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ABSTRACT

A Review of Renewable Energy Supply and Energy Efficiency Technologies

Electricity consumption will comprise an increasing share of global energy demand during the next two decades. In recent years, the increasing prices of fossil fuels and concerns about the environmental consequences of greenhouse gas emissions have renewed the interest in the development of alternative energy resources. In particular, the Fukushima Daiichi accident was a turning point in the call for alternative energy sources. Renewable energy is now considered a more desirable source of fuel than nuclear power due to the absence of risk and disasters. Considering that the major component of greenhouse gases is carbon dioxide, there is a global concern about reducing carbon emissions. In this regard, different policies could be applied to reducing carbon emissions, such as enhancing renewable energy deployment and encouraging technological innovations. Two main solutions may be implemented to reduce CO2 emissions and overcome the problem of climate change: replacing fossil fuels with renewable energy sources as much as possible and enhancing energy efficiency. In this paper, we discuss alternative technologies for enhancing renewable energy deployment and energy use efficiency.

JEL Classification: D61, D62, H23, N50, O13, Q52, Q55

Keywords: energy resources, renewable energy, energy use efficiency, generation technology, carbon emission, green employment

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1. Introduction

Considering that the major component of greenhouse gases (GHGs) is carbon dioxide, there is a global concern about reducing carbon emissions. In this regard, different policies could be applied to reduce carbon emissions, such as enhancing renewable energy deployment and encouraging technological innovations. In addition, supporting mechanisms, such as feed-in tariffs, renewable portfolio standards and tax policies, are employed by governments to develop renewable energy generation along with implementing energy use efficiency for saving energy.

Many countries have started to install facilities that use renewable energy sources for power generation. The importance of alternative energy sources comes together with climate change challenges associated with the excessive use of fossil fuels. There are three primary motivators that stimulate the growth of renewable energy technologies: energy security, economic impacts and carbon dioxide emission reduction. The term “alternative energy” refers to any form of energy other than the conventional sources of energy, including hydropower. In recent years the focus has been on renewable energy sources.

IEA (2012d) refers to two significant global trends that should characterize the deployment of renewable technologies over the medium term. First, as renewable electricity technologies scale up, from a total global supply of 1,454 gigawatts (GW) in 2011 to 2,167 GW in 2017, they should also spread out geographically. Second, the more recent years of high fossil fuel energy use has led renewable technologies to become increasingly competitive on a cost basis with their alternatives in a number of countries and circumstances. According to IEA calculations, wind is the most competitive type of renewable energy technology among the other options, if local conditions such as financing, CO_2 emission levels and fossil fuel prices prove favorable (OECD, 2010).

When talking about clean technologies, there are two primary concepts of energy technologies: energy supply technologies, which refers to alternative sources of renewable energy (e.g., wind and solar power), and energy efficiency technologies, or those technologies which are hired to enhance energy use efficiency, (e.g., combined heat and power (CHP), virtual power plants (VPP) and smart meters). It should be noted that transforming the energy sector and replacing conventional energy with renewable energy is evolutionary associated with technological change and forming markets. Jacobsson and Bergek (2004) indicate that the transforming process for certain forms of renewable energy, such as wind and solar, will happen after 2020, even if the growth rate of consumption is strongly increasing over the next decade. Also, renewable energy markets are not easily formed due to cost disadvantages and the subsidizing of fossil fuels.

The remainder of this study proceeds as follows. In Section 2 we present the different renewable energy supply technologies including solar, wind and hydro power, geothermal and other sources. In Section 3 different energy use efficiency technologies are discussed. These include electric vehicles, combined heat and power, virtual power plants and the application of smart meters. The final section provides a summary and concludes.

2. Renewable Energy Supply Technologies

The renewable energy supply is continuously increasing. A large amount of investment has been made during recent years and the advancement of technology has enabled countries to produce renewable energy more cost effectively. It is forecasted that the number of countries producing above 100 megawatts (MW) of renewable energy will increase significantly by

2017 (IEA, 2012d). Due to some negative and irreversible externalities coming with conventional energy production, it is necessary to promote and develop renewable energy supply technologies. These technologies may not be comparable with conventional fuels in terms of production cost, but they could be comparable if we consider their associated externalities, such as their environmental and social effects. Also, it should be noted that economies of scale could play a key role in reducing the unit production cost. Transmission and distribution costs, as well as technologies, do not differ much among the conventional and renewable energies. Below we present facts about the development of the main renewable energy supply technologies.

2.1. Hydro power

Hydro power is currently the largest renewable energy source for power generation around the world. Hydro electricity generation has had a strong increase over the past 50 years. It was 340 terawatt-hour (TWh) in 1950 and covered about one-third of the global electricity demand. It increased to 1,500 TWh in 1975 and further to 2,994 in 2005. We can compare this to the global consumption of 15,000 TWh of electricity with a global production of 18,306 TWh in 2005 (Ngô and Natowitz, 2009). Currently, hydro power development is difficult due to a large initial fixed investment cost and environmental concerns. Additionally, hydro power has caused problems for local residents associated with the need to relocate large populations, as well as the construction of dams is permanent with a sunk cost of utilities which cannot be removed. The environment is also influenced by hydro power construction because of large engineering works. On the other hand, hydro power is attractive due to a preexisting supply of water for agriculture, household and industrial use, and hydro power is clean and enables the storage of both water and energy. Also, the stored energy can be used for the application of both base-load and peak time power generation.

The largest capacity hydro power plant in the world is the Itaipu Dam installed on the Paraná River and developed jointly by Brazil and Paraguay. The initial capacity was 12.6 GW in 1984, but this has since been increased to 14 GW in 2006 (Ngô and Natowitz, 2009). Many argue that hydro plant construction projects could improve local economies. For example, the US employed thousands of workers to complete the Hoover Dam project, which was constructed during the depression in 1930s (Tester, 2005). Hydro power plays a key role for some countries, such as Norway and Sweden. Based on BP statistics (2012), hydro electricity demand in Norway (122 TWh) constituted almost 64% of the primary energy consumption in 2011, compared to shares of 26% and 8% for oil and natural gas, respectively. Similarly, around 30% of energy consumption in Sweden has been supplied by hydro power (66.5 TWh). China, Brazil and Canada are the top three hydro electricity producers worldwide, with 694.0, 429.6 and 376.5 TWh generated, respectively. Figure (1) shows the general trend of worldwide hydro electricity consumption from 1965 to 2011.