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Evaluation wind energy potential of Torbat-e Jam in Razavi Khorasan Province in Iran

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Abstract: In this research, the potential of wind power in Torbat-e Jam has been investigated consider the affecting factors of wind power efficiency. Due to the Binalood wind power plant in Neyshabur, the possibility of constructing a wind power plant in Torbat-e Jam has been evaluated by the comparison of wind speed in Torbat-e Jam and Neyshabur. Hence, the wind speed diagrams were firstly has drawn for both cities, from 2006 to 2016. The wind speeds in both cities were collected from the meteorological service, which used to create the diagrams on line -point form. Each point and line represents the monthly and daily average of the wind speed, respectively. Data were taken in three-hour period for eight times per a day. By analysing the wind speed in 32120 consecutive periods. It was determined that: the average wind speed in the Torbat-e Jam has always been higher than the largest wind speed in Neyshabur, since 2006. There fore, the results of this study show that the of Torbat-e Jam city has the potential of building a power plant in wind energy. Also, it would cause a significant impact in various sectors such as agriculture, climate change, and the prevention of environmental hazards.

Keywords: - Binalood wind farm in Neyshabur, Torbat-e Jam, Wind power generation potential, Wind turbine

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I. INTRODUCTION

The analyzing of environmental and climatic conditions is essential, according to the expensive cost of implementation and maintenance of renewable energy projects [1]. In these years, the renewable energies have been seriously required. One of its reasons is the global climate change, which is significantly threatening the world. The average world temperature will increase around 6 (°C) over the next 100 years, which can lead to phenomena such as; fault occurrence, severe changes in the climate of different areas of the earth [2]. Therefore, reduction of greenhouse gas emissions is significantly important.

According to the World Health Organization (WHO), air pollution has contributed more to death than other contaminants. In 2011, more than two million people died from air pollution [3]. According to the official Behesht Zahra Organization (BZO) [4] and the headquarters office of Environmental Protection and Sustainable Development of the Tehran municipality (EST) [5], the air pollution killed more than 45000 people per year in just Tehran [6]. A large part of the air pollution results from the release of combustion products (through industries, vehicles, and populations). Sulfur oxides, which come from the combustion of oil and coal, are abundantly scattered by power plants and mines [7]. Also, if the combustion process is not fully completed, it can produce more harmful products. The hydrocarbons, carbon monoxide and nitrogen oxides can be named as the major pollutants by fossil fuel [8]. As well as, population and urban growth, industrial development, technical knowledge and the increasing use of vehicles, can increase the environmental problems, which can decrease the welfare of the residents of the city and create the enormous social costs. These environmental contaminants cause irreparable damage to human well-being.

Air pollution can variously affect the personal and social. These pollutions have some negative effect on human health such as a cough, chest discomfort and finally death. Exiting nearly 30 types of fossil fuel combustion can cause more than 35 types of diseases, such as heart disease, pulmonary disease, dyspnea, intestinal diseases, kidneys, and injuries to the human brain [9]. These figures and many other statistics are alarming for many countries, which will put renewable energy in their basket to prevent more damages of fossil fuels. Due to the high-efficiency in production and consumption of new energy, many countries have found tended to use and develop the use of renewable energy. For this reason, renewable energies in the past decade have had unprecedented growth [10]. More than 80 percent of world energy consumption comes from fossil

fuels. This figure is much higher for Iran. More than 98% of Iran's total energy market are fueling with fossil sources [11].

The use of renewable energy for the replacement of fossil fuels began in the 1980s. Environmental requirements and diversification of energy resources can be mentioned as the reasons for exploiting new energy sources, which is increasingly expanding. In the near future, a greater share of global energy supply will be assigned to renewable energy. Nowadays, renewable energies have become more attractive according to renewability, non-contamination, various sources in the world, and easy usage, especially for developing countries. The green economy can create a large number of new jobs in different sectors of society, which is a vital motive for the sustainable development of any country. The created employment effects can be divided into three categories: direct, indirect and inductive [12].

Investment in renewable energy is increasingly marked towards wind and solar power. In 2015, solar power was ranked first in the energy sector for a number of times, with a huge difference from other types of renewable energy. More than 161 billion dollars was invested in solar power generation, in 2015. In other words, investing in solar energy with a growth of 12% over 2014 has accounted for more than 56% of the total investment in the new energy. The share of wind power was 110 billion dollars and in second place (with a growth of 4% compared to 2014), which is more than 38 percent of total renewable energies market. The outlay of all renewable technologies declined compared to 2014, except solar and wind power. Also, for the first time, the outlay of renewable energy in developing countries grew more than developed countries, in 2015 [13]. Nevertheless, since 1990, development of wind energy has been the highest with the average annual growth rate of more than 26%, between the others' energy sources [14].

Considering the climatic conditions of Iran, it seems that the use of solar and wind energy is more economical and the most affordable type of renewable energy. The direct and indirect employment can grow by increasing the use of renewable energy capacity. As well as, indirect employment has been higher than direct [15]. The use of solar energy is superior to other methods of producing renewable energies, due to the number of sunny days and the amount of solar radiation in many regions of Iran. Nevertheless, one should not overlook the efficiency of the photoelectric cell of solar energy into electricity is about 10 to 15% [16]. Also, solar cells are costly due to the need for advanced technology, and maintenance costs are also high. This issue has caused a lot of attention is focused on the wind energy by some countries in the world including Iran. According to the above, the wind power has recently competed with other power plants in every way (even economically). Five countries, including Germany, the United States, Denmark, India, and Spain, have the largest wind energy market [17]. Germany is ranked first in the installed capacity for wind power generation. In 2007, around 24 percentages of the world's wind power generations were located in Germany [18].

The availability of suitable and diverse sources of energy is an engine of growth and development of countries. Therefore, the government's investment in renewable energy marketing can directly effect on the people and society of a country. In 2000, the World Bank (WB) investigated on trade, foreign exchange and energy policies in the Islamic Republic of Iran. In that research, the analysis of 10 urban and 10 rural households was economically discussed and compared. The undesirable effects and consequences of the current energy subsidy system in Iran were considered, as one of the most important issues. The results of the WB's investigation showed that the energy subsidy is equivalent to 18 percent of Iran's gross national income. As well as, the energy prices were lower than those in the world, which resulted in more energy use and consequently more environmental pollutions. Therefore, the simulation and analysis of various states have been identified, which the capita income for each Iranian can be increased up to 50% by changing of the current pattern of sales and energy consumption [19]. Therefore, Iran can achieve this aim with using of the renewable energy.

II. METHOD AND MATERIALS

Wind speed is one of significant parameters, which is important to build the wind farm in a new place. The speed and direction of wind were obtained from the Meteorological Organization of Iran (MOI) for synoptic weather stations of Torbat-e Jam and Neyshabur in three hours of interval in overnight. In this study, 32120 time intervals for data collection have been used and reviewed. Wind parameters were prepared since 2006 to 2016. Although more than 70,000 data were evaluated in this study. However, there was noteworthy a large number of missing data. Wind is a vector quantity with direction, velocity, and influenced by topography and the type of deposition of upper atmospheric flows. Therefore, it is impossible to determine the direction and wind speed in hours without data. Most researchers, who have studied the feasibility of using wind energy in different geographic areas, have used a statistical period of more than 10 years [20].

Torbat-e Jam is one of the cities of Razavi Khorasan province. The area of Torbat-e Jam city is around 8,184,000 square kilometers and is located 163 kilometers from Mashhad as the provincial capital. The geographical coordinates of Torbat-e Jam are: 35 degrees and 13 minutes north and 60 degrees and 38 minutes east. Fig. 1 shows the geographical location of this city. The height of Torbat-e Jam is around 928 meters above sea level. This city borders with Sarakhs city (north), Fariman, Mashhad and Torbat Heydariyeh cities (west),

Taybad city (south), and Afghanistan and Turkmenistan (east). Torbat-e Jam has five sections: Saleh Abad, Nasr Abad, BojGan, Down, and Central. As well as, Torbat-e Jam has 13 towns and 237 villages [21].

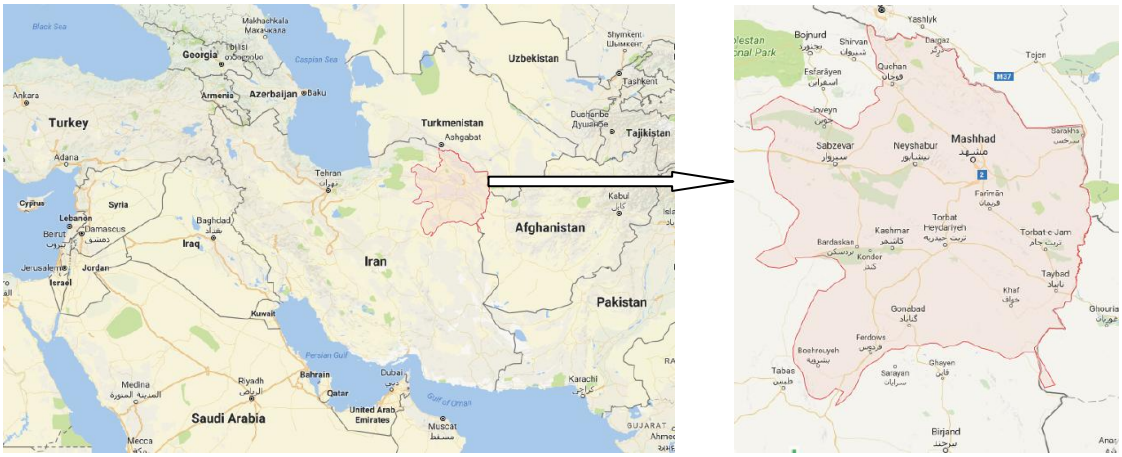

Figure 1: (A) The map of Iran and (B) Khorasan Razavi province (Google Map).

Neyshabur is located between the 35 degrees, 40 minutes of latitude, and 58 degrees, 15 minutes of longitude in Razavi Khorasan province. The geographic location of Neyshabur is shown in Fig. 1. Neishabur is related to the north of Quchan, from the east to Chenaran and Mashhad, to the south with Torbat Heydarieh and Kashmar, and to the west to Sabzevar. It has been one of the historical cities and had been the capital of Iran. As well as, Neyshabur has been located on the accent Silk Road [21]. Binalood wind farm is located to Neyshabur, which was established in 2002. It has 43 turbines with a generating capacity of 660 kW to produce 28.2 MW of electricity using wind power [22].

III. REASALTS AND DISCUSION

Fig.s 2 to 12 refer to the monthly wind speed during the 11-year period from 2006 to 2016, and Fig. 13 is the annual average wind speed from 2006 to 2016 for both Torbat-e Jam and Neyshabur. Fig. 2 shows the wind speed for both cities in 2006. According to this fig. 2, the lowest wind speeds were in January for both cities and the highest were in July and August. As well as, the curve of Torbat-e Jam is located above that's Neyshabur.

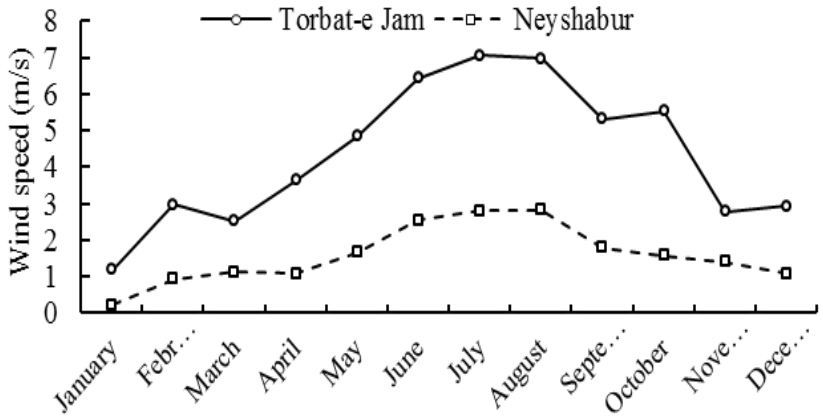

Figure 2. Comparison of wind speed in Neyshabur and Torbat-e Jam in 2006.

Fig. 3 shows the lowest wind speed of Torbat-e Jam was in January and November and for Neyshabur in January and October, in 2007. Also, it shows that the highest wind speed for both cities was in July and August. As well as, the wind speed curve of Torbat-e Jam is located above Neyshabur curve. According to Fig. 3, wind speeds of Torbat-e Jam were more than those of Neyshabur in all period time, in 2007.

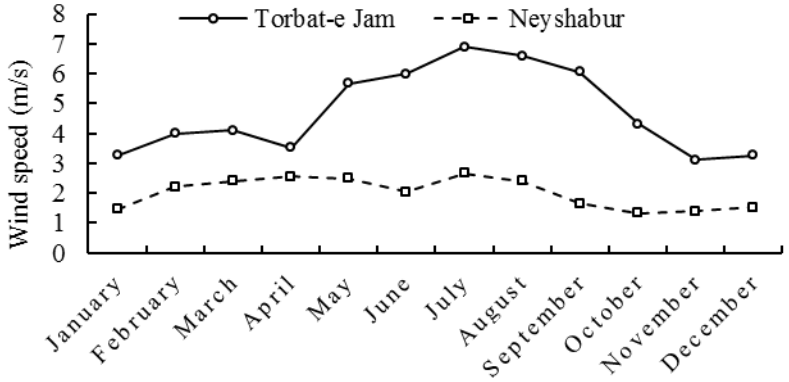

Figure 3. Comparison of wind speed in Neyshabur and Torbat-e Jam in 2007.

Fig. 4 shows the curves of wind speed. The lowest wind speed for Torbat-e Jam and Neyshabur are in December and January, respectively. Also, the highest wind speed for Torbat-e Jam and Neyshabur are in August and June, respectively. Due to Fig. 4, the Torbat-e Jam curve is still located above the Neyshabur diagram.

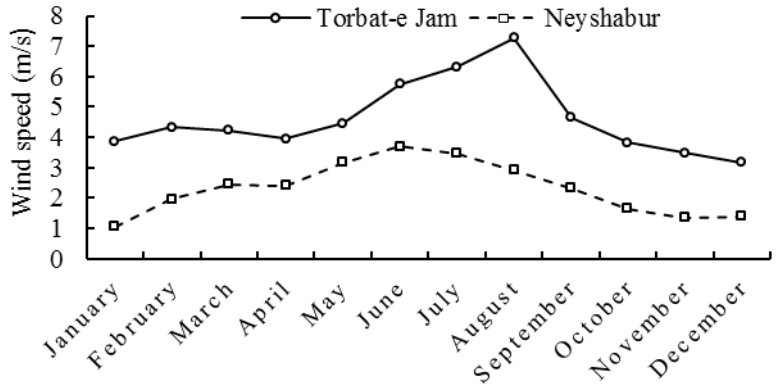

Figure 4. Comparison of wind speed in Neyshabur and Torbat-e Jam in 2008.

Fig. 5 is for 2009. In this year, the lowest wind speeds for both cities were found in December. As well as, the maximum wind speed of Torbat-e Jam and Neyshabur were in June and August, respectively. Also, the curve of Torbat-e Jam was rising up to June, and after this month was falling curve. Nevertheless, Neyshabur curve is almost linear throughout year with a small falling in October.

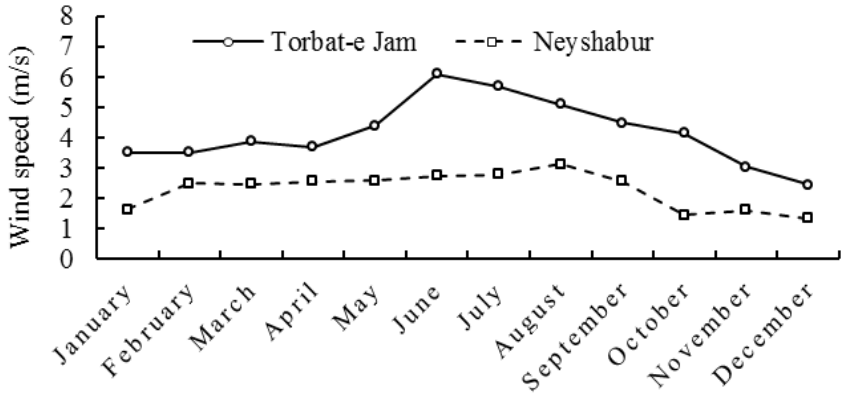

Figure 5. Comparison of wind speed in Neyshabur and Torbat-e Jam in 2009.

The comparative curves wind speeds of both cities in 2010 are shown in Fig. 6. February and December had the lowest wind speed of Torbat-e Jam and Neyshabur, respectively. As well as, the highest wind speed were August and June for Torbat-e Jam and Neyshabur, respectively. According to Fi. 6, curve of Torbat-e Jam is located above that of Neyshabur in 2010.

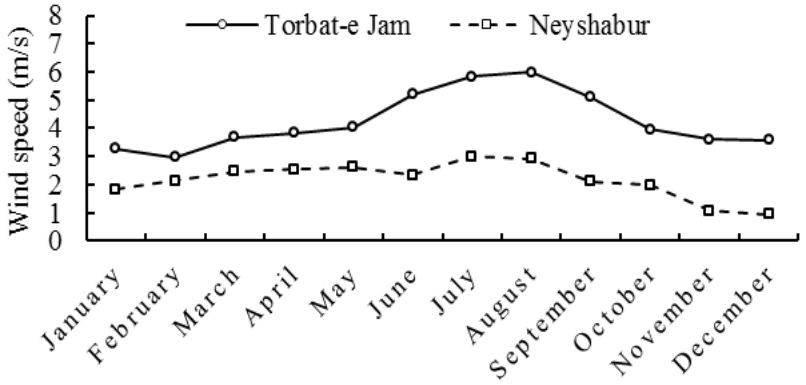

Figure 6. Comparison of wind speed in Neyshabur and Torbat-e Jam in 2010.

The wind speed curves of Torbat-e Jam and Neyshabur are shown in Fig. 7 for 2011. November and December had the lowest wind speed for Torbat-e Jam and Neyshabur, respectively. The highest wind speed was for both cities in July. Also, the curve of Torbat-e Jam is located above that of the Neyshabur. As well as, the curve of Torbat-e Jam raised until July and August, when down warded move. Whenever, Neyshabur curve was up in January. However, it was virtually linear from February to August and was fallen from August to December.

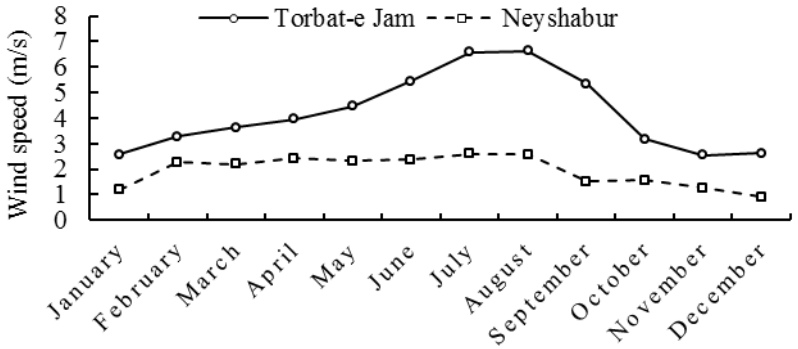

Figure 7. Comparison of wind speed in Neyshabur and Torbat-e Jam in 2011.

Fig. 8 shows the comparative curves of wind speed to both cities in 2012. The minimum of wind speed values were in November and December for Torbat-e Jam and Neyshabur, respectively. As well as, July had largest value of wind speed for both cities. As shown in Fig. 8, Curve of Torbat-e Jam is again on that of Neyshabur in 2012.

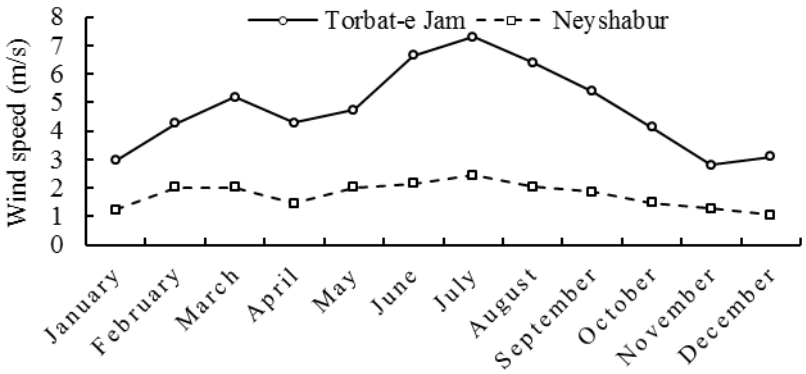

Figure 8. Comparison of wind speed in Neyshabur and Torbat-e Jam in 2012.

Fig. 9 is for 2013. The lowest wind speed for both cities was in January and the highest wind speeds were in August and July for Torbat-e Jam and Neyshabur, respectively. According to Fig. 9, the wind speed of the Torbat-e Jam city is higher with a significant difference from Neyshabur city, in all months of 2013. As well as, both curves in 2013 were found an upward and downward trend.

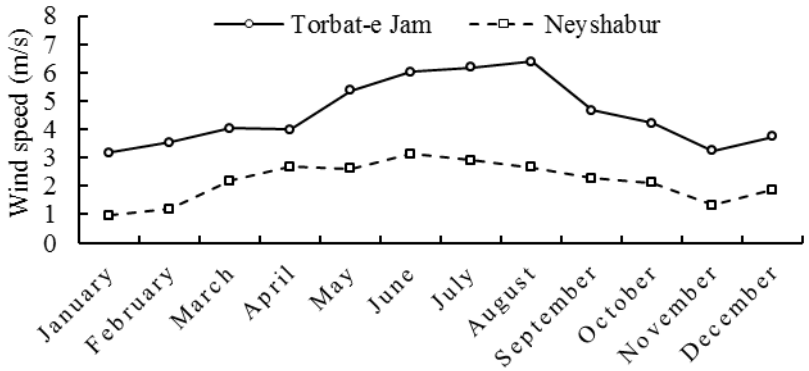

Figure 9. Comparison of wind speed in Neyshabur and Torbat-e Jam in 2013.

The comparison of wind speeds in 2014 is shown with Fig. 10. The minimum of wind speed were in December and November for Torbat-e Jam and Neyshabur, respectively. Also, the highest wind speeds for were due in July and March respectively for Torbat-e Jam and Neyshabur. However, Neyshabur curve approximately goes across linear direction. According to Fig. 10, Torbat-e Jam curve up warded up to July, and then dropped. But, the curve of Neyshabur was found rising, linear and falling.

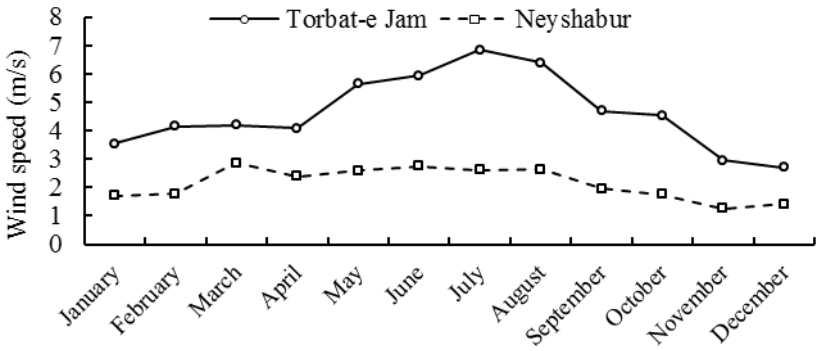

Figure 10. Comparison of wind speed in Neyshabur and Torbat-e Jam in 2014.

Fig. 11 shows comparatively the wind speed of Torbat-e Jam and Neyshabur, in 2015. November had the lowest wind speed for both cities. As well as, the highest value were found in July for both cities. The Torbat-e Jam curve was again above that of Neyshabur in 2015.

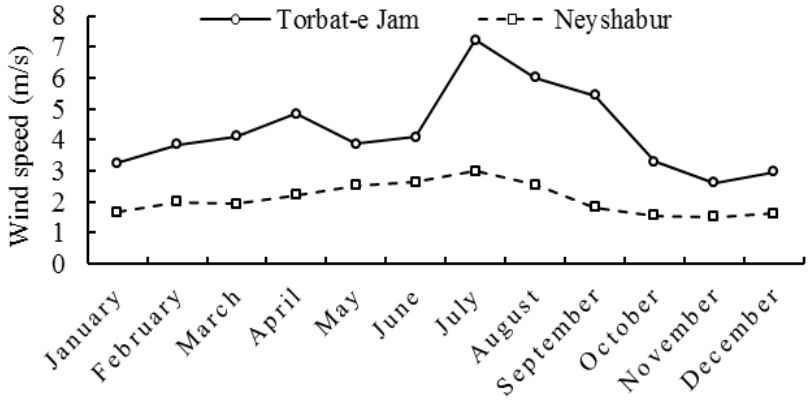

Figure 11. Comparison of wind speed in Neyshabur and Torbat-e Jam in 2015.

The curves of wind speed in 2016 are shown with Fig. 12. The minimum of wind speed for Torbat-e Jam and Neyshabur were in November and December, respectively. Also, the highest wind speed was for Torbat-e Jam and Neyshabur were in the months of July and August. According to Fig. 12, the wind speed of the Torbat-e Jam were significantly higher than those of Neyshabur in June, July, and August.

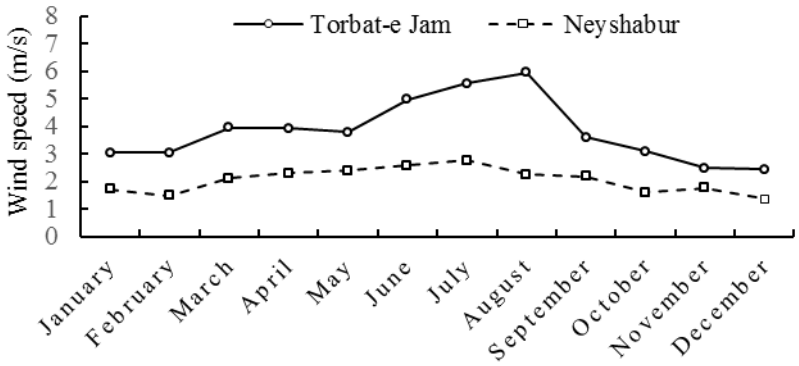

Figure 12. Comparison of wind speed in Neyshabur and Torbat-e Jam in 2016.

Fig. 13 is related to the average annual wind speed during the period 2006 to 2016, for both cities of Torbat-e Jam and Neyshabur. As shown in Fig. 13, the curves of both cities are linear, which indicates the stability of the wind parameters over the course of 11-years. Also, Torbat-e Jam curve is significantly higher than Neyshabur.

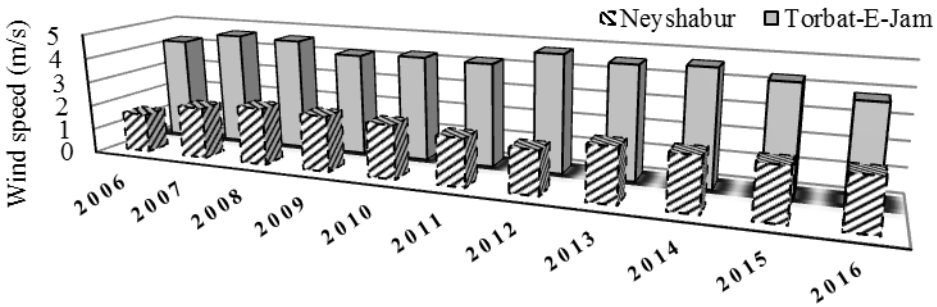

Figure 13. Comparison of wind speed in Neyshabur and Torbat-e Jam from 2006 to 2016.

IV. CONCLUSION

Due to the damages of fossil fuels have brought to the environment in recent years, the using of renewable energy, such as wind, can be a great step to protect and clean the environment. The analysis and evaluation of the diagrams of both cities, from 2006 to 2016, show that:

- The minimum of wind speed values were usually found in November and December for Torbat-e Jam and Neyshabur, respectively, in 11-years period time.
- July and August had the highest wind speed values for both cities, in during time from 2006 to 2016.
- The maximum wind speed of Torbat-e Jam and Neyshabur were 5.93 to 7.29 (m/s) and 2.43 to 3.69 (m/s), respectively.
- Torbat-e Jam had the highest wind speed in two months: July and August. As well as, its lowest wind speed occurred in December, November, January and February.
- The highest wind speeds of Neyshabur were found in July and August. Also, the lowest wind speeds were in the months of January, October and December.
- It is worth to note that, the minimum wind speed in Torbat-e Jam is always greater than the maximum wind speed of Neyshabur.
- The wind speed in Torbat-e Jam is much higher than Neyshabur throughout the year. It should be noted that the maximum wind speeds in the Torbat-e Jam were often greater than 3 to 5 (m/s) from those of Neyshabur.
- Evaluations of curves show that the mean annual wind speed of Torbat-e Jam was too much more than that of Neyshabur in the 11-years period of time (2006 – 2016).

According to the results of this research, it can be concluded that construction of a wind power plant in Torbat-e Jam city can costly be executable more than Neyshabur. Due to the existence of a wind power plant in Neyshabur, the construction of a wind farm in Torbat-e Jam has a technical basis. In other words, Torbat-e Jam has the potential for wind power plant.

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