



Climate Action Tracker

## Wind and Solar benchmarks for a 1.5°C world

# PAKISTAN

February 2026



# Executive Summary

## Context

- ▶ Pakistan’s power system is almost equally supplied by fossil fuels and clean energy sources, with fossil fuels making up 52% of the electricity generation mix in 2023 compared to 48% from clean energy sources (3.4% from wind and solar and 44% from other sources, primarily hydropower and nuclear). The share of renewables in the power mix did not increase in 2024, though [installed capacity distributed energy sources](#) have been increasing steadily - from 1.3 GW in 2023 to 2.5 GW in 2024 to 4.9 GW in 2025.
- ▶ Pakistan has an explicit target to reach 30 GW of renewable generation capacity by 2030.
- ▶ In this report, we look at national studies and global energy system models to assess how much Pakistan’s wind and solar capacity needs to grow to align with the global goal to triple renewables by 2030 and the Paris Agreement’s 1.5°C warming limit.

## Key findings

- ▶ Pakistan’s wind and solar generation needs to grow between three and eight times by 2030 to align with 1.5°C-consistent pathways. This equates to 18-43 TWh of wind and solar generation by 2030, up from 5.2 TWh generated from those sources in 2023.
- ▶ Over 13 GW of new wind and solar installed capacity would be needed by 2030 (almost 10 GW of solar and just over 3 GW of wind). This would require average annual capacity additions of 1.2 GW/yr of solar and 0.43 GW/yr of wind from 2023-2030.
- ▶ Pakistan’s current rollout of wind is not progressing fast enough to achieve this. Under current policies and market conditions, only 59% of the wind energy needed to align with 1.5°C will be installed by 2030. In contrast, solar rollout is currently tracking above the levels required under 1.5°C-aligned pathways by 2030.





## Context

At COP28, governments agreed to triple global renewable capacity by 2030 globally to stay in line with 1.5°C. This report highlights the potential implications of this COP28 decision at the national level, focusing on **Pakistan**.

Wind and solar deployment is accelerating around the world. However, expected wind and solar capacity deployment under current policies falls short of what is needed for 1.5°C, and is concentrated mainly in a few regions.

Research is needed to understand the pace of wind and solar deployment that aligns with the highest plausible ambition and is compatible with 1.5°C

This project aims at answering the following questions:

- ▶ **How much wind and solar generation is needed (TWh) at the national level?**
- ▶ **How much wind and solar needs to be built (GW of capacity)?**
- ▶ **When does it need to be built by, and how quickly?**

## Policy context

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Pakistan's 2035 Nationally Determined Contribution (NDC) commits to [reducing GHG emissions by 50% by 2035](#), with 17% an unconditional commitment and 33% conditional on international finance and support. Also in its NDC, Pakistan aims to reach [62-69% of installed capacity powered by renewables](#) by 2030.

In terms of installed capacity, Pakistan has set an explicit target to reach [30 GW of renewables](#) by 2030 (10 GW solar, 2.7 GW wind, and the remaining from other renewables, primarily hydropower). Achieving this target would mean [renewables would provide 57% of total generation](#) by 2030.

Under current policies and market conditions, [the IEA estimates](#) that **solar capacity in Pakistan will reach 64 GW in 2030**, up from 3.2 GW in 2023. Meanwhile, it projects **wind capacity to reach 3.3 GW in 2030**, up from 2.3 GW in 2023.

## International support

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The key analytical elements (high ambition country-level studies and downscaled 1.5°C compatible global pathways, see [Methods](#)) do not consider financing requirements.

Significant global resource transfers will be required in line with 'common but differentiated responsibilities and respective capabilities' to achieve these benchmarks.

We do not quantify the technical and financial support needed to achieve the wind and solar rollout presented in this report. This should be a country-driven exercise and some governments have already initiated such processes.

High-income countries will need to provide substantially increased climate finance to support emissions reduction abroad, in line with their 'fair share' of climate action.

Achieving these benchmarks in lower-income countries is therefore a global responsibility, rather than a domestic responsibility. Therefore, ambitious climate finance commitments and delivery are essential to support high ambition at the national level.

## National enabling factors

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Key enabling factors for ambitious wind and solar rollout include:

- ▶ **Institutional capacity.** A rapid build-out of wind and solar will require the governance and institutional capacity to develop, implement and enforce policy frameworks.
- ▶ **Just transition.** A just transition will be needed to take along all stakeholders, particularly those employed by the fossil economy.
- ▶ **Grid development.** Substantial increases in both transmission and distribution grid infrastructure will be necessary to integrate large-scale new wind and solar generation into the power system.
- ▶ **Fossil fuel phase-out.** Existing fossil fuel infrastructure often will need to be retired earlier than its economic lifetime. Policies need to be developed to achieve the early phase out of fossil fuel plants.
- ▶ **System flexibility.** Energy storage (diurnal and seasonal), flexible generation technologies such as hydro and geothermal, and increased demand side flexibility will all be crucial.
- ▶ **Market design.** Reform of market designs and regulation adapted to renewable energy-based systems that incentivise and mobilise investments to install renewable energy at the scale needed (e.g., minimise cost of capital, ensure revenue certainty, etc).

## Stages of power sector decarbonisation

■ Current WnS generation 
 ■ Fossil fuel generation 
 ■ WnS generation to cover the phase out of FF 
 ■ WnS generation to meet demand growth 
 ■ Non-WnS clean generation

The stages of the electricity system transition in Pakistan

WnS = Wind and Solar

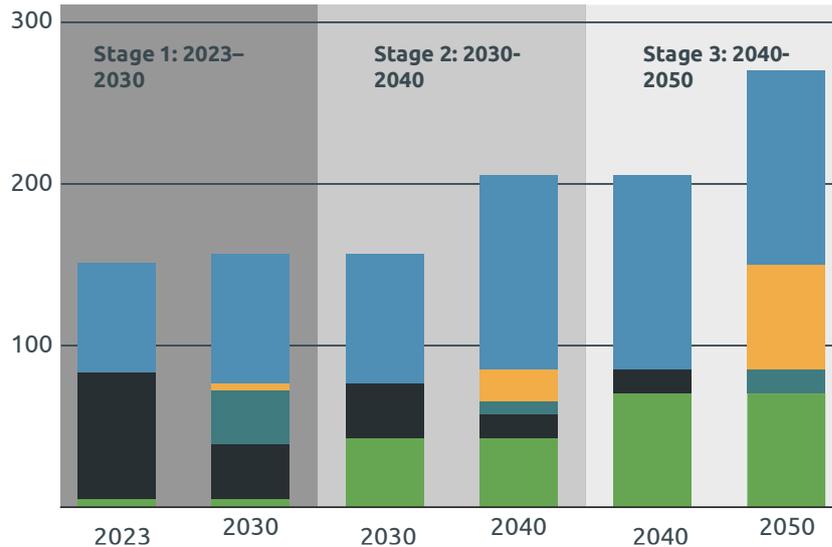


Figure 1 – Electricity generation in each stage in TWh

In a 1.5°C pathway, countries must add solar, wind, and other clean technologies to meet rising power demand while replacing phased-out fossil fuels. The evolution of the power capacity mix over successive decades varies across countries.

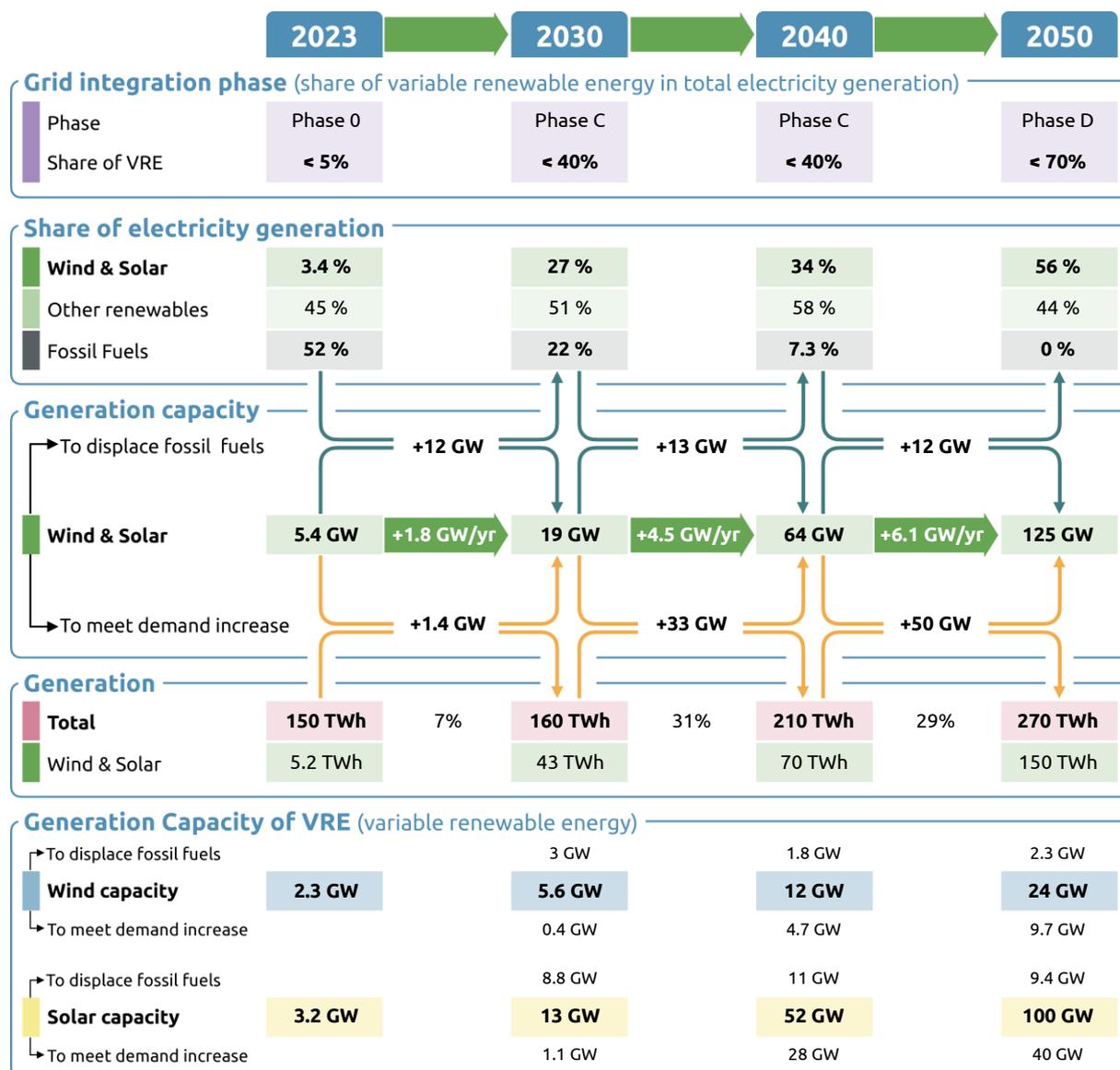
From now until 2030, Pakistan would need to add around 0.4 GW of wind and 1.1 GW of solar capacity to meet growing demand alone. Another 3 GW of wind and 8.8 GW of solar will be needed to displace the share of fossil fuels in the electricity generation mix.

Power sector transformation and the increasing participation of variable renewable energy (VRE) – mainly wind and solar – in a country’s power mix gives rise to a set of technical challenges linked to the integration of VRE sources. Six phases can be distinguished here, from phase 0 (pre-development with negligible amount of VRE shares) to phase E (with over 80% VRE shares). More information about these phases can be found in Annex A.

Meeting the benchmarks for 2030 will put Pakistan in Phase C, with wind and solar making up 27% of the generation mix. Periods in which VRE dominates system behaviour become increasingly frequent. A key operational challenge is maintaining system stability during sudden disruptions in supply or demand. Curtailment of VRE may become necessary to preserve system security. Without structural adjustments, integration constraints of VRE into the system may slow further increases in renewable energy shares despite additional installed capacity.

Figure 1 and Table 1 both show the stages of the transition to a decarbonised power sector in terms of the volumes of existing wind and solar and what is needed to displace fossil fuels and meet demand increases. Figure 1 shows the stages in terms of electricity generation, and Table 1 shows it in terms of generation, capacity and share of the electricity mix.

Table 1: Stages of the electricity system transition detailing how much generation capacity of wind and solar will be needed to displace fossil fuels in the system and meet growing electricity demand

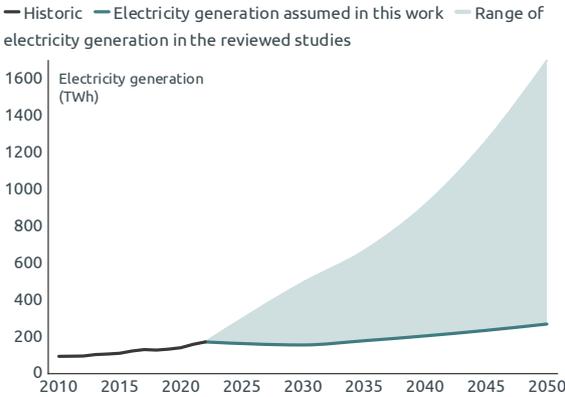


Note: Numbers are rounded to two significant figures, which may contribute to minor differences in totals. The calculations assume that wind, solar, and other renewables contribute equally and proportionally to displacing fossil fuels and meeting demand growth.

## Future electricity demand

Total electricity generation is taken from the [Indicative Generation Capacity Expansion Plan \(IGCEP\)](#). The literature for Pakistan has a wide range of projections for total electricity generation. The scenario we selected was taken from the national energy system planning document. As the IGCEP projections extend only to 2035, the series was extended to 2050 by applying an assumed annual growth rate of 15%. We did this because it is the closest scenario to the [observed electricity generation in 2023](#). However, because the electricity demand is so high in other studies, we harmonised them to match the total electricity generation from the IGCEP. In the resulting scenario, electricity generation reaches 270 TWh in 2050.

Across the broader literature reviewed here, projected electricity generation in 2050 ranges from 270 TWh to 1,287 TWh. This wide range has major implications for the required deployment of wind and solar capacity. The demand estimate adopted here lies at the lower bound of the country-level studies.



We use government projections for electricity generation growth in Pakistan, which are at the lower end of the literature

The solid line shows the electricity generation projection used to develop the benchmarks

Figure 2 – Total electricity generation in TWh

## Pace of fossil fuel phase-out needed

The rate of fossil fuel phase-out is set by the overlap between country-level studies, downscaled 1.5°C compatible global pathways and the global milestones of the [IEA’s Net Zero roadmap](#), where Pakistan achieves a clean power system by 2045 (see [methods](#)).

To align with 1.5°C, our modelling results show that fossil fuel generation falls by 22% to 38% between 2023 and 2030 and fossil fuels must exit Pakistan’s power sector by 2045 as renewables expand to meet growing demand.

**To align with 1.5°C, Pakistan should phase out fossil fuels by 2045 and expand renewables to meet growing demand**

Pakistan would need to achieve clean electricity by 2045

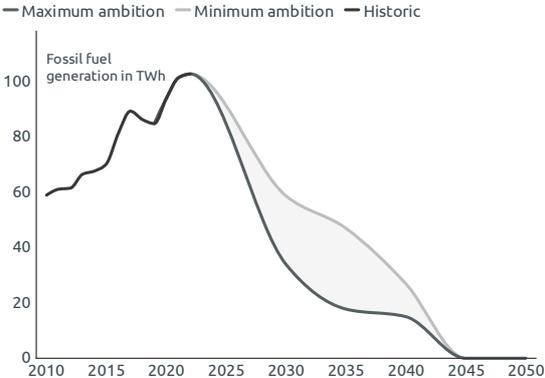


Figure 3 – Fossil fuel generation in TWh

Coal and gas phase-out in Pakistan

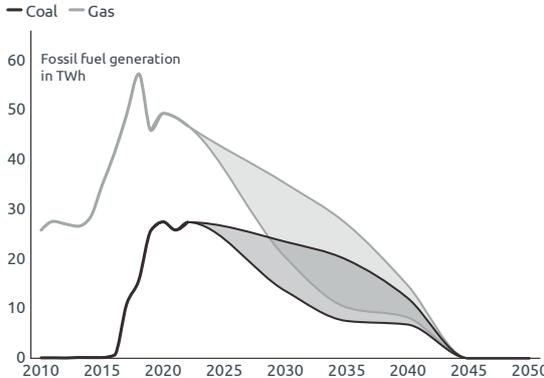


Figure 4 – Fossil fuel generation by fuel type in TWh

## The role of other clean electricity generation

While wind and solar will be the workhorse of the energy transition, other clean electricity generation may play a role. We estimate the role of non-wind and solar clean electricity generation\* (largely hydro, biomass, nuclear and geothermal) from country-level studies.

In our modelling, we assume that generation from non-wind and solar clean technologies in Pakistan would reach 80 TWh by 2030 (51% of total generation) and 120 TWh by 2050 (44% of generation). This generation is provided largely by hydropower.

## Total wind and solar generation needed to align with 1.5°C

The wind and solar rollout is then calculated by combining projected electricity demand growth, the fossil fuel phase-out necessary to align with 1.5°C, and the assumed generation from other clean technologies.

To align with 1.5°C, **wind and solar generation in Pakistan would need to reach between 18 and 43 TWh by 2030**. Given generation in 2023 was 5.2 TWh, this would be a two to eight-fold growth in wind and solar.

Wind and solar provide 11-27% of overall electricity generation in 2030, and 56% of overall generation in 2050. A grid powered primarily by wind and solar would require substantial rollout of batteries and energy storage, support from dispatchable generation such as hydro and geothermal, flexible demand and grid extension to ensure reliability of the system.

**To align with a 1.5°C pathway, Pakistan wind and solar generation would need to increase eight-fold by 2030 relative to 2023 levels**

Wind and solar generation to reach over 150 TWh in by 2050 to align with 1.5°C

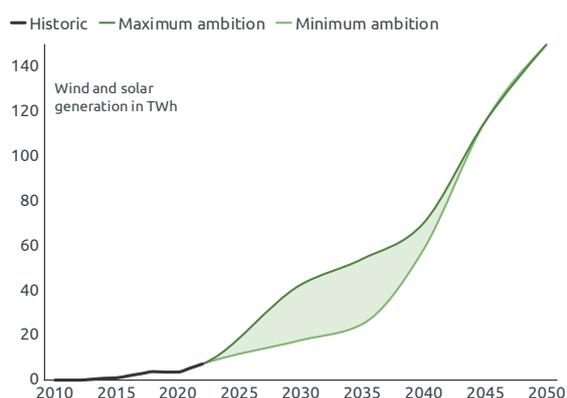


Figure 5 – Wind and solar electricity generation in TWh

The share of wind and solar generation needs to grow rapidly in Pakistan

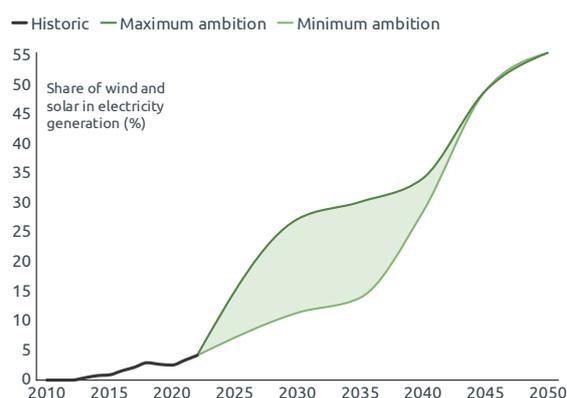


Figure 6 – Wind and solar electricity generation share (%)

\* We do not consider CCS in the power sector, as we do not consider CCS a [viable source of large-scale emissions reductions in the power sector](#).

## Possible splits between wind and solar

The relative share of wind and solar deployment will vary depending on how various factors develop in the future. We explore one key uncertainty, the relative cost of solar and wind electricity generation (see [methods](#)). When accounting for this uncertainty, we see a range of possible future generation mixes between wind and solar.

We highlight the median of the range as our **central benchmark**, but do not suggest that this is the only possible breakdown into wind vs. solar. The model includes a simplified representation of the power grid and does not fully capture transmission constraints, spatial effects, curtailment, or detailed integration costs. These factors could influence the relative balance between wind and solar in practice.

In this scenario, **Pakistan would need to deploy almost 20 GW of new wind and solar capacity by 2030 to align with the 1.5°C temperature limit.** By 2050, total wind and solar capacity would need to reach almost 130 GW.

Importantly, these are cost-optimised modelled pathways that give a useful indication of the pace and scale of wind and solar deployment needed for 1.5°C, but they cannot fully capture real-world context, where industry development, supply chains, workforce, and infrastructure will require stable and sustained development.

### Pakistan needs to reach almost 20 GW of wind and solar installed capacity by 2030 to align with 1.5°C

Solar capacity in Pakistan would reach 13 GW by 2030 in a 1.5°C-aligned scenario

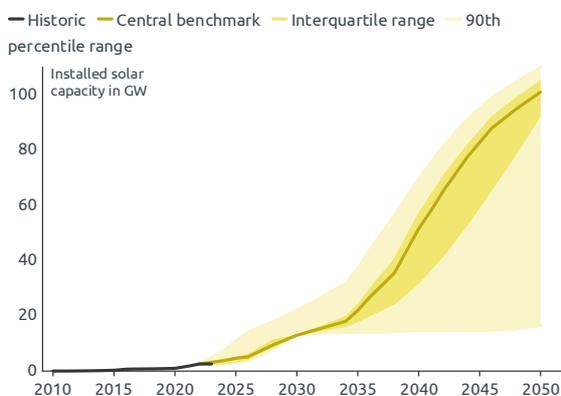


Figure 7 – 1.5°C compatible capacity benchmarks for solar in GW

Wind capacity in Pakistan would reach 6 GW by 2030 in a 1.5°C-aligned scenario

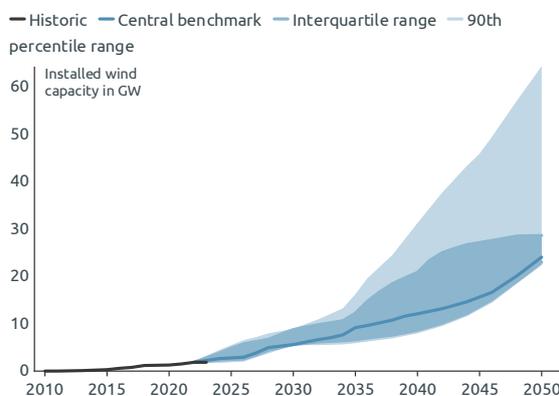


Figure 8 – 1.5°C compatible capacity benchmarks for wind in GW

The following table shows the wind and solar deployment needed to align with the central 1.5°C compatible benchmark produced. 2023 is historical data. All benchmark data from 2030 onwards is reported to two significant figures.

Table 2: Wind and solar electricity generation and capacity (2023–2050)

Scenario	Variable	Unit	2023	2030	2035	2040	2050
Central 1.5°C benchmark	Solar generation	TWh	2.1	19	26	74	160
Central 1.5°C benchmark	Wind generation	TWh	7.6	14	31	40	93
Central 1.5°C benchmark	Solar capacity	GW	3.2	13	22	52	100
Central 1.5°C benchmark	Wind capacity	GW	2.3	5.6	9.2	12	24

Table 3: Benchmarks translated into CAT format

Variable	Ambition	Unit	2030	2035	2040	2045	2050
Share of coal	Minimum	%	12	10	3	0	0
	Maximum	%	5	2	1	0	0
Share of gas	Minimum	%	21	16	6	0	0
	Maximum	%	8	3	3	0	0
Share of renewables	Minimum	%	59	64	81	91	91
	Maximum	%	79	85	86	91	91
Share of wind and solar	Minimum	%	11	14	28	49	56
	Maximum	%	27	30	34	49	56

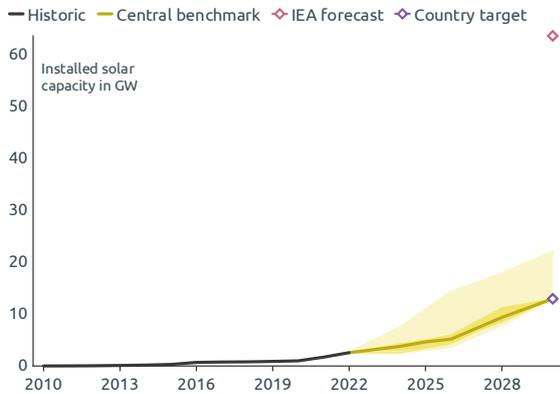
## Comparison to current rollout and country target

Under current policies and market conditions, the deployment of solar exceeds the capacity levels implied by the 1.5°C benchmark, with almost 64 GW of installed capacity projected for 2030 – **51 GW above the 1.5°C benchmark**. However, wind deployment lags behind, with 3.3 GW projected for 2030, which leaves **a capacity gap of 2.3 GW**.

In its national electricity plan, Pakistan has an explicit renewables capacity target of 30 GW by 2030: 10 GW from solar and 2.7 GW from wind. These targets are aligned with a 1.5°C-compatible pathway.

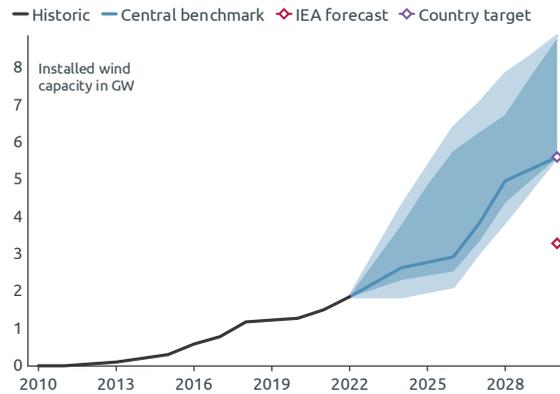
## Pakistan's solar rollout is aligned with 1.5°C, but wind rollout needs to accelerate

In Pakistan, current rollout of solar is accelerating far beyond 1.5°C aligned levels



**Figure 9** – Installed solar capacity in 2030 compared to targets and current policy projections in GW

Pakistan's wind target aligns with our 1.5°C benchmark, but deployment lags behind

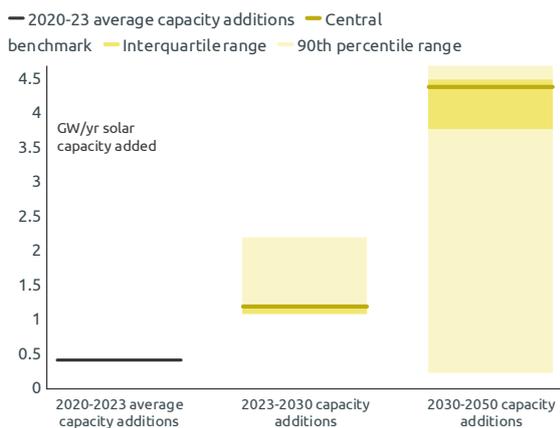


**Figure 10** – Installed wind capacity in 2030 compared to targets and current policy projections in GW

*Note: The target data was last pulled from [Ember](#) in January 2025. The current policies data was last pulled from the [IEA](#) in February 2026.*

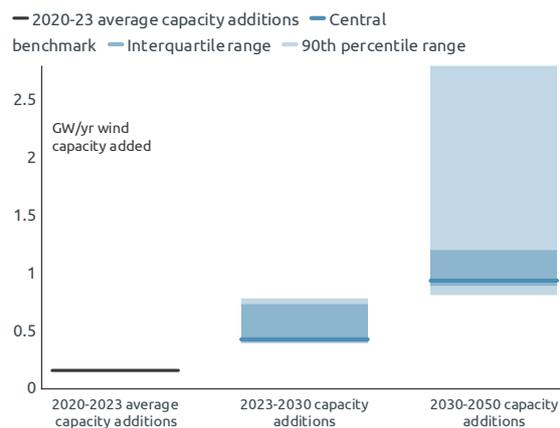
## Wind and solar capacity additions in Pakistan need to accelerate to align with 1.5°C, requiring international financial support

Pakistan would need to add, on average, 1.2 GW/yr of solar capacity until 2030, and 4.4 GW/yr by over 2030–2050, compared to 0.33 GW/yr from 2020–2023



**Figure 11** – Solar capacity additions per year in GW/y

Pakistan would need to add, on average, 0.43 GW/yr of wind capacity until 2030, and 0.94 GW/yr by over 2030–2050, compared to 0.12 GW/yr from 2020–2023



**Figure 12** – Wind capacity additions per year in GW/y

## Comparison with other studies

We compare the wind and solar generation results from our analysis with those reported in the literature on country-level studies. In particular, we highlight the results of modelling from the [Indicative Generation Capacity Expansion Plan](#), Pakistan’s national electricity plan.

Our results fall broadly within the range reported in the national literature after harmonising the studies to match the electricity generation assumed in this work (explained in the section ‘Future electricity demand’), although towards the higher end of this range. Compared with the IGCEP scenario, our analysis shows similar solar generation and higher wind generation in 2030.

### Our benchmarks are broadly aligned with the literature, though at the higher end of the range

#### Electricity generation from solar: comparison with literature in Pakistan

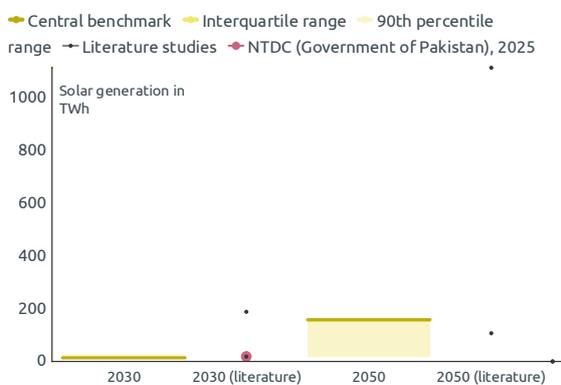


Figure 13 – Solar electricity generation in TWh

#### Electricity generation from wind: comparison with literature in Pakistan

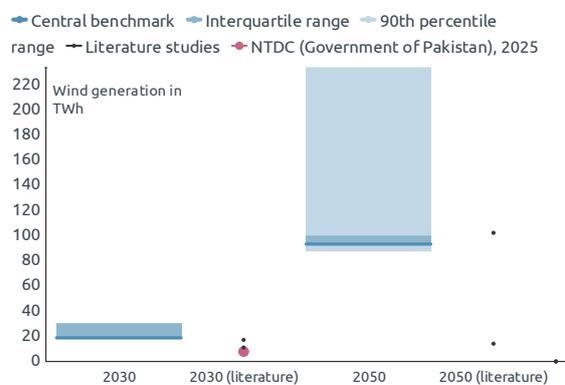


Figure 14 – Wind electricity generation in TWh

### Our benchmarks suggest solar will provide more electricity than wind in Pakistan

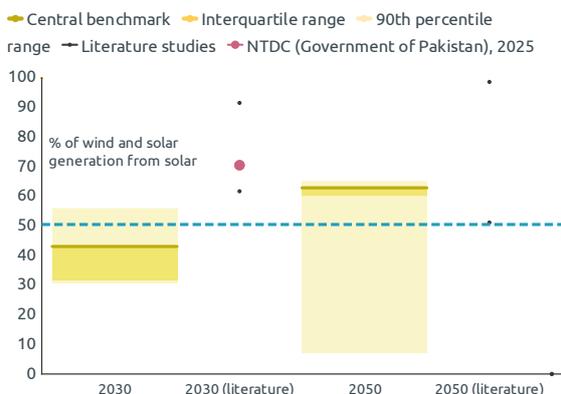


Figure 15 – Generation split between wind and solar (%)

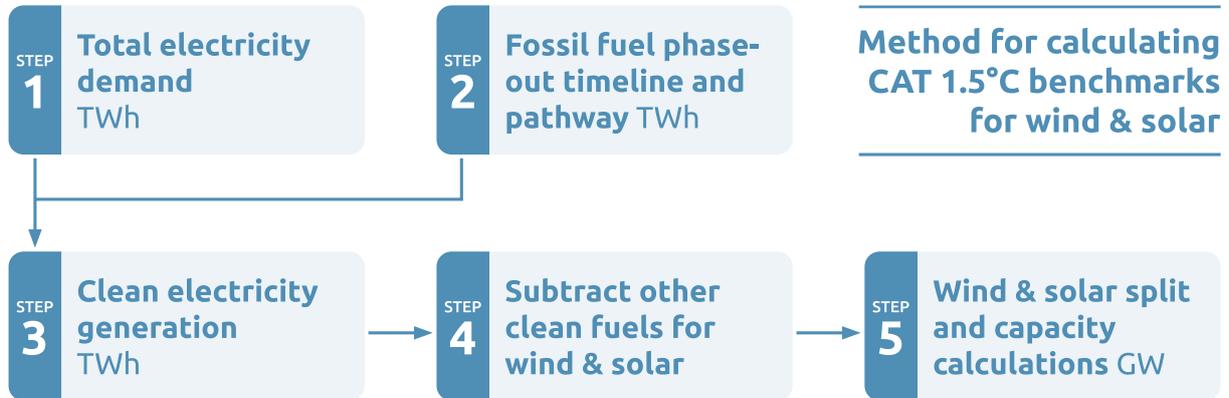
#### Share of wind and solar generation that comes from solar: comparison with literature in Pakistan

The area above the blue dashed line represents a power system in which solar provides more electricity generation than wind



# Methodology

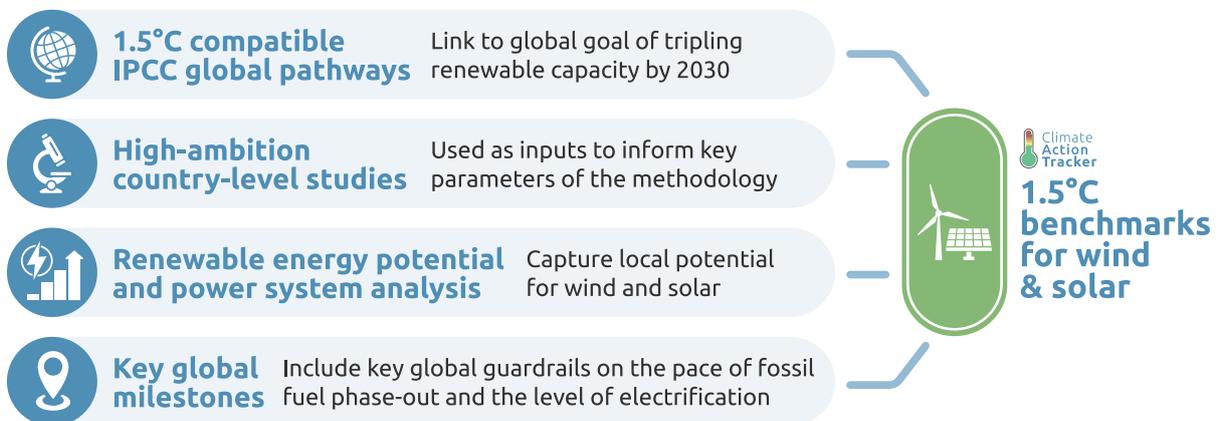
## Summary of our method



Our method takes a series of steps to calculate the wind and solar generation needed for 1.5°C, and the resulting capacity deployment. The key methodological steps are highlighted below.

1. We project future electricity demand in the country.
2. We calculate the pace of fossil fuel phase-out needed to align with 1.5°C.
3. Bringing these trajectories together defines the level of clean electricity generation required to meet electricity demand growth while phasing out fossil fuels in the power sector.
4. We project non-wind and solar clean electricity generation based on country-level literature. This allows us to identify the wind and solar generation necessary to align with 1.5°C.
5. Having produced this wind and solar generation trajectory, we feed it into a simplified electricity system model (PyPSA), which calculates for a given set of cost assumptions around wind and solar, a split into wind versus solar and the associated capacity requirements.

## Overlap of different elements



Our method focuses on the overlap between different elements. By looking at the range of fossil fuel phase-out which is outlined in both high ambition country-level studies and downscaled 1.5°C compatible global pathways, and is informed by key global milestones, we identify benchmarks which are both consistent with a global least cost pathway to limiting warming to 1.5°C but are also aligned with national-level modelling.

Combining multiple different analytical elements can help identify the most robust path to achieving a zero-carbon energy system.

For more details see the [Methods Annex](#).

## List of scenarios selected

Table 4: Country level studies for Pakistan

Study	Publication	Scenario selected
<a href="#">National Electric Power Regulatory Authority (NEPRA) (2025)</a>	Indicative Generation Capacity Expansion Plan (ICGEP) 2025-2035	RCA with ACWA 1800 MW Solar
<a href="#">Sadiqa et al. (2021)</a>	Renewable energy in Pakistan: Paving the way towards a fully renewables-based energy system across the power, heat, transport and desalination sectors by 2050	
<a href="#">ADB (2024)</a>	Pakistan's Low-Carbon Energy Outlook and Technology Road Map	



### Phases of grid integration

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The grid integration phase is adapted from a [de Vivero et al. report](#) detailing a qualitative assessment framework for power system transformation and an [IEA report](#) on integrating solar and wind. We use the share of VRE sources in electricity generation to classify countries into a phase. More information about the characteristics and key challenges of each phase can be found in the report.

**Phase 0** (less than 5% annual VRE share): we assign this phase when wind and solar make up 0-5% of a country's electricity generation mix. Installed VRE capacity is limited, and the impact on power system operation is negligible. Integration does not require significant operational or structural changes.

**Phase A** (between 5% and 15% annual VRE share): we assign this phase when wind and solar make up 5-15% of a country's electricity generation mix. Conventional power system operation remains largely sufficient for day-to-day system management. However, system planning must anticipate higher future VRE shares. This includes improving forecasting tools, integrating forecasting into dispatch decisions and moving toward shorter scheduling intervals and more real-time system operation.

**Phase B** (between 15% and 25% of annual VRE share): we assign this phase when wind and solar make up 15-25% of a country's electricity generation mix. The contribution of VRE varies significantly over time, with periods of very low output and periods of high penetration. This variability increases the need for operational flexibility. Enhanced coordination between system operators, network operators, and distribution system operators becomes critical to maintain system efficiency and security.

**Phase C** (between 25% and 40% of annual VRE share): we assign this phase when wind and solar make up 25-45% of a country's electricity generation mix. Periods in which VRE dominates system behaviour become increasingly frequent. A key operational challenge is maintaining system stability during sudden disruptions in supply or demand. Curtailment of VRE may become necessary to preserve system security. Without structural adjustments, integration constraints of VRE into the system may slow further increases in renewable energy shares despite additional installed capacity.

**Phase D** (between 40% and 70% of annual VRE share): we assign this phase when wind and solar make up 45-80% of a country's electricity generation mix. Periods in which VRE availability exceeds demand occur more frequently than in earlier phases. Ensuring system stability while continuing to increase renewable penetration requires additional measures, such as expanded demand response, stronger interconnections and large-scale energy storage. Market design and regulatory frameworks become increasingly important to enable these solutions. Although particularly critical in this phase, many of these measures should begin in earlier phases (B and C) to provide long-term investment signals and facilitate a smoother system transformation.

**Phase E** (more than 70% share of annual VRE share): we assign this phase when wind and solar make up 80-100% of a country's electricity generation mix. The power system reaches very high VRE penetration. The primary challenge becomes ensuring adequacy during extended periods of low wind and solar availability. Addressing this requires long-duration energy storage, sector coupling allowing for export and import of power between economic sectors in the same country and extensive electricity trade both within regions and between countries.

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## The Consortium



The Climate Action Tracker (CAT) is an independent scientific analysis produced by three research organisations tracking climate action since 2009. We track progress towards the globally agreed aim of holding warming well below 2°C, and pursuing efforts to limit warming to 1.5°C.

[climateactiontracker.org](https://climateactiontracker.org)



Climate Analytics is a non-profit institute leading research on climate science and policy in relation to the 1.5°C limit in the Paris Agreement. It has offices in Germany, the United States, Togo, Australia, Nepal and Trinidad and Tobago.

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