ENERGY
CATALYST

Country Guide: Pakistan

August 2023

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Pakistan is located in the South Asia region. It is the thirty third largest country by area and the fifth most populous country in the world. It shares borders with Afghanistan in the west, India to the east, Iran to the southwest and China to the northeast. It has a 1,046 km coastline along the Arabian Sea and Gulf of Oman in the south. Pakistan shares a maritime border with Oman.

Figure 1 Map of Pakistan. Source: d-maps

Geography and Climate

Pakistan is located in a temperate zone; it is hot and dry near the coast and plains and becomes progressively cooler in the north and Himalayas. It has four distinct seasons: a cool and dry winter from December to February, a hot and dry spring from March through May, the summer rainy season (southwest monsoon) from June to September and the retreating monsoons from October to November. The majority of the country receives very little rainfall, except for northern regions which can receive upwards of 200 mm a month between July and September. Annual rainfalls vary significantly, leading to successive patterns of floods and droughts. El Niño has a significant influence on climate variability in Pakistan.

Government

Pakistan is a democratic parliamentary federal republic with Islam as the state religion. It has a multi-party system today, with a democratic government since 2013. Pakistan is a member of Commonwealth of Nations, the South Asian Association for Regional Cooperation (SAARC), the Economic Cooperation Organization and the G20 developing nations.

Table 1: Pakistan at a glance[1]

Capital	Islamabad
Total Area	881,913 km^2
Population	235.82 million (2022)
Official languages	Urdu; English
Rural Population	62% (2022)
GDP	USD 376.53 billion (2022)
GDP Per Capita [2]	USD 1596.7 (2022)
Currency	PKR (Pakistani Rupee)
Exchange rate 1/03/2023[3]	1 USD = 262.08 PKR
Exchange rate 1/03/2018[4]	1USD = 110.69 PKR
Access to Electricity	94.9 % households (2021)

[1] World Bank Data: Pakistan (as of July 2023)
[2] GDP Per Capita (USD Current Prices): Nepal, IMF (As of April 2023)
[3] US Dollar to Pakistani Rupee Spot Exchange Rates for 2023, exchange rates.uk.org, (as of July 2023)
[4] US Dollar to Pakistani Rupee Spot Exchange Rates for 2018, exchange rates.uk.org, (as of July 2023)

Economy

The gross domestic product (GDP) of Pakistan is currently USD 376.53 billion.[5] Economic growth has lagged between 2000-2022, as a result, the long-term real GDP growth has been slow, averaging at 4.3% annually.[6] Economic growth reached 6.2% in FY 2022[7], driven by accommodative macroeconomic policies, high domestic demand, and recovery from the impact of COVID. However, the floods in June 2022 had a devastating impact on the economy with 9.4 million acres of cultivated land damaged or destroyed, 2 million houses damaged or destroyed, 33 million people displaced, and more than 13,000 km of roads affected. Pakistan achieved significant poverty reduction, with nearly 47 million people escaping poverty in the last two decades, however human development outcomes remain low.[8] Pakistan dropped seven places to 161st out of 192 countries in the Human Development Index (HDI) rankings in the 2021-2022 period due to the multiple challenges of COVID, the Ukraine-Russia conflict and natural disasters.[9] The country's life expectancy at birth reached 66.1 years in 2021, showcasing a meagre change of 6 years between 1990 and 2021. The mean years of schooling increased by 2.2 years and expected years of schooling by 4.1 years.[10] Preliminary estimates indicate that the national poverty rate may increase from 2.5% to 4% as a direct consequence of the flood, pushing nearly 6-9 million people into poverty[11]. Thus, growth is expected to reach only ~2% in FY 2023.[12]

The energy sector in Pakistan

The energy sector in Pakistan is highly dependent on fossil fuels such as natural gas, oil, and coal in the national generation mix, which are the main sources of power generation in the country. In 2022, the installed power capacity in Pakistan was 40.055 GW (excluding nuclear power).[13] About 67% of the capacity came from thermal energy, 26% from hydropower, 5% from wind (~1,838 MW), and about 1% each from other renewable sources including solar (~630 MW) and bagasse (~369 MW).

Technology	Installed Capacity (MW)[14]
Hydel	10,635
Thermal	26,683
Wind	1,838
Solar	630
Bagasse	369
Total	**40,055**

As of year 2021, 94.9% of the population in Pakistan had access to electricity.[15] The per capita electricity consumption (annually) in the country is 644 kWh, among the lowest in the world (~18% of the global average), as per National Electric Power Regulatory Authority (NEPRA).[16] The existing average cost of supplying electricity to end-consumers is ~PKR 26/kWh (nearly ~USD 0.09/kWh). Pakistan is focusing on

[5] World Bank Data: Pakistan (as of July 2023)
[6] Country Overview: Pakistan, World Bank Group (as of July 2023)
[7] Pakistan Economy to Slow in 2023 Amid Strong Climate Headwinds, Asian development Bank, September 2022
[8] Ibid.
[9] Human Development Report 2021/22, UNDP, 2022
[10] UNDP HDI Data: Pakistan, 2022 (accessed as of Aug 2023)
[11] Pakistan's Economy Slows Down While Inflation Rises Amid Catastrophic Floods, World Bank Group, October 2022
[12] Ibid.
[13] Pakistan at 75- State of Industry Report, National Electric Power Regulatory Authority, 2022
[14] Ibid.
[15] World Bank Data: Pakistan (as of July 2023)
[16] Pakistan at 75- State of Industry Report, National Electric Power Regulatory Authority, 2022

reducing this high cost by procuring cheap electricity from indigenous resources like wind, solar, bagasse, micro-mini hydro, etc. preferably at the 11 kV level.[17] As a part of its Nationally Determined Contributions (NDCs), Pakistan plans to achieve 60% of renewable energy capacity by 2030. [18]

Since the last four years, Pakistan has been witnessing a hike in energy prices. Furthermore, the inflation in exchange rates has created a pressure on foreign reserves since the country's economy depends significantly on import of fuels. There is a need to undertake measures on energy efficiency improvements to conserve energy and reduce the burden on foreign reserves. The energy intensity of the country stood at 1.420 in FY 2019-2020.

Years	Final Energy Consumption	GDP (in million)	Energy Intensity
2015-16	4,53,85,026	3,27,25,049	**1.387**
2016-17	5,01,22,303	3,41,75,628	**1.467**
2017-18	5,49,92,889	3,62,78,011	**1.516**
2018-19	5,49,95,685	3,71,84,104	**1.479**
2019-20	5,21,35,439	3,67,10,346	**1.420**

Energy Intensity: (TOE per unit of Economic Output), Source: National Electric Power Regulatory Authority, Pakistan

To overcome the crisis, Pakistan's government has prioritized domestic hydrocarbon production, the increase of natural gas imports, and the diversification of the installed capacity of power generation. One recent improvement has been capacity additions, especially in gas-fired power plants, to meet the growing demand. However, there are a few factors that are acting as barriers to generation of in-house power:

- **Out of economic merit order[19] operations of power plants and under-utilisation:** In the last year, some plants were out of merit order in its operations. The key reason for this was attributed to non-utilization or underutilization of efficient power plants either due to non-availability of fuel or transmission/distribution constraints.
- **Lower efficiencies and part load adjustment charges:** The operation of the thermal power plants on partial loads has resulted in efficiency loss of the power plants, consequently increasing fuel rice charges for end-consumers. The average net efficiency of the main power plants was ~55% during FY 2021-22.
- **Delay in new projects:** Numerous expansion projects have been implemented or are ongoing, often with a delay which has restricted power evacuation.

To address these issues, a comprehensive regulatory regime has been under development for the whole power sector. The most significant achievement so far has been the establishment of National Electric Power Regulatory Authority (NEPRA) through the NEPRA Act 1997. The Act clearly defines the structure, role, and responsibilities of the authority.

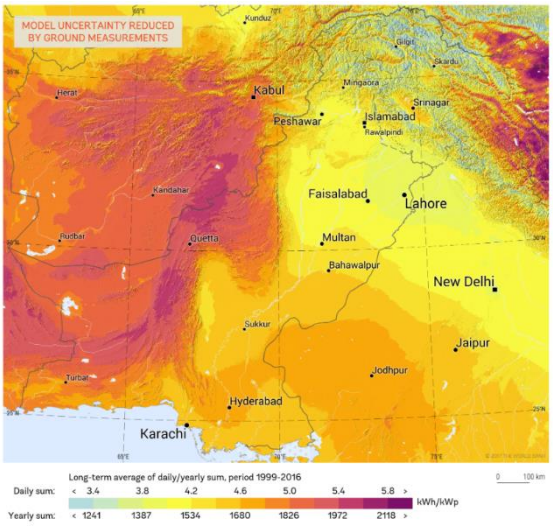
[17] Pakistan at 75- State of Industry Report, National Electric Power Regulatory Authority, 2022

[18] Climate Promise: Pakistan, UNDP (As of July 2023)

[19] The Economic Merit Order (EMO) is the sequence in which power plants are designated to deliver power, with the aim of economically optimizing the electricity supply. The merit order is based on the lowest marginal costs and is prepared based on the fuel cost and variable cost of the power plants available in the power system. NEPRA Report 2022.

Solar power

Pakistan is strategically located in the sunbelt and therefore solar power is the prevailing source of renewable energy in the country. The daylight duration and the sunshine ranges from 8-10 hours / day in most parts of the country, making Photovoltaic (PV) and Concentrated Solar Power (CSP) both options feasible for harnessing the solar energy. By the year 2022, the total installed solar power in the country was 630 MW, produced by 7 major power plants. The capacity increased by ~18% from the previous year.[20] The government plans to install 2000 MW of solar power projects as a part of its National Solar Energy Initiative.



The two provinces with the highest estimated potential for solar energy are Balochistan and Sindh. In parts of these provinces, there is sunshine ranging from 7 to 8 hours per day or more than 2300–2700 hours per year.[21] Large areas of Pakistan are affected by the monsoon, limiting the potential for CSP in this area due to cloud coverage during that season (while PV does still generate during that season in the regions, CSP does not). In 2018, the World Bank launched a USD 100 million Sindh Solar Energy Project to support deployment of 400 MW of solar power plants by independent power producers (IPPs) and distribute solar home systems across 200,000 households.[22]

Many regional government entities such as the Punjab Power Development Board (PPDB), Pakhtunkhwa Energy Development Organization (PEDO), Energy Department (Government of Sindh) and Energy Department (Government of Balochistan) are taking various initiatives towards solar power generation. Punjab Power Development Board (PPDB) has been established to perform its functions as a one-window facilitator for development of IPP based power projects in the province of Punjab. PPDB has contributed to the capacity addition of 500 MW solar PV into the national grid.[23] Another 100 MW solar PV power project is under development. Future projects of PPDB in solar power include 6 solar PV power projects of 975 MW. PEDO has also undertaken solarization of villages, mosques/worship places, construction of mini-grids, and solarization of public sector buildings. The Energy Department, Government of Sindh (EDS) is also working to undertake the competitive bidding for solar PV power. The initial work for 400 MW capacity has been completed. In addition, EDS is working on solarization of public sector buildings and village electrification through standalone solar PV systems.[24]

Solar rooftop: AEDB has been promoting renewable-energy based net-metering since 2015, for consumers in the industrial, commercial, and household sector. As of March 2023, the country had 50,656 net-metering

[20] Pakistan at 75- State of Industry Report, National Electric Power Regulatory Authority, 2022
[21] Variable Renewable Energy Integration and Planning Study, World Bank Group, 2020
[22] World Bank Solar Sindh Project, World Bank, 2018
[23] Pakistan at 75- State of Industry Report, National Electric Power Regulatory Authority, 2022
[24] Pakistan at 75- State of Industry Report, National Electric Power Regulatory Authority, 2022

systems installed with a total capacity of ~863 MW. These systems are deployed by the 307 installers certified by the AEDB.[25]

Some of the key challenges impeding growth of the solar sector in Pakistan are high upfront costs of installing solar PV plants, lack of awareness about benefits and uses of solar power, inadequate grid infrastructure, and limited access to renewable energy financing.

Hydropower including small hydropower (SHP)

Hydropower contributes to more than 25% of the total installed capacity of the country[26]. As of June 2022, Pakistan had a total of hydropower plants (21 large and medium plants and 12 SHPs) operational with a total capacity of 10,635 MW.[27] The largest hydropower plant is Tarbela, with an individual capacity of up to 3478 MW.[28] The capacity of the SHPs ranged from 1 MW to 37 MW. The government aims to increase the capacity of hydropower by 13,000 MW till 2030.

The total hydropower source potential in the country is estimated to be 60,000 MW, mainly across the regions of Khyber Pakhtunkhwa (KPK), Punjab and Norther Areas, according to the Private Power and Infrastructure Board (PPIB).[29] The total potential for small hydropower plants is estimated to be 1,500 MW.

Future projects of PPDB include 20 small hydropower projects of 128.91 MW[30]. While most of the hydropower projects under development are in the public sector, the provincial government has embarked on a multi-pronged strategy for encouraging investment through private and Public Private Partnership (PPP) modes. PEDO is developing 8 hydropower plants of 476.36 MW capacity[31] and PPIB is processing 13 hydropower plants of 5455 MW cumulative capacity[32].

Key barriers to scaling hydropower are high cost of evacuation, lack of transmission facilities, seasonal variation in resource availability, and underutilized capacities, among other factors.

Bioenergy

The installed capacity of biomass (bagasse) was 369 MW as of June 2022, contributing to about ~1% to the total installed capacity in the country.[33] Ther are currently 9 operational sugar mill-based bagasse co-generation plants.[34] The government plans to develop 21 biomass projects with an overall capacity of ~650 MW across the country.[35] The cost of electricity supply was PKR 13/kWh (USD 0.04/kWh) in FY 2021-22.

[25] Energy: Pakistan Economic Survey 2022-2023, Ministry of Finance, 2023
[26] Variable Renewable Energy Integration and Planning Study, World Bank Group, 2020.
[27] Pakistan at 75- State of Industry Report, National Electric Power Regulatory Authority, 2022
[28] Ibid.
[29] Ibid.
[30] Pakistan at 75- State of Industry Report, National Electric Power Regulatory Authority, 2022
[31] Ibid.
[32] Energy: Pakistan Economic Survey 2022-2023, Ministry of Finance, 2023
[33] Pakistan at 75- State of Industry Report, National Electric Power Regulatory Authority, 2022
[34] Ibid
[35] Ibid

Sugarcane production is the main resource for bioenergy in the country. Pakistan produces approximately 17.1 tons of sugarcane per year, leading to a potential of 1,844 MW of electricity generation capacity. Including other crop residue with an average annual production of about 69.5 million tons, the biomass electricity generation capacity is estimated to be around 12,741 MW.[36]

Federal and regional government agencies such as the Private Power and Infrastructure Board (PPID), Alternative Energy Development Board (AEDB) and the Punjab Power Development Board are supporting future sugar mill-based bagasse co-generation and biomass power projects.

The key challenges pertaining to biomass/bagasse generation are lack of availability of agricultural biomass, underutilized capacity due to seasonality of the resources, unwillingness of electricity distribution agencies to procure bioenergy, and legal issues with developers.

Wind power

Pakistan has a theoretical wind potential of 340 GW, with significant opportunities in the southern part of the country, and an exploitable potential of 50,000 MW in the coastal belt of Gharo-Keti Bandar. The country had 36 wind power projects of 1,838 MW cumulative installed capacity as of June 2022.[37] Nearly 600 MW of wind power was added in 2022 alone, through 12 wind projects.[38]

In addition to the federal government, various provincial government agencies such as the Punjab Power Development Board (PPDB) and the Energy Department (Government of Balochistan) are pursuing future wind power projects of 250 MW and 500 MW capacity respectively.[39] The Energy Department (Government of Sindh) has issued letters of intent for 12 wind projects.

Wind projects face major challenges of delayed deployment due to bureaucratic delays and lack of bidding by the relevant agency, despite being cheaper than imported fuel-based power projects. Levelized tariffs of wind projects range from USD 0.031/kWh to USD 0.038/kWh, less than half of the tariffs for electricity procured from thermal sources.[40]

RE mini grids

The development of renewable energy minigrids in Pakistan is at an extremely nascent stage. The government recognizes the potential positive impact of distributed generation, especially to reach the unelectrified population in far off rural areas. The National Electric Power Regulatory Authority (NEPRA) notified regulations for microgrid licensing in 2021-22.[41]

The Pakistan Poverty Alleviation Fund (USD 26 million) by KfW (German Development Bank) has been supporting deployment of RE minigrids in the country. This program has deployed 68 solar minigrid systems with cumulative installed capacity of 500 kW across the regions of Swabi, Karak, and Lakki Marwat districts

[36] Variable Renewable Energy Integration and Planning Study, World Bank Group, 2020.
[37] Pakistan at 75- State of Industry Report, National Electric Power Regulatory Authority, 2022
[38] Ibid
[39] Ibid
[40] Ibid
[41] Ibid

of the Khyber Pakhtunkhwa. The capacity of each minigrid system ranges between 2 kW to 51 kW. Most of these minigrid projects follow the community-based business model, with NGOs/local community members managing and operating the system. The cost of tariff for grant-funded projects is PKR 6 (~USD 0.020) per unit for domestic users. The tariff is determined based on the consumer's ability to pay and cost of operation and maintenance of the minigrid system. [42]

Barriers and challenges that impact the scaling of the mini grid sector in Pakistan include lack of institutional support, absence of specific policies on minigrids (covering aspects such as permits, tariff setting, financial assistance, regulation in case of grid expansion etc.), limited technical expertise to design and operate decentralized RE applications, lack of private sector investment (mainly due to high cost of investment, higher perceived commercial risk, lack of government funding support etc.) and lack of distribution companies mandated to supply electricity in rural areas.

[42] SAARC minigrid study report, 2022

Key government institutions

Institution	Role
National Energy Efficiency and Conservation Authority	NEECA is responsible for initiating, catalysing and coordinating all Energy Conservation activities in different sectors of the economy. The authority to provide for establishment of institutions and enunciation of mechanism and procedures to provide for effective conservation and efficient use of energy. **Website:** https://neeca.gov.pk/index
National Electric Power Regulation Authority (NEPRA)	NEPRA has been created to introduce transparent and judicious economic regulation, based on sound commercial principals, to the electric power sector of Pakistan. NEPRA reflects the country's resolve to enter the new era as a nation committed to free enterprise and to meet its social objectives with the aim of improving the quality of life for its people and to offer them opportunities for growth and development. **Website:** https://nepra.org.pk/index.php
Alternate Energy Development Board	It is the sole representative agency of the Federal Government with the main objective to facilitate, promote and encourage development of Renewable Energy in Pakistan and with a mission to introduce Alternative and Renewable Energies (AREs) at an accelerated rate. **Website:** https://aedb.org/
Private Power & Infrastructure Board (PPIB)	PPIB was created in 1994 as a "One-Window Facilitator" on behalf of the Government of Pakistan (GoP) to promote private investments in power sector. They also facilitate public sector power and related infrastructure projects in IPP mode. **Website:** https://www.ppib.gov.pk/
Punjab Power Development Board	PPDB has been established to perform its functions as a one window facilitator for development of IPP based power projects in the province of Punjab. **Website:** https://ppdcl.punjab.gov.pk/
Pakhtunkhwa Energy Development Organization (PEDO)	An autonomous body of the Government of Khyber Pakhtunkhwa and responsible for fast track development of the energy sector of the province. PEDO is working to explore all possible energy avenues including renewables like hydro, solar and wind energy. **Website:** https://pedokp.gov.pk/Main
Energy Department, Government of Sindh	The Energy Department, Government of Sindh is to solve matters relating to development, generation, supply and distribution of hydro and thermal power. It also determines rates of supply to consumers in bulk and otherwise and may prescribe tariffs within the province except where entrusted to WAPDA. **Website:** https://www.sindhenergy.gov.pk/
Energy Department, Government of Balochistan	The department focuses on enhancing the energy capacity of Balochistan and fuel economic growth by creating an environment that meets the Energy demands of all sectors through sustainable and affordable Energy mix and its efficient use. **Website:** https://balochistan.gov.pk/

Industry associations

Industry Association	Features
Pakistan Solar Association	A non-profit, non-governmental trade body that aims to promote and support the Solar Industry in Pakistan. PSA Member companies are from all segments of the value chain, such as engineering, professional services, small traders, manufacturing and contracting companies. Website: https://pakistansolarassociation.org/
Renewable & Alternative Energy Association of Pakistan (REAP)	Renewable & Alternative Energy Association of Pakistan (REAP) is formed with a mission to minimize the national dependence on conventional resources of energy by promoting renewable resources of energy in Pakistan. REAP is a non-political, non-profitable organization to serve the community without any discrimination of cast, creed, clan, gender or religious discriminations. Website: https://reap.org.pk/

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World Bank Data Indicators
https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=PK

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