DSM in Spain. Results from GAD Project.

Aims, Developments and Ongoing Results

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Abstract— This paper will present an overview of results obtained in GAD Project. First of all as a foreword, advantages of active demand side management are analysed from Transmission System Operator, Distribution System Operator and retailer point of view. Later, results of GAD project are presented, focusing on how embedded systems approach has been used to design devices to enable active demand side management. Finally, following actions to perform are stated.

Keywords-component; Active Demand Side Management, Domestic Customer Segmentation, Customer awareness , ICT infrastructures for active demand side management

I. INTRODUCTION

In a social environment where the construction of new electrical T&D infrastructures becomes a challenge and with an increasing concern about the efficiency on energy consumption, raises GAD project.

Active demand side management can be an opportunity to optimise energy consumption at Spanish homes, and the use of electrical T&D infrastructure in our country.

To depict Spanish electrical system behaviour, we have selected the load curve of the system for 2009 January, 13th.(Figure 1). This is the day in 2009 with maximum hourly average power demand.

In this figure it can be appreciated that the relation between peak and valley for Spanish electrical system is near to 2 (1’73). This effect makes electrical infrastructures to be oversized (in fact, in Spain, in 2008 , 4100 MW were needed only to satisfy the demand of 300h of greatest demand).

The difference between peak and valley demand is even greater in domestic consumption, so this is especially evident in low voltage grids, with high penetration of domestic consumers.

Another consequence of this load pattern is the difficulty to integrate the wind power produced at night. Spain has 18.199 MW of wind power installed (December 2009). Differing some load from peak to valley hours could make easier the operation of the system in windy nights. This load profile of the system caused an extreme situation on 2009, November 8th, when at 3:59 h, 53’7% of power demand was covered with wind power production, due to the volatility of this kind of production.

For the success of demand response, end user awareness is a crucial point. Reporting end users its real time consumption and the effects of consuming at peak hours allows the end user to consume in a more environmental friendly way.

The project aim is to research on mechanisms to implant active demand side management in Spain. These mechanisms include regulatory and economic aspects as well as technology needed to implement an effective active demand side management at domestic level.

Technologically, the great challenge is the bidirectional communication with 26 million electricity meters. The management of 26 million of telecommunication nodes that moreover measure electricity, will change the electricity meter concept, requiring an actualization of its specifications.

With this framework, GAD project, funded by CDTI (Technological Development Centre of the Ministry of Science and Innovation) in the INGENIO 2010 program, pursues research and development of solutions for the optimization of electrical consumption at a domestic level. The National Strategical Consortium of the Electrical Active Demand Management is leaded by Iberdrola Distribución Eléctrica, S.A.. The rest of former companies are: Red Eléctrica de España, Unión Fenosa Distribución, Unión Fenosa Metra, Iberdrola, Orbis Tecnología Eléctrica, ZIV Medida, DIMAT, Siemens, Fagor Electrodomésticos, BSH Electrodomésticos España, Ericsson España, GTD Sistemas de Información, Foresis and Corporación Altra. On top of this, fourteen Spanish research organizations are collaborating.

The project has a duration of four years (2007-2010) and it has a budget of 23’3 M€

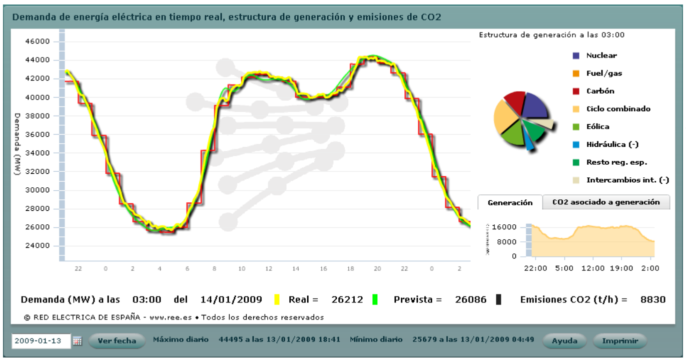

Figure 1: Load curve for 2009 January, 13th. Day with maximum hourly average power demand. Source: REE

II. AGENTS INVOLVED AND BENEFITS

A. General Benefits

Active demand side management aim is to transform electricity demand into an additional controllable variable of the electrical system management, and not a set point to follow.

ADSM can be applied in two scenarios, for planning or for operation of the system. In the first case, demand side management tools allow to defer some investments, due to the shaving of the load curve of the system, as electrical infrastructures are projected for supporting the maximum load.

In the second scenario (operation), demand side management can solve non-permanent overloads, can improve security of supply, and also can reduce loses (as losses depend on current)

Summarizing, general effects forecasted with the application of active demand side management to Spanish electrical system are:

- Infrastructures optimization
- Security of supply improvement
- Development of society awareness about generation costs in peak of demand periods
- Reduction of green house gas emissions
- Development of national industry capacities related to smart grids and smart metering.

B. Specific Benefits. TSO

Due to electricity can not be storage, TSO fuction is to assure instant equilibrium between generation and demand, coordinating generation resources and grid infrastructures in both mid and long term.

This function, traditionally with some exceptions, has been performed using generation and grid infrastructures, not acting over demand. Demand has been considered as an immovable factor in the electrical system framework: A non manageable demand to be satisfied. Nevertheless, increasing issues to develop new generation infrastructures as well as grid infrastructures has arisen due to social and environmental opposition.

This, jointly with a new wish to increase the integration of non manageable production with quality and reliability, is pushing the sector to research and promote a manageable demand. Among the potential benefits for the TSO we can highlight:

- Contribution to the **quality and reliability improvement**. The creation of new services and tools for the demand management that can be used by TSO in critical situations, will contribute to the improvement of quality and reliability of electrical system, providing more flexibility and manageability.
- Possibility of **reducing and postponing the need of new generation and grid infrastructures**. The transfer of the peak consumption to valleys will impact in the peak reduction and therefore in a better use (efficiency) of electrical systems.(Figure 2)
- Enabling the **integration of an increasing amount of non manageable renewable generation**. The ability of giving signals to demand side to differ consumption to hours when renewable generation is higher will avoid the waste of this resources, and will enable the consumption reduction in low production hours.
- **Technical losses reduction** of electrical systems. As technical losses are proportional to the demand in a quadratic factor, the minimization of losses is achieved with a flat consumption profile.
- Contribution to the climate change mitigation. As far as active demand management improve energy efficiency, the reduction of resources used to obtain the same result impacts directly in green house effect gases emission reduction.

C. Specific Benefits. DSO

Specific benefits for distribution system operators derive from the installation of smart metering for the application of demand side management.

The installation of smart metering allows the DSO to have more visibility at low voltage grid. Also, it makes easier the management of the activation and cancellation of customer contracts, and the maintenance of the installations.

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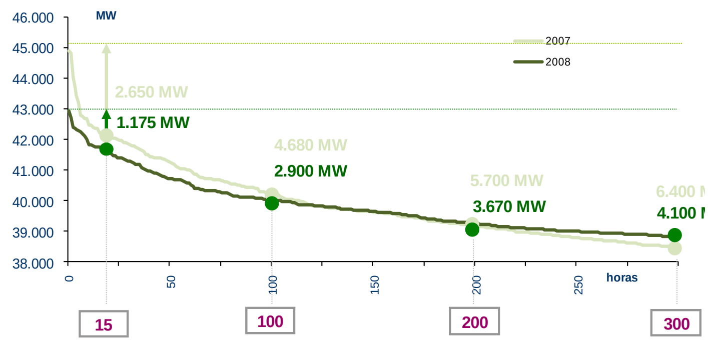

Figure 2: Monotonous curve of Spanish electrical system for 300 h of higher demand during 2007 and 2008.

Technology changes very rapidly, so the selection of one technology can be a thread. To protect the investment of distributors, the European commission has published the M/441 mandate on smart metering standards in Europe. The general objective of the mandate is to ensure European standards that will enable interoperability of utility meters (water, gas, electricity, heat), which can then improve the means by which customers' awareness of actual consumption can be raised in order to allow timely adaptation to their demands

In this framework IBERDROLA as a leader of OPEN meter Project is collaborating in the definition of this standard. The OPEN meter Project will remove the barriers for the wide scale adoption of smart metering and the building of the European Advanced Metering Infrastructure, thanks to the development of a comprehensive set of open and public standards for smart metering. The cooperation in the project of a wide circle of key European stakeholders in the field (as direct project partners or external parties), ensures the final acceptance of the results of the project.

D. Specific Benefits. Retailer

From the retailer point of view, demand side management will allow the differentiation between services offered by different retailers. This aspect is crucial with a product like electricity, that is a commodity. It is very difficult to offer something to keep customers if your product is exactly the same that the one from your competitor. Active demand side management will allow to offer different tariffs adapted to end user consumption. Moreover, it will allow retailers to improve customer service, as they will have data on customer behaviour and consumption uses.

Active demand side management also allows retailers to test new business models, based on demand bidding, as well as new tariff models like time of use, critical peak pricing, real time pricing, peak time rebate, or other models that could arise.

III. GAD Implementation Proposal

After three years research work, the consortium is proud to announce that a solution based on open standards for domestic active demand management has been designed. Following areas has been defined to reach customer houses from TSO and DSO control centers:

- Control WAN : ICT infrastructure to communicate between agents. Will be based on existing secure services.
- Core WAN: From DSO control center to secondary substation.
- ACCESS WAN: From secondary substation to customer meter.
- LAN: Network inside customer house. Allows communicating smart appliances and smart plugs with an in home controller which optimizes demand according to signals received and customer preferences.

Figure 3 shows technologies chosen for each segment.

Focusing on LAN segment, the project defines several devices at customer home, which will be able to manage the consumption of different kind of loads.

The architecture of devices at customer home, are shown on figure 4.

The different developed devices to manage the loads are:

- **DPM** (Domestic Power Manager - ORBIS): This device is the Home Controller. It will execute an algorithm which controls the consumption from electrical appliances. It receives feedback of both the electrical network and domestic appliances. Depending on price, and possible technical restrictions, the DPM moves the load consumption taking into account end-user preferences.
- **DIFU** (User Interface – ORBIS): This device is the User Interface of the system. It is connected with DPM by the Local Area Network (LAN), and shows relevant information to the user, like consumption, active loads, energy prices, CO2 emissions…
- **Electronic Meter** (ZIV) : It acts as a gateway between the distribution network, and the DPM. It also allows the automatic meter reading of domestic consumption.

In all devices developed, costs, size and energy consumption have been taken into account. Devices have been developed as embedded systems, adopting compromise solutions between processing power, and costs. Also size is a restriction, as devices will be installed in customer homes. Demand side management focused on domestic sector has only sense due to aggregation effect. To allow the businesses case to be positive, the devices have to be both cost and energy efficient as well as appealing for the end users.

Nowadays, a test facility of technology developed has been implemented. This installation shows the performance of devices from substation to customer house. (Figure 5)

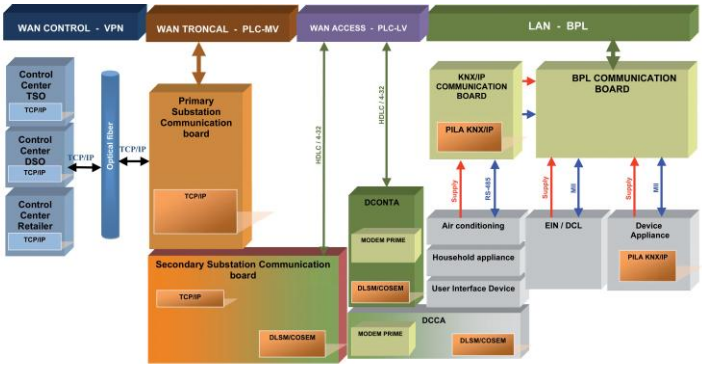

Figure 3: Communication Technologies chosen on each segment

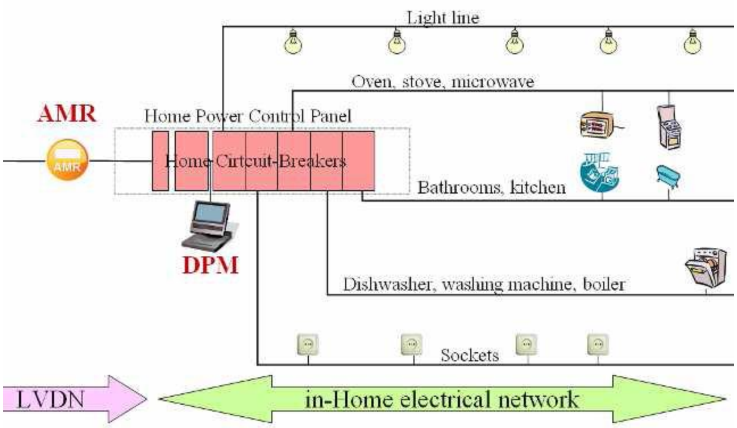

Figure 4: Architecture of devices at customer home.

Figure 5: Test Facility at ITE. GAD1. GAD Project

IV. NEXT STEPS

Once the solution has been designed, we are in the process of identifying next steps to commercialise the solution successfully. To do so, we have identified some barriers as potential threats for the implementation. Some of those barriers to overcome are:

- Standardization of protocols: active demand side management involves the use of smart appliances. Protocols used to manage the demand has to be based on open standards, as we can not ask the user to change its appliances to change from one retailer to another, that offers a different solution to manage the demand. In this direction OPEN Meter Project is defining this standard protocols. Protocols on Home Automation area are also needed.

- Evaluation of Demand side management resource. To be able to analyse the business case of domestic active demand side management, data on customer response and awareness is needed. For this reason, a representative pilot experience is needed, adapted to specificities of the country.

- New legislation to promote demand side management. Nowadays remuneration is based on km of grid constructed, without having into account demand side management. A new approach maybe is needed.

- New tariffs. In Spain, free market for domestic customers is not mature yet. Most of customers have still regulated tariffs. New tariff mechanisms that promote the customer to join active demand side programs have to be designed.

- Customer awareness. End users are blind to hourly changes in energy generation costs. We need to increase the customer awareness about the influence of its consumption on the environment.

ACKNOWLEDGMENT

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