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An Integrated Tool for Assessing the Demand Profile Flexibility

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***Abstract*—The purpose of this paper is to describe an integrated tool whose aim is to assess the residential demand profile flexibility through the control of space conditioning loads, mainly air conditioner and heat pump appliances. This assessment has been divided into two principal tasks—an estimation of the controllable load and a selection of the optimum load control strategy according to a target profile and a set of prefixed constraints. The tool also provides the aggregated load behavior, allowing a comparison between different load strategies.**

This tool can be applied from the customer's and the utility's side. An application example to a real environment is also presented.

***Index Terms*—Direct load control, energy management, load identification, load modeling.**

I. Introduction

In THE last decade, electrical power systems have experienced a series of changes and pressures which have modified the operation and planning of their most complex level: the distribution of the electric power to their end-users. From those changes, we can highlight the deregulation of the power market, the increasing significance of the distributed generation, and the continuous rise of the demand of energy.

In an ideal electricity market, demand-side has the opportunity to participate and compete with supply-side, for example, through demand-side bidding (DSB) [1]. To achieve the establishment of this market, it is necessary to develop and improve tools to manage, forecast, and evaluate the possibilities to perform bidding in these scenarios. Nowadays, unfortunately, the full participation of the demand in the energy and reliability markets is the exception rather than the rule [2].

This market establishment process is also accompanied with both: the technological maturity of small-size power plants, which allows a decentralization of the supply; and the rapid penetration of combined power and heat cogeneration, which improves the economical effectiveness of the distributed energy resources.

With respect to the demand growth, in this decade, the European Union assumes that the requirement of electricity will increase more than any other primary energy resource. This pattern is due to the successful adoption of new electrotechnologies, as well as the emergence of new end-uses in the tertiary and domestic sectors. For example, the growth experienced in the electrical demand of residential users in Spain was up to 30% in the 1997–2002 period.

Traditionally, demand-side management (DSM) has been considered an efficient tool from supply-side. Unfortunately, some barriers have arisen to the DSM policy implementation. The reasons for this decline in the application of DSM policies are the following:

- residential customers are resistant to change in general, mainly due to the comfort problems detected in previous load management experiences;
- energy efficiency is not a high priority, in short term, for medium and large customers—there are a number of issues that have a higher priority, for example competitiveness, productivity, or quality—and they are reluctant to the risk—(i.e., not only from economical point of view)—associated with the changes in technology;
- decrease of governmental and utility funds to promote DSM policies since the beginning of the deregulation process.

In spite of these barriers during the last years, we expect that the new market should offer a lot of interesting opportunities to look for customer demand flexibility based on legal, economical, and technological factors. For example, and from a legal point of view, in a deregulated system, the demand and supply sides compete on an equal footing and they should have a similar potential as tools for the system operator.

For system operation purposes, there is no theoretical reason as to why the load cannot provide some of the services—reliability, energy, or ancillary— traditionally supplied by utilities, and perhaps with a lower response time.

For small and medium residential and commercial customers, the new market is a unique opportunity to reduce their costs through the management of their energy demand, applying load management and/or energy storage policies to perform demand bids in energy, balancing, or ancillary markets. This management of customer demand could be both utility-driven, the traditional DSM, or customer-driven: the so-called demand-responsive policies, not considered yet for small users.

To profit these opportunities, small users—through a demand aggregator—and medium users need software tools, as the one presented in this paper, to evaluate how flexible their demand is, in order to correct or improve their bids in energy markets by an appropriate management of their energy storage loads—air con-

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