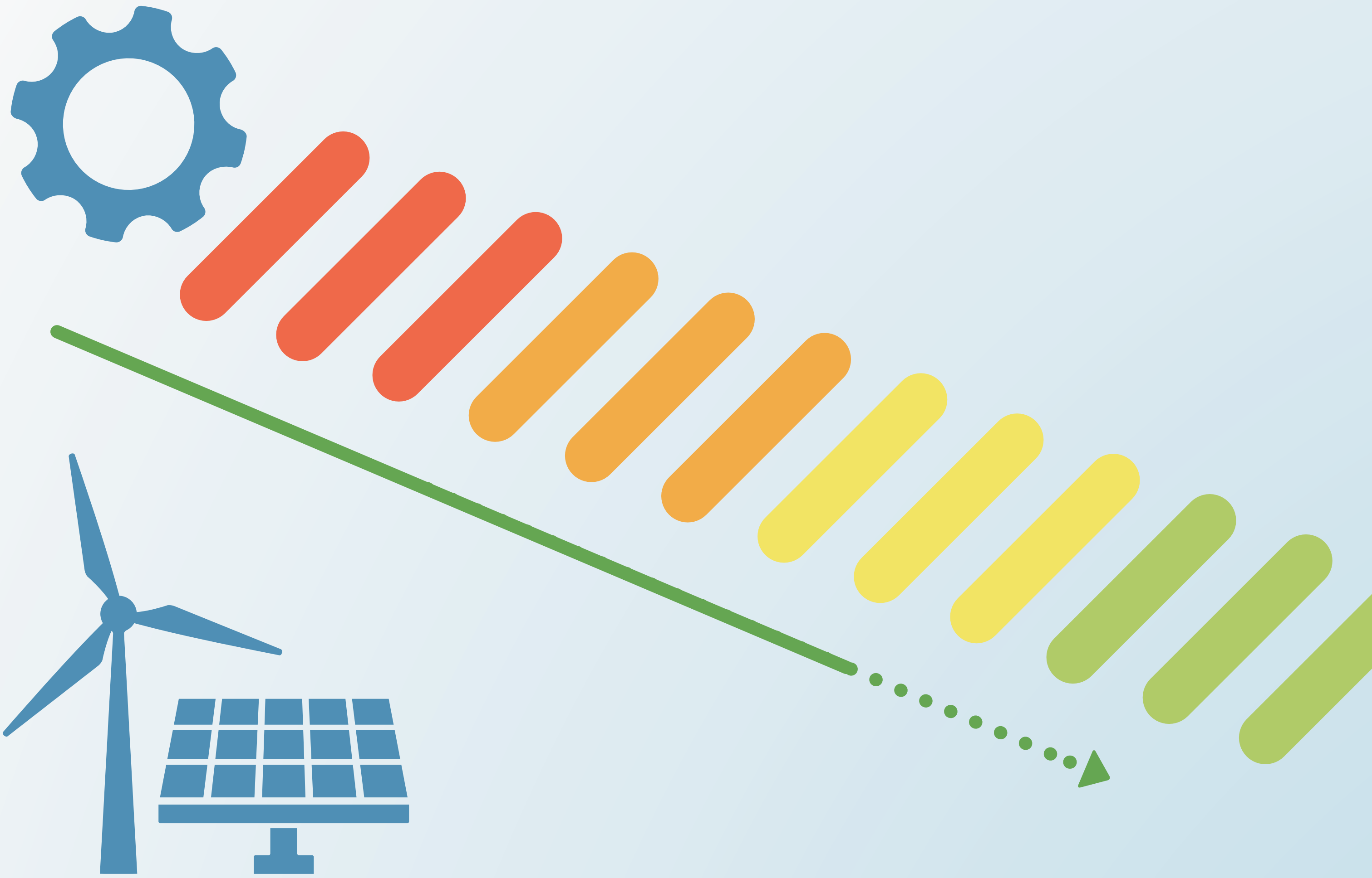


Climate Action Tracker

Wind and Solar benchmarks for a 1.5°C world

METHODOLOGY SUMMARY

February 2026

Introduction

Context

Wind and solar technologies have emerged as key players in the transition to clean electricity, boasting significant growth attributed to technological advancements, improved economics, and favourable policy developments. This growth not only signals a shift toward sustainable energy sources but also presents opportunities for economic growth, job creation, and enhanced energy security.

Despite being major drivers of the imminent peak emissions in global electricity supply, the deployment of wind and solar capacity falls short of the required magnitude and pace. To achieve the ambitious targets of the Paris Agreement, there is a pressing need for comprehensive research on breaking down globally required levels of wind and solar installations to a national scale to ensure robust domestic strategies to safeguard the 1.5°C limit.

Purpose

This report presents a summary of the Climate Action Tracker's stepwise methodology designed to define credible, replicable, and transparent benchmarks for wind and solar capacity, aligning with the Paris Agreement's 1.5°C temperature goal.

Our approach combines diverse building blocks in a step-by-step method to translate global decarbonisation needs of the power sector into national wind and solar benchmarks for 2030, 2040, and 2050. By integrating various lines of evidence, including both national and global perspectives, the proposed methodology aims to align the benchmarks with global temperature goals while considering national circumstances.

The primary focus of the report lies in presenting the methodology that is used to develop benchmarks for 20 selected countries / regions:

- Australia
- Brazil
- Canada
- China
- European Union
- India
- Indonesia
- Germany
- Japan
- Kenya
- Mexico
- Morocco
- Nigeria
- Pakistan
- Philippines
- South Africa
- South Korea
- Thailand
- Türkiye
- United States

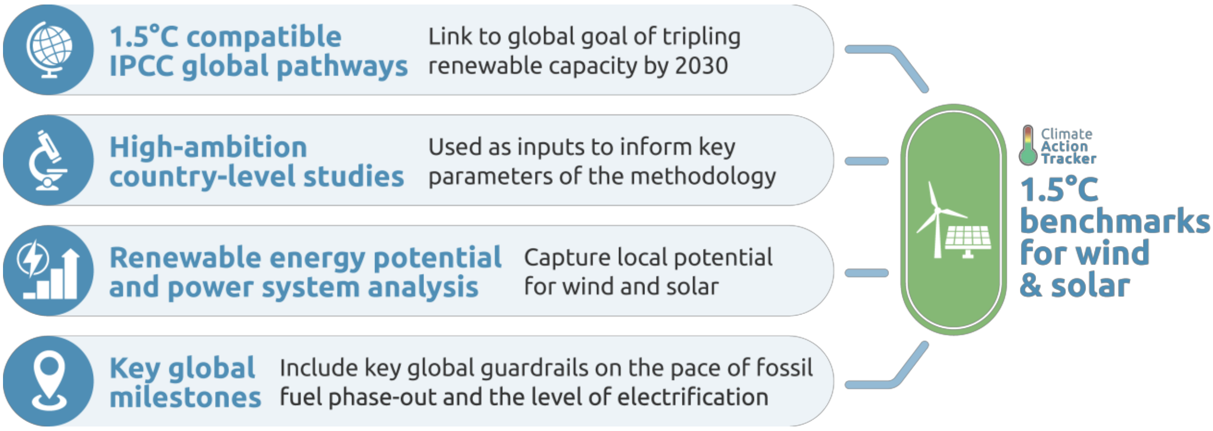
The benchmarks for each of these countries will be rolled out in stages during 2026. You can view them at https://climateactiontracker.org/sectors/power/

Overview of analytical elements

Different analytical elements

Our method takes multiple different analytical elements to try and understand a possible 1.5°C aligned wind and solar rollout that is informed by both bottom-up approaches and top-down perspectives.

The integration of multiple different analytical elements can help compensate for the limitations of any individual perspective, and provide a more robust and better-informed ultimate set of results.



In the following section, we provide some further detail on three of the main analytical elements. For more detail, please see the full Methodology Report.

Global pathways

We use the global 1.5°C compatible pathways to bring a link back between national level action and the global goal of limiting warming to 1.5°C. All our benchmarks are consistent with pathways which achieve this goal at the global level, and in which renewable capacity triples by 2030 relative to 2022.

We focus on a set of 24 pathways from the IPCC's Sixth Assessment Report which avoid unsustainable levels of CDR deployment, as defined by the literature, and in which high-income countries take the lead in reducing emissions faster than low and middle-income countries. For more details see here.

Having selected these pathways, we then downscale them from the regional level (e.g. Sub-Saharan Africa) to the national level. We do this using the SIAMESE tool, which provides a cost-effective breakdown of energy consumption and emissions at the national level.

Country-level studies

We use national-level studies, whether conducted by in- country actors (preferable), or otherwise external studies, to help provide national context. These studies help to ground-truth the top-down evidence being provided by the global downscaled pathways.

Studies are then filtered based on level of:

- **Ambition** : We select studies which full decarbonise the power sector by the 2050s at the latest
- **Scope:** We prioritise studies with energy-wide sectoral representation, high levels of electrification and that provide data out to 2050
- **Robustness:** We focus on detailed power system modelling studies, avoiding simple heuristics.

The resulting set of filtered studies are used to help inform future electricity demand, the future fossil fuel phase-out schedules in the country, and the level of non- wind and solar clean electricity generation that could be deployed out to 2050.

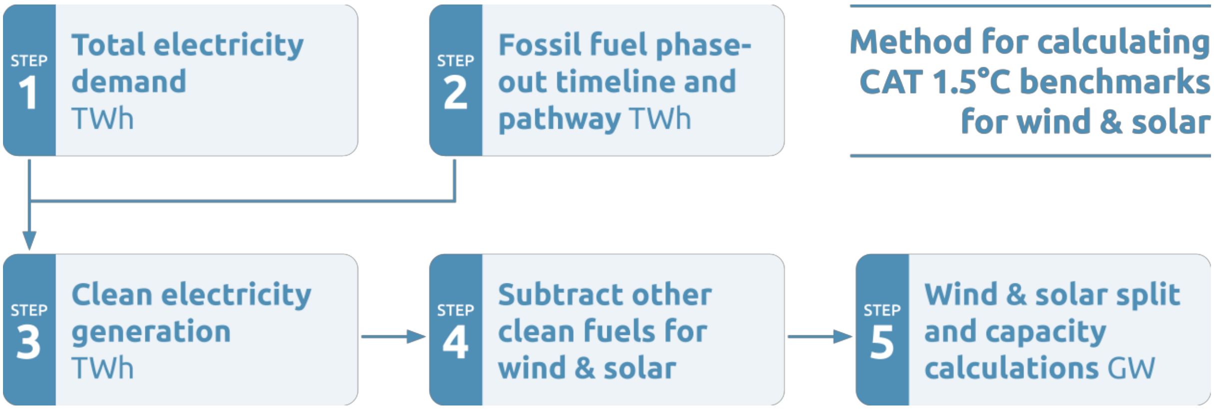
Global milestones

As well as the high-ambition country-level studies and the downscaled global pathways, we ensure that our benchmarks are compatible with the milestones identified in the IEA's net zero scenario, which sees:

- Advanced economies achieving net zero power sector emissions in 2035
- China achieving this milestone in 2040
- All other economies achieving this in 2045

Step-by-step method

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.

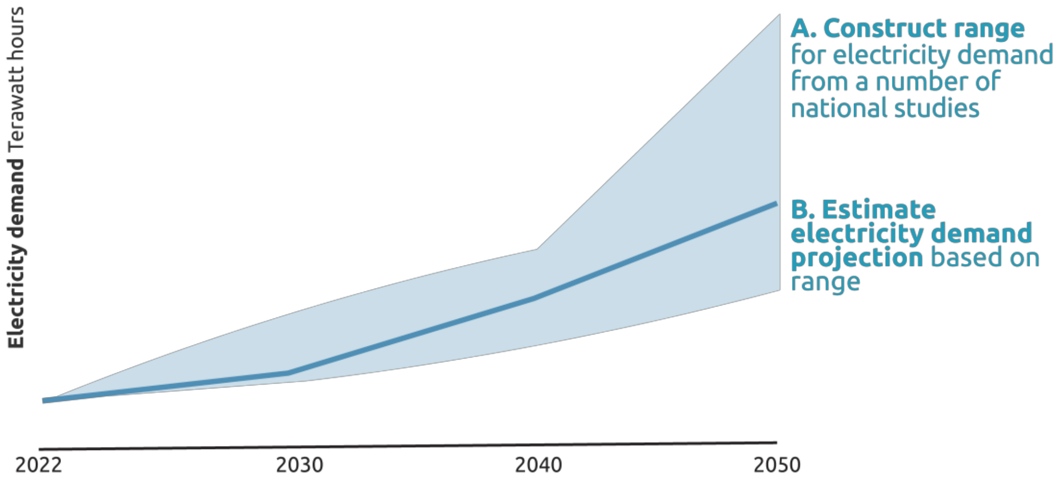
First, we project future electricity demand. We then calculate the pace of fossil fuel phase-out needed to align with 1.5°C. Bringing these data points together, we can calculate the level of clean electricity generation required. We subtract non-wind and solar generation to calculate the wind and solar generation necessary to meet electricity demand growth and phase out fossil fuels in line with 1.5°C.

Having produced this wind and solar generation trajectory, we feed it into an electricity system model (PyPSA), which can then calculate for a given set of cost assumptions around wind and solar, a split into wind versus solar and the associated capacity requirements.

The following section further summarises the method. For a detailed overview, please see the methodology paper released in 2023.

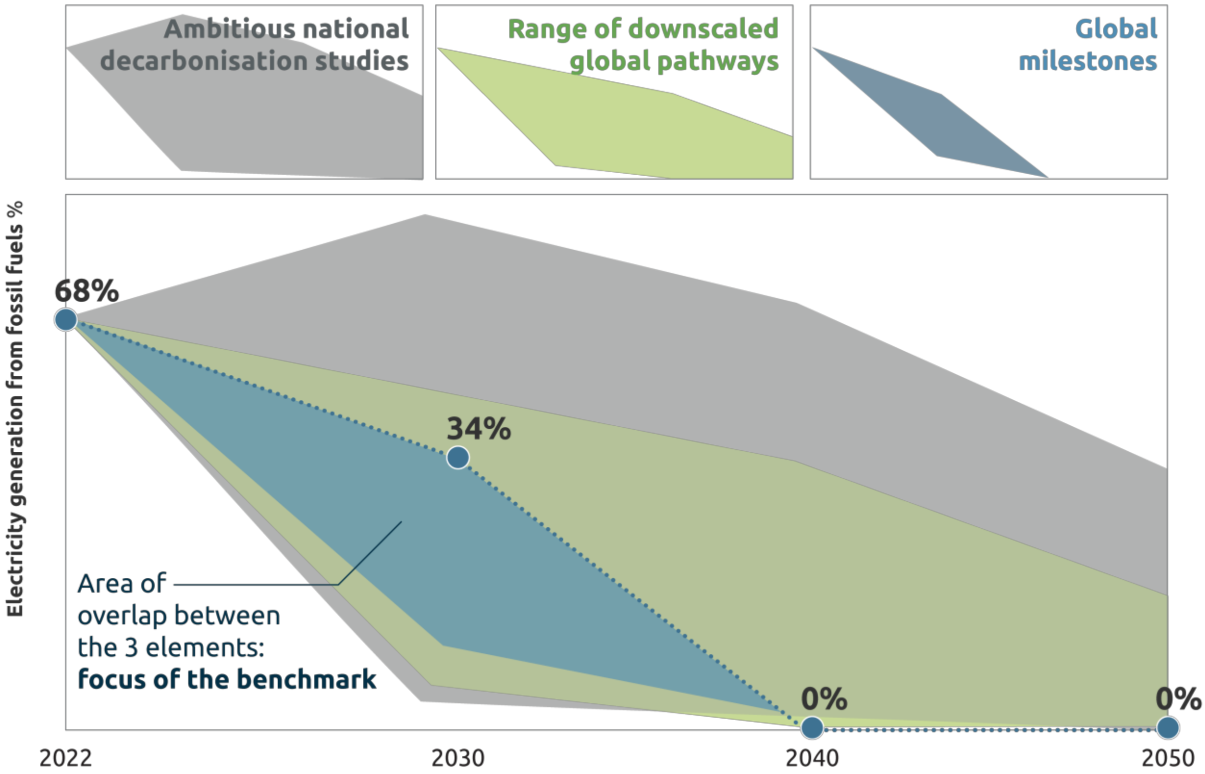
STEP 1
Total electricity demand

- We extract electricity generation projections for 2030, 2040, and 2050 from **ambitious country-level studies.**
- We then identify an electricity generation projection from a scenario to use for our analysis. We focus on identifying studies which capture key elements of the transition, including **high electrification**, and which have been conducted using **detailed energy system models** by **country-level experts**. We incorporate feedback from stakeholders to identify these studies which inform the electricity demand trajectory.



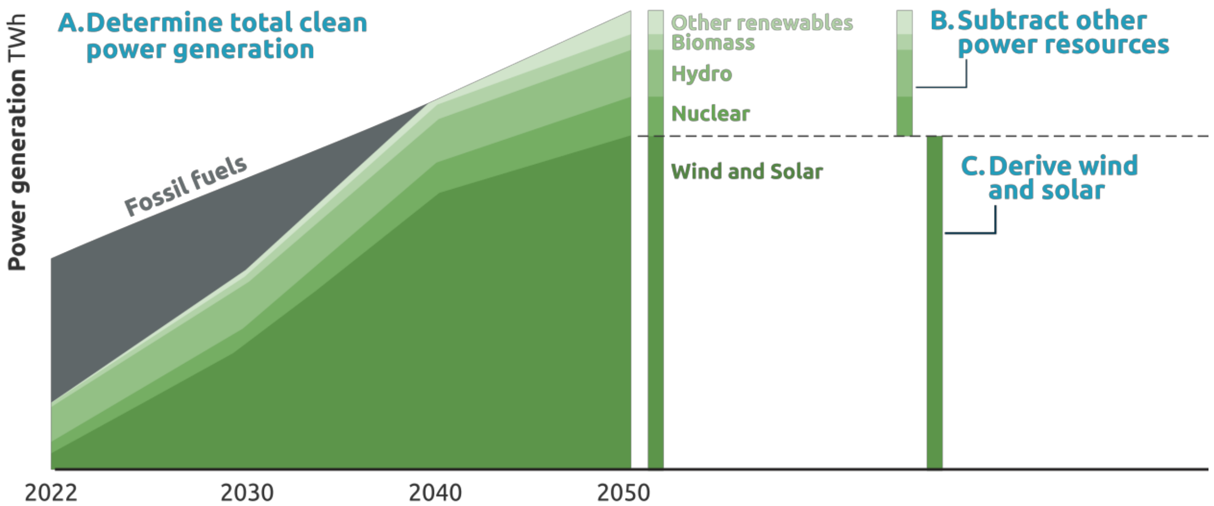
STEP 2
Fossil fuel phase-out

- We calculate a range of electricity generation pathways from fossil fuels based on **ambitious country-level studies**.
- We produce a similar range from **downscaled 1.5°C compatible global scenarios**.
- We identify the intersection of these two ranges, representing the speed and scale of decarbonisation pathways that aligns with the goals of the Paris Agreement while capturing local circumstances in countries.
- We integrate differentiated timelines for phasing out fossil fuel electricity generation, applied as **global milestones** (2035 for advanced economies, 2040 for China, and 2045 for emerging economies).



STEPS 3 & 4
Calculate wind and solar generation

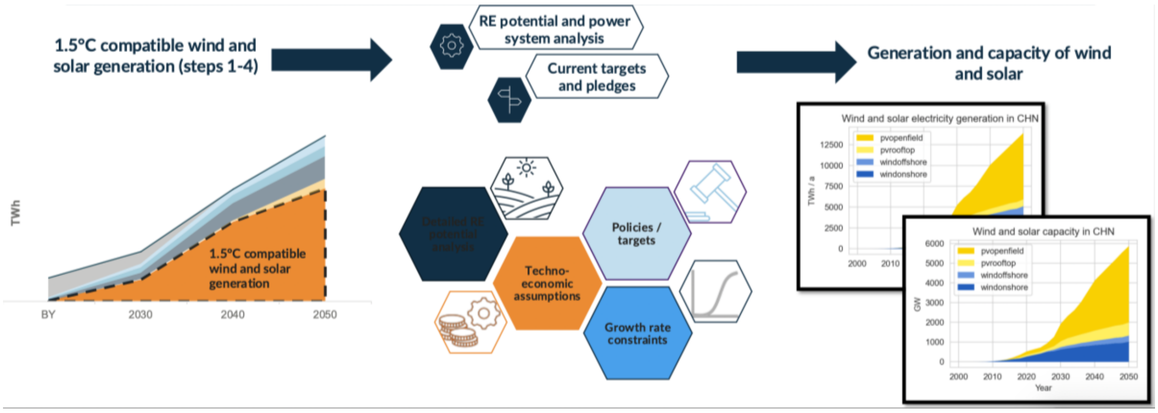
- We obtain electricity generation from carbon-free resources: from total electricity generation (step 1), subtracting fossil-fired generation (step 2).
- We then subtract estimates of electricity generation attributed to hydroelectricity, biomass, other renewable resources, and nuclear power – informed from **country-level studies'** estimates – from the total clean electricity generation** to infer the wind and solar generation.



* 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.

STEP 5
Wind and solar breakdown

- We use a detailed geospatial **renewable potential analysis** to calculate the technical potential of each technology in the country. We then feed the wind and solar generation required into a power system model calibrated to these potentials. For more details on the renewable potential analysis tool used, see Appendix C in this report from Climate Analytics. We use PyPSA to do our power system modelling.
- We force the model to deploy at least the level of solar and wind seen in countries' **current targets and pledges**.
- The power system model then gives a split of wind and solar in the country and the resulting capacity requirements.



Key modelling parameters in the analysis

The following table highlights some of the most relevant parameters which influence the PyPSA modelling used to help estimate the split into wind versus solar

Model feature	Details
Cost resolution	Detailed cost curves for wind and solar are produced based on geospatial weather data, as discussed above.
Growth rates	Solar and wind growth rates constrained to technology specific growth rates set based on analysis of past technology rollout. Current default growth rates for capacity growth are set as: • Wind = 16% per year • Solar = 33% per year These constraints are applied to both total capacity and capacity additions. In cases where the benchmarks require faster growth than this, we relax the growth rates progressively until wind and solar are able to grow to meet the level of generation required in the 1.5°C compatible benchmarks.
Adequacy factor	In addition to the total annual electricity generation from wind and solar having to be met, we require that at a certain proportion of the hourly load is always met by wind and solar. This term in our modelling is called the adequacy factor. The default value for this constraint in countries is 25%. This factor captures the level of storage and dispatchable generation available to meet electricity demand. A higher factor means that wind and solar need to more closely match hourly loads, without the use of storage/dispatchable generation to smooth out mismatches between generation and demand. This would generally lead to an overbuild of wind and solar to ensure adequate power supply at all times, and greater curtailment. Meanwhile a factor of 0% would mean that wind and solar generation can fall to zero for significant periods of time, as long as over the whole year, total wind and solar generation needed is provided. This would imply that there is greater availability of batteries and other dispatchable zero-carbon generation to meet demand in times of low wind and solar output. When in specific countries, the results from detailed country-level energy system modelling suggests a different power system configuration to the results given by adequacy=25%, we tune this parameter to better represent the power system configurations seen in the national level modelling.
Wind and solar costs	We produce a range of different cost curves for wind and solar in each country, based on IRENA data. For more details see the technical annex.

Inferring electricity generation mixes from the wind and solar benchmarks

The Climate Action Tracker sets national benchmarks for the power sector based on the share of electricity generation (%) coming from coal, gas and renewables. Focussing on the share of electricity allows the CAT to compare and contrast countries with very different scale power sectors, for example Morocco and China.

In the latest update of the CAT benchmarks, the CAT is moving to integrated insights from new research that focuses on 1.5°C compatible wind and solar deployment. This switch has been made because the new research better integrates a range of valuable insights, including a greater coverage of in-country bottom-up power system modelling, and detailed country-level renewable potential analysis. It also provides additional information on wind and solar deployment, rather than focusing only on renewables as a whole.

The new research initially focuses on the absolute level of wind and solar deployment needed in countries (i.e. GWs of capacity, TWh of generation) to align with 1.5°C. It focuses on two key questions:

- How fast do fossil fuels need to exit the power sector to align with 1.5°C? Here we use the overlap of downscaled 1.5°C compatible pathways and national studies to identify a corridor of ambition which eliminates fossil fuels on a timeline which aligns with 1.5°C, while also being evidenced by country-level national modelling work.
- How fast does electricity demand need to grow to support widespread electrification of the energy system and phase out fossil fuels in buildings, transport and industry?

Wind and solar deployment needs to be sufficient to meet electricity demand growth while phasing out fossil fuels (with some deployment of other clean electricity generation such as hydropower and geothermal).

The methodology developed for wind and solar deployment can be seen in more detail in the following publications (NewClimate Institute and Climate Analytics 2023, Climate Analytics and NewClimate Institute 2024). The immediate outputs of this methodology are:

1. National electricity demand estimates out to 2050 (TWh)
2. Fossil phaseout trajectory out to 2050 (TWh). This is not immediately disaggregated into coal and gas separately.
3. Total clean electricity required out to 2050 to phase out fossil fuels and meet demand growth (TWh)
4. Total wind and solar generation needed out to 2050 (TWh).
5. Split of wind and solar generation into wind vs. solar, associated capacity requirements and capacity additions needed.

Some further steps are needed to convert this information into % of coal, gas and renewables in overall electricity generation. These steps are detailed below.

Coal and gas benchmarks

1. The share of fossil fuels in the future electricity mix is calculated by dividing future fossil fuel generation by future electricity demand.

2. The split of this fossil fuel generation into coal vs. oil and gas is calculated.
    a. For this, the CAT uses an in-depth literature review of national-level power sector modelling, which is also used as a line of evidence in the original analysis. The median share of coal in overall fossil generation from the literature is used.
    b. In line with previous methodology, the CAT also avoids phase-in of fossil fuels which are not existing in the country in the base year. So, in South Africa, where the current share of coal in total fossil generation is 100% (all fossil generation is coal), this is maintained going forwards and no gas is introduced into the power mix.
    c. In line with previous methodology, coal is assumed to be phased out by 2030 in advanced economies.

Renewables benchmarks

1. Future electricity generation from renewables is calculated by subtracting nuclear generation from the total clean electricity generation benchmark in TWh. We take the median nuclear generation* from the national power sector modelling to capture this.

2. The share of renewables in the future electricity mix is calculated by dividing future renewables generation by future electricity demand.

Differences to previous work

There are not major changes in the overall shape and form of the results between the old and new benchmarks. The overall message remains clear: fossil fuels need to be rapidly reduced to zero to usher in clean power within a generation, driven by turbocharged renewables deployment.

The differences arise in two areas:

1. The date of coal phaseout for some developing countries. In the previous benchmarks, coal generation was entirely phased out by 2040 in developing countries. In these new benchmarks, this date is slightly extended to 2045. This is based on updates to the IEA's Net Zero scenario made in recent years, in which the date of clean power in developing countries has been extended to 2045. This only impacts three countries: India, Indonesia and South Africa. The differences are very minor, with the share of coal remaining in electricity generation in 2040 at 1-4% for India, and 2% for Indonesia and 0-17% for South Africa.

2. The pace of near-term fossil fuel reductions. In some countries the benchmark for 2030/35 becomes slightly less stringent under the new methodology. These differences are also minor: in all countries the share of fossil needs to decline immediately and significantly towards zero. This change comes from a new methodology which better captures the insights of bottom-up national studies into the results and is used in the wind and solar benchmarking work. This change improves the feasibility and robustness of the new benchmarks, but does lead to slight changes in the 2030/35 fossil phaseout and renewables roll-in benchmarks.

* Although nuclear electricity generation does not emit CO_2, the CAT doesn't see nuclear as the solution to the climate crisis due to its risks such as nuclear accidents and proliferation, high and increasing costs compared to alternatives such as renewables, long construction times, incompatibility with flexible supply of electricity from wind and solar and its vulnerability to heat waves.

Authors

Climate Analytics
Tina Aboumahboub
Neil Grant
Fadil Razak
Severin Ryberg
Lara Welder

NewClimate Institute
Emily Daly
Markus Hagemann
Gustavo de Vivero

Editing Cindy Baxter

Design Designers For Climate

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Authors names are listed alphabetically.

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°C limit 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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