International Journal of Computing and Digital Systems

http://dx.doi.org/10.12785/ijcds/020310

# Infrastructure Evaluation for using Smart Metering System (AMI & AMR) in Power Distribution Networks

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*Received 15 Nov. 2012, Revised 15 Mar. 2013, Accepted 30 Apr. 2013, Published 1 Sep. 2013*

**Abstract:** Load annual growth and increasing demand for electrical energy in the country on the one hand, and energy scarcity on the summer peak hours on the other hand causes the topic of energy management is considered a necessity. It must be created secure infrastructure in the distribution system to perform a systematic movement of electrical energy management, and in this case, smart metering grid implementation at the national level is the best option for achieving this goal. Also, it will be doubled to requirement to this system implement by full implementation of targeted subsidies law. In this paper we survey to evaluation of useful architectures and technologies in the implementation of smart metering grid and compare them with each other.

**Keywords:** Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI), Smart metering grid, Data collector unit.

## I. INTRODUCTION

It is time-consuming, tedious and combined with errors to electricity meter reading and registration of customers' power consumption in the common methods and it's considered the main concern of the electricity power distribution companies. It's the appropriate strategy to use smart metering systems for eliminating this problem. AMR (Automatic Meter Reading) is one of the most widely used technologies in smart metering systems. In an ideal AMR system, all of electric meters in the town are reading automatically and remotely from a centre and bill customers are generated automatically with no errors. In addition, by using this system, electricity power distribution Companies can switching customer's electricity remotely, then electricity power distribution Companies can outage bad account subscriber's electricity without send-out persons.

Data collection of energy network's subscribers (water, electricity and gas) and sending this information to a database for billing analyse customer usage patterns and providing IT services to them are among the most important functions and services of automatic meter reading systems (AMR). This technology remove costs for meter reading related to traffic within the city, additionally, provides data processing possible for alternative interpretations of energy meter.

In this case we can provide adaptation possible of energy consumption and production for the consumer and the producer by using the results of the data analysis, that the most important benefits will be reducing energy losses in distribution networks a significant amount.

In a competitive market for electricity, data exchange between energy suppliers and consumers is important. Whatever the data exchange between the parties is stronger, power systems will be utilized in a more secure and as a result, we will see electricity market in more efficient and more competitive structures. Projects implementation related to smart meter electrical will significant impact on the economic and financial power industry. Other benefits of this project are transparency of financial relations in the electricity market and also issues such as loss's control and measures and financial connection with subscriber. Practices and extensive measures in this regard should be based on proper design and taking into account considerations such as the present and future state of relevant technologies, basic requirements for implementation and opportunities and threats posed by its performance.

Development, maintenance and operation of this system needs appropriate technical knowledge at various levels of the distribution and planning in this area is needed now. Meter reading and record customer consumption is one of the most time-consuming processes associated with the error and it's the main concern of the electricity distribution companies.

Meter reading automatically or remotely is an automatic data collection technology from the meters like water, electricity or gas meters that is performing the data transferring process to the information centre for analysis, billing and control cases related to switching power subscribers. Some of the benefits of remote meter reading include lower costs, maintain security, prevent energy losses, reduce unauthorized use or tampering of meters, reduce problems such as lack of subscribers at home at meter reading time or denied entry to the homes of subscribers, meter reading conduct's inadvertent or deliberate error in the recording of meter's usage in the traditional way [1-2].

## II. SMART METERING SYSTEM INTRODUCTION

Smart metering system is not a simple system to collect subscribers use data monthly or two-monthly, but it's an integrated system including hardware, software, networking and communications platform that receives the information such as use, demand, voltage, current and other information in real time or with a delay of the consume. This system creates a two-way platform contacts has the capability to reading, configuration, meters monitoring and control remotely, collect, manage, process and analyse data and produces necessary reports that all these processes are performed automatically.

Smart metering system with advanced two-way telecommunications features in terms of hardware include following:

- measurement equipment in side of subscribers with hardware and appropriate interface circuits for two-way communication and remote reading
- load switching equipment and limiting the use and ...
- used communication network (Which can be a combination of telecommunication systems proportional and according to the available features for each)
- control center or centers (including hardware and software features, such as load management programs, billing system, data analysis and load prediction programs, associated with market and tariff management and ...)

Figure (1) is shown a simple example of a smart metering system.

Since advance smart metering system infrastructure transforming electricity sales operations and consumer management and has new terms and election conditions for power companies and consumers in terms of price, information and a variety of services since they were not considered that is comprise the significant profit potential [3].

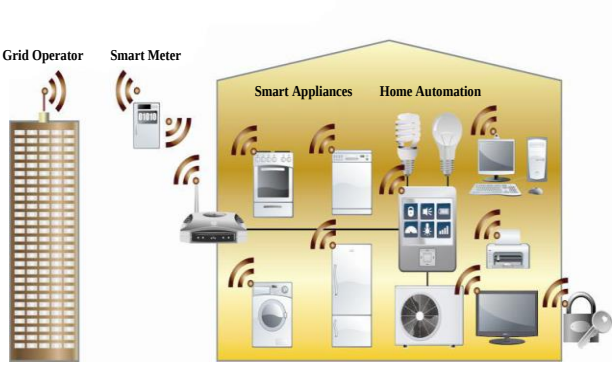


Fig. 1. Transfer of information and communication networks, smart meters

Reduce the cost of operating in distribution network is another advantage of investment on smart metering systems. Especially when you need to read meters constantly and successively and the need to disconnect subscribers due to non-payment of subscription or other and connect it again after a fixed, In addition, it would be no need to spend time and money and dispatched trained personnel to the site, and it does this operation along with other functions by smart meters control and this special advantage, reduces the annual cost of operation greatly.

This technology makes subscribers informed of how to use and how to use the energy at the peak time by displaying consume information and thus reduces subscriber's costs.

Smart metering infrastructure is including a collection of equipment, networks, computer systems, protocols and organized processes that is used to accurate data collection and transmission of power consumption subscribers that can use power and distribution networks. These systems are advanced because they will not only collect customer data, but they are highly reliable, secure and fast and they are updated automatically and spread.

In smart metering system, one of the goals is excluding meters from subscriber's private area, because it is always possible to authorized people access to meters and also be minimized manipulating the meter by subscribers. In this regard, in some countries install subscriber's meters some whither outside of range domain [4-5].

## III. SMART METERING SYSTEM COMPONENTS ARCHITECTURAL

The system architecture is both simple and hierarchical. Simple type of architecture is used more in the general case the high cost of the monthly charge is not much attention, because not provide the necessary telecommunications infrastructure by the service provider.

Hierarchical architecture is the most used type of architecture in smart metering system design, that in this type of architecture, data meters collected in multi-level and be sent to a higher level, or vice versa. A hierarchical architecture component is presented in Figure 2.

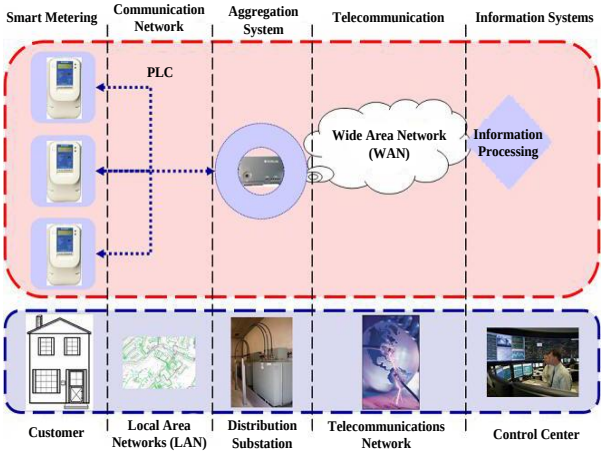


Fig. 2. Components of AMI Systems Network Architecture

### A. Smart Meters

Smart meters should have two-way data exchange capability with the distribution companies. smart meters should be according to the determined standards of industrial equipment, also must have a standard interface for communication with the communication module (such as port RS485) about meters with current transformer and voltage transformer.

In addition to the above, smart meters should have the following features:

Connection and registration of active and passive energy, the interval and the cumulative, each phase separately and total of three phases(total should be calculated as well as the vector and scalar), measurement or register of power and power factor as phase-to-phase and the total measurement and phase angle register separately. Figure 3 shows the internal structure of a smart meter [6-7].

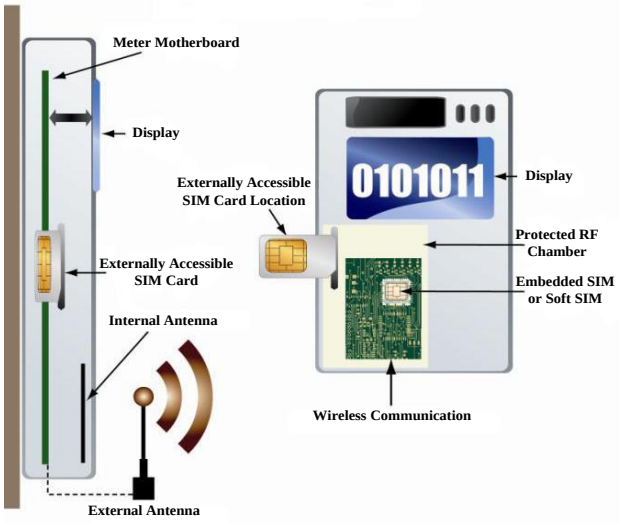


Fig. 3. The internal structure of a smart metering

### B. AMCD Communication Module

This module can be as implemented within a meter or as a separate module that is connected through the communication port to the meter. This module must be able to communicate between the meter and the corresponding local data collectors. This communication module must be in accordance with specified standards of used industrial equipment outside the building. Such as communication module, it must be capable of planning before and after installation. If the communication modules be outside the meter, this module installation should not impact on reading the meter. Communication modules must have standard interfaces for communication with smart meters.

### C. Data Collection

Data collection establish two-way communication between the covered meters and related network management system.

This system must contain at least the following information:

- Data collection must be according to the specified standards of industrial equipment is used outside the building.
- This system should be turned on 24 hours and is not affected by the power failure.
- In case of power outage of data collection, should not lost software, parameters and stored data on it.

Data collection must be with standard interfaces for communicate with communication modules [8].

### D. AMR Network Components

AMR network construction techniques has been based on wiredline and wireless telephone networks (Wired and Wireless Telephony Platforms) and wireless infrastructure with radio frequency (RF) and power transmission and distribution networks (PLC). Also with regard to the related software technology, it's possible to data analysis and forecasting operations for increased or decreased of load, present various reports based on need, customer, billing and remote control and use restrictions by control centre. Figure 4 shows a simple and classic view of an AMR network structure and components [9].

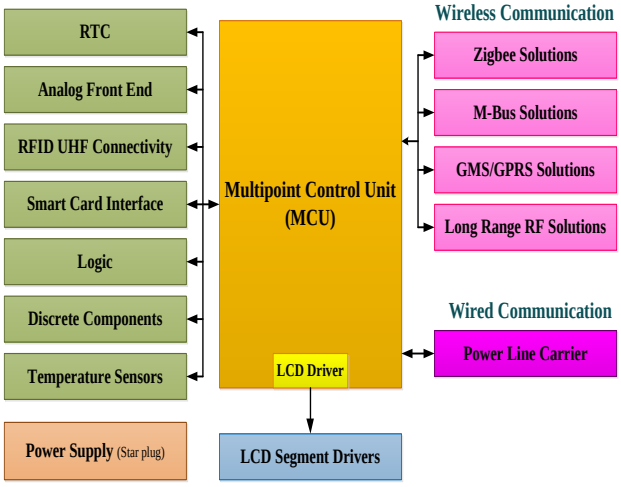


Fig. 4. Diagram block of the AMR network

It's responsible for data collecting to task of consumption data collection and performing centre's command on meters. This information is transmitting to the Gateway intermittently through a local protocol. Data encryption and store a copy of data in encrypted form is the other duties of this device. Local data collection units can be installed in the vicinity of 20 KV / 220V distribution posts and be used in order to use management of the meters that is covered these posts. Up to 15 meters can be connected simultaneously and through PLC to a local data collection unit. The local data collection unit has an internal calendar and clock and can measure consumption per meter in a specific period and then can record this information in its non-volatile memory. The local data collection unit is able to protect stored information when power is interrupted. On the other hand, each data collection unit that is available on the dynamic AMR network can be connected to other local data collection units that is available on the network and to information control unit by using PLC. The stored data in the local data collection unit keep in its memory and they are transmitted to distributed network control centre or network higher layers as requested by them. The local data collection unit can be set by the information control unit automatically. Also there is ability to upgrade its firmware through the parallel port. The local data collection unit has the ability to different tariff on electricity consumption per covered meter [10].

Data collector unit is responsible for middle management of dynamic AMR network and its communication interfaces between the main control centre, local data collection units and the meters available in the network. Data collector unit communicate to the main control centre with phone line or RS232 cable and components of lower layers of dynamic AMR network by PLC. Also RS232 device port can be used for troubleshooting, monitoring, orders loading, improving internal software and device configuration. Although it's also possible to perform all the operations on the data collector unit, the remote (master control centre) and the phone line. Data collector unit is always ready to receive commands from the main control centre and receive stored information on them by sending information request to data collector units or covered meters and store them in its memory. Data collector unit is capable of communicating with 64 local data collection units.

After consumer data measurement in the moment by digital power meter, the first module that starts and begins data collection operations is the data collector unit. It is used to meter boss interface in order to communicate with meters. This boss that is comply with the standard of IEC 61107 and (DLMS / COSEM) IEC, has RS-485 physical layer, RS-232 serial connection and TTL or optical port. The first step is to identify in order to communicate with the meter. It's done by this boss to set date and time, steps to program tariffs, receive consume information and command to power outage. Meter sampling period is programmable and it can be reduced to every 15 minutes. It's used an RTC to meters simultaneous and increase precision of time that is programmed by the Gateway. It have been taken security measures to prevent information listening or transmit information as incorrect and to prevent system performance damage. Early detection meter is used to read data that is designed protection encryption. Also the information is encrypted using cryptographic complex algorithms and this coding is from source to destination and these data is available only for those who have the key.

Also if open the module door or stopping input that is connected to the meter boss, it will send a message about the possibility of manipulating in system. It's using a 32-bit processor based on AMR system for Gateway contact operations [11].

### *E. Gateway*

Each Gateway module can be related to data control modules by the local network on the one hand, and on the other hand, it be related to network centre by a IP-based network. The main task of this system is protocol conversion and synchronization of data control module together and also with the network centre. Other duties of this device are save the data locally and transmit network centre commands to data collectors.

### *F. Software*

This software be installed on the network master control centre and it's responsible for dynamic AMR network management at the highest level. This software perform all system activities and it's configurable according to the intelligence and operational needs of the employer. Dynamic AMR network management software is capable, in addition to controlling the network and data collecting and storing, to provide several reports of the use quality and use quantity of subscribers at different times of the day including peak hours and other periods that define by employer. This software will connect to data collector unit by modem and sends instructions from the data collector unit to meters or receives consume data from meters.

## IV. COMPONENTS OF SMART METERING SYSTEM BASED ON AMI

Smart metering system based on AMI including advanced infrastructure of meter reading includes AMI home network, LAN/WAN or WAN telecommunication networks, data measurement and management systems and (MDM/R) billing. Home network, that is including two-way communications with the meter inside and outside the home, provide the possibility of energy services supply to customers.

Wide Area Network (WAN) provides the communication between local networks and computers. In the advanced measurement infrastructure (AMI), wide area network (WAN) communicates between measurement system and Measurement Data Management system (MDM/R) which may include LAN and WAN network or WAN is only and the information initially arrived to a concentrator and then

sent that is depending on the selective communication technology.

## V. MANAGEMENT AND SECURITY OF AMI MEASUREMENT DATA STORAGE

Meter readings are collected hourly with its date and time recording and will be sent on a daily basis for the controller computer of power company and finally, they are concentrated in the MDM\R and be prepared amounts of time-consuming billing and then it is returned to local distribution complex (LDC) by WAN and local distribution complex provides energy consumption data through bills and online access [12].

Security is a key issue in the information technology. So that in recent years, there has been a growing attention to industrial systems security which has complex and highly dependent. Authorities have great emphasis on the protection of critical infrastructure and industrial automation control systems especially related structures to energy, transport and telecommunications. Measurement system is concerned directly in this category. Security should be considered throughout the measurement process, from the meter and data collector to the data system of control centre which includes any network and admission to communicate (home network, public network and corporate network). Also we need to national security due to the extensive communication between the system components. Hence, all factors, including manufacturers, suppliers and legislators should participate together to increase awareness and ensure the safety of measurement system. Smart system must to prevent following: unauthorized access, theft or unauthorized use of confidential information (There aren't possibility to reading or modifying data on the meters or in transit on the network), loss of integrity or reliability data and data production, loss of system availability (support centre and data processing are reserved), unauthorized changes, failure to properly execute the process that is leading to a function process risk or loss of system capacity, separation of responsibilities for appropriate operation. Security requirements to satisfy emerging needs are as follows:

- access control and operation
- data integration
- reliability of data

## VI. CONCLUSIONS

According to objectives of the country's electricity industry, in order to manage consumption, waste reduction, privatization and electricity market creation, revenue collection system improvement and reduce the cost of electricity production and transmission, it is necessary to create the smart measurement system as a first step to achieve to electricity smart grid. Energy management for energy optimization using AMR new technologies plays a major role to reduce consumption costs of subscribers, optimization of power in low voltage networks, reduce investments of electricity companies to postpone in construction of new power plants in the country, identification and control of network loss and unauthorized splits, improve the network load factor and increase of distribution networks exploitation rate in the future of subscribers automation. In order to knowledge of smart metering systems structure and necessary substrates to implement these systems, will have a major role in the expansion of them in the network.

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