Climate Action Tracker

Wind and Solar benchmarks for a 1.5°C world

UNITED STATES

February 2026

Executive Summary

Context

- The United States is the second-highest global emitter, with per capita emissions double the global average in 2023.
- Electricity accounts for about a quarter of total GHG emissions (excl. LULUCF), with 57% of electricity coming from fossil fuels (43% from fossil gas). US power sector emissions peaked in 2007 and have steadily declined since 2010 due to coal-to-gas shifting and renewables deployment.
- In 2022, electricity supply from renewables overtook coal and nuclear power for the first time, making them the second largest source of electricity generation after fossil gas.
- The Trump Administration's systematic repeal of funding for climate change mitigation and science, policies and targets risks halting the country's progress over the past decades. The Administration abandoned the target for a carbon-free electricity system by 2035, which had been set by the Biden Administration and was aligned with our benchmarks.
- This report examines the wind and solar capacity installation the US needs for a 1.5°C compatible pathway, aligning with the goal of tripling global renewables capacity by 2030.

Key findings

- To meet the 1.5°C benchmark, the US needs to increase wind and solar capacity by 3x and 6x respectively by 2030, on the road to phasing out fossil fuels in the power sector by 2035.
- Beyond ambitious targets, the main gap is in the actual build-up of wind and solar capacity. Wind and solar generation needs to increase 4-5x from 2022 levels by 2030 to be 1.5°C compatible. This means almost 1400 TWh of solar and 1600 TWh of wind. Policies at federal and state levels are needed to drive build up at the scale and speed required.
- The period until 2030 is crucial to stay on track for a 1.5°C compatible pathway. Despite recent progress, the pace of annual capacity installations must accelerate significantly in the remainder of this decade – to reach our benchmarks, wind and solar capacity additions need to more than triple compared to the last three years.
- While historical wind and solar capacity additions are below what is required, the Inflation Reduction Act (IRA) may boost wind and solar deployment in the remainder of this decade.

Wind & solar
1.5°C benchmarks

Generation capacity in **2022**	Generation capacity in **2030**
281 GW	**1,370 GW**
141 GW Wind	**480 GW** Wind
140 GW Solar	**890 GW** Solar

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 **the United States of America**.

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

The Trump Administration withdrew the United States from the Paris agreement, nulling all previous climate targets, including the 2030 nationally determined contribution (NDC), 2035 NDC and the long-term strategy for 2050. The Administration also signed into law the One Big Beautiful Bill Act (OBBB), which undermines future progress in deploying renewable energy and clean energy technology by rolling back most tax credits for clean technology deployment introduced under the Inflation Reduction Act (IRA).

The Trump Administration also abandoned the target of achieving carbon-free electricity by 2035, which had been set by the Biden Administration. Furthermore, the current administration declared national energy emergency in 2025. This declaration directs all agencies to expedite the development of energy production and generation capacity, primarily focusing on domestic fossil fuel sources, while excluding wind and solar energy.

The United States' renewable targets used in this study are to reach **468 GW of solar and 369 GW of wind by 2030**, as per a National Renewable Energy Laboratory study published in 2023. Under current policies and market conditions, the IEA estimates that **solar capacity will reach 383 GW in 2028**, up from 141 GW of solar in 2022. Meanwhile, **wind capacity is projected to reach 232 GW in 2028**, up from 141 GW in 2022.

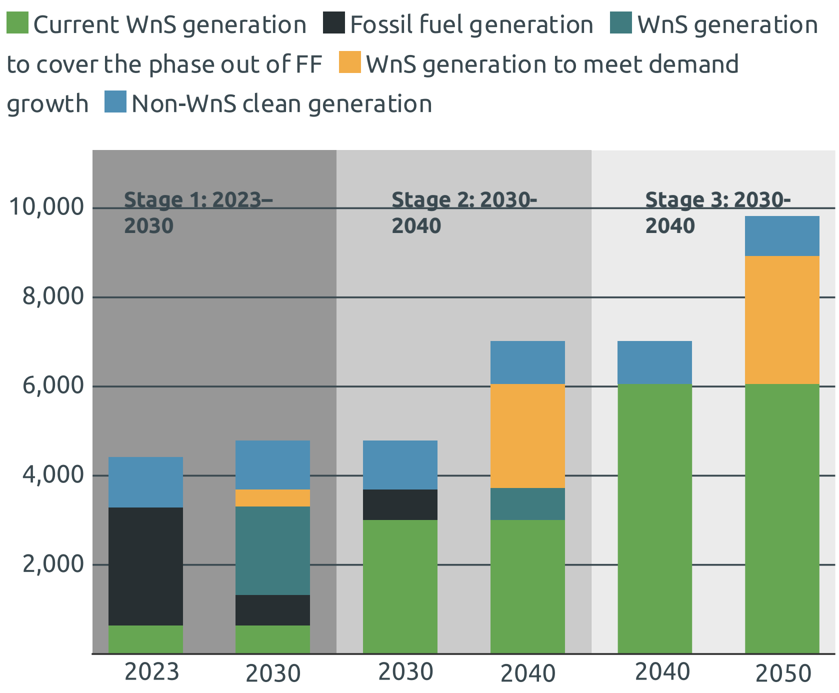
National enabling factors

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 phaseout.** 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 the United States

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, Australia would need to add 51 GW of wind and 110 GW of solar capacity to meet growing demand alone. Another 270 GW of wind and 590 GW of solar will be needed to displace the share of fossil fuels in the electricity generation mix.

(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 the US in Phase D, with wind and solar making up 63% 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 **Error! Not a valid bookmark self-reference.** 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	**15 %**		**63 %**		**86 %**		**91 %**
Other renewables	26 %		23 %		14 %		9.1 %
Fossil Fuels	**60 %**		**14 %**		**0 %**		**0 %**
Generation capacity							
To displace fossil fuels		**+860 GW**		**+320 GW**		**+0 GW**	
Wind & Solar	**350 GW**	**+150 GW/yr**	**1400 GW**	**+140 GW/yr**	**2800 GW**	**+110 GW/yr**	**3900 GW**
To meet demand increase		**+160 GW**		**+1100 GW**		**+1100 GW**	
Generation							
Total	**4400 TWh**	9%	**4800 TWh**	46%	**7000 TWh**	40%	**9800 TWh**
Wind & Solar	640 TWh		3000 TWh		6100 TWh		8900 TWh
Generation Capacity of VRE (variable renewable energy)							
To displace fossil fuels			270 GW		73 GW		0 GW
Wind capacity	**160 GW**		**480 GW**		**800 GW**		**1200 GW**
To meet demand increase			51 GW		240 GW		440 GW
To displace fossil fuels			590 GW		250 GW		0 GW
Solar capacity	**190 GW**		**890 GW**		**2000 GW**		**2700 GW**
To meet demand increase			110 GW		830 GW		690 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 Princeton University Net Zero America study exploring net zero pathways for the United States. We take demand from the E+ (high electrification) pathway, which achieves net zero GHG emissions by 2050, and nearly full electrification of buildings and transport.

Total electricity generation in the US more than doubles by 2050 relative to 2022 levels, reaching 9800 TWh. This is driven mainly by increased electrification.

However, there is a significant range in the studies in terms of the expected electricity generation in 2050 ranging from 5400 TWh to 16800 TWh. This would affect the expected growth of RE significantly. Our demand estimate is at the lower end of that range estimated by country-level studies.

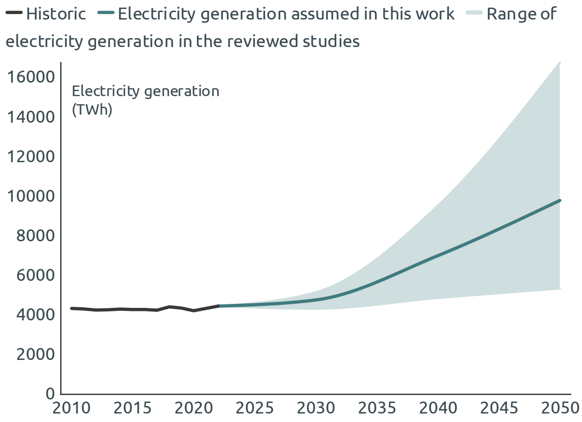


Figure 2 – Total electricity generation in TWh

Electricity generation doubles in the United States over 2022–2050

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 the US achieves a clean power system by 2035.

To align with 1.5°C, fossil fuels must exit the US power sector during the 2030s.

The time frame until 2030 is critical. Fossil fuel generation must fall by 65-75% by 2030, compared to 2022 levels.

The fastest rate of fossil phase-out is set by the REPEAT Project Rapid Energy Policy Evaluation and Analysis Toolkit.

To align with 1.5°C, fossil fuels must exit the power sector in the United States by 2035, even as electricity demand grows.

United States would need to achieve clean electricity by 2035

Coal and gas phase-out in the United States

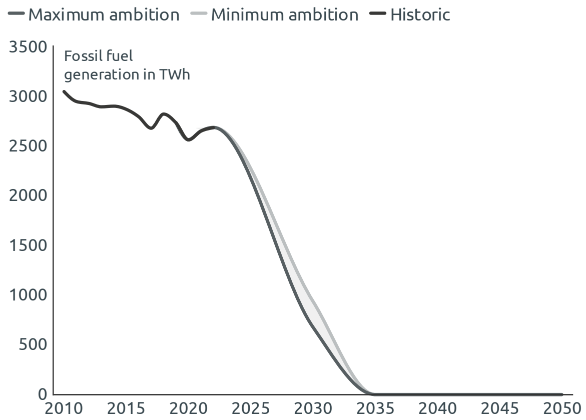


Figure 3 – Fossil fuel generation in TWh

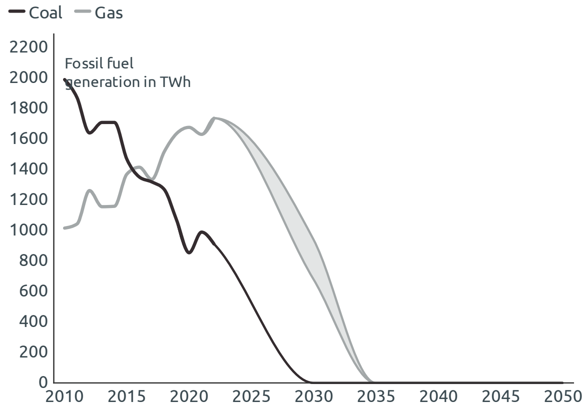


Figure 4 – Fossil fuel generation by fuel type in TWh

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 clean technologies other than wind and solar in the United States would reach 1100 TWh by 2030, before falling back to 900 TWh by 2050. This is provided by nuclear, hydropower, biomass, and other renewable technologies.

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

Wind and solar is then needed to meet electricity demand growth and to drive the phaseout of fossil fuels.

To align with 1.5°C, wind and solar generation in the United States would need to reach between 2750 and 3000 TWh by 2030. Generation from these sources in 2022 was 627 TWh. **This is a 4-5x growth in wind and solar power generation by 2030** relative to 2022.

Wind and solar provides 57–63% of overall electricity generation in 2030, and 91% of overall generation in 2050.

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

Wind and solar generation needs to grow 4-5x by 2030 relative to 2022 in the United States

Wind and solar would need to provide around 90% of electricity generation in the United States by 2050

* 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.

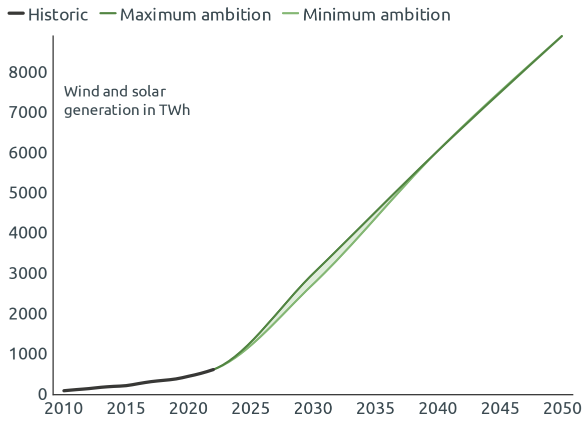


Figure 5 – Wind and solar electricity generation in TWh

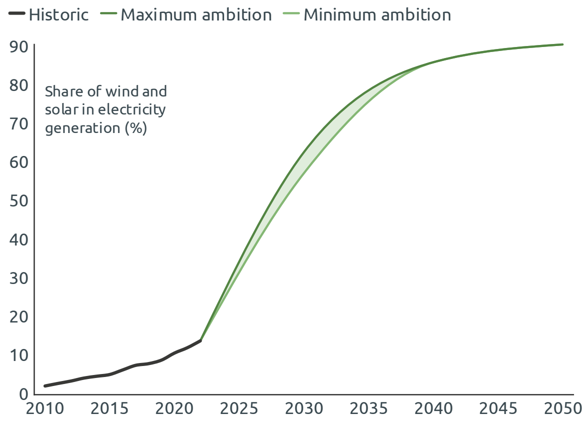


Figure 6 – Wind and solar electricity generation share (%)

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 versus solar. In the central benchmarking scenario, there is a relatively even contribution of wind and solar to total electricity generation in 2050. However, there are other scenarios in which wind provides a much greater contribution, with wind generating four times as much electricity as solar.

In the central benchmark scenario, **the United States would need to deploy over 1300 GW of wind and solar by 2030 to limit warming to 1.5°C**. By 2050, total wind and solar capacity would need to reach towards **3900 GW**. Due to its higher capacity factor, greater wind deployment would reduce total capacity requirement.

The United States needs to install over 1300 GW of wind and solar by 2030 to align with 1.5°C

Solar capacity would reach 890 GW in United States by 2030 in a 1.5°C-aligned scenario

Wind capacity would reach 480 GW in United States by 2030 in a 1.5°C-aligned scenario

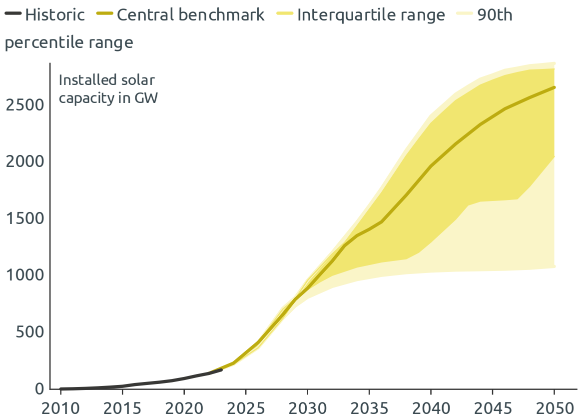


Figure 7 – 1.5°C compatible capacity benchmarks for solar in GW

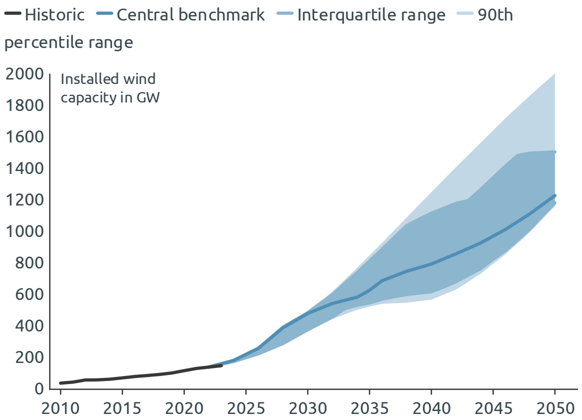


Figure 8 – 1.5°C compatible capacity benchmarks for wind in GW

The following table shows the wind and solar deployment needed to align with the central 1.5°C compatible benchmark produced. 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	202	1400	2200	3200	4300
Central 1.5°Cbenchmark	Wind generation	TWh	425	1600	2200	2800	4600
Central 1.5°Cbenchmark	Solar capacity	GW	140	890	1400	2000	2700
Central 1.5°Cbenchmark	Wind capacity	GW	141	480	630	800	1200

Table 3: Benchmarks translated into CAT format

Variable	Ambition	Unit	2030	2035	2040	2045	2050
Share of coal	Minimum	%	0	0	0	0	0
	Maximum	%	0	0	0	0	0
Share of gas	Minimum	%	20	0	0	0	0
	Maximum	%	14	0	0	0	0
Share of renewables	Minimum	%	65	89	92	94	95
	Maximum	%	70	89	92	94	95
Share of wind and solar	Minimum	%	57	82	86	89	91
	Maximum	%	63	82	86	89	91

Comparison to current rollout and country target

According to our benchmarks, annual capacity additions for wind and solar in the remainder of this decade need to more than triple compared to the last three years. Under current policies and market conditions, the IEA estimates that solar capacity will reach 557 GW in 2030, up from 137 GW of solar in 2022. Meanwhile, wind capacity is projected to reach 251 GW in 2030, up from 141 GW in 2022. The period until 2030 is crucial to stay on track for a 1.5°C compatible pathway. The country must significantly accelerate its pace of annual capacity installations over the remainder of this decade.

While the Biden Administration's 2035 target was aligned with our benchmarks, there was still a gap in the actual build-up of wind and solar capacity compared to the previous national targets. However, the Trump Administration's rollback of climate policies and support for renewable energy undermines the transition to a renewables-based power systen.

There is strong support from businesses for high ambition from the government to transition the electricity system to be powered by renewables, with 97% of executives in the US polled in the Global Business Poll in favour of increasing the share of renewables in the power mix.

The US' wind and solar rollout needs to accelerate to align with 1.5°C

In United States, current rollout of solar is lagging behind 1.5°C-aligned levels

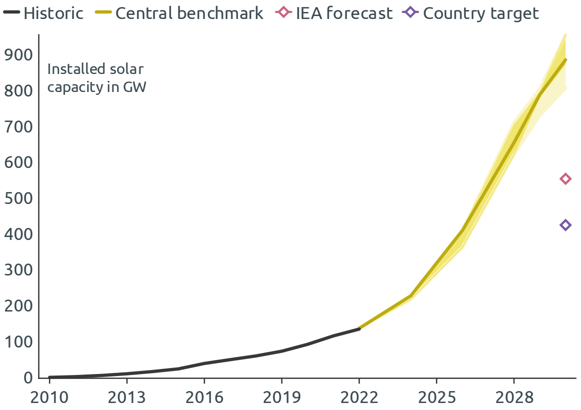


Figure 9 – Installed solar capacity in 2030 compared to targets and current policy projections in GW

The current wind capacity target in United States almost aligns with 1.5°C, but current rollout lags behind

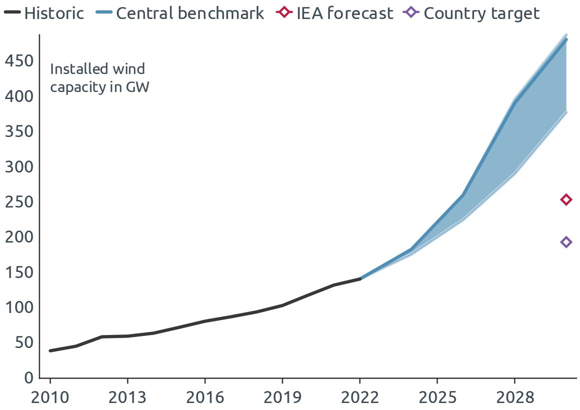


Figure 10 – Installed wind capacity in 2030 compared to targets and current policy projections in GW

Note: The target data was last pulled from Ember in January 2025. The current policies data was last pulled from the IEA in June 2025.

To align with 1.5°C, wind and solar capacity additions in the United States need to more than triple over 2023–30

United States would need to add on average 89 GW/yr of solar capacity until 2030, and 93 GW/yr by over 2030–2050

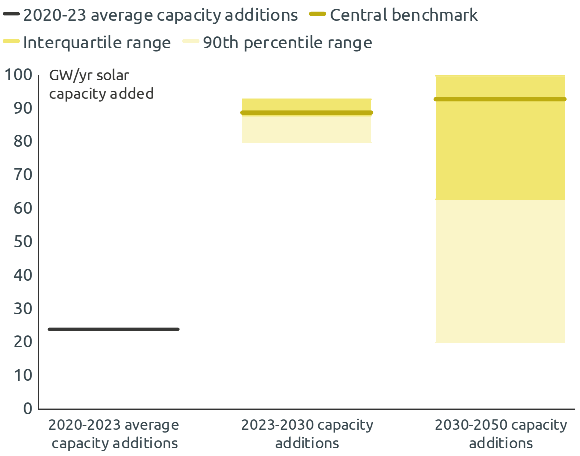


Figure 11 – Solar capacity additions per year in GW/y

United States would need to add on average 40 GW/yr of wind capacity until 2030, and 47 GW/yr by over 2030–2050

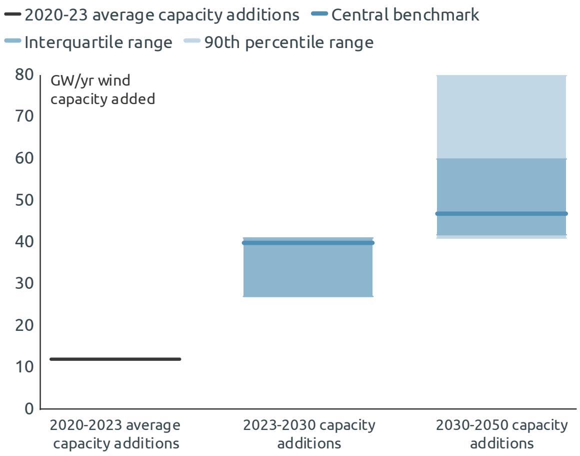


Figure 12 – Wind capacity additions per year in GW/y

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 Net Zero America study, exploring net zero pathways for the United States. We focus on the high electrification (E+) scenario.

We see that the wind and solar generation that our method produces is broadly comparable to the Net Zero American modelling in 2030, however, our benchmarks envisage a faster rollout of solar. In 2050, our benchmarks align with the E+ scenario, though are much less than the E+RE+ scenario.

Wind and solar generation in our benchmarks broadly aligns with the literature

Electricity generation from solar: comparison with literature in United States

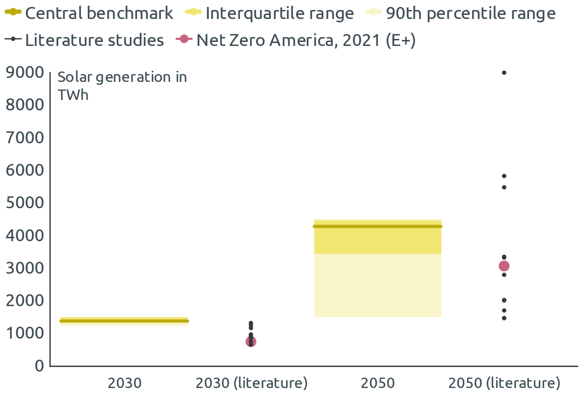


Figure 13 – Solar electricity generation in TWh

Electricity generation from wind: comparison with literature in United States

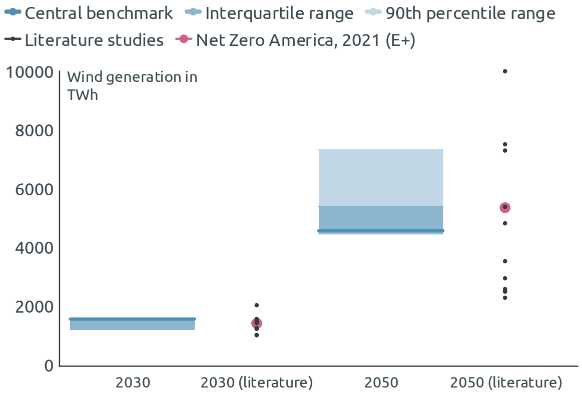


Figure 14 – Wind electricity generation in TWh

Our benchmarks generally suggest that wind will provide more generation than solar in the US

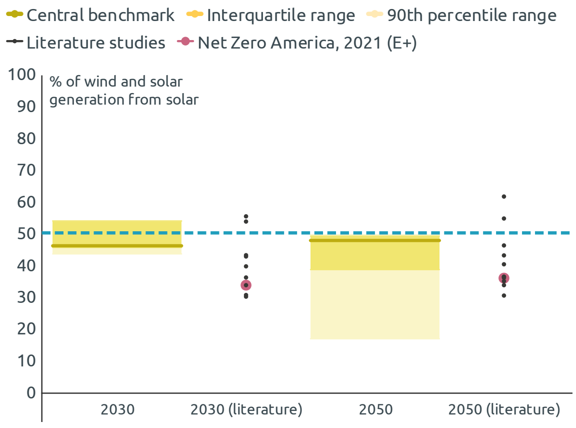


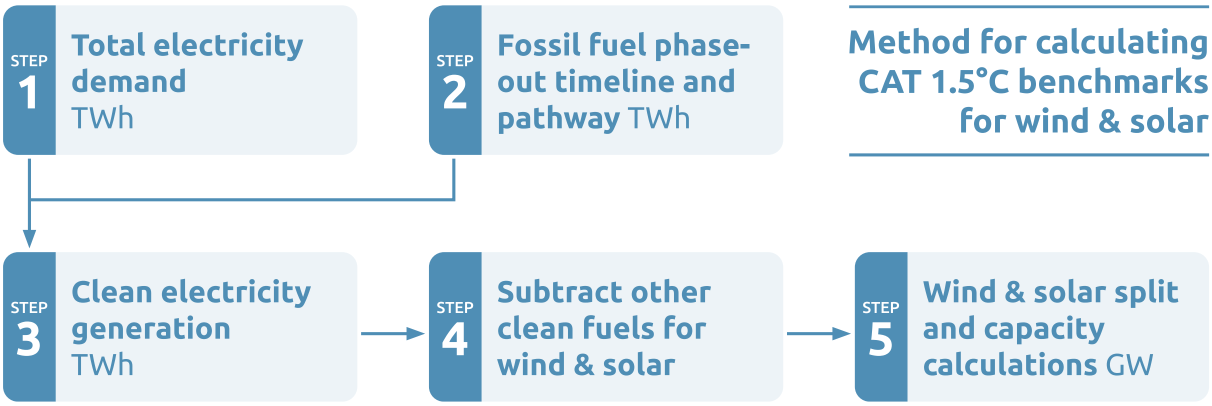
Figure 15 – Generation split between wind and solar (%)

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

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

Methodology

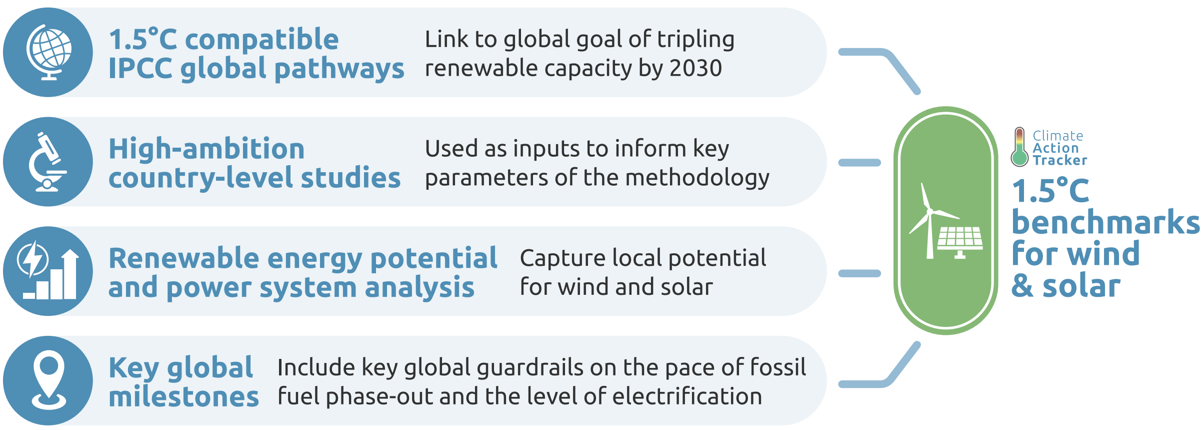
Summary of our method



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°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 the United States

Study	Publication	Scenario selected
Bistline *et al.*, 2022	Implications of variations in renewable cost projections for electric sector decarbonization in the United States	Low
Cole *et al.*, 2021	Quantifying the challenge of reaching a 100% renewable energy power system for the United States	100%
Evolved Energy Research, 2023	Annual Decarbonization Perspective 2023: Carbon-neutral pathways for the United States	• 100% RE • High Hydrogen
Ewing *et al.*, 2022	Pathways to Net-Zero for the US Energy Transition	Princeton High Electrification
Larson *et al.*, 2021	Net-Zero America: Potential Pathways, Infrastructure, and Impacts	• E+ • E+RE+
NREL, 2022	2022 Standard Scenarios Report: A U.S. Electricity Sector Outlook	• Mid-case with 100% decarbonization by 2035 • Low renewables energy costs with 100% decarbonization by 2035
REPEAT, 2023	Rapid Energy Policy Evaluation and Analysis Toolkit	Net-Zero Pathway Benchmark
Williams *et al.*, 2021	Carbon-neutral pathways for the United States	• Central Case • 100% Renewables

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.

climateanalytics.org

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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