# Chapter 8
# Smart Grids and Hybrid Energy Storage Systems: Optimization Techniques Applied in Control Strategies for Hybrid Energy Storage Systems

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## ABSTRACT

*It is very important that the installed renewable energy system should produce the maximum power outputs with minimum costs, and that can only be achieved with the selection of the best optimization technique applied for the best control strategies along with the introduction of the hybrid energy storage systems (HESS). This chapter presents some optimization techniques applied in control strategies for hybrid energy storage systems in distributed renewable energy systems. The integration of energy production and consumption component through the smart grid concept enables increased demand response and energy efficiency. Hybrid energy storage systems and their applications in the renewable energy systems are extensively discussed besides control strategies involved. The storages systems will play an important role in future related to smart grid.*

## INTRODUCTION

The increase in renewable energy systems installations and their integration with the grids is transforming the whole electric generation, transmission and distribution systems around the world. This change from classical to advance techniques is resulting in the evolution of smart grids and the introduction of new storage systems. In past the flow of electricity was one directional but now because of renewable energy power generators such as solar photovoltaic and wind, the excess energy produced by the end user is sent back to the grid using net metering making flow of electricity bi-directional. In future more

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solar and wind generators are expected to be integrated with the grid and it is expected that the inward flow to the grids will be much more than the outward flow from the grid.

As the power generated by the solar and wind generators is not stable and is impacted by the change in metrological conditions. Therefore, energy storage is required at the site of power generation and also smart grid in order to stabilize the power system and to store and use the excess energy properly and efficiently. The microgrids (MG) compromised of distributed generators such as solar and wind are located at the prosumer end also include the storage systems and certain control units for the supply of clean energy and smooth power in the optical way(Tsikalakis and Hatziargyriou, 2011); Logenthiran et al (2010)

In case of micro grids with integration of photovoltaic and wind power systems, the power variations are basically due to the irregular power generations from renewable energy sources and improbability of load consumption Shim et al (2013). The grid connected microgrids have essentially all the support from high inertia power generators whereas off grid micro grids mainly depends on Energy Storage Systems(ESS) in order to balance the mismatch between the power generated by the renewable source and the power being consumed by the user (Tan, Li, & Wang, 2013).

The use of different energy storage systems (ESS) systems in micro grids and various benefits of using ESS such as short term power supply, peak shaving, optimizations of micro source for unit commitment, power quality improvement, ancillary services and seasonal storage are discussed in (Fathima & Palanisamy, 2015). In order to make energy storage more reliable, efficient and cost effective in renewable energy applications hybrid energy storage systems (HESS) are also used. HESS is categorized by a favorable coupling of different energy storage technologies with additional operating features such as energy and power density, self-discharge rate, efficiency, life-time etc.(Bocklisch, 2015). The control strategies play important role in renewable energy applications with HESS. These can be classified into Classical Control Strategies and Intelligent Control Strategies.

The classical control strategies include rule based control (RBC) and filtration based control (FBC) and are mostly require particular mathematical model as they can be effected by the change in parameters (Akcayol, 2004).

Whereas, for reliable and efficient control an emerging predictive modeling systems are required. The optimization plays a vital role in predicting the performance of the renewable energy system with HESS integrated with grid or standalone. The optimization helps not only to improve the performance of the system but also reduces the cost.

For optimization purpose different techniques are used including artificial neural networks (ANN) and fuzzy logic controller (FLC) to improve the dynamic behavior of the system without the need for exact mathematical modelling. These strategies are considered as intelligent although optimal performances are not guaranteed (Brka, Kothapalli, & Al-abdeli, 2015).In order to minimize the impact of parameter variations and to optimize the control strategy algorithms predictive and optimization based control strategies are also very useful. Therefore, these control strategies with higher complexity are required to be developed that will help more smooth integration of renewable energy in system Chong et al. (2016).

The aim of this paper is to review various optimization techniques that can be used to develop the adaptive controls strategies for controlling the power production form renewable energy sources mainly solar photovoltaic and the charging of HESS. The overall effect on performances of the Renewable Energy Power System (REPS) with different optimization techniques is discussed.