



PAKISTAN'S ENERGY TRANSITION IN A WARMING WORLD: Integrating Decarbonization, Climate Resilience and Economic Security

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1. INTRODUCTION

Pakistan's transition to renewable energy is not anymore a matter of policies. The transition has already begun, and the visible signs of this transition can be found in the rapid growth of solar energy systems at household, agricultural, commercial and industrial levels. Imports of solar photovoltaic modules have grown from less than 1 GW in 2018 to more than 51 GW up until early 2026¹⁹. Import capacity does not necessarily mean installed capacity, but it indicates the scale and speed of the change. Official statistics about Pakistan's power sector also support this trend – net metering capacity has increased from 2,813 MW during July-March FY2025 to 7,319 MW during July-March FY2026, which means a jump of 160 percent within one year²⁰.

There are several factors which are responsible for driving this change – reduction in the cost of solar technology, high price of grid electricity, issues related to energy security and increasing demand for electricity among consumers. What is particularly important is that most of the changes are decentralized and demand-driven and thus independent of investments made by the state sector.

19. Centre for Research on Energy and Clean Air (CREA). The Hedge That Paid Off: How Pakistan's Solar Boom Is Shielding It from the Hormuz Crisis. Helsinki: CREA; 2026.

20. Government of Pakistan, Finance Division. Pakistan Economic Survey 2025–26. Islamabad: Government of Pakistan; 2026.

While for Pakistan, the solarisation process cannot be considered merely a development process within the power sector, but rather something that directly impacts its national commitment to mitigating greenhouse gas emissions, climate change resilience, water security, economic competitiveness and energy independence. Hence, the relevant policy issue is not one of increasing solar capacity, but whether a fast technology deployment process can contribute to achieving emission reductions, resilience, and enhanced energy system security.

In other words, the policy approach advocated in this study is that Pakistan should shift from focusing exclusively on an energy transition to adopting a climate compatible energy transition where mitigation and adaptation efforts are undertaken in tandem. Solarisation provides momentum, yet its full potential hinges upon the processes of grid connection, climate risk assessment, GHG accounting, MRV and NDCs, and climate finance.

2. ENERGY TRANSITION AS A CLIMATE-DEVELOPMENT IMPERATIVE

Any discussion of Pakistan's energy transition needs to consider the issue within the larger framework of emissions in Pakistan, which also experiences significant vulnerabilities to climate change. Pakistan's First Biennial Transparency Report indicates that energy, along with agriculture, forestry and other land use, is among the major sectors that contribute to Pakistan's national GHG emissions²¹. The emissions related to energy are not just those associated with power production, but also include emissions from transport, industry, buildings, agriculture, and wider fossil fuel usage in the economy.

The crucial point here is that while de-carbonizing electricity generation is important, it is not enough. Clean electricity should increasingly be used in the lower carbon transport, more energy-efficient industry, better quality buildings and agriculture energy usage. The goal should therefore be the de-carbonization of energy services across the economy.

Pakistan's development needs make this distinction particularly important. Energy demand will continue to rise with population growth, urbanization and economic expansion. A climate strategy based on restricting energy use would be neither realistic nor desirable. The appropriate objective is to improve energy efficiency while meeting growing demand through progressively lower-carbon sources.

At the same time, energy infrastructure itself is increasingly exposed to climate change. Rising temperatures increase cooling demand and can affect power-system performance. Changes in rainfall, snow and glacier dynamics influence hydropower availability, while floods and extreme weather can damage transmission and distribution infrastructure. The energy sector is therefore both a contributor to climate change and a system vulnerable to its impacts.

A successful transition must address both dimensions.

3. PAKISTAN'S SOLAR BOOM AND THE CHANGING ELECTRICITY SYSTEM

The extent of the growth in solar capacity in Pakistan has now become one of the distinguishing characteristics of its energy transition. According to the Pakistan Economic Survey 2025–26, total installed electricity generation capacity stood at 49,651 MW as of March 2026. Hydropower, nuclear and renewables together constituted 50.8 per cent of the installed capacity and produced 53.1 per cent of electricity generated in July–March FY2026.

However, what is really happening now is that distributed solar capacity is increasing rapidly. Solar photovoltaic is being installed in rooftops, agricultural farms, businesses and industries.

21. Government of Pakistan, Ministry of Climate Change & Environmental Coordination. Pakistan's First Biennial Transparency Report under the Paris Agreement. Islamabad: Government of Pakistan; 2024.

The scope of net metering is not an accurate indicator of the trend as much of the capacity is installed behind the meter.

This is important as the traditional planning framework for electricity assumes that the bulk of electricity is generated centrally and is supplied to the consumer via grid. Distributed solar makes this less true. Consumers will keep consuming substantial quantities of electricity but will purchase less from utilities as their demand is partly being satisfied through independent means.

The Economic Survey is one such illustration of this changing trend. Electricity consumption by agriculture from grid sources fell by 42.3 per cent during July-March FY2026 as compared to the same period of the previous year, with adoption of alternate power sources, including solar energy, being counted among the reasons for this. This implies that some of the falling demand from grid might be attributed to technological substitution rather than decrease in productive effort. Pakistan thus is headed toward a system where the consumers themselves would become producers of electricity.

4. FROM SOLAR DEPLOYMENT TO MEASURABLE DECARBONISATION

Solar power installation at a rapid pace is another form of mitigation that deserves consideration, but in no way can installed or imported capacity be considered equivalent to emission avoidance. It all depends on the amount of power generated through such means, the kind of power generation displaced by solar energy, and whether or not there is absorption of this energy.

The process is fairly simple and includes translation of technology installation into electricity generation, which should displace fossil fuel generation and result in verified emission reductions. The latter can then be evaluated against NDC criteria.

Each stage requires reliable data.

In cases where solar energy replaces oil, coal or

gas-fired generation, the mitigation effect may be significant. When renewable energy generation is curtailed, displaces lower-carbon generation or is not well integrated into the grid, the emissions benefits will be much smaller. Hence, there is a need for Pakistan to move from measuring renewable energy capacities to measuring renewable energy generation, emission factors, fuel displacement and avoided CO₂-equivalents.

This has obvious implications for GHG inventories and NDC monitoring at the national level. In view of an increasingly large share of generation taking place "behind the meter," energy data collection must change in order to accommodate that reality. Otherwise, Pakistan may significantly underestimate the changes in electricity consumption, displacement of fossil fuels and mitigation benefits.

Solar energy growth brings about certain practical considerations. High levels of electricity generation during the daytime cause a sharp decline in demand, while the need for electricity increases after sunset. This makes battery storage, demand response, flexible generation, smart metering and better forecasting increasingly important. Thus, the deployment of solar energy without system integration may cause inefficiencies.

System integration should become the priority of the next stage of energy policy.

5. CLIMATE RESILIENCE MUST BE BUILT INTO THE TRANSITION

It is important to note that low-carbon energy infrastructure does not automatically equate to resilient infrastructure. This point is especially relevant for Pakistan because much of the energy infrastructure currently under construction will run for many years under climate conditions very different from those of the past period that was used in the design.

Hydropower generation is subject to changes in river flow, snow melt and hydrological variability. Power lines and substations are susceptible to floods, storms and extremely high temperatures.

Output of photovoltaic panels and performance of the equipment may depend on high temperature, dust and extreme weather. Efficiency of thermal generation may decrease due to high ambient temperature and water-cooling limitations. Thus, climate risk assessment should become an integral part of energy infrastructure development. Major projects need to pass two tests at once – their mitigation credibility and resilience under future climate scenarios.

This is not only a precaution for the environment but also an economic necessity, where infrastructure built on the basis of historical climates could incur greater maintenance costs or even early replacement due to disruption. The use of future projections of climate within the design phase can alleviate these problems and enhance investment.

Consequently, energy transition in Pakistan must rely on one fundamental idea: Low carbon infrastructure must also be climate resilient infrastructure.

6. WATER, ENERGY AND FOOD LINKAGES

Solar irrigation shows how climate policies must be examined holistically as opposed to in isolated sectors. Switching from diesel-powered pumps to solar irrigation systems will bring about reductions in energy costs, dependence on foreign energy and greenhouse gas emissions. In turn, this cheaper form of pumping can lead to greater groundwater exploitation where regulation is poor.

A climate policy that has a positive effect in terms of emission reduction might thus lead to maladaptation. The challenge is not in the solar technology per se, but in its implementation without proper natural resources governance.

This implies that solar irrigation should be accompanied by more efficient irrigation management, groundwater monitoring and accounting, planning for crops and incentivizing increased water productivity. This will allow for retention of emission reduction while minimizing the risks of maladaptation.

The broader point is that there are clear linkages between Pakistan's water, energy, and food systems. Energy choices affect water withdrawals; water availability impacts agriculture and hydro power production; farming practices impact energy and water consumption; and climate change impacts all of these at once. This means that climate policy in Pakistan cannot optimize one system at the cost of another.

7. NDC 3.0 AND THE NEED FOR MEASURABLE IMPLEMENTATION

Pakistan's NDC 3.0, which was submitted in September 2025, constitutes the major national framework within which climate actions should be undertaken. Under this framework, the country pledges to reduce its projected GHG emissions up to 50 per cent in 2035, with 17 per cent reduction being unconditional and 33 per cent being conditional on the provision of financial, technological and capacity-building support from the international community.

The main elements of the national mitigation pathway under the NDC are considered to include renewable energy, energy efficiency, upgrading of transmission systems and storage. Yet the importance of the framework will remain subject to the extent to which national pledges will be turned into measurable sectoral actions.

The presence of such activity as renewable energy capacity, electric vehicles or energy efficiency programs is a good indicator but does not necessarily mean that any progress is made in achieving the national emissions goal.

As such, GHG inventories and MRV become key in climate governance. A comprehensive inventory offers insight into the sources of emissions, variations in emissions and whether the expected results are being achieved through mitigation interventions. It is important that Pakistan maintains and enhances its institutional set-up for data generation, quality assurance/quality control, uncertainty assessments, archiving of data and formulation of country-specific emission factors where necessary. In the long run, the goal must be a

continuous process of national inventory management as opposed to occasional production of inventories mainly for reporting purposes to the international community. The inventory will serve as a yardstick to evaluate energy and climate policies based on emissions trends.

8. CLIMATE FINANCE, INVESTMENT AND SCIENTIFIC CREDIBILITY

Transitioning to a low-carbon future will need investment which will exceed the resources that would be raised by means of the usual fiscal outlay by Pakistan. It will need to raise concessional finance, blended finance, private finance, green bonds and sukuk, international climate finance and, where possible, carbon market finance. Quality of climate evidence will become more important for gaining access to these resources. Baselines, emissions reductions and reporting mechanisms must be reliable in case of mitigation. Climate hazards, vulnerability baselines and improvements must be reliable in case of adaptation investments.

This is how science connects directly with finance. More precise climate forecasts make infrastructure design better²²; better GHG inventories make prioritizing mitigation projects easier; MRV makes us more confident in the results and better-quality evidence makes climate investments more bankable.

So Pakistan needs to move from ad hoc climate projects to ready-to-invest transition programs. Solar storage, grid improvement, transmission infrastructure improvement, efficient cooling, clean energy and renewable public services offer immediate opportunities. Such programs can bring mitigation, adaptation and economic value at the same time.

Furthermore, Article 6 of the Paris Agreement could present some scope for raising more funds for mitigation efforts. Nonetheless, involvement in the carbon market needs to be done cautiously by taking into account the issues of additionality, conservative baselines, transparency in monitoring, avoidance of double counting, and the effects of transferring mitigation outcomes on Pakistan's own Nationally Determined Contributions.

9. TOWARDS A CLIMATE-RESILIENT ENERGY SYSTEM

The solar revolution in Pakistan is a clear example of how technology can progress much faster than traditional planning processes. Now the structures and tools around the energy transition need to play catch-up.

The future power system will have to include more decentralized generation, storage, and flexibility. Climate forecasts will shape infrastructure planning. Energy accounting needs to take account of behind-the-meter generation. GHG inventories need to measure emissions changes. NDCs need to be matched with investment plans, and climate finance proposals need to prove their mitigation and resilience impacts.

All of these aspects should work as part of one cycle of policy: climate science detects risks; GHG inventories detect emission priorities; integrated modeling assesses pathways; policy shapes investments; implementation creates measurable results; and MRV creates the information base for NDC reporting and further policy adjustments.

This approach will give a more meaningful definition of success for Pakistan's transition: it should not be measured by installed renewables capacity. Instead, it should be measured by the ability of the energy system to reduce emissions, enhance resilience, reduce dependence on fossil fuel imports and support economic competitiveness.

10. CONCLUSION

Pakistan is at a crucial crossroads in its climate and energy transition journey. The leap from less than 1 GW of cumulative solar PV imports in 2018 to more than 51 GW by early 2026 and official records of net-metered capacity of 7,319 MW as of March 2026 illustrates the rapid pace of technological change.

22. Intergovernmental Panel on Climate Change. Climate Change 2023: Synthesis Report. Geneva: IPCC; 2023.

These are measures of different aspects of the transition and are not to be confused, but they both prove the transformation of solar power from an emerging technology to a structural part of Pakistan's energy system.

The solar energy transition presents many chances for emission reductions, improved energy security, and decreased dependency on imported fossil fuels. However, renewable deployment alone will not bring success to the climate transition process. More solar deployment will need storage, grid flexibility, increased forecast capacity, and improved management of distributed generation systems. It is also necessary to take into account the climate challenges that the infrastructure will face over its lifecycle.

Pakistan's NDC 3.0 gives the strategic vision, while the Enhanced Transparency Framework, GHG Inventories, and Biennial Transparency Reports²³ are the tools to assess the progress.

The policy challenge is to connect these elements through science-based planning, measurable implementation and investment. Pakistan should thus transition from the technology-led energy transition to a climate resilient development transition. Solar energy should be pursued hand-in-hand with grid modernization; mitigation along with adaptation; energy policy with water and food security; and NDCs with investment and MRV systems.

A low carbon energy system that is vulnerable to climatic extremes will not be resilient; similarly, a resilient energy system that depends on carbon heavy fuels will not be sustainable. The ultimate aim of Pakistan needs to integrate both these aspects.

The boom in solar energy has given Pakistan this momentum; now the task is to translate this momentum into an energy system which is not only low carbon and climate resilient but is economically viable and can ensure sustainable development in the warming world.

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23. United Nations Framework Convention on Climate Change. Biennial Transparency Reports under the Enhanced Transparency Framework. Bonn: UNFCCC.

