



Climate Action Tracker

Wind and Solar benchmarks for a 1.5°C world

JAPAN

February 2026



Executive Summary

Context

Japan continues to face intense energy security pressures, importing over 90% of its primary energy. In 2023, fossil fuels still dominated electricity generation at 64%, with coal providing 28% and LNG 33%. Following the 2011 Fukushima disaster, Japan’s energy self-sufficiency rate [plummeted](#); while it has recovered slightly through nuclear restarts and solar growth, the country remains a top [LNG importer](#), making affordable electricity a constant economic challenge for its energy-intensive manufacturing sector.

Renewable energy reached a record 23% of Japan's generation mix in 2023, led by solar (10%) and hydropower (8%). While solar has expanded rapidly, wind energy remains largely untapped at just 1.2%, despite Japan’s vast coastline. The [6th Strategic Energy Plan](#) (upheld in the 2025 Energy White Paper) targets a 36–38% renewables share by 2030. Looking further ahead, the government is banking on innovative technologies like perovskite solar cells and floating offshore wind to meet a 2040 goal of 40–50% renewable electricity.

In this report, we look at national studies and global energy system models to assess how much Japan’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

Japan’s solar generation needs to grow four times by 2030 and wind 30 times to align with 1.5°C. This equates to 645 TWh of wind and solar generation in 2030, up from 146 TWh in 2023.

- ▶ Almost 390 GW of new wind and solar capacity would be needed by 2030 (300 GW solar, 90 GW wind). This would require average annual capacity additions of 40 GW/yr of solar and 9 GW/yr of wind from 2023-2030.

Japan’s current rollout of wind and solar is not progressing fast enough to achieve this. Under current policies and market conditions, only 38% of the solar and 21% of the wind needed to align with 1.5°C will be installed 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 [Japan](#).

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

Japan's [2030 nationally determined contribution](#) (NDC) aims to reduce greenhouse gas emissions (GHG) by 46% in 2030 relative to 2013 levels. Japan's [2035 NDC](#) is to reduce GHG emissions by 60% by 2035 and 73% by 2040, below 2013 levels. The country aims to reach net-zero emissions by 2050.

Japan also aims to reach 40–50% of renewables in electricity generation by 2040, as of the [7th Strategic Energy Plan](#) published in 2025, up from its 2030 target of 36–38% (set in the [6th Strategic Energy Plan](#)). Currently, renewables accounted for approximately [23% of generation in 2023](#).

Beyond capacity targets, the 7th Strategic Energy Plan (2025) establishes nuclear and renewable energy generation as the "two wheels" of a stable grid. In the context of rising demand for electricity from AI data centres and semiconductor manufacturing, this plan places renewables at the forefront to meet a growing energy appetite.

In policy terms, the plan functions as the energy supply pillar of the broader [GX2040 Vision](#), a long-term decarbonisation framework focused on reaching carbon neutrality while maintaining economic competitiveness, energy security and industrial resilience. While the Strategic Energy Plan restructures the power mix, GX2040 provides the industrial and financial architecture that channels investment into decarbonised production. The GX2040 Vision calls for leveraging carbon pricing and JPY 150 tn in public-private investment to transform heavy industry into a green growth engine.

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 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 Japan

WnS = Wind and Solar

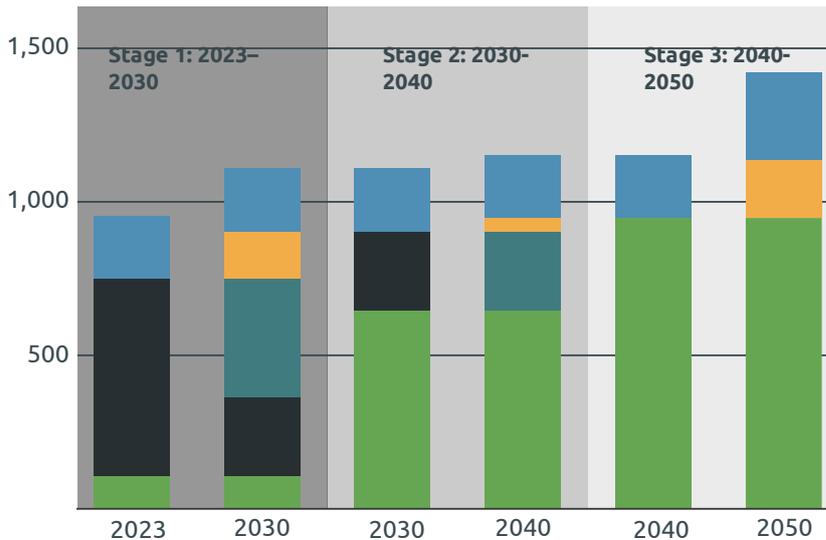


Figure 1 – Electricity generation in each stage in TWh

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.

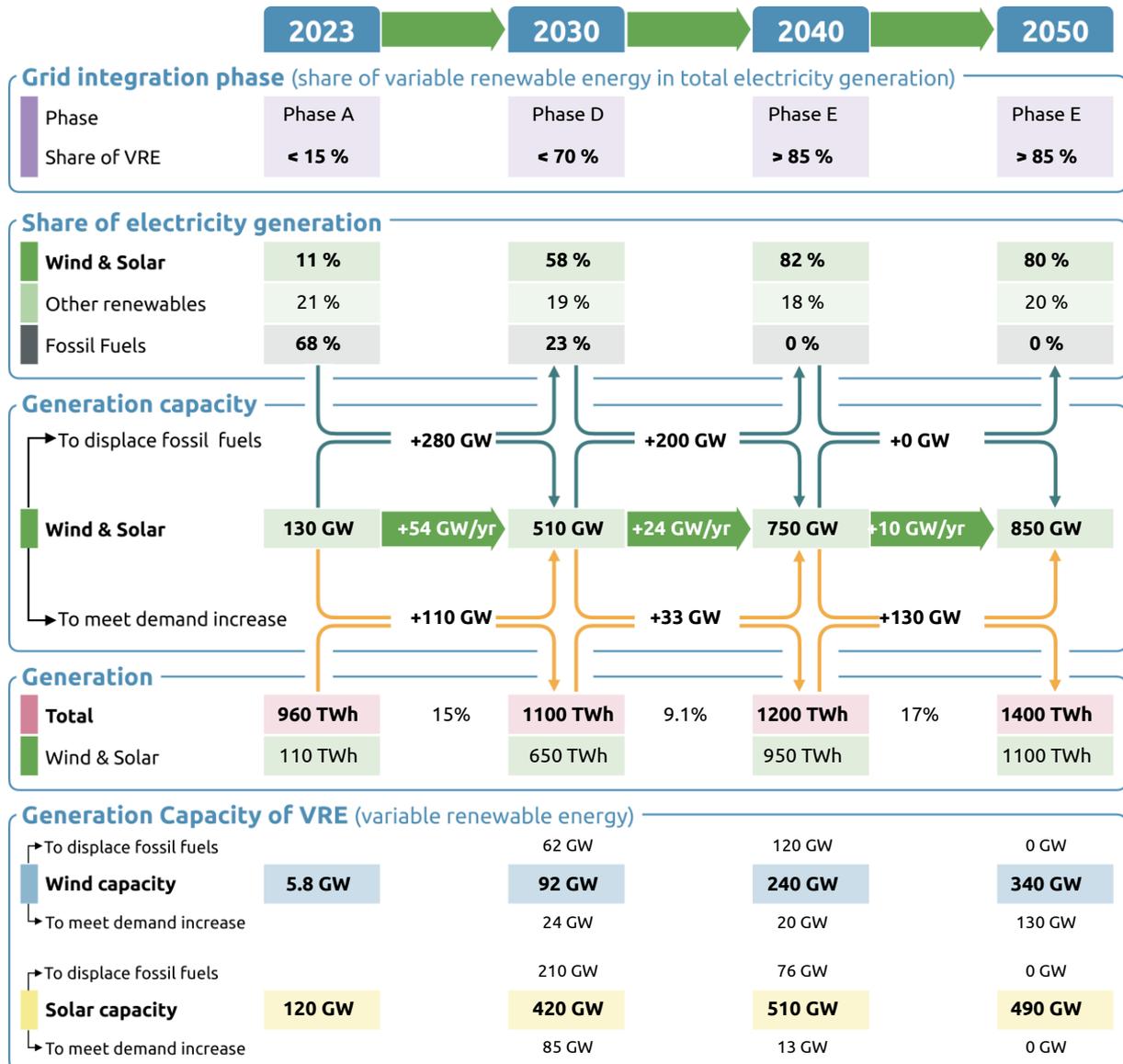
From now until 2030, Japan would need to add 24 GW of wind and 85 GW of solar capacity to meet growing demand alone. Another 62 GW of wind and 220 GW of solar will be needed to displace the share of fossil fuels in the electricity generation mix.

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 Japan in Phase D, with wind and solar making up 58% 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



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

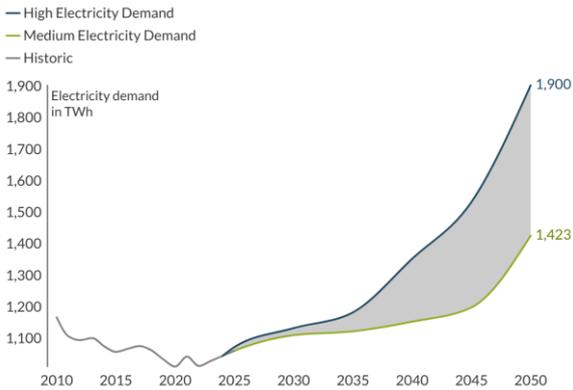
In Japan, our power system modelling shows limited sensitivity to wind and solar costs. In particular, there is a very low-cost resource potential for solar PV which is cost-effective to access across a wide range of plausible solar PV costs. Therefore, we do not see the same spread of wind/solar deployment across cost ranges. However, this does not mean that only one wind/solar rollout is possible or desirable in Japan. To explore a range of possible wind and solar rollouts, we look at different electricity demand levels and different paces of fossil phaseout to capture a range of possible wind/solar rollouts

Electricity demand for Japan is adapted from deep decarbonisation studies exploring net zero pathways for the country. The [high demand scenario](#) is based on a pathway that achieves rapid electrification of transport and buildings by 2050, supported by a large-scale build-out of renewable energy. In this scenario, total electricity generation in Japan reaches 1,900 TWh by 2050. This surge is driven by the extensive electrification of the Japanese economy and a significant requirement for electricity to produce clean fuels domestically, such as green hydrogen and ammonia derivatives, which necessitates a massive expansion of the power sector.

In contrast, the [medium demand scenario](#) projects a total electricity generation of approximately 1,423 TWh by 2050. This pathway places greater emphasis on energy efficiency measures across the industrial and residential sectors to mitigate total load.

This scenario assumes a different strategic approach to clean energy, where Japan relies more on the direct import of hydrogen and other carbon-neutral fuels rather than domestic production. By shifting the energy-intensive electrolysis process overseas, the required growth of the domestic electricity grid is notably reduced compared to more self-reliant pathways.

There is a significant range in the studies in terms of the expected electricity generation in 2050 ranging from 1,423 TWh to 1,900 TWh. This would significantly affect the necessary growth of wind and solar.



Electricity generation grows between 39%-85% in Japan by 2050

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 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 Japan achieves a clean power system by 2040.

To align with 1.5°C, fossil fuels must exit the Japanese power sector before 2040.

Fossil fuel generation falls by 47 to 62% between 2023 and 2030. Coal began a gradual decline in 2015 that must continue and increase pace toward a total phase-out between 2035 and 2040. This is mirrored by fossil gas, which begins to decline around the same time as coal, and is projected to exit by 2040.

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

Japan would need to achieve clean electricity by 2040

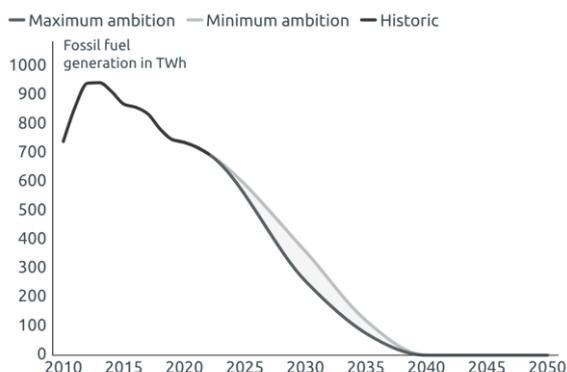


Figure 3 – Fossil fuel generation in TWh

Coal and fossil gas use peaks in 2015 before phasing out in Japan

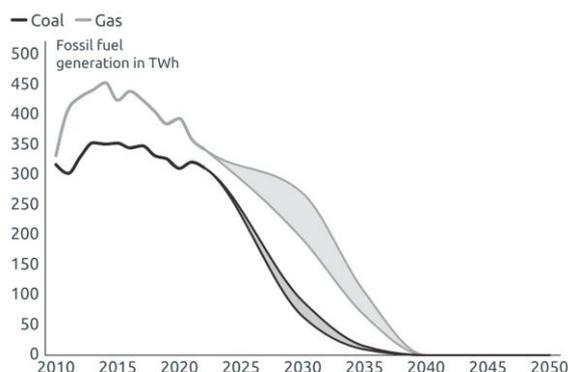


Figure 4 – Fossil fuel generation by fuel type in TWh

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 Japan will reach 205 TWh by 2030 and 286 TWh by 2050. Referencing the wider literature, studies identify several other generation technologies that could provide this capacity. They include nuclear and renewables other than wind and solar (e.g. hydro).

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 Japan would need to reach between 543 and 668 TWh by 2030**. Generation in 2023 was 146 TWh. This is therefore a 3.7 to 4.6-fold growth in wind and solar.

Wind and solar provides 49–59% of overall electricity generation in 2030, and 81 - 85% of overall generation in 2050. A grid powered almost entirely 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.

* 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](#).

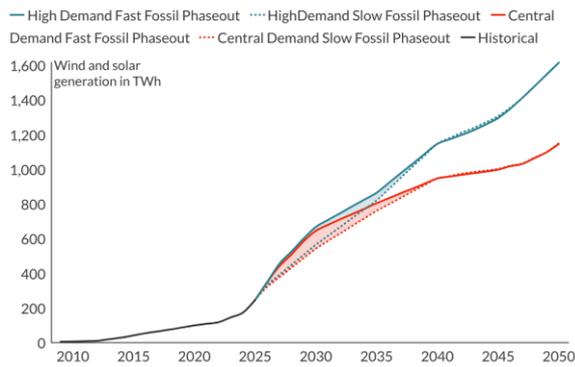


Figure 5 – Wind and solar electricity generation in TWh

Electricity generation from wind and solar grows between eight and eleven times in Japan by 2050

To align with 1.5°C, wind and solar generation would need to grow rapidly in Japan / wind and solar needs to surpass a 49% share of total electricity generation to align with 1.5°C in low- and high-demand scenarios

In a low demand scenario for electricity, wind and solar need to comprise over 49% of total generation by 2030

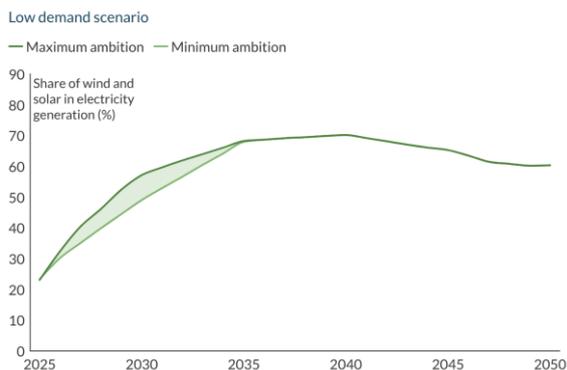


Figure 6 – Wind and solar electricity generation share (%) in a low-demand scenario

In a high demand scenario for electricity, wind and solar need to comprise 59% of total generation by 2030

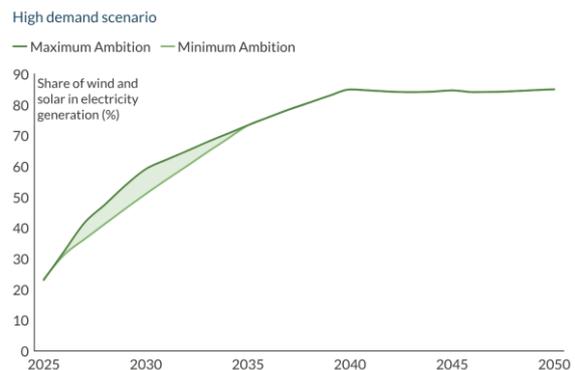


Figure 7 – Wind and solar electricity generation share (%) in a high-demand scenario

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 the central scenario, solar ramps up faster in the near-term, providing over **four times** the electricity generating capacity as wind in 2030. In this scenario, **Japan would need to deploy**

514 GW of wind and solar total installed capacity by 2030 to align with the 1.5°C temperature limit. By 2050, total wind and solar capacity would need to reach 860 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.

Japan needs to reach approximately 510 GW of wind and solar installed capacity by 2030 to align with 1.5°C

Solar capacity in Japan would reach 420 GW by 2030 in a 1.5°C-aligned scenario

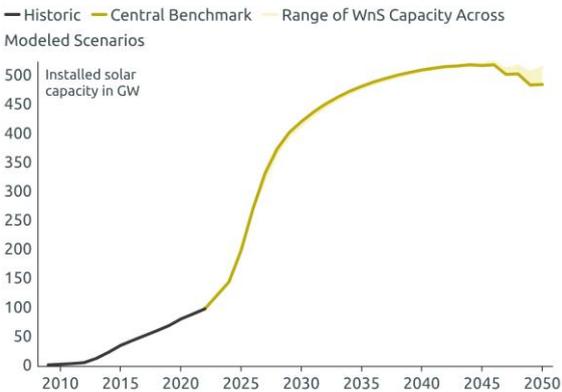


Figure 8 – 1.5°C compatible capacity benchmarks for solar in GW

Wind capacity in Japan would reach 90 GW by 2030 in a 1.5°C-aligned scenario

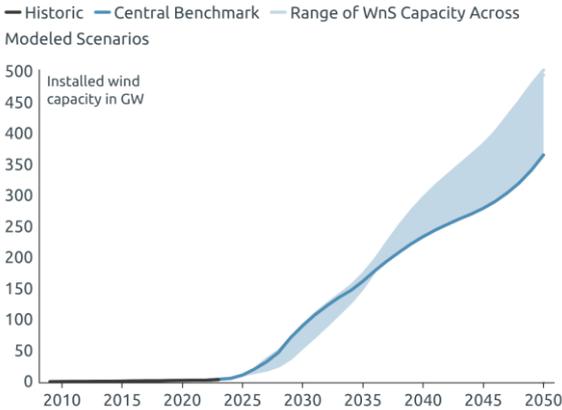


Figure 9 – 1.5°C compatible capacity benchmarks for wind in GW

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	134	430	470	470	410
Central 1.5°C benchmark	Wind generation	TWh	12	220	340	470	730
Central 1.5°C benchmark	Solar capacity	GW	122	420	480	510	490
Central 1.5°C benchmark	Wind capacity	GW	6	92	170	240	370

Table 3: Benchmarks translated into CAT format

Variable	Ambition	Unit	2030	2035	2040	2045	2050
Share of coal	Minimum	%	8	0	0	0	0
	Maximum	%	6	0	0	0	0
Share of gas	Minimum	%	24	10	0	0	0
	Maximum	%	17	6	0	0	0
Share of renewables	Minimum	%	65	88	96	100	100
	Maximum	%	74	91	96	100	100
Share of wind and solar	Minimum	%	49	68	82	79	80
	Maximum	%	58	72	82	79	80

Comparison to current rollout and country target

Under current policies and market conditions, deployment of wind and solar PV in Japan would not align with 1.5°C. The [IEA](#) translates the current policies to reach a target of roughly 160 GW of Solar and 20 GW of Wind. There would therefore be a capacity gap of **260 GW of solar PV** and **72 GW of wind** in 2030 between current rollout and the 1.5°C compatible benchmarks highlighted here.

Current policy projections show a mixed outlook when compared to stated domestic targets. Under the 7th strategic Energy plan, the Japanese government has set targets for national capacity at 118 GW of solar and 24 GW of wind by 2030. Deployment of solar under current policies would exceed by 42 GW solar capacity, while falling short for wind by 4 GW.

Japan's rollout of wind and solar needs to accelerate to align with 1.5°C

In Japan, the current rollout of solar rollout lags behind 1.5°C-aligned levels

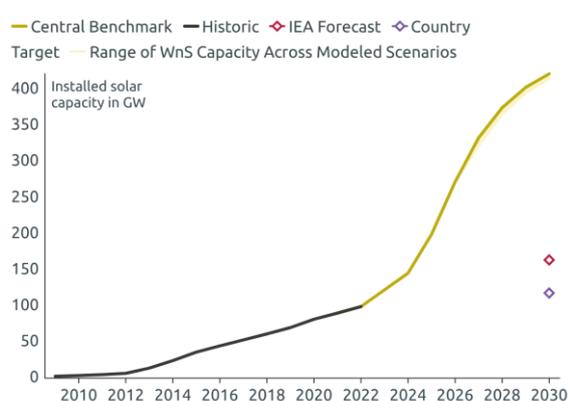


Figure 10 – Installed solar capacity in 2030 compared to targets and current policy projections in GW

In Japan, the current rollout of wind of wind lags behind 1.5°C-aligned levels

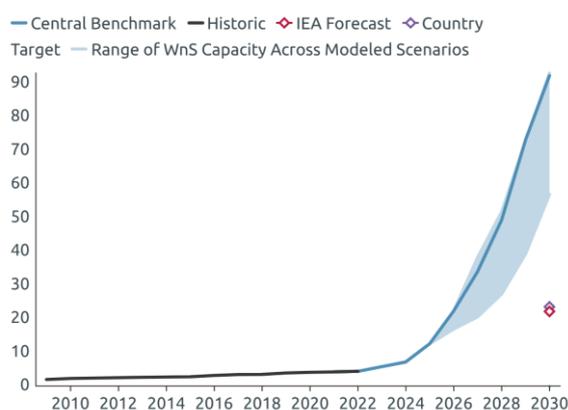


Figure 11 – Installed wind capacity in 2030 compared to targets and current policy projections in GW

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 Japan need to accelerate to align with 1.5°C

Japan would need to add on average 40 GW/yr of solar capacity until 2030, and 5 GW/yr over 2030–2050, compared to 13 GW/yr from 2020–2023

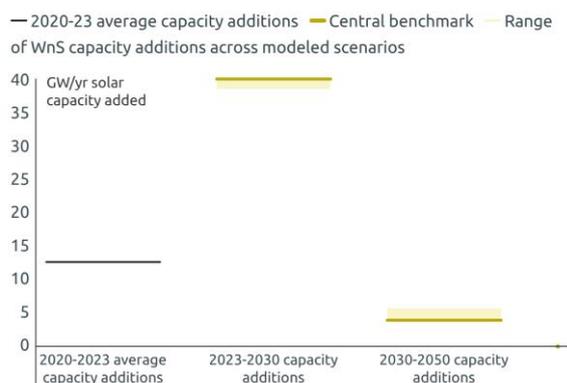


Figure 12 – Solar capacity additions per year in GW/y

Japan would need to add on average 9 GW/yr of wind capacity until 2030, and 18 GW/yr over 2030–2050, compared to 0.5 GW/yr from 2020–2023

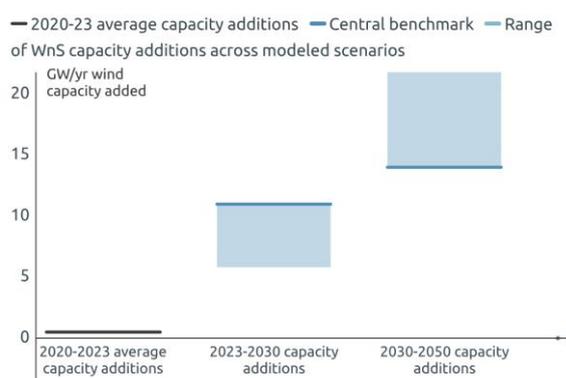


Figure 13 – Wind capacity additions per year in GW/y

Comparison with other studies

In Japan, solar and wind generation would need to undergo a massive transformation to align with a 1.5°C-compatible pathway.

Solar power requires an immediate and aggressive ramp-up to reach a benchmark of **429 TWh by 2030**, a target that sits at the absolute upper bound of current literature and nearly doubles most existing forecasts.

Wind energy follows a similarly ambitious trajectory, with generation targets scaling from **216 TWh in 2030** to a staggering **734 TWh by 2050**. While the long-term wind benchmark aligns with the more optimistic cluster of literature studies, the near-term goals for both technologies highlight a significant ambition gap between current policy trajectories and the accelerated deployment required for a fast fossil phaseout.

Our benchmarks are broadly aligned with the literature

Electricity generation from solar: comparison with literature in Japan

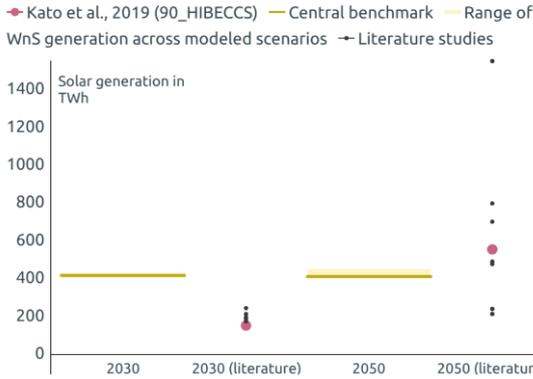


Figure 14 – Solar electricity generation in TWh

Electricity generation from wind: comparison with literature in Japan

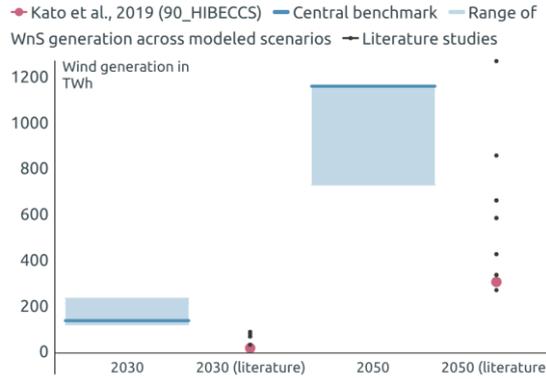


Figure 15 – Wind electricity generation in TWh

In Japan, our benchmarks generally suggest that solar will provide more generation than wind in 2030 and by 2050 wind will outpace solar

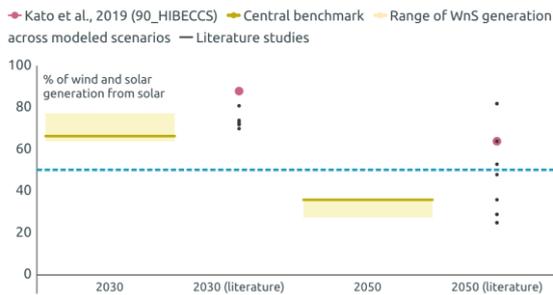


Figure 16 – Generation split between wind and solar (%)

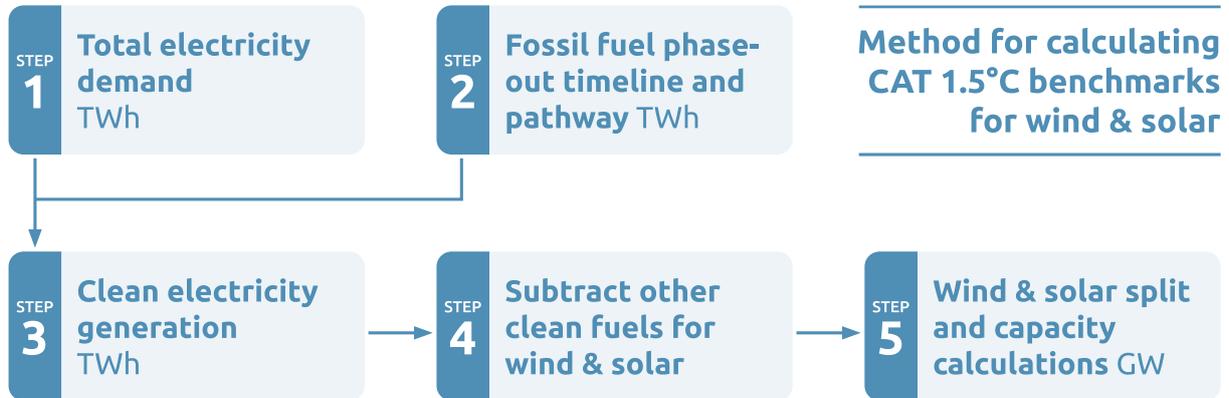
Share of wind and solar generation that comes from solar: comparison with literature in Japan

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



Methodology

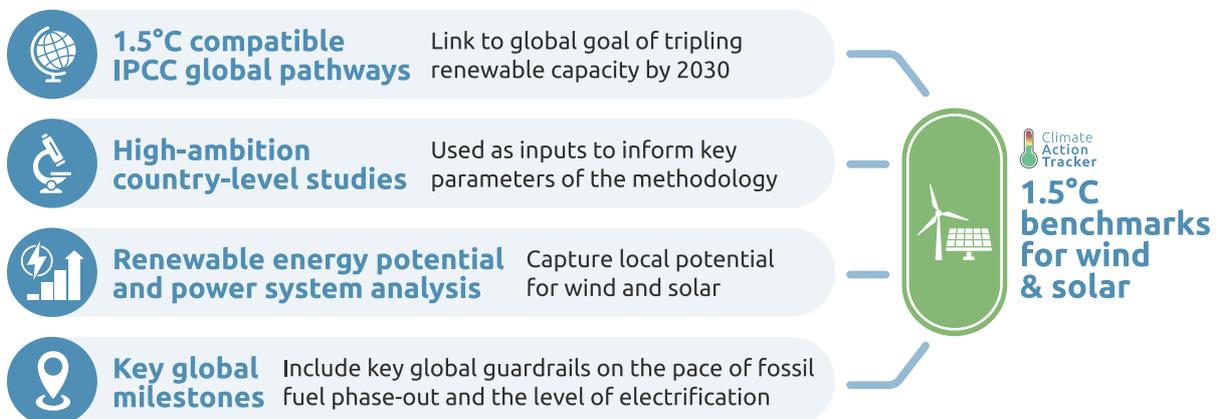
Summary of our method



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 Japan

Study	Publication	Scenario selected
Matsuo et al. (2018)	A quantitative analysis of Japan's optimal power generation mix in 2050 and the role of CO2-free hydrogen	<ul style="list-style-type: none"> • No nuclear, no imports • Nuclear, no imports
Burandt (2021)	Analyzing the necessity of hydrogen imports for net-zero emission scenarios in Japan	<ul style="list-style-type: none"> • No H2 imports • H2 imports at 2€/kg
Shiraisi et al. (2023)	The Japan 2035 Report: Plummeting costs of solar, wind, and batteries can accelerate Japan's clean and independent electricity future	Clean Energy Scenario
Kato et al. (2019)	Evaluation of Japanese energy system toward 2050 with TIMES-Japan – deep decarbonization pathways	<ul style="list-style-type: none"> • 90_HIBECCS_NONU • 90_HIBECCS
LUT University and Agora (2021)	Renewable Pathways to climate neutral Japan	BPS (Autarky)
Ken Oshiro et al. (2024)	Mid-century net-zero emissions pathways for Japan: Potential roles of global mitigation scenarios in informing national decarbonization strategies	NZE-AF
Institute for Sustainable Futures (2023)	Net-zero 1.5 °C sectorial pathways for G20 countries: energy and emissions data to inform science-based decarbonization targets	



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°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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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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