

## Review Article

# Global Renewable Energy-Based Electricity Generation and Smart Grid System for Energy Security

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Received 3 June 2014; Revised 24 July 2014; Accepted 26 July 2014; Published 27 August 2014

Academic Editor: Hua Bai

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Energy is an indispensable factor for the economic growth and development of a country. Energy consumption is rapidly increasing worldwide. To fulfill this energy demand, alternative energy sources and efficient utilization are being explored. Various sources of renewable energy and their efficient utilization are comprehensively reviewed and presented in this paper. Also the trend in research and development for the technological advancement of energy utilization and smart grid system for future energy security is presented. Results show that renewable energy resources are becoming more prevalent as more electricity generation becomes necessary and could provide half of the total energy demands by 2050. To satisfy the future energy demand, the smart grid system can be used as an efficient system for energy security. The smart grid also delivers significant environmental benefits by conservation and renewable generation integration.

## 1. Introduction

Economic growth, automation, and modernization mainly depend on the security of energy supply. Global energy demand is rapidly growing, and, presently, the worldwide concern is on how to satisfy the future energy demand. Long-term projections indicate that the energy demand will rapidly increase worldwide. To supply this energy demand, fossil fuels have been used as primary energy sources. Fossil fuels emit greenhouse gases that highly affect the environment and the future generation [1–6]. The emissions largely depend on the emission factor of primary energy sources (i.e., input fuel of the plant). Among all energy sources, the emission factor of fossil fuels (i.e., coal, natural gas, and oil) is very high, as shown in Table 1. Fossil fuels are widely used as the main fuel in power generation. In Malaysia, fossil fuels (i.e., natural gas [53.3%] and coal [26.3%]) serve as major power generation sources, as shown in Figure 1. Large-scale use of fossil fuels, however, greatly affects the environment. Based on the global CO<sub>2</sub> distribution in 2013, the emission breakdown is as follows: coal (43%), oil (33%), gas (18%), cement (5.3%), and gas flare (0.6%) [7].

Meanwhile, renewable energy sources (solar, wind, hydro, geothermal, biomass, etc.) are emission-free energy sources in the world. Renewable energy technologies are an ideal solution because they can contribute significantly to worldwide power production with less emission of greenhouse gases [8–11]. The “sustainable future” scenario of the International Energy Agency (IEA) shows 57% of world electricity being provided by renewable energy sources by 2050 [12]. Long-term forecast and planning is required to achieve this ultimate target [9]. Renewable energy-based power generation and supply to the national grid for a specific zone are necessary. The conventional grid aggregates the multiple networks, and the regulation system consists of various levels of communication and coordination, in which most of the systems are manually controlled [13]. A smart grid is a new concept that leads to the modernization of the transmission and distribution grid. The smart grid system is the digital upgrade of transmission and new markets for the alternative energy generation of renewable energy sources. Presently, smart grid is an often-cited term in the energy generation and distribution industry [14].