EXPERIENCES FROM A PILOT PROJECT IN IMPLEMENTING SMART METERS

Morteza NAJAFINIA
MEEDC* – Iran
m.najafinia@meedc.net

Mehran GHASEMPOUR
MEEDC* – Iran
m.ghasempour@meedc.net

Morteza HOSSEIN POURARAB
MEEDC* – Iran
pourarab@aut.ac.ir

* Mashhad Electric Energy Distribution Company

ABSTRACT

This paper specifies the functional reference architecture, the functional elements and the interfaces of a pilot project of implementing smart meters in a 20 kV distribution feeder called Shemshad. It also covers aspects of implementing advanced metering infrastructure in the pilot area.

INTRODUCTION

Advanced Metering Infrastructure (AMI) and smart meters, terms often used synonymously, has experienced rapid growth in the past decade. Smart meters, these highly intelligent devices have emerged as the most visible technology of the smart grid. According to a report published by Pike Research, in 2008, less than 4% of the global installed base of 1.5 billion electricity meters could be considered "smart" but 4 years later this penetration will have grown to over 18%, and is forecast to exceed 55% by 2020 [1].
AMI is an integrated system consists of hardware, software, network, and communications platform. This system receives real time information such as energy consumption, demand, voltage, current, and other electrical parameters of the consumer. AMI provides remote reading, monitoring, configuration and controlling, data collection and processing and management through the two-way communication packages. Figure 1 illustrates a simplified system of AMI.

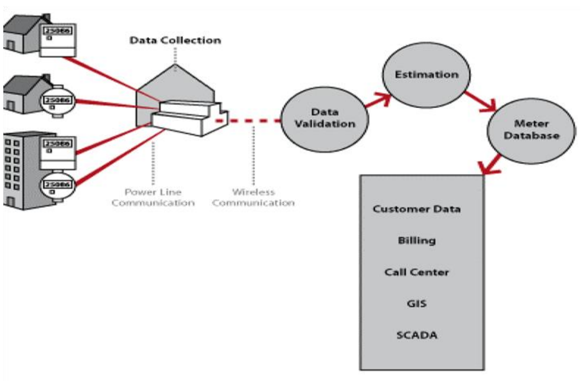

Figure 1. Advanced Metering Infrastructure system

In March 2009 implementation of Iranian national advanced metering infrastructure plan (FAHAM) was placed on the agenda of Iran government and Power Ministry of Iran. The target was decreasing electricity loss at least 1% per year and 14% decrease in overall network loss by 2015 [2]. Afterwards preparation of seven years roadmap to exchange of electricity meters for all customers was started. FAHAM project is funded by Power Ministry of Iran and under the supervision of Iran Power Generation, Transmission and Distribution Management Company (Tavanir).
FAHAM converts the meter from a simple measuring and counting device, to an element of an integrated system of hardware, software and communication platform that can be used to manage the electric services which customers find essential to their lives. Data can be provided at the customer level and for other enterprise level of system either on a scheduled basis or on demand.
In this paper, experiences in implementation of smart metering system in a 20 kV feeder called Shemshad in the city of Mashhad are presented. In this pilot project, these data will be communicated to a central location, and then would be sorted and analyzed for a variety of purposes such as customer billing, outage response, system loading conditions and demand side management.
This project through a two-way communication network, will also send these data to other systems, customers and third parties, as well as send information back through the network and meters to capture additional data, control equipments and update the configuration and software of equipments.

CASE STUDY

Since there is a lot of variation in climate, and atmospheric conditions such as temperature, and humidity have impacts on equipments performance including meters, modems, data concentrators, etc. and some telecommunications infrastructure such as RF, implementation of AMI system differs in areas with different weather conditions.
In addition, geographical conditions including mountains or tall buildings where there is direct observation or paved areas such as plains, which are the direct vision, play an important role in selecting a place for pilot study.
Moreover, environmental and network noises are significant criteria on selecting a pilot area. Areas with poor power quality in terms of harmonics and areas with radio noise (usually in crowded urban centers) have an important impact on implementation of smart metering system.
Considering the above, the Shemshad feeder, located in the city center with residential and commercial consumers, is selected.
Shemshad 20 kV feeder is fed by two 30 MVA distribution substations and consists of 8 distribution transformers

(20/0.4 kV) through 2216 subscribers. The length of this feeder is around 1300 meters.
Table 1 shows the number of subscribers along with the type of smart meters in each zone.

Table 1. Total number of subscribers in each zone of Shemshad feeder

	Single phase smart meter		**Three phase smart meter**		
	RS485	PLC	RS485	PLC	GPRS
Trans. #1	288	12	1	1	6
Trans. #2	180	113	6	21	3
Trans. #3	249	0	6	1	7
Trans. #4	367	0	9	0	4
Trans. #5	206	121	2	13	4
Trans. #6	306	1	5	1	5
Trans. #7	200	60	2	5	3
Trans. #8	0	8	0	0	2
Total	1796	315	31	42	32

This system includes 23 RS485/GPRS based data concentrators and 7 PLC/GPRS based ones. Moreover, in order to accurately calculate the total loss of the feeder, a three-phase GPRS based smart meter is utilized in the distribution substation, at the beginning of the Shemshad feeder using appropriate current and potential transformers.

BENEFITS OF THE PROJECT

This pilot project has some major benefits for distribution system, customers and external parties, including below items:

Economical benefits

- Reducing non-technical losses
- Demand side management (tariff management)
- Improving consumption patterns
- Improving the payment system
- Reducing total costs of meter's reading, operation and maintenance
- Reducing customer's disconnection and reconnection
- Preparation for electricity retail markets

Social benefits

- No need for periodic trips to read the meters
- Establishment of appropriate services for developing E-government
- Increasing electricity sale options with different prices
- Delivering power with better quality and reliability
- Reducing cost of electricity due to reduced operating costs
- Increasing billing accuracy and speed by eliminating the human error factor
- Providing better customer service
- Creating customer's participation in consumption management and costs reduction

Environmental benefits

- Reducing green house gas emissions due to reduction in network losses
- Reducing consumption through network energy management and demand response

In order to implement the project, we need to correct customer's consumption pattern, apply energy management by the network operator in normal and critical conditions, improve meter readings and billing processes, reduce non-technical losses as well as monitor technical losses, improve quality of service, etc.

AMI ARCHITECTURE

Due to the diversity of customers in the Shemshad feeder, three smart metering architectures, including RS485, PLC and GPRS are developed in this pilot area.
The DLMS/COSEM standard is the most widely accepted international standard for data exchange in smart electricity meters. The continued fast growth in the number of meter types certified to be DLMS / COSEM compliant and also membership of the DLMS User Association (UA), obviously demonstrate this global acceptance [3].
The DLMS/COSEM standard has been developed based on two concepts: object modeling of application data and the Open Systems Interconnection (OSI) model [4]. This architecture allows us to continuously extend the scope of DLMS/COSEM to cover new applications and new communication media [5].

Architecture for electrical rooms

In this architecture, the communication platform RS485 in local area network (LAN) and DLMS/COSEM protocol is used for electrical rooms with several smart meters as shown in figure 2.
As the figure clearly represents, the meters located on a distribution panel are integrated to the data concentrator through RS485 protocol so that each concentrator can collect data of the meters and send them to the master station via GRPS communication platform.

Architecture for dispersed consumers

Since some of subscribers, generally commercial and residential, fed by Shemshad feeder, are dispersed geographically, PLC platform with DLMS/COSEM communication protocol has been selected for this purpose and is shown in figure 3. As the figure obviously reveals, in this architecture, concentrators are located besides distribution transformers and collect data from smart meters in the region through PLC communication platform and send them to the control center via GPRS.

Architecture for special consumers

In addition to the previously discussed methods, GPRS platform with DLMS/COSEM communication protocol is used for some of smart meters in dispersed consumers so that the meters can send data directly to the master station.
Figure 4 shows this architecture of implementing smart meters in some distributed subscribers.
Currently meter reading and billing for all the subscribers in the pilot area is done using AMI system. Moreover, electrical parameters such as voltage, current, active and reactive power, power factor, etc. could be received and analyzed in real time via AMI system.

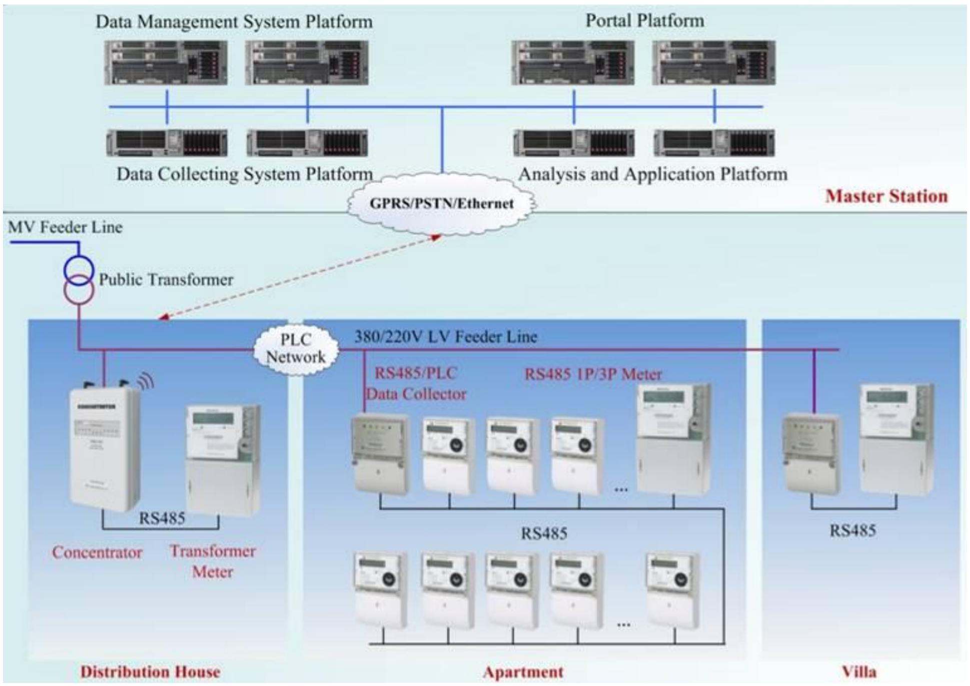

Figure 2. AMI Architecture for electrical rooms

RESULTS AND CONCLUSION

The result of this project is not simply a tool to capture customer consumption of energy, but hardware and software architecture capable of capturing real-time consumption, demand, voltage, current and other information.

Performance of PLC communication platform based on IEC61334 standard were evaluated favourable in underground distribution network, aerial bundled cable system and aged networks [6,7].

On demand reading of meters was done in peak hours. Random customers were selected and in less than 30 seconds demand was read with an error of less than 3 percent. This value decreased up to 2 seconds in off-peak hours.

In addition date and time synchronization with the accuracy of 1 ppm through the central software was done and only 2 percent of the selected region was unsuccessful in synchronization.

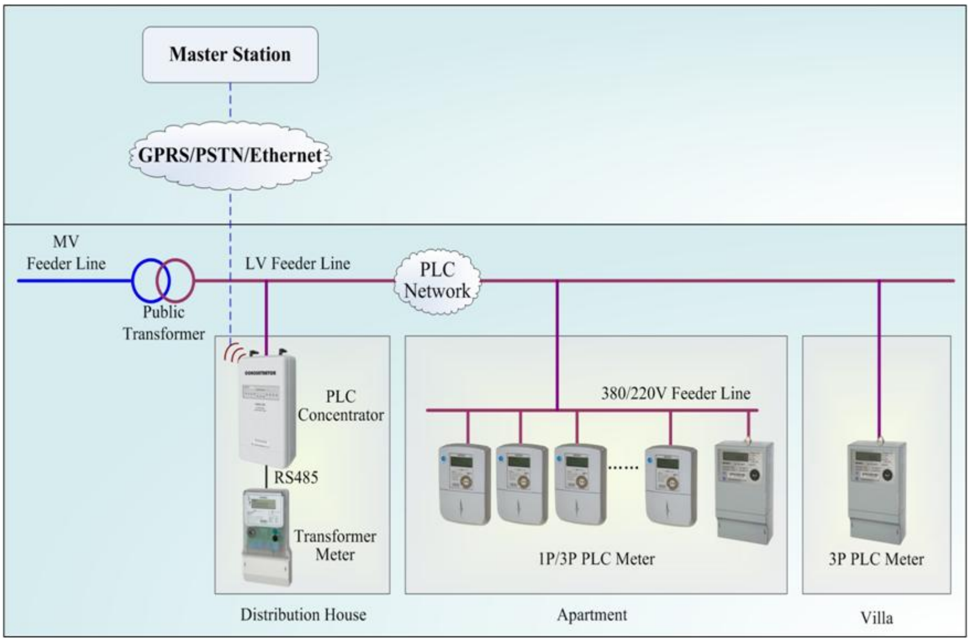

Figure 3. PLC Architecture for AMI system

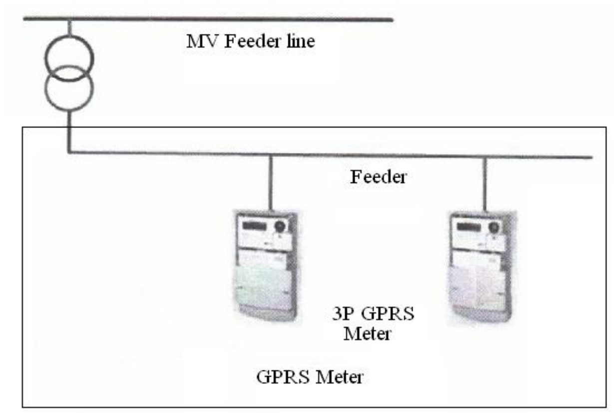

Figure 4. GPRS Architecture for AMI system

Moreover, in more than 97 percent of the selected customers, new tariff scenarios were applied and precision of the implementation was evaluated. The project confirmed DLMS/COSEM as the leading standard for smart metering because of supporting all energy types, all interfaces and all communication media.

REFERENCES

[1] Pike Research institute: http://www.pikeresearch.com
[2] Iran Energy Efficiency organization: http://www.saba.org.ir
[3] Divyang D. Vyas and H. N. Pandya "Advance Metering Infrastructure and DLMS/COSEM Standards for Smart Grid" International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 10, December- 2012.
[4] D. Craemer and G. Deconinck, "Analysis of state-of-the-art smart metering communication standards," Leuven, 2010.
[5] DLMS/COSEM: Architecture and protocols, Ed. 7.0, DLMS UA,2009.
[6] IEC 61850-8-1 ed1.0 - communication networks and systems in substations, May 2004.
[7] C. Brunner, "IEC 61850 for power system communication," Proc. Transmission and Distribution Conference and Exposition, IEEE/PES, pp. 1-6, 2008.