Active demand side management for households in smart grids using optimization and artificial intelligence

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PII: S0263-2241(17)30634-6
DOI: https://doi.org/10.1016/j.measurement.2017.10.010
Reference: MEASUR 5012

To appear in: *Measurement*

Received Date: 7 April 2017
Revised Date: 14 September 2017
Accepted Date: 3 October 2017

Active Demand Side Management for households in smart grids using optimization and artificial intelligence

Abbreviated title: Active Demand Side Management for houses

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Abstract This work aims to develop a methodology to perform the active demand side management for households in smart grids, which contain distributed solar photovoltaic generation and energy storage. Such methodology outcomes a decision-making system that manages the battery aiming to reduce the consumer electricity cost. It also contributes to postpone the investments in expansion of the electricity grid if the higher loading period coincides with the higher electricity tariff of the day. The decision-making system is a validated neural network, trained with optimized data, which can be used in any household metting certain conditions – specific location and electricity tarrif, and consumption profile like to the standard verified by the local electricity utility. To validate this methodology, it was created three consumption and three solar generation profiles, which were combined to each other. The results show that the ANN-based decision-making system operates the baterry efficiently to achieve the minimum electricity bill.

Keywords Energy management; Smart grid; Energy storage; Photovoltaic power; Active Demand Side Management.

1 Introduction

The definition of the smart grid can be a complex electrical power system with a modern infrastructure, composed of automated controls and technologies of sensing, communication, and measurement, as well as modern techniques of electricity management [1]. It covers the generation, transmission, distribution, and consumption of electricity, whose components details are presented in [2]. It is worth mentioning the smart meters, from which is possible to monitor the electric grid, verifing their performance and detecting failures [3].

The definition for smart grid is not universal. Smart grids involve several different techniques and distinct technologies, and each location implements in a different way and proportion, depending on the structure (regulatory compliance, compatibility with local technologies, commercial attractiveness, and availability of investment), and local needs [4, 5]. For example, in Brazil, the main drivers for the implementation of smart grids are: the need to reduce costs, increase the reliability and quality of energy services, reduce technical and commercial losses, prepare the network for the future, and promote environmental sustainability [6, 7]. In the United States, the motivators are: the need to reduce costs and greenhouse gas emissions from electricity generation, create new markets, ensure energy security against cyber attacks and natural events, increase the reliability and quality of the grid, and accommodate intermittent fonts and storege on the grid. In Europe, the motivators are: the need to promote sustainability through energy efficiency and the use of renewable sources, increase the efficiency of the grid to make countries more competitive, and ensure security of energy supply [8].

In general, the main characteristics of smart grids are: energy consumer participation; accommodation of several sources of electricity generation and storage; provision of new products, services, and markets; differentiation of energy quality; asset optimization and operation efficiency; and resilient operation to disturbances, attacks, and natural disasters [4].

From the smart grids, it becomes possible the creation of systems to realize Active Demand Side Management (ADSM) in the households. ADSM is the combination of automated controls with demand side management (actions that encourage the consumer to rationalize the use of energy), which causes changes in the consumer load curve.

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