HOME AUTOMATION EASING ACTIVE DEMAND SIDE MANAGEMENT

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ABSTRACT

Demand Side Management service allows to make an efficient use of electrical grids, balancing generation and consumption. Nevertheless, this service can only be successful with the participation of the customers.
This paper is focused on Active Demand Side Management for the residential market, also known as Automated Demand Response. The home automation technology is proposed as the best technology to fulfil the requirements of this service and the customer's expectation.

INTRODUCTION

The work presented in this paper resumes the experience of the GAD Project [1], focused on the home environment. The aims of this Project are to design an Active Demand Side Management service for the residential market and to develop prototype devices for a final pilot test.

The paper is structured in five sections. The first one describes the home as an actor of the Smart Grids, highlighting the importance of the client to reach the goals of the Active DSM service. The regulators have also an important role providing the suitable framework to this service, so the Spanish regulator's actions are also commented here.
The requirements ad specifications related to customers and their homes has been described in section II. The section III mentions the solution developed at GAD Project and the alternative technologies are analyzed in section IV. The paper finishes with the conclusions of this work.

SECTION I: THE HOME MICRO GRID

Traditionally, homes have been considered as sinks of energy. The residential clients have had the role of consumers, buying the electrical energy from the Distributor Operators (DOs).
Nevertheless, the role of these clients in the next years acquires major relevance. Actually, there are some homes with sun or wind power systems installed and other have also energy storage devices. The Smart Grids designers defined these homes as micro grids because they have the three main functions of electrical grids: generation, consumption and storage [2].

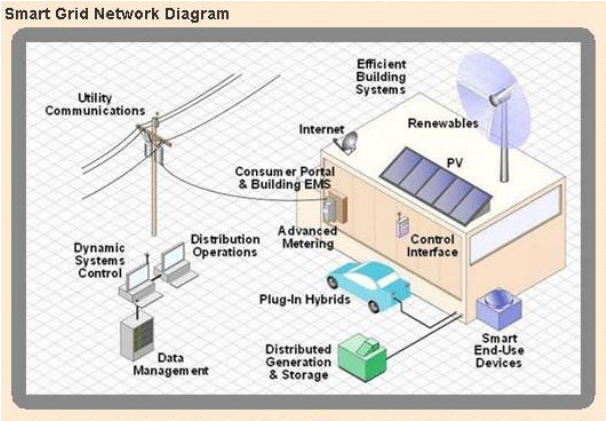

Figure 1: Home micro grid connected to Smart Grid, available on [2].

The home micro grids will be connected to the Smart Grids through gateways, enabling the communication between the operators and ending consumers. This communication is extremely important for both of them; the clients could send or buy energy to operators according to their needs and, on the other hand, the DOs could manage their grid efficiently thanks to the clients' participation.
In the next years, the scenario described above could be reality but, nowadays, the majority of the residential clients don't have these kinds of equipments in their homes. In fact, the smart grid roadmap set two important services as previous steps to turn the homes into micro grids [3]:
- Smart Metering.
- Demand Side Management (DSM).

The DOs need these two services to monitor the whole electrical grid and to manage the residential market. The Smart Metering service is being implanted successfully in Europe. The Automatic Meter Reading (AMR) provides the householder consumption in real time to the DOs.
If the operators know the real consumption of their clients, they can improve the quality of the service by modelling the clients profiles, adapting the generation to their clients' needs or, thanks to the DSM service, balancing these needs with the resources available in the grids.
In fact, the DSM service could be the driver of Smart Grids in the residential market. This service makes the consumers sensitive about the importance of the flattering and reducing their consumption.

Customers' participation

The involvement of the consumers is a key factor for the success of the DSM service. The reduction of the consumptions and the flattering the load profiles imply to change the consumers' habit.

For example, the air conditioning could represent about the 10% of the household electrical consumption. If the consumers improve their installation, they will save up to 30% of their bill. Some DOs provide this kind of information and some advices for reducing the household consumption to their clients on their websites or by mail [4], but these dissemination campaigns don't change the habits of the users.

A recent poll carried out in USA [5] shows that the consumers are interested in reducing their energy bill but only the 15 – 20% of them are willing to sign up for demand response programs. The consumers prefer the investment in cost-saving equipment over a control system managed by the operators.

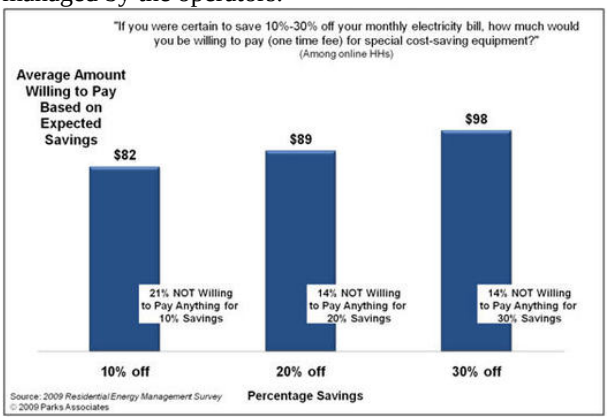

Figure 2: Consumers willing to invest in cost-saving equipment, available on [5].

A possible solution to involve the consumer in DSM services is to offer attractive discounts in their bill in exchange for allowing utilities to manage their consumption. But this management should not reduce the consumer comfort in order to reach the success of this business model.

In addition, it is necessary to keep the dissemination campaigns to make the consumers aware of the demand response programs.

Spanish Regulation Framework

The regulators can also favour the success of this service. This section describes how the Spanish regulation eases the deployment of DSM service, establishing minimum requirements for newly built houses.

In 2002, the Spanish Government published the Royal Decree (RD) 842 updating the regulations for the low voltage installations [6]. Fifty-one proceedings were joined to this decree describing technical requirements for these installations.

One of those proceedings, the proceeding ITC-BT-51, establishes the requirements of automation systems, energy management and security for homes and buildings. The document is addressed to installers defining the main concepts and the European norms that the installations have to fulfil.

This was the first step to introduce the home energy management in the regulations, but it was also a basic one because the proceeding is focused on physical signals, wires, connections and electromagnetic compatibility.

In 2007, Spanish regulator published a technical application guide [7] related with the proceeding ITC-BT-51. The aim of this guide is to specify the installation of home automation systems taking as reference the Smart Home concept.

Homes built after the year 2003 are potentially a Smart Homes, because they have installed the basic infrastructure to access to modern energy grids and to new telecommunication services. The home telecommunication infrastructures are regulated by the RD 401 published in 2003 [8].

Thanks to these decrees, the guide published in 2007 considers four different services that can be deployed in different Home Area Networks (HANs), as shown in Figure 3:

- Multimedia service.
- Voice and data service.
- Information and Communication service.
- Home Automation service.

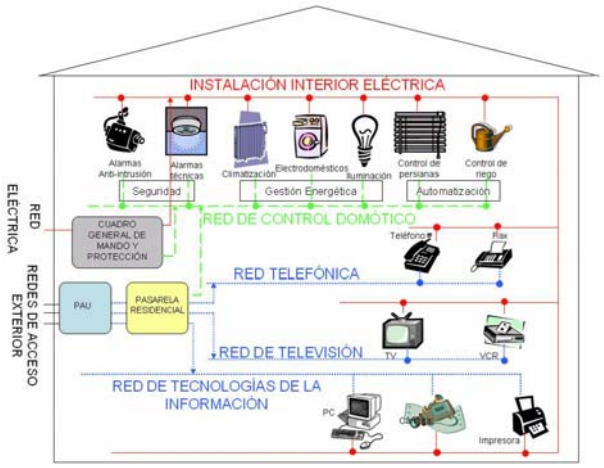

Figure 3: Home Area Networks consired by the Spanish regulator, available on [5].

This guide is focused on this last service. The automation service could be deployed over a specific network but it can be also deployed over the existing home electrical grid. Three applications are considered for the automation service:

- Remote control of household appliances and installation.
- Energy management.
- Security system.

SECTION II: DESIGNING THE HOME DSM SERVICE

The main goal of GAD Project is to make the consumers aware of the importance of the consumption management to improve the quality of electrical service.
The habits and preferences of the consumers have been studied in order to make an attractive DSM service.
Next sections resume the main requirements and specifications detected to design this service at the home side.

Requirements

- Establish the boundary between the DOs and the consumers. The DOs must not manage or monitor directly the household appliances.
- The consumers must have always updated information about the grid state and their current consumption.
- Guarantee the consumer's comfort. The consumers will be notified about the necessity to reduce the consumption.
- The consumers could reject a consumption reduction request sent by the DOs.
- The consumers could set different priorities to their smart appliances.
- Security. Each consumer could only manage its own appliances.
- Usability. The consumers could add or remove appliances in their system easily.
- Universality. To reduce the cost of the equipments it will use standard technologies.
- The home grid will use as communication system in order to reduce the implantation cost and to keep the user comfort.

Specifications

- Domestic Power Manager (DPM). This device will be the boundary between the DO domain and the home.

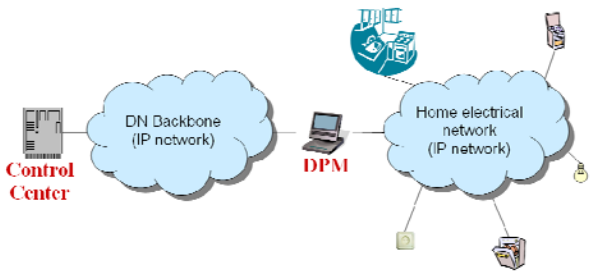

Figure 4: DPM will provide privacy to homes.

- DPM will receive information and technical orders from DO.
- DPM will have an user interface showing to the consumer information received from DO.
- The consumer will use the DPM to configure its preferences and manage the smart appliances.
- The smart appliances will have a button. When the consumer presses this button, this appliance will be add (or remove) to DPM.
- DPM will have also a button. This button will be pressed before adding a new appliance to the system in order to guarantee the security of the system.

SECTION III: GAD PROJECT SOLUTION

In the development task GAD Project has been working with three different technologies, providing a modular system.
BPL technology was selected as best network technology because of:

- The electrical grid is installed in all homes, reducing the cost of installation and the universality of this service.
- All household appliances have an electrical interface. The manufacture of smart appliances will be cheaper than introducing a new communication interface.
- This is a rapidly growing technology in home environment, recently standardized by IEEE [9].

The home automation service is the key for the success of the home DSM. The automation service will allow DPM to manage and control the smart appliances according with the consumer preferences and the electrical grid state. KNX technology was selected because it is a standard technology and widely accepted by the European manufacturers and installers.
GAD Project has designed a specific information model for the application layer. The existing technologies don't fulfil the DSM requirements.

SECTION IV: OTHER TECHNOLOGIES FOR HOME ACTIVE DSM SERVICE

Other technologies have been studied during the design stage. This section comments shortly the main advantages and disadvantages of the most popular technologies that can be used:

- Ethernet: it is an alternative technology for network layer. It is the most widely and reliable technology but it's a wired technology. Only a few percent of the homes have an Ethernet network installed and the installation doesn't cover the whole the home.
- IEEE 802.11 or Wi-Fi: it is an alternative technology for network layer. It is the most popular wireless technology but its main problem is that the saturation of the frequency band used diminishes the quality of the technology.
- IEEE 802.15.4: it is an alternative technology for network layer. This is the wireless technology used traditionally by ZigBee specification. It uses the same frequency band that Wi-Fi.
- ZigBee Home Automation profile [10]: it is an alternative technology for the home automation service. It's a young technology so it is closer to energy management service than KNX. The main problem is

that manufacturers must paid royalties to ZigBee alliance and the use of radio technology cannot cover the home environment. Recently, ZigBee Alliance and HomePlug Alliance announced an agreement to create a wired solution based on BPL technology for energy management services.

SECTION V: CONCLUSIONS

GAD Project is now testing the prototypes developed and the communication and service systems designed in the last three years.
The tests cover all the agents implied in the Active DSM services: Transport Operators, Distributor Operators, Utilities and consumers.
This paper is focused on the last agents. Operators and utilities need the DSM to optimize the resources available in the grids and to keep the quality of electrical service, despite of the continuous growing demand. But residential consumers are not conscious of this problem and the success of DSM service depends on their acceptance.
Regulators and Operators should bear the price and the comfort in mind to make the customers join to this service.

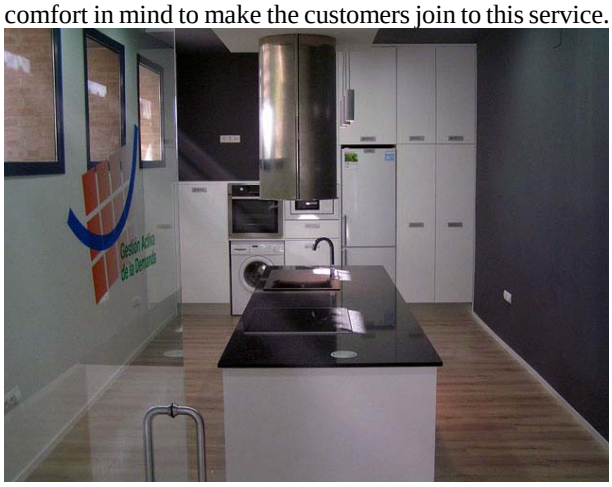

Figure 5: GAD showroom available for pilot tests in ITE installations [11].

In the second part of the paper, the solution designed by the GAD Project was presented. Open and standard technologies have been used in order to reduce the cost of the implantation. On the other hand, the home automation systems ensure to customers comfort and control of their homes.
The paper also presents the Spanish regulations as example that Governments could ease the deployment of this service.

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