

# A Review on Recent Development of Photovoltaics and Wind Turbines

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**Abstract:** Recently, Renewable Energy Resources (RERs) are becoming increasingly more employed for energy generation due to the advancement in power electronics industry, the environmental and economic challenges being faced by the world. Among these RERs are the Photovoltaics (PVs) and Wind Turbines (WTs). The aim of this paper is to discuss the recent development of both PVs and WTs. the figures considered the global development. The figures are obtained from international and local agencies, councils and associations.

**Keywords:** Photovoltaic, Wind Turbine, Renewable Energy Resources, Energy Generation

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## 1. Introduction

The rapid increase in electrical energy demand, environmental challenges being faced by the world, increasing oil prices and climate change concerns have all led to the increasing use of Renewable Energy Resources (RERs) in the generation of electrical energy. Increasing government support such as feed in tariff and efforts in reducing gas emissions also yield to the increase penetration of RERs [1-8]. Enhancing reliability is also considered as an important role of RERs, especially in rural area [9].

Various national and international agencies, councils and associations are interested in quantifying the existing RERs and predicting the future penetration of this equipment in power systems. World Energy Council (WEC) conducts a survey every three years about global energy resources considering technological, economic and environmental aspects assessed on global, regional and country levels. The WEC 2013 report covers all fossil resources such as coal, oil and gas as well as renewable and transitional resources like hydro power, biofuels, solar and wind energies [10]. Renewables information report is another important source of data regarding renewable and waste energies provided by the International Energy Agency (IEA). The 2013 publication provides vital information regarding production, trade,

transformation to electricity and heat, final consumption and installed generating capacity from renewables and waste. Among the renewables considered in 2013 publication are the hydroelectricity, geothermal, solar photovoltaic, solar thermal, wave, ocean, wind, solid and liquid biofuels, biogases and renewable municipal waste [11].

The Global Market Outlook for Photovoltaics 2013-2017 report written by the European Photovoltaic Industry Association (EPIA) and the Global Wind Report Annual market update 2012 published by the Global Wind Energy Council (GWEC) are another important source of information regarding the recent penetration and future proliferation of Photovoltaics (PVs) and Wind Turbines (WTs) in the world, respectively [12, 13].

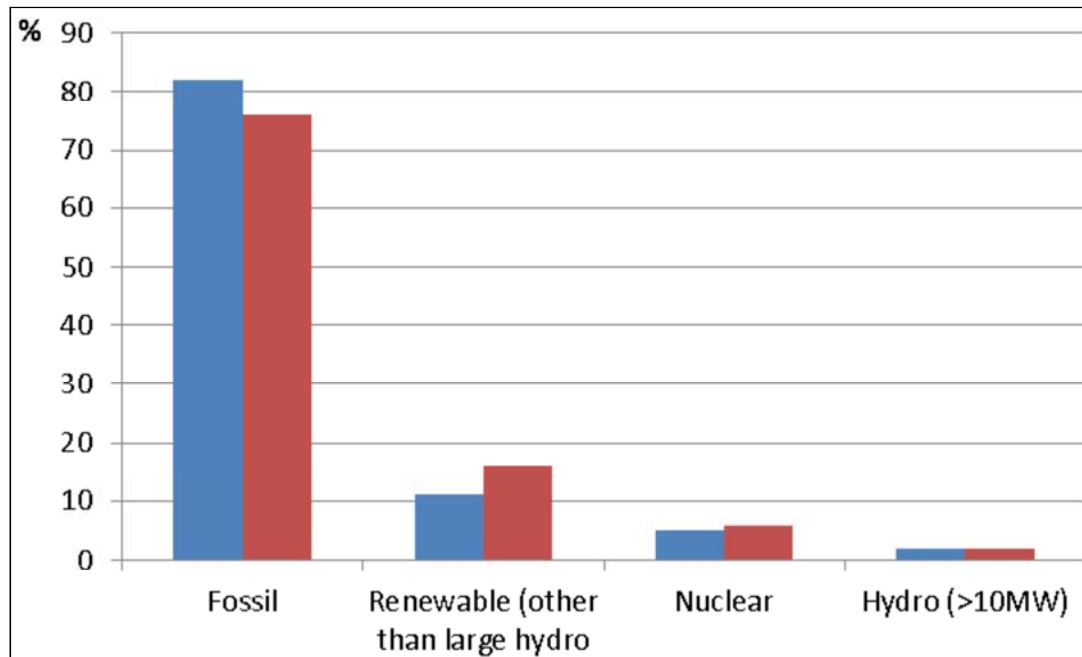
The paper is organized as follows: section II presents important information about RERs. Section III discusses PV development. WT development is introduced in section IV. Finally, section V presents the summary and conclusions.

## 2. Renewable Energy Resources

According to [14], RERs accounts for up to 19% of the total world electricity generation in 2008. [14] defines renewable energy as the energy produced by natural resources such as wind, sunlight, wave, biomass, geothermal and water falls [14, 15]. According to [10], renewable resources accounted for

11% of the total world primary energy supply in 2011 and forecasted to constitute 16% in 2020. If large hydro is included, percentages would be 13% and 18%, respectively.

Figure 1 shows the energy supply by resource in 2011 and 2020.

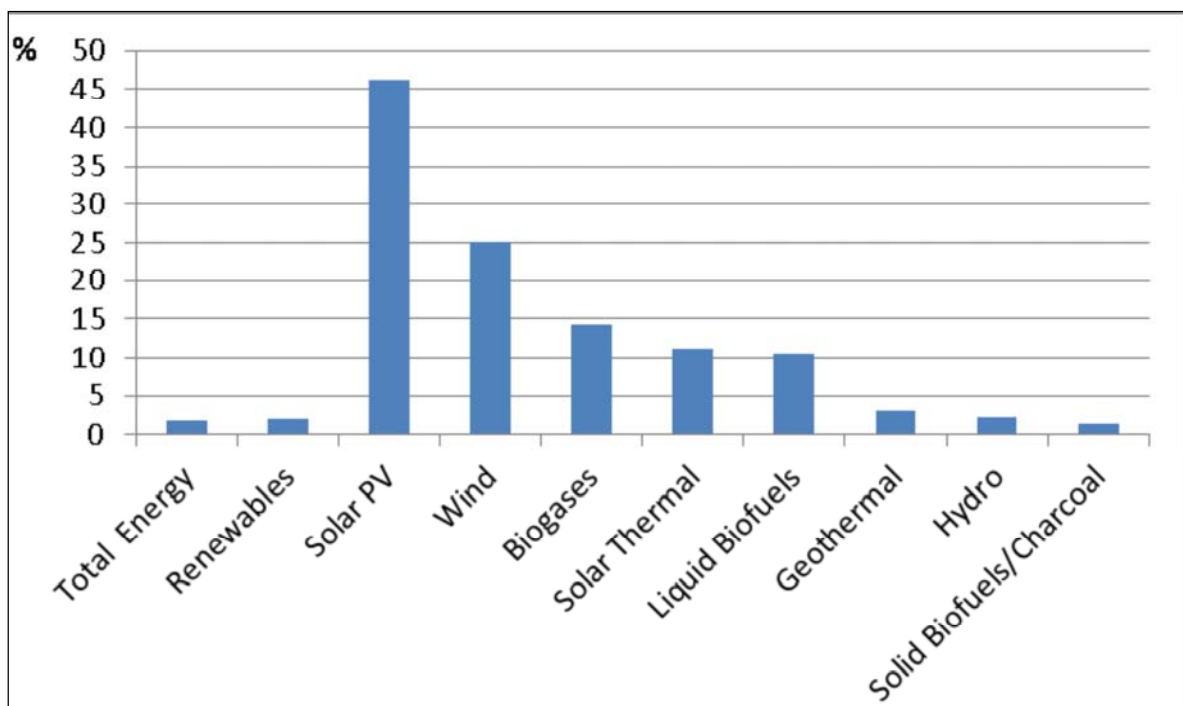


**Figure 1.** Energy supply by resource in 2011 (blue) and 2020 (red).

Moreover, the EU plans to obtain 20% of its energy needs from renewables by 2020 [16, 17]. Another plan has also been adopted in the US to generate 25% of their energy from renewables by 2025 [17].

IEA conducted a survey in 2013 that considered the percentage increases of renewables from 1990 and 2011 as shown in Figure 2. It is also concluded that in 2011,

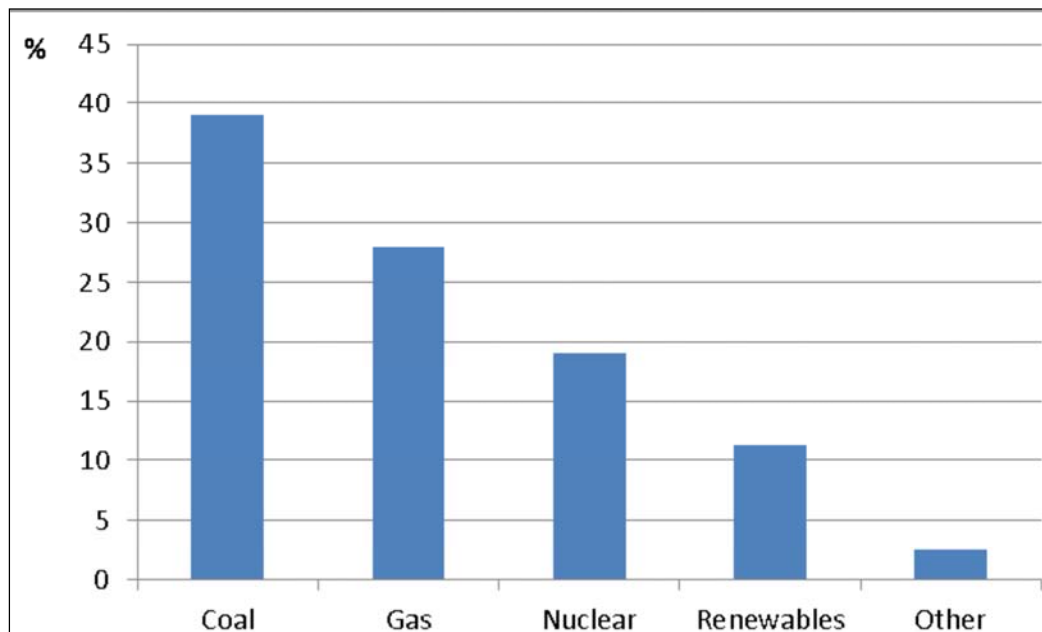
renewables accounted for up to 13% of the global total primary energy supply and 20% of the global electricity generation [11]. Figure 2 also illustrates that renewables grew by 2.0%, slightly faster than the total primary energy supply that rose by 1.9%. However, it can be seen that solar PV and wind are the fastest growing renewables that dramatically increased by 46.2% and 25.2%, respectively.



**Figure 2.** Percentage increases of renewables from 1990 and 2009.

The Department of Energy and Climate Change in the UK said that in 2012 the total energy produced by RERs rose by 19% compared with the previous year and accounted for

11.3% as shown in Figure 3. This is mainly due to the 27% and 63% increases in onshore and offshore wind energy, respectively, and a 71% increase in PV capacity [18].



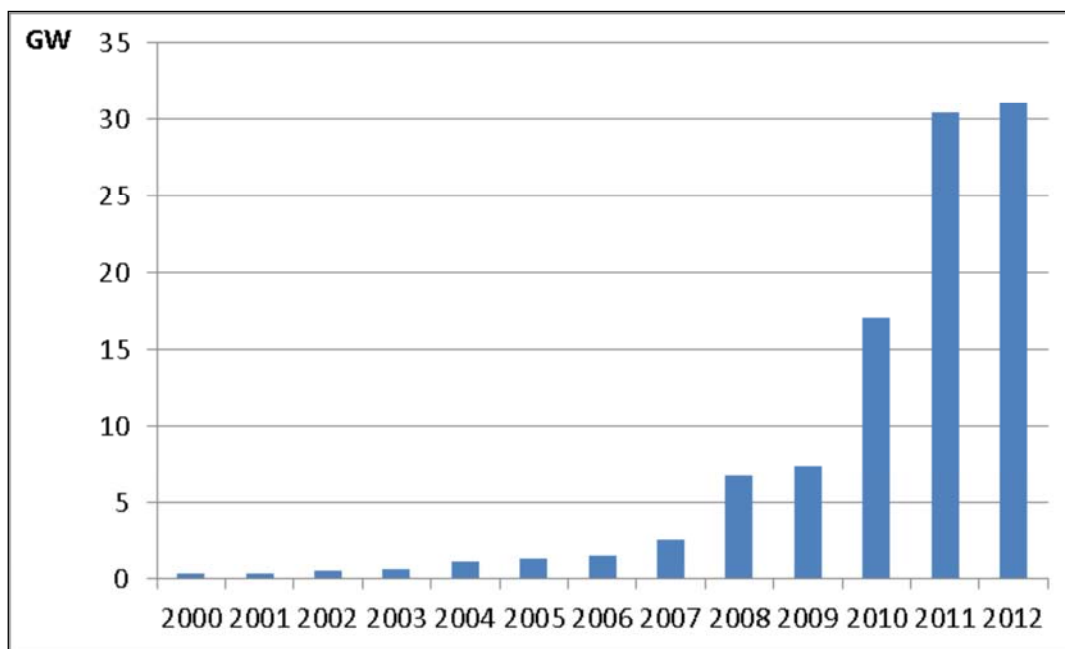
*Figure 3. Electricity generation by fuel.*

Therefore, the focus of this paper is on the latest development of PVs and WTs as it has been shown that they are the fastest growing renewables for energy generation.

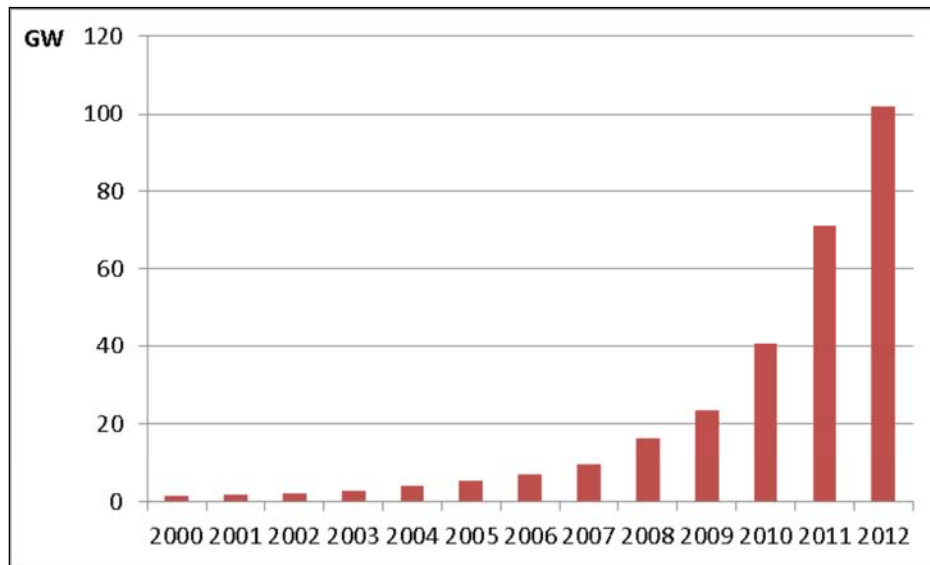
### 3. Photovoltaics Development

Among various sustainable power generation methods, PV arrays are becoming increasingly employed around the world.

EPIA, the world's cumulative installed PV surpassed 100 GW in 2012 [12]. Figures 4 and 5 show how PV annual and cumulative installed capacity rose sharply between 2000 and 2012. According to [10], the sun emits  $3.8 \times 10^{23}$  kW/s energy and only  $1.08 \times 10^{14}$  is received by the earth surface. If only 0.1% of this energy is converted into electrical energy with 10% efficiency, this energy would be enough to generate fourfold the world total generation capacity



*Figure 4. Global PV annual installed capacity.*



*Figure 5. Global PV cumulative installed capacity.*

As long as the Policy-Driven scenario is considered, EPIA estimates that the global annual and cumulative PVs in 2017 would be 84,240 MW and 422,890 MW, respectively [12]. Furthermore, EPIA claims that in 2012, global rooftop PVs account for 21,622 MW and it is forecasted using EPIA Policy-Driven scenario to rise up to 48,000 MW in 2017. On the other hand, global utility-scale PVs generated 9473 MW in 2012 and could reach 36,240 MW in 2017 [12]. According to IEA, PV systems could contribute with up to 16.8% of the world energy demand by 2040 [19].

#### 4. Wind Turbines Development

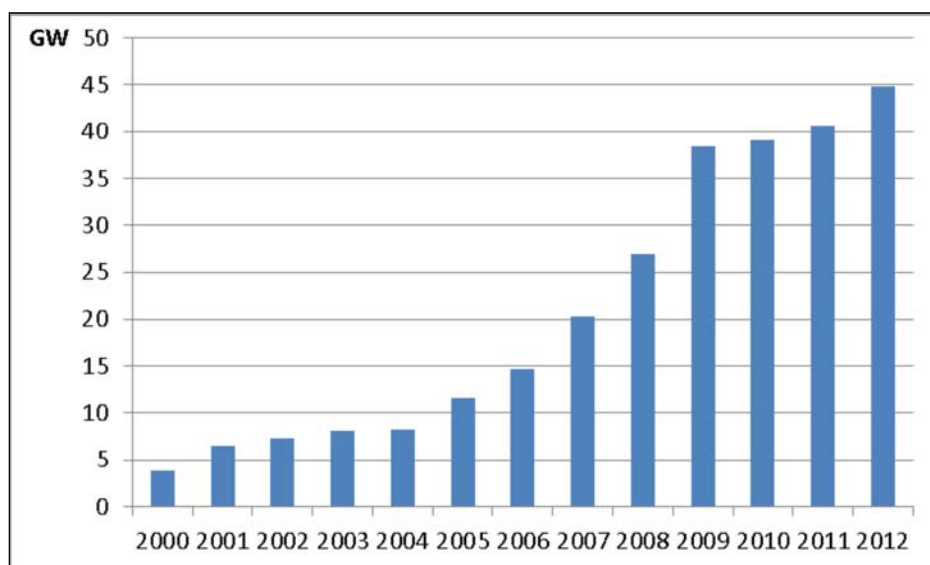
Wind is mainly generated as a consequence of different air pressures that happens when the sun emitting energy causing unequal heat on the earth surface [20, 21]. It has been estimated that if a total land coverage has a 1000 TW of wind energy. If 0.1% was used and load factors of 15-40% were

considered, then this energy would also be enough to generate the world total electricity generation capacity [10]. Therefore, wind is an excellent source of energy. This has led to the vast use and development of WTs as renewables.

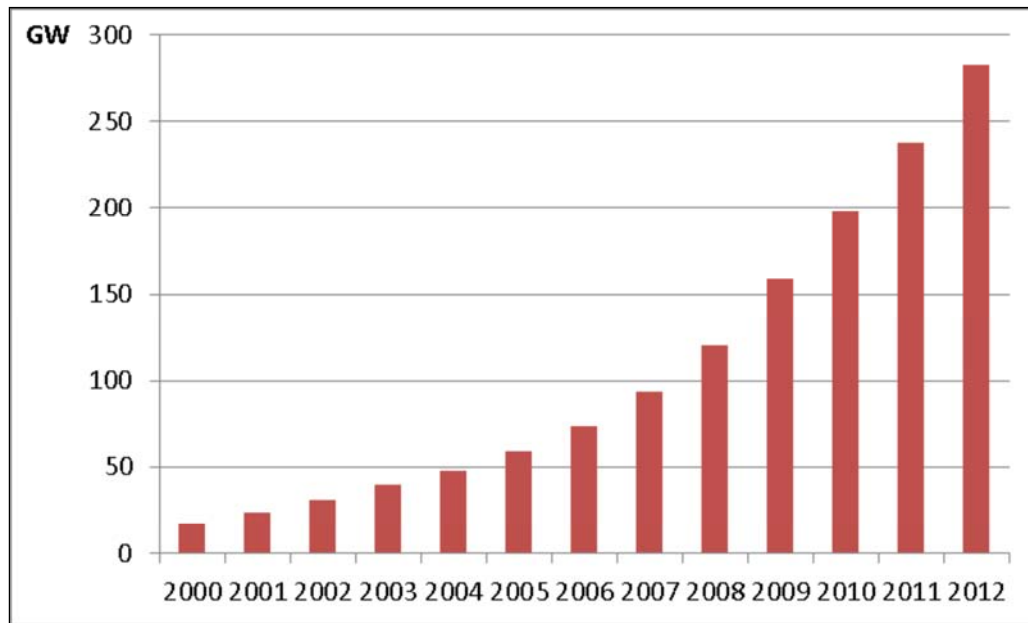
Figures 6 and 7 show how WT annual and cumulative installed capacity rose sharply between 2000 and 2012 [13].

WT generate electric power by converting wind kinetic energy into mechanical energy by means of rotor blades, and then a generator within the WT is responsible for transforming the mechanical energy into electrical energy [22].

It has also been estimated by the Global Wind Energy Council (GWEC) that by 2017, the total cumulative installed wind capacity will rise by 89.72% compared to 2012 to reach 536.13 GW [13]. Moreover, according to [20], in the European Countries, wind will contribute to more than one third of the renewable energy resources capacity by 2020 and about 40% by 2030. Furthermore, [23] predicts that 35% of all renewables in 2020 will be wind energy.



*Figure 6. Global annual installed wind capacity.*



**Figure 7.** Global cumulative installed wind capacity.

## 5. Conclusion

Due to the continuous increase of energy demand, oil prices, gas emissions and climate change concerns, RERs have increasingly used in the generation of electrical energy. Among these RERs, PVs and WTs are promising sources of power that definitely help in improving power system reliability and quality.

This paper gives important information regarding the recent development of RERs, especially PVs and WTs. It has been shown that both PVs and WTs are considered a vital source of energy nowadays and will play an important role in the near future.

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