An Overview of Wind Turbine Manufacturing Experience in Turkey

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ABSTRACT

While wind energy has been utilized by windmills for ages, 1970s oil crises was a turning point for many developed governments to initiate massive efforts to develop modern wind turbines. Starting from almost none in early 1980s, the installed wind power capacity has reached 159.2 GW globally by the end of 2009. While the use of wind turbines for general power utilization dates back to 1986 with a 55 kW capacity, it took another decade for wind farms to appear in Turkey. The Electricity Market Regulatory Authority (EPDK) started accepting wind power production licenses in 2007 reaching to a total of 78 GW wind capacity. As of today, the installed wind power capacity of Turkey is 1329 MW. The Electrical Power Resources Survey and Development Administration (EIEI) plans for a total of 20 GW wind energy within 10 years. In line with the global trend, it will be realistic to estimate Turkish wind market to reach 40 GW before 2030. There is extensive industrial infrastructure that will support production of large wind turbines in Turkey. However, due to lack of turbine technology and know-how only a limited portion of this infrastructure is used towards wind turbine production. Recently Ministry of Energy has initiated the National Wind Energy Systems Project (MILRES) with funding from TUBITAK (The Scientific and Technological Research Council of Turkey). The project aims to develop turbine technologies up to 2.5 MWs as well as to coach potential component manufacturers to develop production capabilities for large turbines.

Keywords: *Renewable energy, wind, turbine, technology, Turkey, MILRES.*

1 GLOBAL WIND ENERGY VIEW

As it is known, wind energy has been harvested by windmills for many ages. It was 1970s oil crises that led developed governments to search and initiate massive alternative energy resources. Wind energy has been a clean and feasible option. Two leading countries are Denmark and Germany. The Danish government started with two R&D projects: the Nibe A and Nibe B. Both turbines were 3-bladed 630kW upwind designs based on the so called Gedser turbine. Investment cost was about 3 million USD for each project [1]. Similarly, Germany spent over 100 million DM to develop its first 2 MW prototype. Starting from almost none in early 1980s, the installed wind

power capacity has reached 159.2 gigawatts (GW) globally by the end of 2009 [2]. It should be noted that a 7 MW stand-alone wind turbine prototype is being developed. As shown in Figure 1, the industry has gained such a momentum that installed wind capacity doubles every three years [3]. Therefore, this trend can be taken as a guideline for projection of wind energy demands. In fact, this approximation curve will be used for Turkey's future plans.

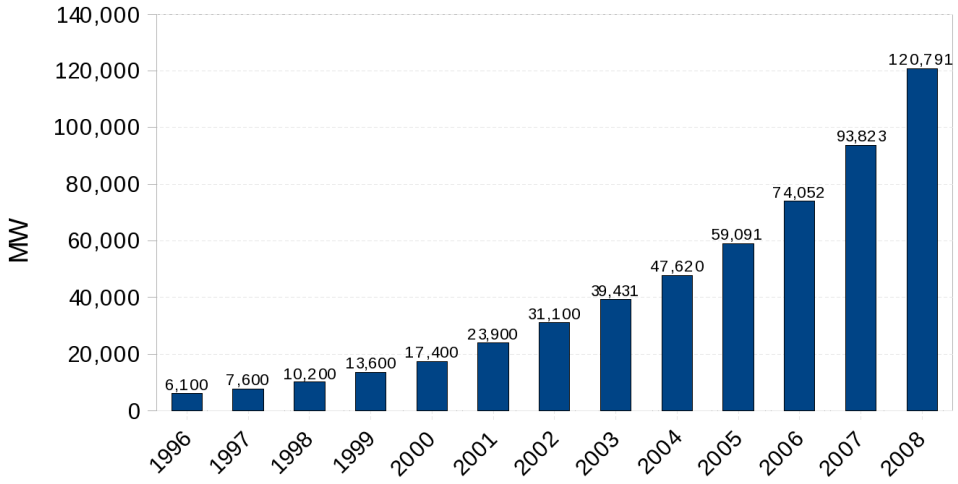

Figure 1. Growth of installed global wind power capacity.

2 A HIGHLIGHT OF TURKISH WIND ENERGY MARKET

A study by the Turkish Ministry of Agriculture showed that there were 41 windmills for generating electricity in 1961. These were mostly used for small power needs such as early radio sets in the Anatolian countryside. A later survey in 1979 revealed 23 electricity producing turbines with capacities lower than 1 kW [4,5].

While the use of wind turbines for general power utilization dates back to 1986 with a 55 kW capacity system at a hotel in Çeşme-Izmir, it took another decade for wind farms to appear in Turkey. The first wind farm with three 500 kW turbines went online near Alaçatı-Izmir in February 1998. However, detailed wind maps were needed for the development of wind resources in Turkey.

The first national wind energy potential map has been published in 1984 followed by a second version in 2002. However, these maps were very rough. They did not have the details and resolution needed by the wind market. The latest version has been issued in 2006 with 200x200 m resolution [6].

Following the publication of wind maps by the Electrical Power Resources Survey and Development Administration (EIEI), The Electricity Market Regulatory Authority (EPDK) started accepting wind power production licenses on November 1st 2007. License applications reached a total of 78 GW wind capacity. So far, the Electricity Market Regulatory Authority has issued wind power generation licenses for a total of 3910 MW. As of today, the installed wind power capacity of Turkey is 1329 MW [7].

The scale of the license applications also reflects the potential growth for wind energy market in Turkey. The Electrical Power Resources Survey and Development Administration (EIEI) plans for a total of 20 GW wind energy connecting to Turkish power grid within 10 years. In line with the global trend which indicates doubling of installed wind capacity every 3 years, it will be realistic to estimate Turkish wind market to reach 40 GW size before 2030. With current market value of 1 million Euro cost of wind turbine per MWs, the Turkey is expected to spend 55 billion USD next 20 years for the turbines alone. Currently, almost all industrial scale wind turbines are imported.

Funneling such large amounts of resources abroad would not be economically viable. Therefore, domestic productions of wind technology and turbine systems are necessary.

3 TYPICAL HORIZANTAL AXIS WIND TURBINE COMPONENTS

Wind turbines can be broadly classified as in-land and off-shore types, and can also be divided into horizontal and vertical axis operating systems. They are complex electromechanical systems involving large forces and massive structures. A typical 2.5 MW turbine may reach 90 m in tower height, 100 m in blade span and over 100 tons in nacelle weight. Such large systems require extensive investment in infrastructure and manufacturing equipment. A wind turbine consists of the following main components: tower, nacelle, blades, and power modules. The nacelle houses the following subsystems: hub, main shaft and bearings, gear box, generator, inverter and transformers, cooling system, control and hydraulic systems. Figure 2 shows schematic of a typical turbine [8].

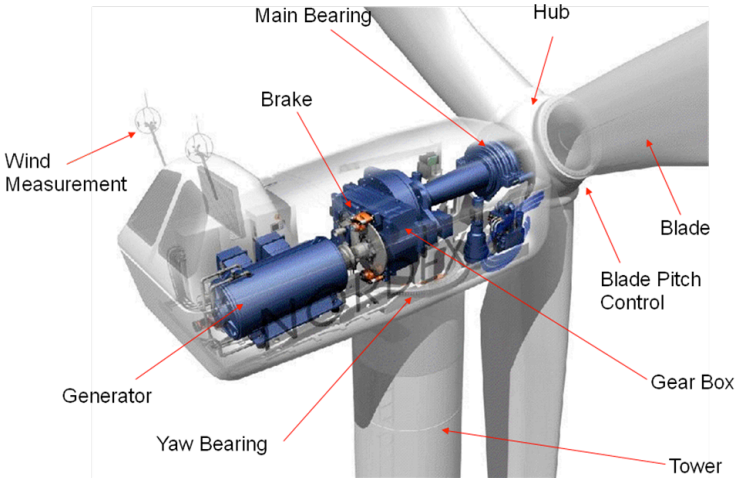

Figure 2 - Components of a typical wind turbine as illustrated on NORDEX N80.

4 TURKiSH WiND TURBiNE MANUFACTURiNG EXPERiENCE

Wind energy industry is its early stages in Turkey. Therefore, there is no large industrial scale (over 2 MW) turbine manufacturing in Turkey. However, there are some manufacturers producing smaller scale machines. One company in Ankara is currently manufacturing its first 1.650 MW turbine under a foreign license. There are several companies trying to develop their own turbine technologies. These companies are many located near cities of Istanbul, Ankara and Izmir. Typically, these turbines are below 100 kW range. Among the turbine manufacturers which are focused on developing their own technology there are two which are known to have turbines over 100 kW. One of them is near Ankara which has ongoing efforts to develop 200 and 500 kW prototypes. The other company in Ankara which has already built its first 300 kW working prototype using a novel/patented blade construction with 3.2 lift coefficient [9]. An installation scene is given in Figure 3. This turbine is designed to achieve an extremely low cut-in speed of 1.5 m/s and to reach full load at 10 m/s wind speed. However, all three turbines have fixed wing attachments without blade pitch control. Government support is necessary to develop 2.5 MW large turbines or their major components. It must be noted that many small components are readily produced by many companies in Turkey. These components include bolts, nuts, cables, switches, circuit breakers, servo motors, high voltage transformers, hydraulics and brakes, cooling systems

etc. The existing industrial infrastructure for large turbine components will be discussed one by one in the following section.

Figure 3 – Installation of the first 300 kW wind turbine developed in Turkey [9].

4.1 Manufacturing of Blades

The composite blades for a 2.5 MW wind turbine can reach 40-50 m in length. There is extensive experience in Turkey in manufacturing of large composite structures such as composite boats and large water slides. However, adopting this experience to wind turbines requires large investments and development costs. A single mold for a typical 45 m blade may easily cost 2 million Euros. Therefore, companies prefer foreign partnership or manufacturing under license. There are two companies that are currently producing wind turbine blades under foreign license in Turkey. Both of these companies are located in Izmir. The first company is established in 2002 as a joint venture with Enercon GmbH. It has annual capacity of 1000 pieces of 22 m blades for E44/E48 turbines. These turbines are relatively small, producing power in 600-900 kW range. The other company produces blades under Fuji Heavy Industries license. This manufacturer is producing 39 m long blades for 2 MW turbines. Recently, a third company in Antalya has signed licensing agreement with a European turbine producer. The company has background and experience in large composite boats and waterslides manufacturing. They are planning to produce blades for 1.5 - 2 MW turbines.

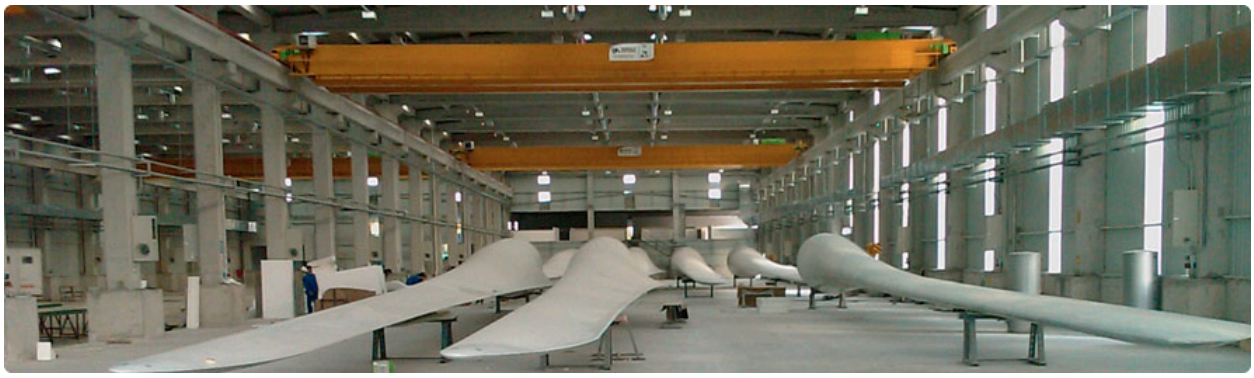

Figure 4 - A view of turbine blade manufacturing plant in İzmir [10].

4.2 Manufacturing of Towers

Turkey has very developed construction and steel industries. Therefore, there are many companies that are capable of manufacturing wind turbine towers. Some of these companies are

already producing towers for foreign turbine manufacturers. The most well know is a company located in Gemlik [11]. It is producing towers for Enercon GmbH and GE Wind Energy. The company has produced over 890 units totaling in excess of 700 MW capacity. Another company recently (2009) partnered with an Italian producer to manufacture towers up to 100 m size. The number of tower producing companies is expected to increase in the near future. Yet another company in Bursa is in the process of producing its first wind turbine tower.

4.3 Manufacturing of Gear Box

Gear box is one of the most challenging components in large wind turbines. As turbines get larger, rotor speeds get slower. This requires gear box ratios well over 100 under extreme torque values. Gear boxes in most large turbines have service periods of 3 years or less. Although there are dozens of gear manufactures in Turkey, only a few can produce MW size gearboxes. All but one has no experience in producing gear boxes for wind turbines. Wind turbines require special planetary gears that are hard to produce. The only Turkish company that has produced gear boxes for wind turbines is located in Izmir. The company has produced 650 kW gear boxes for a wind farm in Turkey. Two other large gear manufacturers are located in Hadımköy and Beylikdüzü near Istanbul. The company with the capacity to produce the largest gears in Turkey is located in Tuzla near Istanbul. The company has produced custom gear boxes up to 3 MW, and capable of producing gears 7 m in diameter [12].

4.4 Manufacturing of Rotor Hubs

Turkey has the 6th place in Europe for casting capacity. There are over 1400 foundries; however, number of companies which can produce castings over 20 tons per piece is limited. One of the largest of such companies is located near Ankara [13]. The company is capable of producing casting up to 30 tons. The company has produced hub castings for foreign wind turbine manufacturers. There are two other companies which can produce castings over 20 tons per piece. One of these companies is located in Bursa, and the other is in Izmir.

4.5 Manufacturing of Generators

There are several companies capable of producing 500 kW generators in Turkey. One of them is near Balıkesir while a couple of them is located in Istanbul. Two of these companies are aid to have capability to produce generators in 1 MW range. A government owned company has equipment and infrastructure in its Diyarbakır plant capable of fabricating generators up to 32 MW and 13 m in winding diameter. However, this equipment has never been used, and company needs generator know-how to produce large generators. Production of permanent magnet generators is almost nonexistent in Turkey.

5 CONCLUSıON

There is extensive industrial infrastructure that will support production of large wind turbines in Turkey. However, due to lack of turbine technology and know-how only a limited portion of this infrastructure is used towards wind turbine production. Most companies are importing know-how via partnerships and licensing. However, these turbines are typically smaller turbines (less than 2 MW) that are being phased out of production in the United States or Europe. Manufacturers in the developed countries are already producing turbines beyond 5 MW range. In order to get in global the wind turbine markets the required technology for larger wind turbines should be domestically developed. Due to massive scales of such turbines large investment costs are involved. Following Denmark and Germany examples in early 1980s, government support is needed through the

learning curve and development phases. Recently Ministry of Energy has initiated the National Wind Energy Systems Project (MILRES) with funding from TUBITAK (The Scientific and Technological Research Council of Turkey). The project aims to develop turbine technologies up to 2.5 MWs as well as to coach potential component manufacturers to develop production capabilities for large turbines. The project team includes researches from several universities and research institutes, including Turkish Aerospace Industry (TAI), Tubitak-Marmara Research Center and Istanbul Municipality Transportation A.Ş.

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BIOGRAPHIES

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