Chapter 12
An Energy Storage System: Experimental Proposal for the Efficiency Improvement of the Electrical Network Management

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ABSTRACT

The increasing greenhouse emissions have led us to take advantage of renewable sources. The intermittency of these sources can be mitigated using energy storage systems. The present work shows three different strategies depending on the power management and other technical factors, such as energy quality, each one with a specific goal. The first strategy tries to improve the electricity quality, the second tries to reduce the penalties imposed by the grid manager to the power plant, and the third one tries to improve significantly the final economic profit of the generation companies. To achieve the above strategies, an intelligent model approach is explained with the aim to predict the energy demand and generation. These two factors play a key role in all cases. In order to validate the three proposed strategies, the data from a real storage/generation system consisting on an electrolyzer, a hydrogen tank, and a fuel cell were analyzed. In general terms, the three methods were checked, obtaining satisfactory results with an acceptable performance of the created system.

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INTRODUCTION

Currently, the concern for climate change has led many countries to take measures to prevent global warming and mitigate its consequences. The effects of such warming can jeopardize the survival of the human race itself. This concern for the environment has led to the introduction of legislation not only internally in many countries, but also to signing international treaties.

Within these international treaties, it is worth to mention the 2015 Paris Agreement, which is expected to replace the Kyoto Protocol in the year 2020. This agreement has been achieved within the United Nations, the Framework Convention on Climate Change. Basically, it is intended to maintain the increase in the global average temperature below 2 °C, and reduce the emission of greenhouse gases.

To control the emission of greenhouse gases, the companies have emission limits. If a company exceeds the amount of gases allowed, it can buy from other companies what it is called emission rights. In Europe, the European Union Emissions Trading System (EU ETS) operates to regulate these emissions.

The energy demand usually increases with the level of development of a society and with the time (Figure 1). Then, it is necessary to improve the efficiency of the electrical systems and to cover the increase of the demand while taking care of the environment.

Two additional factors that must be mentioned in relation to the current trend and that determine the energy source in an electrical system are:

- Limited traditional sources. Factors like the price makes them less promising (Rao, 2011).
- Nuclear power is difficult to control and represents a high risk in case of accident, for example what happened in Chernobyl or Fukushima power plants (Ferguson, 2011).

Due to the previous factors, renewable energy is suitable for power generation. Although these sources have been known for many years, their use in energy generation is still arising. One significant issue that these energy sources have to deal with is the interruptible generation, the energy might be generated when there is not demand from the consumers. For instance, the solar energy is higher in the middle of

Figure 1. Electricity demand in Spain (GWh)