ECONOMICAL AND TECHNICAL VIABILITY OF DEMAND RESPONSE IN THE SPANISH POWER SYSTEM: THE "OPTIGES" PROJECT

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ABSTRACT

This paper presents a project that is being carried out by Endesa in Spain with the aim of controlling peak demand by modifying the consumption of customers within the small and medium enterprise sector. A full load control architecture is being developed and different pilot tests are being specified.

INTRODUCTION

The peak load in Spain has experienced a significant growth over the past decade [1] reaching yearly increases in excess of 10% in some specific areas. This situation leads to operational problems in particular locations of the distribution network and forces companies to search for cost-effective and environmentally friendly solutions to face the issue. One of these possible solutions is implementing demand response programs among their customers. Moreover, electricity suppliers face increasingly variable market prices which make demand response initiatives even more interesting for the retail electricity business [2-3].

In order to unveil the economical and technical viability of demand response initiatives in the Spanish power system, *Endesa Network Factory* and *Tecnalia Energía* have joined forces. The OPTIGES research project presented in this paper aims to control peak demand by modifying the consumption of customers within the small and medium enterprise (SME) sector.

The architecture allows the remote activation of demand response strategies that modify the planned settings of existing EMCSs (Energy Management Control Systems) at customer's premises. HVAC and certain lighting systems are the loads that provide the highest reduction potential while having a minimum impact on customer's comfort. A central controller calculates the optimal control actions according to diverse objectives set by the different businesses of the Endesa Group. The communication between the central controller and the customers is achieved using the Internet.

PROJECT OBJECTIVES

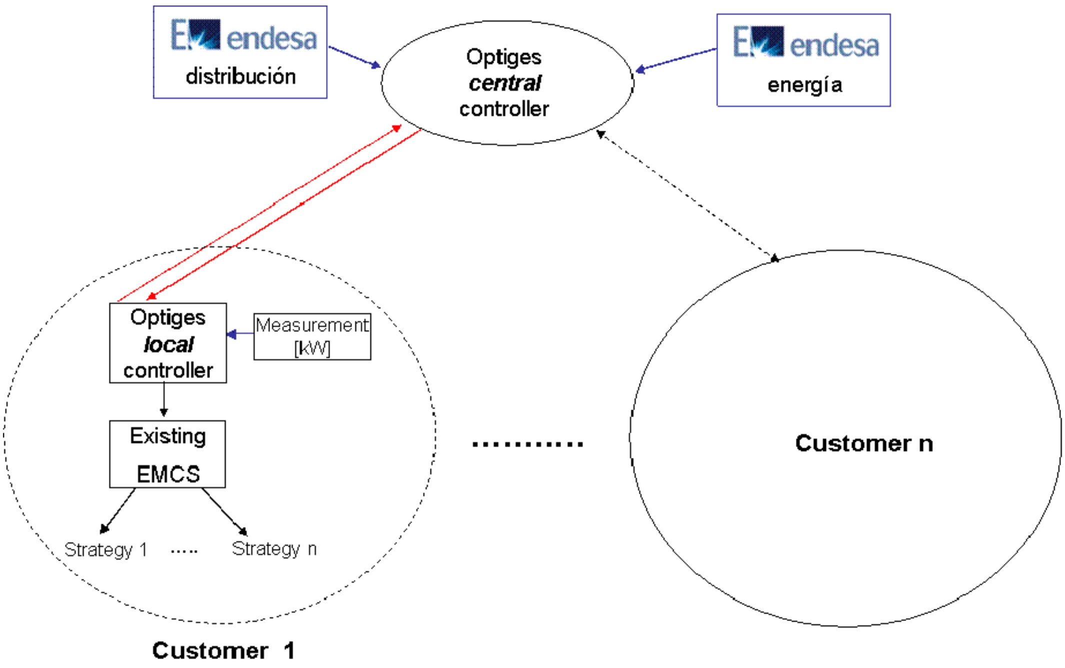
The main objective of the OPTIGES project is to establish the viability of demand response in the SME sector of Spain from both a technical and an economical point of view. Recent problems in the operation of the distribution networks in Spain make clear that alternatives must be found to the traditional operation of distribution networks.

Apart from the improvement of the reliability of supply, the implementation of demand response initiatives provides other potential benefits. The following benefits have been identified:

- *Short term reduction of the investment requirement on transmission, distribution and generation infrastructure* [4]*:* Power systems are designed to serve the peak demand, and some infrastructure is just used during a small number of hours. Demand response could reduce the need for investment on peak capacity.
- *Greenhouse gas emission reduction*: The global warming effect produced by greenhouse gases, has warned Governments around the world, which are trying to introduce ways to reduce emissions urgently. Electricity power generation emissions represent a significant contribution to overall emissions [5-6].The load reduction at peak load periods can avoid the highly pollutant generation that is used at those time intervals.
- *Minimisation of transmission and distribution losses*: The power losses across transmission and distribution lines are proportional to the square of the flowing current. Reducing the consumption at peak times, the amount of energy that must be generated to serve the same load is reduced.
- *Increase in the amount of renewable resources that can be integrated in the network*: the intermittent nature of most renewable electricity sources makes the operation of networks challenging. The load control capability allows a more flexible management of the generation imbalances.

CONTROL ARCHITECTURE

The figure shows a graphical representation of the system:



The system is based on a central controller and on a series of local controllers. Each participating customer will have one locally installed.

The control is centralised in the "Optiges central controller" which is a PC sited in Endesa's headquarters. This computer can be accessed by both *ENDESA energia* (the company that acts as electricity supplier within the *ENDESA* group) and *ENDESA distribucion* (the distribution network operator within the group). The Optiges central controller runs two different algorithms, one for each company.

The objective of *ENDESA distribucion's* algorithm is to ensure that network reliability is maintained. When *ENDESA distribucion* foresees a problem in the distribution network, inputs the following information into the Optiges central controller:

- Incidence period
- Network location of the incidence
- Optimal amount of load that should be reduced to solve the incidence

The algorithm then calculates the customers that should be controlled. The notification time can be as short as 30 minutes.

The objective of *ENDESA energia's* algorithm is to maximise the profit of the utility. The algorithm uses forecasted price information and calculates optimal control actions if this price is above a defined threshold. The notification time is typically longer than in the case of the distribution algorithm.

The actual execution of the actions is the same for both algorithms. Each participating customer has an "Optiges local controller" installed. The Optiges local controller is a mixture of commercially available devices that allows the communication with the central controller and the activation of strategies in the existing EMCS using digital input/output signals. The communication with the central controller is achieved using a GPRS modem connected to the Internet. In this way the OPTIGES system is completely independent from customer's internal data network, avoiding accessibility barriers and possible security concerns.

Once that the central controller runs one of the two algorithms and calculates the control actions, the following process is initiated: the central controller sends notifications to the customers that will be controlled. The starting time and duration of the event is provided. This information is displayed in a display within the local controller. An email and an SMS are also sent to the relevant person.

Customers have the option to override the control action.

For that purpose a physical button is provided.

When the starting time of the event arrives, the central controller sends the "start the control action" order to all the local controllers. When the end of the event is reached, the central controller sends the "stop" order to all the local controllers.

The local controller has no timing capability. If the communication is lost during the execution of the event, a watchdog automatically cancels the control actions.

The system integrates a metering system that measures the whole building electricity consumption and sends it to the central controller every fifteen minutes. The system can also incorporate power sub-meters in order to measure the consumption of particular loads (HVAC and lighting).

Each customer's EMCS is specifically programmed allowing them to understand the outputs of the OPTIGES local controller. The strategies that are programmed in the EMCS are particular for each customer and depend on the capabilities of the EMCS, the loads (possibilities of reduction) and the tolerance to the discomfort. An energy audit will help decide on this. Typical strategies are modification of the normal setting of the thermostats of building zones, and the dimming or interruption of non-critical lights. Strategies for both summer (air conditioning) and winter (electric heating) are considered.

Performance assessment

In order to obtain a preliminary estimation of the savings that can be obtained by the application of HVAC control strategies, each participating building is modelled using the EnergyPlus simulation software [7]. The software provides the estimated heating and cooling loads for particular thermostat settings and weather conditions.

The accuracy of the simulation results obtained from EnergyPlus is to be validated by means of field measurements performed on existing pilot buildings. This assessment is a difficult task. It involves the calculation of the baseline load during the event, which is the consumption curve of the customer if no control actions are executed [8]. It has to be estimated from historical data. Different baseline calculation methods are available. They range from simple techniques that average the hourly consumption on the days that precede the control action, to more complex techniques that make use of the temperature as input data.

COST BENEFIT ANALYSIS

With the aim of assessing and quantifying the benefits that can be obtained from this demand response architecture, a generic cost-benefit analysis methodology has been developed. The methodology can be applied to any network or power system.

The methodology has been applied in the Spanish power system, taking the year 2006 as base case. The selected demand response program involves the yearly execution of 30 events. The duration of each event is fixed to 4 hours. Results show that if the interruptions are executed on the peak price periods, an electricity supplier could potentially increase its revenue on €5888 per reduced MW.

If the events take place on peak load periods, the following benefits could be established:

- A potential of €572000 per reduced MW could be saved on generation and transmission system infrastructure.
- The yearly reduction on transmission and distribution system losses provides an estimated savings of €2789 per reduced MW.
- The estimated greenhouse gas emission reduction is around 7.8 ton CO_2 per reduced MW.

Costs

The costs of implementing a programme such as the one presented in this paper are significant and include:

- Cost of the communication, control and metering equipment
- Communication costs
- Installation cost
- Operation cost
- Economic incentives for participating customers
- Customer support program cost

The final cost-benefit analysis will be performed at the end of the project when the real data from the pilot tests and their cost is processed.

FUTURE WORK

Currently, the architecture is being tested in the laboratory environment. During the course of the next year and a half, four pilot tests on four real customers will be performed. The selected customers belong to the segments that have been identified as the most promising ones. These segments are:

- Office buildings
- Hotels
- Restaurants
- Large supermarkets

The first test will take place in an office building sited in the region of Barcelona.

CONCLUSION

This paper lists the potential benefits of demand response initiatives and describes a particular R&D effort that is being carried out by *Endesa Network Factory* and *Tecnalia Energía* in this field. The work is on-going, and preliminary results indicate that significant economical benefits can be achieved by controlling peak load (both in winter and summer) in the Spanish power system.

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