Climate Action Tracker

Wind and Solar benchmarks for a 1.5°C world

CHINA

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CLIMATE ANALYTICS

NEWCLIMATE INSTITUTE

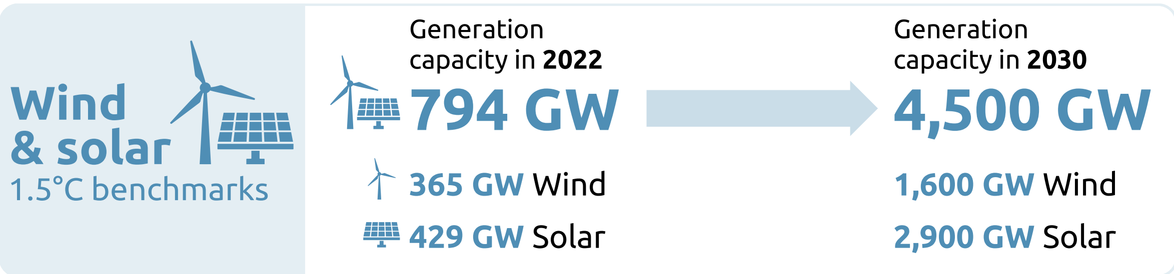
Executive Summary

Context

- China is rolling out renewables faster than any other country in the world. 2024 could mark a turning point, with Chinese power sector emissions on the brink of peaking and beginning a structural decline.
- However, to align with 1.5°C, China needs to not only peak emissions but achieve sustained and rapid reductions in emissions thereafter. The need to substantially displace fossil generation while meeting growing electricity demand means that wind and solar deployment will need to further accelerate.
- In this report, we look at national studies and global energy system models to assess how much China's wind and solar capacity needs to grow to align with the global goal to triple renewables by 2030 and the Paris Agreement's warming limit.

Key findings

- China's wind and solar generation needs to grow between five and six times by 2030 to align with 1.5°C.
- This equates to 6600–7700 TWh of wind and solar generation in 2030, up from almost 1200 TWh in 2022.
- 4.5 TW of wind and solar would be needed by 2030 (2.9 TW solar, 1.6 TW wind).
- Despite impressive growth, the rollout of solar and wind needs to accelerate further to align with 1.5°C and drive reductions in emissions post-peaking.
- China's wind capacity is on course to more than double by 2030 but needs to more than quadruple to meet the Paris goal.



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 **China**.

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

China's 2030 NDC has four main energy-related targets:

- Peaking CO_2 emissions before 2030 and achieving carbon neutrality before 2060
- Reduce carbon intensity in 2030 by over 65% relative to 2005
- Increase the share of non-fossil fuels in primary energy to over 25% in 2030
- Install 1200 GW of wind and solar by 2030

China is on track to exceed this wind and solar target during 2024. A national forecast from GEIDO, a Government-affiliated think-tank, suggests that by 2030 China would have **1025 GW of solar and 800 GW of wind by 2030**. We use this as a proxy for the targets of the Chinese government.

Under current policies and market conditions, the IEA estimates that **solar capacity will reach 3247 GW in 2030**, up from 429 GW of solar in 2022. Meanwhile, **wind capacity is projected to reach 979 GW in 2030**, up from 365 GW in 2022.

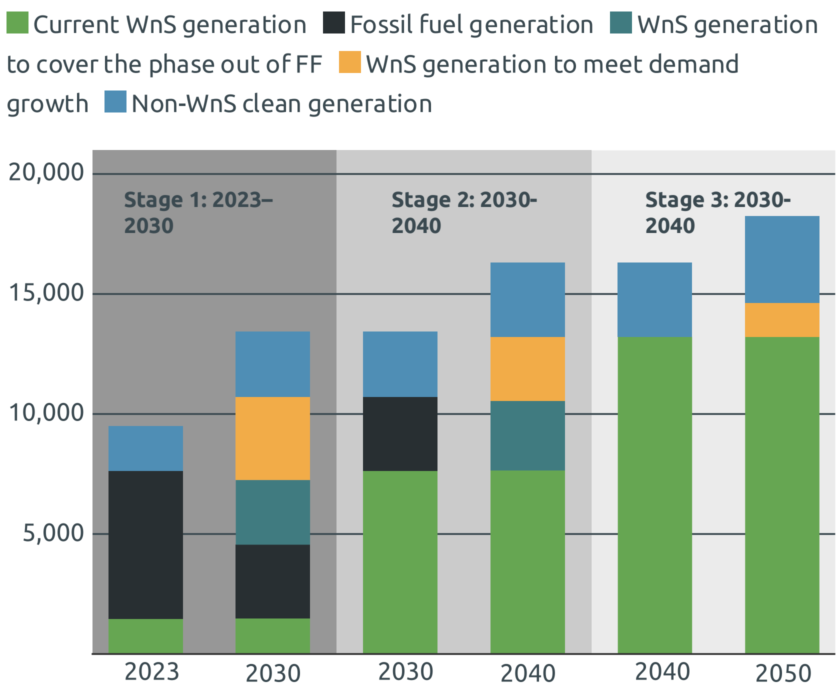
National enabling factors

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 RE-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).

Results

Stages of power sector decarbonisation



The stages of the electricity system transition in China

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, China would need to add 660 GW of wind and 1300 GW of solar capacity to meet growing demand alone. Another 510 GW of wind and 1000 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 China in Phase D, with wind and solar making up 57% of the 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.

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

	2023		2030		2040		2050
Grid integration phase (share of variable renewable energy in total electricity generation)							
Phase	Phase A		Phase D		Phase E		Phase E
Share of VRE	**< 15 %**		**< 70 %**		**> 85 %**		**> 85 %**
Share of electricity generation							
Wind & Solar	**16 %**		**57 %**		**81 %**		**80 %**
Other renewables	20 %		20 %		19 %		20 %
Fossil Fuels	**65 %**		**23 %**		**0 %**		**0 %**
Generation capacity							
To displace fossil fuels		**+1500 GW**		**+2100 GW**		**+0 GW**	
Wind & Solar	**1000 GW**	**+500 GW/yr**	**4500 GW**	**+410 GW/yr**	**8600 GW**	**+140 GW/yr**	**10000 GW**
To meet demand increase		**+2000 GW**		**+2000 GW**		**+1600 GW**	
Generation							
Total	**9500 TWh**	37%	**13000 TWh**	23%	**16000 TWh**	13%	**18000 TWh**
Wind & Solar	1500 TWh		7600 TWh		13000 TWh		15000 TWh
Generation Capacity of VRE (variable renewable energy)							
To displace fossil fuels			510 GW		300 GW		0 GW
Wind capacity	**440 GW**		**1600 GW**		**2200 GW**		**2000 GW**
To meet demand increase			660 GW		280 GW		0 GW
To displace fossil fuels			1000 GW		1800 GW		0 GW
Solar capacity	**590 GW**		**2900 GW**		**6400 GW**		**8000 GW**
To meet demand increase			1300 GW		1700 GW		1600 GW

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

Electricity demand is taken from the China Energy Transformation Program study exploring carbon neutrality pathways for China. We take electricity demand from the CNS-1, which achieves net zero CO_2 emissions in the energy system by 2055. We use this scenario because it is one of the most recent studies, which captures the reality of rapid electricity demand growth in China which some of the country-level studies have underestimated. It is also consistent with ambitious electrification, with electricity providing 54% of final energy by 2050.

In this study, **total electricity generation in China doubles by 2050 relative to 2022 levels, reaching 18,000 TWh**. This is driven by economic development and increased electrification.

However, there is a significant range in the studies in terms of the expected electricity generation in 2050 ranging from 11,000 TWh to 29,000 TWh. This would affect the necessary growth of wind and solar significantly. Our demand estimate is at the higher end of that estimated by country-level studies for 2030, and near the middle of the range in 2050.

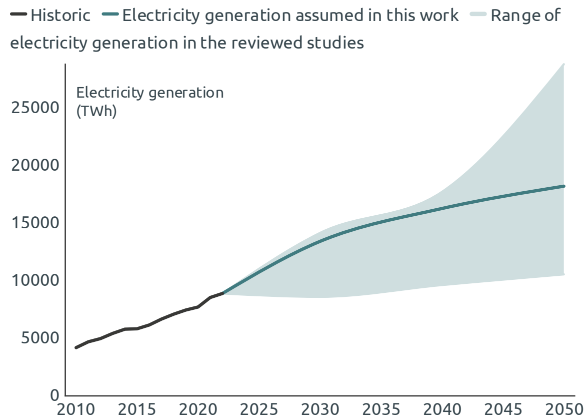


Figure 2 – Total electricity generation in TWh

Electricity generation grows around 50% from 2022–2030 in China

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

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, in which China achieves a clean power system by 2040.

To align with 1.5°C, fossil fuels would need to exit the Chinese power sector before 2040

Fossil fuel generation falls by 28–47% between 2022 and 2030.

The fastest rate of fossil phase-out is set by a study from Lugovoy et al., 2021, exploring the feasibility of China achieving a zero emissions power system by 2050.

To align with 1.5°C, fossil fuels must exit the power sector in China by 2040, even as electricity demand grows rapidly

China would need to achieve clean electricity by 2040

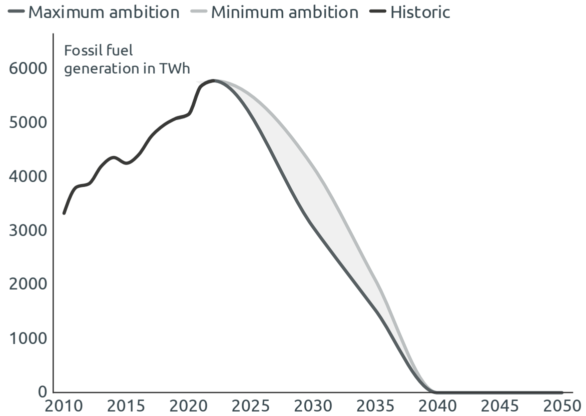


Figure 3 – Fossil fuel generation in TWh

Coal and gas phase-out in China

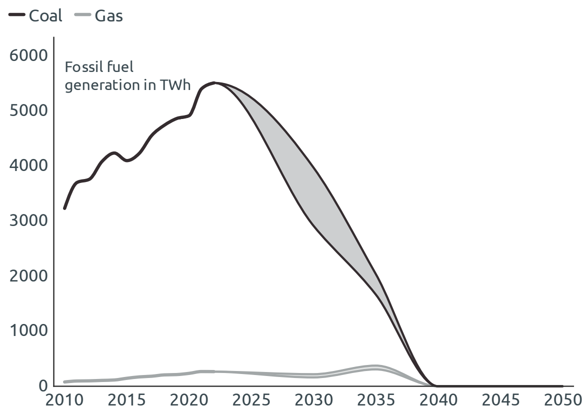


Figure 4 – Fossil fuel generation by fuel type in TWh

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 China would reach 2700 TWh by 2030 and 3600 TWh by 2050. This is provided primarily by hydropower, followed by nuclear and some limited biomass generation.

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 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 China would need to reach between 6,500 and 7,700 TWh by 2030**. Generation in 2022 was 1,190 TWh. This is therefore a 5.5 to 6.4-fold growth in wind and solar.

Wind and solar provides 48–57% of overall electricity generation in 2030, and 80% of overall generation in 2050.

To align with 1.5°C, wind and solar generation would need to grow rapidly in China

Wind and solar generation needs to grow 5-6x by 2030 relative to 2022 in China

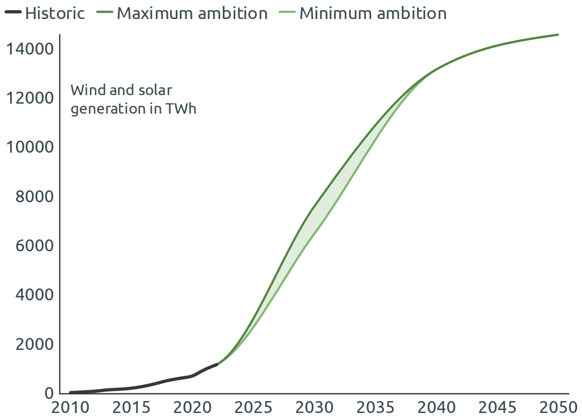


Figure 5 – Wind and solar electricity generation in TWh

Wind and solar would need to provide around 80% of electricity generation in China by 2050

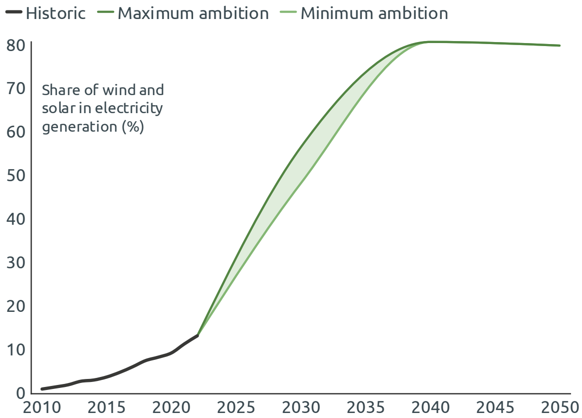


Figure 6 – Wind and solar electricity generation share (%)

* 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. In the central benchmarking scenario, solar becomes the main source of generation, providing on average twice as much generation as wind in the electricity mix by 2050. This will require a rapid uptake of non-fossil flexibility options.

In this scenario, **China would need to deploy around 4.5 TW of wind and solar by 2030 to align with the 1.5°C temperature limit**. By 2050, total wind and solar capacity would need to reach to over 10 TW.

China needs to reach almost 4.5 TW of wind and solar installed capacity by 2030 to align with 1.5°C

Solar capacity would reach 2900 GW in China by 2030 in a 1.5°C-aligned scenario

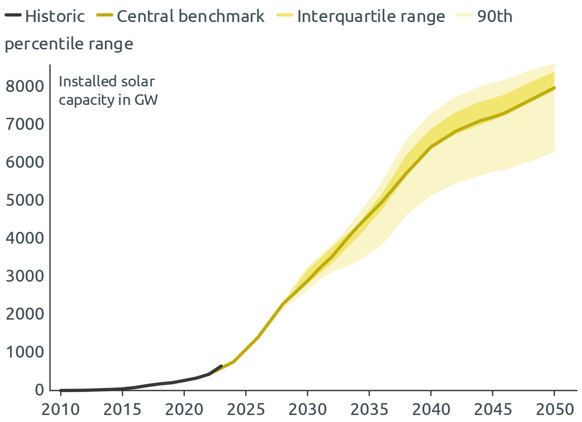


Figure 7 – 1.5°C compatible capacity benchmarks for solar in GW

Wind capacity would reach 1600 GW in China by 2030 in a 1.5°C-aligned scenario

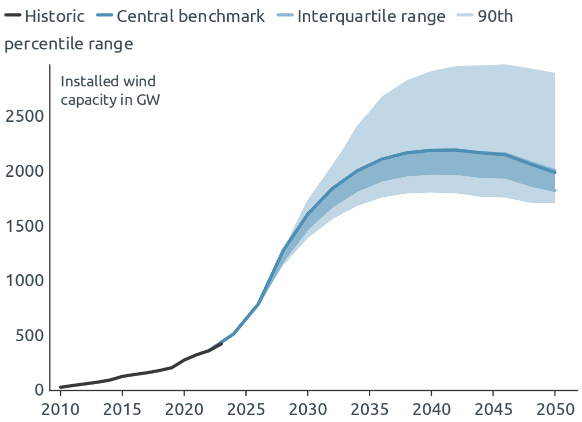


Figure 8 – 1.5°C compatible capacity benchmarks for wind in GW

Note: The benchmarks assume action from 2022.

The following table shows the wind and solar deployment needed to align with the central 1.5°C compatible benchmark produced. 2022 is historical data. All benchmark data from 2030 onwards is reported to two significant figures.

Table 2: Wind and solar electricity generation and capacity (2022–2050)

Scenario	Variable	Unit	2022	2030	2035	2040	2050
Central 1.5°Cbenchmark	Solar generation	TWh	471	3,100	5,200	7,800	9,900
Central 1.5°Cbenchmark	Wind generation	TWh	750	4,100	5,100	5,400	4,800
Central 1.5°Cbenchmark	Solar capacity	GW	429	2,900	4,600	6,400	8,000
Central 1.5°Cbenchmark	Wind capacity	GW	365	1,600	2,100	2,200	2,000

Table 3: Benchmarks translated into CAT format

Variable	Ambition	Unit	2030	2035	2040	2045	2050
Share of coal	Minimum	%	30	15	0	0	0
	Maximum	%	22	12	0	0	0
Share of gas	Minimum	%	2	2	0	0	0
	Maximum	%	1	1	0	0	0
Share of renewables	Minimum	%	64	79	95	95	94
	Maximum	%	72	82	95	95	94
Share of wind and solar	Minimum	%	48	64	81	81	80
	Maximum	%	57	67	81	81	80

Comparison to current rollout and country target

Under current policies and market conditions, deployment of solar PV in China exceeds the minimum level required to align with 1.5°C, reaching 3,200 GW. Our central benchmark would require 2,900 GW of solar installed by 2030.

Meanwhile, we estimate that under current policies and market conditions, wind capacity would reach around 1,000 GW in 2030, which is 600 GW below the central benchmark set here of 1,600 GW.

However, achieving 4.5 TW of wind and solar capacity installed in China by 2030 would require that wind and solar capacity grow at ~24% per year from 2022–2030. This average annual growth rate is the same as that achieved by China's wind and solar sector in 2018–2023. This highlights the feasibility of achieving these benchmarks.

China's solar rollout aligns with 1.5°C, while wind rollout needs accelerating

Current rollout of solar in China aligns with 1.5°C, and significantly overperforms the target

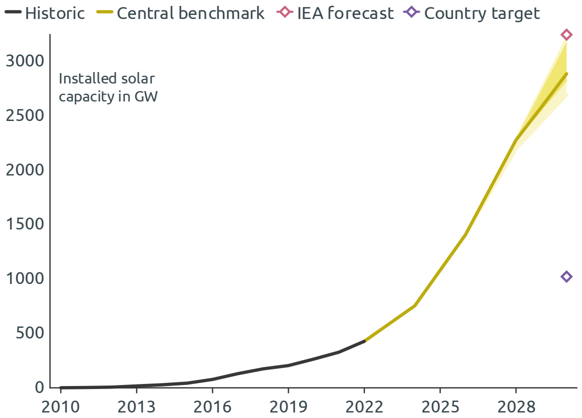


Figure 9 – Installed solar capacity in 2030 compared to targets and current policy projections in GW

Another 600 GW of wind would need to be installed in China by 2030 compared to the rollout under current policies

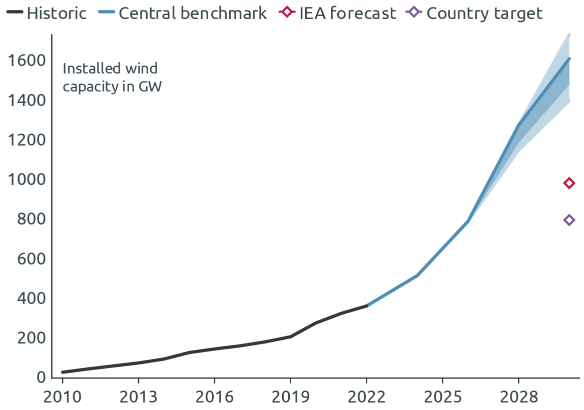


Figure 10 – Installed wind capacity in 2030 compared to targets and current policy projections in GW

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

Wind and solar capacity additions in China need to accelerate to align with 1.5°C

China would need to add on average 310 GW/yr of solar capacity until 2030, and 260 GW/yr by over 2030–2050

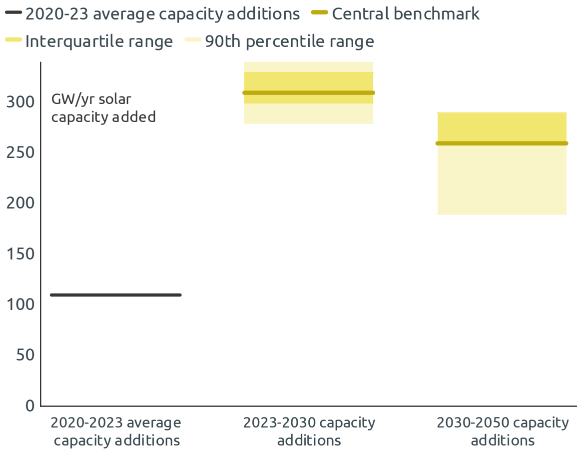


Figure 11 – Solar capacity additions per year in GW/y

China would need to add on average 150 GW/yr of wind capacity until 2030, and 47 GW/yr by over 2030–2050

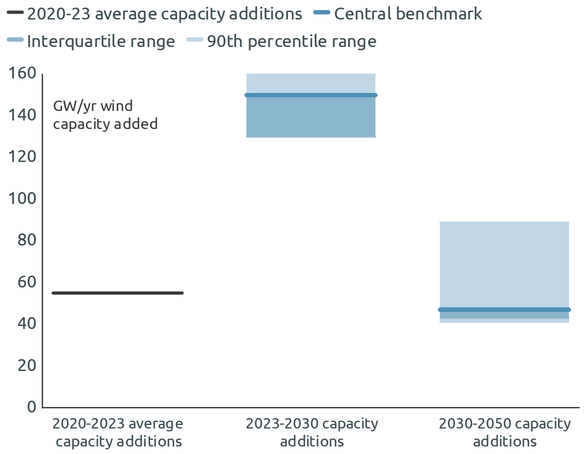


Figure 12 – Wind capacity additions per year in GW/y

Comparison with other studies

We compare the wind and solar generation seen in our analysis to that in the literature review of country-level studies. In particular, we highlight the results of modelling from the China Energy Transition Program (CET), exploring net zero pathways for China.

- Our analysis generally shows higher solar generation than the national studies. However, a question is how much these studies have taken account of recent PV growth and cost reductions in PV in China.
- For wind our figures are closer to the average of the range of existing studies, and less than the wind generation demonstrated by the CET scenarios.
- Both country-level studies and our modelling sees wind still as providing the largest share of generation in 2030. Our scenarios then move to a solar dominated system by 2050, while the country-level studies show a range of possible generation splits in 2050 between wind and solar.

Our benchmarks are broadly aligned with the literature

Electricity generation from solar: comparison with literature in China

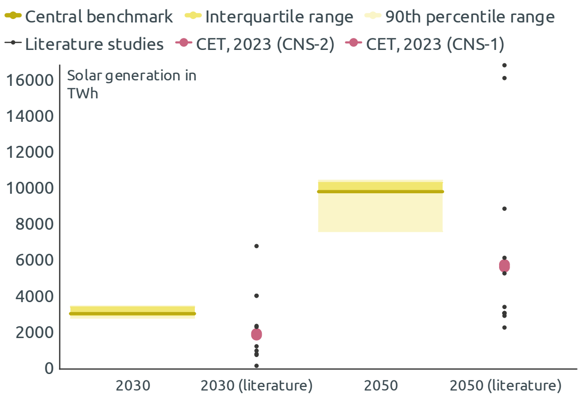


Figure 13 – Solar electricity generation in TWh

Electricity generation from wind: comparison with literature in China

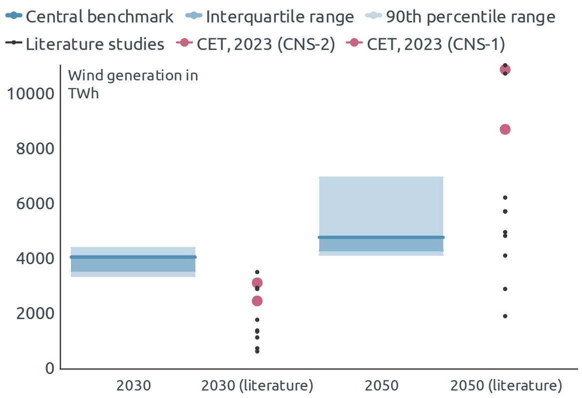


Figure 14 – Wind electricity generation in TWh

In China, our benchmarks generally suggest that solar will provide more generation than wind after 2030

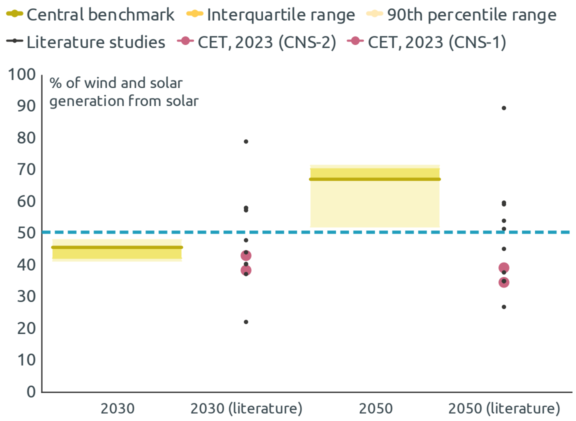


Figure 15 – Generation split between wind and solar (%)

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

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

STEP 1 Total electricity demand TWh

STEP 2 Fossil fuel phase-out timeline and pathway TWh

Method for calculating CAT 1.5°C benchmarks for wind & solar

STEP 3 Clean electricity generation TWh

STEP 4 Subtract other clean fuels for wind & solar

STEP 5 Wind & solar split and capacity calculations GW

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

1.5°C compatible IPCC global pathways Link to global goal of tripling renewable capacity by 2030

High-ambition country-level studies Used as inputs to inform key parameters of the methodology

Renewable energy potential and power system analysis Capture local potential for wind and solar

Key global milestones Include key global guardrails on the pace of fossil fuel phase-out and the level of electrification

Climate Action Tracker

1.5°C benchmarks for wind & solar

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°Ccompatible 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 China

Study	Publication	Scenario selected
Burandt et al., 2019	Decarbonizing China's energy system	Ambitious
Qiu et al., 2021	Energy demand and supply planning of China through 2060	
Lugovoy et.al, 2021	Feasibility study of China's electric power sector transition to zero emissions by 2050	F-NPL-25
He et al., 2020	Rapid cost decrease of renewables and storage accelerates the decarbonization of China's power system	C80
Teske, 2015	energy [r]evolution : A Sustainable World Energy Outlook 2015	▸ Advanced Energy [r]evolution ▸ Energy [r]evolution
ICCSD of Tsinghua University et al., 2023	China's long-term low-carbon development strategies and pathways	2 degrees

Annex A

Phases of grid integration

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

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

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NewClimate Institute is an independent non-profit organisation that develops solutions to tackle climate change and drives their implementation worldwide. Through research, policy advice and knowledge sharing, we aim to raise the ambition for climate action and support sustainable development.

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