

## Wind Energy and Analysis of its Applications

### Abstract

To accurately understand the limitations, obstacles, and facilities available for the use of energy resources in the country, it is necessary to calculate and evaluate the extent of exploitation of the existing energy potentials and the development process of renewable energy carriers in the country in a scientific and accurate manner.

Iran is one of the richest countries in the world in terms of a variety of energy resources, on the one hand, it has vast resources of fossil and non-renewable fuels such as oil and gas, and on the other hand, it has a great deal of renewable energy potential, including wind.

With the development of environmental awareness and economic strategies in the exploitation of non-renewable energy sources, the use of wind energy has increased compared to other energy sources globally. Using wind turbine technology can be a good choice compared to other renewable energy sources for the following reasons.

**Keywords:** Energy, Wind, Renewable, Resources, Environmental

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### Introduction

The importance of energy in recent times and especially in the coming decades is so great, that with the exhaustion of non-renewable fossil energies, human civilization which depends on energy will be disturbed<sup>1</sup>.

The use of solar and wind energy in our country is indeed more economical and affordable, but due to the high cost of converting solar energy into electrical energy, the attention of many countries of the world, including Iran, has been turned to wind energy.<sup>2</sup> Among renewable energies, wind energy is one of the most economical renewable energies in electricity production, which, in addition to being non-polluting, abundant, and permanent, also has the lowest price fluctuations.<sup>3</sup>

The economic evaluation of the installation and construction of wind power plants compared to fossil power plants in Iran has been investigated. From an economic point of view, wind turbines that produce energy are completely competitive with fossil power plants, and from the point of view of technology, environment, and consumption of fossil fuels, wind turbines have better ranking than fossil power plants.<sup>4</sup> Wind energy like other renewable energy sources, is geographically widespread yet almost always sporadically available. For thousands of years, humans have been using only a very small part of wind energy using windmills.

This energy was widely used as an energy source before the Industrial Revolution, but during the Industrial Revolution, the use of fossil fuels replaced wind energy due to its cost-effectiveness and high reliability, until in 1973 and 1978, when two big oil shocks dealt a big blow to the economy of energy derived from oil and gas. This created new tendencies in the use of wind technology to generate electricity used for water pumping and supply electrical energy to remote areas.

In recent years, environmental problems and issues related to global climate change due to the use of fossil energy have increased the intensity of these tendencies. In 1980, the first wind turbine connected to the national grid was installed. Shortly after, the first multi-megawatt wind farm in America was erected and put into operation. By the end of 1990, the capacity of wind turbines connected to the grid globally reached 200MW, which could produce 3200Gwh of electricity annually. Almost all of this production was related to the state of California and Denmark.

Today, other countries such as the Netherlands, Germany, Great Britain, Italy, and India have started special national programs in this direction. Germany is attempting to make the most of this renewable energy by producing more than 18,000 megawatts of electricity.

### Text

Wind energy is the conversion of wind energy into useful forms of energy, such as electrical energy (using wind turbines), mechanical energy (for example, in windmills or windpumps), or the propulsion of boats and ships (for example, in sailboats). Wind is directly used to crush seeds or pump water.

At the end of 2010, the nominal capacity of wind power production worldwide was equal to 197 gigawatts.<sup>5</sup> Today, wind power in the world has an annual production capacity of 430 terawatt hours of electrical energy, which is 2.5% of the world's electricity consumption.<sup>5</sup> The average annual growth of the world's wind power is 27.6%, and the share of wind in the world's electrical energy production reached 3.35% by 2013 and 8% by 2018.<sup>6</sup>

Ancient Iranians first used wind energy to irrigate fields. They used the power of the wind to drive wheels to bring water to the surface of the land and their fields.

Since fossil resources such as oil and gas are non-renewable and will end one day, wind is considered a clean energy source,

and the cost of producing electricity using it is lower than producing electricity using fossil fuels, not to mention that it produces less pollution and greenhouse gases.

Disadvantages have also been identified for this type of energy. The loud noise which is annoying for animals, and especially birds, are among the disadvantages of wind energy. Wind power plants are not able to produce electricity continuously due to variable wind.

A turbine is utilized to generate electricity. The three-bladed turbine is the most common wind turbine. Many countries have turned to this energy. China is ranked first in using wind energy and converting it into electricity.

The countries of Denmark with 21%, Portugal with 18%, Spain with 16%, Ireland with 14% and Germany with 9% are ranked among the top countries in terms of the percentage of electricity production using wind energy.<sup>7</sup>

Wind energy is produced in large quantities in wind farms and connected to the electric grid. Small numbers of turbines are usually only used to provide electricity in remote areas.

Wind is one of the main characteristics of solar energy and moving air, which is converted into wind energy from the sun's radiation that reaches the atmosphere from the outside.

But one of the reasons for the desire of countries to increase the capacity of wind power production is the huge advantages of this method of producing electrical energy because wind energy is considered renewable and clean and exists everywhere in the world, as well as its use compared to the use of fossil fuel energy. It emits less greenhouse gas.

### **History**

The oldest method of using wind energy goes back to ancient Iran.<sup>8,9</sup> For the first time, Iranians managed to use wind power to turn a bucket or well wheel and bring water from their water wells to the fields. Probably, the first wind machine was built by the ancient Persians, the Greeks used wind energy to crush seeds, and the Egyptians, Romans, and Chinese used wind energy for sailing and irrigation.

In the 13<sup>th</sup> century, this technology was brought to Europe by the Crusaders. The Dutch were very active in the development of wind machines so in the middle of the 19<sup>th</sup> century, about nine thousand wind machines were used for various purposes. During the Industrial Revolution in Europe, the use of wind machines decreased.

Wind energy was first used in the United States in 1854. These machines were mostly used to raise water from wells and later to generate electricity. The largest inflatable machine was built by the Americans during World War II.

In the former Soviet Union, in 1931, a wind machine with a horizontal axis was used, which was expected to provide 100 kilowatts of electricity to the grid. The height of the tower was 23 meters and the diameter of the blades was 30.5 meters.<sup>10,11</sup>

### **Wind Energy**

The origin of wind is a complex issue. Since the earth is unevenly heated by the sun, there is less heat energy in the poles than in the tropics. Additionally, temperature changes on land happen faster and therefore land heats up earlier and cools down earlier than the seas. This global temperature difference creates a global heat exchange system that extends from the Earth's surface to the atmosphere, acting as an artificial roof. Most of the energy contained in the movement of the wind can be found in the upper levels of the atmosphere where the sustained wind speed reaches more than 160 kilometers per hour and eventually, the wind loses its energy due to friction with the surface of the earth and the atmosphere.

A general estimate is that there are 72 terawatts (TW) of wind energy on Earth that have the potential to be converted into electrical energy, and this amount can be increased.

### **What are the advantages of wind energy?**

In addition to the mentioned applications, wind energy has various advantages, including:

- Wind energy is cost-effective and since the electricity generated from wind farms is sold at a fixed price for many years, even 20 years, wind energy reduces extreme price fluctuations.
- Wind creates jobs, for example in 2016 more than 100,000 workers were employed in the US wind energy sector, and the wind turbine technician specialty has been one of the fastest-growing US occupations in the past decade. It is said that probably by 2050, wind energy can create more than 600 thousand jobs in various fields of production, installation, maintenance, and support of wind devices.
- Wind energy is a clean fuel source. Wind energy does not emit particles, nitrogen oxide, and sulfur dioxide and pollute the air like fossil fuels such as coal or natural gas. Wind does not produce greenhouse gases or acid rain.
- This energy is a native and sustainable energy source and can be used as long as the sun shines in the sky.
- Wind turbines can be placed on farms, this is especially beneficial for the economy in rural areas where the wind is the best because farmers and ranchers can continue to work in the fields while the wind turbines are Part of their land are occupied and the owners of the wind power plants pay rent to the farmers.

### **Disadvantages of wind energy**

- Although the cost of producing electricity from wind energy has decreased significantly over the past 10 years, this technology requires a higher initial investment than fossil fuels.
- Good wind centers are often located in remote fields and far from the cities that need the electrical supply. Transmission lines must be built to transfer this electricity

from the wind farm to the city, although this cost can be reduced using a variety of methods.

- Development of wind resources on agricultural land may not be the most profitable method for farmers. Farmers can sometimes use their land for more valuable things than generating electricity.
- Turbines may cause noise, although wind power plants have relatively less impact on the environment compared to conventional power plants, noise pollution is created and the negative effect is one of their disadvantages.
- Turbine blades may harm local wildlife, such as birds being killed by flying around these spinning turbines, although many of these problems have been partially eliminated or reduced by the development of technology or the proper construction of wind farms.

### **Wind energy applications**

#### **1- Electricity production**

One of the most important applications of wind energy is electricity generation. For this purpose, a wind turbine is used, which controls the wind energy, and with the movement of the turbine blades, a generator starts rotating and produces electricity.

The popularity of wind energy has doubled, especially since the first electricity-generating turbines were built in 1887 by James Bailey, who used the electricity generated in this way to light his holiday villa.

Today, wind turbines are used in many fields in different parts of the world to supply electricity to millions of homes.

#### **2- Wind sports**

One of the most enjoyable uses of wind energy is in sports such as windsurfing, sailing canoeing on land, kiting, and kite-buggy, all of which rely on the power of the wind.

You may think that sports like skydiving also use wind energy, but this is not the case, these sports are classified as air sports that do not necessarily use wind energy for movement.

#### **3- Applications of wind energy in transportation**

Another important application of wind energy is in transportation. As you know, wind energy has been used for sailing in different civilizations for thousands of years, and researchers believe that sailing has existed since 5,000 BC.

Even today, there are many large and small ships and boats that have sails and move with the power of the wind.

In recent years, modern shipping companies have turned to using wind energy again, and the use of this energy in the long journeys of some ships has reduced fuel consumption by 30%.

#### **4- Applications of wind energy in water pumping**

Wind energy is used to pump water. Wind pumps look like traditional windmills, but instead of grinding grain, they pump water and have been used throughout history to drain land.

Like windmills, wind pumps also fell out of favor with the advent of electric motors.

#### **5- Food production**

In the past, wind energy has traditionally been used to produce food, including flour. Before the Industrial Revolution, windmills were widely used in different parts of the world to grind grains and produce bread flour, although today, with the advancement of technology and with the help of electricity and special motors, there is no need for structures like windmills.

### **Wind energy potential in Iran**

The Islamic Republic of Iran is located in the western part of the plateau and the southwest of Asia. Iran, with an area of 1,648,195 square kilometers, is located between 44- and 63.99-degrees east longitude and 25- and 39.99-degrees north latitude, and more than half of its area is covered by mountainous areas.

The country enjoys a great deal of climate diversity. The northern regions of Iran have a moderate climate and significant rainfall, especially in the western regions of Gilan province. The climate of the western regions of Iran is cold and humid in the cold seasons and dry and moderate in the hot seasons. In the southern regions, air temperature and humidity are higher, very hot summers and mild winters characterize the climate of this region, and daily temperature changes are less noticeable. Eastern and southeastern regions have a desert climate with noticeable temperature changes during the day. To be able to use the available wind resources for electricity generation, the existence of reliable wind information regarding the wind potential of the target area is necessary for the construction of a wind power plant.

In Iran, due to the presence of windy areas, there is a suitable platform for expanding the use of wind turbines. One of the most important projects carried out in the field of wind energy has been the preparation of the wind atlas of the country.

According to the wind atlas prepared and based on the information received from 60 stations in different regions of the country, the nominal capacity of the sites is around 60,000 megawatts. Based on the forecasts, the country's economically exploitable wind energy is estimated to be more than 18,000 megawatts, which proves the significant potential of the country in the field of building wind power plants and the economic value of investing in the wind energy industry.

In carrying out the wind potential measurement project in Iran, Germany's Lahmeyer company has also cooperated as a consultant, and based on the studies of the mentioned company, the wind potential that can be exploited in the country has been estimated at 100,000 megawatts.

### **The prospect of wind energy in Iran**

In the Ministry of Energy, the installation of five thousand megawatts of renewable power plants has been targeted in the Fifth Development Plan, of which 4,500 megawatts have been earmarked for wind development.

The macro policy of our country is based on the perspective of future programs in increasing the role of non-governmental sectors, which is one of the advantages and benefits of reducing the volume and activities of the government. The involvement of the private sector in the field of construction of wind power plants is quite attractive for the private sector. The country's financial, technical, and managerial capacity will increase, and with the start of new projects and activities, the private sector will come to the aid of the public sector and the country will benefit from this partnership. It should also be noted that wind power plants require high initial capital, making their implementation a challenge.

The use of non-governmental investment in the implementation of projects will greatly help the government, as the development of new energies, especially wind energy, which is the most commercial type, is stipulated in the upstream national documents and laws. The topic has gained significant importance in Iran, as, without a doubt, one of the main security considerations in all countries is access to needed energy. The occurrence of problems in the energy supply system will cause wide-ranging disruptions in all economic and social sectors. For this reason, countries include the diversification of energy sources as one of their main strategies to avoid dependence on one or two types of energy and to reduce their vulnerability to the minimum possible.

Based on this, we must provide the energy needed by our country from all available and obtainable energy sources, including renewable energy, and by creating diversity in energy sources, we provide more stability for the country's energy system. Iran is among the countries that consider itself committed to protecting the planet, atmosphere, and environment, and emphasizes the production of energy from renewable sources, including wind energy. In general, by replacing electricity production using fossil fuels with electricity produced using wind power, about three percent of greenhouse gas emissions can be eliminated.

Another issue is that job creation and social transformation in deprived areas are important topics for the development of new energies in the country. Since the windy parts of Iran are often located in areas that are deprived in terms of social development, the development of wind power plants will directly change the social conditions of these areas.

Statistics show that only in 2010, 630,000 jobs were created in the field of wind for every 39 gigawatts of newly installed wind capacity, in leading and developing countries. Another important point is that, due to the problems with operations and

maintenance, the stability of wide networks, the amount of reliance on long networks has been reduced by distributed electricity generation. This is one of the solutions implemented in the electricity industry.

This work is not only economically costly but by reducing the losses in the transmission and distribution network, as well as reducing the need for stored production capacity and increasing stability in the network, the cost of electricity will be significantly reduced. The best types of distributed generation are wind, small hydro, biomass, geothermal, and solar power plants, which are not only distributed in terms of the location of electricity production but also terms of primary sources and do not require the use of gas or oil transmission networks.

Achieving the aforementioned goal means that the country will have the facilities that can provide the most essential electricity needs of different sectors in the event of various accidents and disasters, relying only on local resources and facilities.

The market of wind power plants in Iran is flourishing and entering this market can guarantee a good future for investors in the long term. Therefore, if Iran is viewed as a base for the production of equipment and supply of specialized human resources, the markets of the regional countries can be considered.

## **Conclusion**

For countries like Iran, which have a growing economy, the need for electricity and power generation is an inevitable necessity and should not rely only on fossil fuels. We even witness that many regions and villages are deprived of electricity. It can therefore be concluded that because the national electricity network has not yet reached these regions, alternative methods such as wind energy and turbines should be used.

With the use of this energy, it is possible to create tremendous changes in the economic future of Iran and to save oil products and fossil fuels. With the resulting savings, it is possible to preserve petroleum products and enable their export as well as their conversion into petrochemical derivatives with added value.

The electricity generated from wind energy does not cause environmental pollution and this results in the preservation of nature and sustainable economic and social development. In addition to construction and development, the use of wind energy in Iran has created employment, and by localizing wind energy technology, the country's economy can grow and develop.

## **Appreciation and thanks**

Thanks to their great and humane interpretation of the word sacrifice and to those who sacrificed themselves, thanks to

their full affection and the hopeful warmth of their existence, which is the best support in these coldest times. I dedicate this collection to my dear parents for their never-ending love.

Our fathers  
Our mothers  
Our teachers

Thanks to the three holy beings:

Those who became weak so that we can develop our abilities...

Their hair turned white so that ours can become white...

And they burned with love to warm our existence and illuminate our path...

**Conflict of interest**

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