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An overview of renewable electric power capacity and progress in new technologies in the world



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ABSTRACT

In recent years, the atmosphere has been exposed to a substantial increase in concentration of the trace gases. In 2012, energy-related CO₂ emissions reached a record of 31.6 gigatonnes which corresponds to 1.4% comparing to 2011. According to the International Energy Agency (IEA), an energy revolution is needed to achieve a 50% reduction of global CO₂ emissions relative to current levels by 2050. In this revolution, energy efficiency, energy storage, new transport technologies, nuclear energy and CO₂ capture and storage should play a crucial role. Furthermore, renewable energy technologies comprise a large potential for emission reductions which takes second place after energy efficiency improvements. Until 2035, renewable energy will also have greater impact than other potential alternatives including both CO₂ capture and storage or nuclear energy. For this reason, renewable energy industries, markets, and policy frameworks are developed rapidly in recent years, and they will play a substantial role in the world's future. This paper presents an overview of renewable electric power capacity worldwide and discusses the current status, technologies, industry and recent developments of renewable energy sources (RESs) in detail. In addition, the top countries in terms of total installed renewable electric power capacity are also identified.

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1. Introduction

Energy has always played a crucial role in human and economic development [1–4]. It is essential to social and economic development and improved quality of life all over the world [5]. Entering the 21st century, the fast exponential growth and economic growth of the world's population lead to the urgent

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need and large consumption of energy resources [6]. For this reason, global energy demand for energy is expected to increase at a faster rate in upcoming years [7,8].

Energy resources have been classified as nuclear resources, fossil fuels and renewable energy resources (RESs) [9,10]. Nuclear energy can cause serious problems for the human health and environment [11]. Combustible fossil fuels are the world's main energy resource and are at the center of global energy demands. However, neither oil nor any of the other fossil fuels, such as natural gas and coal, are unlimited resources [1,12], and their large-scale consumption is associated with environmental deterioration. Some negative effects of using fossil fuels are ozone layer depletion, acid rain and global climate change. On the other hand, RES is a simple sustainable energy resource available over the long term at a reasonable cost that can be used for any task without negative effects [13,14]. As seen from Fig. 1, renewable electricity can be produced from solar energy through photovoltaics and concentrating solar power, wind energy, hydro energy, geothermal energy, ocean energy and bioenergy. Renewable heat sources include solar thermal heat, geothermal heat and bioenergy. Biofuels can be used in the transport sector [15,16]. Some renewable energy technologies, such as geothermal and hydro, are very mature from a technical perspective. Others, such as advanced biofuel technologies and marine energy, are just emerging from the development, research and demonstration phase, with deployment at scale just starting to happen [17].

Most RESs originate either directly or indirectly from the sun [18]. Renewable energy is the type of energy obtained from non-depletable sources which create relatively a low level of emissions [19–21]. In this regard, renewable energy necessarily differs from other types of energy like fossil fuels, and therefore, many countries all over the world develop different incentives and subsidy schemes to promote its use [22–27]. Increasing global energy consumption and problems caused by intensive use of fossil fuels force countries to use cleaner and more reliable energy sources [28]. Nuclear and renewable energies are the world's fastest-growing energy sources [29]. The growth of renewable energy worldwide began in the 1990s and accelerated greatly in the 2000s [30]. Since 1990, RESs in the world have grown at an average annual rate of 1.7%. Growth has been especially high for solar and wind [1]. For the renewable energy industry USD 260 billion is invested annually since 2011 [30]. In 2012, an estimated

5.7 million people worldwide worked directly or indirectly in the renewable energy sector. At least 138 countries had renewable energy targets by the end of 2012. As of early 2013, renewable energy support policies were identified in 127 countries, more than two-thirds of which are emerging economies or developing countries [31].

Currently, only about 18% of the world's energy demand is supplied from RESs. Indeed, it has been predicted that the technical potential of renewable energy is more than 18 times that of current world's primary energy consumption. Growing interest for RESs from governments has led to substantial development and deployment of renewable energy over the past two decades. In this study, a comprehensive and timely overview of renewable electric power capacity in the world is presented. In addition, the current status, technologies, industry and recent developments of RESs are discussed in detail.

2. Global renewable electric power capacity and technologies

The worldwide mix of primary energy fuels used to produce electricity has changed a great deal over the past four decades. RESs, in particular, non-hydropower renewable resources are the fastest growing sources of electricity production. For example, the installed global renewable electricity capacity has nearly doubled between 2000 and 2011 [29]. While renewable capacity rises at a rapid rate from year to year, renewable energy's share of total generation is increasing more slowly because many countries continue to add significant fossil fuel capacity, and much of the renewable capacity being added operates at relatively low capacity factors [31]. After RESs, nuclear power and natural gas are the next fastest growing generation sources. Coal continues to be the fuel most widely used in electricity production. The use of oil for electricity production has declined since the late 1970s, when oil prices rose sharply.

In RES technologies, various factors have slowed down and limited the spread and development of renewable energies in practice. These include initial and high operation cost; insufficient investment on localization and efficiency improvement of respective technologies and finally dearth of global, regional and local supportive policies. Nonetheless, researchers and industrialists have continuously made abundant strides to diminish, if not to

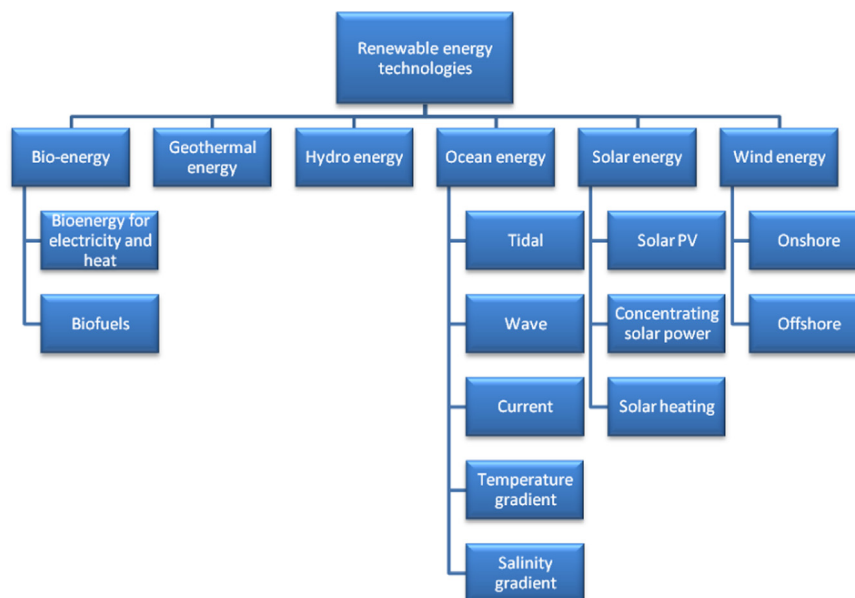


Fig. 1. Renewable energy sources and technologies.

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