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Potential measurement of wind energy uses in Parsabad-Moghan of Ardabil

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Abstract

The ever-increasing demand for energy, the destruction of the environment as a result of the indiscriminate exploitation of fossil fuels, the exhaustion of fossil fuels, the growth of energy demand, and the rapid growth of industries are among the most critical factors that have made modern and industrial societies face more significant challenges. For this reason, using natural, immaculate, renewable energies such as solar, wind, geothermal, hydrogen, and biomass instead of fossil fuels is receiving more attention. Parsabad-Moghan is located in the northern region of Ardabil province, which can be known as one of the windy potentials in the area, which can have a high potential in the production of wind energy. This study calculated the potential of electricity generation from wind energy by considering a sample turbine every month. Based on the results obtained, it can be said that if the wind energy produced in this city is replaced with electricity from the urban grid, fuel consumption can be significantly avoided, and consequently, the amount of carbon dioxide production can be reduced. Based on the findings, it can be concluded that the use of wind energy in this region has high energy supply reliability and the potential to provide sustainable wind energy. Also, this region is prone to use combined powers to achieve a sustainable energy source. These energy sources can combine wind, solar, and biomass energy.

Keywords: Parsabad Moghan; clean energy; wind energy; carbon dioxide; renewable energy

Introduction

In recent years, the growing trend of energy consumption has created the phenomenon of an energy crisis. More than 80% of the world's energy consumption is supplied by fossil fuels, which are rapidly being depleted [1-3]. The ever-increasing consumption of energy from fossil fuels has led to the rapid economic growth of societies; due to the emission of pollutants resulting from the combustion of these fuels (emission of carbon dioxide), the world is facing threatening changes [4-6]. On the other hand, with the end of fossil energies (oil, gas, and coal), human civilization will face a significant challenge due to its direct dependence on energy [7].The ever increasing demand for energy, the destruction of the environment as a result of the excessive use of fossil fuels, the exhaustion of fossil fuels, the growth of energy demand (with the increase in population), and the rapid growth of industries are among the most critical factors that make modern and industrial societies face more significant challenges [8-11]. And for this reason, the use of energies available in nature, especially clean and renewable energies such as solar, wind, geothermal, hydrogen, and biomass, is getting more attention than energy from fossil fuels [12-15]. Global energy and environmental policies emphasize the need to increase the share of renewable energy sources and energy efficiency from plants and provide advanced solutions for electricity production [16, 17]. Clean energy sources have unique characteristics. The act of converting them into usable energy is cleaner than converting fossil energy [18].

The wind turbine system is a system that converts mechanical energy from the wind into electrical energy through a generator [19]. Among renewable energies, it is estimated that wind and solar energies have the most significant potential [20]. Solar and wind energies are clean, safe, low-cost, and ready to meet

the world's energy needs soon, ending threats to public health, energy security, and the environment [21]. Renewable energy systems use a combination of different energies, such as water, solar, and wind, so the generated power can continuously estimate the specified load demand. Their combination can improve system efficiency and overall reliability [22]. Renewable energy sources are associated with seasonal changes, so energy production entirely depends on the seasons: natural sources and factors such as wind speed and sunlight. Create a limit due to seasonal changes while the energy supply is needed continuously. Electricity production compensates for the challenges of renewable energy by using appropriate strategies, technologies, and policies [23].

In 2004, only 25 megawatts of the 33,000 megawatts of electricity in Iran were produced using wind energy. In 2006, the share of electricity produced in Iran using wind energy was 45 megawatts (ranking 30th in the world), which showed a forty percent growth compared to 2005. In 2008, the Manjil wind power plant (in Gilan province) and Binalud (in Razavi Khorasan province) had a capacity of 82 megawatts of electricity. The wind power capacity in Iran in 2009 was 130 MWh. Iran is a member of the World Wind Energy Forum [24]. Iran has invested money in renewable energy and wind power. The amount of subsidies allocated in the fossil electricity sector is about 7.3 billion euros, a severe obstacle to developing renewable energy.Despite contributions, the installed capacity of wind power reached 128 megawatts by the beginning of 2007, producing 307 gigawatt hours of electricity during 2013-2014. This amount of electricity produced has saved 425,000 barrels of oil equivalent in Iran's power plant sector, and its place has reduced one million tons of environmental pollutants between 2014-2015. The usable wind potential in the areas has been calculated using the basic monthly wind information in the country's provinces and the Weibull density equation. Finally, the total wind power potential has been estimated at 3.6 GW. Of course, other calculations have estimated the capacity as up to 6 gigawatts. Based on the country's current energy policies, the net present value and internal rate of return of wind projects in the three provinces of Gilan, Sistan, Baluchistan, and South Khorasan have been calculated, confirming the fact that wind power projects in these three provinces are economically affordable and economical. The results show that by removing subsidies for potential fossil energy along with a market-oriented method, it is possible to increase the wind energy capacity to 3.6 to 6 GW. This installed capacity can save about 47 to 84 million barrels of oil, equivalent to 127,000 to 23,000 per day in Iran's power plant sector.Many studies have been conducted on using wind energy as an alternative system for other energy sources. Kekturk et al. investigated the main issues of wind energy and smart grids and presented a framework for implementing a smart grid in Izmir for wind energy [25]. Li et al., using 10-year average wind speed data at heights of 10, 50, 100, 150, and 300 meters in one year and statistical analysis, evaluated the ability of wind power generation in two locations (Urumqi and Xining) in China [26]. This study aims to investigate the ability to produce electricity through wind energy in Parsabad Moghan city and its environmental effects.

2. Materials and Methods

Ardabil province is located in the middle of a plain with the same name at an altitude of 1500 meters above sea level and between Baghroo (Talesh) and Sablan mountains in the northwest of Iran's plateau and has cold winters and mild summers. Parsabad Mughan city is one of the cities of Ardabil province. This area is one of the windy areas in Ardabil province. The existence of most windy days in this city prompted us to conduct a research on the status of wind energy exploitation in this region. The data required to conduct this research, which includes the average monthly wind speed in the last 10 years, was obtained from Parsabad Meteorology in Moghan and reported in meters per second in Table 1.

Table 1. Meteorological data for Parsabad city

Months	March	April	May	June	July	August	September	October	November	December	January	February
Avarage speed	32	24	17	25	18	14	15	13	13	15	18	18

According to Table 1, the amount of wind blowing in the first half of the year is less than in the second half of the year. The lowest amount of current is in July and August (with 13 meters per second), and the highest is in March (with 32 meters per second).

The wind has been used to generate power for the past few centuries for energy saving. Wind energy is clean, comprehensive, and robust. Advancement in the technology of using wind energy is necessary, considering that wind energy is one of the primary and accessible renewable resources.Small-scale wind turbines are turbines with a minimum capacity of 100 kW. These turbines have different uses. Wind power can be used as a selection potential for buildings in a good wind situation as a power with less pollution and a lower price in the field of power supply. A study on

using small-scale wind turbines is considered an option for the Xscape structural site in Glasgow. The work includes easy research and, going beyond energy costs, how much carbon dioxide emissions can be prevented by doing this.

2.1. Wind turbine

Small wind turbines are designed for wind speeds of 2.5 to 10 meters per second due to accessible areas. A wind turbine is a device that converts the wind's kinetic energy into electrical energy (which can be harnessed for use). Windmills, on the other hand, flip the kinetic energy of the wind into mechanical energy, and self-supporting systems are used primarily to pump water and grind grain. When some of these wind turbines are installed in specific configurations to create several units of electricity, it is generally referred to as "wind farms." Wind energy is clean, accessible, and powerful, with turbines requiring less protection and maintenance than conventional power stations. Germany currently has the largest installed capacity of wind turbines in the world. In 2003, the total installed capacity was estimated at 14/609 MW. In a typical wind year, German wind farms produce enough wind to meet 6% of the country's electricity needs, according to the German wind energy association Bundesver wind energies. Its wind energy industry employs 45,000 people.

In this study, the HY5-AD5.6 model turbine with the capacity of producing 5 kilowatts of electricity was selectively used to investigate energy production. The specifications of this turbine are presented in Table 2.

Table 2. Turbine specifications HY5- AD5.6

Power	5 kW	Rotary speed	Variable Pitch
Turbine diameter	5.6 m	Generator type	PM AC
Wind speed	11 m/s	Annual power	30 MWh
Output voltage	220 VAC	Weight	340 kg

Each wind turbine, based on its characteristics and manufacturing technology, provides the consumer with a characteristic graph for the production amount according to wind speed changes. This diagram is unique for each turbine and invalid for other turbines. Figure 1 shows the characteristic diagram of the HY5-AD5.6 turbine in terms of wind speed.

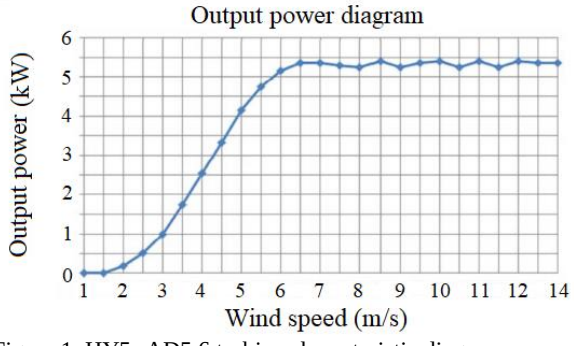

Figure 1. HY5- AD5.6 turbine characteristic diagram

According to the energy balance sheet data, the amount of electricity production in Parsabad Moghan is 1841.4 GWh, of which the share of the gas power plant is 1774 GWh, diesel 0.2 GWh, and hydroelectricity 67.2 GWh. are hours. Considering that the contribution of the diesel power plant is small, and the hydroelectric power plant does not pollute the environment; Therefore, to check the amount of pollution, the gas power plant is restricted.

3. Results & Discussion

This research is the necessary background for the investigation and potential measurement of wind energy in Parsabad Mughan of Ardabil, according to meteorological data and comparing it with the conventional urban electricity distribution system in terms of pollution.

Based on this, due to the lack of required data for the number of windy days per month, calculations were made based on the amount of production per windy day per month.Equation 1 was used to estimate the amount of wind energy production. This relationship theoretically calculates the maximum energy produced by a wind machine.

$$P=0.59*0.5*\rho*v3*A \qquad (1)$$

In this relation, ρ is the air density, v is the average wind speed, and A is the disk surface area. Based on this, if we want to theoretically calculate the production power of the desired turbine in terms of the amount of wind blowing in one hour (Table 3):Considering that the amount of energy produced in the practical situation is very different from the amount of production in the hypothetical case, the amount of electric energy production was calculated based on the diagram in Figure 1, which shows the amount of energy production at different speeds for the desired turbine. This amount of energy will replace the electricity generated from the power plant, so if the energy generated from the turbine replaces the electricity from the power plant, it will prevent the same amount of fuel consumption and carbon dioxide emissions. According to reports from various sources, carbon dioxide is the main greenhouse gas released and has a significant effect on global warming. Therefore, the present study focused on the emission of carbon dioxide gas.The results of calculations in the field of natural gas consumption and the amount of carbon dioxide produced due to it are reported in Table 3. This phenomenon means that if the amount of power produced by the wind turbine is to be replaced by the electricity produced from the gas plant, how much natural gas will be consumed per unit of energy, and how much carbon dioxide will be released? Because about 98% of natural gas is methane, the relationship of methane burning was used to obtain the approximate amount of gas emission. Considering the

relationship of burning methane, about 2.87 kg of carbon dioxide is released from burning 1 kg of natural gas.

Table 3. Results of power generation per 1 hour of turbine operation per month

Months	March	April	May	June	July	August	September	October	November	December	January	February
Average speed	32	24	17	25	18	14	15	13	13	15	18	18
Theoretical energy (kWh)	286	120	43	136	51	24	30	19	19	30	51	51
Graph-based energy (kWh)	5.5	5.4	5.2	5.4	5.4	5.3	5.2	5.35	5.35	5.2	5.4	5.4
Natural gas consumption (cm3)	1.27	1.26	1.2	1.26	1.26	1.23	1.2	1.24	1.24	1.2	1.26	1.26
CO2 emission (g)	0.361	0.36	0.34	0.36	0.36	0.345	0.34	0.35	0.35	0.34	0.36	0.36

$$CH_4+\frac{2}{0.21}(0.21O_2+0.79N_2)\longrightarrow CO_2+2H_2O+\frac{2\times0.79}{0.21}N_2 \quad (2)$$

In this way, the approximate amount of carbon dioxide production based on natural gas consumption was calculated and reported in Table 3.

According to Table 3, using a wind turbine for one hour per month cannot significantly prevent natural gas consumption and carbon dioxide emissions. However, the number of wind hours per month exceeds 1 hour. Consequently, they will include a coefficient of the values reported in Table 3, which will have a significant number for replacement.

According to Figure 1, from the wind speed of 11 and above, the turbine production power is the highest, and there is no significant change in the power production change with speed changes. Considering the monthly wind speed in Ardabil according to Table 2, it can be stated that the wind speed is higher than 11 in all months, and this means that the turbine always works in the maximum range of its production.

The highest amount of production is related to March, with an output of 5.5-kilowatt hours, equal to the consumption of 0.000127 cubic meters of natural gas and the production of 0.361 grams of carbon dioxide. The lowest production potential is related to July and August, with an output of 5.35 kilowatt hours, equal to consuming 0.000124 cubic meters of natural gas and producing 0.35 grams of carbon dioxide per hour of turbine operation per month.

4. Conclusions

The study's main aim is to evaluate the wind energy power in Parsabad Moghan of Ardabil province. The required dataset was collected from the metrological center of Parsabad. The dataset includes the monthly average wind speed in the study area. Parsabad has a high wind energy potential in the region of the study. The analysis was conducted using a standard wind turbine.

Based on the obtained results, it can be concluded:

• The use of wind turbines in the Parsabad region of Moghan can be a suitable alternative for electricity supply, considering the wind potential of this city.

• The use of wind turbines significantly prevents gas consumption.

• The use of wind turbines significantly prevents the production of carbon dioxide.

According to the obtained results, it can be conducted that this region has great potential for renewable energy production. these energies can be considered biomass, solar, and wind energy. Using hybrid energy sources increases the security of sustainable energy production. We propose a life cycle assessment to select the best energy production scenario for future study.

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