Chapter 60
Revolution of Energy Storage System in Smart Grids

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ABSTRACT

Electrical grid is no longer featured in a conventional way nowadays. Today, the growing of new technologies, primarily the distributed renewable energy sources and electric vehicles, has been integrated with the distribution networks causing several technical issues. As a result, the penetration of the renewable energy sources can be limited by the utility companies. Smart grid has been emerged as one of the solutions to the technical issues, hence allowing the usage of renewable and improving the energy efficiency of the electrical grid. The challenge is to develop an intelligent management system to maintain the balance between the generation and demand. This task can be performed by using energy storage system. As part of the smart grid, the deployment of energy storage system plays a critical role in stabilizing the voltage and frequency of the networks with renewable energy sources and electric vehicles. This book chapter illustrates the revolution and the roles of energy storage for improving the network performance.

1. INTRODUCTION

Conventional power systems have been existence for more than a century. A typical power system inclusive the capability of generating, transmitting and distributing the electrical power to consumers works perfectly in a unidirectional power flow. Today, the growing of new technologies, primarily the distributed renewable energy sources and electric vehicles, has been integrated to the electric networks causing new challenges to the management of the local generations and loads. The developed countries have taken various initiatives to ensure the success of renewable energies implementation. Energy policies are conducted to provide stable regulatory frameworks for renewable energy producers. Renewable energies are recognized worldwide as clean and environmental friendly alternative source of power. The main strategies taken by the developed countries include feed-in tariff and eliminate or reduce fossil fuel

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subsidies. The European government also takes initiatives to encourage the installation of renewable energy sources by introducing tax exemption, incentives, loan, rebates and subsidies. Renewable energy has been adopted globally as one of the alternative solutions to overcome the energy and environment issues. However, the existing distribution networks are designed to operate without the consideration of large deployment of renewable energy sources. In a conventional power system, the power flow is unidirectional; a large amount of grid connected renewable energy has the potential to change the power flow to bi-directional, creating a number of technical issues such as voltage rise, voltage unbalance, reverse power flow. These issues can cause equipment interruption, poor network efficiency and poor supply reliability. Smart grid has been emerged as one of the solutions to enhance the usage of renewable and increase the energy efficiency of the electrical grid. The challenge to development of a more intelligent electrical grid is to maintain the balance between the generation and demand. This task can be performed by using energy storage system.

Energy storage system plays an important role in the power management in the distribution networks with large deployment of renewable energy sources such as photovoltaic (PV) systems and wind turbine systems. Various research projects have identified that the energy storage systems are capable of increasing network reliability during generation and demand fluctuations, maximizing the net revenue of the investors by charging during off peak and discharging during peak hours (Fernandes & Philipp, 1977; Svensson & Halvarsson, 2006). Research has been carried out to investigate the use of energy storage for ancillary services and the feasibility of power quality improvement by utilizing energy storage system (Hajizadeh & Feliachi, 2010; Nguyen & Flueck, 2012).

Generally, energy storage can be integrated at various levels of the electrical networks. At the transmission level, it can be utilized for frequency control whereas at the distribution level, it can be used for voltage control and capacity support without limiting the capacity of the distributed generators. Subsequently, energy storage systems to be installed at the consumer level can provide peak shaving.

2. THE TECHNOLOGY EVOLUTION

Energy storage systems are no longer used only for conventional applications such as storage and backup. A coordinated voltage control scheme integrating the electrical energy storage (ESS) is proposed to solve voltage problems caused by PV, wind generation, and electric vehicles (Wang et al, 2014). Integration of energy storage system into the low-voltage distribution networks is a new concept of improving system capacity and stability (Kashem & Ledwich, 2007). The authors (Yang, Li, Andreas, Zheng, & Michael, 2014) have proposed an appropriate sizing method of the battery-based energy storage system to mitigate the risks of distribution companies with the high penetration of renewable energy sources. Optimal allocation of the energy storage systems can maximize the total economic benefits. It can also create a balance between generation and consumption, so that it can reduce the power exchange at the substation (Zheng et al., 2014). A research project in the UK has proposed to integrate the energy storage system for active network management with wind power (Carr, Premier, Guwy, Dinsdale & Maaddy, 2014). Wind power generation is likely to increase in the near future. The use of energy storage systems is one of the potential methods to accommodate a large amount of wind power deployment without limiting the generation. Various research projects have developed their own control strategy for peak load shaving using the energy storage system (Fernandes & Philipp, 1977; Oudalov, Cherkaoui & Beguin, 2007; Wang, Lin, & Pedram, 2014). During peak load period, the control strategy conveys discharge