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A Survey on Implementation of Smart Grid in Iran

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ABSTRACT: *Recently, importance of power consumption, green house gas and renewable energy sources proposed an international requirement, Smart Grids. Advance metering Infra-structure (AMI) and smart meters are fundamental elements of this new field. This new system has ability to configure, manage and process the gathered information and produce graphs and necessary reports.*

In this paper, smart networks and its advantages are discussed especially in Iran. Furthermore, a survey about Smart metering implementation in Iran is done which debate about standardization, metering unit's specifications, localization and other aspects of implementation method.

Keywords: *AMI, AMR, Smart grid, Smart metering.*

I. INTRODUCTION

High quality Electricity generation for Digital Society, optimum combination of generation methods using clean energies and attaining at least 1000kwh till 2050 is priority of world electricity industry[1]. Production of digital tools, which are sensitive to quality of electricity, will increase five times till 2020. Electrical and hybrid cars will be produced more and CO2 emission is necessary to be reduced. Also, entrance of many small distributed generators makes revolution on electricity's network and its component communication.

Xcel Energy announced that they have successfully implemented the Ventyx Smart Grid Operations Solution in Boulder, Colorado. This implementation is the first fully integrated Smart Grid city in the world. The Ventyx Solution will make it possible to convert the data from the Smart Grid into actual information that will assist both utility providers, and consumers alike, in making energy-related decisions. Ventyx is the largest private software, data and advisory services provider for the energy industry and Xcel Energy is a major U.S. electricity and natural gas company[2].

Control of 4000MW load peak, 3% increase of renewable energy's stations by construction of 2000MW renewable power plant and 3000MW distributed generators and other objectives, which are mentioned in book one, objectives of Iran Department of Energy, display deep changes in expansion of electricity network. It means smart grid, smart metering and new management is necessary. Three main parts of this research are **(a)** Definition of AMR, AMI, generic benefit of smart metering. **(b)** Smart metering implementation steps which are done and **(c)** Propose a Smart metering implementation road map. In the following, smart networks definition, AMR and AMI are in section II. Advantages of smart grid are discussed in section III. Smart grid in Iran, Goals of AMI implementation and current project are in section IV. In section V, road map of smart metering is mentioned. Discussion and conclusion of research are in section VI.

II. SMART NETWORKS

A smart network is defined as an energy network where there is a pervasive information and communications technology overlay that effectively enables integrated management of the creation, transport, storage and consumption of energy. Specific emphasis is placed on the application of digital technology to provide accessible, flexible, reliable and economically sustainable electrical energy to users. Fig. 1 depicts plan of a smart network.

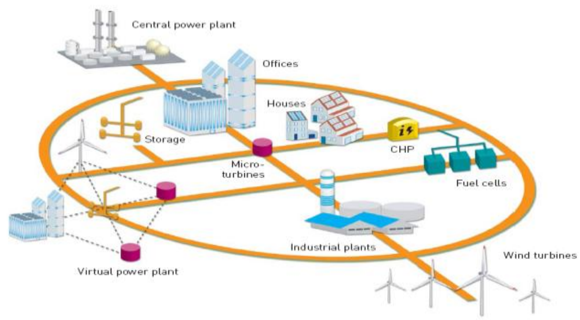

Figure 1. Smart network plan[3]

There are two definitions in Smart grid or network, Automatic Meter Reading (AMR) and Advanced Meter Infra-structure (AMI) which are described in the following.

A. Automatic Meter Reading (AMR)

Automatic meter reading, or AMR, is the technology of automatically collecting consumption, diagnostic, and status data from water meter or energy metering devices (gas, electric) and transferring that data to a central database for billing, troubleshooting, and analyzing. This technology mainly saves utility providers the expense of periodic trips to each physical location to read a meter. Another advantage is that billing can be based on near real-time consumption rather than on estimates based on past or predicted consumption. This timely information coupled with analysis can help both utility providers and customers control better the use and production of electric energy, gas usage, or water consumption. AMR technologies include handheld, mobile and network technologies based on telephony platforms (wired and wireless), radio frequency (RF), or power line transmission.

B. Advanced Metering Infrastructure (AMI)

AMIs are systems that measure, collect, and analyze energy usage, and communicate with metering devices such as electricity meters, gas meters, heat meters, and water meters, either on request or on a schedule. These systems include hardware, software, communications, consumer energy displays and controllers, customer associated systems, Meter Data Management (MDM) software, and supplier business systems. 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 participate in demand response services. Consumers can use information provided by the system to change their normal consumption patterns to take advantage of lower prices. Pricing can be used to curb growth of peak consumption. AMI differs from traditional automatic meter reading (AMR) in that it enables two-way communications with the meter. Systems only capable of meter readings do not qualify as AMI systems[4].

III. ADVANTAGE OF SMART GRID

The benefits most often associated with an AMI and AMR investment are documented and include[5]:

- Improving the accuracy of billing information by reducing the number of estimated meter reads, immediate validation and verification of the accuracy of current usage information, verification that customers are indeed to the appropriate rate schedule; and more timely identification of potential metering problems.
- Early identification of potential revenue integrity issues such as theft; or in the case of a water utility, improved identification of system leaks or improper customer usage (i.e. night time watering of lawns during periods of restrictions);
- Verification of the efficacy of the Utility's load management programs; and an overall improvement in customer satisfaction as the utility is now able to provide customers with better information concerning their usage and cost patterns.

More advanced benefits of AMI and AMR investments comes from integrating AMI and AMR information with other utility operating systems to improve overall management and operation of the utility system. These benefits may be derived from:

- A better understanding of customer usage characteristics; which can then be used in a predictive manner.
- More accurate (real time) characterization of the operating condition of the distribution network that can result in earlier identification that an outage has either occurred or is imminent on the system.

IV. SMART GRID IN IRAN[6]

Iran Energy Efficiency Organization, responsible for implementation and deployment of Smart Metering project (FAHAM) in Iran, started the first phase of the project by selecting contractors through a tender that was executed successfully on 11 Dec 2011. The winners are thereby authorized for installing 1000000 smart meters in five separate distinct and predefined areas under the supervision of Tehran metropolitan, Alborz province, Zanjan province, Booshehr province, and Mashhad and Ahvaz Power distribution utilities. FAHAM is considered as the greatest ICT project in electric industry of Iran. The notable aspects of this project with various stakeholders and using successful projects experience of other countries, led us to employ EPC method to implement this project in Iran.

A. Goals and Benefits of AMI implementation in Iran

There are economical, social and environmental benefits of AMI Implementation in Iran which are mentioned in the following.

1) Economical benefits

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

2) Social benefits

- No need for periodic trips to each physical location to read the meters
- Establishment of appropriate services for developing the electronic government
- Increasing electricity sale options with different prices
- Power delivery with higher 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

3) Environmental benefits

- Reducing polluted gas and CO_2 emissions
- Reducing consumption through network energy management and reducing network losses
- Demand management through sharing the information with customers

B. FAHAM project

Some businesses, which FAHAM project need to perform correctly, are:

- Correcting customer's consumption pattern
- Preparing for complete elimination
- Applying energy management by the network operator in normal and critical conditions
- Improving meter readings and billing processes
- Reducing non-technical losses as well as monitoring technical losses in distribution network
- Improving the quality of service, reducing duration of power cuts and supervision on electric power quality
- Developing distributed generation and clean energy usage
- Possibility of electricity pre-sale and establishing electricity retail markets
- Optimizing operation and maintenance costs
- Providing appropriate management of water and gas meters

V. Smart Metering Implementation Road Map in Iran

A. Standardization

In order to cope with the challenges of an increasing deployment of innovative technologies and to foster the interconnectivity between these technologies, compilation features performance of smart metering system or standardization is an important step of smart metering implementation which has to be offered by responsible organization such as IEEO-SABA.

The European Commission has mandated the European standardization organizations, i.e. CEN, CENELEC and ETSI, to adopt a set of standards for smart grids. Resulting from the mandate M/490, these standards will be a key step for the deployment of smart grids in Europe [CEN/ CENELEC/ ETSI, 2011][7].

A minimum common set of functionalities for smart metering has been put forward by the European Commission with the aim of enabling member states to identify common means of achieving cost efficiencies (and inefficiencies) in their rollout plans. The functionality set, developed jointly by the European Commission's directorates of Energy and Information Society and Media, comprises 10 functionalities. These were determined based on comments from member states in response to an initial list of 13 functionalities based on the ERGEG Guidelines of Good Practice on Regulatory Aspects of Smart Metering for Electricity and Gas. These ten functionalities are[8]:

1) For the customer

- Provides readings from the meter to the customer and to equipment that he may have installed
- Updates these readings frequently enough to allow the information to be used to achieve energy savings.

2) For the meter operator

- Allows remote reading of meter registers by the meter operator
- Provides two-way communication between the meter and external networks for maintenance and control of the meter
- Allows readings to be taken frequently enough to allow the information to be used for network planning.

3) For commercial aspects of energy supply

- Supports advanced tariff systems, including multiple tariffs, time of use registers, block tariff registers, remote tariff control, etc. as applicable
- Allows remote on/off control of the supply and/or flow or power limitation.

4) For security and privacy:

- Provides secure data communications
- Fraud prevention and detection.

5) To allow distributed generation:

- Provides import/export and reactive metering.

  The three functionalities on which there was limited consensus are:
- For the customer: Provides the readings in a form easily understood by the untrained consumer, and with calculations enabling final customers to better control their energy consumption, e.g. in terms of cost, as averages, as comparisons to other periods, etc.
- For the meter operator: Provides for the monitoring of power quality
- For commercial aspects of energy supply: Supports energy supply by prepayment and on credit.

The approximately two-thirds of European member states that have not yet undertaken smart meter cost-benefit analyses are recommended when they do so to use this set of common functionalities.

The functionality set also could serve member states, the metering industry and utilities as a solid basis for their respective investments, facilitate rollout associated procurement, and provide regulators with European reference definitions, the document states.

B. Short-term courses and seminars of smart metering systems

The custodians this field such as FAHAM, universities, related associations and so on should make regular seminars to clear smart metering for experts, managers students and peoples. Fortunately, some short-term courses[6] and Conference such as SEGT2012[9] have been started. Topics of SEGT2012 conference are:

- Power and Energy System Applications (Generation, Transmission, Distribution, Markets, Operations, and Planning)
- Monitoring and Power Quality
- Distributed Generation, Energy Storages, and Micro grids
- Automation and Management of Electrical Energy Systems
- Reliability, Demand Response, Load Management and Forecasting
- Wide-area Metering, Monitoring, Control, and Protection
- Smart Grids Impacts on Fault Management (Protection Infrastructure, Emergency Response, and System Restoration)
- Electric Transportation and Vehicles
- Smart Grid Regulation and Standards
- Required Supporting Communications, Control and Information Systems
- Smart Sensors and Advanced Metering Infrastructure
- Information Technology, Database Management, and Cyber-Physical Systems Security

C. Contractor support

It is necessary to support smart grid's contractors on producing, importing, design and implementation. By this method, contactors work better and Department of Energy will get to its objects completely.

D. Defining of smart metering equipment's specifications

An electrical smart metering tool shall include Built-in or modular communication units to receive or send on-line commands using generic protocols for using in all regions of country. In the following some technical specification are mentioned.

1) RS232 Standard

In telecommunications, RS-232 is the traditional name for a series of standards for serial binary single-ended data and control signals connecting between a DTE (Data Terminal Equipment) and a DCE (Data Circuit-terminating Equipment). It is commonly used in computer serial ports[10].

2) RS-485

This protocol also known as TIA/EIA-485 or RS-485 is a standard defining the electrical characteristics of drivers and receivers for use in balanced digital multipoint systems. The standard is published by the Telecommunications Industry Association/Electronic Industries Alliance (TIA/EIA)[11].

3) PSTN

The public switched telephone network (PSTN) is the network of the world's public circuit-switched telephone networks. It consists of telephone lines, fiber optic cables, microwave transmission links, cellular networks, communications satellites, and undersea telephone cables, all inter-connected by switching centers, thus allowing any telephone in the world to communicate with any other.

4) GSM

Global System for Mobile Communications, is a standard set developed by the European Telecommunications Standards Institute (ETSI) [12] to describe technologies for second generation (2G) digital cellular networks.

5) GPRS

General packet radio service (GPRS) is a packet oriented mobile data service on the 2G and 3G cellular communication system's global system for mobile communications (GSM). GPRS was originally standardized by European Telecommunications Standards Institute (ETSI) in response to the earlier CDPD and i-mode packet-switched cellular technologies[12, 13].

6) Ethernet

This protocol is a family of computer networking technologies for local area networks (LANs). Ethernet was commercially introduced in 1980 and standardized in 1985 as IEEE 802.3. Ethernet has largely replaced competing wired LAN technologies. Since its commercial release, Ethernet has retained a good degree of compatibility. Features such as the 48-bit MAC address and Ethernet frame format have influenced other networking protocols.

7) M-Bus

Meter-Bus[14] is a European standard (EN 13757-2 physical and link layer, EN 13757-3 application layer) for the remote reading of gas or electricity meters. M-Bus is also usable for other types of consumption meters. The M-Bus interface is made for communication on two wires, making it very cost effective. A radio variant of M-Bus (Wireless M-Bus) is also specified in EN 13757-4.

Furthermore communication protocols, Hardware modules which seem benefit for AMI are Data Concentrator, In-Home-Unit-Display, Automation software.

VI. Discussion and Conclusion

Although there is a regulatory framework on implementation of Smart grid, but communication technology and electrical and physical environment is important. Therefore, it's necessary to localize generic smart metering implementation rules. Therefore, it is necessary to localize implementation methods of smart grid in each province of Iran. In the following, practical steps are proposed[15].

a) Formation of committees such as restructuring, DG, micro-grid, IT and automation based on society-economical studies.
b) Importance and aspects of smart grid such as fault following, loss reducing, reliability, supporting of renewable energy sources and asset management using AMI are defined in committees.
c) Division of project to practical phases such as:
   - Internet and library based research on electrical smart grid and advanced metering units
   - Possibility of distributed generation source in region
   - Research on current network and necessities of AMI implementation
   - Smart grid simulation, society-economical analysis, study of results and proposals.

It seems the members of this project should have proficiency on reliability, smart metering and DG, power system programming. Furthermore, having power network software such as DIgSILENT[16] and so on is necessary for this executive-research project.

Therefore, target of this project will be (a) recognition of DG sources, (b) recognition of appropriate to places advanced metering instruments, (c) recognition of technical and economical benefits of smart metering in region. Another result of using smart metering is making of a base for modification of consumption patterns and full implementation of targeted subsidies[1].

Finally, considering the situation, synchronizing of benefit factors and Legal obligations are effective factors for implementation of smart grid.

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