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Smart Meter and Cost Experiment

Abstract. *System that all stakeholders compound the activities (production, transmission, distribution, sale, consumption) to product and to consume quality, constant, reliable and economic electric energy is called Smart Grid (SG) in electric. SG, which its most important component smart meter (Smart Metering- SM), are advanced energy metering devices that give more information than traditional energy meters and that measure the consumption of electric energy. It includes integration techniques and various software applications depending on characteristics of SM electric network. In this study, by giving information about infrastructure of automatic meter, AMI installation levels and its integration to system are explained. An experiment proving the advantages that SM provides to system and consumer has been made and its results have been interpreted.*

Streszczenie. *Układy typu smart meter dają znacznie więcej informacji zużytej energii niż klasyczne liczniki. W artykule przedstawiono infrastrukturę i metody dołączenie do sieci. (**Eksperyment dotyczący zastosowania I kosztu licznmika typu smart meter**)*

Keywords: smart grids, power grids, smart meters, distribution grids.
Słowa kluczowe: smart grid, smart meter.

Introduction

SM solution to meet the needs of metering can be remotely set for electric distribution companies; it provides a clear and advanced metering infrastructure (AMI) [1]. AMI solution is an infrastructure that allows electricity distribution companies to display subscribers who sell energy and consume energy, to manage electricity consumptions, to measure the power quality, to increase reliability of distribution and that provides to meet completely the requests of operations, engineers, subscriber services and market regulatory supreme board in the field [2].

Even though automatic meter reading and its infrastructure (AMI) is one of the key works of Smart Network, SG is beyond the meter reading. Distribution Management, System Optimization and Energy Management System that has spread to the entire network should stand back of AMI so that electricity distribution system can efficiently support its own established system. AMI (Automatic Meter Infrastructure) solution allows electricity distribution company to realize a single SG application as modular and to make march forward and develop this system in time on its own request and then spread to entire network; or, by building a complete SG system, distributor company can begin to benefit from all of the advantages of smart network at once, without having any integration problem [3].

While AMI (Advanced Metering Infrastructure) is defined as transmission and management of energy over a network infrastructure in line with demand or in a regular way, bidirectional data exchange comes into question in advanced infrastructures [4]. In this way, not only transfer of data of energy consumption but also transmission of the other data that could be transmitted by center, such as cut-off and opening at the same time or reflecting the product selection to clients, is provided. SMs are the most important component of AMI. Installation of AMI should not be considered only as assembling or installation of meters. In advance of this, sufficient time and resource should be planned for planning, feasibility and design study of business processes [5]. In addition, throughout the entire process, institutional change and settlement should be managed in such a way as to meet the needs of distribution companies. In the projects to establish AMI, all of the following stages or a part of them, according to the needs of clients, should be made real [6].

AMI installation stages;

1. Planning of AMI infrastructure
2. Creation of Architecture
3. Revision of Business Processes
4. Creation of Functional Requirements
5. Evaluation of Suppliers and Solutions
6. Installation of Infrastructure and Making it Real

Distribution companies, primarily, should plan the factors related to infrastructure. Afterwards, beginning with installation of meters in the field, determination of functional and technical architecture consisting of communication infrastructure and central data acquisition systems and integration points should be done. After putting AMI systems into practice, it is required that to redesign the business processes that will change under distribution and retail sale operations and to demonstrate new business processes. To achieve the required results, it is important to redesign the business process by taking possible changes into account. In this direction, after analyzing current business processes and purposes, redesign should be performed. In next phases, installation of meters and dissemination studies should be practiced.

Concept And Effects Of Smart Grid

Through AMI, not only consumption information but also information about failure and cut-off are transmitted to centre. In this way, network operator can carry out wealth management (failure repair-maintenance system) in a mo re efficient way [9]. SM system that is a part of AMI consists of five main factors:

1. Home Network: Through the system that is also called Home Area Network (HAN), commands came from AMI provide to manage the other devices at home. For example; in a space where electricity price is cheaper, electric vehicle can be remotely charged (from work place, vacation, etc.) and home can be heated. More importantly, as a result of remote commands production based on solar and wind energy can be followed. In this way, unlicensed production can be practiced more efficiently. In timeframes when electric prices are favorable, energy can be stored through remote commands by HAN application.

2. Meter owner endpoints: SMs take part in connection points of production station, free consumers and the other consumers. In particular, practicing bidirectional data transmission in consumer side is one of the most important factors of smart network.

3. Network: Data obtained by meters are transmitted over communication infrastructures such as GSM/GPRS, BPL (Broadband Over Power Line) or PLC (Power Line Communication) and then reached to data base in centre of distribution network.

4. Data center: MDM (Meter Data Management) system, where the data transmitted from field are cleaned,

incomplete data is completed and takes its final form by treated, is in here. Meter Data Management System (MDM) informs us about fault-maintenance management, customer services-invoicing, prediction-load follow-up, market management, distribution operations and investment planning.

5. Back office and management: All data obtained by smart meters are evaluated in the background and required decisions are made by achieving analytic reports. In this direction:

- Distribution Network Management: Making decisions of new investment, fault repair-maintenance follow-up and planning,
- Meter reading, opening and cut-off: Carrying out retail sale services in a cost-efficient, central and consistent way.
- Invoicing and customer services: Remote invoicing, leak check or determination of decline at consumer consumption, checking the data of meter before invoice issue are practiced.

The most important acquisition of SG investments is reducing the cost and increasing the efficiency [10,11]. In the U.S.A and many European countries, SG and SM investments are preferred [12]. In our country, however, SG investments are called under the title of automatic meter reading system (OSOS) and becomes a current issue to transmission and distribution networks. OSOS is composed of remote reading of data automatically and data verification after transferring to a central system, completing the incomplete data and transmission to relative stakeholders in a proper format [13]. Through increased competition in the sale of energy, distribution companies that want to offer better service for their clients (product development, less cut-off), to reduce leaks and to move one step forward in wealth management should cross into SG investments without losing time.

Historically saving descriptive identity data related to SM, data of assessment and invoicing (total active and reactive energy indices, periodical data of the highest demand, load-profile curves) and meter status information (calibration time, low battery warning, opening warn of connector and case cover) in data centers will provide great advantages to have chances to report in different dimensions, to follow the measurement points timely and accurately and also to reduce loss leakage in large measure by feeding invoicing systems with consistent data [14,15]. Advantages are provided by SMs to system can be queued as :

•It provides steady and future guaranteed communication. It provides all of the required band width that will meet SG needs (including the electric selling operation from hibrid automobiles to electricity distribution company) of AMI and sections.

•It provides inclusive network and operation management. To be able to display SG infrastructure provides a complete cycle management involving trouble shooting and maintenance management [16].

•Automatic data acquisition makes gain storage and analyzing ability. It manages meter data acquisition by providing standard interfaces to Meter Data Management of electricity distribution companies [16].

•It provides efficient communication solution in terms of cost. This solution communicate with many technologies including that broadband over power lines (BPL) by each Smart Transducer. Due to electricity distribution company communicate by using its own network with BPL technology, cost unit is lower [16].

Smart Meter Application Experiment

Remote meter reading systems that is one of the initial steps of SG system are found in many countries including Turkey. Many international companies that want to have a voice in future and/or infrastructure of these systems, installed web portals and act in common with electricity distributors. In this context Google, by PowerMeter system, offers an opportunity you to see your instant consumption and invoicing through a "Google Attachment" in a live presentation when you surf in the internet. Besides, savings of many consumers practiced by using this system has been indicated on website. Sample screen display indicating the detailed load graphic by Google Powermeter program is illustrated on Figure 1 [17,18].

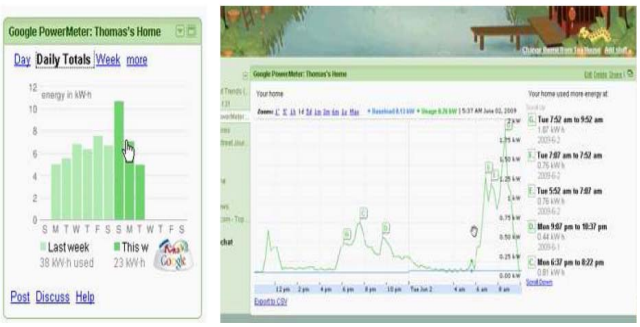

Fig. 1. Google Powermeter attachment screen display and detailed load graphic

In the same way, Microsoft has also begun to provide service its users by Hohm. In the study made by system of Microsoft, system offers a survey about a home and devices in that home, after this an average consumption appears. Microsoft system has the possibility of recording manually invoices of consumers apart from remote reading system by SM. Distribution of load consumption of a sample home in Microsoft Hohm, is illustrated on Figure 2 [19].

Fig. 2. Screen display of Microsoft Hohm and distribution of a sample home consumption

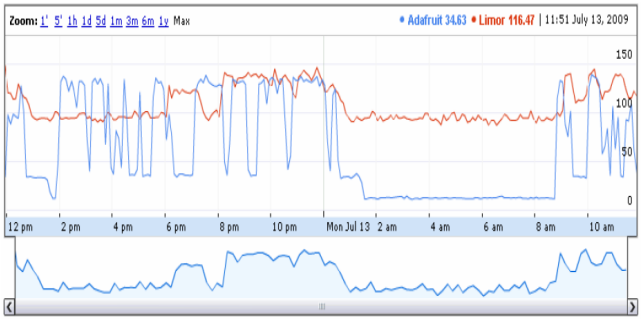

Fig. 3. Daily load usage from a site that uses Tweet-a-Watt

In the study that is made with reference to the idea that there will be a quite market for these systems in Turkey, through systems that could be found easily on internet, electricity consumption is read over wattmeter and then can be published on websites like Tweeter [20]. On "Tweet-a-watt" site that is one of the systems in question, consumption graphics are published with a system that

costs 90 $ in average. Consumption graphic that shows daily load usage for any client, is illustrated on Figure 3 [21].

For this system, in Turkey, experimental status of such a system is obtained by wattmeter and electronically tuned sockets. While there is no "smart network" study in our country yet, there is a study about the advantages in case of a smart network and dimensions of demand side attendance. For this, by measuring the devices in a home through Wattmeter, instant load and hourly load values obtained. At this stage, in the experiment for demonstration purposes, data recorded transiently as if there is a remote reading system with smart meter. Information about instant loads, devices of the house, option of remote tuning are in Table 1.

Table 1. Instant loads, devices in the sample house and options of remote tuning.

Load (Watt)	Device	Adjusted
5	Mobile phone charger	Yes
170	Refrigerator	Yes
1.000	Washing machine	Yes
1.500	Dishwasher	Yes
1.800	The kettle	Yes
2.000	Thermosiphon	Yes
20	Fluorescent lamp	No
30	LCD TV	No
30	Notebook	No
60	Bulb	No

In here, while it depends on choice of consumer which tools will be turned off automatically, in a real system it is possible to control these sockets through electronic control devices can be installed into the sockets in the house. Average load consumption curve of a house in one day, has been obtained and is illustrated on Figure 4.

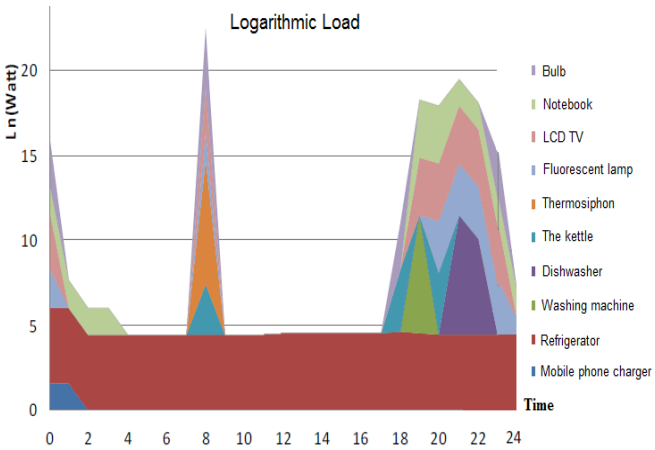

Fig. 4. Average load consumption curve of a house in one day

To see and demonstrate advantages of smart meters in consideration of these load consumptions, a comparison based upon one time and multi-time tariffs has been made. It is seen that using multi-time tariff over this system and consumption increases the cost to be paid. Due to client is at his home around 17:00 o'clock and maintains all the main activities until 24:00. A large part of hours when consumption is around the top level corresponds to the interval that energy price is the highest. Therefore, this client consumes the electricity in peak time, in other words, in the most expensive moments. To prevent this situation, smart meters can be used.

Table 3, for April of 2013, illustrating one-time and multi-time tariffs of public company TEDAŞ that is the biggest distribution company of our country, is in below. In table 2 also costs which occur on the basis of daily, monthly and annual as a result of being priced of the same consumption by one time and multi time tariff.

Table 2. 7 January 2013 dated electricity sale prices of TEDAŞ per tax-free KWh [22].

Consumers that take energy from distribution company (08.04.2013 dated, tax-free prices)				
	One-time (00:00-24:00)	Daytime (06:00-17:00)	Puant (07:00-22:00)	Night (22:00-06:00)
Residence electricity price	*0,1576 $/KWh*	0,1484 $/KWh	0,2336 $/KWh	0,0871 $/KWh
Consumption	*6,7234 KWh*	1,9 KWh	3,2234 KWh	1,6 KWh
Cost	*1,06 $*	0,3106 $	0,7532 $	0,3456 $
Total cost for a day	*1,06 $*	1,4094 $		
Total cost for a month	*31,8 $*	42,2816 $		
Total cost for a year	*381,6 $*	507,38 $		

If loads that can be adjusted in consumption profile are transferred through programmable sockets to time zones in which consumption is more economic, in other words, in case of using SM, A severe load decline is provided by providing automatically to start dishwashers and washing machines up after 22:00. Besides, when electronic sockets are programmed in order to laptops would make battery consumption in puant consumption time and would charge in the end of puant, ultimate consumption, in a system that SMs check in, is like in Table 3.

Table 3. After shifting consumption times of devices can be tuned by SM

Consumers that take energy from distribution company (08.04.2013 dated, tax-free prices)				
	One-time (00:00-24:00)	Daytime (06:00-17:00)	Puant (07:00-22:00)	Night (22:00-06:00)
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Total cost for a day	*1,06 $*	1,4094 $		
Total cost for a month	*31,8 $*	42,2816 $		
Total cost for a year	*381,6 $*	507,38 $		
		After mounting of smart meter		
Consumption	6,7234 KWh	0,9 KWh	0,6 KWh	5,2234 KWh
Cost	1,06 $	0,1336 $	0,1402 $	0,4544 $
Total cost for a day	1,06 $	*0,7282 $*		
Total cost for a month	31,8 $	*21,8469 $*		
Total cost for a year	381,6 $	*262,163 $*		

The same amount of consumption before SM using, while monthly electric bill is 31,8 $ in one-time, annual cosumption is 42,2816 $ in three-time consumption. In such a consumption, it is paid 32.95 % more. However, it

becomes advantageous by including SMs in the system, is paid 21,8469 $ instead 31,8 $. Therefore, without making any limitation with the same consumption, it is paid 31.3 % less due to programming feature of smart meter. Consequently, while it is paid annual 381,6 $ in invoicing by one-time meter that is considered as the minimum cost, it is paid 262,1636 $ by multi-time meter in the system with smart meter. In other words, every consumer can economize 9.9544 $ per month and 119,4563 $ per year in total. SM usage has two-way advantage. These are economizing 9.9544 $ per month and moreover making network control easy by contributing to decline of puant load in the hours when power demand is huge in terms of network.

Conclusions

As a result of privatization of distribution companies, requirement of legal disintegration, increasing competition and technologic requirements , SM/SG necessity comes into prominence in distribution sector of Turkey. In this direction, distribution companies and the other stakeholders should be ready for change and transformation. SMs provide the following benefits to electricity distribution companies:

• Operational Cost Reduction: It allows to collect meter data of distribution companies and to reduce meter reading expenses based on work force. through this, distribution companies will have chance to reduce transport costs that occur against to subscriber telephones or fault reports by remote monitoring the subscriber interruptions.

• Revenue Protection: By providing real-time and clearer invoice details, it removes need of monthly invoice prediction. This model supports, on behalf of revenue protection, both prepayment systems and systems that cuts remotely electricity of subscribers who don't pay their invoices. In conclusion, it supports application of "Energy Robbery Determination" to reduce deficiencies of distribution companies.

• Demand Management: It collects data from network and subscribers, one by one, for advanced level of pricing policies of electricity distribution companies such as pricing according to time when subscribers use electricity within day and/or pricing according to critical peak rates. In addition, it allows subscribers of distribution companies to see their own consumption amounts and to change their life styles in order to reduce or change load rates.

• Home Area Network - HAN: AMI solution provides remote control for distribution companies. By means of this, additional services such as remote opening-closing of meter, Internet connection service, security and automation of home, could be done.

As it can be seen through experiment that is carried out, SM usage has benefit in two way. These are reducing of price that will be paid monthly by consumer and moreover making network control easy by contributing to decline of puant load in the hours when power demand is huge in terms of network.

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