's communication technologies: Radio Frequency (RF) and Power Line Carrier (PLC) and recent advances with regard to these two technologies. This paper also presents different policy and current status as well as future projects and objectives of SG development in several countries. Finally, the paper compares some main aspects about latest products of smart meter from different companies.

***Index Terms*-- Mesh Technology, policy objective, Power Line Carrier (PLC), Radio Frequency (RF), smart meter, Value Proposition**

I. Introduction

Smart meter is one of the most important devices used in the smart grid (SG). Grid is the electricity system that consists of electricity generation, electricity transmission, electricity distribution, and electricity consumption. In traditional power grids, electric power is carried from a few central generators to a large number of load centers with electricity users or customers [1]. A smart grid (SG) is a new type of power grid under development, which allows unconventional power flow and two-way information flow to create an advanced automatic and distributed energy delivery network. Table I shows a brief comparison between the existing grid and the smart grid (SG).

Existing Grid	Smart Grid
Electromechanical	Digital
One-way communication	Two-way communication
Centralized generation	Distributed generation
Few sensors	Sensors throughout
Manual monitoring	Self-monitoring
Manual restoration	Self-healing
Failures and blackouts	Adaptive and islanding
Limited control	Pervasive control
Few customer choices	Many customer choices

Table I Comparison between the existing grid and the SG [1]

The smart meter is an advanced energy meter that obtains information from the end users' load devices and measures the energy consumption of the consumers and then provides added information to the utility company and/or system operator for better monitoring and billing. With smart meter, electrical data such as voltage and frequency are measured and real-time energy consumption information is recorded. Smart meter supports bidirectional communications between the meter and the central system. Also, smart meter has the built-in ability to disconnect-reconnect certain loads remotely and can be used to monitor and control the users' devices and appliances to manage demands and loads within the "smart-buildings" in the future.

Several sensors and control devices, supported by dedicated communication infrastructure, are utilized in a smart meter. Smart meters' data is the combination of the unique meter identifier, the data timestamp, electricity consumption values and so on. Smart meter can collect diagnostic information and data about the distribution grid and home devices, and measure electricity consumption from them to identify parameters and transfer the data to utilities and send back the command signals in order to optimize the customer's bill and power consumption accordingly. Sometimes, a smart meter can also communicate with other smart meters.

From the consumer's perspective, smart meters are offering a number of potential benefits; for example consumers are able to estimate bills from the collected information and thus manage their energy consumptions to reduce their electric bills.

From the utility's perspective, they can use the information collected from smart meters to realize real-time pricing, by which the companies can limit the maximum electricity consumption and tries to encourage users to reduce their demands in the periods of peak load. System operator can terminate or re-connect electricity supply to any customer with proper mechanism remotely in order to optimize the power flows according to the information sent from demand sides. Figure I shows comparison of conventional energy meter and smart meter.

The rest of the paper is organized as follows. Section II outlines various functions of smart meters and the benefits from smart meter; section III presents two kinds of typical technologies for smart meter communication and related

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research; section IV discusses several countries' current situation and the governments' future policy objectives in detail; section V compares some main aspect about latest products of smart meter from different companies.

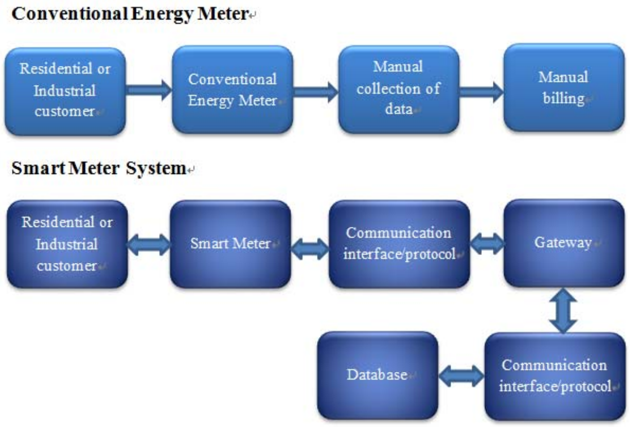

Fig. 1 the metering architectures of a conventional energy meter and a smart meter [2]

II. Smart Meter Functions And Benefits

A. The typical function of smart meter

Commonly, smart meter is expected to have the following functions:

1. The two-way communication function
2. The data collection function
3. The data recording function
4. The data storing function
5. The load control function
6. The programming function
7. The security function
8. The display function
9. The billing function

Figure II shows an actual model of a smart meter.

Fig. 2 an actual model of a smart meter [3]

B. Smart metering system benefits

The benefits for installing smart meters are numerous for many different stakeholders in different aspects of the smart grid system.

Smart Metering Value Proposition for the utilities:

1. It saves a lot of money by improving the remote area reading and billing system.
2. It gives utility the ability to better manage during peak load times.
3. It makes more efficient use of energy and grid resources.
4. It offers new tariff model in the electricity market.
5. It improves the transformer load management for the transmission line.

Smart Metering Value Proposition to Consumers

1. It shows customer data about their electricity usage habit.
2. It gives customer more accurate and timely electrical billing.
3. It helps customer to better use the electrical equipment during the expensive hours.
4. It facilitates customer to switch/delay their electrical equipment with significant consumption to less expensive hours.

Smart Metering Value Proposition for Governments

1. It stimulates the economy by investing in smart metering networks.
2. It improves the environmental condition by reducing CO_2 emission.
3. It leads to reduction of consumption by increasing the awareness of consumption pattern.
4. It helps better load forecasting for power grid and prevent large-scale black out.
5. It gives data for improving efficiency and reliability of service.

III. Smart Meter Technologies

Smart Meter Systems are varied in technology and design but operate through a simple overall process [4]. Smart Meters collect data from the end consumers and transmit this data information through the Local Area Network (LAN) to the data collector. This transmission process can be executed every 15 minutes or as infrequently as once a day based on the requirement of the data demand. After that the collector retrieves the data and then transmits it. The utility central collection points further processes the data by using the Wide Area Network (WAN). Since the communications path is two-way, signals or commands can be sent directly to the meters, customer premise or distribution device [4]. Figure III shows the basic architecture of Smart Meter System operations.

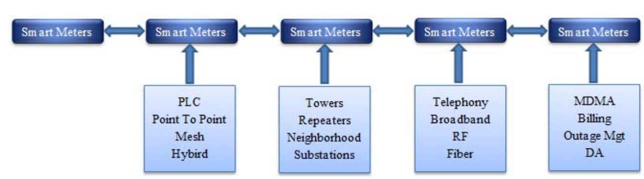

Fig. 3 the basic architecture of Smart Meter System operations [4]

There are two basic types of smart meter system communication technologies: Radio Frequency (RF) and Power Line Carrier (PLC). In smart grid applications, there are different advantages and disadvantages associated with them. The utilities choose the best technology based on their business profits. Making the right decision to choose which technology requires a thorough evaluation and analysis of the existing needs and the future benefits of business.

There are factors that impact the selection of the technology, such as [4]:

1. Evaluation of existing infrastructure;
2. Impact on legacy equipment, functionality, technical requirements as well as the economic impact to the utility's customers.

A. Radio Frequency – RF

Smart meter collects the measurement data from the end consumers and then transmit the data by the wireless radio from the meter to a data collector. Then, the data is processed and delivered by several methods to the utility data systems at a central collection location. The utility billing, outage management, and other systems use these data for operational and business purposes. There are two different types of RF technologies:

Mesh Technology:

The smart meters talk to each other to form a LAN cloud at the collection point. The collector transmits the data using various WAN methods to the utility central location [4].

1. The mesh RF technology has some advantages, such as the large bandwidth, the acceptable latency and the typical operation frequency is at 915 MHz.
2. The mesh RF technology also has some disadvantages, such as the proprietary communications, the topography and long distance issues for the remote areas.

Some research has been conducted in the mesh RF area. Parag Kulkarni *et al.* [5] propose a mesh-radio based solution which is an enhanced version of the RPL (Routing Protocol for Low-Power and Lossy Networks (LLN)) protocol and exhibits self-organizing characteristics. Parag Kulkarni *et al.* [6] also propose a mesh radio based solution with self-organizing characteristics, which has the ability to enhance the RPL protocol, a connectivity enabling mechanism for low power and lossy networks currently being standardized by the IETF ROLL working group. Daniel Geelen *et al.* [7] present and evaluate a real-life implementation of a new routing protocol for use in smart-metering mesh-network grids which is designed with both technological constraints and legislative requirements. Hamid Gharavi *et al.* [8] present a multi-gate mesh network architecture that has been developed to ensure high performance and reliability under emergency conditions when a system expects to receive power outage notifications and exchanges. They take into account both the hop-count and the queue length of each mesh node to introduce a back-pressure based scheduling algorithm. Bill Lichtensteiger *et al.* [9] describe the system architecture and the performance evaluation of a Radio Frequency (RF) mesh based system for smart energy management applications in the Neighborhood Area Network (NAN). Arjun P. Athreya *et al.* [10] propose the resilient and survivable hierarchical communication architecture for the smart grid that mirrors the hierarchy of the existing power grid. Also analytical models are proposed to study the performance of the flattened architecture as a function of outage area, smart-meter density and smart-meter's neighborhood size.

Point to Point Technology:

In this technology, 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 [4].

1. Point to Point RF technology has some advantages, such as large bandwidth, little or no latency, direct communication with each endpoint, better throughput, and can cover longer distances.
2. Point to Point RF technology also has some disadvantages, such as the topography and long distance issues for the remote areas, the proprietary communications, and less interface with Distribution Automation (DA) devices.

Some research has been conducted in the point to point RF area. Sebnem Rusitschka *et al.* [11] propose a Peer-to-Peer (P2P) network of homes with low-cost digital electricity meters which consists of off-the-shelf hardware and existing communication infrastructure. Asma Garrab *et al.* [12] propose an AMR solution with enhanced end-to-end application. It is based on an energy meter with low-power microcontroller MSP430FE423A which includes an energy metering module ESP430CEl and the Power Line Communication standards. Rahman, M.M. *et al.* [13] provides an overview of the characteristic of smart meter, associated communication standard and bandwidth and investigates the propagation delay of smart meter via Ethernet devices using the OPNET IT Guru to ensure efficient operation of a smart meter network. According to the problems such as the imperfect smart electricity meter's detection item, heavy detection task, high working intensity and so on, Cen Wei *et al.* [14] has researched an advanced smart electricity meter automatic detection technology.

B. Power Line Carrier – PLC

The data collected by smart meter can be transmitted from the meter to the utility central collection point by using the utility power lines. And then the delivered data is further processed and analyzed. The utility utilizes these data for operational purposes and predict the future benefits of business [4].

1. PLC technology has some advantages; e.g., it can improve cost-effectiveness for rural lines, and make it possible to work for the remote area or over long distances.
2. PLC technology also has some disadvantages; e.g., it has longer data transmitting time than wireless, less bandwidth and higher cost in cities.

Some research has been conducted in the PLC area. Rakesh Rao *et al.* [15] present a method for identifying outliers among a set of smart meters by measuring the power line carrier (PLC) signal strength between the communication node (transformer) and residential smart meters. The PLC signal is used as a predictor of transmission problems to proactively avert local power outages. Four metrics are presented based on the distribution of signal strengths, with each metric identifying a class of outliers. Mojtaba Rafiei *et al.* [16] propose a practical smart metering approach which can be used for both type of automatic meter reading (AMR) and advanced metering infrastructure (AMI) by using combination of PLC and WiFi protocols. Liang Dong *et al.* [17] present the noise characteristic and transmission characteristic of the power line channel at first, then establish the basic power line channel model according to measured data.

IV. Current Development in Different Countries

A. France

France is a little different from other country in that the electricity and gas markets are dominated by Electricité De France (EDF) and Electricité Réseau Distribution France (ERDF), so these two big companies have the power to decide the activities on the smart meter field. But the French government promulgated a government decree in August 2010 which mandates the installation of electronic meters from January 2012 on and have at least 95% coverage by the end of 2016.

The EDF identified four areas in which smart meter will make great contribution to provide improvements within the energy field in 2006. The four areas are:

1. The billing and customer service
2. Grid operation and monitoring
3. Remote connecting and disconnecting
4. The accounting

For the ERDF, they plan to provide some new services for their energy suppliers by improving their existing processes with the rising potential of smart metering or to install completely new information and data management systems instead.

There are also some other policy objectives for the introduction of smart metering, such as [18]:

1. From January 2012, every new electricity meter installed must be a smart device.
2. By the end of 2014, 50% of all meters must be connected to an automated meter management (AMM) system.
3. By the end of 2016, 95% of the meters must be connected to an AMM system.

B. Germany

The Germany government follows a policy driven by customer demand which means to liberalise the metering service market. From the beginning of 2010, the national legislature requires the contractor to install smart meters in new buildings and the buildings that are refurbished significantly. Since the legal situation is unclear, the investment from the major metering service companies is very small. There are only about 15 out of 800 utilities offering smart metering products in the early 2010. Also the smart meters will lead to additional costs for customers. As a result, only the customers with high consumption are likely to install the smart meter and may benefit from it.

There also some other policy objectives for the introduction of smart metering, such as [18]:

1. By the end of 2010, the metering operator has to arrange smart meter that shows the timetable of use and the real consumption of energy.
2. From the beginning of 2008, the customer has the right to receive a monthly, quarterly, biannual or annual bill.
3. From 2011 on, utility companies are required to provide load-variable or time-of-use tariffs.

C. Netherlands

The Netherlands is one of the front runners and most positive promoter in Europe in the smart meter area. Dutch government allows citizens to install the smart meter voluntarily and can choose between four legal options of different degrees alternative smart meters (from keeping conventional meters to full AMM, to be discussed later) from November 2012. In order to ensure this development, the government issued two major policies.

1. The smart meter will only allow to be read once every two months in the standard situation.
2. The consumer will have the option of refusing the smart meter. This means that the consumer has the right to keep his or her traditional meter.

The four legal options of different degrees alternative smart meter for the consumers are [18]:

1. The first option is to allow the consumers to refuse the installation of a smart meter and to keep their 'traditional' meter.
2. The second option is to allow the utilities to install the smart meter, but never allow sending the consumers' meter readings automatically. It means that the smart meter functions as a traditional meter, and still needs a meter reader.
3. The third option is to allow the utilities to install the smart meter, but with a set of limited capabilities of automatic meter reading for some important information; for example, only allow the meter to be read once every two months in the standard situation or once a year for annual billing.
4. The fourth option is to allow the utilities to install the smart meter and with full function of automatic smart meter reading.

D. Norway

In Norway, the government has already deregulated the control of the power supply system. Currently, the hourly smart metering is only required for large customers. This means that most end customers are free to choose their power suppliers from many of the retailers with different electrical energy tariffs. So the self-reading of the meter has been the most common application for the smaller customers in Norway. Despite the lack of Automatic Meter Reading (AMR) in the second quarter of 2010, there are still 55% of the end customers holding an energy contract related to the market price.

The government only requires the customers whose yearly consumption is larger than 100,000 kWh to install the hourly reporting smart meter. In 2007, there are 100,000 hourly reporting smart meters around the whole country constituting only 4% of the total metering points in Norway, but more than 60% of the total yearly consumption are taken by these large customers.

Smart metering has been a hot topic in Norway for several years and the government has already made some proposal to encourage the smart meter field [18]:

1. In 2002, the government proposed that the new technology of AMR smart meter should be an offer to all end customers.
2. The proposal of introducing the new type of smart metering has not been taken seriously until 2007.
3. The government suggested that the AMR smart meter should be fully deployed by the end of 2012.
4. After several delays, the government changes their suggestion to fully deploy the AMR smart meter by the end of 2017.

E. UK

For the UK government, their objective is to mandate promotion for larger customers to install the smart meters for electricity and gas by the end of 2014, and mandate promotion for domestic to install the smart meters for electricity and gas by the end of 2020.

The government estimated that it would cost at least about £340 for each household and the total cost for installing 26 million houses with smart meter would eventually cost about £8.6 billion by the end of 2020. However, by installing these smart meters, there would be more than £14.6 billion of compensatory savings in the operational costs of energy companies, and eventually would lower the bills for customers.

There are also some other policy objectives for the introduction of smart metering, such as [18]:

1. To mandate the larger or medium businesses to install the advanced meters by the end of 2014.
2. For the industrial and commercial sites, to require half-hourly metering or daily-read metering respectively
3. For the residential meters, to replace 27 million smart meters by the end of 2020.
4. For the small or medium business, to install 2.2 million smart meters by the end of 2020.
5. For the commercial and industrial customers, to install 168,000 smart meters by the end of 2014.

F. The United States

Smart meters will eventually be prevalent everywhere all over the world over the next few decades. In 2008, only less than 4% of the electricity meters in the world were the smart meters. But by 2012, the percentage grows to over 18% and it is expected to rise to 55% by the end of 2020.

But the interesting thing is that, the installations of smart meters will actually suddenly decrease over the next two years in the US. "According to research, the shipments of smart meter in the U.S. will drop by a significant 42 percent between 2011 and 2013, and after 2014 will start to gradually rise again" [19].

There are several reasons to cause this result [19].

1. One reason is because utilities in California which is the leading state to install smart meters in the US will complete many of their installation projects of the smart meter that were started a few years ago.
2. Pacific Gas and Electric Company (PG&E) has already installed almost 9 million meters by year end 2011, and they would finish the deployment by the middle of 2012.
3. Southern California Edison has already installed 4.3 million smart meters in the middle of 2012 and tries to finish all of the planned installations by the end of 2012.
4. The Department of Energy (DOE) released billions of dollars to the utilities for their smart meter installation programs in 2009, most of which would be finished in near future.

In 2010, 20,334,525 advanced ("smart") metering infrastructure (AMI) installations were completed throughout 663 U.S. electric utilities, out of which about 76% were Investor Owned utilities; and about 90% out of the total installations were for residential customers [20]. Table II shows the current distribution of smart meters in the US.

Number of AMI Installations by Customer Type						
Type of Utilities	**Number of Utilities**	**Residential**	**Commercial**	**Industrial**	**Transportation**	**Total**
Investor Owned	108	13,880,141	1,452,929	24,728	36	15,357,834
Cooperative	342	3,416,336	323,082	27,542	0	3,766,960
Municipal	184	278,198	44,757	2,471	0	325,426
Public & State	29	795,233	84,215	4,826	31	884,305
Totals	663	18,369,908	1,904,983	59,567	67	20,334,525

Table II The distribution of smart meters in the United States

V. LATEST PRODUCT

Many companies have produced smart meters on the basis of market demand. According to the different purposes, these meters are categorized into two applications: residential smart meters and commercial & industrial smart meters. In the following, some major smart meters are descried.

A. General Electric (GE) Company

The GE has been offering two standards smart meters, which are the ANSI standard (American National Standard Institute) and the IEC standard (International Electrotechnical Commission). For each standard, it has some series products designed for residential and commercial or industrial purposes.

For the ANSI standard smart meter:

The I-210 series residential meters:

The GE's I-210 series is the single phase electronic meters which includes 3 models: I-210+c, I-210+, I-210. This series cover almost all the metering needs from the basic electronic energy-only meters to the highly-flexible smart meters.

The GE I-210 series have some key benefits, re-stated here from GE official website [21]:

1. Reliable and accurate cash register for utilities.
2. AMR/AMI Plug-n-Play functionality.
3. Multiple communication technologies tied to AMI systems to provide reliable data in a timely manner.
4. Smart Grid metering functions such as Time of Use demand metering and service switch capabilities.
5. Demand side management through pre-payment and demand limiting features.

Table III shows the main parameters between the GE I-210 series meters.

Product Characteristics	I-210+c	I-210+	I-210
Rating Voltage	120 V-240 V	120 V-240 V	120 V-240 V
Rating Frequency	50 Hz or 60 Hz	50 Hz or 60 Hz	50 Hz or 60 Hz
Typical Starting Voltage	5.0 V	5.0 V	5.0 V
Typical Voltage Losses	0.7 V	0.7 V	0.7 V
Typical Accuracy	Within +/-0.2%	Within +/-0.2%	Within +/-0.2%
Operating Voltage Range	+/-20%	+/-20%	+/-20%
Operating Temperature Range	-40°C to +85°C	-40°C to +85°C	-40°C to +85°C
Communication Type	AMR RF Mesh PLC Cellular	AMR RF Mesh PLC	AMR

Table III Main parameters for GE I-210 series meters

The KV2c series commercial and industrial meters:

The kV2c has the function of five demand measures, real-time pricing, and real time data monitoring, which offers easy and powerful functional upgrades to meet the metering needs. There are 2 models (KV2c and KV2c+) in the GE kV2c product family which provides more choices for applications including a polyphase option for a voltage of 600V.

The GE KV2c series have some key benefits, re-stated here from GE official website [21]:

1. AMR/AMI Plug and Play designed to accommodate: RF, PLC, Cellular (GPRS/CDMA), Ethernet.
2. Complete range of S-base and A-base forms.
3. 4-quadrant industrial or substation measures.
4. Powerful functional upgrades provide 4-channel 64 kb, 20-channel 192 kB, or 20-channel 384 kB recording for voltage, current, energy, apparent power, reactive power, distortion power, power factor, THD, TDD, DPF.
5. Per phase AC instrumentation (amps, volts, and frequency).

The GE kV2c+ offers the following benefits in addition to those offered with the kV2c [21]:

1. Enhanced power supply to support a variety of AMI technology.
2. 57-120V auto-ranging power supply for low voltage applications.
3. Ability to serve 600V applications.
4. Revenue Guard option preserves billing integrity when a phase voltage is lost.
5. Available in Switchboard form (Z base).

Table IV shows the main parameters of the GE KV2c series meters.

Product Characteristics	KV2c	KV2c+
Rating voltage	120 V-480 V	57 V-120 V, 600 V
Rating frequency	50 Hz or 60 Hz	50 Hz or 60 Hz
Typical accuracy	Within +/-0.2%	Within +/-0.2%
Operating voltage range	+10% to -20%	+10% to -20%
Operating temperature range	-40°C to +85°C	-40°C to +85°C
Communication type	AMR RF Mesh PLC Cellular	AMR RF Mesh PLC Cellular

Table IV Main parameters for GE KV2c series meters

For the IEC standard smart meter:

The SGM3000 series smart meter:

The GE's SGM3000 series is the most popular meter series comprise of advanced capabilities. It contains eight meters in the series for both residential and commercial demand, including single phase, polyphase, dual-element and CT metering.

The GE SGM3000 series have some key benefits [21]:

1. Improved energy efficiency from the utility to the house.
2. Advanced co-generation applications using configurable, full quadrant measurements.
3. Modular communications with field replaceable options.
4. Extensive relay and multi-element configurations for application flexibility.
5. Scalable, future-proof metering with ample embedded resources.

The SGM1100 smart meter:

The GE's SGM1100 meter is the single phase smart meter which was designed for residential and small commercial energy customer. In this meter, PLC AMI communications based on the Powerline Intelligent Metering Evolution (PRIME) standard and DLMS/ COSEM protocol [21] are available.

The GE SGM1100 has some key benefits, re-stated here from GE official website [21]:

1. Dual pole relay for old residential infrastructure resulting in a more secured and safe service disconnection.
2. Remote upgradable firmware and meter configuration via PLC communications to reduce on-site visits for service and maintenance.
3. Designed to facilitate quick and easy installations in difficult environments.
4. Integrated PRIME PLC modem; providing, reliable and interoperable communications with PRIME compliant data concentrators.
5. Local communications via an optical port, enabling local configuration, firmware updates, and diagnostics as needed.

Table V shows the main parameters of the GE SGM3000 series and the SGM1100 meters.

Product Characteristics	SGM3000 series	SGM1100
Voltage Rating	220 V, 230 V, 240 V	230 V
Frequency Rating	50 Hz, 60 Hz	50 Hz
Current	10 A	10 A
Operating voltage range	+/-20%	+/-20%
Typical accuracy	Within +/-0.2%	Within +/-0.2%
Single phase	SGM3011, SGM3013 SGM3022, SGM3023	SGM1100
Three phase	SGM3030, SGM3031 SGM3033, SGM30C2	
Operating temperature range	-40^{o}C to +70^{o}C	-25^{o}C to +70^{o}C
Communication type	RF Mesh Cellular WiMAX ZigBee	PLC

Table V Main parameters between the GE SGM3000 series and SGM1100 meters

B. Itron Company

Itron's smart residential meters deliver the two-way communications due to customers need to build their advanced metering infrastructure. Itron's smart meters are built upon industry standards and provide unprecedented interval data storage, remote upgradeability and configuration changes, and the gateway to consumer smart devices.

The Itron CENTRON OpenWay meter:

The Itron's OpenWay smart meter system provieds an enhanced security and a reliable approach to data collection and communications between the smart meter and the network system.

In the Itron advanced smart meter the usage data can be calculated within the meter instead of insert a network communication card into a standard meter. This designed smart meter can allow utilities to leverage time-base rates, demand response, home networking and many other smart grid applications.

OpenWay smart meter is unique and offers the following distinguishing features [22]:

1. Time-of-use and critical peak pricing data.
2. A two-way, unlicensed RF module and adaptive-tree radio frequency local area network architecture.
3. ZigBee radio for interfacing with home area networking and load control devices.
4. A remote service switch with load limiting capabilities to support many new services, such as prepaid metering.
5. Tamper detection including meter inversion, meter removal and reverse energy flow.

CENTRON Bridge Meter:

The CENTRON Bridge smart meter is the first meter available with compatibility between the Itron's CENTRON OpenWay network and the Itron's ChoiceConnect mobile environment. It is the bridge between Itron communication architectures that enable AMI and smart grid functionality. The meter's adaptability allows it to be incorporated along with the existing Itron smart meters with a mobile collection system, delivering advanced metering benefits associated with interval data, remote service switch and demand reset. This revolutionary capability is perfect for customers that require advanced metering functionality in a mobile environment today.

Table VI shows the main parameters of the Itron OpenWay and Bridge meters.

Product Characteristics	OpenWay	Brudge
Voltage Rating	120 V, 240 V	120 V, 240 V
Frequency Rating	60 Hz	60 Hz
Starting Current	20 mA, 5 mA	20 mA, 5 mA
Battery Voltage	3.6 V	3.6 V
Operating voltage range	+/-20%	+/-20%
Operating temperature range	-40^{o}C to +85^{o}C	-40^{o}C to +85^{o}C
Communication type	RF Mesh ZigBee	RF Mesh ZigBee

Table VI Main parameters between the Itron OpenWay and Bridge meters

C. Sensus Company

Sensus's iCON smart meter make consumers (residential, commercial and industrial) deliver the accurate and reliable results between customers and energy companies. Combined with the FlexNet advanced meter infrastructure, electricity supplies can install and upgrade the iCON meter's electricity management platform for significant efficiency.

iCON A residential meter:

The Sensus iCON A smart meter with the SmartPoint integrated display is one of the most reliable and efficient Advanced Metering Infrastructure (AMI) smart meters available. An optional remote disconnect switch allows operators to disconnect or reconnect services by using the Regional Network Interface (RNI) software.

The FlexNet communications network is approved by FCC for operation on an unshared primary-use licensed spectrum. It offers a reliable, simple, and an economical way for meter deployments, strategic deployments, and rural applications.

The iCON A has some key benefits [23]:

1. Integrated FlexNet™ AMI on display board
2. Power Quality reporting
3. Time-of-Use
4. Remote configuration and meter firmware downloads
5. Accuracy exceeds ANSI C12.20 (Class 0.2)

iCON APX commercial and industrial meter:

Although the traditional iCON*APX* Commercial and Industrial meter provides stability in the fluid landscape of the developing smart grid, it lags behind contemporary social requirement of a smart metering device with the flexibility to balance a wide variety of ever changing factors and service quality demands. Combined with the FlexNet advanced meter infrastructure, electricity supplies can install and upgrade the iCON*APX* meter's electricity management platform for significant efficiency.

The iCON APX has some key benefits [23]:

1. Accuracy exceeding ANSI C12.20 (Class 0.2)
2. Reliable, unbreakable one-piece cover
3. Complete DC immunity
4. Inversion-proof
5. Advanced user-friendly configuration software-iCONFig

Table VII shows the main parameters of the Sensus iCON A and iCON APX meters.

Product Characteristics	iCON A	iCON APX
Voltage Rating	120 V, 208 V, 240 V	120 V to 480 V
Frequency Rating	60 Hz	50 Hz, 60 Hz
Starting Voltage	5 V	5 V
Operating voltage range	+10% to -20%	+10% to -20%
Typical accuracy	Within +/-0.2%	Within +/-0.2%
Operating temperature range	-40^{o}C to +85^{o}C	-40^{o}C to +85^{o}C
Communication type	RF Mesh ZigBee	RF Mesh ZigBee

Table VII Main parameters between the Sensus iCON A and iCON APX meters

VI. Conclusion

This paper reviews several important aspects of smart metering. It presents the advantages of smart meter system from the points of view of utilities, consumers and governments respectively. In addition, two kinds of typical technologies for smart meter communication and related research are presented in detail. Moreover, several countries' current situation and the governments' future policy objectives are discussed in detail. Finally, the paper compares some main aspects about latest products of smart meter from different companies.

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VIII. References

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