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RESEARCH ARTICLE

Sustainability of Renewable Energy Options as Compared to Coal-Fired Power Plants in Pakistan

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Abstract: Though frequent availability of energy is vital for economic growth, using any energy source can have a certain degree of impact on the environment. Pakistan is facing the worst power crisis nowadays. The government of Pakistan has been focused to find energy solutions in fossil fuels. As the world moves toward a clean sustainable direction, coal sources are cheap at the moment, and new coal-based power plants can be put up quickly with a predictable output, but with the degradation of the environment, Pakistan can utilize sustainable energy resources such as biomass, solar energy, hydropower, and wind power, which are frequently available in Pakistan and can generate environment-friendly power above 40,000 MW. It is necessary to consider these sustainable energy resources, as their prices have been dipping dramatically, and it is now cheaper to build new commercial plants based on improved technologies able to generate more electricity. The present paper discusses the insight environment-friendly sustainable energy options available in Pakistan other than coal-fired plants to overcome future energy demand.

Keywords: coal power, environmental degradation, sustainable energy options, renewable energy, Pakistan

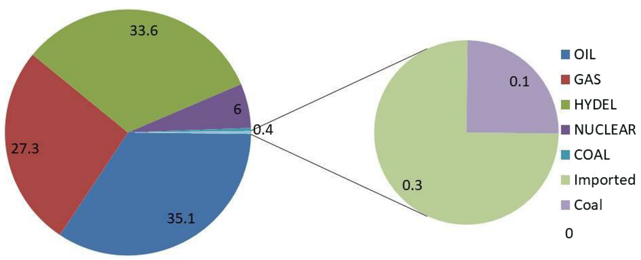
1. Introduction

In modern times, the frequent availability of clean energy without interruption is vital for sustainability, prosperity, and economic growth. Advancement in production activities needs more energy [1]. Worldwide, the energy crisis is swelling with the increase of population. Increased energy demand has changed energy systems, globally [2]. The way in which electricity is supplied to industries, heat homes, and fuel cars has been transformed. These transformations have extensive effects on industries, businesses, governments, and individuals soon [3].

The spreading out of industries and population growth have also led to an increase in energy consumption in Asian countries including Pakistan [4]. Competitiveness exists among conventional energy sources: coal, natural gas/oil, and renewable energy sources for providing economic stability in Asia's developing economies [5]. Most developing countries in Asia depend on coal, with China and India being the main participants [6]. Recently, Pakistan has a step for harvesting million tons of coal to fulfill its electricity demands [7]. It is expected that by 2040, the energy demand in the Asia Pacific region will increase by over 40% [8]. It is estimated that global energy consumption will be increased by almost 56% during the period 2010–2040 [9].

Forty percent of households in Pakistan have yet no access to electricity, and merely 18% of households receive piped gas, so there is a massive energy demand [10, 11]. The demand for electricity has increased over the past decade from 10,000 to 25,000 MW resulting in intermittent power cuts, especially in peak summer hours. The country has tried to meet the energy demand by increasing the power generation as well as improvement in transmission capacity [12]. The country has currently faced a "demand-supply gap" that needs to be met up with an improvement in the renewable energy mix for the increased supply at cheaper prices. Presently, Pakistan mainly generates electricity from three sources: thermal energy, hydropower, and nuclear energy. In general, the energy mix relies on thermal power generation and is obtained through the use of imported oil, coal, and natural gas [13]. The electricity generation resources in Pakistan are shown in Figure 1. The share of renewables has been greater than before due to the increased share of hydropower and nuclear sources in energy mix.

Figure 1
Fuel sources for electricity generation in Pakistan



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An integrated energy plan needs to be marked that will not only helpful in the prediction of future energy demand and supply paths but also helpful in the formulation of long-term policy options. As a long-term strategy, to avoid the impact of climate change, the country must shift its electricity generation from coal-based production to renewable energy sources. However, since there are 175 billion tons of coal reserves here, it has been a vision to meet the demand of coal-based power plants. Five coal-based power plant projects already have been initiated [14]. This situation requires studying the cost of coal in terms of the environment as we have several examples of countries producing power using coal and how the degradation of the environment occurred there.

Although Pakistan has abundant coal reserves in Thar (175 billion tons) and has the capability of producing 5000 MW for 40 years [15], the country as well has a large amount of sustainable, environment-friendly renewable energy resources, such as biomass, hydropower, solar energy, and wind energy. These resources must bring together for electricity generation in order to obtain cheaper and environmentally friendly solutions to fulfill the "demand-supply" gap. The present paper explores the environmentally friendly and sustainable energy resources available for power generation. A comparative analysis of sustainable energy resources and coal-based resources in terms of sustainability will be presented.

2. Coal Fire Power Plant

Abundant coal reservoirs, more or less 186 billion tons, are distributed in four major regions of Pakistan [16]. These coal assets are sufficient to meet the nation's future energy demand for the next few decades. Thar coal reserves, almost 175 billion tons, keep a potential of almost 100,000 MW of power generation. To extract coal and its use in power plants to generate energy, Pakistan has taken practical steps to set up the coal-based five power projects in the initial phase [17]. Table 1 [18] shows the location and capacity of power plants. Almost 11,760 MW would be harvested through coal-fired power plants to maintain the present demand of 16,000 MW in the next 4–5 years [19].

Table 1
Planned coal-based power projects in Pakistan

Location of coal-fired power plant	Projected power generation (MW)
Gaddani	6600
Larkana	1320
Thar	1320
Jamshoro	1320
Sahiwal	1200

2.1. The impact of coal on the environment

In the situation of the current energy crisis, coal-based power generation seems to be a very lucrative and economically attractive option, but it does come with its baggage and a set of problems that will have to be dealt with in the future [19]. The utmost understandable issue is atmospheric pollution and its impact on the environment. The quality of coal in Pakistan is relatively low and composed of 2% sulfur, 7% ash, and 24% carbon [20]. Such contents (ash, sulfur, and carbon) would possibly be discharged through the exhaust of the power plants and will be the cause of smog [21]. The major cities in the region are already facing the problem of smoothing the start of winter every year [22].

Another issue with Thar coal is the utilization of land; almost 20,000 acres of land will be utilized for open-pit mining, and additional similar-sized lands will be required as the project grows [23]. Although the cost of energy generated is calculated to be low, the cleanliness of the environment will be high. So, Pakistan needs environmentally sustainable energy sources for power generation. Sustainable energy harnessed from biomass solar energy and hydropower source can sustainably meet the purpose.

2.2. Water usage

High-pressure steam is produced from water in thermoelectric power plants to drive the steam turbines for electricity generation. For this purpose, pure water is used, free from all kinds of impurities, including dissolved solids. In the process of making water pure, a lot of fresh water has been wasted. Water is also widely used in heavy quantities for cleaning purposes. Power generation is considered the second largest freshwater consumer country of fresh water after agriculture. Every 1000 MW of power from coal-fired power plants consumes almost 38 million cubic meters per year.

2.3. Carbon emissions

Coal is burned in thermal power plants to obtain the energy invested in chemical bonds between carbon atoms. The combustion process originates various toxic airborne waste products and releases ease heavy metals to contaminate the environment and water bodies [24, 25].

The environmental impact of a few pollutants is given below.

1) **Mercury:** As a toxic heavy metal, mercury is a commonly released element in coal-fired power plants. It can interrupt the nervous, digestive, and immune systems of humans. It can pose a serious threat to children's development from mental illness [26, 27].
2) **Sulfur dioxide:** The chemical composition of Pakistani's coal reservoirs showed the presence of a high quantity of sulfur. When the coal burns, the sulfur released from coal is converted to sulfur dioxide by reacting with atmospheric oxygen. Sulfur dioxide further reacts with water vapors to produce acidic particulates. The acidic particulates can damage the lungs of the human body. Lung diseases like asthma and bronchitis are related to these particulates. It is caused by smog and acid rain. Crops and other ecosystems are affected. Lakes and water streams become acidified [28, 29].
3) **Nitrogen oxides:** These are very dangerous gases for human health. Human inhalation of this gas will stimulate lung tissue, which will lead to many chronic respiratory diseases, such as asthma [30–32].
4) **Particulate matter:** The coal smoke keeps ash-like particulate matter. When released into the atmosphere, it can damage the human bronchioles, causes asthma, and results in heart attacks. Premature deaths are reported in urban areas [33–36].

2.4. Global warming

Various heat-trapping gases are emitted by the burning of coal in boilers of coal thermal power plants. Such gases are the major and irreversible cause of global warming. It is the main impact that causes an increase in atmospheric temperatures, heat waves, heavy rainfall intensified storms, speed up the sea level rise, risks of drought, and species loss [37].

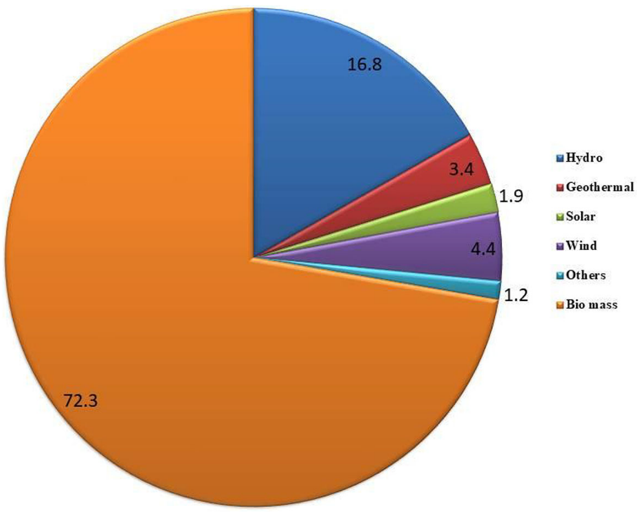
From a chemical perspective, coal contains 60%–80% carbon, so carbon dioxide is the core by-product produced by its combustion. Burning just 1 g of carbon can release 4 g of CO_2. Coal mining activities release methane into the atmosphere, which is many times higher than carbon dioxide [38, 39].

3. Sustainable and Renewable Energy Resources

Just reliable, clean, and sound energy resources are the guarantee of prosperity and comfort in modern life [40]. Now the world has realized that only sustainable energy resources can ensure the future, as the optimal application of these resources can reduce their impact on the environment [41].

These include solar energy, wind energy, biomass energy, and hydropower energy. Currently, about 14% of global energy comes from these resources [42]. So, the sustainable energy can be produced at a lower cost compared to conventional sources [43], which is not important in the world. Many parts of the world keep sustainable energy sources as shown in Figure 2. Biomass, hydropower, solar energy, and wind energy resources are not pollutants and obey the principles of sustainability. Sufficient dividends can be earned if these sources are explored, exploited, and developed [44].

Figure 2
Sustainable energy sources worldwide



3.1. Sustainable energy resources in Pakistan

The frequent availability of energy is vital for socioeconomic development. For the past two decades, a global debate is on for use of cleaner and sustainable energy alternatives for power generation to get rid of fossil fuel energy resources [43–45].

However, without the use of sustainable energy resources, Pakistan is unable to meet its total energy demand. Indigenous conventional fuel resources are limited and carry adverse environmental impacts [46]. Coal mining is also costly. It spreads dust and particulate matter when it burns. So, its mining and burning harm humans [47, 48]. So, the energy generation potential of coal has remained exploited. Same-wise energy generation potential of renewables remains untapped. Sustainable energy projects are although capital intensive in comparison to coal-fired generation systems but much cleaner and environment-friendly [49]. Pakistan is blessed with wind, hydro, solar, and biomass Sustainable energy resources are available in abundance and can support the commercial energy requirements if harnessed in full [50–53]. Key sustainable energy resources for Pakistan are presented in Table 2 [50–53].

Table 2
Key options in sustainable energy resources for Pakistan

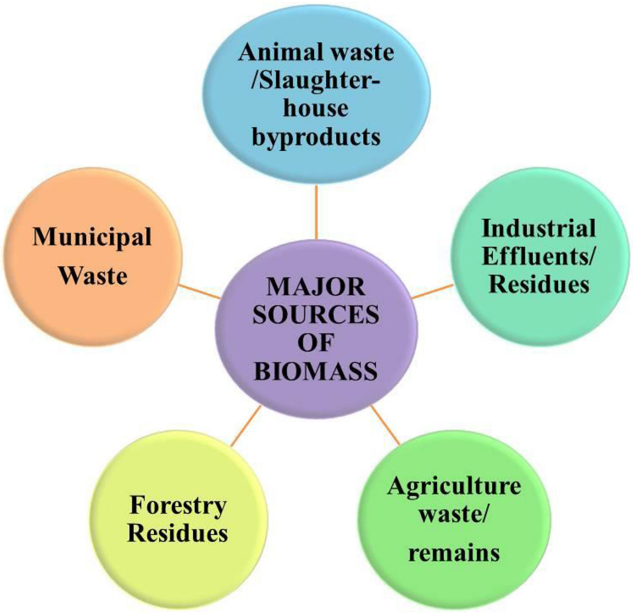
Sustainable energy resource	Energy usage options and conversion technologies
Biomass	Electricity generation and heat production (high-pressure steam) through pyrolysis, gasification, and anaerobic digestion
Solar power	Electricity and heat energy, harnessed solar rays through solar photovoltaic, thermal power generation, water heaters, solar dryers, and solar cookers
Wind power	Electrical and mechanical energy through wind generators, windmills, and water pumps
Hydropower	Electricity generation through turbines

The capacity of sustainable energy generation is as follows: 120,000 MW can be harvested from wind, 2,900,000 MW from solar, 5500 MW from biomass, and 23,000 MW from hydro. It shows the significant potential to overcome the present energy crisis. Pakistan must go for the exploration of the above potential to save the environment with strong commitment and political willpower. These sustainable energy alternatives will create a healthier climate, healthier citizens, and a sustainable economy [54–63].

3.2. Biomass

Biomass is the biological material, make happened from plants through photosynthesis phenomena. Since the dawn of humans, the required energy provided is capable to substitute for present fossil fuel consumption. Biochemical interaction of carbon dioxide with water in the presence of solar rays creates glucose, the initial building blocks of carbohydrates in the photosynthetic process that joined to form complex biomolecules. These biomolecules further react to form plant structures. Figure 3 represents major sources of biomass. Feed, food, fiber, and other materials are provided by these plant structures. The plant material not used for feed, food, or fiber is disposed to natural decay that results in fossil fuels over very long periods. Recently, with novel techniques, the same material may be transformed into useful synthetic fuels in a short time [64–68].

Figure 3
Major sources of biomass



3.2.1. Energy from biomass

The huge volume and diverse nature of biomass have the genuine potential to a play vital role in combating the growing energy crisis in Pakistan. It is considered a clean and environment-friendly source of energy, as the carbon dioxide released is recycled through the process of photosynthesis. Green electricity, heat energy, and many biochemicals can be harvested from biomass. Through the utilization of biomass, Pakistan can be benefitted in various manners including improvement in the economy and clear environmental and employment generation. Various characteristics, "caloric value, moisture content, ash content, carbon content, hydrogen content, cellulose, hemicellulose, and lignin", are required for the utilization of biomass resources and are well known [69–72].

Pakistani biomass includes animal waste, raw materials from crop fields such as stems, straw, litter, sugarcane dregs, rice husks, husks of other crops, forests waste, wood chips, bark, and green leaves. Currently, it is estimated that agricultural waste, agro-industries waste or lignocellulosic waste, and wood – waste based are about 20,494, 25,271, and 1,121 million tons, respectively. In terms of energy, Pakistan can generate 50,000 GWh, which can meet up to 36% of the country's total energy [73–75].

3.2.2. Potential agricultural waste

A large volume of agricultural waste, including rice and wheat husks, cotton sticks, and sugarcane trash, is produced. Non-agricultural waste, the wood part, can also contribute significantly to energy production. Cotton is the cash crop of Pakistan, giving an average production of 2,000,000 tons, cultivated on 2.67 million hectares (Economic Survey 2019–2020). Waste cotton stems obtained can be about 5,898,771 tons, with a power potential of 614 GWh. In sugarcane production, Pakistan is ranked 4th. Sugarcane cultivation in Pakistan was measured at 63,920,000 tons and 575,800 tons of waste with an energy potential power of 9,475 GWh is produced. Currently, sugar mills are exporting up to 2,000 MW to the national grid [76–80].

The country is ranked third globally for wheat production. Other than these major crops, small crops such as corn, rice, and grams cover a large portion of the total agricultural waste available for energy conversion. Wood and wood waste is another source that far and wide fulfills the home and small industries' needs. Fruits of many kinds are produced here. Citrus, mango, apple, and banana waste are also a source of sustainable energy in Pakistan [78, 81, 82].

3.2.3. Potential of animal manure

Being an agricultural country, Pakistan is blessed with livestock. The number of cattle and buffalo in Pakistan is estimated at 67,294,000 with an annual growth rate of 4%. The resultant animal manure volume is about 400,00 tons, which can produce biogas above 20,000 GWh [83–86].

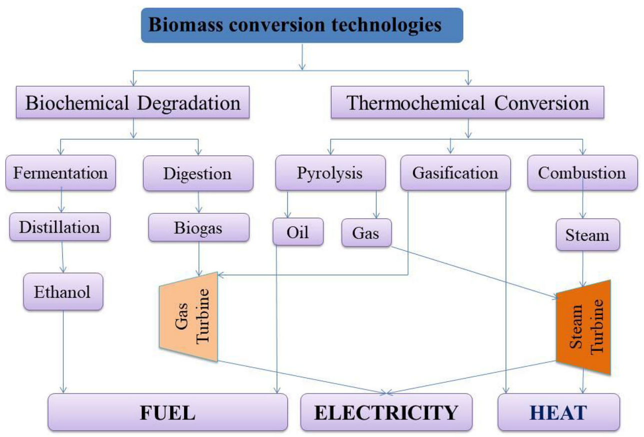
3.2.4. Municipal waste

The urban areas in Pakistan are heavily populated, producing more than 64,000 tons of municipal solid waste per day. Sustainable bioenergy production by thermochemical processes, gasification, and pyrolysis from the waste can be a solid pollutant treatment tool [87, 88].

3.2.5. Processing of biomass

Biomass can be processed through various techniques based on moisture content. There are two major categories of biomass processing: (1) the conversion techniques, which include direct combustion, liquefaction fluids, and the conversion to gas, heat, and decay and (2) the conversion techniques, which include anaerobic decomposition and fermentation. Biomass conversion technologies and their application as fuel and electricity have been presented in Figure 4.

Figure 4
Biomass conversion technologies and their application as fuel and electricity



Biochemical techniques, fermentation, and anaerobic digestion are much more appropriate for biomass materials containing high moisture levels. For dry materials, techniques like gasification, pyrolysis, or combustion are more economically right. Other significant factors in the choice of suitable processing technique are ash content, alkali, and trace component [89–95]. Major pathways for processing biomass into useful energy are presented in Table 3 [89–108].

Table 3
Various technologies/pathways for the processing of biomass

Processing technology	Major advantages of current improvements
Gasification	The ignition engine can be driven by syngas to generate electricity through turbines
Pyrolysis	At high temperatures (300–500°C), biomass results in fuels for use to generate useful forms of energy
Hydrothermal liquefaction	The most used technique to harvest energy from biomass as the product almost resembles petroleum crude.
Enzymatic hydrolysis	Enzymatic hydrolysis is performed at pH 4.8 and 45–50°C temperature, can reduce the processing cost. Pentose sugars can also be utilized for bioethanol directly
Dilute acid hydrolysis	Feedstock size is decreased to improve the recovery of sugar and pre-treatment cost
Concentrated acid hydrolysis	Better recovery of sugars with minimum inhibitor concentration
Ionic liquids	Ionic liquids are environment-friendly in nature
Mechanical extraction	Very simple process, so skilled labor is not required
Chemical extraction	Environment and human-friendly process
Transesterification of fat/oil	The product is non-toxic, easily decomposable, and recyclable

3.3. Solar energy

In the process of continuously exploring alternatives to meet global energy needs, low-cost solutions employing indigenously available resources are being explored worldwide [109]. The pollution-free, environment-friendly, and economical energy to sustain human survival on Earth just can be acquired from the sun [110]. Applications of photovoltaic utensils at large scale seem to be a practical solution to the current energy crises in Pakistan. Different solar-based techniques such as photovoltaic electricity generators, and active and passive solar heating can be applied [111].

Fortunately, the location of Pakistan is blessed with a maximum solar shield. The average solar radiations in the country are 5.5 KW/m^2 [112]. Almost 95% of the surface in Pakistan receives 1500–3000 h of sunlight annually, with more than 300 clear sunny days throughout the year. Average received solar radiations are 5–7 kW/m^2/day, equal to 200–250 W/m^2. This solar energy perspective can be explored with different photovoltaic and solar techniques, such as photocells, and solar thermal units for many applications. From solar power, water can be heat up, steam is generated, and cooking can be done in the form of solar cookers. The fruits and vegetables can be dry with solar dryers to increase their shelf life. Water desalination plants can also be operated on solar power [113–115]. Therefore, many applications can be operated by solar photovoltaic and solar thermal-based techniques. Especially, the Baluchistan province, the eastern location of Sindh province, and area of the southern Punjab keep the highest solar potential where economically favorable solar power facilities can be set up. The outstanding solar potential of Pakistan is highly suitable for decentralized usage of energy, so solar power can be the best-preferred choice for offsetting the "energy supply and demand gap" especially in the peak summer season [116, 117].

Since the 1990s, the country has just set up 18 solar power projects with a capacity of 440 kW. Solar cells are in use as a major sustainable energy resource in Pakistan, although their production cost is yet to be reduced. Unfortunately, due to certain reasons, the full potential of solar power has not been explored yet. The unavailability of management and operational staff is the major reason. There were no appropriate policies to promote this green energy source. In the remote areas, there was no awareness. Lack of investment in the sector was also one of the major reasons [118–120].

3.3.1. Advantages of solar power

There is no doubt that solar energy is environment-friendly as compared to any other energy resource as it neither releases greenhouse gases nor any solid or liquid waste is emitted. So, it is a sustainable energy resource. Some of the advantages of solar power systems are highlighted below [121–123].

1) Greenhouse gases such as CO_2 and NOx are not emitted
2) Toxic gasses, for example, SO_2 and particulate matter, are not released into the atmosphere
3) Barren land can be used for the installation of solar power system
4) Zero or reduced cost of transmission lines
5) Safe and secure energy supply
6) Electrification of hard-approached rural areas.

In Table 4 [121, 123–125], solar power systems and their various applications are listed.

Table 4
Applications of solar power systems and its major advantages

Type/applications of the solar system	Major advantages
Solar photovoltaic (PV)	Solar PV units are capable to convert solar energy into electrical energy. The electrical energy can be further utilized
Solar thermal units	Solar energy can be converted into thermal energy by available solar thermal facilities. Such solar thermal facilities can be used in cooking food, heating water, etc.
Concentrated solar power	Steam can be produced by the convergence of solar rays. With steam turbines can be derived to generate green electricity. Heat stored in oil or molten salts can be used to generate electricity outside of solar light hours and increased supply during peak demand hours.

3.4. Hydropower

The tidal energy and flow speed of the water can be used to move turbines for sustainable electricity generation. Hydropower is globally recognized as a sustainable energy resource. Over 150 countries around the globe generate energy from this environment-friendly resource with an installed capacity of about 970 GW. Hydropower resources are versatile in their design and type. During the power harvesting process, water is not consumed or polluted. The distribution of water on Earth is not uniform.

Certain portions of the world are prone to floods while others remain susceptible to drought. To fulfill human needs, at all times water is placid in the big pond. These big ponds became the base of large dams and reservoirs. Sustainable energy sources are by and large shared by hydropower as it provides 90% of total renewables share with the provision of 16% of global electricity demand [126–130].

Still, huge potential of hydropower is unexplored here that must be made available. The current trend of rise in power tariffs can be overturned by the addition of cheap hydroelectricity. From the 40,000 MW potential of electricity generation through hydropower, the total installed capacity is only 6,800 MW. After the commissioning of the Ghazi Barotha project in 1985, no noteworthy hydropower project has been developed. Large hydropower projects require at least 20–30 years for their completion. In the recent past, unavailability of resources, relocation of communities, and lack of political will resulted in the operation of just 19 out of a total of 142 proposed projects in KPK, in Punjab; out of 296 projects, only 8 are in operation, while 38 are under implementation [131–134]. Table 5 [59, 131–134] explains the environmental benefits of hydropower being a sustainable energy source for Pakistan.

Table 5
Key advantages of hydropower for Pakistan

Features of hydropower	Key advantages
Key sustainable energy resource	Just kinetic energy of the water flow is harvested for the generation of hydroelectricity; the definition of sustainable energy is fulfilled as no sources are exhausted
Support to other sustainable energy resources	Hydropower projects can cater to fluctuations in electricity consumption due to extraordinary operational flexibility. So, it can better support the placement of other sustainable energy facilities
Tariff consistency and energy security	The water coming from the rivers is a local resource and not linked with an international market. So, it is free from any tariff fluctuation
Availability of freshwater	Another advantage of the construction of dams/reservoirs is the availability of fresh water, thus avoiding the depletion of aquifers
Stability in the electric grid	Electricity grids can be better managed in peak hours of power demand, and the service can be quickly restored
Climate change	The hydropower projects release minimum greenhouse gases and help to slow down global warming
Air quality/pollutants	No air pollution and better replacement of fossil-fuelled generation. Decreased chances of acid rain and smog
A cheaper tool for sustainable development	Hydroelectricity facilities generate green electricity at affordable rates and are socially responsible. It can help the development of a community

The hydrothermal energy generation ratio in Pakistan is 30:70, which has created problems in terms of import bills and high tariffs. The ratio should be tilted, if the use of sustainable energy sources will have been started by replacing thermal components [59].

Hydroelectricity stakes almost 20% of world electricity generation. The water resources of Pakistan include rivers and glaciers having snow that melt and can provide up to 400,000 km^2 convertible to 42 GW of hydropower [44, 135].

Only 11% of hydropower potential is in operation, which generates almost 7228 MW, while a capacity of more than 60,000 MW is identified in Pakistan. The country can overcome the power crisis easily by the installation of small hydropower facilities. These small hydropower facilities can avoid the consumption of 120 million tons of coal or 83.3 billion liters of oil per year. Furthermore, such plants are favorable for the environment. The global employment potential of small hydropower facilities is almost 0.2 million. Currently, 0.7 million people in the country are benefitted from the installation of 1100 small hydropower facilities [136–138].

3.5. Wind power

Globally, wind power is the second leading sustainable energy technology applied for electricity generation, in terms of development and commercialization. Wind energy can be in working when wind energy is converted into electrical energy through wind turbines or mechanical power transformed through windmills. The kinetic energy present in the air is firstly transformed into mechanical energy, and then this mechanical energy is used to generate electrical energy [139, 140]. The major issues related to wind turbines have been reviewed in Table 6 [141–144].

Table 6
Issues of wind turbines and their solution

Challenging issues	Possible remedies
Fatigue problems	Fatigue-related issues can be solved through improvement in materials (multilayered coating) and by designing analytical models
Vibration problem	Rotor blades of improved material and appropriate technology can evade the vibrational issues of the wind turbines
Ice deposit issues	Efficient models can avoid ice deposition
Noise issues	Improved friction-free materials can decrease the noise problems of wind turbines
Load issues	Integration with other sources of electricity such as hydropower can solve the uncertainties in the system load

The present wind turbine technology can only extract kinetic energy from the air in the range of 40–50%. There is a dire need for improved and cheaper wind turbines for wind power plants. The wind power farms are constructed through the installation of wind turbines from 5 to 300 MW. Pakistan's wind energy capacity is in the range of 20,000 × 109–50,000 ×109 KWh per year [55, 145, 146]. Wind energy is one more significant area where Pakistan can do good as the estimated wind potential is up to 50,000 MW. Currently, installed wind power capacity is only 106 MW [147–149].

4. Conclusion and the Way Forward

To be competitive globally, it is necessary to meet energy needs through environment-friendly energy sources. The solution is so simple, just replacing traditional power sources with sustainable energy. Although coal had been entrenched in the global fuel system, world has started to get rid of this source. A search for indigenous cheaper, sustainable energy sources that do not burden the economy is going on. The coal will sooner or later be phased out due to its unclean nature, and burdensome on foreign exchange, with health and safety issues. This time, Pakistan must react to hug up the sustainable energy revolution. The country should shift its emphasis from using furnace oil for thermal energy generation to using sustainable energy for power generation. Sustainable energy sources like wind, solar, hydrogen, and biomass are indigenous, abundant, and green by their very nature. The cost of electricity generation from conventional sources such as coal is on the rise, while the cost of electricity by source of sustainable energy (solar energy and wind energy) is dropping dramatically. The price drop has been so sharp that new solar installations cost dropped by 26% last year, and 79% in the last decade. Pakistan must be committed to foregoing coal and adopting clean and environmentally friendly technologies.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by the author.

Conflicts of Interest

The author declares that he has no conflicts of interest to this work.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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