RENEWABLE ENERGY RESOURCES IN PAKISTAN: PAVING A WAY FORWARD

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ABSTRACT: Pakistan has 2.83 percent of the world's population, making it the fifth-most populated country. At 0.37 percent of the world's total, it ranks 35th in energy usage. Per capita, energy availability is 43W, 1/7th of the world average. Pakistan's installed capacity is 34233 MW, however, it can only generate 22000 MW against a peak load of 25000 MW, generating a 3000MW power shortfall. Not using the existing capacity, which is 8000MW larger than the peak load, is a sore issue for technical, economical, and administrative reasons. Circular debt in the electricity sector stems from significant reliance on imported petroleum and inefficient financial flow across tiers. The electricity shortage causes outages and hinders economic progress. The energy problem calls for concrete actions to alleviate the shortfall. A way ahead is to transition the country's power industry from imported oil-based thermal power plants to more feasible indigenous resources, such as renewable energy resources, of which Pakistan is rich and has great exploitation potential. This article surveys the availability of renewable energy sources, including hydro, solar, wind, and biomass, and their present and prospective penetration in the total power generating mix, with recommendations. Pakistan can extract 30 GW from hydropower and 11 GW from wind by 2030. According to estimates, a vast untapped potential of solar power must be brought into service with biogas as a supplement to meet future power needs. The comparative analysis has been done by doing a case study on different renewable energy strategies and techniques adopted by other countries.

Keywords: RET, IPP, NEPRA, NIO, PMD, NREL.

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INTRODUCTION

In Pakistan, like other countries in the South Asian area, is evolving. To support this expansion, energy requirements have increased dramatically due to expanding population and industry. Pakistan is heavily reliant on fossil fuels to supply all of its energy needs (TPSDC, 2020) In 2011-2012, the country's total primary energy supply was 64.727 million tonnes of oil equivalent. For power generation, the country's energy industry is mostly based on petroleum, natural gas, coal, and LNG. In actuality, the use of fossil fuels, either directly or indirectly, accounts for 80 percent of total energy, with renewable resources providing only 1 percent. Natural gas is the greatest contributor, accounting for 49.5 percent, followed by 30.8 percent oil, 12.5 percent hydropower, 6.6 percent coal, 1 percent nuclear power, 0.5 percent liquefied petroleum gas, and 0.1 percent imported electricity. Rising fossil fuel and electricity prices have created a significant energy crisis in the country, resulting in power outages in rural regions that have been prolonged by 14-18 hours, and power outages in metropolitan areas that have been extended by 8-10 hours[1] (Abdul Ghafoor and Anjum Munir, (2015). Power deficits have ranged from 4000 to 6000MW during the last decade (World Bank Group, 2020). For the production of electricity from renewable sources, particularly solar PV, Pakistan offers enormous potential. The correct incentive exists for investigating the potential contribution of solar resources to Pakistan's future energy supply, given the declining trends in worldwide cost and Pakistan's excellent solar insolation conditions due to its location in the Sun Belt region. In Pakistan, the energy industry is the main source of GHG emissions. As Pakistan seeks to satisfy its rising electrical demand, power generation capacity has expanded dramatically in recent years from all energy sources. However, high reliance on imported fossil fuels, the development of contentious hydropower projects, and a growing reliance on antiquated coal technology are not only weakening energy security but are also seriously impeding economic progress (Waqar Uddin et al., 2016).

Literature Review: On Pakistan's energy dilemma, there are many books, articles, and studies. Renewable energy articles and books provide information and awareness of numerous resources and processes. Not adequate data was discovered on a comparative examination of renewable energy methods used by China and Spain, renewable energy pioneers, and their successful application in Pakistan for sustainable energy resources Irfan Mirza and researchers at Penn State's Energy Institute studied Pakistan's solar energy resources. The

article aims at conducting an analysis of Pakistan's geography and suggests solar energy installation choices in distinct places. Photovoltaic cells, solar dryers, cookers, water heaters, and solar desalination have been examined in length. The article highlights government policies for renewable energy and RD&D initiatives for solar energy in Pakistan. According to P.R. Shukla of the Indian Institute of Management in Ahmadabad, Animal dung, wood, plants, and weeds are all sources of biomass in India. The rising cost of fossil fuels has underlined the necessity of biomass energy. The author also analyzed Indian government policies regarding effective renewable energy resources, and their barriers, and advised policy adjustments to profit more from Biomass energy resources in India. Oxford's Xin Li outlined China's wind power potential. The author describes China's wind energy development from 2000 to 2015. Government policy and weather conditions favor wind power producers in northern China.

Methodology: The research aligns with the qualitative research method. The articles aim to be mostly analytical in nature, with the goal of identifying the various renewable energy resources in Pakistan as well as factors associated with the energy industry in Pakistan. Based on the examination of the acquired data, the findings will help in a better understanding of ground realities and the way forward. The comparative analysis approach will be utilized to explore different strategies employed by other nations in the Renewable Energy industry, with the fittest for Pakistan being emphasized based on available resources and environmental circumstances in Pakistan.

The Prospects of Renewable Energy

Solar Energy: In all renewable energy sources, Pakistan has enormous solar potential. Across numerous large sections of the nation, the average global solar insolation is 5-7 kWhm^{2}day.The average accessible solar energy is close to 5.5 Whm^{2}day^1, with an annual sunlight period of 8 to 10 hours per day and 1500-3000 hours. According to the Alternative Energy Development Board (AEDB), the average solar irradiation on a horizontal surface is around 200 - 250 Whm^{2}day^1, amounting to 6840 - 8280 MJ /m^2 per year. According to a study conducted by the United States National Renewable Energy Laboratory (NREL) in partnership with USAID, Pakistan has 2.9 million megawatts of solar potential. This potential may be used to generate electricity or any kind of thermal energy. Electricity produced by stand-alone or grid-connected solar systems may be directed towards lighting or the operation of household/industrial appliances and machinery for the home and commercial sectors, eventually closing the energy gap. Pakistan has tremendous potential to generate solar and wind power. According to the World Bank, utilizing just 0.071 percent of the country's area for solar photovoltaic (solar PV) power generation would meet Pakistan's current electricity demand.

According to a study of off-grid solar systems used for household electrification, the unit cost of power is Rs 14.8 per kWh cheaper than the regular electricity supply (Irfan et al., 2019).[2] Solar energy may be utilized to generate thermal energy, which can be used for sterilization, extraction, drying, hydrolysis, evaporation, distillation, cleaning, and washing, among other things. Temperatures ranging from 60°C to 280°C may be achieved for the aforementioned operations using several kinds of commercially available concentrated and non-concentrated collectors. Most agricultural processes are thought to benefit from temperatures in the mid-range. Unfortunately, owing to a lack of popular knowledge and technical know-how about the benefits these systems provide, the adoption of these technologies has been delayed. Although demand for these systems has increased, with households and small-scale industries switching to solar in the face of load-shedding, financial constraints, a lack of incentivization, and abundant commercial availability, implementation of solar systems is lacking due to a lack of funds and public awareness.

Numerous areas of the nation have vast tracts of unused land. Photovoltaic technology can be used for on-grid power generating projects in the locations with the greatest potential and where a grid is also present. Projects connected to the grid that have a range of capacities can be installed across the nation. Six utility-scale solar PV power facilities totaling 430 MW in total installed capacity are currently operational and producing electricity to the national grid. In addition, there are currently four solar PV power plants under development with a combined capacity of 250 MW, and there are many more in the works.

During the research of the literature, it was discovered that Ghafoor and Munir's work presented the design and economic analysis of non-grid-based solar systems for powering houses and allowing remote populations to adopt photovoltaic solutions depending on their needs. It was also discovered throughout the course of the literature study that Faisalabad Agricultural University has already initiated research on solar technology and has produced useful technologies such as solar tunnel dryers, roasters, hybrid dryers, and solar desalination systems, among others. Solar energy accounts for barely 1% of the renewable energy sector's contribution to national electricity demands.[3] It is critical for the current government to implement a comprehensive strategy that provides incentives/subsidies to allow communities to withstand higher initial system costs and lower power/energy prices per unit of output, as is done in industrialized nations to promote this

technology. Successful models of solar technology adoption point to consumer incentivization. A few big banks have provided loan financing for system installation in order to entice local populations to transition to solar.

Wind Energy: Pakistan also has enormous potential for wind power production, which is a plentiful, renewable, and clean energy source (Ghafoor and Munir, 2015). In 2002, the Pakistan Met Department (PMD) conducted a survey with the assistance of the Ministry of Science and Technology to assess wind direction in Pakistan's coastal areas, which identified wind corridors across large tracts of land, particularly in coastal expanses of Balochistan and Sindh provinces. Wind speeds in coastal Balochistan and Sindh varied from 4-9 ms-1 at 10 m heights and grew up to 12.5 ms-1 at 50 m heights. In 2007, the US National Renewable Energy Laboratory (NREL) did another research in collaboration with USAID to assess the wind energy potential in Pakistan. According to their studies, there is a potential of around 346,000 MW, of which 120,000 MW is realistic. According to a PMD research, the available wind energy potential in Sindh's coastal area is 43,871 MW, with a realistic potential 11,000 MW more than in Balochistan. In this analysis, regions with greater economic potential for wind farm construction were also identified.

The report said that long-term strategies must be developed to utilise the country's wind potential through rewarding the private sector/people. The average wind speed at several places at a height of 80 metres. The average wind speed surpasses 5 m per second in most months of the year, which is sufficient for power production using available wind energy in that location. The influence of altitude on mean wind speed at the Gharo-Keti Bandar wind tunnel. Work on the wind energy industry in Pakistan has begun, although it is still in its early phases. To reap the advantages of wind energy, some groups have built a few wind turbines.

During the projected period of 2022–2027, the market for wind energy in Pakistan is anticipated to grow at a CAGR of more than 5%. Due to challenges locating raw materials and transporting finished goods, the COVID-19 epidemic temporarily disrupted ongoing initiatives. Aside from this, Pakistan experienced a considerable power surplus because of increased capacity and less demand than anticipated, in part because the pandemic temporarily made wind energy projects unprofitable. Since the start of the previous decade, wind energy has been rapidly adopted in Pakistan, largely because of the government's increasing mandate for the use of renewable energy sources in the country's energy mix and advancements in wind energy technology that have resulted in higher efficiency and lower costs. In comparison to other renewable energy sources, onshore wind energy is one of the least expensive ways to generate power globally, claims the International Renewable Energy Agency (IRENA). The average cost of producing power using onshore wind energy was USD 0.039/kWh in 2020.

Organizations such as Fauji Fertilizer Company (FFC) (50 MW plant in Jhimpir, Sindh) and ZorluEnerji Pakistan Ltd. (56.4 MW plant) have taken the lead in using the country's wind power generating potential (Mathew et al., 2018). According to one report, using a 50 MW wind farm might result in annual emissions offset of 131,361 to 290,885 tonnes (CO2 equivalents). If the system has a service life of 20 years, the wind farm would likely offset 26.6 to 58.8 million tonnes of CO2 equivalents. Wind power facilities have a large initial cost, thus local communities cannot afford them. As a result, it is the responsibility of the public sector to launch and operate large-scale plants in order to demonstrate the efficacy of these projects and attract private-sector investment for potential Build Operate Transfer (BOT) contracts to exploit the wind energy potential in Pakistan's coastal belt. Wind energy should be employed in these provinces to prevent energy loss due to transmission to other parts of the nation.

Biomass: Most of the time, waste from plants, animals, and farms is used to make biomass. In rural areas, it is used for many things like cooking, heating, etc. Compared to fossil fuels, about 220 billion tonnes of biomass are made each year from animal, plant, and agricultural waste around the world (Mathew et al., 2018a).[4] These biomasses can be used to make a lot of energy without releasing other greenhouse gases or a lot of carbon dioxide. Pakistan is mainly an agricultural country, with about 70% of its people living in rural areas. Because of this, there is a lot of biomass in these areas, especially biomass from agriculture and livestock, like crop waste and animal waste. People in these remote places don't have easy access to utility power and new technologies, so they use traditional methods to get the energy they need. India and China are way ahead of the rest of the world when it comes to using biogas technology to make electricity. Biogas technology is also being used by the government of Pakistan as an alternative energy source.

Pakistan has abundant biomass resources, but it has not yet been scientifically assessed how much energy it can produce overall. Agricultural stalk, straw, rubbish, agro-industrial bagasse, paddy husks and shells, forestry and woodchips, barks and trimmings, and riverfront greens are all examples of feedstocks that are included in the definition of biomass. This definition goes beyond habitat and animal waste. According to current estimates, there are roughly 20,494, 25,271, and 1,121 million

tonnes of agricultural waste, agro-industrial waste, or lignocellulosic waste, and wood-based residues, respectively. Pakistan's projected overall biomass potential is 50,000 GWh/year, which may provide up to 36% of the country's total energy needs.

Hydropower: Hydropower is a renewable energy source that has been around longer and is more reliable. It makes up about 20% of the world's energy market (Saghir and Andreas, 2020).[5] It is an important part of how many countries around the world get their energy. India connects its major rivers to its own river system to better control water flow, and in 2012, it increased its production to 54,000 MW (Saghir and Andreas, 2019).[6] It is also the main source of power for China. Pakistan's main source of clean energy is also hydropower, especially in the area between the Arabian Sea and the mountains. Pakistan has a lot of potential to make use of hydropower. These features make sure that the falling water has enough potential energy to create the most pressure. There are also big rivers that flow into the Indus that can be used to make electricity. Pakistan could get more than 42,000 MW of power from hydropower, but only 16 percent of that has been developed so far (Saghir and Andreas, 2019).[7]

While other initiatives, including Ghazi and Barotha (launched in 2004), are significant additions to Pakistan's overall hydropower capabilities, major hydroelectric projects like Tarbela, Mangla, and Chashma have lately been reported to be showing decreases in their storage capacity of 20%. With a hydroelectric capacity of 60 GW, 800 possible locations in Pakistan's Indus basin have been identified. Only 11% (6,720 MW) of the project's total capacity—the hydropower plants at 134 sites—are already in operation; the other 89% is still being implemented and is entirely unfinished. By efficiently completing the following major projects, Pakistan can increase the hydroelectric portion of the country's overall energy output: Kalabagh, Bhasha, Bunji, Dasu, Kohala, Patan, Neelam-Jhelum, Thakot, Munda, and Ahori. These projects have respective energy generation capacities of about 3,600-3,800, 4,500-4,600, 5,400, 3,800, 1,100, 2,800, 950, 2,800, 750, and 600 MW. In addition to these significant projects, Pakistan has a large number of mini- and micro-hydropower sites with an estimated potential of 5% that can be used to generate 1,000 MW of hydroelectric power.

Conclusion: Energy is a key part of every country's economic and industrial growth. The world is slowly moving away from traditional sources of primary energy and toward renewable resources. In this way, Pakistan is still working on efforts to use renewable energy. But because there is a power shortage of about 5,000 to 8,000 MW in the summer, the rate of power growth is 8 to 10 percent per year, and there is a lot of reliance on fossil fuel, commercial use of renewable alternative energy must be fully operational as soon as possible to support conventional energy options. Pakistan has a lot of resources for solar, wind, water, and biomass energy. This gives the country a huge chance to meet its current fuel needs, and it gives each province an equal share. Pakistan's electricity needs are expected to reach 11,000 MW by 2030. To make the most of the potential of renewable energy and make sure the country has a sustainable energy future, it is important to deal with all of these issues.

BIBLIOGRAPHY

Anwar, Z., Gulfraz, M., and Irshad, M. (2014). Agro-industrial lignocellulosic biomass a key to unlock the future bio-energy: a brief review. J. Radiat. Res. Appl. Sci. 7, 163–173. doi: 10.1016/j.jrras.2014.02.003

Asif, M. (2009). Sustainable energy options for Pakistan. Renew. Sustain. Energy Rev. 13, 903–909. doi: 10.1016/j.rser.2008.04.001

Bhutto, A. W., Bazmi, A. A., and Zahedi, G. (2013). Greener energy: issues and challenges for Pakistan—wind power prospective. Renew. Sustain. Energy Rev. 20, 519–538. doi: 10.1016/j.rser.2012.12.010

Farooq, M. K., and Kumar, S. (2013). An assessment of renewable energy potential for electricity generation in Pakistan. Renew. Sustain. Energy Rev. 20, 240–254. doi: 10.1016/j.rser.2012.09.042

Farooqui, S. Z. (2014). Prospects of renewables penetration in the energy mix of Pakistan. Renew. Sustain. Energy Rev. 29, 693–700. doi: 10.1016/j.rser.2013.08.083

Ghafoor, Abdul, and Anjum Munir. (2015) "Design and Economics Analysis of an off-Grid PV System for Household Electrification." *Renewable and Sustainable Energy Reviews* 42 496–502. https://doi.org/10.1016/j.rser.2014.10.012.

Harijan, K. (2008). Mode Lung and Analysis of Tile Potential Demand for Renewable Sources of Energy in Pakistan. Jamshoro: Mehran University of Engineering and Technology

Harijan, K., Uqaili, M. A., and Memon, M. (2008). "Renewable energy for managing energy crisis in Pakistan," in International Multi Topic Conference: 2008 (Berlin; Heidelberg: Springer), 449–455. doi: 10.1007/978-3-540-89853-5_48

Malik, S. N., and Sukhera, O. R. (2012). Management of natural gas resources and search for alternative renewable energy resources: a case study of Pakistan. Renew. Sustain. Energy Rev. 16, 1282–1290. doi: 10.1016/j.rser.2011.10.003

Matthew J.BurkeaPersonEnvelopeJennie C.Stephensb, Matthew , Jennie C.Stephensb,(2017) "Political Power and Renewable Energy Futures: A Critical Review." Energy Research & Social Science. Elsevier, November 15, 2017. https://www.sciencedirect.com/science/article/pii/S2214629617303468.

Naqvi, S. R., Jamshaid, S., Naqvi, M., Farooq, W., Niazi, M. B. K., Aman, Z., et al. (2018). Potential of biomass for bioenergy in Pakistan based on present case and future perspectives. Renew. Sustain. Energy Rev. 81, 1247–1258. doi: 10.1016/j.rser.2017.08.012.

Sheikh, M. A. (2009). Renewable energy resource potential in Pakistan. Renew. Sustain. Energy Rev. 13, 2696–2702. doi: 10.1016/j.rser.2009.06.029.

Sheikh, M. A. (2010). Energy and renewable energy scenario of Pakistan. Renew. Sustain. Energy Rev. 14, 354–363. doi: 10.1016/j.rser.2009.07.037.

Solar Energy Development in Pakistan. (2002). Barriers and Policy Recommendations." Accessed at https://www.researchgate.net/publication/331320658_Solar_Energy_Development_in_Pakistan_Barriers_and_Policy_Recommendations.

Transforming the Power Sector in Developing Countries: Geopolitics .. (2022) https:// www. atlanticcouncil. org/in-depth -research- reports/ issue- brief/ transforming- the-power-sector-in-developing- countries-geopolitics-poverty-and-climate-change-in-pakistan/.

TPSDC. (2020). Transforming the Power Sector in Developing Countries. Geopolitics, Poverty, and Climate Change in Pakistan," Atlantic Council, https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/transforming-the-power-sector-in-developing-countries-geopolitics-poverty-and-climate-change-in-pakistan/

Uddin, Waqar, B. Khan, Neelofar Shaukat, Muhammad Majid, G. Mujtaba, Arshad Mehmood, S.M. Ali, U. Younas, Muhammad Anwar, and Abdullah M. Almeshal. (2016) "Biogas Potential for Electric Power Generation in Pakistan: A Survey." *Renewable and Sustainable Energy Reviews* 54 25–33. https://doi.org/10.1016/j.rser.2015.09.083.

Waqar Uddin, Younasa Muhammad, Anwarb Abdullah, M. Almeshalc, et al. (2015) "Biogas Potential for Electric Power Generation in Pakistan: A Survey." Renewable and Sustainable Energy Reviews. Pergamon , https://www. sciencedirect. com/ science/ article/ pii/ S1364032115010539.

Abdul Ghafoor and Anjum Munir. (2015) "Design and Economics Analysis of an Off-Grid PV System for Household Electrification, , , Pages 496-502," Renewable and Sustainable Energy Reviews 42 (February 1, 2015): 496–502, doi:10.1016/j.rser.2014.10.012.

Muhammad Saghir, Andreas Hornung, (2019) "Frontiers | Unlocking the Potential of Biomass Energy in Pakistan | Energy Research," https://www.frontiersin.org/articles/10.3389/fenrg.2019.00024/full.

Matthew J. Burke and Jennie C. Stephens, (2018a) "Political Power and Renewable Energy Futures: A Critical Review," *Energy Research & Social Science*, Energy and the Future, 35: 78–93, doi:10.1016/j.erss.2017.10.018.

World Bank Group. (2020). Expanding Renewable Energy in Pakistan's Electricity Mix. World Bank. https://www.worldbank.org/en/news/feature/2020/11/09/a-renewable-energy-future-for-pakistans-power-system.

Waqar Uddin et al., (2016): "Biogas Potential for Electric Power Generation in Pakistan: A Survey," Renewable and Sustainable Energy Reviews 54, no. C 25–33.

Muhammad Irfan, Zhen-Yu Zhao, Munir Ahmad and Marie Claire Mukeshimana, (2019) "Solar Energy Development in Pakistan: Barriers and Policy Recommendations.

Ghafoor and Munir, (2015) "Design and Economics Analysis of an Off-Grid PV System for Household Electrification, February 1, , Pages 496-502."

Matthew J. Burke and Jennie C. Stephens, (2018) "Political Power and Renewable Energy Futures: A Critical Review," *Energy Research & Social Science*, Energy and the Future, 35): 78–93, doi:10.1016/j.erss.2017.10.018.