EMBER

Global Electricity Mid-Year Insights 2023

Global power sector emissions plateaued in the first half of 2023 as wind and solar continue to grow. However, adverse hydro conditions prevented emissions from falling.

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EMBER

About

This report analyses changes in global electricity generation from January to June 2023, compared to the same period last year, to measure the progress of the global clean energy transition.

The report analyses monthly electricity data from 78 countries representing 92% of global electricity demand and includes estimated changes in the remaining generation. It also dives deeper into the top five CO2 emitting countries and regions, accounting for over 70% of global CO2 emissions in the power sector.

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Cover image

Solar panel technicians working a Spanish factory.

Credit: Cavan Images / Alamy Stock Photo

Disclaimer

The information in this report is complete and correct to the best of our knowledge, but if you spot an error, please email **info@ember-climate.org**

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-8.5%

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+0.1%

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Global power sector emissions plateaued as wind and solar continue to grow

However, adverse hydro conditions—likely exacerbated by climate change—prevented emissions from falling in the first half of 2023.

Power sector emissions plateaued in the first half of 2023, with a slight increase of 0.2% compared to the same period last year, as wind and solar continue to grow. Wind and solar were the only electricity sources that significantly increased both their generation as well as share in the global power mix. Despite this, adverse hydro conditions—likely exacerbated by climate change—prevented emissions from falling. The deficit created by hydro, particularly in China, led to a small increase in fossil fuels. However, low electricity demand helped to suppress further emissions growth at a global level by reducing the consumption of fossil fuels. Falls in demand led to significant emissions falls in the European Union, United States, Japan and South Korea, while moderate demand growth in India led to slower emissions growth.

01

Global power sector emissions plateaued

Global emissions from the power sector rose only 0.2% (+12 million tonnes of CO2) in the first half of 2023 when compared to the same period last year. Major falls in emissions were seen in the EU (-17%), Japan (-12%), the US (-8.6%) and South Korea (-3%), as a result of falls in coal generation—most notably in the US (-27%) and EU (-23%), but also in Japan (-7.4%) and South Korea (-2.5%). A slower increase in emissions was seen in India, with an increase of 3.7% in the first half of 2023 versus 9.7% in the same period last year. Power sector emissions rose by 7.9% in China due to a record fall in hydro generation.

02

50 countries hit new solar records

Wind and solar were the only two electricity sources that significantly increased their share of global electricity, rising to 14.3% in the first half of 2023, compared to 12.8% in the same period last year. However, their generation grew more slowly than in the same period last year. Wind grew 10% in the first half of 2023, compared to 16% in the same period last year. Solar grew by 16%, compared to 26% in the first half of 2022. Across the globe, 50 countries set new monthly solar generation records in the first half of 2023. China continues to be the leader in solar generation, providing 43% of global growth in solar generation, while the EU, US and India accounted for about 12% each.

03

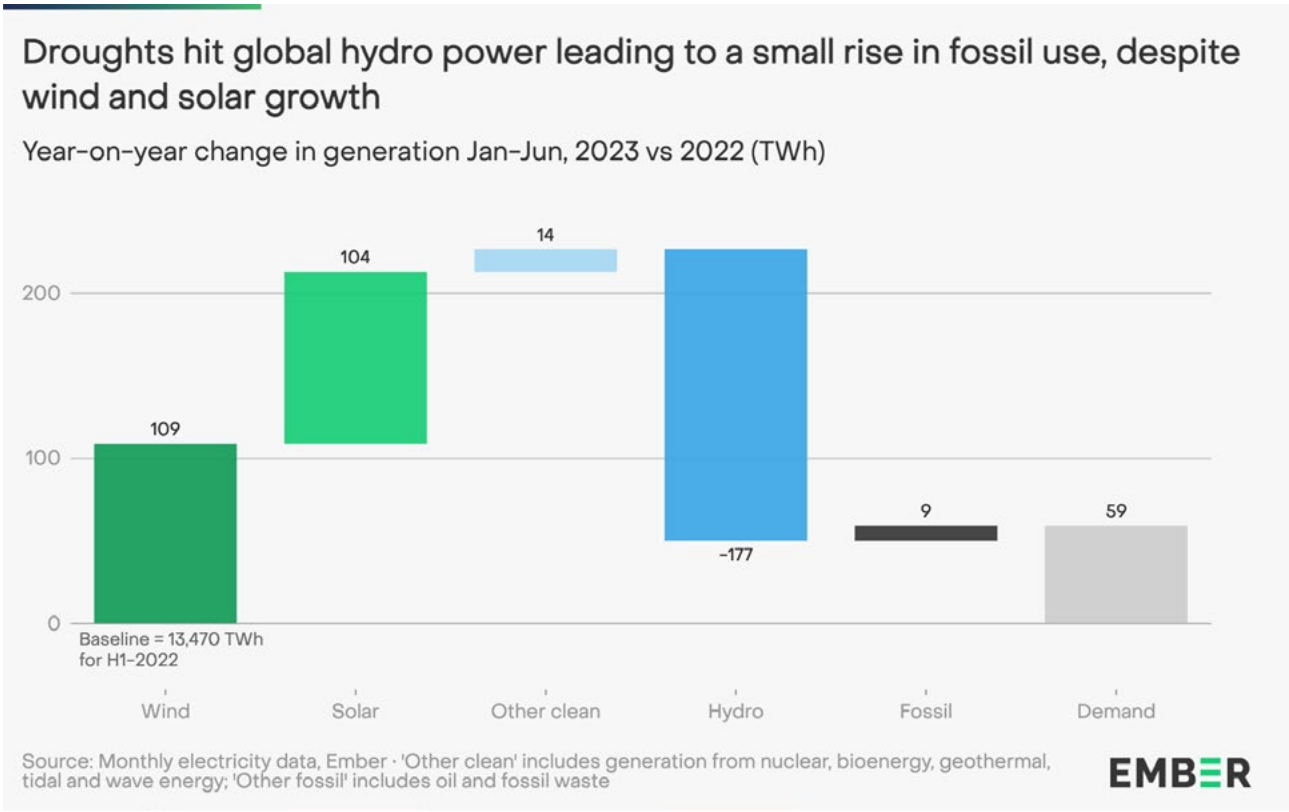
Historic fall in global hydro output

Hydro generation, the largest electricity source among all renewables, fell significantly (−8.5%, −177 TWh) in the first half of 2023 due to droughts. This was especially notable in China which accounted for around three-quarters of the global fall. Fossil generation increased slightly to meet the deficit created by hydro. Power sector emissions would have fallen by 2.9% had global hydro generation been at the same level as last year.

04

Low demand growth worldwide

Global electricity demand rose only 0.4% in the first half of 2023 compared to the same period last year, which is much lower than the average annual growth between 2012 and 2022 of 2.6%. Falls in demand in high-income economies were a major driver, including in Japan (−5.6%), the EU (−4.6%), the US (−3.4%) and South Korea (−1.4%) where this led to an overall fall in fossil fuels. Lower-than-expected demand growth in India of 3.1%, compared to a 10.7% increase in the same period last year, was another factor lowering global demand.



Fossil fuels and emissions would have fallen in the first half of 2023 if weren't for a historic fall in hydro generation due to droughts. It is unclear whether the situation will improve in the rest of the year. For now, the turning point for the power sector remains hanging in the balance.

Nonetheless, it is clear from the latest global data on electricity generation that the world is nearing the point of falling power sector emissions. Earlier this year, Ember's analysis showed that 2023 may be the first year with structurally falling global emissions from the power sector, if clean power growth continues. Before this point, power sector emissions have been structurally rising, and there have only ever been falls during global economic shocks such as the 2008 financial crisis or the 2020 Covid-19 pandemic. It still remains too close to call whether power sector emissions will fall across the full year in 2023.

Reaching 'peak' fossil emissions in the power sector is a crucial milestone in the global transition to a clean, electrified economy. But the most critical part is what happens next. To achieve the rapid declines in emissions required this decade, there needs to be a rapid acceleration in the deployment of wind and solar power. Tripling global renewable capacity by 2030 is the single biggest action that governments can take to put the world on course for a 1.5C aligned pathway.

"It's still hanging in the balance if 2023 will see a fall in power sector emissions. While it is encouraging to see the remarkable growth of wind and solar energy, we can't ignore the stark reality of adverse hydro conditions intensified by climate change. The world is teetering at the peak of power sector emissions, and we now need to unleash the momentum for a rapid decline in fossil fuels by securing a global agreement to triple renewables capacity this decade."

Malgorzata Wiatros-Motyka
Senior Electricity Analyst, Ember

"The message is simple: tripling renewable energy capacity by 2030 is the clear route to reducing emissions from the power sector, along with building a new energy system that delivers clean, secure and just power to the world. With hydro conditions now being affected by climate change, the challenge to world leaders and policy makers is growing; COP28 is the time for the world to rise to that challenge and deliver a clear target of tripling renewable capacity by the end of the decade and set the world on the course for net zero by 2050"

Bruce Douglas
CEO, Global Renewables Alliance

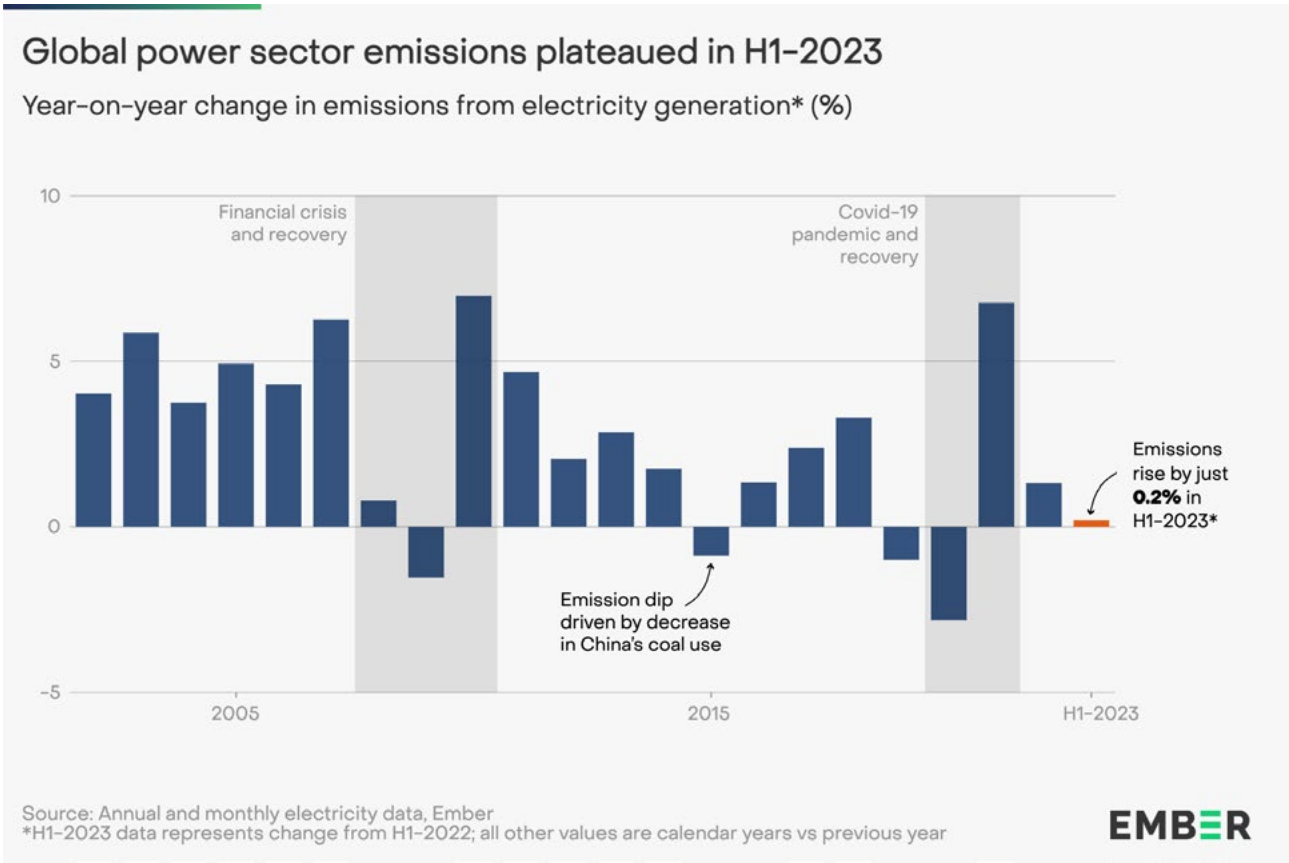
Chapter 1 | Global Analysis

Global power sector emissions plateaued

Global power sector emissions remained almost unchanged in the first half of 2023, as wind and solar continued to increase their share in the world's power mix. However, adverse hydro conditions–likely exacerbated by climate change–prevented emissions from falling in the first half of 2023.

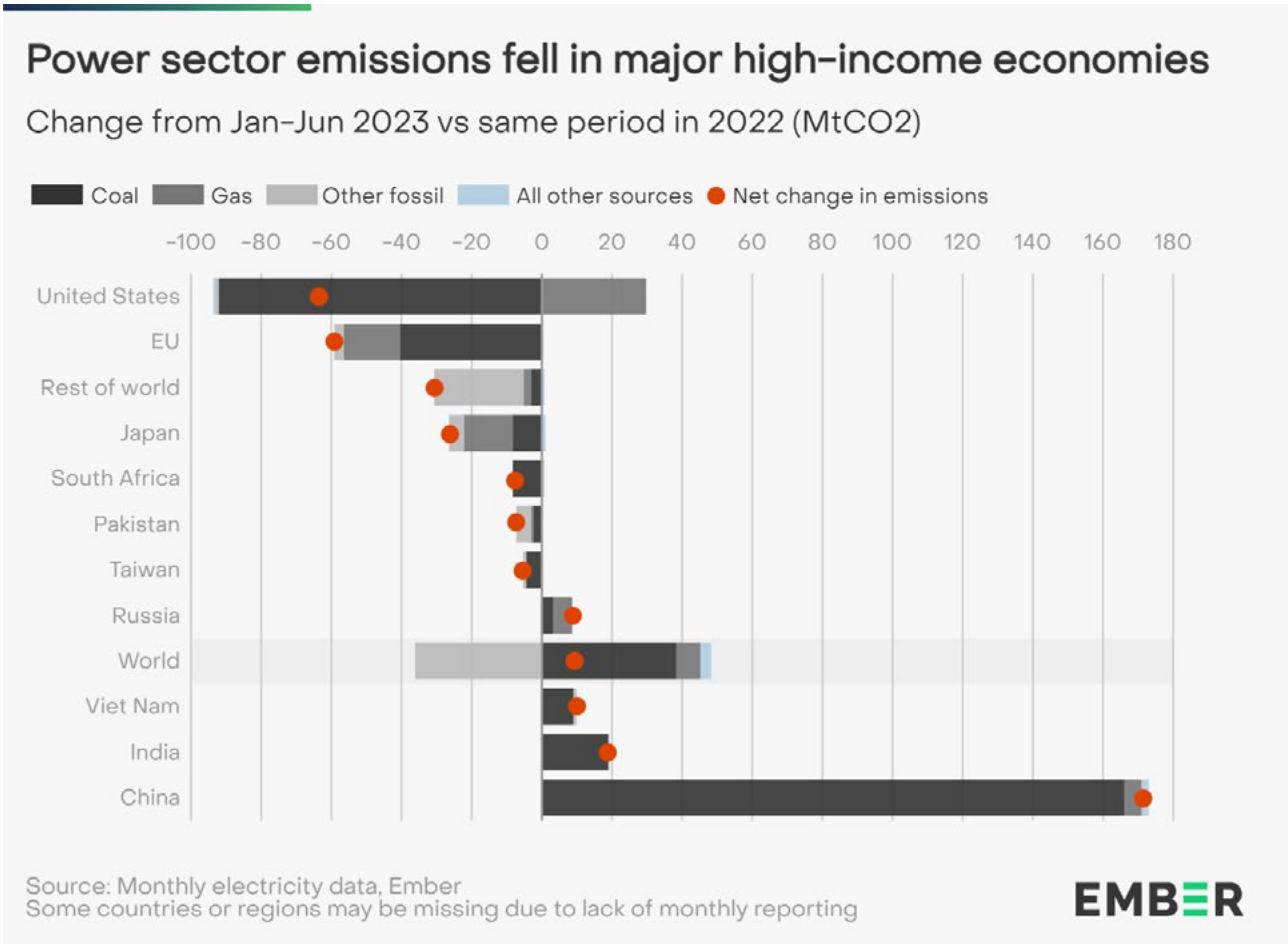
Global power sector emissions plateaued in H1-2023

The global power sector produced 5,795 million tonnes of carbon dioxide (mtCO2) in the first half of 2023, almost unchanged from the same period last year, with a slight increase of 0.2% (+12 mtCO2).



The plateau in 2023 is notable. Historically, power sector emissions have been rising structurally. There have only ever been falls during global economic shocks such as the 2008 financial crisis or the 2020 Covid-19 pandemic.

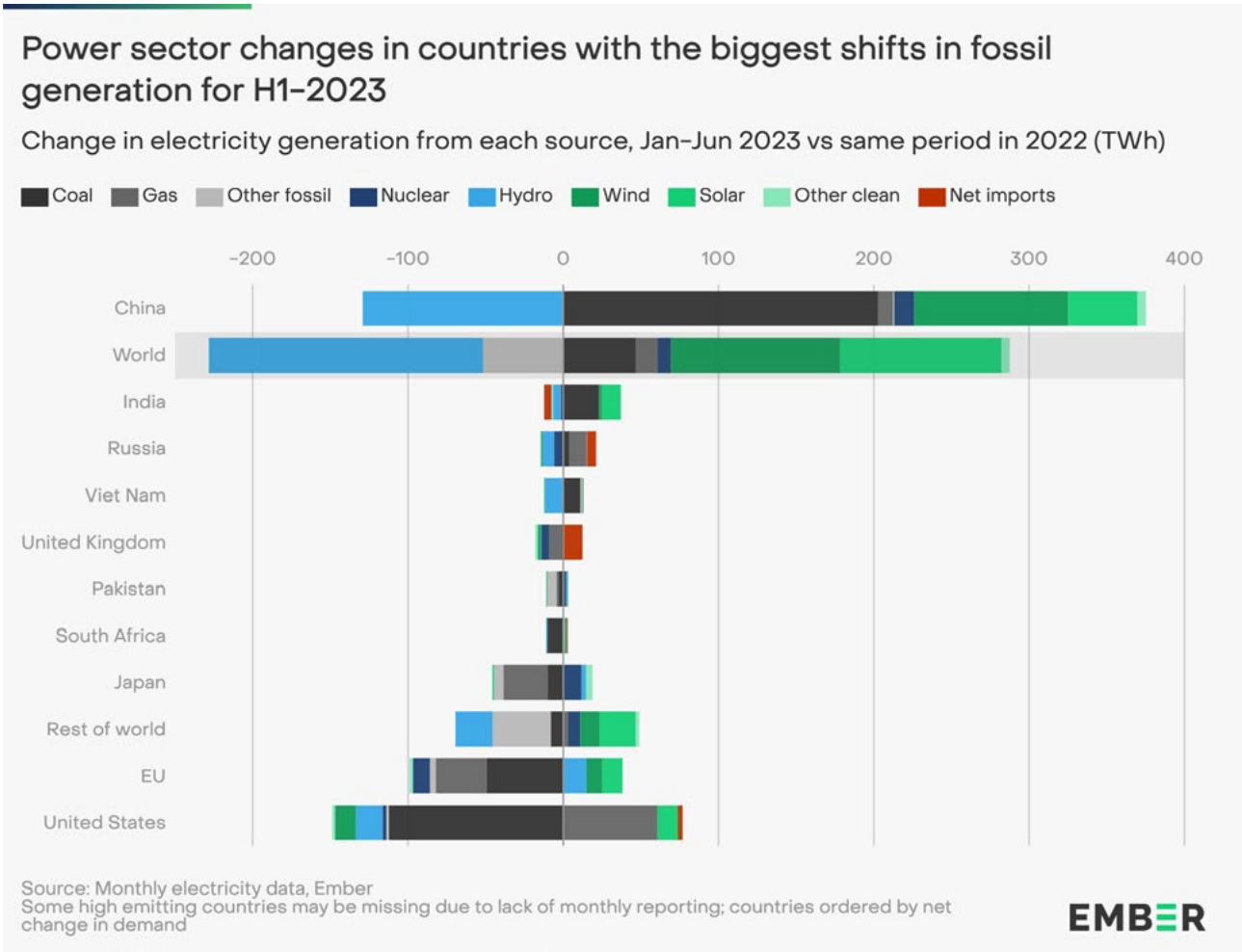
Major high-income economies saw some of the biggest falls in emissions. Emissions fell in the EU by 17% (-59 mtCO2), in the US by 8.6% (-64 mtCO2), in Japan by 12% (-25 mtCO2) and in South Korea by 3% (-3.6 mtCO2). India saw a slower increase in emissions, with emissions rising by 3.7% (+19 mtCO2) in the first half of 2023 compared to a 9.7% increase (+45 mtCO2) in the same period last year. In China emissions rose by 7.9% (+173 mtCO2), in large part due to poor hydro conditions.



Global fossil generation remained almost unchanged

Fossil fuels generated 59.9% of global electricity in the first half of 2023 (8,100 TWh), compared to 60.1% in the same period last year (8,091 TWh).

Global fossil fuel generation remained almost unchanged, rising by only 0.1% (+9 TWh) in the first half of 2023, compared to the same period last year. Coal generation increased by 1% (+47 TWh), gas generation rose by 0.5% (+14 TWh) but other fossil fuel (mainly oil) generation fell 15% (−52 TWh). Changes at the regional and country level varied significantly.



Japan and the EU were the only two high-income, high-polluting economies that saw a fall in both coal and gas. In contrast, in the US coal fell but gas generation increased.

Coal generation fell in some major high-income economies in the first half of 2023: the EU (−23%, −49 TWh), the US (−27%, −112 TWh), Japan (−7.4%, −10 TWh) and South Korea (−2.5%, −2.2 TWh). These falls were driven by the falls in electricity demand in these countries, and in the US also because of the coal-to-gas switch.

Elsewhere, coal fell in Chile (-33%, -3.8 TWh) despite demand slightly increasing (+0.5%, +0.2 TWh). Coal generation also decreased in South Africa (-9.8%, -10 TWh. In contrast, coal generation increased in China (+8%, +203 TWh) and India (+3.8%, +23 TWh) and some other developing nations.

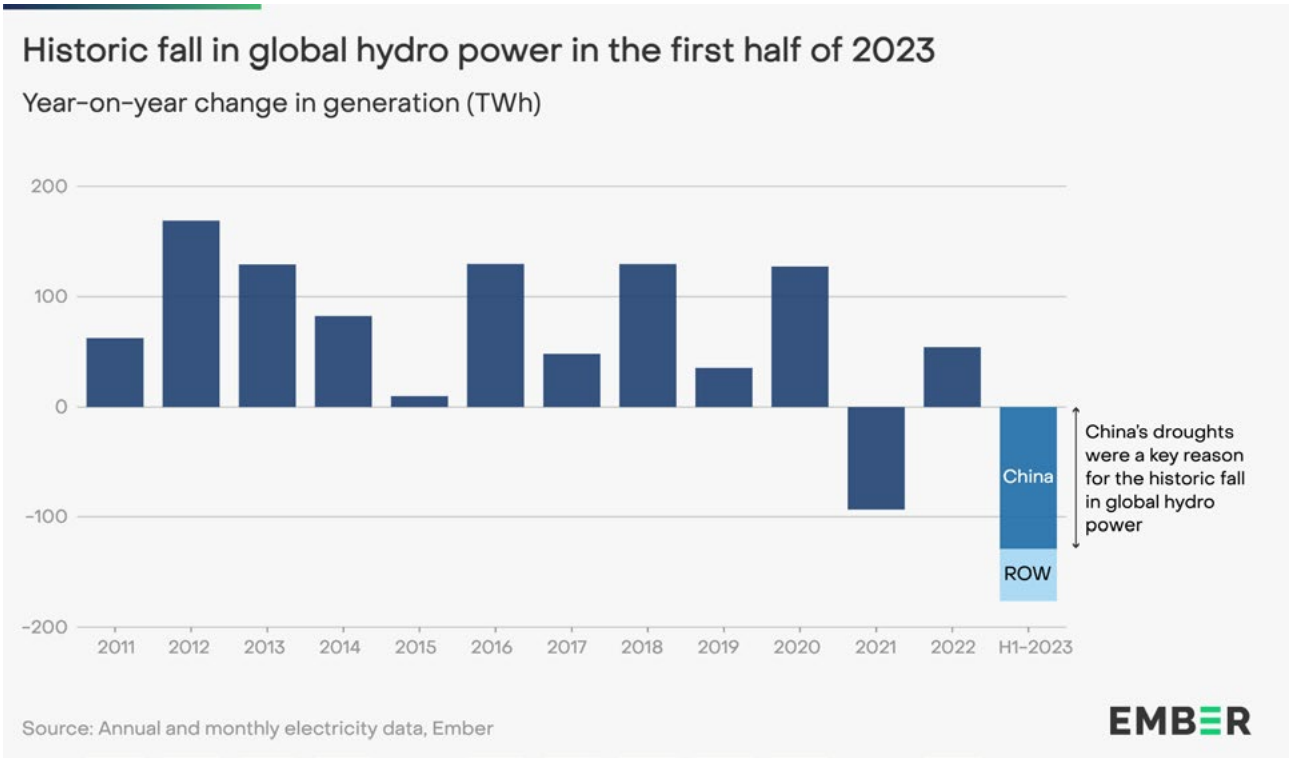
Gas generation fell in the EU (-13%, -33 TWh). Gas generation also fell in Japan (-17%, -28 TWh), and in India (-3.4%, -0.5 TWh), but increased in the US (+8.1%, +61 TWh) and in China (+8%, +9.7 TWh). In the US, gas generation has been increasing since 2005 while coal has been declining, a trend that is expected to continue at least in the near-term.

Generation from other fossil fuels, mainly oil, fell globally, with falls including the EU (-12%, -3.8 TWh), Japan (-22%, -6.1 TWh) and the US (-8.5%, -1.6 TWh) among many other countries.

Global hydro output sees historic fall

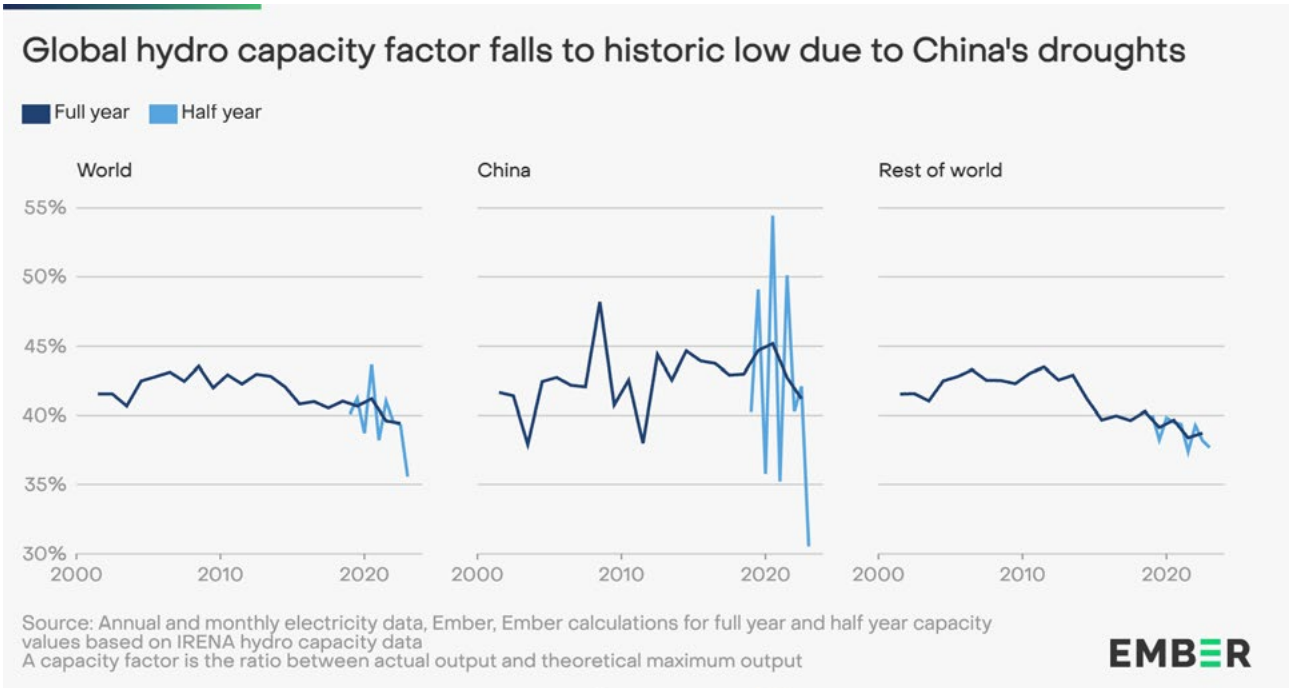
The first half of 2023 saw a historic decline in global hydro generation of 8.5% (-177 TWh), caused by droughts which were likely exacerbated by climate change. The fall in the six months to June was larger than any decline recorded across a full year in the last two decades. Three-quarters of the fall came from China (-129 TWh). As a result, hydro generated 14% (1,898 TWh) of global electricity in the first half of 2023, compared to a share of 15% (2,075 TWh) in the same period last year.

The adverse hydro conditions prevented a fall in global power sector emissions. Had hydro generation remained at the same levels seen in H1-2022, fossil generation would have not had to compensate for the hydro deficit of 177 TWh. Instead of a small rise, fossil generation would have fallen 168 TWh, leading to a fall in power sector emissions of 2.9% (-119 million tonnes of CO2).



The decline in hydro came despite additions in hydro capacity, as a result of worse hydro conditions in China, the US, India and other countries. This is evident in the capacity factor, which shows the actual output relative to the theoretical limit of the existing capacity. The first half of 2023 saw dramatic falls in the global capacity factor of hydro generation, which fell to 35.6%, nearly four percentage points lower than in H1-2022. Although the capacity factor for hydro fluctuates significantly between the first and second half of the year due to seasonal variations, H1-2023 represents a dramatic fall compared to historical values. Across the last 10 years, the average global capacity factor was 40.9%. This new low in 2023 comes after the global hydro capacity factor already hit two consecutive all-time annual lows in 2021 (39.6%) and 2022 (39.4%).

The hydro issues were particularly notable in China, where last year's droughts and ongoing heat waves in 2023 affected reservoir levels and hydro output. China's hydro capacity factor fell to 30.5% in H1-2023, ten percentage points below the first half of last year and the lowest value seen since at least 2015. With China representing nearly a third of the world's hydro generation (30% in 2022), conditions in China strongly influence global hydro output.



2023 as a whole is likely to set a record for the lowest global hydro capacity factor in recorded history if conditions don't substantially improve in the second half of the year.

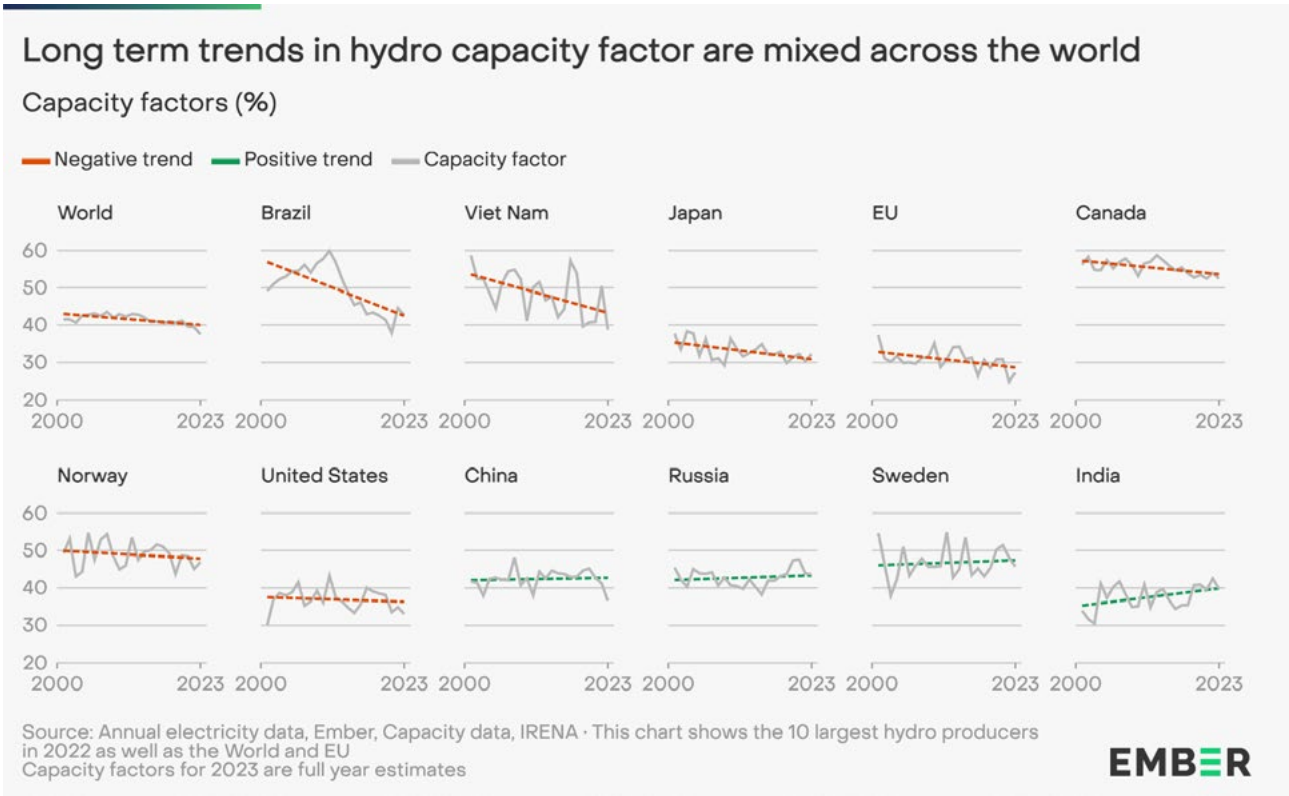
Uncertainty around structural decline in hydro conditions

The global long term outlook on the effect of climate change on hydro output is uncertain as effects of climate change on hydro potential are geographically varied. Changes in rainfall patterns and intensity as well as increased evaporation will affect hydro output both positively and negatively depending on the region. The IPCC's AR6 WGII report states that by 2080, climate conditions could affect production between +5% and −5% under a high emissions scenario. While central Africa, India, central Asia and northern high latitudes are expected to have higher hydropower potential, southern Europe, the southern US and others could see their hydro potential worsen.

Many countries are experiencing lower hydro output than at the start of the century. Recent years have been marked by periods of droughts and reduced hydro output, notably in China, Europe, and other regions.

However, the historical long-term trend regarding global hydro conditions remains ambiguous, with significant regional disparities in the impacts of structural factors like climate change on hydro conditions.

It is true that the global capacity factor for hydro has seen a slight downward trend in the last two decades. However, at the same time, India, Russia, Sweden and China have seen their capacity factor increase over this time period, the latter even holds when accounting for China's recent downturn. Consequently, it is difficult to predict future trends for hydro generation at a global level.



What the hydro lows mean for the electricity transition

This year's record fall in hydro generation is a warning shot that hydro output could negatively affect the speed of the electricity transition.

In the IEA's net zero scenario, hydro generation would have to rise by 4% annually from 2021 to 2030 to be on track for net zero emissions by 2050. However, this has not been met in either 2021 (-2.2%), 2022 (+1.3%) or H1-2023 (-8.5%).

When hydro generation remains below expectations, it leaves a deficit that new low-carbon electricity (mostly wind and solar) has to make up for in addition to meeting additional electricity demand and replacing fossil fuels. Only when sources like wind and solar grow fast enough to overcome both the uncertainty of output from other clean sources as well as growing electricity demand will we see substantial reductions in fossil generation and emissions.

Wind and solar continue to increase their share in the global power mix

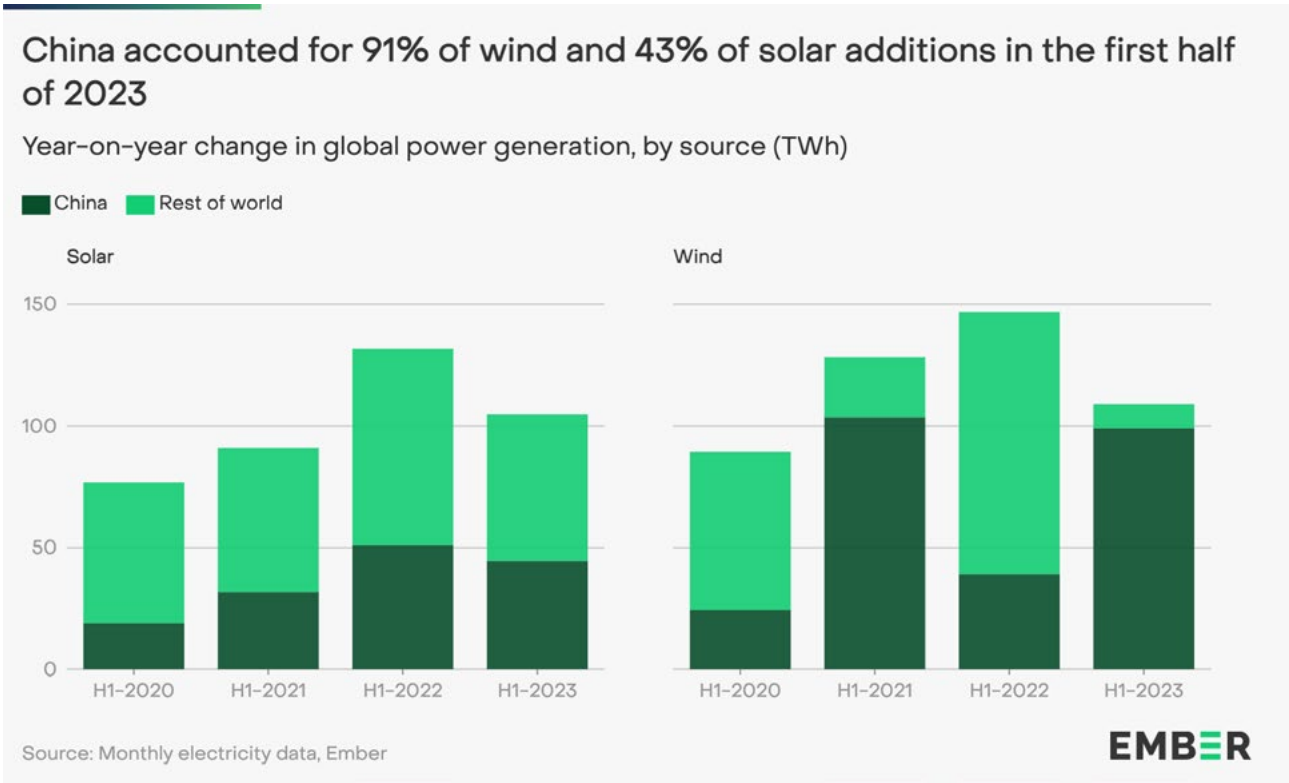
Wind and solar were the only two electricity sources that significantly increased their share in the global power mix. Together wind and solar generated 14.3% of global electricity in the first half of 2023 (1,930 TWh), a 1.5 percentage points increase from the same period last year, when they generated 12.8% of global electricity (1,717 TWh). In the first half of 2023, 5.5% of global electricity came from solar and 8.8% from wind.

Globally, wind and solar both grew in H1-2023 compared to the same period last year, although at a slower rate than they did last year. Wind generation increased by 10%, lower than the growth in the same period last year (+16%). Solar generation rose 16%, also lower than the 26% increase in the same period year. Such increases are below the growth needed for net zero, which requires a yearly average growth of 17% for wind and 24% for solar, according to the IEA's net zero scenario.

In absolute terms, wind and solar gain also remained below last year's level: solar grew by 104 TWh compared to 132 TWh in the same period last year. Wind generation increased by 109 TWh compared to gains of 147 TWh in the same period last year.

China remains a global leader in wind and solar

China accounted for 91% of global growth in wind power and 43% of global growth in solar generation in the first half of 2023. The next largest contributors were the EU and India, who each accounted for 12% of global growth in solar generation.

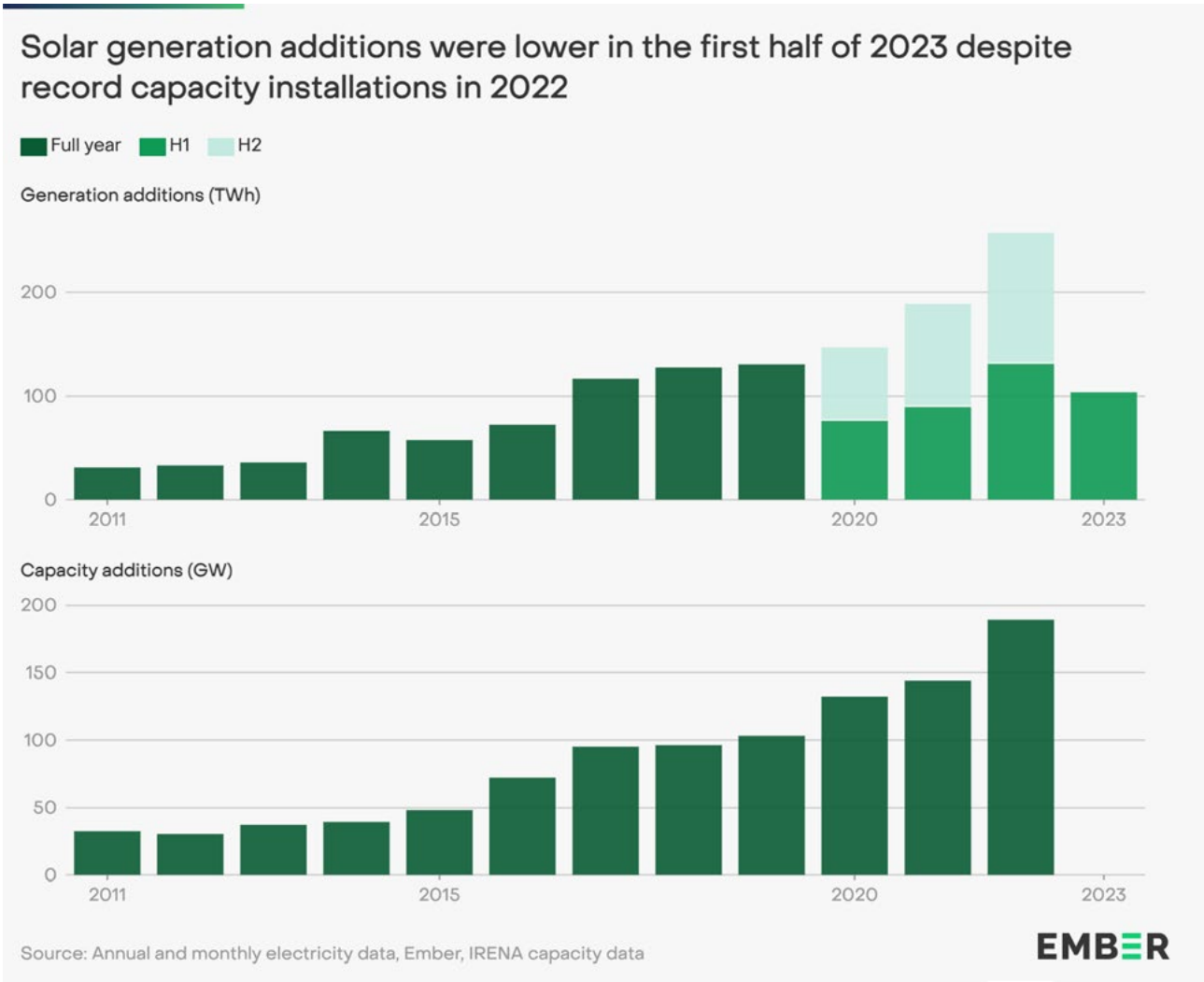


The EU, US and Japan are lagging behind China's progress on wind generation. China achieved a 26% growth in wind generation in the first half of 2023 compared to the same period last year. In comparison, wind generation only grew 4.8% in the EU, while Japan recorded only a 2.4% increase from an already low baseline. The US saw wind generation fall 5.6% due to poor wind conditions.

Similar to wind, the EU, US and Japan are also lagging behind China's progress on new solar generation. China's solar generation grew by 21% in the first half of 2023 compared to the same period last year. India, however, had an even higher growth rate (+26%) in the first half of 2023, but from a much lower base than China. In comparison, solar generation grew only 13% in both the EU and the US, while it fell in Japan by 2%.

Solar generation growth lower than expected given capacity additions

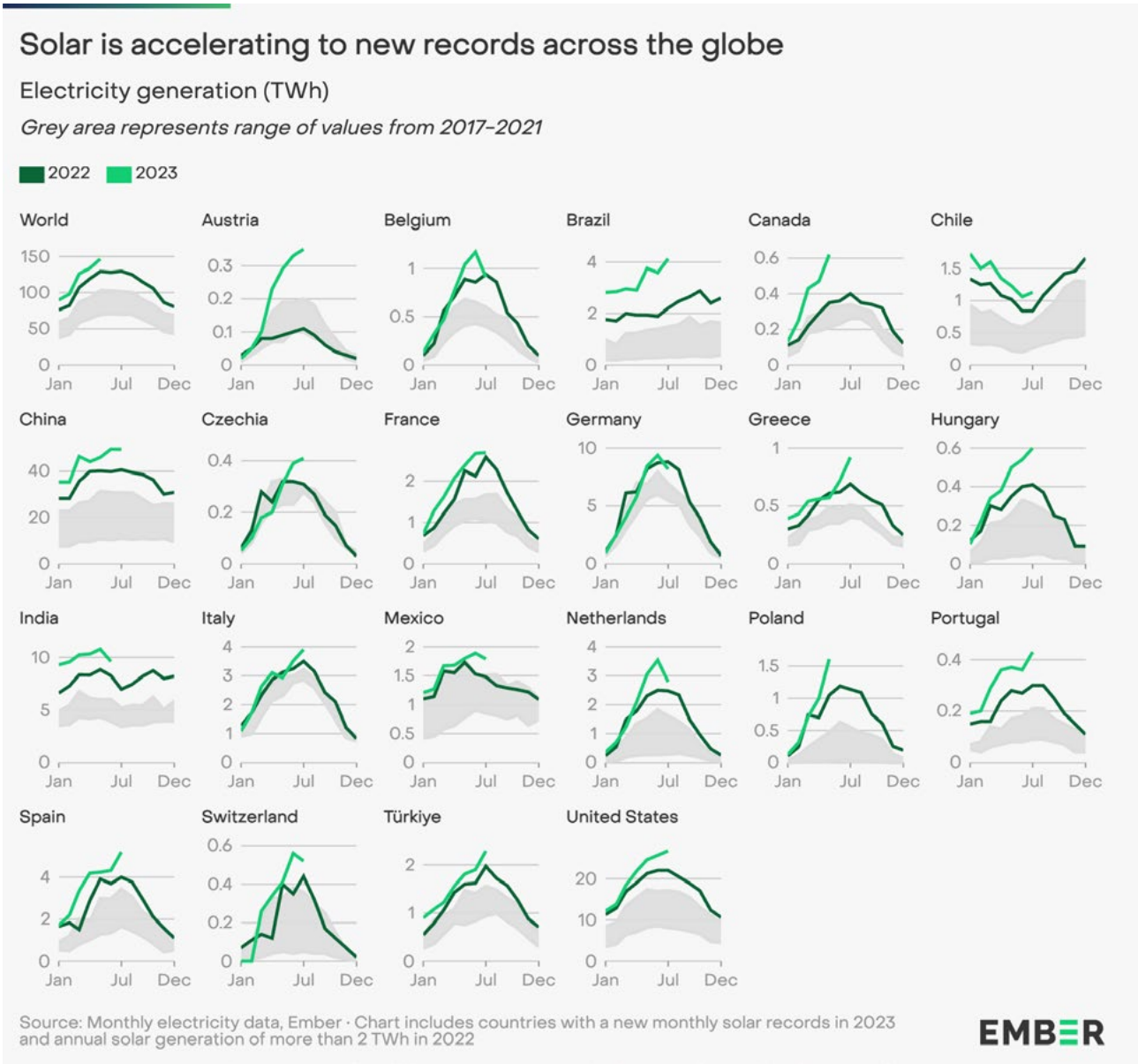
Based on capacity addition estimates by the IEA, it would have been expected that solar generation would increase by around 140–160 TWh in the first half of 2023. Therefore, the actual observed increase in solar generation of 104 TWh is 26–35% below the expectation.



The difference in expectations compared to actual growth can partially be explained by weather conditions. Another possible reason is an increase in unmeasured behind-the-metre capacity being installed on rooftops, which can lead to lower reported demand as well as underreporting in actual solar generation and growth.

50 countries hit new monthly records for solar generation

Despite slower-than-expected solar generation growth, 50 countries across the globe experienced new monthly records for solar generation in the first half of 2023.



In Asia, China and India were among those with new monthly records. For example, China generated 50 TWh (6.4% of its electricity) from solar in June 2023, an increase of 9.7 TWh when compared to June 2022. The electricity generated from solar in China in just the month of June (50 TWh) would be enough to power a

country like New Zealand, Qatar or Hungary for a whole year. India achieved a new record in May 2023, generating 10.8 TWh (7.3% of its electricity) from solar, an increase of 2 TWh compared to May 2022.

In the EU, 24 of the bloc's 27 members saw new solar highs as of June. For example, the Netherlands generated 3.5 TWh (36%) from solar in June 2023, compared to 2.3 TWh in May 2022, while Poland generated 1.9 TWh (16%) in May 2023, compared to 1.2 TWh in May 2022. Records were also broken in the US, Mexico, Brazil and Chile, among many others in the Americas and around the globe. For example, the US generated 26 TWh (7% of its electricity) from solar in June 2023, compared to 22 TWh in June 2022. Chile generated 1.7 TWh (24%) from solar in January 2023, compared to 1.3 TWh in January 2022.

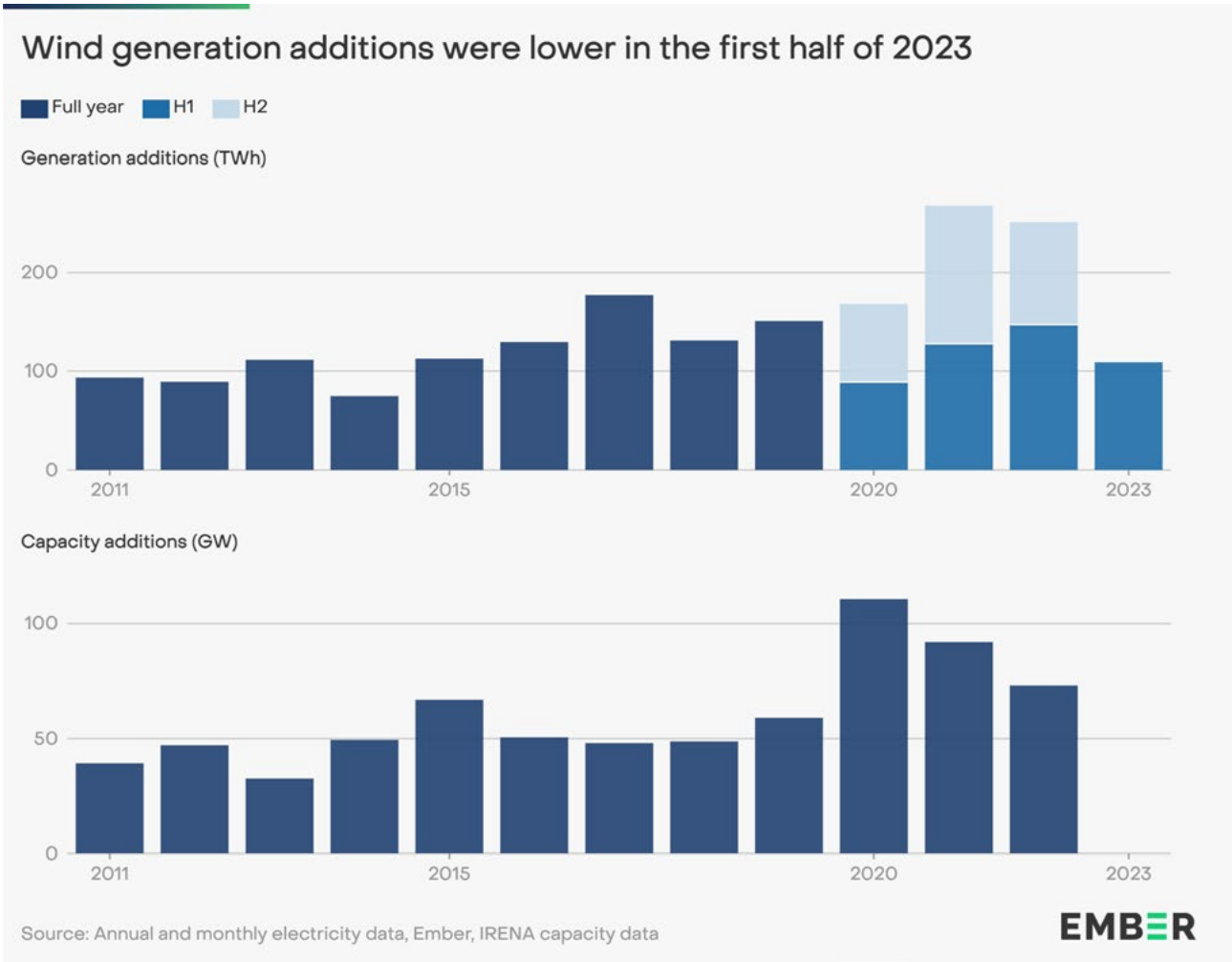
Slowdown in global capacity additions for wind power

In contrast to the steady growth in annual solar capacity additions, wind capacity additions are not trending upwards. After peaking in 2020, wind capacity additions were smaller in the following two consecutive years. In 2020, 111 GW of wind capacity was installed worldwide, compared to 92 GW in 2021 and 73 GW in 2022.

As a result, the growth in wind generation has slowed in recent years. 2021 saw the largest growth in wind generation in history (+268 TWh), but this slowed in 2022 (+251 TWh) and the first half of 2023 has seen an increase of 109 TWh in new wind generation in comparison to last year.

Among major economies, the EU, the US, and Japan are lagging behind on wind growth while China was responsible for 91% of the global growth in wind generation in the first half of 2023.

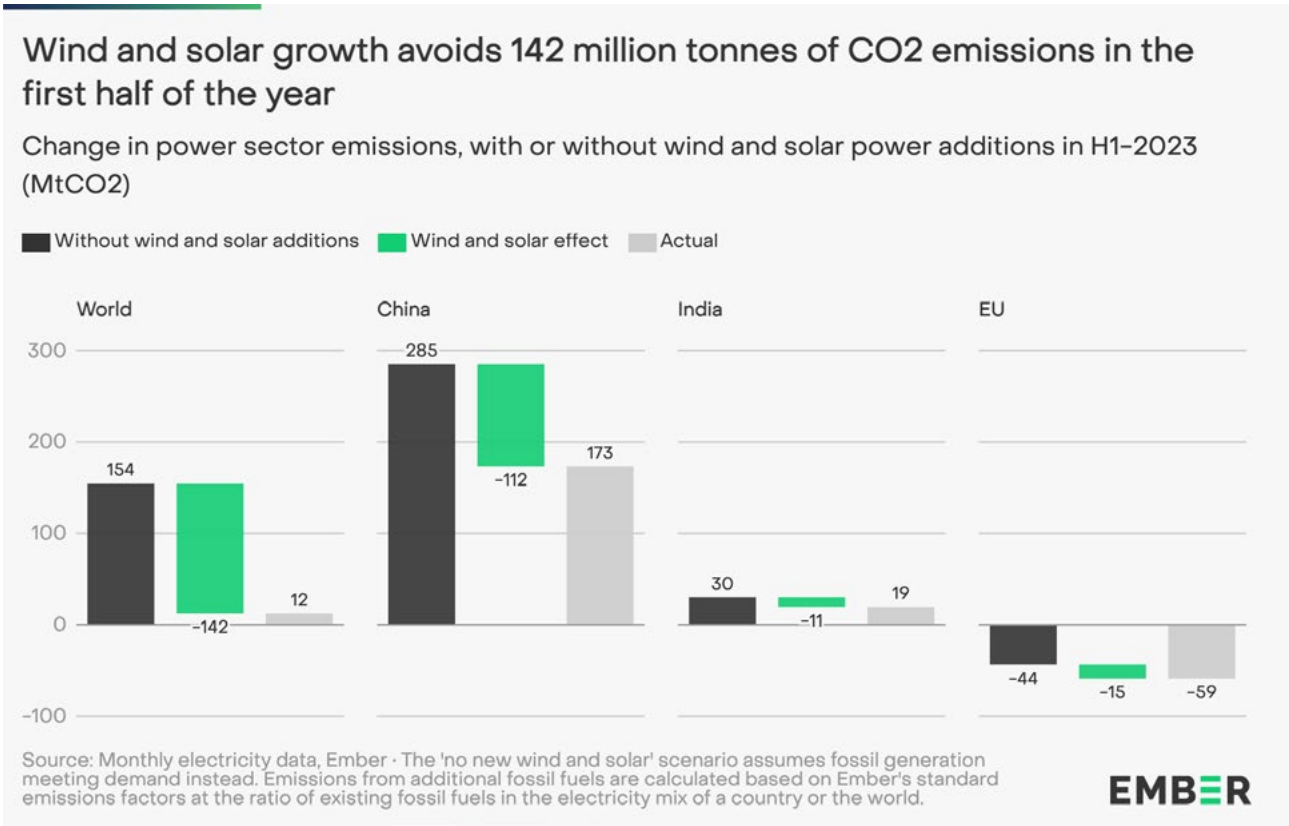
There are significant barriers holding back wind deployment in many parts of the world, including permitting and grid connection delays. Additionally, as expected, temporary weather conditions affected wind generation in some countries, notably in the US in the first half of 2023, where wind generation fell by 5.6% (–13 TWh). It is clear that many governments need to take action to speed up additions in wind.



Wind and solar additions prevented major emissions increase

Wind and solar additions continue to be the main driver of the electricity transition as additions in H1-2023 avoided 142 million tonnes of CO2 emissions.

In H1-2023, wind and solar generation increased by 213 TWh compared to the same period last year. This uptick met all of the rise in electricity demand and compensated for some of the decline in hydro generation. Without this contribution from wind and solar, the shortfall would have been met by fossil fuels, resulting in a higher emission increase. Instead of a 0.2% increase in power sector emissions, equivalent to 12 million tonnes of CO2, the increase would have been 2.6%, or 154 million tonnes. Due to the growth in wind and solar generation, the potential emissions increase was reduced by 92% (-142 million tonnes of CO2), which is equivalent to more than the total power sector emissions of South Korea in H1-2023.



This dynamic is especially evident in China. Without wind and solar additions meeting the 6% increase in electricity demand, fossil fuels would have met the demand increase instead, resulting in an emissions increase of 285 million tonnes of CO2 (+13%). Instead, China's power sector emissions rose by 173 million tonnes of CO2 (+7.9%).

In India, wind and solar growth prevented an increase of 11 million tonnes of emissions. Power sector emissions rose by 19 million tonnes of CO2 (+3.7%), instead of a potential 30 million tonnes of CO2 (+5.7%) if wind and solar had remained at the same level as in H1-2022.

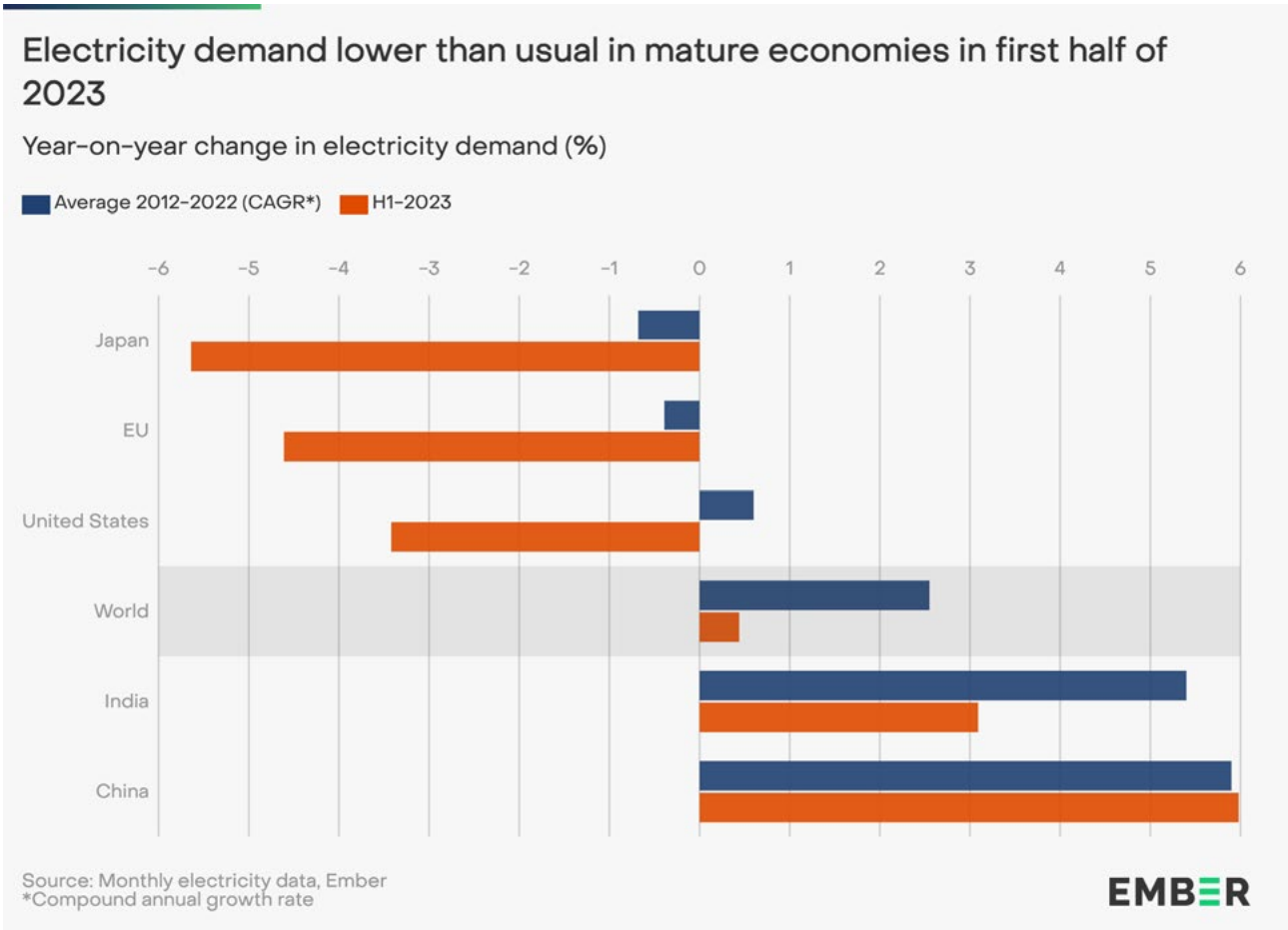
In the EU, power sector emissions fell, as lower demand reduced the need for some fossil generation. Additions in wind and solar reduced fossil generation further. Emissions fell by 17% (-59 million tonnes of CO2). Without wind and solar additions, they would have fallen by 13% (-44 million tonnes of CO2).

Low demand growth worldwide

Global electricity demand rose only 0.4% (+59 TWh) in the first half of 2023; a much lower rise than 2.8% in the same period last year. The increase is also lower than the yearly historical average over the last decade of 2.6%. Such low growth was driven by demand falls in a number of mature economies, and by lower than expected demand growth in India. Electricity demand fell by 5.6% in Japan, 4.6% in the EU, 3.4% in the US and 1.4% in South Korea. Such falls in demand contributed to reducing emissions in each of these countries and to flattening emissions at the global level.

Demand falls in high income economies were due to varying reasons. In the EU, the electricity demand falls have continued since March 2022 in the wake of Russia's invasion of Ukraine. The fall in the first half of 2023 is larger than the falls due to the Covid-19 pandemic in 2020. Since 2022, the demand falls can be attributed to a combination of factors: policy measures aimed to reduce demand amidst the energy crisis and security of fossil gas supply concerns, a large cut by energy-intensive industries, mild weather in winter, and reduced personal electricity use due to a cost of living crisis. Under-reporting of behind-the-meter solar generation is also leading to some misattribution, showing electricity demand falling, instead of solar rising. This is a problem in many European countries, made apparent by the unprecedented surge in new rooftop solar installations. In the US, demand fell due to slower economic activity and milder weather. In Japan, demand fell due to milder weather but also due to some electricity saving measures.

Demand increased in China and India as these countries continue to advance their economies. In China, electricity demand increased by 6%, in line with national estimates for 2023 and similar to the historic average for 2012-2022 (+5.9%). In India, demand increased by 3.1%, which was lower than the average growth for 2012-2022 (+5.4%) and much slower than the 11% growth seen in the same period last year, when the country was recovering from Covid-19 lockdowns as well as experiencing some heatwaves.



Slow demand growth, and especially the falls seen in some mature economies, is unlikely to continue to the same level in the future. As countries electrify their economies, their electricity demand is likely to increase, even as efficiency improves. This means that countries cannot rely on falling demand to reduce emissions from the power sector. Instead they need to increase their clean electricity sources. At the same time, electricity demand is expected to increase across rapidly-growing economies, including China and India, as they continue to advance their economies and increase access to electricity.

Chapter 2 | Country and region analysis

Deep dive on the five biggest power sector emitters

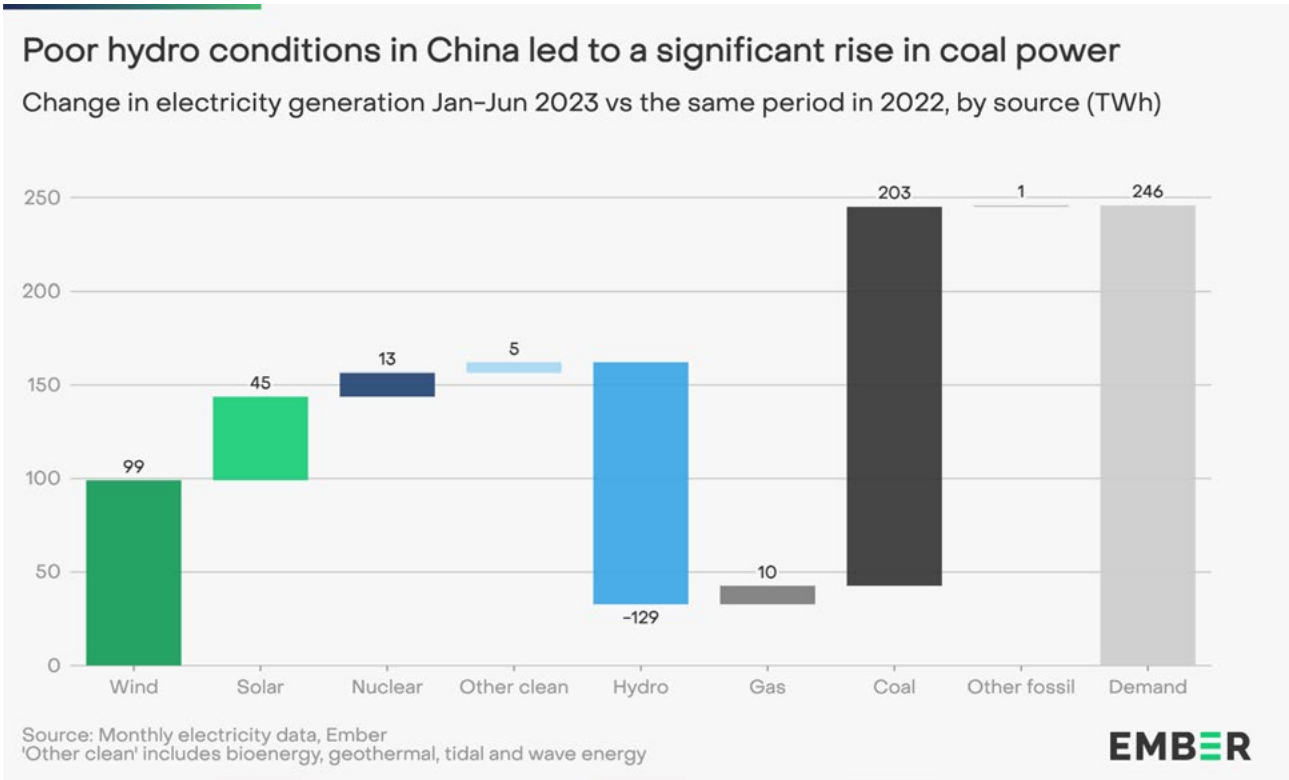
Electricity demand fell in some high income economies (the EU, Japan, and the US), driving their emissions down and contributing to flattening emissions at the global level. In India, demand grew moderately leading to slower growth in coal generation compared to the same period last year which in turn slowed down emissions rise. Demand also increased in China where problems with hydro necessitated higher coal consumption and led to increased emissions.

China

China accounted for two-thirds of global growth in wind and solar generation in the first half of 2023, but poor hydro conditions led to an increase in coal power.

China is the world's largest power producer, accounting for 31% of global generation, and it will continue to be responsible for most future global demand growth. Hence, what happens in the country's electricity sector is critically important to the global electricity transition.

In the first half of 2023, China accounted for 67% of global growth in wind and solar generation, but poor hydro output meant that China also saw a significant increase in generation from coal.



China's demand increased above the world average

China's electricity demand grew 6% (+246 TWh) in the first half of 2023, a larger increase than the 2.4% growth seen in the same period last year. However, the country's growth this year is in line with its average growth over the last decade (2012–2022) of 5.9%. As usual, China's demand growth in the first half of this year was significantly higher than the global average of 0.4%.

Demand growth in China was mainly caused by economic growth, which is forecast to be about twice the world's average this year, as well as heat waves over May and June resulting in increased demand from air conditioning in that period. Despite the temporary weather-related increases, the demand growth of 6% this year so far has been in line with the China Electricity Council forecast for 2023 of 6%.

China remains a global leader in new wind and solar generation

China continues to be the global leader in the build up of wind and solar, accounting for 67% of the global increase in wind and solar generation in the first half of 2023.

China's wind generation increased 26% (+99 TWh) in the first half of 2023, compared to the same period last year, which is almost three times faster than the global average. China's fast growth in wind generation is outpacing growth in the EU, Japan and the US where generation either grew moderately or saw small falls. This meant that 91% of global additions in wind generation in H1-2023 came from China. At the same time, China's solar generation grew 21% (+44 TWh), higher than global solar growth of 16%. In the first half of 2023, China provided 43% of the global increase in solar generation. Combined, the two sources grew 24% (+144 TWh) in China, nearly double the global average growth of 12%.

Generation from wind and solar in China has doubled in just three years. In H1-2020, 369 TWh were produced from wind and solar. In H1-2023, this had increased to 738 TWh. Consequently the share of wind and solar generation also increased substantially, from 11% in H1-2020 to 17% of China's electricity in the first six months of 2023. It is the first six-month period in which China has generated more than a sixth of its electricity from wind and solar.

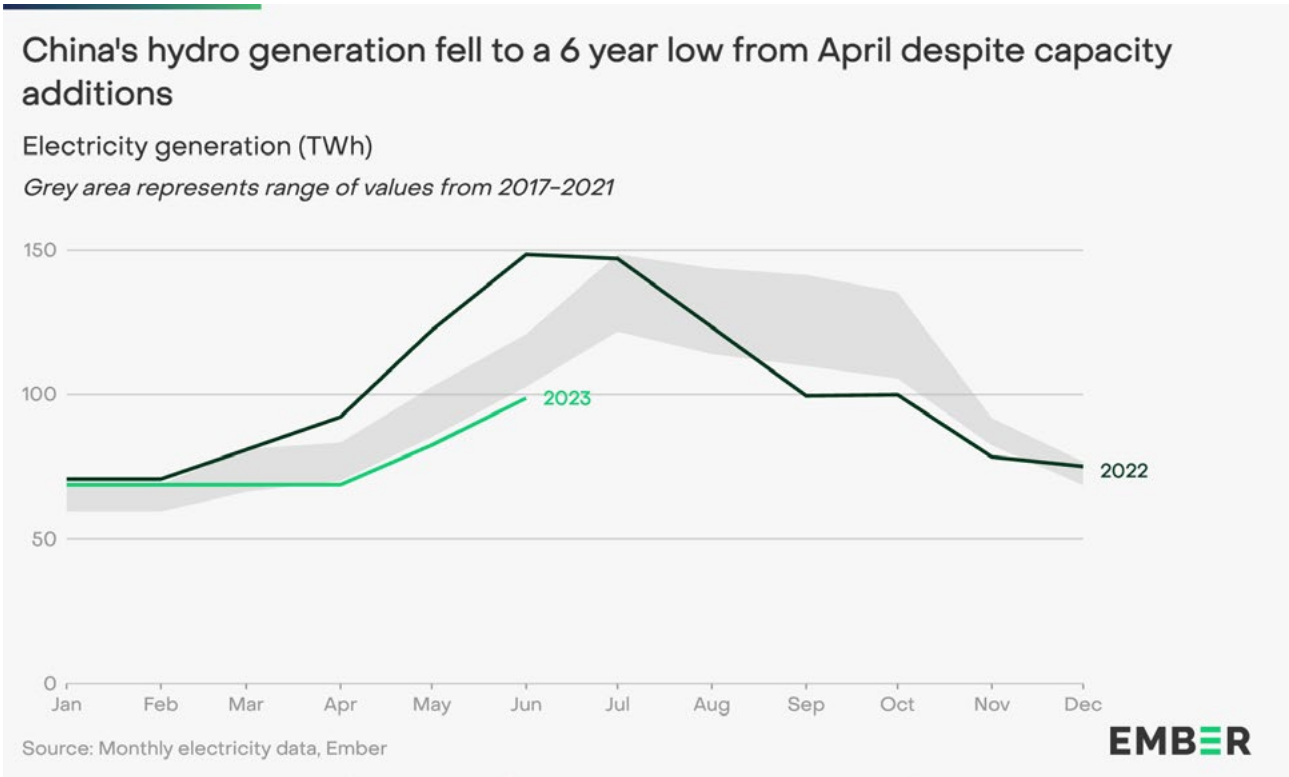
China remains a global leader in new wind and solar generation

Wind and solar additions covered 58% (144 TWh) of the increase in China's electricity demand. Small increases in other clean generation, such as nuclear and bioenergy, contributed less than 10% (18 TWh) of the rise in demand. New hydropower projects were also completed, but droughts saw output from hydropower fall by 22% (-129 TWh).

This hydro deficit—alongside the rise in demand that was not met by clean power generation—created a large shortfall which was filled by coal generation, which increased 8% (+203 TWh) to a new record high.

Had hydro generation been unchanged year-on-year, China's coal generation would have increased far more slowly, as it would not have had to make up for the large hydro deficit of 129 TWh. With the hydro deficit, China's coal generation increased by 203 TWh (+8%) in the first half of 2023, compared to the same period last year. Without this deficit it would have risen by 74 TWh (+2.9%). This would have been enough to turn a rise in global coal generation of 47 TWh into a fall of 82 TWh.

It is still possible for China's hydro output in 2023 to recover. Severe droughts started to have a negative effect on China's hydro generation in the second half of 2022, and continued into the first half of 2023. Average or good hydro conditions in the second half of 2023 could therefore see a return to output significantly above the previous year's levels.



China's power sector emissions rise

Driven by the increase in coal generation, emissions from China's power sector jumped 7.9% (+173 million tonnes of CO2) in the first six months of 2023. In comparison, global power sector emissions rose much more slowly (+0.2%). Most of the increase in China occurred from March to June. As of February, China's power sector emissions had been 1.4% below levels seen in the first half of 2022. However, from March onwards, poor hydro conditions led to an increase in coal generation.

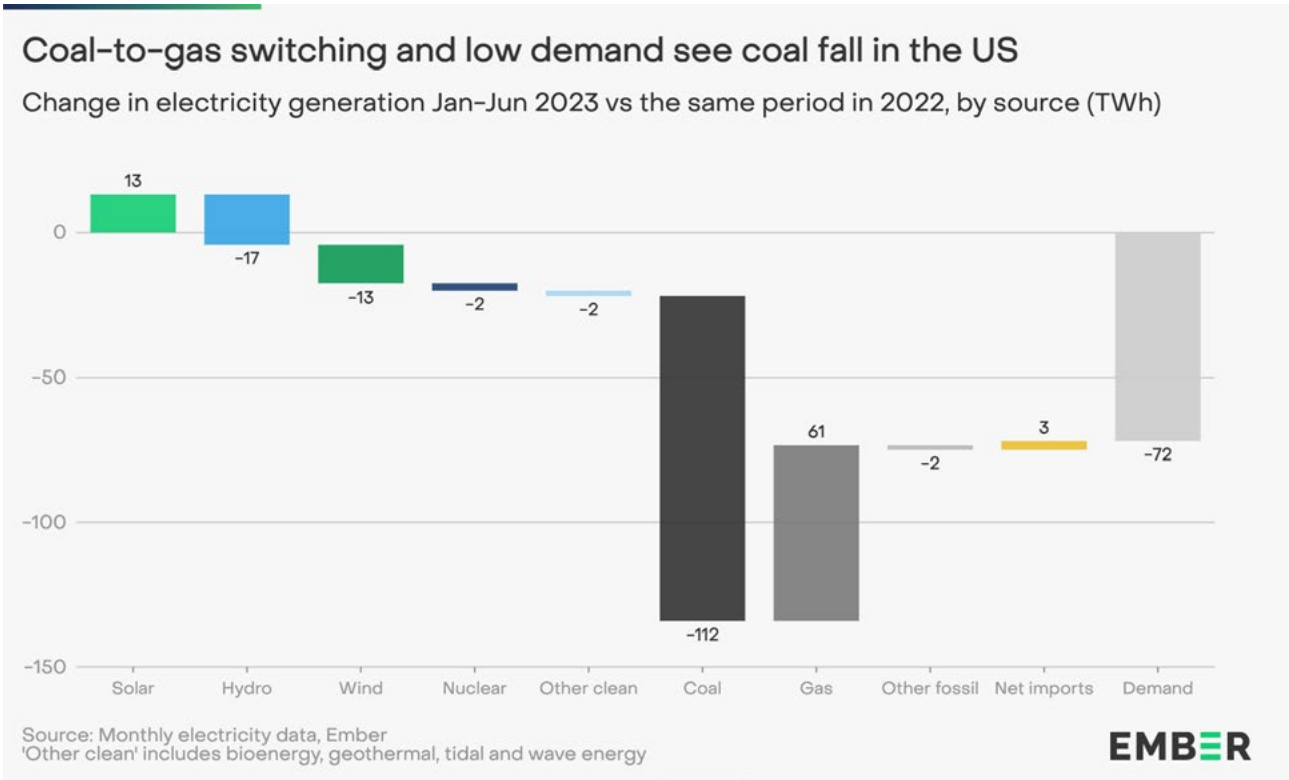
Whether further increases in China's power sector emissions can be avoided depends on several factors. If wind and solar continue to increase at their current growth rates, their additions alone could soon be enough to meet all of China's

increase in electricity demand. It will then depend on other clean sources such as nuclear generation and volatile hydro conditions as well as the rate of economic and demand growth, when we see the first structural emission falls in China's power sector.

United States

United States responsible for 13% of global solar growth in the first half of 2023.

The US contributed 13% of global growth in solar generation in H1-2023, despite national growth rates (+13%) lower than the global average (+16%). At the same time, wind generation in the US fell 16%, due to worse wind conditions than in the previous year. As a result of demand falling and coal-to-gas switching, US power sector emissions fell by 64 million tonnes, which helped ensure that global power sector emissions plateaued rather than increased.



Coal-to-gas switching pushed US coal generation down

US coal generation fell by 27% (−112 TWh) in the first half of 2023 compared to the same period last year. This was a result of a switch to gas generation, which increased by 8% (+61 TWh), as well as significant falls in electricity demand of 3.4% (−72 TWh) after two years of above average demand growth. The reduction in demand in the US was caused by both slower than expected economic growth as well as milder temperatures in Q1 of 2023. Both economic growth and electricity demand are expected to rise again in 2024.

US renewables stall as wind and hydro dip

Renewable electricity generation in the US fell by 3.7% (−19 TWh) in the first half of 2023, compared to a global increase of 10%. US wind generation fell by 5.6% (−13 TWh), in contrast to a global rise of 10%. US hydro generation fell by 12% (−17 TWh), similar to the global decline of 12%. Other renewables and bioenergy saw only minor changes. US solar generation grew 13% (+13 TWh), but remained below the global trend (+16%).

This year's fall in US hydro generation follows multiple years of hydro decline or stagnation since the peak in H1-2017, with the exception of H1-2021. Compared to H1-2017, hydro generation H1-2023 was down 23%.

The reduction in US wind generation of 5.6% is surprising given the 6% increase in wind capacity in the 12 months to June 2023. However, good wind conditions in H1-2022 caused wind generation to grow by 25%. Wind generation in H1-2023 was still up 18% compared to two years prior in H1-2020.

In addition to the 6% increase in wind capacity, the eia reported a staggering 25% increase in US solar capacity in the 12 months leading up to June 2023. Solar and wind generation look poised to increase substantially, depressing coal generation further if hydro conditions remain at current levels or improve.

Fall in US power sector emissions due to lower demand and coal to gas switch

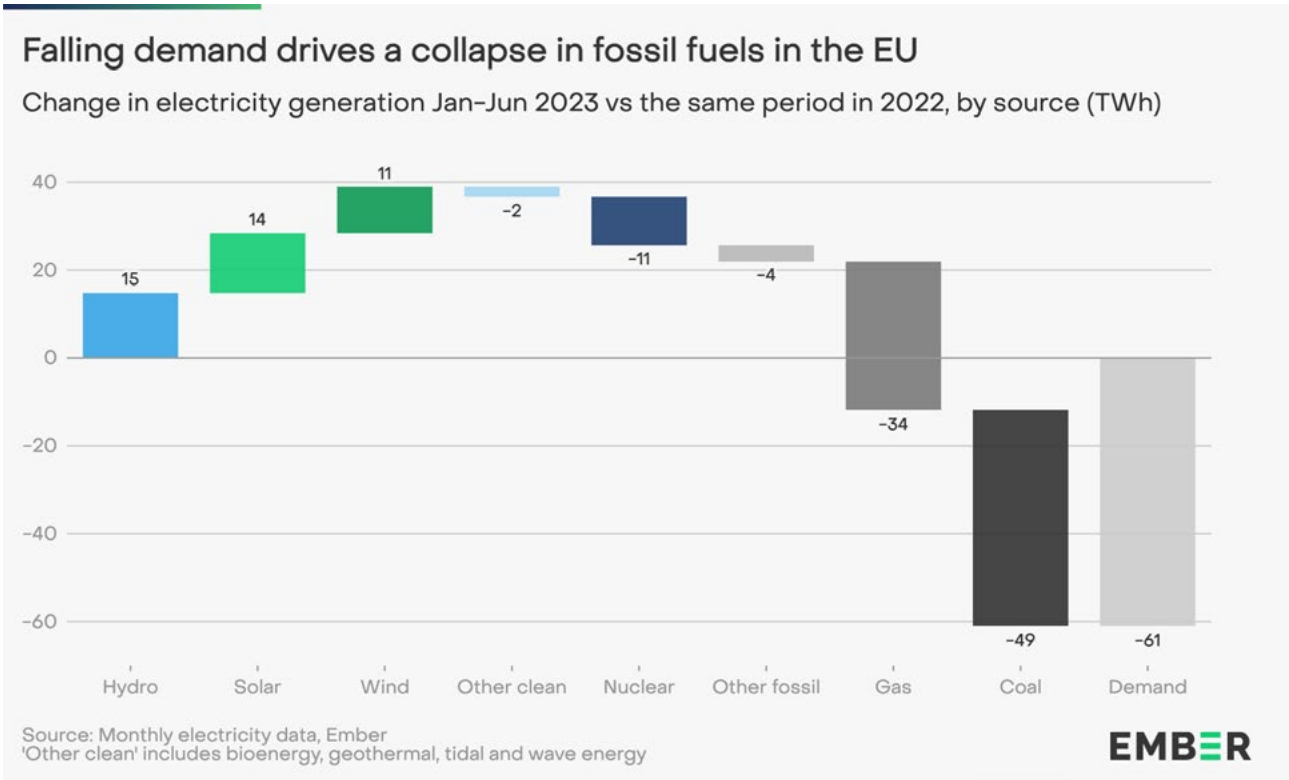
The substantial fall in coal generation caused US power sector emissions in H1-2023 to fall 8.6% (-64 million tonnes of CO2). The fall in US emissions is equivalent to 1.1% of global power sector emissions and contributed to global sector emissions plateauing with an increase of just 0.2% (12 million tonnes of CO2) in the first half of 2023.

Due to the continued additions of renewables, power sector emissions in the US have been structurally falling for more than a decade. For the full year of 2022, power sector emissions were 17% below the level 10 years earlier in 2013. However, the falls in H1-2023, although significant, are still lower than previous falls seen in the pandemic year of H1-2020, or H1-2016 when coal consumption decreased as gas and oil increased. For the US to continue with significant emissions declines, it cannot rely on demand reductions to drive falls in fossil generation. Instead, a fast build of wind and solar is required to meet new electricity demand and drive fossil generation out of the mix.

European Union

Decline in EU fossil generation contributes to plateau of global power sector emissions.

EU electricity demand continued to fall in the first half of 2023, slowing global demand growth. The EU contributed 11% of global growth in wind and solar generation in H1-2023, despite the fact that its growth rates were lower than the global average. As a result of demand falling and renewables increasing, fossil fuel generation fell dramatically. Consequently, the EU's power sector emissions fell by 59 million tonnes (-17%), which helped ensure that global power sector emissions plateaued rather than increased.



EU electricity demand falls continue

EU electricity demand fell 4.6% (-61 TWh) in the first six months of 2023, in contrast to a global rise of 0.4%. The fall in electricity demand in H1-2023 is the continuation of a trend that started with Russia's invasion of Ukraine in the spring of last year, with demand in the EU falling 1.4% in the first half of 2022 and 3.3% across the whole of 2022. High electricity prices due to high gas import costs as well as security of supply concerns arising from Russia's invasion of Ukraine in early 2022 led to significant demand saving measures by European nations.

Low electricity demand in the first half of the year and further additions in wind and solar generation also led to the first recorded month—in May—in the EU where wind and solar produced more electricity than fossil fuels. With the continued build up of wind and solar, these records are set to become the norm as the EU's electricity transition continues.

Moderate renewables growth in the EU

The EU increased its solar and wind generation moderately in the first half of 2023. Wind generation increased by 4.8% (+10 TWh), far slower than the global average growth of 10%, while solar increased by 13% (+13 TWh), also below the global increase of 16%. Nevertheless, wind and solar growth in the EU contributed 11% to the global increase in the first half of 2023, and the EU remains one of the regions with the highest share of wind and solar generation (27% in H1-2023 in contrast to global average of 14%), because the bloc deployed wind and solar much earlier than other regions. In H1-2023, there were 17 EU countries that achievedrecord high renewable generation. For example, renewables provided a record 50% of power in Greece in the first half of 2023, and reached 75% in Portugal and 79% in Denmark for the first time.

EU fossil generation falls to a record low

Lower demand and renewable growth led to EU fossil power falling by 17% (-86 TWh). This was only one percentage point less than the reduction seen during H1-2020 when the Covid-19 pandemic caused demand and fossil generation to fall by 18%.

The EU's fossil generation in the first half of 2023 was the lowest since at least 2000 at 410 TWh. The fall was Europe-wide, with a decline of at least 20% in eleven countries, and more than 30% in five (Portugal, Austria, Bulgaria, Estonia, Finland) as described in detail in Ember's latest review of the EU's power sector transition.

EU coal generation fell the most—a massive 23% (-49 TWh)—in contrast to a global rise of 1%. Coal generation comprised less than 10% of the EU's electricity generation for the first time ever in May, with May and June marking the two lowest coal months on record.

EU gas generation decreased by 13% (-33 TWh), in contrast to a global rise of 0.5%.

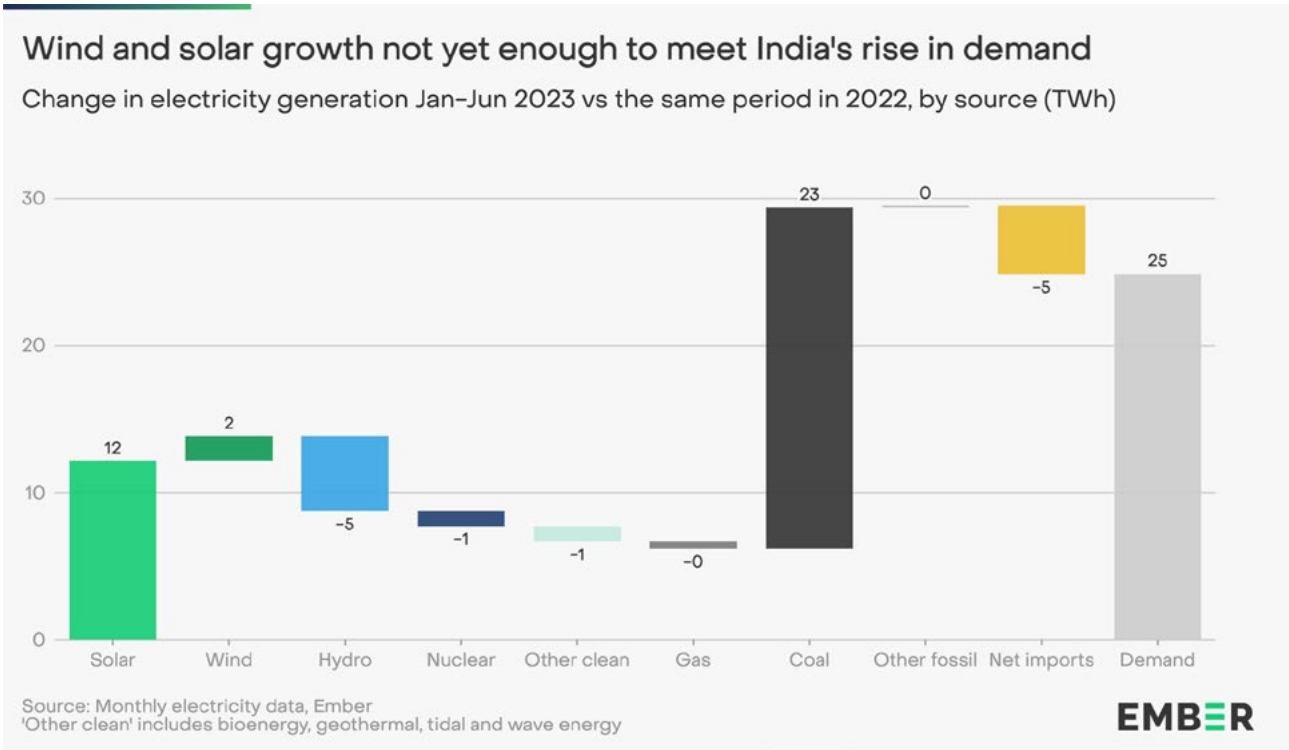
EU's power sector emissions fall

EU power sector emissions were down 17% (-59 million tonnes of CO2) as a result of the fall in fossil generation, after both H1-2022 and H1-2021 had seen emissions rise. The fall in the EU's emissions is equivalent to 1% of global power sector emissions and contributed to global sector emissions plateauing with an increase of just 0.2% (12 million tonnes of CO2) in the first half of 2023.

India

India responsible for 12% of global growth in solar in the first half of 2023.

India's solar growth was above the global average in the first half of 2023 and contributed 12% of global growth in solar generation. Consequently, India's emissions growth slowed, as moderate demand growth and the rise in renewables helped temper fossil fuel expansion.



Moderate demand growth in India

India's electricity demand increased 3.1% (+25 TWh) in the first half of 2023, above the global average of 0.4%. India's demand growth so far this year is significantly below the rates seen in H1-2021 (+13%) and H1-2022 (+11%), although those growth rates have to be seen in the context of an economic recovery after the Covid-19 pandemic as the country caught up to demand growth rates seen before 2020.

India's renewables increase, but not strong enough to stop fossil from rising

India's growth in solar generation (+26%, +12 TWh) in the first half of 2023 was above the global average growth (+16%) and enough to meet more than half of the country's demand increase. In H1-2023, India contributed nearly as much new solar generation as the EU, with 12% of the global additions. However, India's solar generation grew at a slower rate compared to the same period last year where it increased by 35%. Though it is worth noting that in absolute terms both the first half of 2023 and first half of 2022 saw the same increase in generation from solar (+12 TWh). To maintain high percentage growth rates as solar expands, India needs to see larger generation additions each year.

Other clean sources performed less well. India's wind generation increased by only 4.9% (+1.7 TWh) in the first six months of 2023, which is below the global average (+10%). Moreover, this growth rate was significantly below the increase in wind generation in India in H1-2022 (+13%, +4 TWh).

India's generation from all renewables increased 4.8% (+7.7 TWh). The growth would have been higher if there was no fall in hydro, which decreased by 7.5% (-5.1 TWh), a slightly smaller fall than seen worldwide (-8.5%). India's bioenergy also fell by 11% (-1.1 TWh), in contrast to a global rise of 1.7%.

India's fossil generation rose 3.7% (+23 TWh) to meet a substantial deficit created by low hydro output, falls in nuclear generation and higher electricity exports to neighbouring countries. India's fossil growth was much higher than the global growth of 0.1%. This was driven by a rise in coal generation which increased by 3.8% (+23 TWh) in contrast to a global rise of 1%. At the same time India's gas generation fell by 3.4% (−0.5 TWh), which was faster than the global fall of 0.5%.

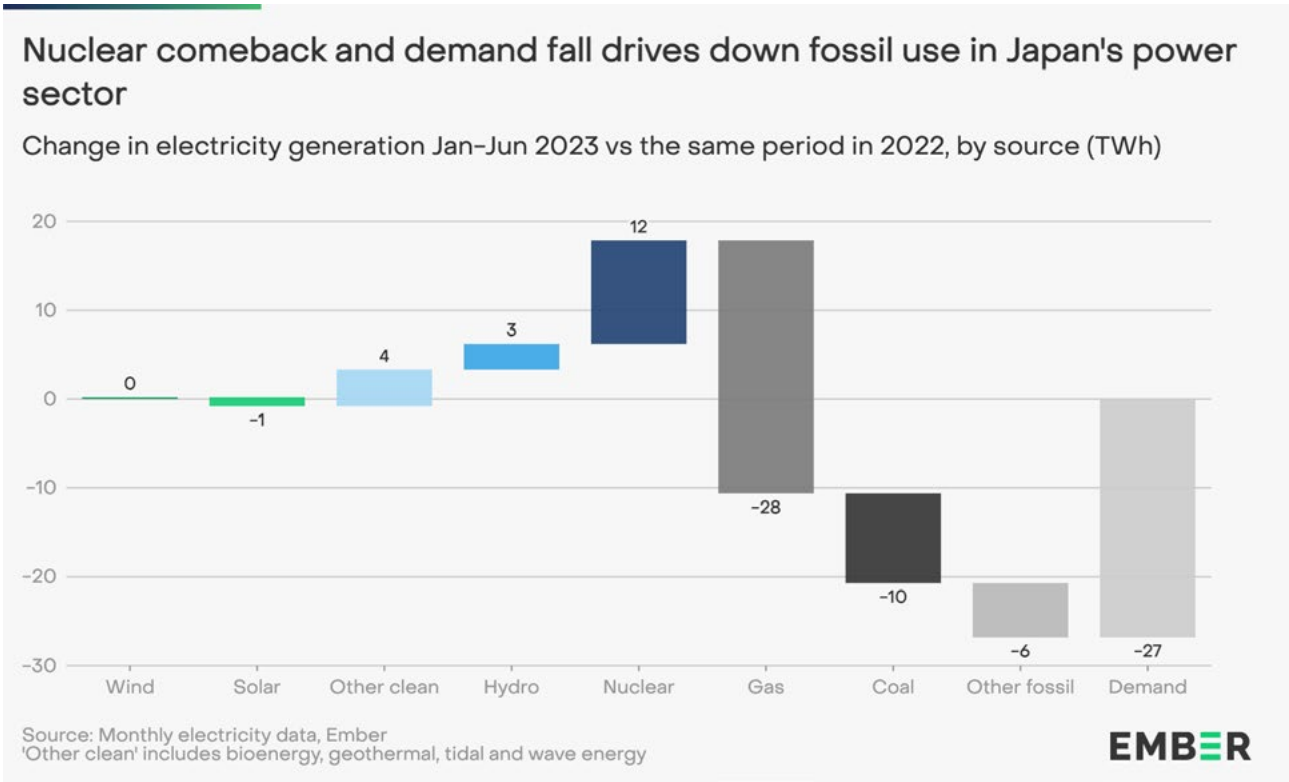
Slower emissions growth in India

India's power sector emissions grew by 3.7% (+19 million tonnes of CO2) in the first half of 2023. This represents a significant slowing of emissions growth, less than half of the growth seen in the first half of 2022 (+9.7%, +45 million tonnes of CO2). India's emissions growth was slower as coal generation did not have to rise aggressively to meet the growth in demand. Demand growth was lower in the first half of 2023 (+3.1%) compared to the same period last year when demand grew strongly (+11%) as the country was recovering from the Covid-19 lockdowns. Lower demand increase in the first half of this year meant a slower rise in India's coal generation (+3.8%) compared to the same period last year (+10%), and consequently lower emissions growth.

Japan

Decline in Japan's fossil generation contributes to plateau of global power sector emissions.

Japan's rapid decline in fossil fuels in the first half of 2023 led to a fall in power sector emissions of 25 million tonnes of CO2, contributing to a plateau in global power sector emissions. Japan's nuclear growth was above the global average, and demand fell significantly, driving the decline in fossil fuels. However, both wind and solar remained at similar levels to last year.



Nuclear comeback and demand falls in Japan drive down fossil fuels

Japan's nuclear generation saw a significant increase in the first half of 2023, growing 47% (+12 TWh) compared to the same period last year, as reactors were returned to service after maintenance. The growth in Japan's nuclear generation was much higher than the global average growth of 0.7%.

In recent years, between 2020 and 2022, Japan's nuclear fleet has been experiencing delays in reactor maintenance as the country sought to reintroduce more nuclear power to the mix after it had phased out nuclear power completely in the aftermath of the 2011 Fukushima disaster. More reactors started to come back online during 2022 after completing maintenance. As a result, in H1-2023, nuclear generation was up 47% (+12 TWh) compared to H1-2022.

At the same time, Japan's electricity demand fell by 5.6% (-27 TWh) in H1-2023 amid efforts to reduce electricity consumption. This helped to lower global demand and consequently helped global emissions to plateau.

The additions in nuclear generation paired with the fall in electricity demand and small increases in both generation from bioenergy and hydropower output reduced Japan's reliance on fossil fuels significantly. Fossil generation in H1-2023 was down 14% (-45 TWh) compared to the same period last year. Most of the reductions came from gas generation (-17%, -28 TWh), though coal generation (-7.4%, -10 TWh) and other fossil fuels (-22%, -6.1 TWh) also fell substantially.

Japan's wind and solar remain muted

For the full year of 2022, Japan's solar generation saw an increase of 11% (+10 TWh), less than half of the global increase of 25%. However, H1-2023 showed no signs of continued growth, as solar generation fell slightly by 1.9% (-1 TWh), compared to the global increase of 16%. Similarly Japan's wind generation saw almost no change (+2.4%, +0.2 TWh) in H1-2023 compared to the same period last year, which is far below the global growth of 10%. The deployment of wind generation remains a major untapped potential for Japan to accelerate its transition away from fossil fuels and to a clean power sector.

Falls in Japan's fossil generation lead to emissions decline

Japan's 14% fall in fossil generation resulted in an emissions fall of 12% (-25 million tonnes of CO2) in the first half of 2023. The fall in Japan's emissions is equivalent to 0.4% of global power sector emissions and contributed to global sector emissions plateauing with an increase of just 0.2% (12 million tonnes of CO2) in the first half of 2023.

Conclusion

World teetering at ‘peak fossil’ in the power sector

Emissions fell in some of the major CO2 emitting economies, but more ambitious action is required to bring global power sector emissions down

The global power sector needs to achieve net zero by 2035 in OECD countries and by 2040 in the rest of the world, to put the world on a pathway to limiting global warming to 1.5C. Global emissions plateaued in the first half of 2023, an important first step in the electricity transition as the world seeks to ‘peak’ emissions and begin the process of decline.

However, power sector emissions need to be falling fast this decade, not just plateauing. Moreover, having falling emissions when demand is exceptionally low is not enough; emissions must be falling even when global demand is increasing as the world consumes more electricity and moves towards electrifying the entire economy.

For global power sector emissions to fall, more clean sources need to be added, so they can not only meet growing electricity demand but start replacing fossil fuel generation. In particular, wind and solar need to become the backbone of the future electricity system, providing about 70% of global power by 2040, and other clean sources like nuclear and hydro need to increase too.

Although wind and solar have been growing much more than any other electricity source, their deployment needs to triple by 2030 and they need to maintain a high growth rate year on year of about 20%. This can only be achieved if strong policies are in place that not only incorporate ambitious targets but also deliver the policy enablers needed to incentivise and de-risk the deployment of more wind and solar. These include streamlining the permitting process, focusing on grid development and modernisation, and building supporting infrastructure like interconnections, adequate storage and more. An increase in international funding is also crucial to support fossil-dependent emerging economies to transition to clean electricity.

As the situation with hydro generation shows, it is also crucial to mitigate the impact of climate change on clean electricity generation. So for example solutions such as floating solar panels on hydro reservoirs can be considered to reduce evaporation, as well as better reservoir management.

As international calls for a tripling of renewables continue to grow ahead of COP28, the stakes have never been higher. Already in 2023 we have seen record-breaking global temperatures and accelerating impacts of climate change. Decarbonising electricity by accelerating wind and solar is the single biggest action we can take this decade to put the world back on track.

Supporting materials

Methodology

Summary

This report analyses the latest monthly power sector data for 78 countries representing 92% of global power demand, as well as annual data for 215 countries. Data is collected from multi-country datasets (EIA, Eurostat, BP) as well as national sources (e.g China data from the National Bureau of Statistics). The latest annual generation data is estimated using monthly generation data. Annual capacity data is collected from GEM, IRENA and WRI. A detailed methodology can be accessed here. All the data can be viewed and downloaded freely from Ember's website.

Capacity factors

Capacity factors are calculated based on IRENA capacity data and Ember generation data. Capacity build up throughout the year is interpolated from end of year values to arrive at mid-point capacity for full years or half years (H1, H2). End of year capacity values for 2023 are based on capacity addition estimates by the IEA.

Emissions scenario

The scenario for emissions changes if hydro had not fallen uses a two-thirds coal, one-third gas ratio for the reduced fossil fuel generation and the subsequent reduction in power sector emissions.

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