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WIND ENERGY: ANALYSIS of THE TECHNOLOGICAL POTENTIAL and POLICIES in TURKEY

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ABSTRACT
At the beginning of the 21st century, due to increase in fossil fuel prices and environmental concerns, many countries started to invest in alternative energy resources. In addition, global environmental problems and climate change due to greenhouse gas emissions from fossil fuels showed the importance of renewable energy resources, especially wind energy. The major reason for this interest in wind energy technologies is the bulk availability of this resource without any cost.
Due to increasing demand for wind energy, the technology and know-how in this field is increased expeditiously in this field. However, in order to increase the efficiency of wind turbines most of the system components must be enhanced. The research and development in this area mainly focuses on the turbine components such as blades, gear box, tower structure, control system, and generator technologies. Out of these, turbine, blade, and generator are the most important. The technological improvements or the next major breakthrough in wind turbines will be directly related to the increase in the capacity of these systems and their related size.
In this paper, advancements in wind energy systems are investigated in detail by focusing on advantages and major problems in these systems, and analysing the current and future wind energy applications and policies in Turkey.
Keywords: Energy Technologies, Renewable Energy, Wind Energy, Wind Turbine

1. INTRODUCTION
Wind is one of the most important renewable energy sources, and mankind has been seeking various options to harness this energy for a long time [1]. Utilising 1% of the energy available in earths wind spectra (per annum) could easily supply annual global energy demand [2]. In the last 30 years, there has been an increasing will in the utilisation of wind energy for electricity production [3], due to economical and social reasons [4].
In the beginning of 1900's, only 10% of the energy available in the wind spectra could be converted into mechanical energy, however, today this ratio increased almost to 50%, with the help of modern energy conversion systems [5]. Advances in wind turbine design and reduction in material costs, price of wind based electricity decreased from 35 cent/kWh in 1980 to 5 cent/kWh in 1997 [6]. Under current conditions, wind energy is becoming a leading alternative to fossil based fuels for electricity production [7].

Due to the increase in the demand for wind energy the technology and know-how in this field is increasing exponentially. In the literature, there are many investigations related to wind energy technologies [3,8,9,10]. In order to increase the efficiency of wind turbines most of the system components must be enhanced. The research and development in this area mainly focuses on the turbine components such as blades, gear box, tower structure, control system and generator technologies. Out of these, the turbine, blade and the generator are the most important. The

technological enhancements in wind turbines are directly related to the increase in their capacity and related size. The wind turbines are designed either as vertical or horizontal axis. Based on the location, wind spectra and the operation of use these two types of wind turbines have their unique advantages and disadvantages. Although, horizontal axis wind turbines are the most common configurations, vertical axis systems can also be used in various applications. The number of blades and their size directly affects design of the turbine and hub structure. Aluminum, steel, fiberglass, wood and composite materials are used for blade design, though wood is not used any more as a material of construction for wind electricity production systems but for water pumping in rural areas in the form of wind pumps. Horizontal axis wind turbines are designed generally as three blade conformations due to the balance between power production and torque, in addition the visual appearance of such systems are more eye-friendly. Thus, three bladed systems have the biggest share in global wind energy market.

Gear box, is believed to be the most troublesome point of wind turbines, most of the problems happens in the gear box due to sudden changes in wind speed and related power adjustments. In the literature, there are various solutions and opinions related to these problems. Various components and operating parts of the wind turbines are monitored through control systems. Instantaneous position of generation, different temperature at the generator, rotor and generator rpm are the basic control parameters. The basic purpose of control systems is to optimize power generation in wind turbines. Various control techniques found in the literature is analyzed based on power optimization.
In this paper, the global wind energy market is reviewed based on this agenda. Then, advancements in wind energy technology systems are investigated in detail by focusing on the advantages and disadvantages of these systems in wind energy applications of Turkey.

2. GLOBAL WIND ENERGY MARKET

Electricity production from wind energy has been steadily increasing since 1990's. At the end of 2008, global installed wind energy capacity was 121,188 MW, and it was predicted this capacity would be doubled by the end of 2012 [1]. Today, the United States is the world leader in installed wind energy capacity with 31,109 MW and there is 5567 MW of wind energy power plant is under construction [12]. China, India, Germany, Spain and Italy are following United States in the wind energy market as global players.

3. WIND ENERGY IN TURKEY

Turkey is a major energy importer [13] and 60% of the electricity consumption is satisfied from these imports [14]. Like any other developing country Turkey's energy demand is increasing steadily. Under these conditions, in order to gain energy independency and obtain healthy sustainable growth Turkey must invest in renewable energy sector. The geographical location and its climate provide various advantages for renewable energy investments and production in Turkey. Therefore, in order eliminate dependency on foreign petrol and tackle environmental problems related to the consumption of fossil fuels, Turkey must start investing in renewable such as wind, solar, biomass and geothermal [15]. Feasibility studies confirmed that Turkey has a great potential for wind energy production [16]. Theoretically, Turkey's wind energy potential is 160 TWh, annually, which is twice the annual consumption [17]. In addition, technical wind energy potential of Turkey is estimated as 48000 MW [18]. However, Turkey could not utilize this potential efficiently and wind energy investments are far behind US and Europe.
In Turkey, wind energy investments started in 1995 based on build-operate-transfer model at small scales. The first wind energy farm in Turkey was constructed by Demirer Holding in Cesme Germiyan, with installed capacity of 1.74 MW [19]. In the last 15 years, wind energy capacity of Turkey increased 430 times and reached to 760 MW [20].
Although there are various advantages of wind energy, which is highly documented in the literature there are also some serious disadvantages that this renewable energy source upholds. Therefore, before making any judgment and future plans for the utilization of this renewable energy source these disadvantages must be well understood.

4. WIND ENERGY TECHNOLOGIES

At the beginning of the 21st century, due to increase in fossil fuel prices and environmental concerns, many countries started to invest in alternative energy resources. In addition, global environmental problems and climate change due to greenhouse gas emissions from fossil fuels showed the importance of renewable energy resources, especially wind energy. The major reason for this interest in wind energy technologies is the bulk availability of this resource without any cost.
In order to increase the efficiency of wind turbines most of the system components must be enhanced. The research and development focuses on the turbine components. Distributed generation is not a widespread generation area in Turkey. Commercial wind turbine type is the most common configurations. Horizontal wind turbines are design to work on upcoming wind spectra and systems, which utilize reverse current is very rare. The most important advantage of upwind systems is the elimination of wind turbulence, which is most common in down wind machines. However, horizontal systems require yaw and pitch mechanisms and advanced breaks to control the upwind and produce the required power output. According to many researchers, upwind horizontal wind turbines are the most suitable systems to be operated at Turkey. Vertical axis systems are designed to operate where, rotor shaft is arranged vertically. The most important advantage of these systems when compared to horizontal axis wind turbines is that these systems do not require to be pointed directly into upwind to be effective. In locations where the speed of the wind changes instantaneously these systems can be used. However, vertical axis systems have low rotational speed and higher costs compared to horizontal axis wind turbines [3].

Wind power has been converted to electrical power by using a gearbox and an induction generator. Turbines generally have a three-stage gearbox which is constituted gears and parallel shafts. Various control techniques found in the literature is analyzed based on power optimization. Some of these techniques are fixed or dynamic pitch speed controlled wind turbines, pitch-angle controlled wind turbines, and torque controller using stator current demand. In order to improve stability and reliability of wind farm, static reactive power compensator (STATCOM) and dynamic braking resistor (DBR) is used.

5. CONCLUSION AND RECOMMENDATIONS

In Turkey, the major solution to the dependency on foreign energy resources is domestic production, development and operation of renewable energy resources. Wind energy is the most important resource of renewable energy resources. In Turkey pay back guarantee for renewable sources, in this case wind based electricity is around 5-5.5 eurocent per kWh [24]. However, comparing the purchasing power this value is very low compared to European Union counterparts. Thus, in order to increase or promote wind energy investments in Turkey the purchase guaranteed price of wind based electricity must be increased and incentives must be given to the investors. It is believed that the guaranteed purchase of wind based electricity should be around 10 eurocents per kWh to promote these investments.

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