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The evaluation of feed-in tariff regulation of Turkey for onshore wind energy based on the economic analysis

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ABSTRACT

Renewable energy sources have become popular with the technological developments, the increase in the price of fossil fuels and the environmental concerns. These factors have also prompted Turkey to utilize her rich renewable energy sources to meet her increasing electricity demand which is around 7% annually. Therefore, the Renewable Energy Law was enacted in 2005 to incentivize the utilization of domestic renewable sources with feed-in tariffs. In this study, onshore wind energy potential of Turkey is analyzed to find out whether these regulations and incentives will help the utilization of onshore wind energy potential. To that end, some background information about technology and cost of onshore wind power plants, the wind energy potential of Turkey and the current regulatory framework related to wind energy are explained. Then, a model is set up to conduct economic analysis by calculating NPV for the base case scenario and under the uncertain environment. The results show that an onshore wind energy potential of about 13 GW having a wind speed of 7.5 m/s or higher can be utilized profitably with the current feed-in tariff as the wind capacity of more than 100 GW cannot be utilized economically.

1. Introduction

Wind energy has become very popular in the last few years due to the environmental concerns, the increase in the price of fossil fuels and the desire of the developed countries to decrease their dependence on foreign fossil fuels. In addition to these developments outside the sector, the decrease of the cost of wind-generated electricity has supported the popularity of wind energy. As a result, wind energy that is abundant and inexhaustible has become the world's fastest growing energy source (Ilkilic and Turkbay, 2010). The same problems are also valid for Turkey especially in terms of the reliance on foreign sources with a share of around 75% in the primary energy consumption (Akdag and Guler, 2010). In addition to high dependence on foreign energy sources, the burning of fossil fuels to produce electricity causes environmental problems. Therefore, the utilization of renewable energy sources is the best option to meet the electricity demand in the future.

The economy of Turkey, one of the world's first 20 largest economies, is dynamic and grew significantly in the past few years despite the last global economic crisis. As a result, the electricity demand is continuously increasing, which compels the construction of new power plants necessary to meet the increasing demand. For example, the electricity demand increased by 5.3% annually between 2000 and 2009 despite the adverse effect of the global economic crisis in 2008 and 2009 (TEIAS, 2010). In addition, TEIAS (2010) forecast about 7% annual increase in the electricity demand for the next decade. To meet this significant increase in demand, Turkey has to install as much as 35–60 GW of capacity by 2020 which is a very large number compared to the current installed capacity of 44.7 GW as of 2009 (TEIAS, 2010; Kaygusuz, 2011). Unfortunately, Turkey does not have domestic fossil fuel resources, except some low quality lignite, to feed this capacity and currently she is highly dependent on foreign energy sources.

On the other hand, Turkey has a very high renewable energy potential, especially for wind energy. In fact, she is the first ranked country in Europe in wind energy potential (Kenisarin et al., 2006). Therefore, the utilization of wind energy sources is the best option to meet the extra electricity demand in the future. Based on these concerns, the Renewable Energy Law was enacted in 2005 to incentivize the renewables by setting the feed-in tariffs which were revised in 2007 and 2010 with the amendment of the mentioned law. These regulations have helped the wind energy installed capacity to increase from 10 MW in 2005 to 1367 MW as of March 2011 (EMRA, 2011) though the share of wind energy is still very low.

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The most important characteristic of the sector is that the market share of public is still very high despite the privatization efforts since 1984 and the liberalization process that started in 2001. The state controls 54% of the installed capacity directly and 21% indirectly through the systems which are Build–Operate–Transfer (BOT), Build–Operate (BO), and Transfer of Operational Rights (TOR) contracts (TEIAS, 2010). The share of privately controlled capacity is only 25% which belongs to autoproducers and independent power producers (IPP). This market structure is one of the most important obstacles against the free market because the state can easily control and determine electricity price which should be determined in the market to institutionalize the free market framework.

In addition to the shares of different players in generation sector, the weight of different sources helps to understand the structure of the sector. Currently, natural gas is the dominant source in the sector with a share of 36.5% while the share of all other fossil fuel sources is around 30%. There is no nuclear plant in Turkey, so the remaining 35% belongs to renewables which are hydropower, wind, geothermal and biomass. Nonetheless, except large hydropower plants with a share of 32.5%, all other renewable sources are still marginal.

Regarding wholesale market, the day-ahead market based on the marginal pricing model is implemented during 5 years. Thus, the price has been determined in the market by the bids of market participants including generators and wholesale companies. However, the day-ahead market model is so young that wholesale prices are fluctuating. In addition, the intervention of the ministry in prices in the market to prevent the realization of very high prices exacerbates the situation.

In this study, we analyze the onshore wind energy potential of Turkey to find out whether onshore wind sources of more than 100 GW can be utilized economically based on the current regulated prices and the current wind power plant costs collected from the literature. In the literature, there are numerous studies conducting economic analysis of wind energy in Turkey, but, to our best knowledge, all of these studies analyze only a specific site or a number of sites, not the potential of the whole country. For example, Akdag and Guler (2009) analyze the potential of Canakkale region; Akdag and Guler (2010) perform a cost analysis for 14 selected locations; Arslan (2010) carries out techno-economic analysis for Kutahya region; Celik (2007) analyzes potential of Iskenderun region. In addition to these studies, we can mention Gokcek and Genc (2009), Ozerdem et al. (2006) and Vardar and Cetin (2009) among other studies carrying out the economic analysis of specific site(s) in Turkey. However, in this study, the economic analysis of the whole onshore wind energy potential of Turkey is done to show how much of this potential can be utilized economically under the current technological, economical and regulatory structure. So, this study is the first in this aspect.

In Section 2, the electricity generation technology and cost of onshore wind power plants are discussed based on the literature survey. In Section 3, some background information about wind energy potential of Turkey are discussed by giving some detailed information about how the wind energy potential is calculated and what is the potential of each wind class. In Section 4, wind energy support mechanism in Turkey is explained by focusing on the economic incentives. In Section 5, economic analysis of onshore wind energy potential of Turkey is done based on the cost data and the technical parameters given in Sections 2, 3 and 4. To this end, we construct a complete model in Excel and calculate cash flows which are used to calculate the net present value (NPV) for each wind class. In addition to the base case scenario, uncertainty analysis is done for a chosen wind class to see how NPV values fluctuate under uncertainty. Lastly, in Section 6, the main results of the economic analysis of onshore wind energy potential of Turkey are summarized and the sufficiency of the current feed-in tariff is analyzed.

2. The cost of wind energy

Wind power has become cheaper since 1980 thanks to, mainly, the increase in the capacity of turbines and the rise of the size of wind power projects (Hammons, 2004). In addition, the efficiency and the reliability of wind turbines has enhanced with the technological improvements. As a result, in the USA the unit cost of wind-generated electricity decreased from $0.35/kWh in 1980s to $0.04/kWh in 2001 (Herbert et al., 2007). Currently, wind-generated electricity from the sites with high wind-speed is getting competitive in some electricity markets.

The cost of wind energy projects consists of capital cost and O&M cost. Among these two main cost components, capital cost constitutes 80% of the total cost of a wind energy project during lifetime while the remaining is caused by O&M cost (Blanco, 2009). Contrary to the conventional energy sources like natural gas, coal and nuclear, wind farms' fuel cost is zero.

In this section, the main cost components and technical parameters of an onshore wind farm are explained and some data collected from the literature is summarized. Firstly, the capital cost is discussed by classifying it into three categories: turbine cost, grid connection cost, and civil work and installation cost. Then, the content, the importance and the magnitude of O&M cost are explained. After cost components, five main technical parameters of wind farms that determine the level of cost and revenue are discussed. These parameters are wind speed, capacity factor, economic lifetime, salvage value, and discount rate.

Capital cost: The weight of capital cost is significant for onshore wind farms. The capital cost consists of turbine cost, grid connection cost, civil work cost, and other installation cost; the share of each component in a typical wind project in Europe is given in Fig. 1.

The enhancement in wind turbine technology provided a continuous decrease in the unit capital cost of wind turbines between 1970s and 2000s. Nonetheless, this downward trend has ended in the beginning of 2000s when the wind technology reached a stable level. The most important factor for this situation is that the capacity of wind turbines reached the optimal level at around 5 MW. After 2004, the trend reversed and the capital cost has increased because of several reasons. These reasons include the booming demand for wind turbines, a decline in the value of the U.S. dollar relative to the other currencies, and the increase in the price of materials like steel, copper, lead, cement, aluminum and carbon fiber which are used to manufacture wind turbines (Blanco, 2009; Wiser and Bolinger, 2010).

The data about each component of capital cost are given in Table 1–3.

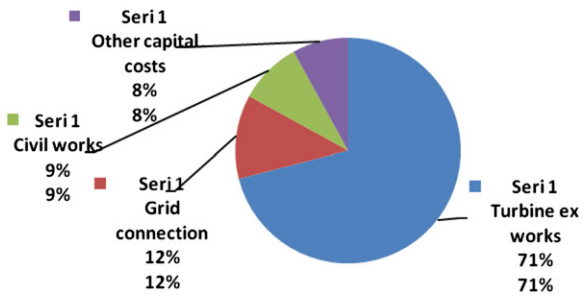

Fig. 1. Capital cost distribution of an onshore wind project in Europe. *Source*: Blanco (2009).