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SmartCity Málaga, a real-living lab and its adaptation to electric vehicles in cities

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ABSTRACT

The new energy requirements that will be necessary in the coming years will demand a change in the current paradigm of electricity grids. The need to integrate a higher level of renewable resources to achieve the objectives set by the EU (the famous 20–20–20), flattening the load curve, the imminent arrival of electric vehicles, and the possibility of actively controlling all devices connected to a grid, are some examples of these new challenges. In order to maintain the stability of the distribution network, all medium-voltage lines in the city of Malaga (Spain) have been analyzed and modeled over the past five years, to optimize electric-vehicle charging with the use of available energy during the night valley using pricing signal, control of the electric vehicle charging manager and signals from the Distribution Company, with regard to grid availability (vehicle-charging posts) and available energy. The project has developed new management, control and integration systems for all elements of consumption, production and energy storage over the distribution network. All deployment within the SmartCity Málaga Project of ENDESA includes smartmeters for all customers and new automation and communication systems over the grid connected by a broadband Power Line Communication network.

1. Introduction

In recent years, energy distribution companies encountered problems of constantly-increasing energy demands and high peaks of load curves for only a few hours per year requiring an over-engineering of the grids. Simultaneously, new standards were introduced, such as the 20–20–20 objectives set by the European Union (Alvarez and Rudnick, 2010). These circumstances have caused serious problems for the utilities, which, regarding the traditional model, need to expand the grids by investing in expensive and long term inversions, along with the difficulties of obtaining the necessary licenses.

In recent years, the installation of distributed generation, highly promoted in the country, has been seen to increase exponentially in the medium and low voltage networks. The imminent development and massive deployment of electric vehicles must also be taken into account along with the consequent questions that this generates. According to ENDESA, the company establishes fundamental and exigent levels of security, sustainability, quality of service and system and network adaptability.

For all these reasons, The Malaga SmartCity Project has emerged with the task of adding intelligence to the conventional power grid with a bidirectional transmission of information between supplier and consumers building an efficient and self-healing network[1] (Cédric, 2011).

The current grid is a unidirectional system in which the source has no real-time information about the service requirements (Wang et al., 2009; Rahat Hossain et al., 2010).

This inefficiency can be solved with the concept of a smartgrid. It is based on a totally connected and informed network, where the control center receives information about everything that is happening at the end of the power chain, and is also capable of sending information to the lowest level. In this case, the grid can be optimized to the point that the load curve is flattened; the valleys can be filled with distributed energy resources or vehicle-to-grid (V2G) technology, and the peaks can be reduced by using renewable sources or stored energy (Shireen and Patel, 2010; Hajimiragha et al., 2010).

2. Scope of the project

Based on these ideas, ENDESA creates the SmartCity Málaga project (Fig. 1). This is a pilot where new networks are not built.

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[1] European SmartGrids Technology Platform: Vision and Strategy for Europe's Electricity networks of the future.EUR 22040, 2006. Hajimiragha et al. (2010).

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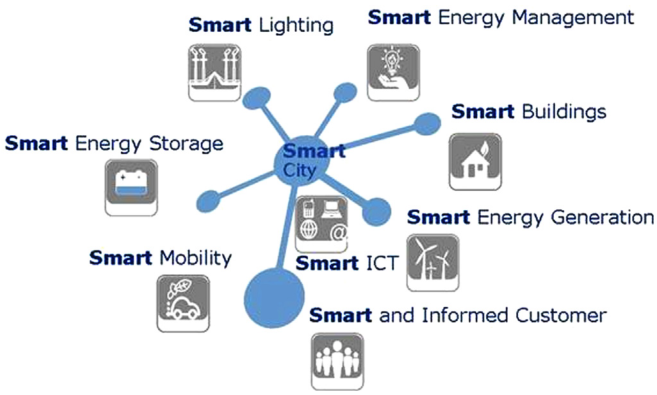

Fig. 1. Scope of the project.

Instead new systems and elements are added and installed in order to improve management of power infrastructure and optimize its use, achieving the concept of a smartgrid. The project area has a population of 50,000 inhabitants including 12,000 residential clients 300 industrial clients and 900 service clients. Therefore, it is a project developed in completely real conditions.

The SmartCity budget is 31 million euros and is funded by the Centro para el Desarrollo Tecnológico Industrial (CDTI) from the Ministry of Industry, Tourism and Commerce (Spain), with support from the Junta de Andalucía (regional government) and the Malaga Council. A total of 25 companies and research organizations take part in the project, organized into a consortium of 11 leading companies in the sector headed by ENDESA.

In this pilot project, customers and the distribution company collaborate to achieve the energy challenges; increasing the use of renewable energy sources, moving generation closer to consumption and pledging a rational and efficient consumption, all combined with storage facilities, to give support to the grid in critical moments (Kyohei et al., 2011). It is being developed in an urban area whose supply comes from five medium voltage (MV) lines that depend on the same substation.[2] The main goals are

- Advanced Metering Infrastructure (AMI),
- Deployment of a broadband Power Line Communication (PLC) network, for transmitting any real-time data related to the grid and the connected users,
- Distributed Energy Resources (DER) deployed in the medium voltage (MV) and low voltage (LV) grids,
- Automated MV network,
- Residential, small and medium-sized companies and public buildings with energy-efficiency facilities,
- Deployment of an electric vehicle fleet and charging posts, with V2G technology,
- Efficient public lighting, and
- Energy storage.

The Málaga SmartCity Project is a demonstration project whereby customers and the Distribution Company work together to achieve the energy policy goals, by increasing the use of renewable energy sources and energy efficiency, while bringing the generation closer to consumption and encouraging consumers to a more sustainable use of energy[3] (Ngar-yin Mah et al., 2012).

To achieve the above objectives, it is necessary to use the following infrastructures:

[2] European Commission, "SmartGrids: from innovation to deployment", Brussels, 2011.

[3] "DENISE: Proyecto de Distribución ENergética, Inteligente y Segura", Memoria Técnica, Endesa, 2010.

- Advanced Metering Infrastructure (AMI). The efficient use of electricity first needs consumer habits to be modified. For this, we introduce smartmeters with the objective to better understand the demand responses of buildings and homes. With smartmeters, the load curve of customers can be flattened (Von Dolen, 2008).
- Communications using a real-time IP network.
- Distributed Energy Resources (DER). For this there are different aspects to consider
  - (a) By having generators close to consumers, it is possible to minimize technical losses.
  - (b) By diversifying and increasing the number of generators, the criticality of each individual generator is reduced once redundancy in generation is maximized.
  - (c) Energy storage: due to the increase of renewable generation sources, it is essential to store energy generated in low consumption moments.
- Advanced Distributions Automation (ADA). The increasing complexity and criticality of the electricity grid requires advanced methods of protection and control in order to maximize its efficiency.

The proposed telecommunication architecture will be deployed over a highly reliable broadband PLC network reusing the electrical MV lines, complemented by WIMAX technology (Fig. 2). The implementation is based on the development of new functionality for smartgrids on the central systems, integrated with a distributed system (Römer et al., 2012).

On the central system the following are essentially involved: the Monitoring and Diagnostic Centre (CMD), the Advanced Metering Management System (AMMS), the Maintenance Unified Management Centre (CGUM), and playing a key role, the Advanced Distribution Management System (ADMS).

The distributed system is composed of two main Intelligent Electronic Devices (IED), capable of execute decentralized control logics based on grid efficiency and reliability criteria: the iNode and the iSocket (Hughes, 2010):

- The iNode is an aggregation device, a sort of data concentrator. It controls all iSocket devices connected to the same electrically-connected segment of the grid, concentrates all the data downstream collected and is coordinated in real-time with upstream grid control centers. It is installed within transformation centers.
- The iSocket is the final device controlling an energy point, a sort of local data manager. It receives commands from the iNode device to be executed and sends it real-time information. It is installed within the end users' power equipment.

In Málaga SmartCity project an Active Demand System has been developed that has two different possibilities for control the energy consume in the customers,

(1) offering signal prices to the customers from the retailer, and
(2) demanding decreasing energy consume directly from the DSO Operation center.

Furthermore, the smartmeters are prepared for 6 period tariffs.

In the Málaga SmartCity project, the following has currently been installed or undertaken:

- 12,000 smartmeters,
- implementation of 22 automated MV/LV substations,
- 72 MV/LV substations connected by PLC, with a total of 40 km MV lines connected,
- 12.94 MW of MV generation and 43.25 kW of LV generation,