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The Importance of Renewable Energies with Emphasize on Wind Power

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***Abstract*:- Nowadays, energy plays a vital role within the world economy, security, and politics. Every country must develop its resources and policies concerning energy and environmental contaminants for better future planning. Fossil fuels are the primary recourse for global energy needs (80% of total energy consumption). Because of the emission of greenhouse gases, they are gradually replaced with renewable energy resources. Additionally, renewable energy resources are stable, unlike fossil fuels, which may use up in less than one century. Nowadays, several kinds of renewable energies utilize around the globe, particularly in developed countries. For instance, solar power, hydropower, geothermal energy, and wind power are different kinds of renewable energies. According to recent studies, each of them has its own positive and negative points.**

This article discusses the various kinds of renewable energy, in particular wind energy and the advantages of this type of energy resource. The author eventually provides a short description of a simple wind turbine.

Keywords: Renewable energy, solar power, Hydropower, Geothermal energy, wind power.

1. INTRODUCTION

Nowadays, Sustainable development has been identified as the most important response to urban challenges. Consumption of renewable energies is one of the essential components of sustainable development. As this would protect the environment and conserve the current natural resources for future generations. Currently, 80 percent of the world's energy comes from fossil fuels, which are the most important contributor to greenhouse emissions. Besides, fossil fuels are a serious contributor to global climate change, and this drawback is additional pronounced in developing countries. These countries should seek alternatives to reduce carbon dioxide emissions. [1]

Climate researchers believe that greenhouse gas emissions have devastating effects on the ecosystem and cause changes within the climate of the planet. The highest proportion (25%) of greenhouse gases generated by the production of heat and electricity. thus, increasing the utilization of renewable energy sources (RES) is an effective strategy in reducing the negative impacts of the emissions. Therefore, facilitating and accelerating the development of renewable energy technologies for the generation of heat and electricity is a key point in the global debate about the energy transition as it requires a structural change to the energy system. [2]

According to the United Nations (UN), by 2050, about 66 percent of the world's population will live in cities. Given this unprecedented global urbanization and the need for sustainability at all aspects of a city, the concept of "Smart Cities" emerged as a desired goal for present and future urban development and attracted the attention of many researchers in the field.

As a result of the increasing urban population, scientists believe that energy consumption is increasing rapidly. As major energy sources are depleting and emit harmful emissions, the world is experiencing severe challenges in providing a clean and sustainable energy supply to mass populations.

Given the consequences of utilizing fossil fuels, the need for renewable energies is greater than ever. This paper discusses the different types of these energies and introduces each one's positive and negative effects. The beneficial effects of using renewable energies are undeniable, according to the studies. The most significant effects in utilizing this type of resource are economic benefits, environmental protection, reduction in air pollution, etc.

2. CONCEPTUAL MODEL

Given the numerous issues of fossil fuels on the one hand and also the economic and environmental benefits of renewable energy, on the other hand, the tendency to research in this area is increasing. Here are four types of renewable energies, as well as water, wind, geothermal and solar energy. In this study, there are explanations relating to wind energy, as well as literature review, benefits, and positive effects of using this sort of energy. Figure 1 illustrates the conceptual model.

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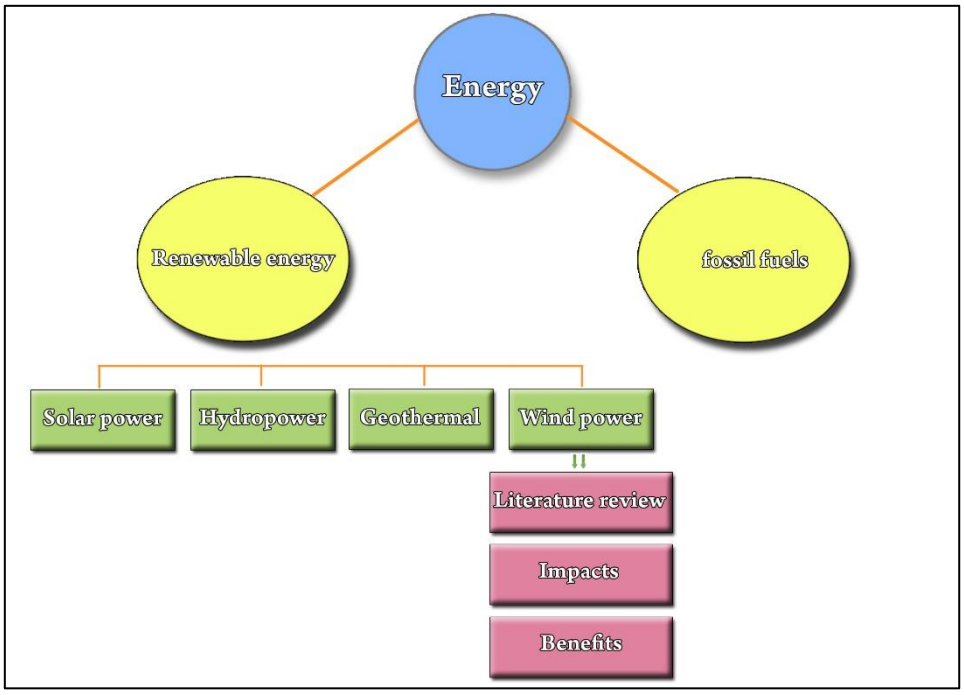

Fig. 1. Conceptual model.

3. RENEWABLE ENERGY

Humans have been utilizing Fossil fuels since ancient times. Today, due to the increased use of it, the amount of carbon dioxide rises in the atmosphere. About 30 billion tonnes of carbon dioxide emitted each year due to the utilization of fossil fuels, which is higher than the amount recoverable by nature. The release of this volume of CO2 has contributed to higher global temperatures. The global average temperature has increased to 1.02 ° C since 1900-2015 and this trend is also on the rise.

Reports indicate that if humans do not take appropriate steps in this regard, it is possible that by 2100 the Earth's temperature will rise to about 4 °C. As a result, this process could lead to the extinction of many plant and animal species on Earth. This can be a serious threat to humans, and this natural disaster will cause human injury and death. [3]

Given the devastating effects of greenhouse gas emissions, scientists are perpetually looking for a solution and think about renewable energies the most effective way to minimize co2 emissions. Reports recommend that burning coal emits 1.4– 3.6 pounds of CO2E/kWh. However, using renewable energy sources, such as wind, can turn out as very little as 0.02–0.04 pounds of CO2E/kWh. This distinction is noticeable. [4]

Also, since the fluctuations in fossil fuel prices which negatively affect investment decisions and exhaustible features of fossil fuel sources, renewable energy becomes a preferable alternative to non-renewable energy. Therefore, renewable energies ought to replace fossil fuels round the world. [5]

As a result, renewable energies are an appropriate option for non-renewable energy sources due to many of the above-stated reasons. There are several types of renewable energies today and most of them are available across the world. It should note that the usage of various forms of energy due to specific circumstances are entirely different.

3.1. Solar power

Solar energy is one of the endless energy sources. All human energy consumption throughout the year will supply, with minimal environmental impact, the hourly solar flux incident on the earth's surface. Fossil fuel shortage, pollution, and global climate change crisis in recent years reveals the importance of this type of energy. The conversion of solar energy into sustainable energy such as heat or electricity is an important factor in making this energy suitable. [6]

Solar energy regards as one of the most attractive alternatives among all renewables due to the extreme advantages of being green, low cost, and renewable. Using the energy source, concentrating solar power (CSP) or solar thermal electricity (STE) is a technology that is capable of producing utility-scale electricity, offering firm capacity and accessible power on demand by integrating thermal energy storage or in hybrid operation. [7]

Considering the high energy saving and high energy efficiency, CSP plants predict to produce a global electricity contribution of 7% by the year 2030 and 25% by the year 2050. [8] In addition to electricity generation, CSP also has tremendous potential in job creation and global CO2 emissions reduction. [9]

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CSP technology

In CSP power plants, by concentrating solar radiation electrical energy generates. Generally, CSP plants consist of several components such as solar concentrators, receiver, steam turbine, and electrical generator. Today, scientists find four different kinds of CSP power generation plants; those are 1) solar parabolic dishes (SPD), 2) parabolic trough collectors (PTC), 3) solar power tower (SPT), and 4) linear Fresnel reflectors (LFR). Fig. 2 shows the various CSP technologies and their installed ratios in the technology mix, where the PTC represents the highest establishment, globally. [1]

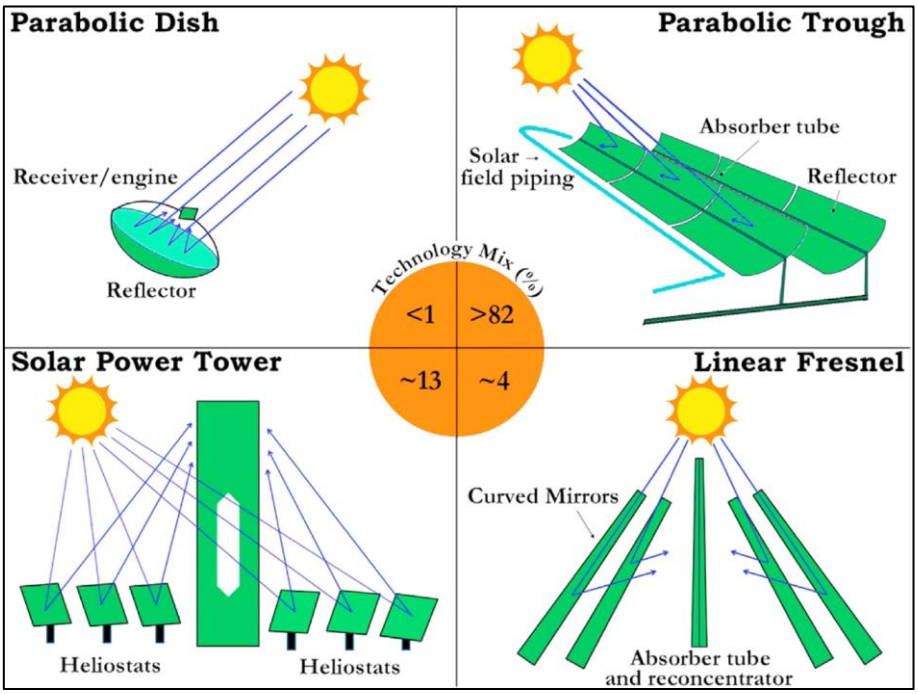

Fig. 2. Various CSP technologies along with their installed ratios.

According to conducted research, potential locations for the deployment of CSP plants are identified and located by using the global distribution of Direct Normal Irradiance (DNI). [10]

Some of the earth's zones are known as the "Sun Belt," where solar radiation is more accessible than in other regions. North Africa, the Middle East, the Mediterranean, and vast U.S. regions such as California, Arizona, Nevada, and New Mexico. Geographically, the Belt is appropriate for CSP plants, as there are massive land areas with extraordinary solar irradiation, well suited to install a large number of solar-energy harvesting systems. [11]

Regular generation of electricity causes problems such as the threat of a sudden decrease in supply amounts, and greenhouse gas emissions such as carbon dioxide. It also causes several environmental drawbacks. CSP is capable of generating large amounts of electricity and many of the industrialized nations invest heavily in CSP technology. Among the four different types of CSP technologies, the parabolic trough collector (PTC) and the solar power tower (SPT) are the two leading technologies that currently install in several countries. [1]

3.2. Hydropower

By 2010, nearly 150 countries benefited from hydropower. Among renewable energy sources, water energy accounts for the most important share of electricity generation in the world. That is, hydropower produces about 16 % of all electricity in the world. However, the growth of this energy expansion is slower than in other renewable energies. The top countries for hydropower capacity are China (213GW), Brazil (80.7GW), The US (78 GW plus 20.5 GW of pumped storage), Canada (75.6 GW), and Russia (55G W); they account for approximately 52% of global installed capacity. [12]

The cost of producing electricity using water energy is more economical than other sources of energy production. Hydro dams play other necessary socioeconomic roles besides electricity generation, including flood control, irrigation, and public water supply. [13]

In addition to the positive impacts of hydro dams on the region's economic development, these dams will have to affect the ecological balance of lakes and lagoons and damage the environment by increasing moisture in their surrounding areas. Also, sometimes the lives of individuals living close to these dams suffer from its social disadvantages. [14]

Hydropower has provided clean, affordable, reliable, and renewable electricity and supported economic development. it also provides a stable and consistently low-cost energy supply throughout decades of fluctuations and fundamental shifts in the electric sector. Hydropower could be a scalable, reliable generation technology that offers operational flexibility to take care of grid reliability and support the integration of variable generation resources. [15]

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The opportunity

Increasing hydropower can simultaneously deliver an array of advantages. Power plants have several benefits that directly affect air quality, public health, economic efficiency, and water security. Based on the research conducted by the US government in 2017, In addition to economic and environmental advantages, power plants also have long-term social benefits that can be provided by hydropower and exceed the initial industry investment. [15]

The Risks

Given that many of the efforts and attempts to develop hydropower as a significant source of energy within the future are crucial, these require the continuing development of technology to extend efficiency, reduce costs, and create market mechanisms on the market. Failure to take conscious action to remedy these issues reduces the likelihood of potential benefits being complete. It will also promote positive environmental impacts by promoting appropriate social interaction with users and other stakeholders. It is vital to continue researching and analyzing energy policies and electricity prices, the advantages and impacts of energy for providing accurate information to policy manufacturers, and public discourse. Lastly, it is essential to update priorities among groups and stakeholders to ensure coordinated methods in the future. [15]

3.3. Geothermal energy

In the 21st century, most of the countries focus on biomass, solar energy, wind power, and electricity to produce energy. While geothermal energy received the least attention. The most important reason for this can be the fact that geothermal energy is available in certain places on Earth, mostly near tectonic plate boundaries. [16]

The term "geothermal" is rooted in Greece literature. Geo means earth and thermal meaning heat. Geothermal energy originates from the heat in the mantle and core of the earth, and deep faults enable water to transfer to these sources of heat. Increasing the amount of hot water creates a geothermic reservoir which will reach temperatures of 350 ℃ or higher. [17]

Geothermal energy is considered a renewable energy source that is reliable, safe, and clean. Different types of geothermal systems can be divided into three categories: i. direct use and district heating systems. ii. Electricity generation via geothermal power plants. iii. Geothermal heat pumps. Direct use and district heating systems use hot water from reservoirs or springs located near the surface of the earth. And, electricity generation in geothermal power plants requires water or steam at high temperatures (300–700 °F or approximately 150–370 °C). Also, geothermal heat pumps utilize the constant temperatures near the surface of the earth to heat and cool buildings/structures. [18]

Geothermal energy generates about 0.3 percent of the world's total energy. Geothermal energy production has been increasing since 2017 and is that by 3.1%. However, there are a few countries that have a greater proportion of this energy. As: Kenya (over 40% of power), Iceland (over 25%) and New Zealand (18%). [19]

Geothermal energy benefits

Geothermal energy can play a significant role in reducing CO2 emissions and different greenhouse gas emissions. It should be noted that 26 countries use this energy directly to generate electricity. It is also available in 82 countries around the world. Geothermal energy has several benefits, including:

- Provide reliable electricity at a stable price;
- Facilitate states diversify the combination of fuels they use to produce electricity;
- Generate electricity during a manner that produces negligible environmental impacts and emissions;
- Help states meet renewable portfolio standards;
- Generate economic development opportunities, particularly in rural areas; and
- Provide heat for agricultural, industrial, and house heating applications. [20]

Main challenges geothermal energy

In general, for geothermal projects, the leasing process and finding the desired location is one of the main challenges, and this process can be amid uncertainty. Although the price of generating power from geothermal resources has fallen by concerning 25 percent over the past 20 years, exploration and drilling are still expensive to obtain. Drilling costs account for a significant portion of the total cost, accounting for one-third to one-half of the whole budget. And therefore the method of identifying geothermal reservoirs has grown significantly in recent years.

Since the most effective geothermal resources are located in remote areas, exploiting them due to the expansion of the facility transmission system will be expensive. The location of power plants and systems exploitation this energy should directly close to geothermal resources. As a result of the transport of hot water and steam over long distances is impossible and costly. Also, here are a number of the challenges ahead in utilizing this energy source:

- Lack of national and local legislation;
- Poor management of human resources; and
- Inability in technology transfer [20]

3.4. Wind power

Wind energy from the distant past has attracted human attention. As early as 200 B.C., the ancient Persians used windmills. In the 18th century, the first wind turbines in the United States with a capacity of 12 kW began to generate electricity from this

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sustainable supply. Wind energy is accessible worldwide, in addition to being more affordable than other renewables due to its cost-effectiveness and low cost. Furthermore, wind energy has the lowest production of carbon dioxide lifecycle footprint among the other sorts of renewable resources. [12]

Literature review

Until now, scientists have done numerous researches related to wind control potential and attributes in a couple of nations around the globe. General information about these studies illustrates in the table below. It should be noted that these studies have been performed mostly in Asia. According to the results of this researches, the use of wind energy is one of the basic strategies in replacing fossil fuels. With the expansion of the use of this type of renewable energy, environmental pollution reduced, on the other hand, this type of energy is very economical compared to other types of renewable energies.

Table 1: Research in the field of wind energy

Essay	Case study	Results
Dabbaghiyan A, Fazelpour F, Abnavi MD, Rosen MA. Evaluation of wind energy potential in the province of Bushehr, Iran. Renew Sustain Energy Rev 2016;55:455–66. [21]	Iran, Bushehr	It was accounted for that the normal wind power density in the examined locale is around 265 W/m2 at the tallness of 40 m.
Ayodele TR, Ogunjuyigbe ASO. The wind energy potential of Vesleskarvet and the feasibility of meeting the South African ′ s SANAE IV energy demand. Renew Sustain Energy Rev, 56, 226–234; 2016. [7]	Antarctica, Vesleskarvet	Utilizing day by day normal wind speed estimated during a time of 11 years. In their examination, the normal wind speed and wind control thicknesses were 10.9 m/s and 1650 W/m2, individually.
Ko DH, Jeong ST, Kim YC. Assessment of wind energy for small-scale wind power in Chuuk State, Micronesia. Renew Sustain Energy Rev 2015;52:613–22. [22]	Micronesia, Chuuk State	Utilizing Weibull and Rayleigh appropriation to speak to the wind speed information during 2013. Their outcomes show that a 20 kW turbine was appropriate for power age delivering about 36,841.73 kW h/year.
Belabes, B., Youcefi, A., Guerri, O., Djamai, M., & Kaabeche, A. (2015). Evaluation of wind energy potential and estimation of cost using wind energy turbines for electricity generation in north of Algeria. Renewable and Sustainable Energy Reviews, 51, 1245-1255. [23]	Six Algerian cities	Utilizing Weibull circulation. As per the announced outcomes, Tiaret and Oran demonstrated the most significant wind power density with 238 W/m2 and 171 W/m2, individually.
Baseer MA, Meyer JP, Alam MM, Rehman S. Wind speed and power characteristics for Jubail industrial city, Saudi Arabia. Renew Sustain Energy Rev 2015;52:1193–204. [24]	Saudi Arabia	Utilizing hourly wind speed information from 2008 to 2012. The successive wind speed was 3.5 m/s while the yearly normal wind power density was observed to be 168.46 W/m2.
Irwanto M, Gomesh N, Mamat MR, Yusoff YM. Assessment of wind power generation potential in Perlis Malaysia. Renew Sustain Energy Rev 2014;38:296–308. [25]	Malaysia, Chuping, and Kangar in Perlis	It was demonstrated that the windy period was from January to April. Also, it was demonstrated that Kangar was the appropriate area with wind speed and power thickness of 2.5 m/s and 19.69 W/m2, individually.
Khahro SF, Tabbassum K, Soomro AM, Liao X, Alvi MB, Dong L, Manzoor MF. Techno-economical evaluation of wind energy potential and analysis of power generation from wind at Gharo, Sindh Pakistan. Renew Sustain Energy Rev 2014;35:460–74. [26]	Pakistan, Gharo	Utilizing wind information estimated from 2003 to 2007 at 30 m height. The creators evaluated the most continuous wind speed as 9.356 m/s and the power density as 260 W/m2 dependent on the Weibull dispersion.
Hernández-Escobedo Q, Saldaña-Flores R, Rodríguez-García ER, Manzano-Agugliaro F. Wind energy resource in Northern Mexico. Renew Sustain Energy Rev 2014;32:890–914. [27]	Northern Mexico	They presumed that Tamaulipas was the windiest state in September and October with a wind power density of 1000 W/m2.
Sharma K, Ahmed MR. Wind energy resource assessment for the Fiji Islands: Kadavu Island and Suva Peninsula. Renew Energy 2016;89:168–80. [28]	Fiji Islands	They announced 3.88 m/s on the island of Kadavu and 6.38 m/s in the Suva Peninsula as normal wind speed at 34 m tallness utilizing WAsP programming.
Karthikeya BR, Negi PS, Srikanth	Singapore	The outcomes demonstrated that Pandan Gardens was the best

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N. Wind resource assessment for urban renewable energy application in Singapore. Renew Energy 2016;87:403–14. [29]		site with the most extreme wind power density of 45 W/m2.
Sobchenko A, Khomenko I. Assessment of regional wind energy resources over Ukraine. Energy Proc 2015;76:156–63. [30]	Ukraine	Introduced an evaluation of wind assets for seven destinations in Ukraine over a time of eleven years to recognize the site with a poor wind potential (Lviv with a thickness intensity of 70 W/m2) and the site with a decent one (Simferopol with a thickness intensity of 180 W/m2).
Al Zohbi G, Hendrick P, Bouillard P. Wind characteristics and wind energy potential analysis in five sites in Lebanon. Int J Hydrog Energy 2015;40(44):15311–9. [31]	Lebanon	looked at the wind qualities of five destinations in Lebanon. The most extreme estimation of wind speed was recorded in Daher El Bayder while the base one was recorded in Cedars.
Shu ZR, Li QS, Chan PW. Statistical analysis of wind characteristics and the wind energy potential in Hong Kong. Energy Convers Manag 2015;101:644–57. [32]	Hong Kong	The most noteworthy normal wind speed was found at TMS (Tai Mo Shan climate station) with an estimation of 9.04 m/s while the lower one was at HKO (Hong Kong Observatory station) with an estimation of 2.55 m/s.

This paper describes wind power, especially in the United States. And it should be noted that this information has been taken from the Wind Technologies Market Report, which is published by the United States Department of energy in 2017. Global wind additions equaled roughly 52,500 MW in 2017, below the 54,600 MW added in 2016 and below the record of 63,000 MW added in 2015. With its 7,017 MW representing 13% of new global installed capacity in 2017, the United States maintained its second-place position behind China (Table 2). Cumulative global capacity grew by 11% and totaled 539,000 MW at the end of the year (GWEC 2018), with the United States accounting for 17% of global capacity—a distant second to China by this metric (Table 2) The United States also remains in second place, behind China, in annual wind electricity generation. [33]

Table 2. International ranking of world power capacity

Annual Capacity (2017, MW)		Cumulative Capacity (end of 2017, MW)	
China	19660	China	188392
United States	7017	United States	88973
Germany	6581	Germany	56132
United Kingdom	4270	India	32848
India	4148	Spain	23170
Brazil	2022	United Kingdom	18872
France	1694	France	13759
Turkey	766	Brazil	12763
South Africa	618	Canada	12239
Finland	535	Italy	9479
Rest of world	5182	Rest of world	82391
Total	52492	Total	539019

Source: The Wind Technologies Market Report, 2017

Benefits

The advantages of wind energy divide into two categories: 1) Economic advantages and 2) Environmental benefits. At first, we will discuss the economic effects of using this type of energy. According to the studies in this field, the use of wind energy in reducing electricity consumption is very significant. As a result, energy costs will be significantly reduced.

1) Economic benefits:

Scientists have been studying different scenarios in terms of wind penetration, wind forecasts, and wind curtailment to analyze the impact of wind power on electricity prices. The results of the studies state that electricity costs decrease and electricity price volatility increase with wind penetration. [34]

The development of wind power will impact local economies. The further beneficial impacts of using wind energy are as follows:

- Wind power development directly affects the employment and income of these operating in the industry, particularly during the development phase of a project.
- Wind power construction and operations expenditures could generate indirect demand for products and services (e.g., gravel, concrete, vehicles, fuel, hardware, and consumables) produced or sold by different industries in the local economy, contributing to enhanced employment and income in those industries.
- Property taxes or payments instead of property taxes paid by wind energy operators can contribute to increased local government revenues.
- Payment on products and services in the local economy by native residents and governments from these additional sources of financial gain as well as by employees concerned in construction or operations activities will induce further local economic impacts.

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- Wind power development might positively or negatively affect the desire of individuals to measure, visit or add the community, successively touching migration and traveling flows and income from the commercial enterprise as well as demand for land, with subsequent potential impacts on property values, property tax revenues, and other aspects of the local economy.
- Wind power development in one community might affect the employment and income of individuals by inducing increased demand for goods and services from nearby communities, or by affecting commuting or migration to these communities. Development in economic activity in nearby communities can affect economic activity in the areas where wind power development is occurring. [35]

2) Environmental benefits:

In this article, the environmental benefits are divided into two categories.

Air emissions benefits: according to the report of National Renewable Energy Laboratory (NREL), which reported the value of wind technology innovation in 2017, Wind technology advancements will lead to power sector air emissions reductions by displacing fossil generation with economically competitive wind energy. In this study, they report sulfur dioxide, nitrogen oxides, and carbon dioxide emissions estimated directly from the ReEDS model. Lower power sector emissions are found in situations with greater wind preparation. Emissions reductions are also sensitive to the type of fossil generation displaced as well because of the regional implementation of emissions management equipment.

In conclusion, Reductions in air pollution emissions will have health and environmental benefits for local and downwind communities also as global implications. [36]

Reduce water consumption: The development of wind energy technologies will lead to reduced water consumption in energy production. This savings comes from the lack of water consumption in wind turbine technology and therefore the reduction in reliance on cooling water in thermal power plants.

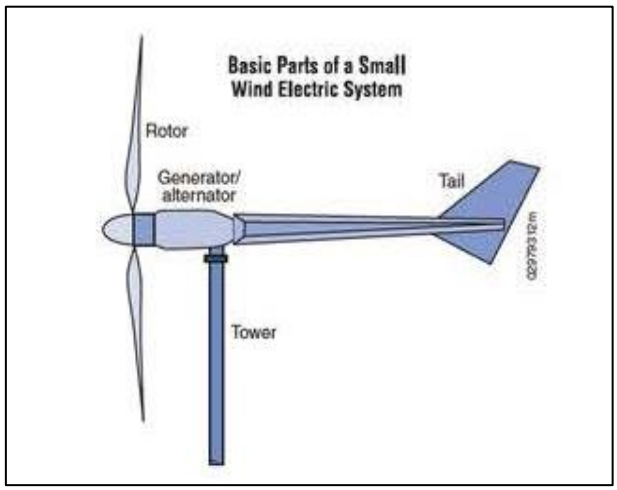
Water use is estimated within the ReEDS electric sector model based on the performance and characteristics of a unique generation and cooling system technologies. ReEDS distinguish between water consumption-water removed from the source for power plant cooling and not returned and water withdrawals-water removed, however, came back to the supply, potentially at higher temperatures. Only operational water use is estimated as it contains the overwhelming majority of total life-cycle water use for several generation technologies. [36]

4. WIND ELECTRIC SYSTEM

The basic parts of a small wind electric system

In this part, a brief explanation of the different parts of a small wind turbine is provided. Home wind energy systems generally comprise a rotor, a generator or alternator mounted on a frame, a tail (usually), a tower, wiring, and the "balance of system" components: controllers, inverters, and batteries. Through the spinning blades, the rotor captures the kinetic energy of the wind and converts it into rotary motion to drive the generator, which produces either AC or wild AC (variable frequency, variable voltage), which is typically converted to grid-compatible AC electricity. As shown in Figure 3. [37]

Fig 3. Basic parts of a small wind electric system



Source: Windexchange.energy.gov/small-wind-guidebook

- Wind Turbine

Small wind turbines can be divided into two groups: horizontal axis and vertical axis. The most commonly used turbine in today's market is the horizontal-axis wind turbine. These turbines typically have two or three blades that are usually made of a composite material such as fiberglass. Vertical-axis wind turbines consist of two types: Savonius and Darrieus. A Savonius turbine can be recognized by its "S" shaped design when viewed from above. Darrieus turbines look like an eggbeater and have vertical blades that rotate into and out of the wind. [38]

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- Tower

Because wind speeds increase with height, the turbine is mounted on a tower. In general, the higher the tower, the more power the wind system can produce. The tower also raises the turbine above the air turbulence that can exist close to the ground because of obstructions such as hills, buildings, and trees. A general rule of thumb is to install a wind turbine on a tower with the bottom of the rotor blades at least 30 feet (9 meters) above any obstacle that is within 300 feet (90 meters) of the tower. Relatively small investments in increased tower height can yield very high rates of return in power production. [39]

There are two types of towers: self-supporting (free-standing) and guide. Guyed towers, which are the least expensive, can consist of lattice sections, pipe, or tubing (depending on the design); supporting guy wires, and the foundation. They are easier to install than self-supporting towers. However, because the guy radius must be one-half to three-quarters of the tower height, guyed towers require space to accommodate them. Although tilt-down towers are more expensive, they offer the consumer an easy way to perform maintenance on smaller lightweight turbines (usually 5 kW or smaller). Tilt-down towers can also be lowered to the ground during hurricanes and other hazardous weather conditions. Aluminum towers are prone to cracking and should be avoided. Most turbine manufacturers provide wind energy system packages that include a range of tower options. [40]

- Balance of System

Costs in addition to the turbine and the tower are the balance of system, including parts and labor, which will depend on your application. Most manufacturers can provide you with a system package that includes all the parts you need for your application. For example, the parts required for a water-pumping system will be different from the parts required for a residential, grid-connected application. The balance of system equipment required will also depend on whether the system is grid-connected, stand-alone, or part of a hybrid system. For a residential grid-connected application, the balance of system parts may include a controller, storage batteries, a power conditioning unit (inverter), wiring, foundation, and installation. Many wind turbine controllers, inverters, or other electrical devices may be stamped by a recognized testing agency, such as Underwriters Laboratories or Intertek.

- Batteries for Stand-Alone Systems

Stand-alone systems (systems not connected to the utility grid) require batteries to store excess power generated for use when the wind is calm. They also need a charge controller to keep the batteries from overcharging. Deep-cycle batteries, such as those used for golf carts, can discharge and recharge 80% of their capacity hundreds of times, which makes them a good option for remote renewable energy systems. Automotive batteries are shallow-cycle batteries and should not be used in renewable energy systems because of their short life in deep-cycling operations.

Small wind turbines generate direct current (DC) electricity. In very small systems, DC appliances operate directly off the batteries. If you want to use standard appliances that use conventional household alternating current (AC), you must install an inverter to convert DC electricity from the batteries to AC. Although the inverter slightly lowers the overall efficiency of the system, it allows the home to be wired for AC, a definite plus with lenders, electrical code officials, and future homebuyers. For safety, batteries should be isolated from living areas and electronics because they contain corrosive and explosive substances. Lead-acid batteries also require protection from temperature extremes. [41]

- Inverters for Grid-Connected Systems

In grid-connected systems, the only additional equipment required is a power conditioning unit (inverter) that makes the turbine output electrically compatible with the utility grid. Batteries are usually not required.

The best site for a wind turbine

A proper site assessment is a detailed process that includes wind resource assessment and the evaluation of site characteristics. With this in mind, you may wish to consider hiring an experienced small wind site assessor who can determine your property's optimal turbine location. The following information highlights the key steps in the site selection/assessment process.

- If the surrounding area of a potential site is not relatively flat for several miles, then an evaluation of the main topographic features is necessary, both nearby (macro siting) and at the proposed turbine site (micro siting). The topographical evaluation should include shape, height, length, width, and distance and direction away from the proposed turbine site of any landforms. "Nearby" could include influences from large objects such as hills, groves of trees, or high wind breaks up to a mile away, and smaller objects could include single trees and buildings, especially within 500 feet of the proposed turbine location.
- Owners of projects located near complex terrain should take care in selecting the installation site. Landforms (or orography) can influence wind speed, which affects the amount of electricity that a wind turbine can generate. Elevated areas not only experience increased wind speeds because of their increased height in the wind profile but also may cause local acceleration of the wind speed, depending on the size and shape of the landform. If you site your wind turbine on the top of or on the windy side of a hill, for example, you will have more access to prevailing winds than in a gully or on the leeward (sheltered) side of a hill on the same property. Other elevated landforms (bluffs, cliffs) can create turbulence, including back eddies, as the wind passes up and over them. Siting the tower to avoid the zones of turbulence created by the landform is critical.
- Turbulence intensity is a major issue for small turbines because of their tower height and location around "ground clutter." Turbulence can reduce the annual energy output estimate from 15% to 25% because wind turbine power curves are typically developed based on measurements taken at sites with relatively low turbulence intensity compared to typical small wind project sites.
- Varied wind resources can exist within the same property. In addition to measuring or finding the annual wind speeds, you need to know about the prevailing directions of the wind at your site. Knowing the prevailing wind direction(s) is essential to

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determine the impact of obstacles and landforms when seeking the best available site location and estimating the wind resource at that location. To help with this process, small wind site assessors typically develop a wind rose, which shows the wind direction distributions of a given area. The wind rose divides a compass into sectors (usually 8 or 16) and indicates the average wind speed, average percentage of time that the wind blows from each direction, and/or the percentage of energy in the wind by sector. Wind roses can be generated based on annual average wind speeds, or by season, month, or even time of day as needed. [37]

- In addition to geologic formations, you need to consider existing obstacles such as trees, houses, and sheds, and you need to plan for future obstructions such as new buildings or trees that have not reached their full height. Your turbine needs to be sited upwind of buildings and trees, and it needs to be 30 feet above anything within a 500-foot horizontal radius. You also need enough room to raise and lower the tower for maintenance, and if your tower is guyed, you must allow room for the guy wires.
- Whether the system is stand-alone or grid-connected, you also need to consider the length of the wire run between the turbine and the load (house, batteries, water pumps, etc.). A substantial amount of electricity can be lost as a result of the wire resistance the longer the wire run, the more electricity is lost. Using more or larger wire will also increase your installation cost. Your wire run losses are greater when you have direct current (DC) instead of alternating current (AC). So, if you have a long wire run, it is advisable to invert DC to AC. [42]

5. CONCLUSION

The global trend to develop renewable energy has accelerated, and many countries in the world are utilizing various types of renewable resources for different purposes but mostly for electricity generation and direct heating. It should not be ignored that fossil fuel reserves will be exhausted in less than one century; this fact illustrates the importance of expanding renewable energy around the globe.

A majority of countries have established policies to direct, support, and strengthen renewable energy applications. Especially, developed countries are contributing more to increase renewable energy proportion globally; for instance, the United States is one of the leading countries in the use of wind power.

The use of wind energy has many benefits that can be attributed to the reduction of greenhouse gas emissions and environmental degradation as its most significant positive impact. Also, the effects of using this kind of energy in economic efficiency are undeniable. As a result, according to the need of communities to produce energy, the power of this type of renewable energy as one of the sources noted.

List of abbreviations

WT: wind turbine
R&D: research and development
RES: renewable energy sources
GHG: greenhouse gas
CSP: concentrating solar power
STE: solar thermal electricity
SPD: solar parabolic dishes
PTC: parabolic trough collectors
SPT: solar power tower
LFR: linear Fresnel reflectors
DNI: Direct Normal Irradiance
GWEC: Global Wind Energy Council
NREL: National Renewable Energy Laboratory
AC: alternating current
DC: direct current

Declaration

Ethics Approval and Consent to Participate

Not applicable

Consent for publication

Not applicable

Availability of data and supporting materials

All sources of data and materials analyzed in the course of this paper a listed in the reference section.

Competing interests

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AUTHORS' CONTRIBUTIONS

The author has collaboratively contributed to all phases of the research and in the development of the manuscript.

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